EXPLORATORY CASE STUDIES TO IMPROVE EFFICIENCIES THROUGH LEAN TECHNIQUES IN CONTINUOUS PROCESSES IN TWO SOUTH AFRICAN COMPANIES

by

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Exploratory case studies to improve efficiencies through lean techniques in continuous processes in two South African companies.

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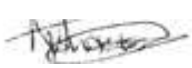

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ABSTRACT

Lean manufacturing principles have various tools and techniques that have been commonly used in discrete manufacturing processes. The literature on the use of lean techniques in continuous processes is scant, particularly from a South African perspective. Therefore, it is not clear whether manufacturers using continuous processes use lean techniques in their automated processes. This study aimed to explore lean techniques that can improve efficiencies in continuous processes in two South African case studies by identifying the various forms of waste that exist within their continuous process manufacturing environments, determining the lean techniques that are used in the two continuous process environments, and identifying how efficiencies can be improved within the two continuous process manufacturing environments. The interpretative paradigm was chosen, and an exploratory study was conducted that followed a qualitative research methodology. The data were collected through a desktop literature review, workplace observations of two case study environments that use continuous processes, and twenty-four semistructured face-to-face interviews. These interviews were analysed using content analysis, and workplace observations and a literature review were used to triangulate the data collected. The findings of the study revealed: recycling of waste can also be viewed as a form of waste due to the additional employment of resources in the form of staff, energy, time, effort and money; workers need to be involved in the decision-making capability of the production facility by sharing information, deciding how work is performed and suggesting continuous improvement and enhancement of production efficiency; management has put standard operating procedures in place for workers, but workers do not follow those standard operating procedures; there are various continuous improvement methods (Six Sigma DMAIC, Fishbone, 5 Whys and root cause analysis) used in continuous processes to solve production problems; maintenance staff prioritise maintenance to machines that prevent the complete stoppage of the production process in continuous process facilities; maintenance staff mostly conduct reactive maintenance to avoid lengthy production downtime; the lean manufacturing techniques that are applied in continuous processes are TPM (preventative and corrective maintenance), continuous improvement (Six Sigma DMAIC, 5 Whys, root cause analysis and fishbone analysis), 5S, recycling and TQM. The following recommendations were made: managers must monitor the adherence to standard operating procedures; a monthly forum should be established where workers can be taught and informed of the impact of the statistical data and number of defects and allowed to provide input into how process efficiencies can be improved; management must facilitate proper maintenance execution through effective monitoring and control strategies; and lean manufacturing should be adopted as a philosophy within the case study examples. This study is of value to all organisations that use the continuous process. Recommendations for future studies are as follows: the sample can be enlarged to generalise the findings, and other countries may be considered.

Keywords: continuous process, lean manufacturing, 5S, Six Sigma, continuous improvement, total productive maintenance, total quality management, standard operating procedures, processes, waste

TSHOBOKANYO

Dintlhatheo tsa tlhagiso e e fokotsang tshenyo mme e oketsa tlhagiso di na le didiriswa le dithekeniki tse di farologaneng tse di ntseng di dirisiwa ka tlwaelo mo tlhagisong ya ditlhagiswa tse di bonalang. Dikwalo tse di ka ga tiriso ya dithekeniki tse difokotsang tshenyo mme di oketsa tlhagiso ga di kalo, bogolo segolo mo ntlheng ya Aforikaborwa. Ka jalo, ga go bonale sentle gore a batlhagisi ba ba dirisang ditirego tse di tswelelang pele ba dirisa dithekeniki tse di fokotsang tshenyo mme di oketsa tlhagiso mo ditiregong tsa bona tsa itiriso. Thutopatlisiso eno e ne e ikaeletse go tlhotlhomisa dithekeniki tse di fokotsang tshenyo mme di oketsa tlhagiso tse di ka tokafatsang nonofo ya ditirego tse di tswelelang pele mo dithutopatlisisong tsa tobiso di le pedi tsa Aforikaborwa, ka go supa mefuta e e farologaneng ya tshenyo e e gona mo tikologong ya tsona ya tlhagiso ya tirego e e tswelelang pele, le go supa ka moo nonofo e ka tokafadiwang ka gona mo ditikologong tse pedi tsa tlhagiso ya tirego e e tswelelang pele. Go tlhophilwe sekao sa

thanolo, mme go dirisitswe thutopatlisiso e e tlhotlhomisang e latela mokgwa wa patlisiso o o lebelelang mabaka. Go kokoantswe *data* ka tshekatsheko ya dikwalo mo khomphiuteng, kelotlhoko ya kwa mafelotirong ya ditikologo tse pedi tsa thutopatlisiso ya tobiso tse di dirisang ditirego tse di tswelelang pele, le dikopanopotsolotso tsa namana tse di batlileng di rulagane di le 24. Dikopanopotsolotso di lokolotswe go dirisiwa tokololo ya diteng, mme *data* e e kokoantsweng ka kelotlhoko ya kwa mafelotirong le tshekatsheko ya dikwalo e dirisitswe ka mekgwa e e faraloganeng. Diphitlhelelo tsa thutopatlisiso di senotse gore: go dirisiwa gape ga leswe go ka tsewa e le mokgwa wa tshenyo ka ntlha ya tiriso ya ditlamelo tsa tlaleletso di tshwana le badiri, motlakase, nako, matsapa le tšhelete; badiri ba tshwanetse go nna le seabe mo bokgoning jwa tseoditshwetso jwa setheo ka go abelana tshedimosetso, go swetsa gore tiro e dirwa jang le go tshitshinya tokafatso e e tswelelang pele le tokafatso ya nonofo ya tlhagiso; botsamaisi bo beetse badiri dithulaganyo tse di rileng tsa go dira, fela badiri ga ba latele dithulaganyo tseo tse di beilweng; go na le mekgwa e e faraloganeng ya tokafatso e e tswelelang pele (Six Sigma DMAIC, Lerapo la tlhapi (Fishbone), Goreng ba ba 5 (5 Whys) le tokololo ya sebako sa motheo) e e dirisiwang mo ditiregong tse di tswelelang pele go rarabolola mathata a tlhagiso; badiri ba tlhokomelo/paakanyo ba baya paakanyo ya metšhini e e thibelang go emisiwa gotlhelele ga tlhagiso jaaka setlapele mo ditlamelong tsa tirego e e tswelelang pele; badiri ba tlhokomelo/paakanyo gantsi ba dira paakanyo go tsiboga e le go tila gore go nne le nako e telele e go se nang tlhagiso mo go yona; dithekeniki tsa tlhagiso tse di fokotsang tshenyo mme di oketsa tlhagiso tse di dirisiwang mo ditiregong tse di tswelelang pele ke TPM (paakanyo ya thibelo le paakanyo), tokafatso e e tswelelang pele (Six Sigma DMAIC, Goreng ba ba 5 (5 Whys), tokololo ya sebako sa motheo le tokololo ya lerapo la tlhapi), 5S, tiriso gape le TQM. Go dirilwe dikatlenegiso tse di latelang: batsamaisi ba tshwanetse go baya leitlho kobamelo ya dithulaganyo tse di beilweng tsa tiro; go tshwanetse ga simololwa foramo ya kgwedi le kgwedi moo badiri ba ka rutwang le go sedimosediwa ka ditlamorago tsa *data* ya dipalopalo le palo ya diphoso mme ba letlelelwe go dira dikakgelo malebana le gore nonofo ya ditirego e ka tokafadiwa jang; botsamaisi bo tshwanetse go bebofatsa tiragatso e e siameng ya paakanyo ka ditogamaano tsa peoleitlho e e bokgoni le taolo; mme tlhagiso e e fokotsang tshenyo mme e oketsa tlhagiso e tshwanetse go amogelwa jaaka mogopolo mo dikaing tsa thutopatlisiso ya tobiso. Thutopatlisiso eno e mosola mo ditheong tse di dirisang tirego e e tswelelang pele. Dikatlenegiso tsa dithutopatlisiso tsa mo isagong di a latela: go ka okediwa sampole gore diphitlhelelo di kgone go akaretsa, mme go ka akanngwa ka dinaga tse dingwe.

Mafoko a botlhokwa: tirego e e tswelelang pele, tlhagiso e e fokotsang tshenyo mme e oketsa tlhagiso, 5S, Six Sigma, tokafatso e e tswelelang pele, paakanyo e e tokafatsang tlhagiso ka botlalo, botsamaisi jwa boleng ka botlalo, dithulaganyo tse di beilweng tsa go dira, ditirego, tshenyo

OKUCASHUNIWE

Izimiso zokukhiqiza ukuqedwa kanzima kwemfucuza zinamathuluzi namasu ahlukahlukene asetshenziswe ngokuvamile ezinqubeni zokukhiqiza ezihlukene. Imibhalo ephathelene nokusetshenziswa kwezindlela zokuqedwa kanzima kwemfucuza ezinqubeni eziqhubekayo mincane, ikakhulukazi ngokombono waseNingizimu Afrika. Ngakho-ke, akucaci ukuthi abakhiqizi abasebenzisa izinqubo eziqhubekayo basebenzisa amasu okuqedwa kanzima kwemfucuza ezinqubeni zabo ezizenzakalelayo. Lolu cwaningo luhlose ukuhlola amasu okuqedwa kanzima kwemfucuza angathuthukisa ukusebenza kahle ezinqubeni eziqhubekayo ezicwaningweni ezimbili zaseNingizimu Afrika ngokuhlonza izinhlobo ezahlukene zemfucuza ezikhona ngaphakathi kwenqubo yazo eqhubekayo yokukhiqiza izindawo, kunqunywa amasu okuqedwa kanzima kwemfucuza asetshenziswa ezindaweni ezimbili eziqhubekayo zenqubo, kanye nokuhlonza ukuthi ukusebenza ngempumelelo kungathuthukiswa kanjani phakathi kwezinqubo ezimbili eziqhubekayo zokukhiqiza izindawo. Kwakhethwa indlela ebandakanya abacwaningi ukuze bahumushe izingxenye zocwaningo, kwase kwenziwa ucwaningo lokuhlola olulandela indlela yocwaningo egxile ekutholeni imininingwane ngokusebenzisa ukuxhumana okuvulekile nokuxoxa. Imininingwane yaqoqwa ngokubuyekezwa kwemibhalo ekuqoqeni imininingwane ezinsizeni ezikhona, ukubhekwa kwendawo yokusebenza kwezindawo ezimbili zezifundo ezisebenzisa izinqubo eziqhubekayo, kanye nezingxoxo ezingamashumi

amabili nane zobuso nobuso ezingahlelekile. Lezi zingxoxo zahlaziywa kusetshenziswa ukuhlaziya okuqukethwe, futhi ukubhekwa kwendawo yokusebenza nokubuyekezwa kwemibhalo kwasetshenziswa ukuhlukanisa indawo ibe ngonxantathu ukuze kulawe imininingwane eqoqiwe. Okutholwe ocwaningweni kwembule: ukugaywa kabusha kwemfucuza kungabuye kubhekwe njengohlobo lokumosha ngenxa yokuqashwa okwengeziwe kwezinsiza ezifana nabasebenzi, amandla, isikhathi, umzamo kanye nemali; abasebenzi kudingeka babambe iqhaza ekuthatheni izinqumo kwesikhungo sokukhiqiza ngokwabelana ngolwazi, banqume ukuthi umsebenzi wenziwa kanjani futhi baphakamise ukuthuthukiswa okuqhubekayo kanye nokuthuthukiswa kokusebenza kahle kokukhiqiza; abaphathi babeke izinqubo ezijwayelekile zokusebenza kubasebenzi, kodwa abasebenzi abazilandeli lezo zinqubo ezijwayelekile zokusebenza; kunezindlela ezihlukahlukene eziqhubekayo zokuthuthukisa (Isu lekhwalithi eliqhutshwa yimininingwane elisetshenziselwa ukuthuthukisa izinqubo, indlela ebonakalayo yokubheka imbangela nomphumela, indlela yokubuza futhi ephendula umbuzo othi "Kungani?" kanye nenqubo yokuthola umnyombo wezinkinga ukuze kutholakale izixazululo ezifanele) ezisetshenziselwa izinqubo eziqhubekayo zokuxazulula izinkinga zokukhiqiza; abasebenzi bezokulungisa babeka phambili ukugcinwa kwemishini evimbela ukumiswa okuphelele kwenqubo yokukhiqiza ezikhungweni zenqubo eqhubekayo, abasebenzi bezokulungisa bavame ukwenza umsebenzi wokulungisa ukugwema isikhathi eside sokukhiqiza; amasu okukhiqiza kokuqedwa kanzima kwemfucuza asetshenziswa ezinqubeni eziqhubekayo yi-TPM (ukugcinwa kokuvimbela nokulungiswa), ukuthuthukiswa okuqhubekayo (Isu lekhwalithi eliqhutshwa yimininingwane elisetshenziselwa ukuthuthukisa izinqubo, indlela yokubuza futhi ephendula umbuzo othi "Kungani?", ukuhlaziya kokuthola umnyombo wezinkinga ukuze kutholakale izixazululo ezifanele kanye nokuhlaziya okubonakalayo kokubheka imbangela nomphumela), uhlelo lokuhlela izindawo ukuze umsebenzi wenziwe ngempumelelo nangokuphepha (5S), ukugaywa kabusha kanye nokuphathwa kwekhwalithi okuphelele (TQM). Kwenziwa iziphakamiso ezilandelayo: abaphathi kumele baqaphe ukulandelwa kwezinqubo ezijwayelekile zokusebenza; kufanele kusungulwe isithangami sanyanga zonke lapho abasebenzi bengafundiswa khona futhi baziswe ngomthelela wemininingwane yezibalo kanye nenani lamaphutha futhi bavunyelwe ukunikeza umbono wokuthi ukuphumelela kwezinqubo kungathuthukiswa

kanjani; abaphathi kumele benze lula ukugcinwa kokulungiswa ngendlela efanele ngamasu okuqapha nokulawula ngempumelelo; futhi ukukhiqizwa kokuqedwa kanzima kwemfucuza kufanele kwamukelwe njengesimo sokuziphatha ngaphakathi kwezibonelo zesifundo socwaningo. Lolu cwaningo lubalulekile kuzo zonke izinhlangano ezisebenzisa inqubo eqhubekayo. Iziphakamiso zezifundo zesikhathi esizayo zimi kanje: isampuli ingakhuliswa ukuze kuhlanganiswe okutholakele, futhi amanye amazwe angacatshangelwa.

Amagama asemqoka: inqubo eqhubekayo, ukukhiqiza kokuqedwa kanzima kwemfucuza, uhlelo lokuhlela izindawo ukuze umsebenzi wenziwe ngempumelelo nangokuphepha, Isu lekhwalithi eliqhutshwa yiminininingwane elisetshenziselwa ukuthuthukisa izinqubo, ukuthuthukiswa okuqhubekayo, ukugcinwa okuphelele kokukhiqiza, ukuphathwa okuphelele kwekhwalithi, izinqubo zokusebenza ezijwayelekile, izinqubo, imfucuza,

DEFINITIONS OF KEY TERMS

Keywords	Definition and reference	Reference
Continuous process / Process industry	Manufacturing where the complete product are substances that cannot be discretely separated (e.g., chemicals, electricity, glass); in other instances, the complete items might be separated, yet their production calls for processes where the elements being worked on cannot be separated (e.g., steel, pharmaceuticals)	(Abdulmalek, Rajgopal and Needy, 2015).
Lean manufacturing	An approach for refining business performance in many manufacturing, which removes unnecessary procedures, to increase productivity, improves quality and reduces lead times thereby, decreasing the overall costs,	(Panwar, Nepal, Jain and Rathore, 2015).
Lean manufacturing goal	The lean manufacturing goal refers to the aim or purpose of lean manufacturing.	Bhattacharyaa and Ramachandran, 2021)
Lean manufacturing principles	Lean manufacturing refers to the guiding values of lean manufacturing.	(Bhattacharyaa and Ramachandran, 2021)
Lean manufacturing tools and techniques	Lean techniques are methods that are used to identify and eliminate the root causes of waste.	(Panizzolo, Garengo, Sharma and Gore, 2012)
Discrete manufacturing	Produces countable, different products and is recognisable in a project-, jobbing-, batch- and mass process types	(Lyons, Vidamour, Jain and Sutherland, 2013)
Process type	There are five process types, namely, Job shop, batch, mass, project and continuous.	Stevenson (2012)
Preventative maintenance	Preventative Maintenance (PM) takes place at prearranged breaks or according to arranged standards and is	Stenstrom, Norrbin, Parida and Kumar (2016)

Keywords	Definition and reference	Reference
	projected to decrease the probability of equipment breakdowns.	
Corrective maintenance	Corrective maintenance (CM) takes place after a fault has been identified; it is projected to put the failed item back into a state in which it can achieve its required purpose.	Stenstrom et al. (2016)

Source: Author’s own work

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ABBREVIATIONS AND ACRONYMS

5S	-	Sort (seiri), Set-in- Order (seiton), Shine (seico), Standardise (shitsuke), and Sustain (seiketsu)
CSM	-	Current State Map
DMAIC	-	Define, Measure, Analyse, Improve and Control
FSM	-	Future State Map
JIT	-	Just in Time
TPM	-	Total Productive Management
TQM	-	Total Quality Management
VSM	-	Value Stream Mapping
WIP	-	Work in Process
KPIs	-	Key Performance Indicator

CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

This introductory chapter presents a summary of the research project. The first section provides the background and context of the problem. This chapter reviews the global practices of lean manufacturing in the manufacturing process. Thereafter, the research gap is identified, and a problem statement and the aim and objectives of the study are provided. From there, the research paradigm, trustworthiness and credibility, the impact and significance of the study, ethical considerations and limitations and delimitations of the study are discussed. This chapter ends with the chapter outline of the research project and is followed by the chapter conclusion.

1.2 BACKGROUND TO THE STUDY

South Africa is a developing country that annually invests significantly into manufacturing but still experiences load shedding, delays during manufacturing, cost overruns and various types of waste (Maradzano, Dondofema and Matope, 2019). Companies continuously look for effective and efficient strategies to respond to challenges, meet customers' needs and improve the overall performance of the organisation (Panwar et al., 2015). James Womack and Daniel Jones developed lean manufacturing thinking from the Toyota production system whereby all manufacturing staff work together to reduce waste (Melton, 2005). Lean manufacturing is a good initiative for manufacturing companies to remain competitive and productive in the universal market. Lean manufacturing principles have turned out to be the most broadly identified philosophy that aims to decrease waste and worthless activities to increase performance in cost efficiency, enhance conformance to quality, improve productivity, decrease inventory levels and reduce output times (Deflorin and Scherrer-Rathje, 2012). Figure 1.1 is an illustration of lean thinking levels.

Lean goals/philosophy
Reduce cost, eliminate waste and improve quality to increase customer value.

Lean principles
1. Elimination of waste; 2. Alignment of production demand; 3. Creative involvement of the workforce; 4. Integration of suppliers

Lean tools and technique/ Operational level
1. Cellular manufacturing, take-time-pacing, one-piece flow, mixed-model production, Pull systems and levelled production.
2. TPM, quick changeover, mistake proofing, 5S, statistical processcontrol visual control and standard operations.
3. Long term contracts, JIT deliveries supplier rationalisation and Supplier development activities
4. Quality circles, automation, Team-based problem solving, job rotation, cross-functional training and Worker-driven kaizen.

Figure 1. 1: Lean thinking levels

Source: Lyons et al. (2013)

Lean thinking levels (figure 1.1) have three different levels: lean goals or philosophy, lean principles, and lean tools and techniques. Each of these levels can be further broken down into smaller components. The significance of these levels is that they explain how lean is viewed and implemented within organisations. Lean goals explain the main aim of the lean manufacturing system, which is to eliminate waste, reduce costs, improve quality, and increase customer value. Lean principles are the guiding values of the lean manufacturing system. Lean tools are techniques that can be used to pinpoint the major sources of waste and guide management through corrective actions. Lean manufacturing principles are used globally in different industries, such as process industries, the aviation industry, manufacturing, the textile industry, and the service industries. Melton (2005) points out that lean is not only about using tools or changing a small number of steps in production methods but also relates to the transformation of how the supply chain functions, how the directors direct, how the managers manage, and how workers go about their everyday work.

Masemola, Makhanya and Nel (2021) conducted a study to assess the application of lean manufacturing in South Africa as well as to identify the types of waste affecting the performance of the case study company with recommendations for waste management. The findings of the study identified waste as defects, transportation, inventory, waiting and unused workers' ideas, all of which influence the organisation's performance. The study also discovered that standard work, 5S and kanban are the most frequently used lean manufacturing tools and techniques. It is unclear whether lean application occurs in discrete or continuous processes.

Two case study examples that follow continuous processes in manufacturing were identified in this study. The first case study example produces glass bottles in South Africa. The glass company operates three furnaces that supply nine forming lines at its manufacturing facility. The company serves a broad market in local and multinational customers in the beverage and food industries.

The second case study example produces electricity in South Africa. The plant has 6 production lines that produce 4,000 MW, and it is the largest direct dry-cooled power station in the world, with six 665 MW turbo-generator units. The annual power supplied from the plant amounts to approximately 24,000 GW.

1.3 GLOBAL PRACTICES OF LEAN MANUFACTURING IN MANUFACTURING PROCESSES

Stevenson (2012) refers to the manufacturing process as one or more activities that transform inputs (raw material) into outputs (final product). Process types are general approaches to managing processes and are differentiated in manufacturing and services (Slack, Brandon-Jones, Johnston, Singh and Phihlela, 2017). Different terms are used to classify process types according to manufacturing or service processes. Slack et al. (2017:79) define process types as "the situation of a process on the volume – variability continuum that shapes its whole design and the overall approach to managing its activities". The following manufacturing process types exist: project, jobbing, batch, mass, and continuous processes. Lean manufacturing principles have been applied within all these process types. Krajewski, Ritzman and Malhotra (2013) explain several ways of structuring a process, either by organising resources around the process or by organising resources around the products. However, Slack et al. (2017) state that the design of any procedure should be directed by the volume and variety of the expected production.

The first four process types – project, jobbing, batch and mass – are classified as discrete processes. The cluster of process industries consists of only continuous processes. Table 1.1 provides a brief description of each process type, and an example of where the process type had found an application is also shown in table 1.1.

Table 1. 1: Description of process types

	PROCESS TYPES	DESCRIPTION	EXAMPLES
Discrete processes	1 Project processes	Deals with separate, regularly customised goods, frequently with a relatively lengthy timescale between the finish of each item, where each job has been well defined from the beginning and to finish.	Construction of bridge, stadium and hospitals
	2 Jobbing processes	Deals with high variety and low volumes and includes specialist toll making and furniture restorers.	Goods produced in dye shop and tool.making
	3 Batch processes	Used when a reasonable volume of products or services is preferred, and it can handle a reasonable variety in goods or services.	Manufacturing of fashion clothing and variety of bread or cakes.
	4 Mass processes	Steps that manufacture items in high volume and relatively narrow variation. These methods may include vehicle assembly.	Manufacturing of cars, Fridge and computers
Process Industries	5 Continuous processes	These methods have greater volumes and frequently lesser variation than mass processes. They also function for longer periods. Others are continuous in that their products are attached and produced in a never-ending flow.	Electricity production and glass manufacturing.

Source: Stevenson (2012)

Table 1.1 illustrates different types of processes with their descriptions and examples. The first four process types (project, jobbing, batch and mass) are referred to as discrete processes. Discrete processes have high variety and low volume. The last process type is a continuous process that is highly automated with a low variety of products. Abdulmalek et al. (2015) confirmed that lean manufacturing had been implemented globally. Abdulemalek and Rajgopa (2007) adapted the application of lean principles in continuous processes at an integrated steel mill company in the United States of America. Value stream mapping was used to detect improvement opportunities for lean techniques to be introduced. A simulation model was put together to demonstrate the benefits of using lean to managers, which included decreased production lead time and lower WIP inventory. Applying lean techniques in continuous processes improves efficiency, reduces waste, and increases productivity.

Mahaptra and Mohanty (2007) conducted a cross-sectional survey study in manufacturing organisations in India that use continuous processes. Chemical, textile, pharmaceutical, electronics assembly, fast-moving consumer goods, and metal manufacturing are the organisations used for the survey. The case study highlighted knowledge and understanding of lean manufacturing in Indian firms and how lean can be adapted and diffused for enhanced benefits. Studies on how lean manufacturing has been applied in continuous processes in the South African context could not be found. Table 1.2 illustrates the differences between continuous and discrete processes.

Table 1. 2: Differentiation between continuous and discrete processes

Continuous processes	**Discrete manufacturing**
• high volumes, • low variety products, • large and inflexible equipment, • long setup times, and • less flexible than discrete manufacturing.	• low volumes, • high variety of products, • flexible equipment, and • more work-in-process and queues to facilitate challenges or delays like operation, transport and rework and set up.

Source: Mahapatra and Mohanty (2007)

The above table 1.2 illustrates the difference between continuous processes and discrete manufacturing. Continuous processes have high volumes, low variety products, and inflexible machines, whereas discrete manufacturing has low volume, high variety, flexible machines and is divided into four types of processes, as illustrated in table 1.1. Table 1.3 indicates how lean manufacturing principles have been applied in various studies according to the different process types.

Table 1. 3: Summary of how lean has been applied in various process types

Process types	**Authors**	**Title**	**Lean techniques used**	**Finding of research**
Project processes	Senaratne and Ekanayake (2012)	Evaluation of the application of lean principles to precast concrete bridge beam production process.	Continuous improvement and people's involvement	The researchers recognised that approximately 57% of the activities (59) were a conversion of activities and 43% of the activities (44) were flow activities. Among the 44 recognised stream activities, 17 can be removed and 58 activities can be improved
	Jorgense and Emmitt (2008)	Lost in transition: the transfer of lean manufacturing to construction	JIT and continuous improvement	There is a need to apply lean principles in construction to identify waste.
Jobbing processes	O'Neill, Jones, Bennett and Lewis (2011)	Application of lean thinking to nursing processes	Work standardisation, 5S and work visual (visual indicators)	Outcomes indicate that lean thinking is an operational enhancement.
	Sharma, Dixit and Qadri (2015)	Impact of lean practices on performance measures in context to Indian machine tool industry	5S, TQM, Poka-Yoka, VSM, cellular manufacturing, and SMED	Strategic partnerships with suppliers and cross-functional cross-organisational design, as well as development teams, significantly influenced most of the important performance measures.
• Batch processes	Bamford, Forrester, Dehe, and Leese (2013)	Partial and iterative lean implementation: two case studies	JIT	Three findings were: 1. Lean has operational and strategic application and benefit.

Process types	Authors	Title	Lean techniques used	Finding of research
				2. The limited diffusion of lean may occur due to external organisation constraits, fluctuating demand patterns, untrustworthy suppliers, insufficient change management strategies and the like. 3. The financial costs are offset against operational risk identified when diffusing lean.
	Hodge, Ross, Joines and Thoney (2011)	“Adapting lean manufacturing principles to the textile industry”	VSM, policy deployment, visual management, continuous improvement, standardised wok and just in time.	Lean manufacturing is an approach that can be applied in both large and small businesses where all workers can be involved in improving processes to meet the customers’ needs.
• Mass processes	Deflorin and Scherrer-Rathje (2012)	“Challenges in the transformation to lean production from different manufacturing-process choices: a path-dependent perspective.”	People involvement, problem solving process standardisation, and continuous improvement	The study reveals that there are many differences (people involvement, process standardisation, changes in behaviour) that must be considered during the transformation to lean manufacturing,
Continuous processes	Panwar et al. (2015)	On the adoption of lean manufacturing principles in	5S, TPM, quality management programmes,	Lean techniques can be applied in continuous process types and discrete process types.

Process types	Authors	Title	Lean techniques used	Finding of research
		process industries.	VSM, work standardisation, teambased problem solving and continuous improvement	

Source: Author's own work

Table 1.3 summarises how lean manufacturing principles and techniques have been successfully applied in various process types in other countries. The table has been structured to include the authors, title of the articles, and lean techniques that were used in the respective study and outlines the major findings of the research that was conducted. The table was compiled from different articles that were read by the researcher. The current literature offers many articles about lean manufacturing principles in discrete processes (project, jobbing, mass, and batch) and fewer in continuous processes. A desktop literature review also revealed that the use of lean principles in continuous processes is limited and outdated.

Operational efficiency includes a few approaches and techniques used to achieve the basic goal of bringing quality goods to customers in the most cost-effective and timely manner (Kurukwar and Katwale, 2021). Amos, Adebola, Asikhia, and Abiodun (2018) explain that manufacturing companies around the world are dealing with the challenges of managing waste and maintaining operational efficiency. Okolocha and Anugwu (2022) highlight that the lean manufacturing method has an effect on efficiency. Lean manufacturing principles and techniques have been pointed out to improve manufacturing efficiency. The goal of lean thinking is to decrease waste in companies by improving the efficiency of their processes to have a continuous flow of production without disruption (Ribeiro, Sa, Ferreira, Silva, Pereira and Santos, 2019). Lean manufacturing is widely used among various industries because it can decrease manufacturing waste without adding resources. Lean manufacturing practice produces a better working environment, decreases product defects and decreases training costs (Indrawati, Azzam and Ramdani, 2019).

1.4 PROBLEM STATEMENT

Continuous processes have high volumes, low variety products, and inflexible machines, whereas discrete manufacturing has low volumes, great variety, and flexible machines and is divided into four process types, as illustrated in table 1.1. Panwar et al. (2015), Abdulmalek and Rajgopal (2007), and Mahapatra and Mohanty (2007) argue that lean manufacturing principles are well established in most manufacturing and should not be restricted to discrete manufacturing. Discrete manufacturing produces distinguishable and countable products (Lyons et al., 2013).

Given the high cost of production and maintenance in continuous processes, the implementation of lean manufacturing principles has numerous challenges that do not exist in discrete manufacturing (Rono, 2013). Some of the challenges experienced during implementing lean manufacturing in continuous processes include a lack of understanding of lean techniques (Almanei, Salonitis and Tsinopoulos, 2018), rendering implementation into business processes problematic. Salonitis and Tsinopoulos (2016) also confirmed that the absence of knowledge regarding lean manufacturing principles and their various techniques is a challenge during implementation. Workers are not trained in lean manufacturing.

The existing lean literature offers many examples of how lean principles, lean philosophy and practices have been incorporated in discrete manufacturing. It is also clear that a highly automated and continuous operation that produces continuous high volumes of product/s may have additional constraints. However, it is not a deterrent for excluding new considerations and tools to be incorporated into the operational processes. There are not sufficient and recent publications on lean in continuous processes. (Lyons et al., 2013; Abdulmalek et al., 2015; Panwar, Jain, Rathore, Nepal and Lyons, 2018; Rono, 2013).

Dondofema, Matope and Akdogan (2017) conducted an investigation into publications where lean manufacturing was applied in the South African industry. The findings of this study revealed that the application of lean manufacturing in South Africa is still at the startup stage. It is unclear whether the lean application for the study occurred in discrete or continuous processes. The gap identified in the study is that there is a lack of research pertaining to the application of lean techniques in continuous processes, particularly from a South African perspective. This may indicate that lean manufacturing principles have not been applied sufficiently in continuous processes. The research problem for this research can be demarcated as follows:

Manufacturing companies using continuous processes in South Africa accumulate waste throughout the manufacturing process, and it is not clear whether manufacturers are using lean techniques in their manufacturing processes to improve efficiency.

1.5 AIM OF THE STUDY

The aim of this study was to explore lean techniques that can be used in two continuous processes in South Africa to improve efficiency.

1.6 RESEARCH QUESTION

This study sought to answer the primary research question:

Which lean techniques can be used to improve efficiencies in two continuous process case studies in South Africa?

Secondary research questions

- What are the various forms of waste within two continuous process manufacturing environments in South Africa?
- Which lean techniques are used in two continuous processes in South Africa?
- How can efficiencies be improved within two continuous process manufacturing environments in South Africa?

1.7 OBJECTIVES OF THE STUDY

To answer the research question, the following primary and secondary objectives were formulated:

Primary objective

To explore which lean techniques can be used to improve efficiencies in two continuous process case studies in South Africa

This study sought to achieve the following **secondary research objectives**:

- To identify the various forms of waste that exist within two continuous process manufacturing environments in South Africa
- To determine the lean techniques that are used in two continuous processes in South Africa
- To identify how efficiencies can be improved within two continuous process manufacturing environments in South Africa

1.8 PARADIGM

According to Malterud (2016), the research paradigm refers to the most important assumptions about a world view and knowledge. A paradigm can be defined as a "set of interrelated assumptions about the social world which offers a philosophical and conceptual framework for the organised study of that world" (Ponterotto, 2005:127). The paradigm selected directs the researcher in philosophical assumptions about the study and choosing tools, instruments, participants, and methods used in the research (Ponterotto, 2005). The paradigms used most often to guide research are constructivism or interpretivism, postpositivism, positivism, and critical theory. A paradigm that is associated with qualitative study is interpretivism: it values subjectivity. Interpretivism research concentrates on attaining an empathic understanding of how individuals feel and on interpreting individuals' daily experiences, their deeper meanings, feelings and distinct reasons for their behaviour (Rubin and Babbie, 2013).

The interpretivistic paradigm provides an understanding of dynamic human and social realms, where socially derived and historically situated interpretations are reinforced by various concepts and philosophies used to create an understanding of the social world. This study employed an interpretivism philosophy, which is explained by Blumberg, Cooper and Schindler (2008) as the social world that is experimented with by viewing what descriptions people give to it and interpreting these meanings from their perspective. It involves participants talking to them, observing them in their normal working environment, and interacting with them in person to avoid miscues and construed information. The paradigm embraces beliefs in pluralistic, interpretive, open-ended and contextualised perspectives toward reality (Creswell and Miller, 2000).

1.9 TRUSTWORTHINESS AND CREDIBILITY

According to Bless, Higson-Smith and Sithole (2013), trustworthiness refers to how much belief can be given to the study procedure and results. Credibility strives to convince us that the results represent the truth of the reality under investigation. Marshall and Rossman (2011) describe triangulation as collecting data from numerous sources through various methods, using theoretical lenses, and discussing their emergent results. Methodological triangulation was utilised to verify and increase the trustworthiness of this study by comparing data from interviews with data from direct observations (Bless et al., 2013). This study was therefore triangulated by using data from a literature review, observations and interviews. The researcher combined the notes gathered during observations and interviews to provide further insights into the analysed interview data and identify similarities.

To increase the level of trustworthiness of the study, the researcher listened to each recorded interview and compared it to the transcription to reduce errors. To prevent bias from creeping into the study (Arksey and Knight, 1999), the researcher did not phrase questions in a way that directed the interviewee on how to answer and did not interrupt the interviewee. The researcher made notes to also highlight the tone of the participants and asked one question at a time to reduce participant confusion. The researcher was responsible for collecting all the data; no other agents or workers were used. In addition, the researcher applied the open coding method to increase the reliability of the study. Open coding is a process of making notes comprising words and short phrases to summarise the sixty-one content from the transcript (Strauss and Corbin, 1990). The basic aim of the open coding process is to organise large quantities of text into fewer content categories. Guba and Lincoln (1989) parallel reliability to dependability.

The researcher also used member checking (Lincoln and Guba, 1985) as informant feedback to increase the credibility of the study. Member checking refers to the debriefing and verification of interpretations and assumptions made by the researcher with the relevant participant (Strauss and Corbin, 1990). The transcript and identified themes with the participant's direct quotes were emailed to each participant for their perusal and further comment. Last, to increase trustworthiness in terms of the literature, the researcher used reputable journals that followed a peer review process and integrated the observational and interview data to form relevant triangulated findings.

1.10 IMPACT AND SIGNIFICANCE OF THE STUDY

This research contributes to the literature and knowledge that is available regarding continuous processes from a South African perspective. First, the review explored the use of lean techniques to improve efficiencies in continuous processes in South Africa. Second, the review also offered an analysis of lean tools and techniques that have been applied or may be applied in continuous processes that may not currently be in use. By implementing lean strategies, the use of resources may be optimised in continuous processes in South Africa. The findings of this study will help continuous process manufacturers enhance productivity, decrease waste and improve efficiencies. This study contributes to both industry (by identifying lean manufacturing techniques used in continuous processes manufacturing) and academia (by contributing to the existing body of knowledge on lean manufacturing and continuous processes from a South African perspective).

According to Bless et al. (2013), transferability refers to how results relate to other related settings. In this regard, this study will not be transferable to other organisations because the sample does not represent the larger population. However, certain components of this study may be useful to other settings.

1.11 ETHICAL CONSIDERATIONS

The researcher obtained ethical clearance to conduct the research from Unisa’s College of Economic and Management Sciences Research Ethics Review Committee to ensure that the research adheres to the university’s ethical guidelines:

- The researcher honoured and protected the dignity, privacy and confidentiality of all participants and organisations.
- The anonymity of participants was ensured through the removal of personal information to mitigate loss, damage and unauthorised access as required by the Protection of Personal Information (POPI) Act, No. 4 of 2013. As such, the researcher assigned pseudonyms to each participant. Any identifiable information was removed.
- Privacy requirements were adhered to; the researcher informed the participants of their rights to confidentiality. The researcher respected the participants' privacy by disassociating names from respondents during the coding and recording process (Creswell, 2014).
- The researcher explained the objectives and motivation of the study to the participants.
- The researcher provided information relating to the purpose of the study and unknown terminologies to the participants.

- All participants had to sign a consent form to explain the study's purpose, procedures and possible benefits. All participants were over 18 years old, and no parental consent was necessary.
- The researcher ensured that the interviews were conducted in a private and very quiet room to minimise interruptions.

1.12 LIMITATIONS AND DELIMITATIONS OF THE STUDY

Leedy and Ormrod (2015) explain that delimitations reflect what the researcher did not do or did not plan to do. This study focused on the application of lean techniques within continuous processes and not on how lean techniques are used in other discrete processes. Another limitation relating to the data collection process is that information attained during the interviews was dependent on what the participants were able and prepared to share.

1.13 CHAPTER OUTLINE

The research study consists of six chapters whose contents are outlined next:

Chapter 1 is the introduction of the study. It contains background, problem statement, research question, objectives, research design, limitations of the study, and chapter outline.

Chapter 2 is the literature review and theoretical background of the study. It provides an overview of the theory that underpins this study, lean manufacturing, a critical review of the literature that focuses on global practices of lean manufacturing principles and techniques that have been applied in different types of manufacturing processes and types of waste. It also focuses on the benefits of implementing lean manufacturing principles and techniques, the application and implementation of lean manufacturing in continuous processes, and the challenges faced when implementing lean manufacturing principles and techniques. Moreover, it focuses on the review of lean manufacturing principles and techniques and frameworks that have been developed.

Chapter 3 comprises the research methodology of the study. The research methodology considered qualitative case study examples in two organisations that use continuous process types in the productions. The data collection and data analysis methods are explained

Chapter 4 presents the data collected through all three processes, namely, the literature, observations and interviews.

Chapter 5 provides a general discussion of the analysis of the data presented in chapter 4. It summarises the implications and findings of the study. It reports a framework that was developed from participant responses.

Chapter 6 presents the conclusions, recommendations and areas for further research studies.

1.14 CHAPTER CONCLUSION

This chapter provides an introduction, background of the study and global practices of lean manufacturing in different process types. This chapter also presents the research problem underpinning this research, the research questions and the aim and objectives of the study. The paradigm of the study is also briefly explained, and the methodology is further expanded in chapter three. It provided a brief overview of ethical considerations and methods to ensure trustworthiness and credibility of the study. Limitations and delimitations of the study were highlighted, and the impact and significance of the study were outlined. The chapter concludes with a layout of the chapters. In the next chapter, the literature review is presented.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Chapter 1 introduced the study and aspects relating to the background of the research problem, the theoretical framework that underpins this study, the global practice of continuous processes, the research methodology, trustworthiness and credibility, ethical considerations, the expected impact and significance of the study, keywords that are covered in the study, and the chapter layout. The primary objective of this research is to explore which lean techniques can be used to improve efficiencies in two continuous process case studies in South Africa. The secondary objectives are to identify the various forms of waste that exist within two continuous process manufacturing environments in South Africa, to determine the lean techniques that are used in two continuous processes in South Africa, and to identify how efficiencies can be improved within two continuous process manufacturing environments in South Africa.

This chapter provides an overview of the theory that underpins this study, a critical review of the literature that focuses on lean manufacturing, types of waste, benefits of the implementation of lean manufacturing principles and techniques, and challenges faced when implementing lean manufacturing principles and techniques. It also considers global lean manufacturing practices in manufacturing processes, lean manufacturing application and implementation in continuous processes, and a review of lean manufacturing techniques implementation frameworks that have previously been developed. Finally, a summary will conclude this chapter.

2.2 AN OVERVIEW OF THE THEORY THAT UNDERPINS THIS STUDY

Before applying lean, it is significant for organisations to understand the environmental setting in which they are functioning to choose the appropriate lean tools and techniques that apply to their environment. Contingency theory assumes that there is no correct way for an organisation to be organised and that not every strategy will be equally effective (Galbraith, 1973). Netland (2016) agrees that, according to contingency theory, there is no best way to lead a company or a process; instead, the best solution is dependent on the situation. Solutions need to be customised for specific situations and contexts. Contingencies are features of a context that make every situation different. For organisations to be most efficient, they should be designed with social and technical subsystems that fit the requirements of one another, the organisation's purpose, and the external environment (Pasmore, Francis, Haldeman and Shani, 1982).

Deflorin and Scherrer-Rathje (2012) and Panwar et al. (2015) mentioned that lean manufacturing techniques are practised differently according to the manufacturing environments. Through the lens of contingency theory, the application of lean manufacturing philosophy can be adapted to any other production process environment because the continuous process environment will have to group lean manufacturing principles and techniques that are best suited according to the contextual factors to attain optimal performance (e.g., enhanced quality of the product, increased quantity of the output and improved profit). Therefore, the focus of this study is to understand how lean manufacturing techniques can be best practised when applied in continuous processes organisations.

There is no one size fits all; every organisation needs to customise how they are going to organise themselves, which aspects of the organisation they are going to focus on, and how they will layout their operations. Some organisations may place a larger focus on improving performance. In contrast, others may focus on reducing costs, enhancing conformance to quality, improving productivity, reducing inventory levels, solving problems, developing people, or improving throughput times. The organisation needs to choose the right lean principles and techniques that fit the chosen focus. Therefore, contingency theory underpins this study.

2.3 LEAN MANUFACTURING

Abdulmalek and Rajgopal (2007) as well as Jasti and Kodali (2014) indicate that after World War II, Japanese manufacturers were challenged with a lack of material, monetary, and human resources, and the situation led to the birth of the concept of lean manufacturing, which aims to reduce waste and improve productivity. Womack, Jones, and Roos (1990) presented the term “lean” as the strategy for improving manufacturing. Womack and Jones (2003) defined lean to do more with less human effort and less equipment in a reduced time while using fewer resources to provide customers with exactly what they want.

Stevenson (2012) defines lean manufacturing as a flexible method that requires fewer inputs to produce more output (goods and services). Lean manufacturing is beneficial for any organisation if it is carefully adapted to the new environment according to the required organisational process. According to Yogesh, ChandraMohan and Arrakal (2012), lean manufacturing is mostly implemented by organisations to decrease waste and improve the quality of products. Applying lean manufacturing principles is recognised as one of the most essential concepts that helps manufacturing to be competitive in the market (Godinho, Filho, Ganga and Gunasekaran, 2016). The following table illustrates the types of waste and lean manufacturing tools and techniques used. All manufacturing organisations producing any kind of product are forced to continuously address the matter of improving the efficiency of their production lines, increasing their production capacity and increasing the quality of a product (Kliment, Trebuna, Pekarcikova, Straka, Trojan and Duda, 2020). Naeem, Ahmad, Hussain, Nafees and Hamid (2021) stated that lean manufacturing practices can make production activities faster and reduce the amount of waste. The main objective of being lean is to decrease waste from operations. Lean manufacturing removes inefficient processes in the production line without sacrificing the product or service efficiency. Textile manufacturers are slowly using lean manufacturing practices to improve efficiency to reduce costs and lead times. Table 2.1 describes the types of waste and practised lean manufacturing tools and techniques with the resultant improvement that occurred as a result of using lean.

Table 2. 1: Description of types of waste and practised lean manufacturing tools and techniques

Categories of waste	Description of the type of waste	Applied lean manufacturing tools and techniques	The efficiency improvements
1 Overproduction	Producing more goods than needed.	Heijunka (level production) VSM (mapping of cycle times in production processes) SMED (reduce setup times) Continuous improvement (improvement event, work teams)	production efficiency and process efficiency
2 Inventory	Any quantity that is left over and adds to cost.	Continuous improvement (kaizen event to improve inventory system) Andon system (visual control of inventory levels) VSM (transfer of raw materials and finished product from supplier to plant or from plant to the customer) Kanban (level the flow of materials) Just in time (eliminate all inventory that represents waste in purchasing, manufacturing, distribution activities)	material efficiency, production efficiency and operational
3 Transportation	Any unnecessary transportation that does not enhance value to procedures.	• Value Stream Mapping (identification of transports in the different stages of the process) • Continuous improvement (continuous focus on improvement and improvement of logistics processes) •	Process efficiency
4 Defects	Manufacturing faulty goods.	• Jidoka (automation with people control) • Total Productive Maintenance (preventative maintenance plans) • Poka-Yoke (Anti-error system) • Value Stream Mapping (value chain mapping to identify defects) • Continuous improvement (continuous improvement initiatives) • Kanban, 5S and Andon System (Visual control)	Production efficiency, machine and equipment efficiency and productivity
5 Processing	Any techniques that are nonvalue adding to manufacturing.	Continuous improvement (to eliminate unnecessary steps in work activities) Value Stream Mapping (process mapping to identify activities that do not add value from the customer's point of view)	process efficiency
6 Motion	Movement of workers or machines.	• Value Stream Mapping (identify on the map the movements that are found and that do not add value to the client) • 5S (organise work so that unnecessary movement is	Employee efficiency and machine efficiency

Categories of waste	Description of the type of waste	Applied lean manufacturing tools and techniques	The efficiency improvements
		minimised, ensures work areas are consistently clean and organised)	
7 Waiting	Idling labours or nonactive machine periods that add no value.	• Jidoka (automation with presence) • Value Stream Mapping (identification and adjustment of lead times in production) • Continuos improvement (to decrease waiting times in the value chain) • SMED (Single-Minute Exchange of Dies decrease waiting times in machine preparation)	• Equipment and machine efficiency, and employee efficiency

Source: Jasti and Kodali (2016); Rahani and Muhammad (2012), and Solis-Quinteros, Zayas-Márquez, Ávila-López and Carrillo-Gutirrez (2021)

Table 2.1 defines the types of waste and applied lean manufacturing techniques with the resultant improvement that occurred as a result of using lean. The first column lists categories of waste, the second column is the description of the type of waste, the third column demonstrates applied lean manufacturing tools and techniques that can be relevant to solving these waste issues, and the last column speaks to the efficiency improvements gained by implementing lean techniques.

Lean manufacturing consists of three different stages, namely, lean goals and philosophy, lean principles, and lean tools and techniques (see Figure 1.1). The importance of these stages is that they clarify the structure of how lean is observed and applied within organisations. Bicheno and Holweg (2016) state that lean manufacturing is driven by the behaviour of workers, which is built through worker training, coaching and demonstration of how work should be done so that workers can gain self-confidence. Lean philosophy is the theory that acts as the road map or distillation of culture or core values that inform all aspects of business practices to improve organisational efficiency. Lean goals describe the main purpose of the lean manufacturing system, which is to produce quality products that meet the customer's needs, meet the demand with small resources as is necessary by removing waste to decrease costs and improve quality. Processes may become more streamlined to improve productivity and create a more satisfied workforce while enhancing the customer experience.

Lean principles are the guiding standards of the lean manufacturing system (which include elimination of waste, the alignment of production demand, creative involvement of the workforce and integration of suppliers). Lean manufacturing principles involve the implementation or integration of lean principles into the daily activities of the production processes and the supply chain. With regard to the elimination of waste, Di Maio and Rem (2015) argue that it is essential to recover as much material value from waste as possible through effective recycling to move towards more sustainable development (reusing what is still useful after the manufacturing process has been completed).

The World Economic Forum [WEF] (2014) and Mathews, Tang and Tan (2011) defined the circular economy as a closed-loop system that reduces the consumption of nonrenewable and toxic resources and reuses waste products, finished products and services that are at the end of their life cycle as inputs into new processes and business models for continued use and consumption. Goyal, Esposito and Kapoor (2016) mentioned that the recycling paradigm involves an active decrease in waste by converting waste products into new resources, thereby building a balance between the production and consumption of resources. The recycling process focuses on recovering and reusing solid and electronic waste to produce new products as well as to reduce material leakage and maximise economic value (the new products produce jobs and create new products, thus either extending the life cycle of used goods or creating new lifecycles if goods find an alternate use). However, workers should not be careless when manufacturing products and services because the possibility of recycling exists, as carelessness creates waste in the form of used resources (materials, electricity, use of machines, workforce) and wastes time and effort. Recycling aims to manage waste more responsibly, which is a component of sustainability. In addition, how goods and services are manufactured also needs to be subscribed to sustainability measures. Green manufacturing has emerged as a concept that aims to produce goods and services that are friendlier to the environment and to focus on how goods and services are produced.

The different practices of green manufacturing are as follows (Malhotra and Kumar, 2017):

1. Adapting production processes to minimise waste and pollution.
2. Using environmentally friendly inputs in the production process reduces the environmental impact.
3. Internal reuse of water, energy, chemicals and metals.
4. Improved housekeeping to keep a facility in good working and environmental order by separating waste, minimising chemical and waste inventories, fitting overflow alarms and automatic shutoff valves, eliminating leaks and collecting waste from spillages. Regular inspections can assist in pinpointing environmental concerns and

malfunctioning within the production process to enhance the management and control of machinery to optimise maintenance schedules.

The existing lean literature offers many examples of the philosophy and practices of lean principles and techniques in other countries. Table 2.2 illustrates the application of lean manufacturing principles and techniques in different manufacturing processes. In addition, the benefits derived from using lean have also been indicated for each study. These benefits indicate efficiency gains.

Table 2. 2: The application of lean manufacturing in different manufacturing processes

Process types and explanation	How lean manufacturing was used	Impact/Benefits derived from using lean manufacturing (efficiency gains)	The purpose and Findings of the study
1. The project process has a low volume and high variety of goods and services. Converting resources may have to be prearranged specifically for each element because each element is different. The procedure may be complicated, partly because the tasks in such processes often involve important decisions to act according to practised judgement.	Lean manufacturing was implemented in construction by conducting Value stream mapping (VSM), which allows for the analysis of the value stream of the product in order to identify waste and activities that did not add value to the project. When conducting VSM, the current state was mapped and analysed, changes were made for improvement and a new map was created.	The implementation of VSM eliminated nonvalue adding activities and improved the construction processes.	**Purpose:** To determine if lean practices could bring about improvements in construction. The **findings** of this study indicated the following: 1. Lean manufacturing implementation can bring improvement in construction processes. 2. The five main lean manufacturing principle that are practiced in project processes are customer focus, workplace standardisation, culture/people, continuous improvement build-in quality and removal of waste. 3. The abovementioned lean manufacturing techniques were found to be very effective and the results showed that there was a space for improvement of project processes in construction.(Salem and Zimmer, 2005)
2. Jobbing process refers to a great variety and low volume of goods and services. In jobbing processes, each product must share the process' resources with several others. Resources will process a sequence of items but, although each one will require related consideration, they may vary in their particular needs.	The wood and furniture industry in **Malaysia** implemented lean manufacturing using 5S in order to increase efficiency, to increase utilisation of space, and to clean up and organise the workplace. 5S was implemented to increase the housekeeping level and to increase workshop space.	**The following challenges were identified:** lack of labour resources, lack of implementation expertise, employees' resistance to change, technical knowledge, training, and financial resources during the early phases of lean manufacturing implementation.	**The purpose of the reseach** was to discovery the challenges, barriers, motives and practices of lean manufacturing in the Malaysian wood and furniture industry The **findings** of the study revealed that only employee training, 5S and quality control are applied to the wood and furniture industry. Abu, Gholami, Saman, and Zakuan (2019)
3. Batch processes may appear like jobbing processes but do not have a similar variety of products. Batch processes can be repetitive.	Lean manufacturing was implemented in the wine sector and value stream mapping (VSM) was used as the basic lean tool. The mapping of the current situation was developed to show the information flow and material flow. The map revealed the problems and where waste	The application of lean in this sector has reduced the total lead time (the time it takes to produce a product) by 60%; reduced the amount of information between processes; allowed better use of the physical space and machinery; and achieved a better distribution	**Purpose:** The purpose of this study was to demonstrate the applicability of lean manufacturing to the wine sector and value stream mapping was used as the key tool to classify opportunities for enhancement.

	occurred. The winery received more grapes than what was necessary, and the working methods was adapted. Lean tools like Just in time (JIT), Kanban and single-minute exchange of dyes was only applicable to certain parts of the winery, while VSM and TPM could be used in the entire process in the winery.	of work among operators; and reduced the purchase of raw material by 13% and saved costs.	**Findings:** The study revealed that manufacturing challenges in the wine sector could be undertaken by using lean techniques, making certain changes according to the type of manufacturing. (Jimenez, Tejeda, Perez, Blanco and Martinez, 2012)
4. Mass processes manufacture items in great quantities and have relatively small diversity. Examples of mass processes are frozen food production, automatic packing lines, automobile plants, television factories and DVD production.	Interviews were conducted with ten textile companies that were using lean manufacturing. Different lean manufacturing techniques (visual management, 5S, VSM, JIT, standardised work, continuous improvement) were used by the companies; Visual management and 5S had been used by all of the ten companies. VSM was used by nine companies. 5S was cited as one of the first lean techniques to be implemented.	The **benefits** of practicing lean manufacturing in the textile industry included: reducing raw materials; increased production (after implementing 5S, one company experienced 16% gain in 1 month; and a reduction in production time); **Challenges/Barriers for implementing lean manufacturing:** resistance to change by both shop floor employees and management; shop floor employees are reluctant to offer suggestions for improvement; shop floor employees are not native English speakers and training needs to be multilingual.	**Purpose:** The aim of this study was to find which lean manufacturing principles are suitable for application in the textile industry. **Findings:** 1. The application of lean production should begin with policy deployment toolto start cultural change; 5S; TPM can be used over production facility; continuous improvement project must be developed; and standardised work tools are used to develop standard operating practices and set cycle time to meet customer requirements, and Just in Time technique which decrease waste to ensure that customers obtain the right product at the right time should also be practiced. Hodge et al. (2011)
5. Continuous process	When compared to discrete manufacturing, not all lean principles were used in continuous processes. The waste elimination techniques that are not dependent on continuous process characteristics are: 5S, TPM and visual control. 5S, TPM and visual control originate from the discrete process, but they can also be implemented in continuous processes because they are not dependent on the environment characteristics.	Lean manufacturing is similarly beneficial to continuous process given that it is carefully adapted in the new environment according to the process, supply chain, market characteristics and contingency factors. Benefits: VC, TPM, and 5S aid to improve overall equipment effectiveness, decrease other wastes such as piling up of inventories and defects of products due to poor quality.	**Purpose:** This study synthesize the literature with an emphasis on classifying the scope for lean manufacturing in the process industry and related benefits. The review offered an analysis of the lean techniques that have been practiced or have possible application in continuous process types. **Findings:** Lean techniques that can be implemented anywhere in the manufacturing process are TPM, 5S, VSM Quality management programmes, Work standardisation, continuous improvement and teambased problem solving are appropriate in the process industry. Panwar et al. (2015)

Source: Author's own compilation work

Table 2.2 demonstrates the application of lean manufacturing techniques in different manufacturing processes. The first column is the process type and explanation, the second column is how lean manufacturing techniques were used in the study, the third column explains the impact or benefits derived from using lean manufacturing (efficiency gains), and the last column explains the purpose and findings of the study.

Adbulmalek, Rajgopal and Needy (2006) also stated that the implementation of lean manufacturing has been slow with continuous processes and managers have been slow to adapt lean tools because not all the lean tools are fully applicable to a continuous process. Lean tools and techniques that are most helpful in reducing waste are value 5S, stream mapping (VSM), quick changeover, total productive maintenance (TPM), automatic line stoppage, visual controls and mistake proofing. Value stream mapping (VSM) is a very effective and vital technique to detect nonvalue-adding activities (Panwar et al., 2015). Quick changeovers, when applied, decrease the number of shutdowns in continuous processes. Lean tools and techniques that are most helpful in improving quality are work standardisation, total quality management, statistical process control (SPC) and zero defects. Abdulmalek et al. (2015) mentioned that some lean manufacturing techniques that do not rely on the process characteristics are work standardisation, TPM, quality management programmes, 5S, team-based problem solving, and VSM, and continuous improvements were strongly applicable with continuous processes.

Salonitis and Tsinopoulos (2016) argue that there is no unique roadmap to implement lean manufacturing principles and techniques and that it must be custom-made for different organisations to account for specific conditions. Panwar et al. (2018) and Rathi and Farris (2009) agree that process industries have unique characteristics, making the adoption of lean manufacturing not as simple to implement as it is in discrete industries. Rathi and Farris (2009) highlighted the findings of the theoretical applicability of lean manufacturing principles and techniques as follows:

- 5S, SMED, standard work (SW), and cellular manufacturing have a larger expected influence on job order and batch process industries than on mass production process industries.
- JIT, kanban systems, and production smoothing have a greater expected influence on mass and batch process industries than on job order process industries.
- There would seem to be relatively little difference in the anticipated impact of TQM, visual control, and, to a lesser extent, TPM across process industries types, TQM and TPM slightly favour mass/flow industries. In contrast, visual control slightly favors job order production.
- For job order production specifically, tools with the greatest expected overall influence include standard work, cellular manufacturing and 5S.

The lean tools and techniques discussed next have been practised in both discrete and continuous processes (as highlighted in Table 2.2).

2.3.1 Value Stream Mapping

Lean manufacturing implementation usually starts with value stream mapping (VSM), which builds an understanding of the current situation and assists in identifying opportunities for improvement to guide future adaptations of the process. Other lean manufacturing techniques may be used afterward or in conjunction with VSM. VSM is applicable to continuous processes because it helps to pinpoint waste and idleness by mapping the current production process with the aim of identifying nonvalue adding activities (Abdulmalek et al., 2015; Jimenez et al., 2012). During VSM, the current state map (which highlights the flow of information and material) and the future map (which closes the gaps identified in the current state map by removing nonadding value activities) are developed. Nunes, Jacobsen and Cardoso (2017), Panwar et al. (2015) and Jimenez et al. (2012) explain that VSM is precise, effective and a vital tool to recognise nonvalue-added activities and allows for the pinpointing of opportunities for improvement through the display of the flow of inventory and information in the manufacturing organisation.

When VSM is practiced, it leads to decreased lead time, cycle time and WIP inventory levels (the total cost of unfinished goods currently in the production process at the end of each accounting period) (Chowdary and George, 2012), improved quality, and utilisation of resources (Goriwondo, Mhlanga and Marecha, 2011). Value stream mapping also identifies bottlenecks and interdependencies in the processes and involves employees in the change process. Value stream mapping contributes to flexibility, operation cost reduction, and the ability to meet customer demands. The decrease in nonproductive activities saves resources and allows reallocation of resources to improve throughput and profitability.

VSM has been applied in both discrete and continuous processes by mapping the flow of information and material as the current issues are identified to be rectified. In addition to identifying nonvalue-adding activities, VSM also helps to identify value-adding activities. Value stream mapping helps as a critical tool that can expose significant opportunities to reduce costs, improve production flow, save time and reduce inventory. Continuous improvement is the next technique for implementation after pinpointing the main flows and opportunities for improvement. Some activities can lead to the reduction of waste (workers need to map the current production process and identify sources of waste, where after actions need to be planned to reduce or eliminate the identified wastes). As demonstrated in the next section, VSM can be used with other strategies for maximum effect and optimisation. Continuous improvement, also known as kaizen, will be outlined next.

2.3.2 Continuous improvement/Kaizen

Sahno, Shevtshenko, Karaulova and Tahera (2015) stated that to be competitive and successful in the market environment and meet customers' needs, organisations need to constantly improve their production processes and product quality. Customers' needs and product quality can be improved by conducting daily meetings to provide feedback about the previous day's production challenges that were experienced, success stories that were recorded, and benchmarking with their competitors. Constantly conducting surveys with their customers and implementing measures to address customer concerns may improve customer satisfaction.

According to Sundar, Balaji and Satheeshkumar (2014), continuous improvement is important for sustaining the organisation in the market, but continuous improvement depends on employees' perception, adaptation, teamwork, leadership engagement, motivation and empowerment. Continuous improvement comprises different tools and techniques that may include communication, training of employees, teamwork or involvement of employees, rewards, problem solving and contingent remuneration (Marin-Garcia and Bonavia, 2015).

McLean, Anthony and Dahlgaard (2017) explain that continuous improvement aims to build a culture of ongoing improvement by working with everyone involved as a team (workers' involvement) and capitalising on the training and development of employees. The most important part of continuous improvement is to solve problems on an ongoing basis (Nunes et al., 2017).

Marin-Garcia and Bonavia (2015) highlight that the successful implementation of different lean manufacturing tools such as TQM and continuous improvement depends on concurrently implementing high workforce involvement practices. Abdulmalek and Rajgopal (2007) mention that a system of continuous enhancement that employs participative management is centred on the customer's needs (end-user). McLean et al. (2017) said that some of the criticisms of continuous improvement are that it leads to unrealistic targets that may result in disappointments if targets are not met; inconsistent incentives are paid to workers; workers become change fatigued and despondent; inadequate budgets are formulated to encourage continuous savings in the form of lower costs; and if there is a lack of senior management commitment to continue monitoring continuous improvements in the organisation. If these issues are not adequately managed, it may lead to an unproductive organisation, despite implementing measures to enhance efficiencies.

According to Smętkowska and Mrugalska (2018), Six Sigma is an element of continuous improvement that seeks to improve customer satisfaction, simultaneously reduce ineffectiveness, decrease the number of mistakes and improve quality in the organisation. One of the strategies used for quality improvement is define-measure-analyse-improve-control (DMAIC). Six Sigma is not only a method for resolving the problems with manufacturing but also a strategy to improve business processes. An incident is an unplanned, undesired event that affects completing a task. When an incident occurs, it is a sign that something is not going well in the process.

Incidents do not just happen; they are caused by something that usually stems from an unsafe act. The aim of conducting an incident investigation is to determine the cause of the incident and initiate corrective action to prevent the same incident from happening again (DeVaul, 2021). The 5 Whys are commonly used in lean manufacturing to investigate what the problems are for them to be resolved. The 5 Whys analysis emerged in Toyota to address staff who were blaming each other when faults occurred in the manufacturing environment. Mistakes cannot be avoided, and the best way to deal with mistakes is to find the root causes of the errors and talk about those causes (Ohno, 1988).

The cause and effect diagram, also called a “fishbone” diagram, can assist in categorising the origins of issues. A fishbone diagram is a structured method whereby the problem or effect is shown at the head or mouth of the fish. Contributing causes are listed on the “bones” that can be grouped to classify potential sources for a problem that might not otherwise have been considered. Staff with specialised knowledge of the processes and systems involved in the problem or event must form part of this exercise.

2.3.3 The 5S system (Sort, Set-in-order, Shine, Standardise and Sustain)

According to Jimenez et al. (2012), 5S applies to continuous processes. Wyrwicka and Mrugalska (2017) mention that 5S is effective when using standardised work processes (discussed in 2.2.6). According to Hodge et al. (2011), 5S is a five-step process that can improve the overall function of a business that comprises Sort (seiri), Set-in-Order (seiton), Shine (seico), Standardise (shitsuke), and Sustain (seiketsu). Abdullah (2003) explains that 5S is a lean technique that ensures that the operational space is clean and neat, ensures good housekeeping and better workplace organisation, and supports the targeted objective. Sharma, Sachdeva and Gupta (2017) mentioned that cleanliness in the workplace includes the cleanliness of machines and equipment through the daily maintenance of oiling and greasing. The cleanliness of equipment results in an increase in the effectiveness of the machines. 5S works on organising what is necessary per a specific process and arranging tools according to what is needed within a specific process. Nunes et al. (2017) state that 5S leads to total production maintenance, which is essential through training the team to take care of their own equipment. Total productive maintenance (discussed in 2.2.4) also focuses on overall equipment effectiveness.

2.3.4 Total productive maintenance (TPM)

Agustiady (2018) states that total productive maintenance (TPM) is an all-inclusive approach to equipment maintenance that tries to achieve near-perfection in production processes. TPM is a useful maintenance technique in which the involvement of all workers is expected and which takes place through small group activities (such as completing breakdown request forms, completing maintenance forms, recording of inventory and daily maintenance of oiling and greasing activities) to avoid breakdowns and which targets to make the best use of optimise equipment efficiency and enhance working performance. TPM advances the continuing enhancement of the quality of products, ongoing maintenance of equipment, continuous cleaning of machines and the working environment (cleaning leaking oils), and following instructions of how to operate machines (standard operating procedures and instructions from management). A clean working environment decreases injuries and accidents.

Total productive maintenance accentuates proactive and preventative maintenance to maximise the lifespan and productivity of the equipment. Arslankaya and Atay (2015) state that TPM primarily aims to improve the equipment performance; improve workbench efficiency; improve the product quality; decrease faults; decrease losses; decrease waste; decrease inconsistency of different shifts not setting the temperature of machines correctly (an effective management system should comply with management policies as well as technical specifications to enable optimum efficiency of machines and equipment); decrease inventories; and decrease work accidents. The total productive maintenance process provides for fewer breakdowns, stoppages and defects while lowering costs and involving employees.

There are various types of maintenance, such as preventative maintenance, corrective maintenance and autonomous maintenance. Hashemi and Asadi (2020) as well as Machado, Filho, Carrazo, Oliveira, Avila, Ferreira and Campos (2017) explained that maintenance activities are categorised into two general types: corrective maintenance and preventative maintenance. Corrective maintenance refers to the urgent maintenance of equipment and machines due to unforeseen machine breakdowns or defects that are detected in the product it produces. Corrective maintenance is unexpected and unpredictable maintenance practised on a system (component) that has already failed to bring it back to a working condition (it is reactive and will fix equipment that was broken so that it can start working again). Corrective maintenance is also referred to as reactive maintenance in this document. Stenstrom et al. (2016) also stated that corrective maintenance takes place after a fault has been identified; it is intended to put the breakdown item back into a state that can execute its required functions.

Preventative maintenance refers to the careful planning of maintenance activities of equipment and machines before any breakdown takes place (Hashemi and Asadi, 2020). When applying preventative maintenance, machines that have not broken down are fixed by replacing malfunctioning components and lubricants such as oils and water. Preventative maintenance is scheduled maintenance that is executed on an operating system (component) to bring it to an improved working condition before the machine or equipment breaks down. The goal of preventative maintenance is to provide maximum system reliability and safety with the smallest maintenance resources. The advantages of preventative maintenance include providing quality products to customers and increasing the working life span of machines.

Autonomous maintenance is when operators are involved in maintaining their own equipment while stressing proactive and preventative maintenance (Agustiady, 2018). Improved processes and a continuous improvement methodology are key fundamentals of total productive maintenance. Effective communication techniques and top management support are critical to the functionality of total productive maintenance. Therefore, any form of maintenance implies that the machines will not be working while the maintenance is being performed. As such, maintenance can be disruptive in the manufacturing process. That is why in continuous processes, machines run nonstop unless there is breakdown. Unless it is minor maintenance of equipment or a normal routine such as checking, repairing, and servicing of the operating equipment, businesses can operate without interruptions. Maintenance checklists can be used to better track records of actions performed for safety and quality purposes.

2.3.5 Total quality management

Abdulmalek et al. (2006) describe total quality management (TQM) as a management philosophy intended at reaching high customer satisfaction through high-quality products. Sharma et al. (2017) states that quality products mean reduced defects and fewer disagreements during production (different shifts may have different perspectives and create conflicts), which leads to less work. TQM is also considered to be a key principle to achieving customer satisfaction and production performance by producing quality products that may lead to cost savings on electricity and other manufacturing costs, best safety practices (good quality of tools and correct clothing), and delivering products on time to customers (Jainury, Ramli and Rahman, 2012). TQM principles have been used to ensure high-quality products by decreasing defects according to the set standard of procedures and improving production processes.

2.3.6 International standards

The International Organisation for Standardisation (ISO) is a universal nongovernmental organisation consisting of national standards bodies; it develops and publishes a wide range of registered, manufacturing, and commercial values and comprises representatives from many national standards organisations (Kenton, 2020). There are many standards that have been set almost more than twenty, including everything starting from the production of products and technology to food safety, healthcare, and agriculture. The ISO plays a vital part in facilitating world trade by providing common standards among diverse countries. The ISO standards are meant to ensure that services and products are reliable, safe, and of good quality. For the end user and consumer, these standards ensure that certified products conform to the minimum standards set internationally. ISO 9001 discusses quality. It gives direction for organisational structure. Organisational structure and quality go together if you follow the ISO 9001 guidance (Gibbs, 2022). There are many ISO standards that can be practised in diverse disciplines. For example, ISO 9001 talks about quality standards, while ISO 45001 and ISO 18001 practice health and safety. These standards are worldwide directives that are used to develop national and international policies.

2.3.7 Standardisation of work

Standardisation of work is utilised to confirm that all workers follow the same steps in the manufacturing process to achieve similar manufacturing quality. Every department has standard operating procedures giving guidance on how to manage different situations and incidents, but the way that one organisation operates may be different from how another organisation operates, even though both organisations may produce the same goods and/or services. Standardisation of work is an important technique of lean manufacturing, regarding both the sequence of tasks to be done by each employee and how those tasks are to be done (Monden, 1983). If each worker does not follow a standard operating procedure and decides to do their own ways, there will be no basis for quality analysis or flow stabilisation calculations, and task rotation cannot be introduced without affecting the flow of production. Therefore, it is crucial that all employees perform their tasks according to standardised procedures and principles.

The standardisation of work aims to obtain uniformity in how the work is performed (Olivella, Cuatrecasas and Gavilan, 2008). Sundar et al. (2014) also refer to the standardisation of work as the safest and most effective method to carry out a job in the shortest repeatable time because of the effective utilisation of resources such as people, machines, and materials. Work standardisation can be described as a group of analysis techniques that result in a group of standard operating procedures that have operator work processes such as work sequences, process steps, cycle time, process control and work-in-process. Rahani and Muhammad (2012) argue that work instruction, performing standard work or using standard operating procedures are the methods that optimise the combination of workforce, material, machinery, and methods. Shift work can create inconsistency of output because workers can set the temperature of machines differently, especially when they do not follow standard operating procedures. Other workers do not report incidents that happen during their shifts. Different shifts should follow the same standardised operating procedure to maintain consistency during production and report incidents during their shift.

2.3.8 Employee involvement

Employee involvement refers to how workers share in making decisions about their jobs and working conditions. HRM practices are integrated into lean factories to enable employee involvement (Neirotti, 2020). Marin-Garcia and Bonavia (2015) empirically test the effect that employee involvement has on lean manufacturing principles being used in the production process. In Marin-Garcia and Bonavia (2015), employee involvement was implemented through four variables: empowerment, training, contingent remuneration and communication. This study only used waste elimination

(5S, visual controls, standard operations, TPM, quick changeover and statistical process control) and workforce involvement (quality circles and cross-functional training/job rotation). The results of this study have shown that success in implementing lean manufacturing depends more on the mindset change of the employees than on the actual use of lean manufacturing principles and techniques.

Employee involvement in lean activities can be enhanced by empowering employees through training, information sharing, and new forms of recognition and compensation (Marin-Garcia and Bonavia, 2015). Providing employees with information about costs, productivity, quality and performance will cultivate an understanding of how their actions or lack thereof support the implementation of lean manufacturing.

Panwar et al. (2018) stated that when management does not pay serious attention to skill development, training and education of the employees, the employees may mishandle equipment, be ignorant and execute improper operating procedures in the plant. The human element is an important consideration during lean implementation. The human dimension at Toyota is termed “The Toyota Way”, which states that workers need to be respected and understood so that they achieve self-realisation, thus maximising their performance (Magnani, Carbone and Moatti, 2019). Workers are directly involved in performing tasks and solving problems that may arise during production. Bicheno and Holweg (2016) mention that different levels of lean are driven by the behaviour of the workers, which is built through worker training, coaching and managers can also support workers through mentoring. Machines are replacements for mundane and repetitive tasks, but the human interface cannot be removed completely. Technological integration requires constant transformation (Muro, Maxim and Whiton, 2019).

Alefari, Salonitis, and Xu (2017) explained the importance of top management involvement during lean implementation by providing a clear vision, ensuring enough financial resources, and strategic leadership. In addition, senior management should lead from the front in the initial stages and not leave the implementation to workers on the shop floor. Top management engages middle managers who engage employees and operators through training, practicing, mentoring, and coaching. Thus, top management may practice and apply Gemba and provide strategic guidance, but it is the middle managers and the operators who solve problems and practice root cause problem solving (Alefari et al., 2017). Gemba refers to observing the actual process execution within the work environment, understanding the work, asking questions, and learning from those who do the work (Simona and Cristina, 2015). By doing so, top managers can adapt the strategy and formulate competitive advantages for the manufacturing capability.

The control room is usually operated by engineers, also referred to as control room operators. Control room operators monitor equipment, machines and other systems in the plant electronically. They monitor equipment temperature and investigate and log the causes of defects electronically using visual systems. Simona and Cristina (2015) explain that visual or audio notification systems are used in manufacturing to alert management, maintenance staff, and other workers when help is needed. The systems further indicate production statuses and empower operators to stop the production process when a quality or a process problem occurs.

Gibson, Porath, Benson, and Lawler (2007) state that workers who have a better understanding of manufacturing outcomes of the organisation could be more adept at adjusting their behaviours to attain goals, improve their proactiveness, act on potential opportunities, use initiative, and persist until transformation occurs. The study concluded that the use of lean-being techniques must be supplemented with training and empowerment to guarantee the success of the implementation of lean manufacturing.

2.4 BENEFITS OF IMPLEMENTING LEAN MANUFACTURING PRINCIPLES AND TECHNIQUES.

According to Mathur, Mittal, and Dangayach (2012), lean manufacturing principles and techniques eliminate nonvalue-adding activities, improve quality and decrease production costs. Radnor and Johnston (2013) state that lean manufacturing principles and techniques help process improvement and customer service. The main benefits of improving internal operations through implementing lean manufacturing principles and techniques have been shown to include increased customer satisfaction through better customer service/quality, improved staff attitudes, staff retention and compliance, an enhanced competitive position, and improved financial performance.

Lean tools effectively cope with existing competitive challenges (Martinez-Jurado and Moyano-Fuentes, 2014) related to improving delivery reliability, delivery times, production quality, and productivity while reducing inventory and decreasing operating costs. Piercy and Rich (2015) and Negrao, Filho, and Marodin (2016) found that the adoption of lean thinking can also result in improved sustainability, more stable operations, increased finance and better environmental performance through recycling and waste elimination. Salonitis and Tsinopoulos (2016) cite growth in market share, improvement of key performance indicators (contingency theory supports that every organisation can customise its improvement strategies based on the work environment or contextual factors), drive to focus on customers, and requirement or motivation by customers as benefits emanating from lean (Nawanir et al., 2013). Solís-Quinteros (2021) state that lean manufacturing implementation is significant in some areas (not necessarily all areas may benefit from using lean principles), as different tools are used (based on the manufacturing environment) to benefit the company and its employees.

2.5 CHALLENGES FACED WHEN IMPLEMENTING LEAN MANUFACTURING PRINCIPLES AND TECHNIQUES.

Martinez-Jurado and Moyano–Fuentes (2014) mention that the major challenges of implementing lean manufacturing techniques are related to the people: historical lack of employee education and training; absenteeism of workers (absenteeism can affect productivity); and carelessness of workers with organisational resources (for example, workers depend on recycling of defects and not making efforts to reduce defects and not putting a bucket under leaking machines to recycle). In addition, Abu et al. (2019) mention additional challenges such as a lack of labour resources, lack of implementation expertise, employee resistance to change, technical knowledge, and financial resources. Almanei et al. (2018) and Hodge et al. (2011) add that failure to implement lean principles successfully is because of insufficient integration of lean principles and tools into the supply chain, top management not supporting lean manufacturing initiatives, staff not sufficiently or correctly using lean manufacturing tools, poor understanding of lean tools and techniques and last, resistance to change by both shop floor employees and management. If the mentioned challenges are not managed well, production and staff morale may suffer.

Shop floor employees may be hesitant to offer recommendations for improvements to avoid becoming the culprit of errors and faults and take on more work than is necessary. Employees may also not be able to articulate issues properly in English if it is not their primary language, and training may need to be offered on a multilingual platform. There is a perception that discrete processes have a highly skilled workforce, whereas continuous processes have lower-skilled workers (Berry and Copper, 1999). High-skilled workers are efficient and able to produce (maximise productivity). In contrast, low-skilled workers produce low productivity and may require an investment in outside training or education programmes, which can be an added expense. Salonitis and Tsinopoulos (2016) state that a lack of necessary resources (financial, labour, equipment and materials) prohibits the implementation of lean manufacturing.

2.6 LEAN MANUFACTURING FRAMEWORKS THAT HAVE BEEN DEVELOPED

The frameworks that will be discussed in this section are based not only on continuous processes but also on general lean manufacturing techniques that may be applied in continuous processes. Sahno et al. (2015) presented a framework for the continuous improvement of production processes that demonstrates the Six Sigma DMAIC (define, measure, analysis, improve, and control) methodology. The framework enables engineers to perform daily monitoring of production processes based on the data from the previous day, determine failures that are most harmful in the production process from a quality and cost point of view, perform continuous improvement of production processes and monitor key performance indicators to improve customer satisfaction and financial performance of the organisation.

The framework helped the organisation decrease costs by eliminating waste through continuous improvement by identifying critical problems that have a financial impact on the final product. The Sahno et al. (2015) framework is designed for the batch process manufacturing capability and may not be suitable in its current form to use in a continuous process environment. In addition, the framework focuses on only one lean manufacturing technique, whereas other lean manufacturing techniques can be relevant in a continuous process environment. The framework was compiled to improve only product quality and cost, whereas other efficiencies that may be considered could include operational efficiency, process efficiency, production efficiency, lead time, workbench, equipment efficiency and productivity.

Deshkar, Kamle, Giri and Korde (2018) developed a framework using value stream mapping for a plastic bag manufacturing unit. VSM is a pencil and paper approach in which data are collected by walking around the shop floor and mapping the process flow. VSM techniques were used to highlight nonvalue-adding activities that were subsequently removed. Simulation of the current state map provided insights into the root causes of the waste (idleness, underproduction, unwanted WIP, high TAKT times, lack of pull and proper scheduling). Implementation of a lean manufacturing framework increased the value-added time by 74.5%. Simulation results indicate that the framework could be appropriate for other small industries (Deshkar et al., 2018: 7677). TAKT time (the rate at which the organisation needs to complete a product to meet customer demand) was reduced from 46.6 min to 26 min, the number of plastic rolls made daily increased to 50, and the cycle time (the amount of time a team spends working on producing a product) of the process was reduced, thus increasing the pace of the overall process. Deshkar et al.’s (2018) framework focuses on a plastic bag manufacturing organisation, and it is not clear if the framework can be used in a continuous process environment. The framework focuses on implementing value stream mapping only, whereas other lean manufacturing techniques can be used in a continuous process environment. The study is conducted in a small organisation that has only 25 employees, whereas the study could have been conducted in other large-scale organisations as well.

2.7 GLOBAL PRACTICES OF LEAN MANUFACTURING IN CONTINUOUS PROCESSES

Energy availability is paramount in manufacturing capabilities and has become an indicator of socioeconomic development. Electricity is a kind of energy produced using different energy sources, such as hydroelectric, coal, nuclear, oil natural gas, or renewable energy. Many developing countries still experience energy outages and unreliable access to energy, limiting commercial activities and social interactions. In recent years, much stress has been focused on moving to more sustainable energy sources that are less harmful to the environment. Ethiopia uses hydroelectric plants to generate most of its energy and incorporates wind energy (Bekeya and Boneya, 2012). Most developed countries are increasingly relying on energy from domestic resources.

The electricity in Nigeria is generated from hydro stations and thermal stations that constantly need new electrical installations and upgrades (Oyedepo, 2012). China generates electricity from hydroelectric sources, coal sources, natural gas sources, oil sources, nuclear sources, and renewable sources (Dogan and Tugcu, 2015). India produces electricity from coal sources, hydroelectric sources, natural gas sources, nuclear sources, oil sources and renewable sources (Dogan and Tugcu, 2015).

Odinikuku (2018) considered the analysis of quality losses in the manufacturing process of spirit bottles in Nigeria. The analysis included the factors that affect the quality of the glass bottles and how the manufacturing process can be optimised to minimise defects. The defects and deviations from target standards were due to insufficiencies in the manufacturing process, operator faults, machine breakdowns and inappropriate proportions of raw materials used. Control charts recorded the number of rejections after warning systems were introduced to take corrective action to minimise the number of defects created. The matter that caused the variances in the production process was identified and removed.

2.8 CONCLUSION

This chapter provided an overview of the contingency theory that underpins this study. The literature has revealed that lean manufacturing principles and techniques have been applied in continuous processes, even though not all lean techniques are applicable to a continuous process. To successfully implement lean manufacturing techniques in continuous processes, the organisation needs to understand the environment in which they operate to select the right techniques to be used. The chapter discussed lean manufacturing and lean manufacturing frameworks that have been developed and applied in continuous processes. The following chapter will discuss the research methodology that was used in this study.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

The research problem identified for this study was that manufacturing companies using continuous processes in South Africa accumulate waste throughout the manufacturing process, and it is not clear whether manufacturers are using lean techniques in their manufacturing processes to improve efficiency. The aim of this study was to explore lean techniques that can be used in two continuous processes in South Africa. The primary objective of this study is to explore which lean techniques can be used to improve efficiencies in two continuous process case studies in South Africa. The secondary objectives are to identify the various forms of waste that exist within two continuous process manufacturing environments in South Africa, to determine the lean techniques that are used in two continuous processes in South Africa, and to identify how efficiencies can be improved within two continuous process manufacturing environments in South Africa. This chapter provides an outline of the qualitative research design, methodology and paradigm that was utilised to achieve the objectives of this study. The chapter also explains the population and how the sample has been selected. The data analysis techniques that have been employed are discussed, as well as the ethical considerations that have been applied. The chapter concludes with a chapter summary. The main themes of this chapter are depicted in Figure 3.1.

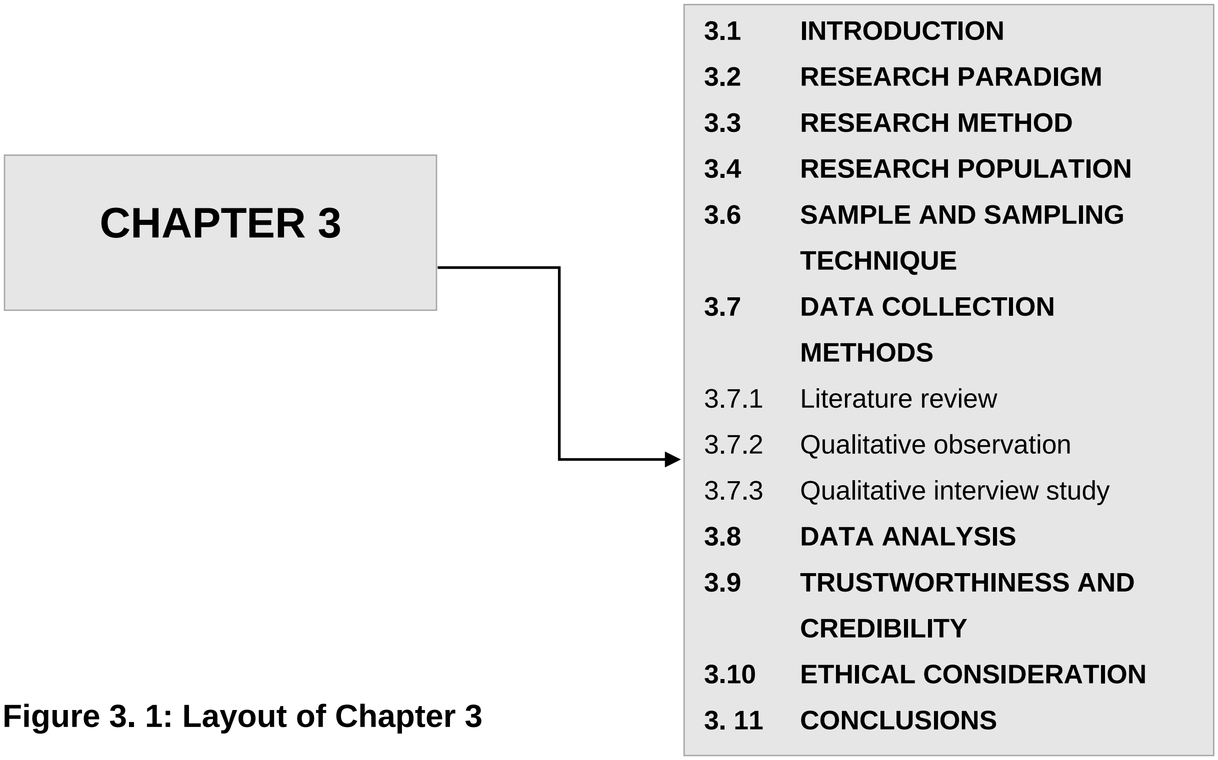

Figure 3. 1: Layout of Chapter 3

Source: Author's own compilation

3.2 RESEARCH PARADIGM

According to Johnson and Christensen (2014), research paradigms refer to a view held by a community of academics founded on shared beliefs, concepts, standards, and practices. It is a way of thinking about and undertaking research. The paradigms can be defined as lenses used by the researcher that influence the approach used to collect and analyse data, as well as the results. This study used an interpretivism philosophy, which is explained by Blumberg et al. (2008) as the social world that is experimented with by viewing what descriptions people give to it and interpreting these meanings from their perspectives. The paradigm allows participant involvement through conversing with them, observing the participants in their normal working environment while taking note of their views, feelings and ideas to avoid miscues and misconstrued information. Another reason the researcher chose interpretivism was that there was a limited number of studies regarding the implementation and use of lean manufacturing principles in continuous processes, particularly from a South African context. Therefore, this paradigm allowed the researcher to probe for clarity. The basic principles of interpretivism are as follows (Blumberg et al., 2008):

- The social is constructed and is subjectively given meaning by people
- The researcher is part of what is observed
- The research is driven by interest

Interpretivism implies the following assumptions:

- The social world is observed by interpreting the meaning given to phenomena from various perspectives.
- Social phenomena can only be understood by holistically looking at the phenomena.

Kivunja and Kuyini (2017) describe the following features of the interpretivistic research paradigm as the acknowledgement that the social world cannot be understood from an individual standpoint; the assumption that realities are multiple and socially constructed; the recognition that the researcher interacts with the participants; the understanding that context influences knowledge and knowing; the belief that knowledge formed by the findings is presupposed by a specific set of predetermined values that have been made known; and the belief that contextual factors need to be considered in any systematic pursuit of understanding. Since not much research is available on lean manufacturing principles and techniques being used in continuous processes from a South African perspective, this research is exploratory, and an interpretivistic paradigm is the most suited for this research.

3.3 RESEARCH DESIGN

Kumar (2011) indicates that research design consists of two key functions: the first one has to do with conceptualising an operational plan to undertake the various process to gain valid, objective, correct answers to the research questions and tasks required to complete your study. A research design articulates both the structure of the research problem and the strategy of investigation used to obtain empirical evidence on associations of the problem (Blumberg et al., 2008). The research design is the plan for gathering, measuring, and analysing data. It helps the researcher allocate resources. Creswell (2014) confirms that research design is the method of investigation within qualitative, quantitative, and mixed methods methodologies that offer specific direction for procedures in a research study. In contrast, research methods encompass the procedures of data collection, analysis, and interpretations that researchers recommend for their studies (Blumberg et al., 2008).

There are various research methodologies used by researchers in conducting research. The first approach is a quantitative methodology, which deposits more value upon information that can be mathematically manipulated (Maxwell, 2013). The second methodology is qualitative research that concentrates on different opinions and mental states and the value of an occurrence or experience (Maxwell, 2013). Creswell (2014) explains qualitative research as a method for discovering and understanding the meaning that individuals or groups ascribe to social or human challenges. Qualitative research begins with interpretive or theoretical frameworks that inform the study of the research problem (Creswell and Poth, 2018). To study this problem, qualitative researchers use an emerging qualitative methodology for inquiry, the collection of data in a natural setting sensitive to the people and place understudy, and data analysis that may be both inductive (generate new knowledge) and deductive (researcher observed the workers while working, to observe their normal routines) to establish patterns of themes. Qualitative research usually creates new theories with an inductive approach, which consists of an analysis of data with limited theory or structure by using the data collected to develop a structural analysis (Burnard, Gill, Stewart, Treasure and Chadwick, 2008).

The characteristics of qualitative research are outlined below (Rossman and Rallis, 2012, cited in Marshall and Rossman, 2011):

- Qualitative research occurs in the natural setting in continuous process environments (the researcher conducted observations in the workplace).
- It involves various interactive and humanistic methods (data were collected through face-to-face interviews with participants and observations in the workplace).
- It concentrates on context (the researcher asked probing and follow-up questions to obtain richer descriptions from participants where needed, and interview questions were rephrased to confirm that consistent responses were provided to those who did not understand the questions).
- It is developing rather than tightly prefigured (a semistructured interview process was followed whereby the researcher can clarify further certain aspects as they arose during the interviews).
- It is primarily interpretive (Keywords were identified using open coding after identified keywords were attached with meaning. Thereafter, groups of codes were identified that translated into themes.

Contingency theory was best suited for this study because the theory is based on the assumption that there is no single way for an organisation to be organised and that not every technique of organising that was used in another organisation will result in the same effectiveness (Galbraith, 1973). The qualitative methodology supports contingency theory because it offers in-depth insights and details through direct contact with participants. Qualitative methodology is primarily interpretive, and the researcher can explore the use of lean manufacturing techniques to gather the information that could improve efficiencies in continuous processes in South Africa. Appell (2011) also used contingency theory and collected data through two case studies that successfully implemented lean manufacturing.

In addition, Fereday and Muir-Cochrane (2006) suggest that qualitative research is primarily concerned with the properties, state and character (nature) of phenomena. Qualitative methods naturally produce detailed data about fewer people and cases. Qualitative data offer depth and detail through direct quotations and careful descriptions of circumstances, events, interactions and observed behaviours. A qualitative design will be used to design the research instruments for this study.

A multiple case study design was used, which Yin (2009) defines as the study of a contemporary phenomenon in depth and within its real-life context, mainly when the boundaries between phenomenon and context are unclear. Huberman and Miles (2002) describe the case study method as a research approach that focuses on understanding the dynamics existing within a single site. This study used two case studies within the South African context.

3.4 RESEARCH POPULATION

Salkind (2012) explains a population as a group of potential participants to whom you want to generalise the research results. According to Rubin and Babbie (2013), a population is a group or aggregation that a researcher is interested in generalising about. The population for this study was South African organisations whose production lines make use of continuous processes. Continuous processes are usually highly automated and run continuously (24/7) with minimal human intervention. A continuous process environment makes use of shifts where different workers are assigned to different shifts to ensure that production can continue around the clock. As such, high volumes, low-variety products, large and inflexible equipment and long setup times of production lines are prevalent.

3.5 SAMPLE AND SAMPLING TECHNIQUE

This study used nonprobability sampling and, in particular, purposive sampling. Bless et al. (2013) state that purposive sampling rests on the assumption that the investigator specifies what kind of participants are needed. According to Davis (2013), the sample size is not as important as the actual sample drawn. Two plants whose processes use continuous processes were chosen purposively to collect primary data from. The two organisations that were selected represent organisations that use continuous processes because they have low variety and high volume, and the machines run nonstop (24/7) and are highly automated. The researcher set out to research continuous process types, and it was not a requirement for the sample organisations to produce similar goods. The researcher used the two case studies based on the accessibility of the plants and the willingness of the organisations to participate in the study. The two case studies also gave the researcher a geographical spread because the two organisations are located in two different provinces in South Africa. One of the organisations also has plants in other countries, and therefore, an international view could also be obtained.

The participants from the two organisations consisted of four shop floor supervisors, four managers and four workers in total within each of the two case study environments. Twelve interviews were conducted in each of the two organisations using three groups (levels), namely, workers, supervisors, and managers, to obtain strategic and operational information. Four participants per group (level) were selected to ensure that rich information was sourced. Participants were chosen based on their experience, knowledge and availability. It was a requirement that participants must have three years of working experience in the organisation in this focus area of the research and the required job level, as previously mentioned. The workers provided operational information, supervisors provided operational and strategic information, and managers provided mostly strategic information. The researcher chose four participants per level that came from different sections (e.g., one manager from the quality assurance section, maintenance section, safety section and operations management section) to obtain a more holistic view of the organisation. Data saturation was reached with the twenty-four selected participants. Pseudonyms were given to each of the participants to protect their identities.

3.6 DATA COLLECTION METHODS

This study used three methods to collect data, namely, a literature review, qualitative observations and qualitative face-to-face semistructured interviews. The focus of this chapter is to present data collected through all three methods. Each method is explained below:

3.6.1 Literature Review

A desktop literature review was conducted by using the internet on a computer to access peer-reviewed published journal articles from credible journals, conference papers, books, documents and dissertations on lean management principles, in particular those used within continuous processes. The articles were sourced from various search engines, including Google Scholar, ResearchGate, Web of Science, Sabinet African journals and Ebsco databases (Business Source Ultimate, Academic Search Ultimate), using relevant key words such as lean manufacturing, lean principles, lean techniques, continuous processes, manufacturing industries, discrete processes and process types. For the research design section, the keywords used included qualitative methodology, research paradigm, worldviews, research design, population, sampling methods, sample, case study, interviews, data analysis, content analysis, trustworthiness and ethics.

3.6.2 Qualitative Observations

Marshall and Rossman (2011) explain that qualitative observations are crucial because they involve getting to know people while observing people in their natural work setting within their working environment for the researcher to observe and learn from employees’ routine and actions. Saunders, Lewis and Thornhill (2012) state that observation consists of consistent watching, recording, description, analysis, and interpretation of participants’ actions. The researcher visited each of the two plants that formed the sample of the study for a full week to observe the whole production process to increase her understanding of the natural setting and what production staff within the environment of continuous processes do.

The observations were recorded based on what the researcher noticed during plant visits (see Figure 4.1 and Figure 4.2, which reflect the processes as observed by the researcher). The observations were done during the day shift for two hours per day over a working week in each case study environment because of the availability and operational requirements of the organisations. It was not possible to spend more than two hours in the workplace due to the highly regulated working environment because of safety and operational measures for both case study environments.

The researcher took notes during the observations and clarified what they did by asking questions. The researcher asked open-ended questions to allow employees to provide detailed explanations where needed. The researcher mapped the current production process (illustrated information flow and material flow — see Figure 4.1 and Figure 4.2). The process map revealed areas of concern and waste. The limitation is that the interviewees may change their behaviour when they know they are being observed. The process mapping was completed while the observation was being conducted. The researcher clarified that she was observing the work not individuals. It was noted that during the observation, the workers started to feel comfortable with the researcher after the researcher clarified the purpose of the research, thus confirming Lincoln and Guba (1985) that a prolonged visit in the field aims to build trust with participants to solidify evidence in the field. The observations enabled the researcher to, later on, contextualise and confirm data that were collected from qualitative interviews in the last phase.

3.6.3 Qualitative interview study

Creswell (2014) explains that in qualitative interviews, the researcher conducts face-to-face interviews with participants and telephone interviews or may take part in focus group interviews with six to eight interviewees in each group. Blumberg et al. (2008) state that a private interview is a two-way talk started by an interviewer to obtain information from a participant. The interview questions were semistructured (see Appendix B); 24 face-to-face interviews were held with participants to collect data. Semistructured interviews were chosen because they afforded the researcher a chance to probe for clarity, as well as to garner responses based on the demeanour of the participant. Creswell (2014) defines semistructured interviews as interviews that normally start with specific questions but allow the interviewee to follow his or her own thoughts later. Probing techniques are usually used to evoke other information from the respondents. Page and Meyer (2006) define semistructured interviews as structured questions asked of all participants; these should be open-ended questions with no boundaries on how the participant can answer. Open-ended questions were asked so that the participants could share their own views and experiences. Research interview questions (see Appendix C) were developed to compile an interview guide. The questions were based on the literature review and aimed to address the research question of this study. The interview guide was emailed to each participant beforehand. By asking the same questions to each participant, the researchers were able to focus on more specific issues and the collection of similar data from participants (Chilisa and Preece, 2005); thus, the standardisation of meaning (Adamson, 2004) could be achieved.

The researcher recorded the participants during the interview by using a voice recorder to obtain an unbiased record and evidence of the data collected. The researcher ensured that the participants were comfortable; hence, they were interviewed in their workplace in private and quiet rooms, and the doors were closed to ensure confidentiality. Participants were interviewed one to one at a time. Generally, each interview took between twenty minutes and one hour. The working environment is highly automated, and the speed at which the production line runs creates significant pressure for the workers who need to constantly monitor operations. It was therefore not possible to conduct hour-long interviews with each of the participants. The researcher tried to probe as much as possible during the shorter interviews as permitted by the participants. The researcher encouraged participants to voice out their opinions freely, and the researcher tried by all means to prevent all forms of disruptions. The researcher asked follow-up probing questions during the interview to obtain an in-depth understanding and to obtain clarity about certain aspects of the responses as and when the need arose. The interviews were conducted in English.

3.7 DATA ANALYSIS

Before data analysis could begin, the recorded interviews were transcribed verbatim. Tilley and Powick (2002) describe verbatim transcription as the exact duplication and writing of the recorded voices. The key advantage of this kind of transcription is that it provides a correct reconstruction of what transpired during the interview. It also seeks to capture the meaning and perception given during the interview. In terms of the current study, the transcription was outsourced to a third-party transcriber, but the researcher listened to all the recordings to ascertain the quality and accuracy of the transcript. Where mistakes were identified, they were properly corrected. Voice modulations were also recorded during the note-making process. After confirming the corrections of each transcription, the researcher read through all the transcribed data to obtain a general picture of the data collected during the interviews. The researcher read the transcriptions a second time while making general notes.

According to Labuschagne (2003), qualitative data analysis refers to the nonnumerical organisation of data to discover patterns, themes, forms and qualities found in field notes, interviews, transcripts, open-ended questionnaires, diaries, and case studies. Creswell (2014) explains various ways of analysing qualitative data, but the aim is to make logic from the text and image data. According to Creswell and Poth (2018), the analysis of data in qualitative research consists of sorting and organising the data (i.e., text data as in transcripts or image data as in photographs) for analysis, then grouping the data into themes through a process of coding and finally representing the data in figures, tables, or a discussion. Open coding was used to categorise keywords after meaning was attached to the identified keywords that were allocated. Thereafter, groups of codes were identified, which were translated into themes. After themes had been developed, the researcher extracted meanings.

The researcher followed Creswell's (2014) steps: organise and prepare the data for analysing, verbatim transcribe the data, and analyse the transcriptions to identify common elements and themes. The themes were identified through reading and rereading the data. The themes and subthemes were identified from the transcript of each interview. The researcher combined the data into themes for each plant and then merged the data per theme for the two plants. This study used content analysis to analyse the data.

According to Blumberg et al. (2008), content analysis is based on the manual coding of transcripts and documents. The researcher continued to read through the transcripts several times, during which notes were made, and keywords were identified through open coding. Meanings were attached to the keywords, and codes and categories were identified as per the matching groups of codes. The simple theory of content analysis is that words or phrases that occur more often are grouped to allow for making inferences. Supporting this, Page and Meyer (2006) state that content analysis involves analysing transcripts with respect to their content, with the aspects of interest most often recounting to meaning or how many times (frequency with which) particular phrases or terms appear. According to Elo, Kaarianinen, Kanste, Polkki, Utriainen and Kyngas (2014), a requirement for a successful content analysis is that data can be summarised into themes that define the research phenomenon by creating categories, themes, a model, a conceptual system, or patterns.

Data were analysed and interpreted. The researcher integrated the notes accumulated during observations and interviews to provide further insights into the analysed interview data. Figure 3.2 illustrates the data analysis process.

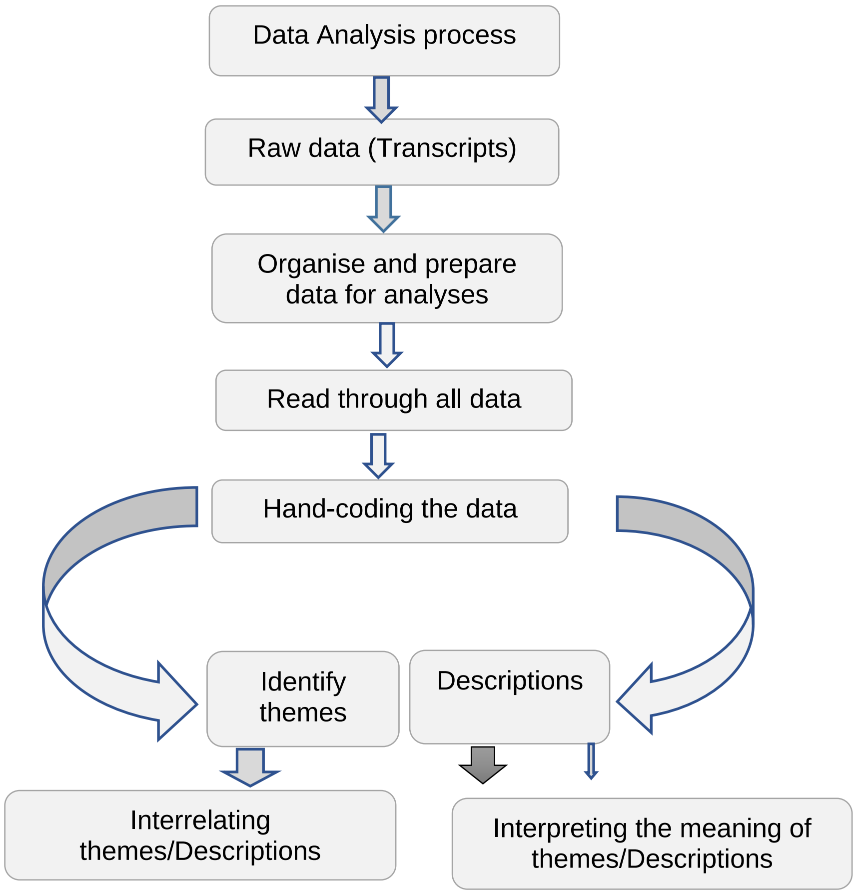

Figure 3. 2: Data analysis process

Source: Author's own work

Figure 3.2 explains the steps that were followed during data analysis. The researcher read through the transcripts to obtain a general understanding of the data. Notes were made with the second and subsequent reads. Themes and subthemes were identified.

3.8 TRUSTWORTHINESS AND CREDIBILITY OF THE STUDY

According to Bless et al. (2013), trustworthiness refers to "how much belief can be given to the study procedure and results". In contrast, credibility strives to convince that the results represent the truth of the reality under investigation, or, in other words, that they make logic. The following set of procedures was used to ensure trustworthiness was achieved: credibility, dependability, conformability, transferability and authenticity

(Lincoln and Guba, 1985 cited in Creswell and Poth, 2018). Anney (2014) describes these procedures as follows:

Credibility refers to the assurance that can be placed in the accuracy of the research findings. Triangulation was used to verify and increase the trustworthiness of this study by comparing data from interviews with data from direct observation and the literature. Marshall and Rossman (2011) describe triangulation as collecting data from numerous sources through various methods, using theoretical lenses, and discussing their emergent results. Methodological triangulation was utilised to verify and increase the trustworthiness of this study by comparing data from interviews with data from direct observation, as well as theoretical triangulation, which refers to the use of theoretical perspectives in the interpretation of data (Bless et al., 2013). Shenton (2004) confirms that triangulation consists of the use of diverse methods, especially observation and interviews, which form the major data collection strategies. This study is therefore triangulated by means of a literature review, observation, and interviews. The interviews were recorded by means of a digital recorder to provide an unbiased record of the data collected. Although the researcher was responsible for collecting all the data, all aspects of the research were meticulously recorded to prevent any bias from creeping into the study. The credibility of the findings is measured in terms of the richness of the information and not the number of participants.

Member checking was used by emailing the transcripts and themes to participants to confirm that the correct interpretations were made and correct errors (Lincoln and Guba, 1985). Member checking is informant feedback or respondent validation, which increases the credibility of the study. It refers to the debriefing and verification of interpretations and assumptions made by the researcher with the relevant participant interviewed (Corbin and Strauss, 1990). Informants were asked to read their transcripts of dialogue in which they had participated to verify its correctness. All interviews were recorded to provide evidence of the conversations and the data that were collected. The transcripts of the interviews and resultant coding used in the study were emailed to each participant for confirmation prior to it being included in the study. As such, the information used was verified and controlled by the participants.

Pseudonyms were assigned to each participant, and all identifiable information was removed. Interview questions were emailed beforehand to all participants to allow them an opportunity to prepare for the interview. No risks to physical, psychological or social aspects occurred.

Dependability refers to the stability of findings over time; it involves participants evaluating the findings and the interpretation and recommendation of the study to ensure that they are all supported by the data received from the informants of the study. Triangulation was used (observations, interviews and literature reviews). Marshall and Rossman (2011) define triangulation as gathering data from numerous sources through various methods, using theoretical lenses, and discussing their emergent results. The researcher relied on previously peer-reviewed published literature to validate some of the assertions made during the interview process (the researcher compared the findings of other studies, such as this study, to check for consistency of the findings).

Peer checking occurred when completed chapters and coded primary data that were sorted into themes were given to fellow academics who are experts in the field of lean manufacturing to provide guidance and to improve the quality of the write-up and analysis. Gunawan (2015) refers to peer checking as a process of using a panel of professionals or experienced colleagues to reanalyse some of the data, as a method of confirming that the researcher has analysed the data appropriately. The transcripts and interpretations of the interviews were also sent back to interviewees (member checking) to confirm the interpretations that were given to each of the interview data that were analysed. Two interviewees responded via email to provide additional information to clarify certain aspects that the researcher further prompted as part of the member checking process. In addition, parts of the study were submitted to two conferences where the abstracts were peer-reviewed. The feedback that was received during the presentations was incorporated into the study.

In this study, immediately when the research obtained the data from the first twelve interviews, the researcher analysed the information to facilitate subsequent data collection. The method helped to ensure rigour (Strauss and Corbin, 1990). Member checking was performed after transcribing and coding the interviews. Transcripts and coding were sent to the participants to confirm the content and interpretations that emerged. Member checking also creates the dependability of the data and the credibility of the findings of the study (Amadi-Echendu, 2016). The data were saved in a safe place throughout the research. The data will be kept in a safety deposit box for the next five years, and thereafter, they will be shredded.

Conformability indicates the degree to which the results of an inquiry can be confirmed or verified by other researchers (Anney, 2014). The researcher used triangulation by means of literature, interviews and observations to ensure that the results represent the perceptions of the participants and not the preferences of the researcher. Triangulation assisted with conformability because the researcher had three different sources of information that provided similar information. In this study, the researcher triangulated by using a desktop literature review, observations in the workplace and semistructured face-to-face interviews.

Transferability refers to the degree to which the results of qualitative research can be transferred to other contexts with other respondents; it is the interpretive equivalent of generalisation in quantitative studies (Anney, 2014). Thick and rich descriptions were used to describe lean manufacturing in continuous processes, which were the phenomena under investigation. Gunawan (2015) explains thick descriptions as a comprehensive description in this area that can be a vital provision for supporting credibility, as it helps to contextualise the information. Without insight, it is problematic for the reader of the final account to regulate the extent to which the overall findings may find application. The study is not transferable because the sample is small; however, the organisations that the researcher has chosen have a national footprint because they supply services nationally. Therefore, certain aspects of what they are doing may be transferable because what they do and the volumes they produce are nationally significant.

The fifth approach that was added to ensure trustworthiness is **authenticity**, which refers to the degree to which academics honestly show a range of realities (Lincoln and Guba, 1985; Polit and Beck, 2012 cited in Elo et al., 2014). Fairness and trustworthiness are the strategies used to ensure authenticity by treating all participants equally. All participants were asked the same questions in the same sequence. Participants were given an opportunity to speak without being interrupted. Fleshing out questions were asked by the researcher during the interviews and observations to obtain clarity regarding certain responses without influencing how the participants responded. The researcher assured the participants that all identifying information would be removed from the data, pseudonyms would be allocated to the participants and the information they shared would be kept confidential. As part of the trustworthiness strategy, the researcher ensured that these assurances were executed. Attention was given to all the voices (literature, interview data, observation data, making sense of the information) in the study.

3.9 ETHICAL CONSIDERATIONS

Research ethics refers to the study of the correct behaviour and discusses how to conduct research in a moral and accountable way (Blumberg et al., 2018). Bless et al. (2013) confirm that ethics is connected to the term morality, which refers to one's manner or personality. A moral issue is concerned with whether conduct is correct or wrong, whereas an ethical issue is concerned with whether the behaviour follows a code or a set of principles. The researcher obtained ethical clearance from the university to ensure that the research adheres to the university's ethical guidelines (see Appendix A):

- The researcher respected and protected the dignity, privacy, and confidentiality of all participants by removing any identifiable information.
- A formal request for permission to undertake the study was sent to Company A (see Appendix D). The researcher was granted written approval from the organisation — organisational consent (see Appendix D). A formal request for permission to undertake the study was also sent to Company B (see Appendix E), and the researcher was granted written approval from the organisation (see Appendix E). The top managers (gatekeepers) that provided the organisational consent also helped the researcher to identify the

participants in each of the organisations identified. Each participant also needed to provide individual consent before the interviews took place. Interviews were conducted until data saturation was reached.

- Anonymity — the researcher ensured that the personal information of participants used for research purposes was adequately protected to prevent possible loss, damage and/or unauthorised access as required by the Protection of Personal Information (POPI) Act, No. 4 of 2013. As such, the researcher assigned pseudonyms to each participant.
- Privacy — the researcher informed the participants of their rights to confidentiality. The researcher respected the confidentiality of the participants by disassociating names from respondents during the coding and recording process (Creswell, 2014).
- The researcher explained the objectives and motivation of the study to the participants.
- The researcher provided the appropriate information to the participants before the interviews commenced.
- The researcher requested all participants to complete and sign an informed consent letter (see Appendix C). The first part of the informed consent letter contained the aims, objectives, procedure and possible benefits of the research as well as an outline of the ethical matters relating to the rights of the interviewees to decline to participate or withdraw from the research project at any time should they wish to do so without any negative consequences being incurred. All the participants were adults and could provide their own consent.
- The researcher ensured that the interviews were conducted in a private and very quiet room that minimised interruptions.

3.10 LIMITATIONS AND DELIMITATIONS

This study focuses on the use of lean manufacturing techniques in continuous processes and process industry processes in South Africa but not on the use of lean manufacturing in discrete processes. This study predominantly focuses on waste and not directly on value creation. An assumption made by the researcher is that operations would be optimised when waste is reduced. The data collection process information attained during the interviews was dependent on what the participants were able and prepared to share with the researcher. During the observation phase, employees may change their behaviour when they know that they are being observed. The researcher only used two case studies that represent a continuous processes environment. Therefore, the study cannot be transferable, but some of the aspects of the study can be adapted to a continuous processes environment.

The delimitation of this study is that the researcher used purposive sampling for this study, whereby participants were chosen based on predetermined requirements that they must have 3 years of working experience in the organisation in the following areas: quality assurance section, maintenance section, safety section and operations management section.

3.11 CONCLUSION

This chapter provided a detailed discussion of the research design, paradigms, and methodology that were used in the study. The justification for choosing a qualitative approach was provided in accordance with the objective and the context of the research. The chapter further discusses the data collection methods, data analysis methods, trustworthiness, credibility and ethical considerations of the study. In the next chapter, the collected, transcribed, and analysed data will be presented.

CHAPTER 4: PRESENTATION OF EMPIRICAL DATA

4.1 INTRODUCTION

In this chapter, the primary data collected for the study are presented and explained. Mbowana (2016) asserts that data analysis includes the categorising, ordering, manipulating, and summarising of data to obtain answers to the research questions. The information presented in this chapter sought to answer the primary research question, *“Which lean techniques can be used to improve efficiencies in two continuous process case studies in South Africa?”* The lean manufacturing philosophy was identified as a good strategy to eliminate waste and nonvalue-adding activities to improve performance, reduce costs, enhance conformance to quality, improve productivity, reduce inventory levels and improve throughput times (Deflorin and Scherrer-Rathje, 2012). This study collected data through a desktop literature review, observations in the field and face-to-face semistructured interviews. The focus of this chapter is to present the data that were collected through all three processes.

This chapter is organised into sections, each containing its own subsections; the first part of this chapter presents the on-site observation data, and the second part of the chapter presents the interview data. Interpretation of the research data includes taking the outcome of the data analysis and creating interpretations pertinent to the research relations studied to complete these relationships that arise (Mbowana, 2016).

4.2 PRESENTATION OF THE OBSERVATION DATA

The researcher conducted direct observations at each plant for a full week during the day shift to observe the whole production process to enhance her understanding of the natural setting (what production staff within the environment of continuous processes do) and to identify the lean techniques that are currently used in continuous processes in South Africa. The researcher took notes during the workplace observations and mapped the current processes after the observations were completed. The disadvantage during the workplace observation phase is that employees may change their behaviour when they know that they are being observed. However, the researcher explained to them that she was observing the processes and not the individuals. During the workplace observations, the workers began to feel at ease with the researcher after the researcher explained the purpose of the study.

4.2.1 Case study example 1: Company A production process

Figure 4.1 illustrates different areas of the production process of a bottle manufacturer, namely, the batch mixing area, three furnaces, hot end with nine lines, control room, quality assurance area and shrouder (areas will be explained individually). The batch mixing area is where glass manufacturing begins when raw materials such as sand, soda ash, lime felt spa and red oxide are mixed together according to the design colour. The correct ingredients and the correct ratio of the ingredients that are being mixed are of great importance. The mixing of ingredients takes place automatically and electronically according to preprogrammed specifications. The correctness of the ingredients is ensured by technicians in control through computer systems. The machines run continuously, and the processes are highly automated. Waste was not identified during this phase. During the mixing process, workers are only observing to ensure that everything is going well and are not physically involved in the process. The lean manufacturing techniques that were observed in this area are 5S (cleaning of equipment and automated machines, changing of oil, collecting broken glass from the floor and other working surfaces and cleaning the floor of the plant to remove oil, glass and other elements that may be hazardous to workers), continuous improvement (ensuring that machines are set to the correct temperature to reduce defects) and maintenance of automated machines and equipment in the industrial plant (TPM). Records of all these activities are kept and filed by workers and discussed by managers during the daily morning meetings. From the batch mixing area, ingredients are transported in a conveyor belt to three furnaces.

Company A operates three furnaces that operate at 1,400 degrees Celsius, where the ingredients from the batch mixing area are melted to make molten glass.

The hot end is a section that contains nine different production lines where glass conditioning takes place, whereby glass is cooled down prior to cutting it into gobs. Gobs are molten glass that has been cut to size to suit the weight of the bottle. Gobs are then fed into a blank mould. The gobs are dropped through tubes to form a parison (a rounded mass of glass) that is transferred to the final mould. Two processes are used in the hot end by machines: press, which refers to how the bottles are formed, and blow, which refers to the process of air being blown on both sides of the parison. Air is blown into the mould until it takes the final shape of a bottle. All processes in the hot end are automated.

All the bottles with defects that have been identified by the system are manually removed by staff and taken to the cullet plant (where the bottles are broken) to reduce waste. Quality assurance already occurs from the hot end onwards. Machines need constant maintenance because they are old and cannot be replaced easily due to their high costs and continuous use. Thus, TPM is used to maintain the equipment and machines. TPM is a management strategy that can be implemented to decrease unexpected machine failures during work progress (Feld, 2000). TPM improves machine dependability and effectiveness speed by removing unwaiting waiting in a process (Chan, 2005).

Despite the ongoing maintenance activities, the researcher observed that oil leaks from the machines in the hot end area are caught in buckets placed under the leaking machine for the oil to be recycled. Machines are not fixed immediately when they breakdown, as breakdowns are prioritised and fixed according to the level of priority assigned to the breakdown. The staff, therefore, conduct reactive maintenance based on the urgency identified. The researcher observed that workers practice housekeeping by cleaning the floor to reduce accidents (collecting bottles on the floor, whipping oil and water on the floor and cleaning machines) known as 5S. The 5S is a method of the organisation that aims to achieve a clean, stable, and efficient work environment by sorting/labelling items that involve the analysis of all objects that are in the production area to determine what needs to be kept and what can be removed (Gavriluta, Nitu and Gavriluta, 2021).

While still in the hot end area, a special coating is automatically applied by machines to the bottles. Hereafter, the coated bottles undergo an annealing process where the temperature is controlled and gradually reduced to remove stress (air bubbles and uneven thickness) in the glass as the glass is cooling down. The annealing process helped produce strong, stable, and heat-resistant glass. Workers wearing safety attire remove defective bottles. The lean manufacturing techniques that are practised in this part of the hot end area are 5S (cleaning of the floor and machines), maintenance of equipment (TPM), continuous improvement (technicians are constantly monitoring the variables electronically), and TQM (inspection). The elimination of waste is applied by recycling defects (bottles with cracks) that are identified during or after production.

After the bottles have been coated and annealed, they undergo quality assurance, which is the last manufacturing section before the bottles are despatched for distribution. Quality assurance is a TQM lean technique that aids an organisation in developing standard operating procedures (specifications) that the organisational workers should follow during work activities to attain well-defined outcomes, and quality assurance is the section that is responsible for enforcing TQM in an organisation (Isaksson, 2006). Various machines are used in the quality assurance process. The quality assurance area is fitted with various machines that perform specific electronic inspections. The M-Cal machine is a sidewall camera that detects any inclusions in the bottle (foreign objects such as air, ceramic, stone or metal that can be added to the glass during the manufacturing process). When defects are detected, they are removed from the production line by the equipment and not the staff. The multimachine inspects the base (bottom part) of the bottle, the finishing and any defects highlighted through the camera. The MX Atlas machine conducts base checks for small cracks, measures the thickness and ball control of the glass, checks the whole bottle for any cracks and leaks and measures the glass distribution thickness.

In the quality assurance section, 5S is also practised by keeping the area clean and neat. TPM is also practiced on machines, and preventative and corrective maintenance occur. Machines that breakdown unexpectedly are fixed, and planned maintenance is scheduled. The workers from the quality assurance section are responsible for performing the final checks at the end of the quality assurance process, whereafter no further manual interventions occur. International standards must be adhered to during the manufacturing process (ISO 9001:2015). Dale, Bamford and Van der Wiele (2016) mention that TQM has seven principles that are explained in the ISO 9001 (2015) standards and include the following: leadership support, customer focus, the involvement of workers, relationship management, evidence-based decision-making, and process improvement. Batch production reports are discussed every day at management meetings held in the morning.

After the quality assurance process has been completed, the glass cools for 24 hours in an open space where after the bottles are sent to an area that is known as a shrouder where the finished product is automatically placed into pallets and shrink-wrapped. Bottles are then sent to a warehouse for distribution to local and international customers. In the shrouder, lean techniques being used include 5S (packing equipment neatly, sorting files, and cleaning machines), TPM, TQM and continuous improvement (reviewing the production report during the meeting and coming up with solutions).

The control room is at the centre of the factory activity and has state-of-the-art technology that gives technicians full control to monitor the mixing of ingredients in the batch mixing area, the temperature in the furnaces and the hot end area, and the performance of all machines and equipment. Constant and close control of the temperature of the furnace and hot end area ensures that top-quality glass containers are produced. Workers adhere to safety regulations by wearing safety clothes in all plant areas, including the control room. In the control room, machines show failures (when the bottles do not meet specifications) and malfunctioning of machines.

Generally, when unusually high volumes of defects are detected, workers are informed by the control room to fix errors that may have occurred in the production line, e.g., temperature settings may be incorrect, or the ratio of the ingredients could be out of sync and blotches on the camera that creates false defects) The researcher observed that teamwork, communication and reporting of defects are practised during the production process. Most of the bottles that were referred to as defects had cracks or the bottles were not cut correctly by the machines. Incidents are recorded to make different shifts aware of occurrences and failures so that outstanding maintenance can be performed and focus is created for specific issues to be mitigated and improved as part of continuous improvement initiatives. Human errors are also recorded for training purposes, as the errors may have detrimental impacts on production.

Figure 4.1 illustrates Company A’s production process flow observed during the observation process. Only the high-level production process steps have been mapped, but all the steps have been explained above.

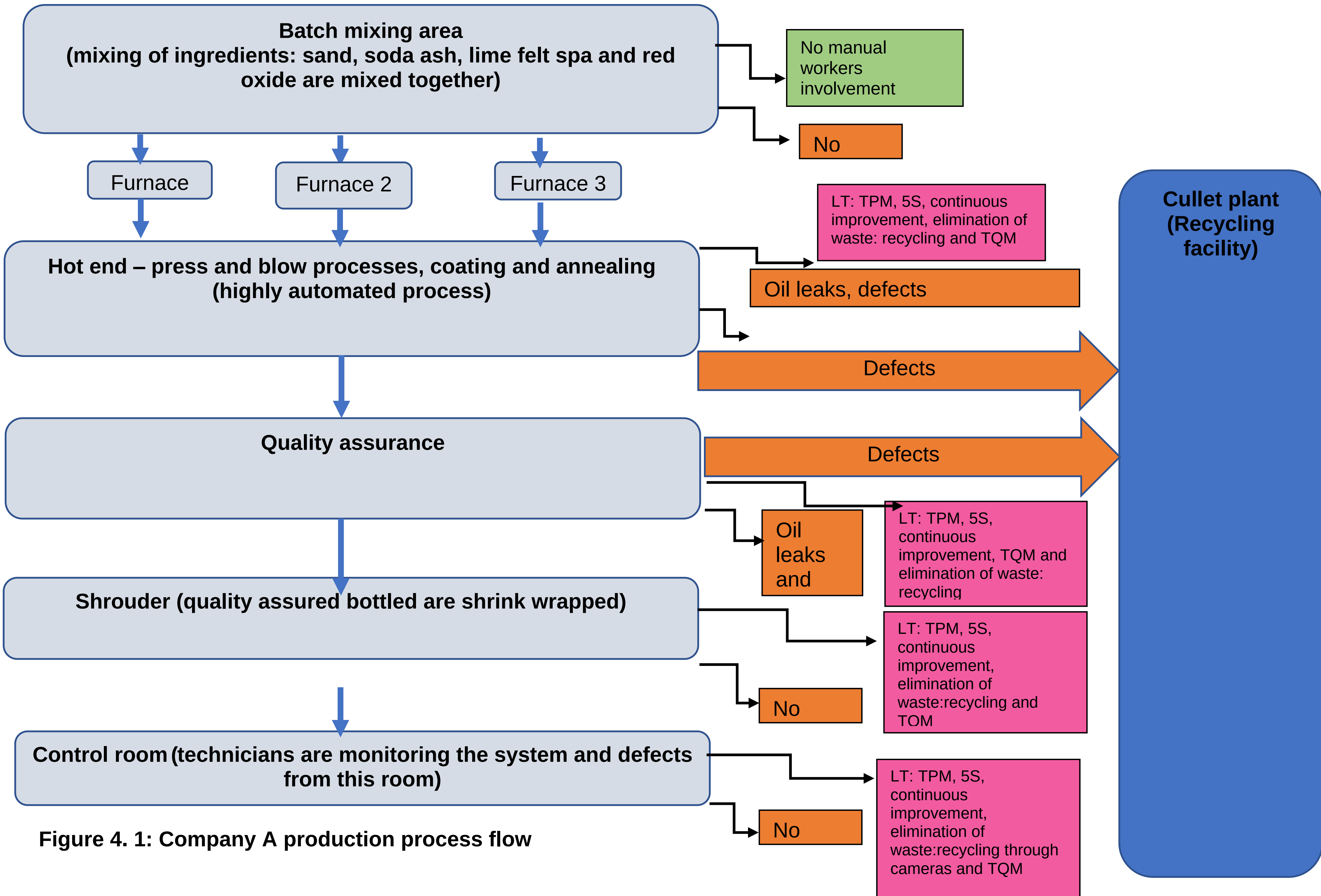

Figure 4. 1: Company A production process flow

4.2.2 Case study example 2: Company B production process

Company B was the second plant where in-person workplace observations were conducted. Although the company consists of various areas of business, the researcher was focused on the generation component of the company's business. The generation of electricity comprises the following areas: external mine, coal bunkers (contain the silos and stockyard), milling plant, boiler, control room, and turbine floor (which contains the turbine and a generator). There are many ways to generate electricity; however, the plant that was used to collect data uses coal from a nearby mine (20 km away) to generate electricity.

The coal is mined from the earth in the mine. Coal is transported from the mine through a conveyor belt to the stockyard in the coal bunker. Approximately 3000 tons of coal is transported per hour. When the conveyor belt is damaged, it causes spillages of coal, which results in coal waste. The company eliminates the waste of resources by recycling coal that falls from the conveyor belt. Workers manually pick up coal that falls from the conveyor belt and load the coal into dump trucks. Apart from the collection of coal waste, the whole process is highly automated and continuous. The lean techniques that are used at this initial stage of the process are 5S (cleaning the conveyor belt to ensure that it does not have foreign objects, for example, if metal can mix with coal, it can damage the plant components; changing the oil of the automated machines and other equipment; cleaning the floor and other work spaces to remove oil, coal and other substances) and TPM (ensuring that the conveyor belt is maintained and damages to automated machines and equipment are repaired; preventative and corrective maintenance and changing oils and water in the automated and industrial machines). Workers compile reports of these activities that form part of the information that is exchanged between shifts and discussed in management meetings.

Coal from the mine arrives at Company B's stockyard, which is part of the coal bunker. The mine concluded a contract with Company B and must supply coal according to contract specifications. The coal bunker comprises the stockyard and the silos. When coal arrives at the stockyard, the moisture content is tested using moisture analysers to ensure compliance with the contract. From this point, four conveyor belts are used to transport coal to different areas of the plant. Coal that is not deemed suitable for use because of its high moisture content is sent to the stockyard, where it is stacked for five to seven days to reduce the moisture content before it is sent to the silos for storage. As an in-house draining system, coal in the stockyard is stacked at an angle so that water (for example, from rain) can flow and easily drain away from the stockyard. An on-site operator evaluates the coal levels in the different areas and manually despatches coal to the different areas. Apart from this manual decision-making capability, the entire process in the coal bunker is automated. Manual working procedures are in place to compensate for offline situations or failure modes.

When coal that has a high level of moisture is used in the process, it may cause damage to the equipment and affect the combustion process. Suet also builds up in conveyor belts that must be monitored continuously and cleaned out regularly. Failure to clean the conveyor belt may result in the conveyor belt breaking down and not being able to transport the coal. Bearings and other conveyor belt parts must be maintained and replaced regularly to avoid oil and grease spillages. The lean principles that have been identified as operating in this area are 5S (cleaning of conveyor belt), TPM (replacing worn parts) and TQM (moisture analyses and storage). Continuous improvement initiatives can also be applied to find more effective ways to transport, store, and operate the coal in this area.

The mill is where coal is crushed into fine particles before the powder is transported into the boiler. At the milling plant, within the reject system, pure coal is separated from rocks that might have been collected with the coal. The rocks are discarded and not used in the rest of the process. The process is highly automated, and workers are involved with the maintenance of the equipment and machines, cleaning the facility and the machines, and collecting the coal and oil spillages. When the milling plant is not well maintained, it causes oil leakages (waste). Coal spillages can occur if the conveyor belt is damaged. The lean manufacturing techniques that are practised in this area are 5S (cleaning of equipment), TPM (maintenance of machines and equipment), TQM (quality inspections of the coal before crushing by removing rocks) and continuous improvement (improving the effectiveness of machines and reducing waste). According to Bhattacharyaa and Ramachandran (2021), visual controls (a lean technique usually practised in continuous processes), such as light signals, charts, cartoons, safety instructions, warning sign lane markings on the floor and Poka-Yoke instructions, can be shown everywhere in the workplace. The mill and rest of the plant have floor markings to indicate where workers can safely walk, and no-go areas are clearly marked. The area has a floor plan that indicates emergency evacuation areas as part of their safety requirements. From the mill, the powdered coal is transported to the boiler.

The boiler is divided into two areas: a furnace where the coal is burned and an evaporator where water becomes steam. The crushed coal is blown into the furnace and used as fuel to create a flame that produces heat. Dams and reservoirs supply water to the plant that undergoes water treatment prior to being pumped into the evaporator of the boiler. The flame from the furnace provides combustion to heat the water converted into steam. Flue gas is a pollutant generated from coal combustion that escapes into the air through a chimney. Due to the age of the equipment, oil and water leakages from the equipment are prevalent. Workers attempt to recycle these leakages by placing buckets to capture them until maintenance can be executed. The burning coal produces ash that is removed through pipes into the ash dumping area where it is sold to external organisations. The processes in the boiler are highly automated. The lean manufacturing techniques that are practised at this stage are TPM (machines being maintained to ensure effective production), 5S (cleaning the work environment and machines) and continuous improvement (ensuring that all machines are running effectively and reducing human errors) of the whole production process based on the production report. The steam from the evaporator in the boiler is directed to the turbine floor.

In the turbine floor area, the steam from the boiler (evaporator) contains thermal energy that is converted into kinetic energy in the turbine, which causes the blades of the turbine to start turning, thus creating mechanical energy. The turbine is connected to the shaft of a generator, which then rotates to convert the turbine's mechanical energy into electrical energy, that is, electricity. The electric current is sent through power lines to businesses and homes for consumption.

The control room is where technicians control and monitor all machines and equipment in the plant. Faults and failures are monitored via the control room screens, and technicians are requested to attend to the issues identified. Indicator sounds such as an alarm or hooter alert workers of a failure or breakdown. The computer describes the fault that had occurred. Where staff from the control room cannot restart machines in the production line, workers are despatched to manually perform the activities as a manual workaround.

TPM is one of the most important lean techniques that are practised in the control room. The TPM incorporates maintenance staff, operators and management who need to work as a team to improve the overall operation of the plant. Maintenance staff should recognise oil or air leakages and noisy or vibrating motors and can be equipped with the skill to make simple maintenance to avoid major and expensive breakdowns (Bhattacharyaa and Ramachandran, 2021). Corrective maintenance is practiced more often because maintenance staff usually wait for technical indicators before equipment is fixed. Redundant equipment (previously used equipment that is still able to operate but is no longer in use) is used when preventative maintenance is executed. However, boiler maintenance requires a complete shutdown, as there is only one boiler in operation. Essentially, electricity generation capacity must be managed across the different generation plants. A few smaller plants may not be sufficient to replace the electricity generation capacity of a larger plant during maintenance that requires the operations to be halted, thus impacting the supply of electricity to households and businesses.

At the time of the research visit, there were a few vacancies in the engineering and maintenance department, which reflected a lack of technical expertise to support the operation of the plant. As a result, the maintenance of equipment was delayed. The vacancies could not be filled due to budget constraints. Machines, boilers and conveyor belts were damaged for a week, as at the time of the research visit, the maintenance staff still had to attend the required maintenance actions and repairs. The housekeeping of the whole plant is very good to avoid accidents on the floor. Housekeeping is one of the lean techniques known as 5S, which is related to keeping the floor clean and replacing oil in machines. The 5S strategy benefits the workplace by removing unwanted items from the work area and sets the benchmark for continued use and compliance.

Proper communication, correct reporting and teamwork are paramount to the success of the production process. Operations were run on a 5-shift system with 8-hour shifts occurring daily. Proper planning of human resources will accommodate staff training, leave (planned and unplanned) and other absenteeism. Managers provide leadership by physically engaging with staff on the production floor, inspecting the condition of the plant, confirming that maintenance is properly executed and ensuring that work is performed safely. In addition, all managers are part of the daily production meeting where all production and staff issues are discussed.

Panwar et al. (2015) confirmed that lean manufacturing techniques that can be practised anywhere in the production process are quality management programmes, 5S, VSM, TPM, team-based problem solving, work standardisation and continuous improvement. Abdulmalek et al. (2015) agree that lean manufacturing tools that do not depend on the process features are team-based problem solving, TPM, work standardisation, 5S, quality management programs, VSM, and continuous improvements, which are strongly applicable in continuous processes. Durakovic, Demir, Abat and Emek (2018) also indicate that not all lean principles and techniques may be practised in other industries, but a few that can be applied will increase productivity in that industry. Jimenez et al. (2012) added that visual aids, continuous improvement and 5S are universally practiced. VSM is mostly used to identify waste during the production process. Masemola et al. (2021) found Kanban, standard work and 5S to be the most used lean manufacturing tools. Figure 4.2 shows the electricity production process flow of Company B, which was mapped during the observation process that took place at the workplace.

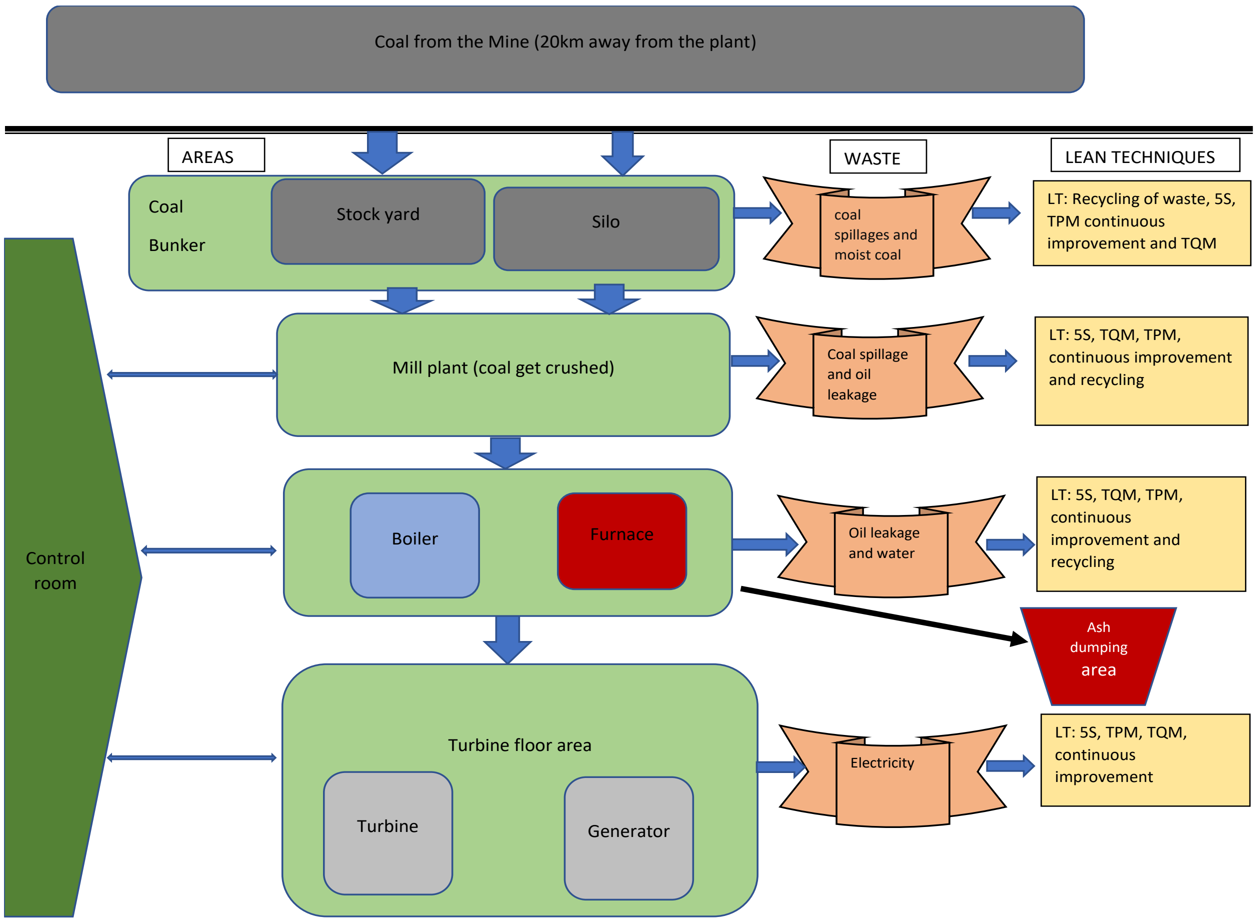

Figure 4. 2: Company B production process flow

4.3 PRESENTATION OF THE INTERVIEW DATA

This section presents data that were collected from the face-to-face interviews. This study sought to explore lean techniques that can be used in continuous processes in two South African companies. This section considers the primary data that were collected. All interviews were transcribed verbatim. Although an external person transcribed the interviews, the researcher confirmed the correctness of each transcribed interview by listening to each interview. The researcher compared the recording against the transcriptions to ensure that the transcriptions are accurate reflections of what was said during each interview. The researcher continued to underline relevant aspects identified in the study, made notes and captured annotations on each transcription, and allocated themes to each of the underlined words.

Themes and subthemes were identified from the interview transcripts. The researcher combined the themes for each plant into one table and then added the tables of themes and subthemes with the respective direct quotes from each participant of the other plant. This enabled the researcher to identify common areas across the two plants and to statistically count the number of instances that specific issues were mentioned. Table 4.1 reflects an excerpt of the different responses from participants to demonstrate how the interview data were grouped into the various themes that were identified.

The themes and subthemes that will be discussed represent all the data across the two case study environments that were considered. Each participant was given a pseudonym to protect the identity of the participants. All identifying information has been removed. The participants are workers, supervisors and managers from both organisations. To protect the confidentiality of the participants, the transcriptions are not included as addendums to this dissertation. As a result, this chapter aims to showcase as much of the data that were collected. Three main themes emerged from the data, namely, waste of resources, people’s involvement, and continuous improvement. Language errors were not corrected, and all direct quotes are the actual words the interviewee had said during the interview. Table 4.1 is an example of the themes identified.

Table 4. 1: Example of the themes and subthemes identified for the interviews

Themes	Subthemes	Quotes
1 Waste of resources	Elimination of waste	We used to have one drum per A, B, C, D crew that they were sharing, we were not recording, but since we've introduced, we take one guy to look after those oil, each crew and they record. So, the waste there, it's, we used to use maybe six drum per month, but now we went back to three, since we've got that process. **(Worker-2)**
	Recycling of waste	Resort is like in the, if the bad bottles have passed, we have to hire people to come and repack them again... we are using extra people to… We are using a cheaper plastic, but we are hiring extra people to do the work again. **(Supervisor-1)**
	Waste of resources	The oil leakage is obviously the whole day some couple here and there, but we get it sorted. I know there was an oil leak by, the not, really two months back. **(Worker-7)**
	Faults indicators/Technical indicators	If there are any problems, you'll hear this other sound that, sort of like a hooter, that ring. It shows that there is a problem in one of the sections of the machine that needs to be sorted out… Any slightly problem that we'll encounter, either it can be from the mechanical side or the electrical side, we've got different sounds or hooters that will say there is a problem, then it will be attended to, ja. **(Manager-1)**
	Delays/disruptions	The only time that we get disturbed it's when it comes to this loadshedding that is done by Eskom. That is where that it's costing us a lot from, from the point, maybe if we start operating with RUPS, you have to use the diesel and the diesel is costing us, but if it wasn't the loadshedding and all of that, we were not going to have this waste issue of cost, because it's costing us a lot. **(Manager-1)**
	Causes of waste	… there're two things that we currently are struggling with. Is we're sitting with a lot of waste, which is potentially defects which goes through our system where it gets

Themes	Subthemes	Quotes
		inspected and based on the inspection it gets automatically rejected by the equipment, but this is camera vision-based equipment and it needs constant monitoring, tweaking, verifying, you know. Because the machine or the camera vision can see that TV as a rock, but in the meantime it's not a rock, it's a TV, you know what I'm saying? **(Manager-2)**
	Rejections or defects of finished and in-process products	On a normal present state, our reject rate is sitting at about twenty, plus minus 20%. **(Manager-3)**
	Challenges to meet target	We strike quite a lot of things, that we are not reworking, because we need to pack at least 82% to 90%. We are averaging 68%. **(Manager-3)**
	Mitigation of waste	… for instance, now we are not, like we are not using any of the main principles. We can adopt the main principles, but we can also in my view adopt route cause analysis methodologies. **(Manager-6)**
	Increase in costs	Re-sort is like in the, if the bad bottles have passed, we have to hire people to come and re-pack them again …we are using extra people to… We are using a cheaper plastic, but we are hiring extra people to do the work again. **(Supervisor-1)**
2 **People's involvement**	Training of workers	it's training, technical training, management training maybe because we can source people from outside and that's what I'm saying, but technical training it's, it's a problem. According to what I see. Previously what we were doing, we were taking the guys and training them in students. We stopped that about seven years ago, meaning whatever we have, we learnt it seven years ago and the technology keeps on changing. **(Manager-3)**
	Teamwork	then the team will take those one and two things and start unpacking them,

Themes	Subthemes	Quotes
		individually looking at, if I say it is a, it is a card or it's a, let's say a proximity that could potentially lead to this problem, then we start listing those things under that. Up to the point where you start eliminating the issues completely, but it's not an individual sitting and do problem solving at all. It's, it's team based where the whole team gets involved and even with our job descriptions, we do exactly the same. **(Manager-2)**
	Communication	… from a quality point, we have started now, where we communicate to the line inspectors on their 24 hours defect analysis that gives them a snapshot of what actually transpired on this line in the past twenty-four hours, which gives him the heads-up. **(Manager-2)**
	Meetings	looking at our production meetings, it involves mainly the, the head of departments like a filming face manager or a coding face manger or a line supervisor, but I think, I think the people are not that involved. That's my personal opinion or view, which I also highlight daily in our production meetings, because there's a lot of valuable discussions that's happening there, especially around trends and the percentage losses and certain sections that repeats itself, but we're not doing enough to take that discussion back to the people, so that they actually know about these trends and these ongoing defects. **(Manager- 2)** Every morning in our production meeting we go through twenty-fours plant, all nine production lines, discussing the top three defects, critical defects, repeat incidences, trends, machine availability, which involves technical there to understand, you know, issues on the machine, because if the machine is not available, in this process, how it

Themes	Subthemes	Quotes
		works is if the machine available, let's say 80%, you will produce 20% plus, defects, because it's all temperature based. **(Manager- 2)**
	Compliance with the set standard of procedure	We just need to go back to basics, that's number one. For the last twelve years I've been here, comparing twelve years and now, it's not, we are no longer doing the basics…Like the SOPs are not being followed, due to another disciplining voice. **(Manager- 3)**
3 Continuous improvement	Accountability	yes there are waste, but the ones that are in my control – oil. So, we reduce and manage oil. We've even selected a new panel of older people, which are managing oil in terms of filling and also making sure that the area is clean and other resources, how we optimise, is we make sure every operator knows what they should be doing and their also issued gloves on time, so from gloves to oil to tools, which is a swab itself, which is issued to them by number. So, we reduce and use what we're supposed to use correctly, so we don't throw away things before they're completely done. So, we have to make sure we don't just spend. **(Manager- 4)**
	Staff	Those kinds of things, like competencies are not there. That's my assumptions, I never did a study on that. Those are some of the challenges. **(Supervisor-6)**
	Unskilled labour	we also have those people, we are using them just for cleaning, also, just of picking up stuff. **(Supervisor- 4)**
	Skilled labour	So only people who are licenced dispose and handle those uh, quiets when we're removing them from site, are the ones which are now the service providers, so fortunately as commerce licenced people like our subsidiaries. **(Manager-5)**
	Reporting	On an hourly basis, where we, we go to each and every machine that we have, we analyse what we are losing versus to what we're packing. What we do is, we are

Themes	Subthemes	Quotes
		checking on all the defects in that, is this defect supposed to be rejected by the machine? Firstly, if there's a good way from it, we make adjustments on the machine to pack whatever that is clean and good ware and then obviously for defects, we report back to, to the layer inspector who then**…(Supervisor-3)**
	Maintenance of equipment	Ja, because they only react when there's a problem. Saying there's a problem, they will review the whole process of checking the quality, but the production, the IS, the furnace, we don't…**(Manager-3)**
	Production processes	Activities in the production process, they are reviewed quarterly, during the management review, quarterly management review. **(Manager-6)**
	Monitoring and evaluation	I'm not too sure, but with regards to the production, regarding us on the floor, we, we, we, we are always monitoring our losses. That is like on a hourly basis, on a maybe every thirty minute basis, just to make sure that everything is… Everything that is being produce is of good quality. So, with regards to the guys at production on shift, it's an ongoing process. We are, we are monitoring continuously, yes. **(Supervisor-2)**
	Inspection	we're dealing with glass bottles. In order to reduce waste, we need to produce quality bottles. Quality ware. So, in order to produce quality ware, our hourly inspection on our bottle sets, need to be done religiously. If not, then we're going to have webbing thrown away for unnecessary defects on the bottle, so by, by the guys doing the set checks every hour we are reducing that, in that way we are reducing and optimising loss on our production end. **(Supervisor-2)**
	Measuring	it's measured every minute, I would say, because it's a live system that, that runs, which is IAFIS, which is our production monitoring system, but from a shift point I

Themes	Subthemes	Quotes
		would say they are, you know, they measure themselves from, form hour to hour, if I can put it that way, alright? And that measurements is around quality, defects produced, it's about the forming machine availability, rate, speed, quality into the lere, percentage produced which is rejected on the inspection side and obviously the, the, the output, packed them out…So, that's measured on an hourly basis and then shift basis and then we review it as management on a 24 hours basis. **(Manager- 2)**
	Investigating potential failures or problems	so we do incident investigations, it means that if, let's say there is a plant that fails, whether it is a coal plant or something fails, the System Engineer for that plant has to go and do an investigation. **(Manager-6)**
	Quality check	Then, we check those that doesn't really meet the customers' specifications. **(Manager -3)**
	Monitoring and measuring systems	CEP is a software application program, we use it to log, you have, it has defend uhm, applications within it. Uhm, you use it to log calls if you have a problem, you whatever thing that you want to fix in your office, it is either you want to change the chair, you want to change your table, uhm, you want a certain application like any other applications, you'll use that uhm, application system to log uhm, we use it so that we will be able to track all the calls that you have made and we also check if uhm, if you have logged a call and it was not really fixed and then you log it for the second time. That's when we have the record that you've logged multiple, uhm, issue. **(Supervisor- 5)**
	Control	Where if using what they call a dashboard to check the guys, also to check the quality from those guys. Yes, we've also got those. **(Supervisor- 4)**

Themes	Subthemes	Quotes
	Quality inspection system	that's the issue, but then those are the things that need to be resolved here so that we can be on the same path. Remember, as a quality foreman I'm going to shift now, half-past two to half-past ten. I might find when I come in that the foreman that is going now was taking something and then I come in, I reject that thing and they're going to say, but the previous one was packing this. Why are you rejecting it? That's how it is. **(Worker- 1)**

Source: Author's own compilation

Table 4.1 contains three columns. The first column indicates the themes identified, the second column addresses the subthemes for the study, and the third column indicates the direct quotes of the interviewees. The three categories of themes that were identified during the coding process as highlighted by the excerpts included in Table 4.1 are further discussed below:

4.3.1 Theme 1: Waste of resources

Theme 1 comprises ten subthemes namely: elimination of waste, recycling of waste, waste of resources, fault indicators/technical indicators, delays/disruptions, causes of waste, rejections or defects of finished and in-process products, challenges to meet the production target, mitigation of waste, and increase in costs. These subthemes are not discussed separately but under the main theme. According to Rahman, Sharif and Esa (2013), lean manufacturing refers to producing goods and services with minimal waste. Jasti and Kodali (2014) indicate that waste comprises seven types: waste from waste of waiting time, overproduction, transportation waste, waste of motion, processing waste, and waste from product defects. Waste may be identified in policies, procedures, processes and product designs and in operations processes. Waste consumes resources but does not enhance the product value (Malhotra and Kumar, 2017). Durakovic et al. (2018) mentioned that the VSM technique makes it simple to identify waste movement. Naeem, Ahmad, Hussain, Nafees and Hamid (2021) conducted a study to determine the impact of lean manufacturing practices of textile companies on their operational efficiency. The findings of the study revealed that lean manufacturing principles and techniques significantly influence operational efficiency. The research results recommend that the involvement of customers, employees and suppliers causes an increase in the operational efficiency of companies. Furthermore, it is established that some lean manufacturing implementations, such as 5S, Just in time (JIT), automation continuous improvement and equipment layout, have a significant and positive effect on the operational efficiency of companies.

The direct quotes of different participants are used as evidence of the waste identified in their operational processes. Manager-1 highlights the types of waste that they encounter during the production process, such as glass that was not produced according to specification and must be recycled to be remanufactured (defects) and electricity (when the company does not produce the output that it intended to produce, and electricity is used to rework the recycled material to produce the same bottle). Water is reused to minimise the waste of water. Staff members are made aware of what wastes are and are taught how to dispose of the waste. Management has come with strategies of having bins inside the plant to put all the waste that they encounter. 5S is practised by ensuring that waste is not discarded anywhere in the plant so that cleanliness can be maintained in the plant to avoid accidents. Manager-1 said:

> *Because, most probably here the only waste that we encounter is glass. Electricity waste, we have, it's not really waste, we have…like generators from that other side…It has to be recycled in such a way that we don't waste that water, we reuse the water and make sure that we use less when it comes to water wastage…Then the other thing also is to make sure that they are aware of the waste removals as in waste bins where they need to put their general waste and making sure that they don't just throw anything everywhere. To avoid looking at maybe sort of like plastics if we're using plastics to go into the drains and all of that. We're not doing that.*

Manager-3 also mentioned the wastage of electricity by reworking the same defects/recycled waste and argued that staff is also part of waste because they do not follow standardised work procedures:

> *the only thing just is we are wasting a lot of electricity. Because we are using the same electricity to rework the same scrap that we should have produced quality ware. I'm not sure about the waste on units, but I know the production wise which is about plus minus 20%... We are part of the waste, part of the problem. I'm just going to respond in three, neh? We are part of waste, I don't want to lie, we are not managing it, we are just trying to make, what can I say? The waste, we are not managing it, we're just trying to run them lines. We are not doing the basics, no-one is doing the basics, that's a pure, pure discipline issue.*

Manager-3 indicated that waste is created by not following the correct standard operating procedures from the beginning, which leads to waste of electricity because they have to rework the defects that are caused by negligence. A standard operating procedure is a guide with instruction to assist workers in performing specific operations efficiently. The key objective of the standard operating procedure is to ensure consistent and quality output, while concurrently reducing misunderstanding and doubt, they do not practice continuous improvement according to the feedback provided by the production report. All spoken orders should be converted to SOPs to eliminate dependency on skilled personnel in reaching the expected product quality level, uniformity, efficiency and effectiveness (Bhattacharyaa and Ramachandran, 2021).

Alarmingly, Manager-3 also indicates that they do not have statistics regarding the waste that occurs per unit. All output is recorded, and the different types of waste are also discussed at management meetings daily. By admitting to not having these statistics, Manager-3 also unintentionally admits to not being able to control the number of defects being produced. The utterance “we’re just trying to run them lines” creates the impression that the workforce simply goes through the motion of producing bottles with little insight and foresight being used as to how the process is executed.

Not managing the waste has many repercussions, such as reworking waste, which results in an increase in production costs because electricity is used again (more energy consumption and hiring staff to sort the recycled bottles according to colours). During the observations, the researcher observed that workers are not making an effort to reduce defects; they are relying on recycling and technical indicators to highlight faults and machine failures. Workers are not putting in an effort to ensure that waste is reduced.

The following participant (Supervisor-1) agrees with Manager-1 that waste is created by having to hire additional staff to address defects that were not identified in the production line, which results in increased costs. The company has identified areas to reduce costs, but the savings are used to fix issues that have been overlooked during the process:

> *Re-sort is like in the, if the bad bottles have passed, we have to hire people to come and re-pack them again…we are using extra people to… We are using a*

cheaper plastic, but we are hiring extra people to do the work again. ***(Supervisor-1)***

Supervisor-1 explains that they try to save cost by using a cheaper plastic, but unfortunately, the company ends up paying more money by compromising quality because it leads to reworking the defects. When the company recycles, they have to hire additional staff who need to be paid to sort the bottles as shown above. Thus, recycling results in cost inefficiency.

Manager-7 also highlighted types of waste that are caused by unplanned accidents and damages to various types of property. Incidents such as motor vehicle accidents where employees using company vehicles can crash the car and the company would need to bear the cost. Employees who were injured during working hours may need time off from work to recover, but the company must still pay their salaries. Workers should be careful when using the company resources; they should handle it with care (workers must be trained before using machines and comply with standard operating procedures).

In terms of what type of waste can be done. It can be waste of costs, it can be waste of property damages, we have incidents, we have what we call motor vehicle accidents, where someone could have got injured and it is the property damage, there is costs being recurred in terms of that. The time that people invest in their work doing unsafe things, there is time that is being wasted, so those are the type of waste that I can think of.

The following participants from both Companies A and B agreed that they both waste oil through leakage from equipment that is in use or when they apply oil during maintenance. The workers are aware of the overuse of oil (which indicates that the matter has been previously addressed with them), and they are trying to manage it. In a continuous environment where machines run continuously, it is difficult to save electricity. It is therefore important to ensure that the expected output is produced per batch. Malfunctioning of machine components (“jam-ups”) causes defects because the production process is delayed and results in defects that must be recycled and reworked again. Manager-4 also added gases as another form of waste but added that the workforce cannot truly control that form of waste:

Well, in my department we generally use oil, too much oil to lubricate all my modes, so waste, it will be more of how much dope do we use, we always try to minimise it and keep it at least a litre per shift on a particular machine, because we are running three lines per phase…So that is one major one, because other waste is just gases, which we, it's out of my department's control…we tend to waste when we have jam-ups…On jam-ups, we throw away a lot of product, so that is just one of our downside. ***(Manager-4)***

Supervisor 8 also mentioned that workers are careless and do not pay attention to the capacity of the machines when refilling oil, which results in oil spillage and overfilling of the tank. There are different oils used for various reasons; for example, bunker 150 oil is used for the start-up of the system. Applying oil on machines and equipment is part of TPM because they want to ensure that machines are running effectively. However, by not adding the correct quantities of oil, production efficiencies can be compromised when maintenance activities are increased, which forces the machines to be stopped. In a continuous process-type environment, having to switch off any machines can have a detrimental effect on costs.

Oil can be wasted in many ways. Sometimes we might have oil spillages, over filling of the tanks, but sometimes we can waste –, it is not just waste, but we use oil mostly, like we have got different types of oil. We have got the bunker 150 oil that we use for the start-up of the systems so that we can get the temperature for all the systems up. Up until we get to put the oil on standby and put in the pier. The waste can only come when we do have spillages, like sometimes you will find that we have got a lot of oil leakages. ***(Supervisor-8)***

Another form of carelessness is when staff overspray powder without following specifications, which may also cause defects with resultant cost increases. When the job of welding or spraying is given to someone who is less skilled, it is easy for them to overspray powder, which results in waste. It is important for the organisation to employ skilled workers or to adequately train them. Hiring unqualified employees, particularly for skilled positions, can have shortcomings associated with production and overall organisation performance.

when you're welding, the overspray of that powder, that is where our waste is… it depends if it can be modified or not, but most of the time, we modify them, and we carry on, but it's a waste, because we have to pay more to modify, it's a waste… The main ways that we have at the moment is this one-off, it's something that need the management to support those guys. The main waste is the skill. ***(Supervisor 4)***

Supervisor 8 stated that it is important to hire skilled workers because unskilled workers can waste resources by overspraying or welding with a high flame:

…you need the skilled people in terms of welding, in terms of filing, in terms of how much welding do you need, all those things, because if you don't have those people, you just have a person, he can just weld with a high flame, over spraying and then create risk.

The most mentioned waste by participants from both company A and B is the leaking of oil, which is mainly caused by damaged equipment that causes leakages. The researcher also confirmed the oil leakages during her workplace observations where buckets were used for the leaking oil to drip into. Worker-7 also confirmed that they experienced oil leakages that lasted the whole day before it was fixed: "The oil leakage is obviously the whole day some couple here and there, but we get it sorted, I know there was an oil leak by, the not, truly two months back".

Defects refer to products or services that do not meet client specifications or requirements, cause client unhappiness, or do not complete the functional or physical requirements that are anticipated from the product or service. What Worker 8 referred to was actually waste and not defects. Worker-8 may view wastes as defects. Incorrect understandings and misaligned knowledge levels may also lead to increased inefficiencies and more defects being produced. Worker-8 describes the types of waste that they incur are water leaks and metal scraps from the production process:

Defects I am referring to water leaks on the pipes or on the clamps, oil leaks, maybe XXX while was working when they were putting new things they forgot some off, there are metal scraps there at the plant, they must come and remove *everything. Everything which is at the plant and is not supposed to be there. Normally our defects, apart from the plant, damages, there were leaks here and whatsoever. Noisy vibrations, it might be when maintenance they are doing, they are working on certain equipment then they do not go with all boosted erection staff. (**Worker-8**)*

The participants below confirm that defects are identified when they perform quality assurance on the bottles. TQM is practised by checking if the bottles produced meet the customer's specifications. The bottles that do not meet the customer's specifications are referred to as waste because they have to be reworked, which results in more electricity, additional input resources, more time required from staff, and machines working to produce the same output that was previously delivered, which translates into more costs. Defects are recognised as a type of waste (Liker, 2004; Rahman et al., 2013; Jasti and Kodali, 2014):

I work in cold-end and that's where we most specially check quality on bottles that are already made. So, the only waste we come across if we maybe reject ama-defective bottles, that's the only waste we have. ***(Worker-3)***

Temperature control and constancy are important to manufacturing processes because they have a direct impact on production. Incorrect temperatures affect product quality, consistency and wastage and have an important effect on energy consumption (in the event of a rework) and production costs (where additional raw materials, labour and other resources are used to remake a product that was previously produced incorrectly). Every Monday ("white check") and during each shift the workers check if the temperature is set correctly. Worker 7 stated: "And the white check is done continuously on Monday and on shift from operating side to check the temperatures on the care boxes". Another cause of defects is when workers do not measure the correct ingredients (decreasing inputs that are not according to specifications), which can create defects such as cracks on the bottles. Every morning management discusses the top three defects and causes of those defects with the aim of finding solutions to the problems to discover if it is a machine or temperature issue:

the lower the input, the higher you create defects, because cracks on glass, is all temperature related, so when certain sections are down, you know for breakdowns, the whole machine actually cols down. So, you've got hot and cold spots on the machine, which now creates defects… Every morning in our production meeting we go through twenty-fours plant, all nine production lines, discussing the top three defects, critical defects, repeat incidences, trends, machine availability, which involves technical there to understand, you know, issues on the machine, because if the machine is not available, in this process, how it works is if the machine available, let's say 80%, you will produce 20% plus, defects, because it's all temperature based. ***(Manager-2)***

Manager-6 further explained that the moisture content of the coal is tested before it is used, and the ash content is also analysed before it is sold. The amount of coal used is also measured or calculated. Moist coal cannot be used because it can damage the furnace and other equipment. Company B measures the moisture levels before coal is dispersed to the relevant section.

coal accounting looks at the moisture content in the coal itself, coal accounting looks at ash content of the coal and really the amount of coal that is coming in ne, so it is and different ways that now coal is wasted

Based on the above discussion, it is evident that waste of different forms is experienced in continuous processes. Worker-3 supported what Manager-2 had said that incorrect setting of temperature has an effect on the waste that is experienced. When workers identify defects, they immediately notify the section where the defect originated to quickly address the cause of the defect. Once the problem is identified, maintenance staff attend to it so that good bottles can be produced. TPM is practised in such situations whereby machines that are malfunctioning or have stopped working are repaired (reactive maintenance):

Oh, operations, machines, settings, the temperature of the bottle… so that's where whenever we find defective bottle, we send a message that side to, for them to check with the section that we're finding difficulty on, either they fix it with temperature or operations. Then, after that they give us good bottles.

Even Worker 4 also confirms that machines need to be operated at the specified temperature and sometimes temperature can malfunction due to machines having incorrect oil levels:

> *Ja. Because it needs to be, the machine needs to be operated at a safe temperature, it must not go up, ja, so if it is up you need to check what could have been the problem, is it the cooler or you not having enough oil to cool your*

In continuous processes, lean manufacturing strategies should be combined with green manufacturing because they are both concerned with the elimination of waste. According to Malhotra and Kumar (2017), green manufacturing is a manufacturing system that uses lean principles for green strategies and techniques to produce more eco-friendly and eco-efficient systems. These systems aim to consume less material and energy, reduce unwanted outputs (pollution and waste) and convert outputs into inputs through recycling. (Bhattacharya, Jain and Choudhary, 2011). Companies A and B both use recycling of waste as a method to eliminate waste. Lean tools (continuous improvements, value stream mapping (VSM), 5S, visual systems, total productive maintenance (TPM), total quality management (TQM), work standardisation and people's involvement) are techniques that can be used to pinpoint the main sources of waste and to guide management through corrective actions. Manager-5 outlined that they use recycling to reduce waste and reusing oil to manage waste:

> *a waste product is produced, we try to see whether we can rejuvenate it. If it's an oil, we can re-generate it or we can refurbish the oil through oil plant process circulation. So, in that way, we minimise the waste because it means we can reuse it…In due time, the transformer oil deteriorates, you can just cancel, pick up and. In due time the transformer oil goes out of specification or to develop as CTT or have ceros sulphur. It will be in a state whereby it cannot be used. There are ways where you can re-generate it and reuse it. By doing so, we're trying to uhm, minimise waste and manage the quantities. So, some sort of recycling or re-functioning it.*

Manager-1 confirms that they try to manage waste by recycling approximately 90% of the defective glass to be reused in the process. Water is also recycled, although the water recycling process can be further improved:

> *What normally happens it goes through the system and gets back to the production line again. It gets crushed, then recycled to make another glass. Me, what I can say to you is that if we have 100% of the glass that has been manufactured, if we are going to recycle, we're going to recycle about 90%, plus minus 90%... we do slightly recycle water, but not as effective as we want, so those are the two, I would say, principles that I will say at least are trying to manage waste. Because, most probably here the only waste that we encounter is glass.*

A circular economy is grounded on recycling (reusing waste products into new resources for additional use and consumption), reconditioning and reusing processes, which have the potential to increase sustainable economic growth, contribute to creating jobs for the economy and finally drive businesses to invest in supporting programmes (Trica, Banacu and Busu, 2019). Manager-3 mentioned that they do not throw away defects of bottles, but they recycle them." Fortunate enough, our waste, we don't throw it away, we are recycling. I'm just talking about the production's point of view because glass is 100% recyclable".

Supervisor-3 also shared that they recycle used glass and recycling is used as a strategy to mitigate waste and defects:

> *we do a lot of recycling in our business. Our glass, we are a glass manufacturing company, when the, after our consumers have used our product, we, we, we get, we collect the glass and it comes back to the plant and we recycle it.*

Worker-6 explains that they have dumping areas for ash (coal that has burned and is no longer useful). The ash is sold to external organisations. The circular economy's goal is to decrease the volume of waste produced by converting waste into resources. The theory of the circular economy was introduced to assess the efficiency improvements obtained through reuse, reduction and recycling of waste generated during production (Salguero-Puerta, Leyva-Díaz, Cortés-García and Molina-Moreno, 2019). 5S is practised by sorting resources within the workplace and allocating areas for waste to keep the environment tidy:

> *We clean the spillage and then we dump it at the dumping area. We have dumping area where we dump coal and then we have dumping area where we dump ash…*

The researcher also witnessed that recycling is used as a method to reduce waste during workplace observations. However, Worker-6 speaks about coal spillages that can be reused in the production line as waste. The only waste that the researcher identified during her observations was the ash that was disposed of in the dumping area after the coal had burned and was no longer able to be used in the production line. Coal spillages in the production line are sent back to storage to be reused.

Theme 1 discusses the type of waste that is incurred in a continuous process environment (defects of glass that were not produced according to specification and have to be recycled to be remanufactured, oil leakages from the machines and overfilling tanks, water leakage, electricity when the company does not produce the output that it intended to produce, and coal spillages). The data collected reveal that waste of resources is caused by workers' negligence, carelessness and not following standard operating procedures. The theme has revealed that in continuous process environments, lean manufacturing techniques can be used with green strategies simultaneously to reduce waste. Recycling is recognised as a strategy to reduce waste, but in fact, it has cost implications. Lean manufacturing techniques that are practised in continuous processes to reduce waste and enhance efficiencies are 5S, TQM, TPM and continuous improvement.

4.3.2 Theme 2: People's involvement

This main theme is made up of the following subthemes: training of workers, teamwork, communication, meetings, accountability, staff, unskilled labour, skilled labour, compliance with the set standard of procedure and reporting. These subthemes are discussed under the main theme and not under separate headings. Performance can be improved by maintaining a close relationship with workers and maintaining high involvement of staff when solving problems and discussing production reports (Marin-Garcia and Bonavia, 2015). Coetzee, Van Dyk and van der Merwe (2018) believe that employee involvement is the most important principle in lean manufacturing. Employee involvement refers to the degree of workers' involvement in the organisation's strategic planning activities (Barringer and Bluedorn, 1999). According to Marin-Garcia and Bonavia (2015), the effect of employees' involvement in lean manufacturing is operationalised through four related variables, namely, training, empowerment, communication and contingent remuneration. Kareem, Askari and Muhammad (2017) stated that involving workers and obtaining their views is the critical stage in the effective application of lean manufacturing. It is not enough to lead from the office, but management must also take part in work activities personally on the shop floor. Manager-2 mentioned that the workers are not involved in the meetings; it is only attended by supervisors and managers, which causes a gap between management and the workers. Workers are not part of the daily production meeting that addresses trends, percentage of losses and ongoing defects. Managers do not seem to make the information from these meetings available to the workers. The information that is discussed at those production meetings is valuable to improve the production processes.

> *looking at our production meetings, it involves mainly the, the head of departments like a filming face manager or a colding face manager or a line supervisor, but I think, I think the people are not that involved. That's my personal opinion or view, which I also highlight daily in our production meetings, because there's a lot of valuable discussions that's happening there, especially around trends and the percentage losses and certain sections that repeats itself, but we're not doing enough to take that discussion back to the people, so that they actually know about these trends and these ongoing defects.*

When managers do not effectively communicate information to staff, as mentioned above, staff and management may have different views and expectations that may cause misalignment and conflict. According to Noah (2008), employee involvement is a unique form of delegation whereby workers obtain more control and more freedom of choice with respect to closing the communication gap between the workers and management. However, given the different shifts that operate in continuous manufacturing production facilities that formed part of this study, it is crucial for any independent work and freedom of choice to be exercised within the confines of the standard operating procedures and working conditions of the respective company. The participant responses show that communication among the workforce and reporting of incidents, faults and breakages are paramount.

The successful implementation of different lean manufacturing tools, such as TQM and TPM, depends on implementing employee involvement practices (Ahmad, Schroeder and Sinha, 2003; Alfalla-Luque, Marin-Garcia and Medina-López, 2012). Teamwork includes stimulating individual and professional development, sharing opportunities for growth and maximising personnel and team performance (Liker and Hoseus, 2008). Manager-2 explained that workers providing input into processes and job descriptions may be complete and of a higher value than when managers compile the information in isolation. Much of the waste that is experienced by the company can be reduced by involving workers.:

> *four or five of these packaging operators come and sit around the table and you know, HR will facilitate that, where these guys actually write their own job descriptions or roles and responsibility. And we have seen that it's, it's double and more valuable that when, you know, a manager sits and writes it by himself. Because, there's a big misalignment of what a manager expects his people are doing and what his people thinks the manager is expecting… I think we're having a lot of waste that we can reduce by, by including people and you know, deeper investigations, proper downware analysis*

Manager-6 also highlighted that on a quarterly basis, all production processes are reviewed. The revision not only looks at certain processes in isolation but also incorporates the provision of services and how the different processes interrelate with each other, the impact of existing contracts and the effect that each of the components may have on each other:

> *Activities in the production process, they are reviewed quarterly, during the management review, quarterly management review… So, we have the management review, so we will do it on a quarterly basis ne, so in the quarterly basis we look at all of the process for production but also in-service provision, so we not looking only the production but also service provision, so we look at all of*

> *the processes and the intermated processes. So here we will look at the customer satisfaction product deliverance against the station contract*

Training is significant because it represents a good chance for workers to develop their knowledge base and advance their work skills to become more productive in the work environment. If workers are not sufficiently trained, there will continuously be queries about how the organisation is doing things. Kareem, Askari and Muhammad (2017) stated that it is essential to provide accurate training and essential instructions to workers. The training requirements of the workers are to be determined and managed by the managers of the company. Training and retraining of workers are key for the effective application of lean manufacturing. Lean manufacturing requires constant training of workers. If the workers are not trained correctly, the lean manufacturing application would be faulty. Durakovic et al. (2018) agree that a lack of understanding of lean performance and its measurements will produce failure of lean application.

Manager-1 indicated that workers are trained. They have compulsory training (safety training, production and operational training, and induction when you join the company) for all new employees. The company also provides specialised training based on the department in which staff will work and not general training only. However, workers do not implement what they have been trained. If workers choose not to follow what they have been taught, it is no longer a training issue but a disregard for standard operating procedures and management. Leadership training is not available for all workers. Where external providers have been contracted to provide training, staff become responsible for their own development.

> *We'll train all of them on the production line, so that they can understand how production works, so that they can understand the safety and precautions of our machines and how to, things like, what you need to wear when you wish to go the plant, like the induction. When you go to the induction, then the induction will also give you a guide to say this is what we're expecting when you're coming here. Then, it will depend on the department that you're going to work, then we'll give you that training based on the product or the job responsibilities that you'll be carrying out. The only time whereby we don't train our guys is like when we, like on the leadership development. Then we've got partnerships through the*

UCT's, the UNISA's and we are able to send them in those, but when it comes to production, operational, then we got to train themselves for that.

The following manager and supervisor support Manager-1 that from management's perspective, they do provide training to workers, but workers do not implement and use what they have been trained on. External suppliers of oil come to the company to train staff on site. Workers are also trained about and made aware of the importance of following standard operating procedures in a specific way. Due to the training interventions, staff are aware of the wastages that they incur:

they are educated to follow ama-process, example, they go to training, especially the oil that I've actually mentioned a lot. You also get [type of oil] the one from America, so the ones that they actually manufacture. So, they come on site and show us how to use it, when to use it and why we're using it, so people are aware of the fumes that they are wasting instead of swabbing too wet, they need to swab too dry. So, the education around why processes needs to be followed around that particular waste management area of oil. So, guys are aware of what they are doing. So, that's how we manage it. ***(Manager-4)***

Manager-3 confirmed that management on their side provides workers with standard operating procedures (manuals to follow procedures during production), but workers do not follow standard working procedures. Durakovic et al. (2018) also indicated that management may sometimes be willing to apply lean, but employees may not be prepared to implement and use new systems. Workers need to return to apply the basics to enhance operational efficiency:

We just need to go back to basics, that's number one. For the last twelve years I've been here, comparing twelve years and now, it's not, we are no longer doing the basics… Like the SOPs are not being followed… We have them in place, but we are not really, really, It's one of those basics that, if we can, I know if we can do them, we'll be able to get at least another five to ten percent into our efficiencies then.

Manager-5 added that the organisation has set waste management procedures in place, but the workers are still not following them:

> *So, they, what we do we write strategies so on how to remove it from site and how to handle it to minimise, to eliminate all spillages and to ensure we comply on the procedure in terms of oil handling… they need to follow our waste management procedure.*

Manager-7 also stated that the organisation has quality standards that conform to global practices that should be used as a guideline when standard operation procedures are compiled. There are different ISO standards that deal with different disciplines. For example, ISO 18001 is an International Occupational Health and Safety Management Standard that governs safety in the workplace. There are ISO standards that deal with quality and other areas.

> *Like I said, it is a whole lot of management systems that we have come with or in strategies, what I talk about management system we have what we call our ISO 18001, which is a safety management system it is got different disciplines and elements that touches on almost everything, operational control, housekeeping, documentation, these are all the things that we have put in place, that we must make sure that we comply to in order to prevent this wasteful expenditure of incidents. So, by preventing an incident we are saving costs and preventing waste from a safety point of view.* ***(Manager-7)***

Kareem et al. (2017) mentioned that ethical instructions and commands play an important role in the effective application of lean manufacturing in companies. Worker-1 confirms that staff do not follow standard working procedures. Different shifts may have different perspectives, and conflicts can arise if one shift deviates from what is necessary. This leads to the company not meeting customer expectations because of the absence of uniformity in the production process:

> *So, there are those people who are forming, doing the bottle, so we fight a lot. Remember if I see that here's it and then I say no, this stop, it's too big and the guy who's doing the bottle, say no, this one, it's small, we don't have to, we're not going to do it anything with the customers. That's how we fight and then I have to*

reject this… Certain people will understand, no this is faulty, but other saying this is not faulty, so that's the issue, but then I do believe if you can just go to a customer and see this makes a problem, it affects a customer this way, but then. Remember, we are just doing a bottle here, we pack the bottles, they go to customer and then I'll only know after some time that there's a customer complaint because of this and this and this and this. So, we're not going to the customer, we don't know what's happening at the customer

Worker-2 agrees with Worker-1 by saying that lack of agreement causes conflict and impacts the customer experience because there is no uniformity and quality standards are not followed: "Someone will say reject certain pallets because of this, someone will say no, these pallets are okay. We are not on the same."

Supervisor 2 explains that a number of bottles that have been identified as defects may not be defects in the true sense. The worker noticed that oil marks on good bottles are reflected as defects that can be reduced by manually removing oil marks instead of having to recycle the bottle that has no other defect. The worker had the confidence to approach his manager with the observation, and the process to rectify this matter was reviewed:

I did speak to one of my supervisors, XXX, regarding our losses at one of the cameras on the single lines, where we can, we're having a lot of problem with oil marks on the, on the bottle, so I did bring up a suggestion that we bring on roller brushes on that, on those bottles, so that we can brush off the oil marks and then by doing that, we are reducing the losses on that camera, on that inspection equipment. I think the guys are in the process of trying to organise something, but that was something that I could see that we are losing a lot of good bottles.

Supervisor-5 also highlighted that writing down incidents that occurred during a shift helped the next person or the next team continue with the work. The following shift can reveal what had occurred in the previous shift. All faults, maintenance and related issues must be captured in a daily document that shifts can refer to:

And then we, by doing that we also have right procedures. Where no, if you have encountered a certain problem and then you write it down, how did you resolve *the problem so that the next person, even if you have left, you know the next person will have something to refer to. And how to solve a certain uhm, issue.*

Supervisor-3 confirms that reporting of defects can reduce the number of defects created during production because workers who are causing defects are informed to take corrective actions: “Maybe it’s 1% that you can save, you know. However, if it’s purely defects, obviously you report all of that to the back-end where they are in the forming side.” Even during the observations, it was confirmed that workers communicated with each other if defects were detected for corrective action to commence.

Worker-1 also confirmed that workers are informed to fix the problem, and he also confirmed that fixing problems on time reduces defects. Reporting of defects can reduce waste/defects by a certain percentage: “I report to the guys at the back, maybe by say half-past four to five, they try to fix, it was 15% and then it goes down.”

Even as defects are reported for the problem to be fixed, the products are already defects and need to be reworked: “We identify the defects in the cold end, we report them to the hot end”. **(Worker 4)**

Supervisor-1 also confirmed that communication and reporting play an important part during the production process: “We do that, let’s say I see like maybe one machine is losing 5%, I’ll go check what is it losing, then give the hot-end guys to fix the problem.” Supervisor-8 added that reporting of defects can reduce waste as the areas of concern are narrowed down due to proper reporting mechanisms. By implication, several areas must be checked and monitored, and defects can also be caused by the integration of various issues that must all be monitored. Proper reporting can pinpoint specific areas and their relationships for staff to address:

> *“Yes, they are, because if they did not report any defect, or any fault then what does it tell you? There has been a waste somewhere, because we might have some leakages on the water side, on the oil side, on the spillage, on the coal side, but there are also directly involved.”* ***(Supervisor 8)***

Theme 2 discussed that management has daily meetings, but they do not involve workers in being part of those valuable conversations that can help organisations enhance efficiency. Management has indicated the compulsory trainings that they have for workers and highlighted that leadership training is not compulsory. Different shifts may have various perspectives, and conflicts can arise because of not following the correct specification according to the standard operating procedure. Standard operating procedures are available for workers to use them, but workers do not follow SOPs. Reporting incidents is important because it helps the next shift to know what has happened and can also assist in reducing waste.

4.3.3 Theme 3: Continuous improvement

This theme consists of the following subthemes: maintenance of equipment, production process, monitoring and evaluation, inspection, measuring production output, investigating potential failures or problems, quality checks, monitoring and measuring systems and control, and quality inspection system. These subthemes are discussed under the main theme and not under separate headings. Sundar et al. (2014) explain that continuous improvement is simply an improvement initiative that increases successes and reduces failures. The impetus of lean manufacturing techniques is the process of continuous improvement through the removal of waste or nonvalue adding tasks (Burton and Boeder, 2003).

The DMAIC (Define-Measure-Analyse-Improve-Control) technique in Six Sigma is often defined as a method for problem solving (De Mast and Lokkerbol, 2012) and is aimed at improving business processes. Worker 4 mentioned that they use Six Sigma in their operations: “We’re currently using Six Sigma although it’s not well established, but we’re trying”. During the workplace observations, the researcher observed that workers use Six Sigma to investigate the causes of defects and analysed it. Then, once the problem has been identified, they correct the cause of defects to reduce the probability of the error occurring again; for example, defects can be caused by setting incorrect temperatures. In identifying the root cause of a problem (issue, waste or defect), Six Sigma practitioners ask consecutive “why” questions five times. Taiichi Ohno is the father of TPS and used this method to determine the causes of problems and put corrective measures in place (Alukal, 2007).

The ‘5 Whys’ technique is one of the most widely taught approaches to conducting root cause analysis (Card, 2017). Root cause analysis is a process intended for use in exploring and categorising the root causes of incidents of safety, health, environment, quality, reliability and production. Root cause analysis identifies how and why an incident transpired. Only root cause identification of incidents will enable workable corrective measures that can be prevented in the future (Rooney and Vanden Heuvel, 2004). Neither managers nor workers can solve problems on their own. They need each other. Lean tools are techniques that can be used to pinpoint the major sources of waste and to guide management towards corrective actions. Manager-6 explained that they only do investigations to have a paper trail but never implement the findings:

> *If I can show you the scope, it is millions of rands, let’s say R7 000 000 for an outage but the outage comes back on slip, so it means you have taken that money and put it down the drain. But then we do not investigate our slips, if do not investigate them we just doing it as paper work, do you understand?... so we do incident investigations, it means that if, let’s say there is a plant that fails, whether it is a coal plant or something fails, the System Engineer for that plant has to go and do an investigation …for instance, now we are not, like we are not using any of the main principles. We can adopt the main principles, but we can also in my view adopt root cause analysis methodologies*

Manager-2 indicated other strategies such as 5 Whys and fishbone analysis that they use to investigate problems, “from operations to production to technical it might differ, where we would use either the fishbone, we would use things like the five whys, the five whys principles”.

Conducting investigations when there is a problem and providing a report helps other shifts to know what has happened on a previous shift and to know how to mitigate such incidents. Manager-6 confirmed that they do incident investigation,” so we do incident investigations, it means that if, let’s say there is a plant that fails, …, the System Engineer for that plant has to go and do an investigation.” Manager-7 mentioned that management comes up with different strategies to prevent incidents and they also do management system audits:

so we look in to prevention of incidents, that is what we mostly look at, so it is different ways of preventing incidents, we come up with strategies to promote a safety culture within the organisation, we do management system audits, it is to see that we comply with the legal and other requirements, that is in summary what the safety management do within the station.

Supervisor-1 also agrees with other participants that they conduct investigations in order to solve problems: "Yes, we do that, let's say I see like maybe one machine is losing 5%, I'll go check what is it losing, then give the hot-end guys to fix the problem."

Supervisor 2 stated that they do checks every hour to improve production. Losses can be curbed by limiting the number of defects being produced if issues can be identified and dealt with on the hour. During the observations, the researcher confirmed that technicians are monitoring the production process continuously through computer systems in the control room. The lean manufacturing techniques applied here are continuous improvement of the production process by continuously inspecting the bottles on an hourly basis to ensure that defects are identified and reduced. TQM is also applied by performing set checks every hour to ensure that the bottles are produced according to customer specifications without defects:

we're dealing with glass bottles. In order to reduce waste, we need to produce quality bottles. Quality ware. So, in order to produce quality ware, our hourly inspection on our bottle sets, need to be done religiously. If not, then we're going to have webbing thrown away for unnecessary defects on the bottle, so by, by the guys doing the set checks every hour we are reducing that, in that way we are reducing and optimising loss on our production end. ***(Supervisor-2)***

Manager-2 added as well that they have a monitoring system that measures production every minute so that they can improve when the need arises. Workers also measure production every hour to check the quality of the bottle, the rate and speed of the machines and the percentage at which defects are being produced. The hourly measurement is also compared according to the shift over the full 24 hours, as this is a continuous production facility. TQM and continuous improvement are practised by continuously measuring production on an hourly basis and measuring the quality of the bottles and defects produced to improve efficiency:

> *it's measured every minute, I would say, because it's a live system that, that runs, which is [machine] which is our production monitoring system, but from a shift point I would say they are, you know, they measure themselves from, form hour to hour, if I can put it that way, alright? And that measurements is around quality, defects produced, it's about the forming machine availability, rate, speed, quality into the lere, percentage produced which is rejected on the inspection side and obviously the, the, the output, packed them out… So, that's measured on an hourly basis and then shift basis and then we review it as management on a 24 hours basis.* ***(Manager-2)***

According to Ahmad, Hossen and Ali (2018), total productive maintenance is the pillar of improvement of overall equipment efficiency (OEE). Jimenez et al. (2012) explain that lean manufacturing requires some tools to achieve its objectives and mention techniques that are worth mentioning. Total production maintenance (TPM) is regarded as providing employees with basic consistent working maintenance tools and authority to attend to any abnormality, always looking for ways to prevent problems rather than correct them and increasing the availability of the manufacturing team and machinery. Machado et al. (2017) highlight the two types of maintenance they identified: corrective maintenance and preventative maintenance.

The maintenance that is performed after machine or equipment failure is intended to restore the equipment or machine to a state where it can perform properly is referred to as corrective maintenance. Manager 8 indicated that workers conduct online maintenance and offline maintenance daily (preventative maintenance). The organisation has developed a maintenance strategy that guides the maintenance staff about when a certain machine should receive maintenance that will be scheduled (planned). Certain types of maintenance need to occur within specific intervals. An organisation usually will have a maintenance strategy, but the maintenance plan will outline specific types of maintenance for specific machines and timelines, as the frequency of maintenance required for different machines will not all be the same. Manager-8 stated:

It is a day to day thing, because we do online maintenance and offline maintenance. Online maintenance could be that you're having a running defect then we load the notification and create an order for somebody to go and do maintenance, we got what we call prevented, okay that is corrective maintenance and we have got preventative maintenance, preventative maintenance mainly it is planned, what normally happened is when you start, you have what we call a maintenance strategy which tells you this component should be maintained at a certain frequency and there is other activities that you need to do and maintain it. So, what happened is from there, from the strategy developed, on the strategy you've got prevented of maintenance plan, so you take that, you do what we call preventative maintenance orders. Say for instance it could be weekly, it could be monthly, three monthly, six monthly, nine, twelve monthly. Then, what you do is you try and when you set it out in the beginning, you go and do the activity and see how much time it takes and how many people it takes to execute then that you put it in the order, so that when place the person who does the resource planning already know that on this order I need two people for four hours unlike, because if you, if you do not do that you have got, let's say it is one hour, one person one person goes there they cannot wait they have to come back, look for somebody else and they still going to have to go through the whole four hours which could end up being five hours. ***(Manager-8)***

Manager-1 confirmed that they have planned maintenance: "We've got a planned maintenance…Ja, we've got a maintenance plan that is taking us about a year and a half planned". However, Manager-3 disagreed with the above participants. Manager-3 indicated that maintenance staff only react when there is a problem:

*Ja, because they [maintenance staff] only react when there's a problem. Saying there's a problem, they will review the whole process of checking the quality, but the production, the IS, the furnace, we don't…****(Manager-3)***

Manager-6 confirms that if there is a problem, they will hear a sound like a hooter or an alarm that will indicate a failure. The maintenance staff are informed of the failure and are placed under pressure from the technical indicators to fix the failure as quickly as possible as it affects production. Certain types of failures will result in increased waste, whereas other types of failures may suspend production altogether. As such, corrective or preventative maintenance is prioritised and scheduled according to the number of current failures that must be addressed, the amount of backlog that may need to be removed and the availability of parts, components and skills for certain types of maintenance to occur. Sometimes scheduled maintenance must be rescheduled, and production staff will request that maintenance not be done.

> *So, they will tell you one of their technical indicators [machine] is planned capability loss factor, so basically, they are saying that there are plant production is to stop with this planned maintenance* ***(Manager-6)***

Supervisor 6 confirms that maintenance staff react when they hear an alarm sound (technical indicators) and respond to solve the problem:

> *Okay, on the performance, how is the plug performing. So, if there's anything wrong, then there will be an alarm that is indicating that something is wrong. And then that person send another operator for it.* ***(Supervisor-6)***

Manager 8 stated that management has lockdown meetings to plan for maintenance that must take place for the following week. They prioritise urgent maintenance and delay less urgent maintenance. For example, oil leakages that do not affect production or increase defects may be viewed as a lesser priority, and maintenance to fix the leak may be delayed:

> *Waste in terms of time, I think it is more to do with, on your planning, what we do is on a weekly basis we plan like on, today is Tuesday, on Wednesday there is what we call a lock down meeting, lock down meetings basically to say this is what we planning to do next week from Monday to Friday and that the planned maintenance, also corrective maintenance because some corrective maintenance things are not urgent so you plan them to say I will do them maybe in four weeks' time.* ***(Manager-8)***

It was evident from the observation because some machines were leaking oil, and interviews also confirmed that maintenance people only respond to breakdowns of machines. The reason for the leaking of equipment could be that both organisations practice reactive maintenance rather than preventative maintenance. Manager-3 agrees that their organisation only maintains equipment when there is a problem. The maintenance staff review production processes to ensure quality, but they check all equipment and machines except the furnace:

> *Ja because they only react when there's a problem. Saying there's a problem, they will review the whole process of checking the quality, but the production, the IS, the furnace, we don't…* ***(Manager-3)***

Worker-6 stated that the organisation fixes machines based on priorities; if it is not a priority, they take their time. Priorities have stages; for example, priority one is attended to immediately, whereas priority four can be fixed after some time:

> *No, depending, depending on which plant it is leaking but, depending on the priority of, the priority of… Priority one is immediate, that one is attended with immediate effect but priority two they can plan for five days it must be fixed, priority three it takes three months maybe they are going to look in to the spare, if they have a spare to fix that and then priority four it can take eight months, meaning we are waiting for opportunity of outage.*

Supervisor 4 confirms what Worker 6 said that the maintenance staff focuses on important machines if it is not one of the priorities; then, they take time to fix it:

> *It depends on if it is an emergency or not. If it is not that emergency –, emergency I mean the one, which is critical. If it is not working we might lose some megawatts and we do have what we coal a load lost, but if it is not such an emergency, that will depend if they do prioritise them, that pitted under priority one, two, three, four. If it is priority four then they must do it within a period of, maybe eight to twelve hours. They must finish the job.*

Efficient communication methods and top management support are important to the functionality of total productive maintenance. Manager 2 stated that they communicate with the line inspectors to give them ideas of occurrences on the production line within specific time periods:

from a quality point, we have started now, where we communicate to the line inspectors on their twenty-four-hour defect analysis that gives them a snapshot of what actually transpired on this line in the past twenty-four hours, which gives him the heads-up.

TPM improves machine working conditions and allows kart time achievement at the maximum possible machine effectiveness and reliability. TPM also extends the lifespan expectancy of machines, decreases or removes breakdowns, removes slow running or minor stoppages and aims for zero defects and zero accidents. Manager-5 shared that maintenance of equipment prolongs the life of machines:

we are trying to determine uhm, the, the life out of the plant so we can get the most useful life out. So, we used the whole, the plant can use its whole life span so the, this are the strategies that uhm, the employee, the, the, the employees are involved in. We're trying to find, we try to ensure that uhm, we understand the life span of the component, we try to understand about the plant itself or any other thing so that we can be able to, what is the right word, predict properly how long it will last so that we can use the rest of it. It's like having a car, if you have a car and after five years it starts giving problems, it doesn't mean that you can't use it anymore. You want to see what is the problem and then you want to sort that out so you get the most out of it. ***(Manager-5)***

The literature and the above statement from one of the participants confirm that maintenance of equipment prolongs the life span of machines. TPM considers the entire equipment life cycle. Top management support is crucial for TPM strategies to succeed. Therefore, executive management must work directly with front-line supervisors, middle management and support functions. The TPM coordinates key staff, events, suppliers, operators, engineers, and vendors through team-based activities at all organisational levels. Worker-7 explained that the maintenance process starts by walking on the plant floor to check for faults. They record faults identified and apply for repairs to be affected. When maintenance takes place, the production process must stop:

That one we have operating department, they are working every shift, they have shift workers, we have people that they are taking plant in three shift, so that is *where, they went, they walk through the plant, they write… You go and you check it out, you record it on SAP, then you get the shop papers, you apply for repairment to work, operating stop the plant, when operating stop the plant, they do check the isolating, you do the team talk with your people, you go change…To your team, obviously the first thing you talk to your is for me you sit in the office you talk to your team.*

Agustiady (2018) stated that equipment and machines must be kept clean. TPM incorporates 5S (housekeeping, cleaning oils and greasing on machines) and autonomous maintenance. Autonomous maintenance is where maintenance is implemented by machine operators and not by dedicated maintenance engineers. Autonomous maintenance provides operators with "ownership" of their machines and equipment. It enhances the operators' knowledge of the equipment and machines that they operate by ensuring that equipment and machines are inspected, well cleaned, and lubricated (oiled and greased). Evolving problems are recognised before they turn into failures, allowing maintenance staff to concentrate on more advanced activities. According to Sun and Yanagawa (2006), 5S (sorting, straightening, shining, standardising and sustaining) is a lean manufacturing technique to clean up, sort out and organise the operation. Masemola et al. (2021) mentioned that 5S is part of a continuous improvement technique, which is a foundation for any organisation. Manager 4 stated that workers waste oil, but they have reduced the wastage and now better manage it. Management has developed the strategy of selecting older staff to manage oil in terms of filing the tanks and cleaning the area. Management enforces that workers take responsibility for managing waste. 5S is practised by ensuring that the area is clean and there are no oils on the floor:

So, yes there are waste, but the ones that are in my control – oil. So, we reduce and manage oil. We've even selected a new panel of older people, which are managing oil in terms of filling and also making sure that the area is clean and other resources,

Worker-6 highlighted that management has added key performance indicators (KPIs) where they are also measured by housekeeping (ensuring that there are no bottles on the floor) and oil management to ensure that workers take responsibility for using resources sparingly. 5S is practised by ensuring that the floor is clean without broken bottles to avoid injuries:

> *we're having this thing of KPI, where they measure you about production, housekeeping, even this oil, where you, you save things. We do it after three months, but for this oil it's doing daily, because we've got the record of it, then every Friday they check, they compile everything… We're checking if the floor, there's no bottles on the floor, because we're making bottles, they're on the conveyor, sometimes they fall. So, you must make sure that the floor is clean, because if the floor is not clean, if you can slippered, you will fall on the bottle, then it's going to have more injuries…We're checking if the floor, there's no bottles on the floor, because we're making bottles, they're on the conveyor, sometimes they fall. So, you must make sure that the floor is clean, because if the floor is not clean, if you can slippered, you will fall on the bottle, then it's going to have more injuries.*

Lean manufacturing values the worth of a product or service as per customer satisfaction and strives for excellence through continuous improvement by removing waste and separating value-added tasks from nonvalue-adding tasks. Continuous improvement has tools that are required to determine the main cause of inefficiency in the workplace and applies measures to reduce those inefficiencies. Management must develop a stable workforce that has organisational knowledge to eliminate waste such as idle time, waiting time, inventory and resource problems. Continuous improvement success depends on workers' views, training, process problem solving and development of ideas.

TPM improves workers' equipment-related knowledge and skills, enhances internal communications, builds teams, improves collaboration, establishes baseline equipment specifications, facilitates auditing and diagnostic capabilities, decreases the number of defects, removes unplanned interruptions, and cements quality control standards. According to McLean et al. (2017), a continuous improvement initiative aims to create a culture of ongoing improvement by including everyone involved and investing in the training and development of employees. Improvements are attained through the organised application of lean techniques targeted at the identification and elimination of waste and removal of variations in all processes. Mukhopadhyay and Ray (2006) applied Six Sigma and TQM tools to reduce packaging defects. Compliance with the set standard of performance is a method of ensuring quality.

Theme 3 discussed the continuous improvement strategies used to solve problems (Six sigma DMAIC, fishbone analysis, root cause analysis and 5 Whys). The themes also discussed other lean techniques, such as TPM (corrective and preventative maintenance), TQM and 5S.

4.4 CONCLUSION

This chapter presents the data that were gathered in this exploratory study. The data that were presented were obtained through literature, observations and interview data. The qualitative approach was used to explore how lean techniques are used in continuous processes to improve efficiencies in South Africa. The data were discussed under three themes that were identified during the coding process, namely, waste of resources, people's involvement and continuous improvement. The data represented in this chapter are direct words that were used by the participants, and the wording was not changed to comply with language rules, i.e., quotes were provided verbatim. The next chapter will be a discussion chapter that aims to interpret the data presented in this chapter as well as link the data to the literature and observations that were collected during the data collection phase. How the data can be triangulated will aso be reflected in the next chapter and findings of the study will be presented.

CHAPTER 5: DISCUSSION OF THE DATA ANLAYSED

5.1 INTRODUCTION

The previous chapter presented the data collected during the data collection process. The data comprised replies from participants who were part of twenty-four semistructured, qualitative interviews. The data were integrated with literature and workplace observations that were conducted. A detailed presentation is presented in Chapter 4. This chapter provides a discussion of the research findings as per the objectives. This chapter provides an overall discussion of the analysis conducted in the previous chapter. It summarises the implications and results of the study. It reports a framework that was established from participant answers. The following research question was formulated:

RQ: Which lean techniques can be used to improve efficiencies in two continuous process case studies in South Africa?

Secondary research questions:

- What are the various forms of waste within two continuous process manufacturing environments in South Africa?
- Which lean techniques are used in two continuous processes in South Africa?
- How can efficiencies be improved within two continuous process manufacturing environments in South Africa?

Emanating from the research question were the following objectives that guided the research process:

The **primary objective** of the study was as follows:

To explore which lean techniques can be used to improve efficiencies in two continuous process case studies in South Africa

This study sought to achieve the following **secondary research objectives**:

- To identify the various forms of waste that exist within two continuous process manufacturing environments in South Africa
- To determine the lean techniques that are used in two continuous processes in South Africa
- To identify how efficiencies can be improved within the two continuous process manufacturing environments in South Africa

5.2 DISCUSSION OF THE ISSUES THAT EMERGED FROM THE RESEARCH DATA

The analysis of the data led to the identification of three main themes, and each main theme comprised subthemes that were discussed in Chapter 4. Theme 1 is waste of resources and consists of ten subthemes, namely, elimination of waste, recycling of waste, waste of resources (oil), fault indicators/technical indicators, delays/disruptions, causes of waste, rejections or defects of products, challenges to meet the production target, mitigation, and increase in costs. Theme 2 is people's involvement and consists of ten subthemes, namely, training of workers, teamwork, communication, meetings, accountability, staff, unskilled labour, skilled labour, compliance with the set standard of procedure and reporting. Theme 3 is continuous improvement and consists of ten subthemes of maintenance of equipment, production process, monitoring and evaluation, inspection, measuring, investigating potential failures or problems, quality checks, monitoring and measuring systems, control and quality inspection system.

Within the lean manufacturing context, the term 'waste' is credited to all worthless, nonessential activities that do not improve the value of the product and that can be removed immediately to enhance an organisation's productivity (Liker, 2004). The eight forms of waste are described as follows (Liker, 2004):

- Transportation: any unnecessary resources and equipment that are moved everywhere without improving value to the product.
- Inventory: Everything that is more than what is needed by the customer negatively influences cash flow and wastes valuable floor space.

- Motion: Examples of pointless movement of workers or machines and equipment may be looking for something, reaching for something and general walking around.
- Waiting: Waiting includes idling machines, running out of material and resources, waiting for information and equipment tools.
- Overproduction: Manufacturing anything additional than what is mandatory by the customer.
- Overprocessing: Examples of nonvalue-added methods consist of reworking and inspection.
- Defect: Any goods that do not meet the customer specifications.
- Underutilisation of worker creativity: Workers are the most vital asset of any organisation. Therefore, an organisation should involve workers' minds (not just their bodies) in continuous improvement.

The interviews and observations have demonstrated that a continuous process environment does experience waste during the production process. The researcher witnessed the spillage of coal, moist coal that could not be used immediately, the leaking of oil, the leaking of water and the manufacturing of defects (bottles) during the workplace observations, and the interview data also confirmed the wastes that were observed within the two case study environments. Bottles with defects that have been identified by the system are manually removed by staff, while the automated process may also remove some defects. Time is another form of waste (additional time is used to rework the same defects; recycling requires that time is spent collecting defects, spillages and dropped coal; time is spent recruiting additional staff and training them; time is spent fixing equipment and machines that were not properly maintained), and effort (additional effort is used to rework the same defects; recycling requires that effort is spent collecting defects, spillages and dropped coal; effort is spent recruiting additional staff and training them; effort is spent fixing equipment and machines that were not properly maintained).

Most of the bottles that were referred to as defects had cracks or the bottles were not cut correctly by the machines. Defects (any product that does not meet the customer requirements or specifications) are one of the eight forms of waste as described by Liker (2004). In total, there were fifteen comments related to glass as waste that were contributed by eight participants. Manager-1 stated, "Because, most likely here, the only waste that we encounter is glass." Alarmingly, Manager-3 admitted that statistics regarding the waste that occurs per unit are not available even though all output is recorded. The different types of waste are also discussed at management meetings daily, but not being able to pinpoint the number of wastes per unit indicates an inability to adequately manage the number of defects being produced.

Electricity is used to rework the recycled material to produce the same bottle (when the organisation does not produce the output that it intended to produce). The additional use of electricity will result in higher electricity bills. Manager-3 mentioned the wastage of electricity by reworking the same defects/recycled waste and argued that staff is also part of waste because they do not follow standardised work procedures:

> *the only thing just is we are wasting a lot of electricity. Because we are using the same electricity to rework the same scrap that we should have produced quality ware. I'm not sure about the waste on units, but I know the production wise which is about plus minus 20%... We are part of the waste, part of the problem. I'm just going to respond in three, neh? We are part of waste, I don't want to lie, we are not managing it, we are just trying to make, what can I say? The waste, we are not managing it, we're just trying to run them lines.*

Of importance to note here is that additional waste can occur when standard procedures are not followed or when staff perform their work negligently. Mainly, the managers spoke about electricity as a form of waste that may be connected to the management of the overall costs of production and process efficiencies. Electricity as waste was mentioned in both case study environments. When a certain amount of electricity has been generated within a production plant and one of the units within the plant trips (the automatic or manual shutdown of the plant) before the electricity is posted to the grid (the transmission network), the electricity would be lost and unable to be used, thus resulting in waste. This will result in load shedding. Money is also wasted (additional workers require wages; additional training funds for extra staff employed, higher electricity bills to be paid; additional input resources {sand, soda ash, lime felt spa red oxide, powder, oil, water, coal} need to be purchased to replace defects; additional recycling facilities had to be put in place that need to be maintained on an ongoing basis; additional components and maintenance activities for equipment and machines that work to reproduce the same defective products).

Water as a resource is used in both case study environments. South Africa is a semiarid country (Malobane, Nciizah, Wakindiki, and Mudau, 2018), and water is, therefore, a scarce resource. As a result, water is reused in both case study environments to minimise the waste of water. Four participants (manager, supervisor and worker) referred to water as a resource in six comments. Participants said:

> *It has to be recycled in such a way that we don't waste that water, we reuse the water and make sure that we use less when it comes to water wastage* ***(Manager-1)***

> *Defects I am referring to water leaks on the pipes or on the clamps, oil leaks, maybe Rotek while was working when they were putting new things they forgot some off, there are metal scraps there at the plant, they must come and remove everything. Everything which is at the plant and is not supposed to be there. Normally our defects, apart from the plant, damages, there were leaks here and whatsoever. Noisy vibrations, it might be when maintenance they are doing, they are working on certain equipment then they do not go with all boosted erection staff. We refer to that* ***(Worker-8)***

Workers waste different resources, such as oil. Workers are careless and do not pay attention to the capacity of the machines when refilling oil, which results in oil spillage and overfilling the tanks of machines. There are different oils used for the different machines and equipment. However, by not adding the correct quantities of oil, production efficiencies can be compromised, and maintenance activities increase, which may force the machines to be stopped. When machines are stopped, production is interrupted, and this will have a negative impact on the company's bottom line. Oil as a wastage was referred to by eight participants on all levels, which indicates that it is a well-known and prominent issue in the production processes of both companies. Participants mentioned:

> *Oil can be wasted in many ways. Sometimes we might have oil spillages, over filling of the tanks, but sometimes we can waste –, it is not just waste, but we use oil mostly, like we have got different types of oil. We have got the bunker 150 oil*

that we use for the start-up of the systems so that we can get the temperature for all the systems up. Up until we get to put the oil on standby and put in the pier. The waste can only come when we do have spillages, like sometimes you will find that we have got a lot of oil leakages. ***(Supervisor-8)***

One thing that I've seen on our machines where we waste is the oil. ***(Worker-2)***

The circular economy suggests a structure in which waste is changed into subproducts. Salguero-Puerta et al. (2019) mentioned that the circular economy is categorised by the elimination or mitigation of wastes and subproducts in various manufacturing processes, and if that removal or decrease were not possible, this new paradigm considers that wastes and subproducts must be combined into similar productive methods or others of similar or different nature with the aim of avoiding negative externalities and defending the environment. The following participants confirmed that a circular economy is practised in their organisation by selling waste products to external parties to be used in different processes outside the case study environment:

I would say if there's anything maybe at this stage that I know off and I've learnt that XXX does that. XXX does and has been selling the ash. ***(Manager-5)***

Supervisor 7 added that boxes and oil are collected by external companies that are responsible for waste management:

*so that is how we manage our waste and then for general waste like boxes and other stuff they are taken by, there is a contractor in place for that, so they are collected by XXX and then for oil it is also collected by XXX so that is how… It is a contractor that is responsible for waste management around the station… They collect, what I know is that they collect general waste for us and then they also collect oil, (****Supervisor-7)***

The circular economy approach plays a significant role in the sustainable strategies of the country and companies. According to Goyal et al. (2016), the circular economy involves creating a closed-loop ecosystem for the effective consumption and utilisation of resources. A circular economy means reconfiguring the material flow from a linear approach (resource-product-waste) to a closed-loop approach (resource-product-waste-new resource). Even during the observations, the researcher was shown where ash is kept for collection by external organisations that will reuse it again. Therefore, the observations, interviews and literature confirm that the circular economy approach plays a significant role in reducing waste in the continuous process environments that formed part of this research.

Ironically, all defects are taken to the cullet plant (where the bottles are broken) to decrease waste. It must be noted that this recycling process actually adds to the original process and involves more staff members and equipment. Due to the additional resources needed, it can therefore be argued that this recycling process to help reduce waste may be viewed as a form of waste in itself.

Workers depend on the recycling of defects as the main strategy to eliminate waste. By not ensuring that defect-free products are manufactured, reworking waste is the next focus area. Production costs are increased by the reuse of electricity, hiring contractors to recycle spillages of coal and the hiring of extra staff to sort the recycled bottles according to colours. The recycling of water also has cost implications because the water must be treated with chlorine again. During the observations, the researcher observed that workers are not trying to reduce defects; they are relying on recycling and technical indicators to highlight faults and machine failures that may result in the production of defective products. Supervisor-1 agrees with Manager-1 that waste is created by having to hire additional staff to address defects that were not identified in the production line, which results in increased costs. The company has identified areas to reduce costs, but the savings are used to fix issues that have been overlooked during the process:

> *Re-sort is like in the, if the bad bottles have passed, we have to hire people to come and re-pack them again…we are using extra people to…We are using a cheaper plastic, but we are hiring extra people to do the work again.* ***(Supervisor-1)***

Supervisor 8 said, “Yes, the waste is there, but it is not that bad. The only time when we do have some spillages is when the coal is spilling from the conveyor, but we do take out that coal and we put it again back onto the stockpiles.”

Supervisor-3 stated, “We do a lot of recycling in our business. Our glass, we are a glass manufacturing company, when the, after our consumers have used our product, we, we, we get, we collect the glass and it comes back to the plant and we recycle it.*”* A lot of waste can be reduced by following organisational standards of procedure regarding quality that will remove the need to recycle defective products. Both organisations rely on the recycling of waste.

Finding 1: Recycling of waste can also be viewed as a form of waste due to the additional employment of resources in the form of staff, energy, time, effort and money.

One of the eight wastes, as described by Liker (2004), is the underutilisation of worker creativity. Workers are the most significant asset of any organisation. Therefore, an organisation should involve workers’ minds (not just their bodies) in continuous improvement. Cappelli and Neumark (2001) suggest that workers' involvement is the main concept behind all the research examining high-performance work systems and organisational performance. Womack (2008) elaborated that sufficient communication during problem solving should be ensured. Implementing teamwork as a foundation of the organisation is also important (Liker, 2004). Manager-2 mentioned that the workers are not involved in the daily production meetings where the statistics from the previous day’s production are discussed that address trends, percentage of losses and ongoing defects:

> *looking at our production meetings, it involves mainly the, the head of departments like a filming face manager or a colding face manager or a line supervisor, but I think, I think the people are not that involved. That’s my personal opinion or view, which I also highlight daily in our production meetings, because there’s a lot of valuable discussions that’s happening there, especially around trends and the percentage losses and certain sections that repeats itself, but we’re not doing enough to take that discussion back to the people, so that they actually know about these trends and these ongoing defects.*

Valuable staff contributions may be lost by not making them part of the decision-making forum. By not filtering information from strategic and planning meetings back to the staff, a gap may be created between management and the workers. The gap may lead to different views and expectations that may cause misalignment and conflict. Workers may not feel appreciated, although they are the ones who are in the perfect job position to give recommendations for enhancing the productivity of the job they do (Sim and Rogers, 2009). Staff offering valuable input to existing problems was confirmed by Manager-2 as follows:

> *I did speak to one of my supervisors, Evinet, regarding our losses at one of the cameras on the single lines, where we can, we're having a lot of problem with oil marks on the, on the bottle, so I did bring up a suggestion that we bring on roller brushes on that, on those bottles, so that we can brush off the oil marks and then by doing that, we are reducing the losses on that camera, on that inspection equipment. I think the guys are in the process of trying to organise something, but that was something that I could see that we are losing a lot of good bottles.*

In this instance, a staff member identified a solution to reduce the number of defects created. In addition to the problem-solving initiatives, staff can also contribute to how work is performed. Supervisor 2 highlighted that staff can also write their own job descriptions:

> *four or five of these packaging operators come and sit around the table and you know, HR will facilitate that, where these guys actually write their own job descriptions or roles and responsibility. And we have seen that it's, it's double and more valuable that when, you know, a manager sits and writes it by himself. Because, there's a big misalignment of what a manager expects his people are doing and what his people thinks the manager is expecting… I think we're having a lot of waste that we can reduce by, by including people and you know, deeper investigations, proper downware analysis*

During the workplace observations, it was observed that managers only visit the plant to conduct specific issues under investigation but do not monitor how workers perform their work. The offices that are occupied by managers are outside the plant, and managers seem to spend most of their time in their offices. Staff is used according to their capabilities; for example, older staff are used to clean oil spillages and conduct general housekeeping activities of the plant.

*We've even selected a new panel of older people, which are managing oil in terms of filling and also making sure that the area is clean and other resources, how we optimise…it is one of our people which have been here way longer and some of them are close to retirement, so they're not fit enough to continue with the same duties that they had used to before…So, instead of just leaving or send them off, we give them lighter jobs, essentially a light job. Excuse my older, but ja. (**Manager-4**)*

*we also have those people, we are using them just for cleaning, also, just of picking up stuff (**Supervisor-4**).*

Staff from different sections of the plant and staff from different shifts communicate with each other regarding any failures and breakdowns experienced. Worker-3 responded: "we always communicate because the, the what is this? The process whereby we communicate with them on what is bad this side and what is not…we send them messages on which sections to look at, to concentrate at so that we can minimise the waste, the waste, I mean."

However, communication between managers and workers seems to be limited. Developing a tradition that produces the participation of every person in the organisation is important for implementing lean as lean works efficiently if driven by all workers in the organisation, not only senior management (Radnor and Walley, 2008).

Manager 2 stated: "From a quality point, we have started now, where we communicate to the line inspectors on their twenty-four-hour defect analysis that gives them a snapshot of what transpired on this line in the past twenty-four hours, which gives him the heads-up." Supervisor 3 added: "The line controller yes, we give those defects to the line, line controller and as well, are taking those bad bottles back to the operator or whoever is the senior at the back for them to correct, you know. Therefore, we do this and do some analysis. In my department, I've got specialists who are doing that; they report these things in meetings, ja, so if they, you know. Right now, there's guys checking and making sure that we, we, we understand what we are losing." It appears as if the statistics are compiled for the daily management meetings, but there is no evidence from the interview data that feedback is given to workers regarding the discussions that occur at the management meetings.

Finding 2: Workers need to be involved in the decision-making capability of the production facility through the sharing of information, contribution to how work is performed and suggestions for continuous improvement and enhancement of production efficiency.

Sundar et al. (2014:1880) explain standard operating procedures (SOPs) to be “the safest and most effective method to carry out a job in the shortest repeatable time as a result the utilisation of resources such as people, machines, and material is effective”. Gidey (2012) describes SOPs as a set of written and detailed instructions that document a routine or repetitive task followed by an organisation to attain consistency of the performance of a task. De Treville, Antonakis and Edelson (2012) state that SOP ensures that all workers are performing tasks in the same way to ensure a consistent and uniform output. SOPs assist in removing differences in understanding and execution among workers when completing activities in a working environment because the SOP process document specifies detailed aspects of all tasks pertaining to various processes to reduce mistakes, misunderstandings, miscommunications, procedural mix-ups, uncertainties, confusion and safety concerns. The interviews revealed that management has put standard operating procedures in place, but workers do not follow those standard operating procedures during production. Manager-3 said:

> *We just need to go back to basics, that’s number one. For the last twelve years I’ve been here, comparing twelve years and now, it’s not, we are no longer doing the basics… Like the SOPs are not being followed… We have them in place, but we are not really, really, it’s one of those basics that, if we can, I know if we can do them, we’ll be able to get at least another five to ten percent into our efficiencies then.*

Manager-5 confirmed that the organisation has set waste management procedures in place, but the workers are still not following them:

So, they, what we do we write strategies so on how to remove it from site and how to handle it to minimise, to eliminate all spillages and to ensure we comply on the procedure in terms of oil handling… they need to follow our waste management procedure.

Quality assurance is a lean TQM technique and aids an organisation in developing standard operating procedures (specifications) that the organisational staff must abide. According to Manager-3, the quality assurance department is the only department that regularly reviews its SOPs: “Only the only department that I can say they are reviewing their processes is the QA”.

SOPs can facilitate knowledge transfer and ensure compliance, accountability, and efficiency. SOP is not one-size-fits-all. Different organisations will each develop their own SOPs, even if they produce the same goods and services. This thinking is also in line with the contingency theory that has been adopted for this research. Rahman et al. (2013) continue that organisations must develop standard operating procedures for all processes involved in manufacturing lines by improving the current policy to make the production process more efficient in the future. Hodge et al. (2011) mentioned that lean manufacturing implementation should start with policy deployment tools to initiate cultural changes because management and workers are often cited as the main barriers to implementing lean policy.

The process of developing an effective SOP is critical to its successful implementation, and the process should be inclusive and consider the input of everyone. The best practice to develop SOP calls for the active involvement of workers. Highly effective managers actively involve their teams, and it is human nature that people support what they help create and managers who write SOP without the involvement of workers run the risk of offending them, while those who recruit the talents of their workers increase buy-in. Companies that test, refine, and implement workers’ creative suggestions are likely to end up with higher quality SOP; they have the advantage of fostering teamwork, and for continuous organisational improvement, established procedures need continuous enhancement. There are various responses from participants that indicate that staff has veered away from following the standard operating procedures:

Whereby we sit down, we discuss the day's production, what has went wrong? How best can we correct that thing so that it does not happen, based on our standard operating procedures, we are supposed to do this like this, but it did not happen like this. It has gone out of line, so we need to correct that. ***(Supervisor-7)***

*We have them in place, but we are not really, really, It's one of those basics that, if we can, I know if we can do them, we'll be able to get at least another five to ten percent into our efficiencies then. (**Manager-3**)*

*Maybe not following the right procedure of, of reporting defects. Because some defects stay too long on M.N.R.'s (**Supervisor-3**)*

*I think it's a standard, if we can be all on the same standard so that we can understand much better. (**Worker 1**)*

*There's no standard in which one to pack and which one (**Worker 1**)*

Managers have put together standard operating procedures for staff to follow. However, Manager-3 clearly articulated, "We are not doing the basics, no one is doing the basics, that's a pure, pure discipline issue." Although staff received area-specific training to teach them what is expected from them in their particular jobs, it is clear that they do not follow what they are taught. Management also does not seem to be hands-on involved in the production process to enforce the execution of standard operating procedures and ensure the minimising of waste during the process. Another explanation for staff veering away from the written standard operating procedures may be that the SOP may no longer be relevant if changes that have occurred render certain components invalid or no longer applicable. It is thus important to revisit these documents as technological, process and other major updates and changes are introduced. The researcher did not specifically delve into this issue.

Finding 3: Management has put standard operating procedures in place for workers, but workers do not follow those standard operating procedures.

Holtskog (2013) defines continuous improvement as a long-term, often management-driven, effort that has deep cultural implications in the workplace. Continuous improvement is also referred to as kaizen. Nunes et al. (2017) explain that continuous improvement involves the improvement in everything (quality, cost, processes, scheduling). The most important part of continuous improvement is to solve problems regularly. Toyota refers to the following five-phase problem-solving process to address problems (Womack, 2008):

- Managers ask the workers about the challenges that the workers are facing to determine the real problem, not just the surface problem.
- The workers are then asked what caused the problem to determine the root cause. The worker should provide proof from the actual work to be examined in collaboration with the manager.
- The workers are then asked to propose a way out and provide a reason for the specific solution as opposed to alternatives.
- The workers are also asked how they (the manager and worker) will know that the problem is solved. How can it be monitored?
- Once an agreement is reached on the correct course of action, the worker implements it.

During the observations, the researcher witnessed that workers continuously define problems during production processes when they experience defects. Workers measure the production output and compare it with the previous day's production. Other workers monitor the production process from computers in the control room to ensure that the correct temperatures are used and that cameras that assist with quality control are working properly. Workers report and improve any faults identified by the system. Control and monitoring take place every day. The responses from participants show that different methods are used to solve different types of problems. Manager-2 mentioned:

> *in this case you would take the problem, which you would sit and, and write a problem statement and based on the problem statement, you start unpacking and then throughout the process, you're unpacking the first, the first point where we, where we, where we take the machine maybe, let's say a check plus or a XXX or a whatever and we say right, this is the problem and what is those things that could potentially lead to this failure and you list those two things or three, five things… Then the team would go out and one of those things will then, you know, be investigated by an individual to go and actually dig into one thing and see what, you know, if he could potentially pick up a problem. So,*

when the, when the group comes back you normally find that, that you can eliminate three or four of those five things, alright?... then the team will take those one and two things and start unpacking them, individually looking at, if I say it is a, it is a card or it's a, let's say a proximity that could potentially lead to this problem, then we start listing those things under that… Up to the point where you start eliminating the issues completely, but it's not an individual sitting and do problem solving at all. It's, it's team based where the whole team gets involved and even with our job descriptions, we do exactly the same… it's to constantly challenge our inspection equipment to see or learn to see what we know as defects, so that we don't spend enough time on and I think, I think we're having a lot of waste that we can reduce by, by including people and you know, deeper investigations, proper downware analysis. Now, downware is what you have rejected, okay.

*so we do incident investigations, it means that if, let's say there is a plant that fails, whether it is a coal plant or something fails, the System Engineer for that plant has to go and do an investigation...Now where accountability comes in, you request a Production Manager ne, for this they give you, then you want to say okay let's go [indistinct] which is the quality issue management process ne, I want to see the root cause for this in, was this incident investigated? If it was investigated, what are the causes, there is no repeat. A month later it is not investigated, so you see the accountability that I am talking about. (**Manager-6**)*

*from operations to production to technical it might differ, where we would use either the fish bone, we would use things like the five whys, the five whys principles…We just introduced Six Sigma people, to check the quality before they reach packed ware, so it limited the number of held-ware that we had, especially on the wine bottles and then we had trained other, like the blue, the sorters that we have about the quality of the bottles, so that they can also know the defects. And we've introduced less green workers and we've just bought new machines that are with higher inspections. So, our held-ware, regarding of re-sorting and hiring more people to re-sort, it has decreased a lot (**Manager-2**).*

*We're currently using Six Sigma although it's not well established, but we're trying (**Worker-4**)*

The continuous improvement methods that a continuous processes environment uses to reduce waste to investigate production problems are root cause analysis, 5 Whys and fishbone analysis. Continuous improvement of the production process can also be achieved using Six Sigma DMAIC (Define, Measure, Analysis, Improve, and Control) steps. Although not all participants were familiar with specific terminology, it is evident that many of the continuous improvement methods outlined are already being used within the production environments of the case study examples of this study. Other lean tools, such as VSM, may also be considered in addition to the techniques and tools that are already informally being practiced. Durakovic et al. (2018) confirmed that VSM can be used to identify sources of waste.

Finding 4: There are various continuous improvement methods (Six Sigma DMAIC, Fishbone analysis, 5 Whys and root cause analysis) used in continuous processes to solve production problems.

According to Ahmad et al. (2018), total productive maintenance is a stepwise strategy that combines the best features of productive and preventative maintenance with total employee engagement to maximise overall equipment efficiency. For every manufacturing company, the objective is to produce goods at a profit, and this can only be achieved using an effective maintenance system that helps to maximise the availability of equipment by minimising machine downtime due to unwanted stoppages. The stoppage losses can be divided into six major categories, which affect the overall performance of the equipment, namely, breakdown losses, setup and adjustment losses, idling and minor stoppage losses, speed losses, rework, quality defect losses, and yield losses.

Agustiady (2018) stated that total productive maintenance (TPM) is a holistic approach to equipment maintenance that strives to achieve near-perfection in production processes. The total productive maintenance process ensures that fewer breakdowns, stoppages and defects occur while also lowering costs and engaging shop floor workers. The reliability of equipment on the shop floor is very important, as machine breakdowns affect the entire production line. Maintenance staff prioritise the maintenance of machines and equipment that can cause production lines to stop and delay maintenance of machines and equipment that do not affect the production line. For example, oil leakages that do not affect production or increase defects may be a lesser priority, and maintenance staff will delay fixing those leaking machines. During the workplace observations, the researcher witnessed some machines leaking oil where buckets were placed under the machines to contain the leaking oil. Interview data also confirmed that maintenance staff prioritised machine breakdowns. This is what the staff said:

> *No, depending, depending on which plant it is leaking but, depending on the priority of, the priority of… Priority one is immediate, that one is attended with immediate effect but priority two they can plan for five days it must be fixed, priority three it takes three months maybe they are going to look in to the spare, if they have a spare to fix that and then priority four it can take eight months, meaning we are waiting for opportunity of outage.* ***(Worker-6)***

> *No, depending, depending on which plant it is leaking but, depending on the priority of, the priority of…* ***(Worker-5)***

> *No, you can conduct, we do some equipment depending on the critically to fit, we conduct maintenance before anything can happen. (****Manager-5****)*

> *Priority one is immediate, that one is attended with immediate effect but priority two they can plan for five days it must be fixed, priority three it takes three months maybe they are going to look in to the spare, if they have a spare to fix that and then priority four it can take eight months, meaning we are waiting for opportunity of outage.* ***(Worker-5)***

> *It depends on if it is an emergency or not. If it is not that emergency –, emergency I mean the one which is critical. If it is not working we might lose some megawatts and we do have what we coal a load lost, but if it is not such an emergency, that will depend if they do prioritise them, that pitted under priority one, two, three, four. If it is priority four then they*

> *must do it within a period of, maybe eight to twelve hours. They must finish the job.* ***(Supervisor-8)***

From the data, it is clear that production in continuous processes must continue at all costs. All maintenance is scheduled to ensure that production is not unduly halted. Redundant equipment (previously used equipment that is still able to operate but is no longer in use) replaces equipment that are in use during preventative maintenance to ensure that production can continue. Certain machines and equipment (such as the boiler) do not have a backup capability and require a complete shutdown of operations and production. The situation is further compounded when considering aging machines and equipment that are prone to more failures and breakdowns. Older equipment may be less reliable and have more breakdowns, thus affecting production.

> *We could not, their plant could not continue to run anymore because remember plants are old. The life span of plant equipment is 25 years; we are on the 25th year now, but according to the books, we are supposed to change, but chances are we are going to run this plant for another 20 years* ***(Manager-7)***

It is crucial to balance preventative and reactive maintenance activities — discussed next. Essentially, all maintenance should work towards keeping production flowing. Maintenance staff, therefore, mostly conduct reactive maintenance based on the urgency of the problem, failure or breakdown identified.

Finding 5: Maintenance staff prioritise maintenance to machines that prevent the complete stoppage of the production process in continuous process facilities.

Maintenance is aimed at increasing the lifespan of machines and equipment. Various types of maintenance may occur. Preventative maintenance has to do with regular planned maintenance on all equipment. Workers must carry out regular equipment maintenance to prevent any irregularities from occurring to reduce unexpected breakdowns of machines. These preventative actions usually occur at predetermined intervals (Erkoyuncu, Khan, Eiroa, Butler, Rushton and Brocklebank, 2017). During the interviews, participants confirmed that they conduct periodic preventative maintenance according to a maintenance plan. The intervals of maintenance depend on the type of machinery and equipment, as these may require maintenance at different intervals.

we've got a planned maintenance… Ja, we've got a maintenance plan that is taking us about a year and a half planned, ***(Manager-1)***

They're supposed to maintain them after three months, but in three day, they were supposed to, section by section. ***(Worker-2)***

It depends on various plants, the time, the time for maintenance, it varies. So, some, some, some plant is, is, is weekly, some is monthly, some is two-yearly, six monthly, double yearly ***(Manager-5)***

Like in terms of the outages department, where they service the plant after maybe a year or like it depends on that. ***(Supervisor-6)***

I am in maintenance, what we do is basically maintaining the plant, try and try and prolong the life of plant. ***(Manager-8)***

It is a day to day thing, because we do online maintenance and offline maintenance. Online maintenance could be that you're having a running defect then we load the notification and create an order for somebody to go and do maintenance, we got what we call prevented, okay that is corrective maintenance and we have got preventative maintenance, preventative maintenance mainly it is planned, what normally happened is when you start, you have what we call a maintenance strategy which tells you this component should be maintained at a certain frequency and there is other activities that you need to do and maintain it. So, what happened is from there, from the strategy developed, on the strategy you've got prevented of maintenance plan, so you take that, you do what we call preventative maintenance orders. Say for instance it could be weekly, it could be monthly, three monthly, six monthly, nine, twelve monthly. Then what you do is you try and when you set it out in the beginning, you go and do the activity and see how much time it takes and how many people it takes to execute then that you put it in the order, so that when place the person who does the resource planning already know that on this order I need two people for four hours unlike, because if you, if you do not do that you have got, let's say it is one hour, one person one person goes there they cannot wait they have to come back, look for somebody else and they still *going to have to go through the whole four hours which could end up being five hours. (**Manager-8**)*

We are maintaining the whole like, currently maintaining all the belts that takes coal inside the power station and the ones that takes the ash outside...Maintenance is done on that conveyor every Tuesday ***(Manager-7)***

Yeah, in other ways used to reduce waste –, the only way that we can do is to maintain the plant to be always in a healthy condition. That is the only way, otherwise if the plant is not in a healthy condition we are not going to survive ***(Supervisor-8)***

Okay, it is different maintenance. So far, I know, so the short once where you just have to check if your machine is in the right condition to operate and then some you have to change some parts of your machine. ***(Worker-5)***

The researcher also observed that the maintenance staff only reacted when there was a problem that arose. During the observation, the maintenance staff had to wait for a bell to ring (fault indicator) before they reacted. The corrective maintenance action involves the replacement of a failed system, subsystem or component to ensure that the complete, fault-free working condition is restored (Erkoyuncu et al., 2017). Corrective maintenance also covers those unpredicted failures that can negatively affect operations and production. Manager-1 highlighted:

If there are any problems, you'll hear this other sound that, sort of like a hooter, that ring. It shows that there is a problem in one of the sections of the machine that needs to be sorted out…Any slightly problem that we'll encounter, either it can be from the mechanical side or the electrical side, we've got different sounds or hooters that will say there is a problem, then it will be attended to, ja.

Okay, on the performance, how is the plug performing. So, if there's anything wrong, then there will be an alarm that is indicating that something is wrong. And then that person send another operator for it. ***(Supervisor-6)***

Ja, because they [maintenance staff] only react when there's a problem. Saying there's a problem, they will review the whole process of checking the quality, but the production, the IS, the furnace, we don't… ***(Manager-3)***

In continuous processes, production runs endlessly. A challenge in continuous processes is the length of production downtime during maintenance activities. Having extensive downtime due to scheduled maintenance will cause interruptions to the whole process (Abdullah, 2003). The maintenance staff conducted corrective maintenance to fix failures that had occurred. Corrective maintenance is an unscheduled replacement action to restore the failed product to an operating state. Preventative maintenance is a planned action of repairs to minimise the chance of possible failure to decrease the consequential cost of product breakdown (Ullah, Ayat, Rehman and Batala, 2020). Where no backup capabilities exist, certain types of maintenance will stop production, which can be very costly for the business that results in waste (time and production intended for the day not met), and the costs incurred by these interruptions may far outweigh the immediate cost of repairing a part.

The performance of production staff is linked to the production capability and thus the availability of operating machines and equipment of the facility. However, inadequate maintenance activities and inefficient workarounds will also negatively affect production capabilities. Production staff that do not operate the machines and equipment correctly will also increase maintenance activities. Maintenance and production work to achieve the same goal (enable machines and equipment that work optimally) but approach it from different directions.

Good maintenance should work towards not only fixing failures but also preventing failures from occurring in the future. To achieve maximum efficiency in production, the organisation is required to move away from reactive maintenance and repair modes of maintenance into a preventative maintenance based on knowledge of the technical condition of machinery and equipment (Misztal, Butlewski, Belu and Ionescu, 2014). The production team and the maintenance team need to work together to achieve this common goal but often find themselves at loggerheads. Management can do a lot to ensure that these disparate groups function in cohesion within the working environment and build a culture of collaboration and support (Jacobyansky, 2022).

Pressure from production staff sometimes prevents maintenance staff from conducting preventative maintenance so that production is not affected. This is the reason why maintenance staff end up doing corrective maintenance more than preventative maintenance. Manager-6 said:

> *So, they will tell you one of their technical indicators [machine] is planned capability loss factor, so basically, they are saying that there are plant production is to stop with this planned maintenance.*

It is evident that both organisations that form part of this research have a maintenance plan according to which they conduct all the different types of maintenance (preventative, corrective and autonomous) but seem to prioritise maintenance reactively (corrective maintenance) as opposed to proactively (preventative maintenance. Maintenance staff tend to wait for fault indicators before attending to failures and breakdowns. TPM focuses on overall equipment effectiveness, and the cleanliness of equipment also leads to an increase in the effectiveness of machines. Nunes et al. (2017) state that staff should also be trained in 5S activities so that the team can learn how to take care of their equipment.

Finding 6: Maintenance staff mostly conduct reactive maintenance to avoid lengthy production downtime.

TPM focuses on overall equipment effectiveness. Sharma et al. (2017) state that 5S leads to cleanliness in the workplace; for example, daily maintenance (oiling and greasing) of the equipment leads to the enhanced effectiveness of machines. Therefore, 5S enhances the level of TPM implementation in continuous processes. Thomas, Barton and Chuke-Okafor (2009) also supported the idea of implementing 5S and TPM collectively. TPM is aimed at reducing interruptions in machine processes by removing equipment failure, adjustment delays, idle time, downtimes, reduced processing speed, and processing defects.

During the observations, the researcher observed that the lean manufacturing techniques that were practised are 5S (cleaning of equipment and collecting bottles on the floor, wiping oil and water from the floor and cleaning machines), continuous improvement (ensuring that machines are set to the correct temperature to reduce defects and technicians are constantly monitoring the variables electronically) and maintenance of equipment through preventative and corrective maintenance (TPM) and TQM (the bottles go through inspection to ensure that they meet customer specifications, and after the bottles have been coated and annealed, they undergo quality assurance, which is the last manufacturing section before the bottles are despatched for distribution). With regard to TPM, participants mentioned the following:

> *if we are doing maintenance or anything, then I will come up with a strategy and say let's, this is what I've discussed with you, let's, let's treat this oil, let's test it, let's exhaust all the options to say we cannot use the oil anymore. (**Manager-5**)*

> *The maintenance happens robust to do measure from there (**Manager-6**)*

Continuous improvement is also practiced by continuously monitoring production processes electronically and correcting errors to reduce defects and reviewing the production report during meeting and coming up with solutions. Six Sigma DMAIC is used to investigate problems with the aim of providing a solution to the problem.

> *We just introduced Six Sigma people, to check the quality before they reach packed ware, so it limited the number of held-ware that we had, especially on the wine bottles and then we had trained other, like the blue, the sorters that we have about the quality of the bottles, so that they can also know the defects. And we've introduced less green workers and we've just bought new machines that are with higher inspections. So, our held-ware, regarding of re-sorting and hiring more people to re-sort, it has decreased a lot (**Manager-2**).*

> *We're currently using Six Sigma, although it's not well established, but we're trying (**Worker-4**)*

Recycling is used to eliminate waste (defects, leaking oil and coal spillages).

> *So, which means that whatever we have produced, which is not in quality, we cannot just throw it away. We're able to go and recycle again from, from the production line. Then the other thing that we normally use again, is like we have on our waste bins, so there is a place where we put our general waste, where we put glass for recycling again (**Manager-1**)*

TQM is also practised in the case study environments:

> *we're dealing with glass bottles. In order to reduce waste, we need to produce quality bottles. Quality ware. So, in order to produce quality ware, our hourly inspection on our bottle sets, need to be done religiously. If not, then we're going to have webbing thrown away for unnecessary defects on the bottle, so by, by the guys doing the set checks every hour we are reducing that, in that way we are reducing and optimising loss on our production end. (**Supervisor-2**)*

> *we measure all the time, the, our, our system is forcing us to measure all the time, because we've got inspectors. (***Supervisor 4***)*

The following participants confirmed the use of 5S lean manufacturing techniques that are practised:

> We clean the spillage and then we dump it at the dumping area. **(Worker-6)**

> *The training is focused on the plant monitoring and maybe operation itself, when we do operate how can we operate to the plant safely and looking at the safety of the other people and the person, himself, who is operating the plant, is he or she operating the plant safely and other plant users, meaning the people who are cleaning on the plant, people who are maintaining the plant, the maintenance guys are they working safe all the time? And the cleaning of the area also, it must ensure that the plant is clean, if it is not clean then it must be reported. (**Supervisor-4**)*

> *We're checking if the floor, there's no bottles on the floor, because we're making bottles, they're on the conveyor, sometimes they fall. So, you must make sure that the floor is clean, because if the floor is not clean, if you can slippered, you will fall on the bottle, then it's going to have more injuries. (**Worker 2**)*

Based on the observations and interviews, the researcher identified that the lean manufacturing techniques used in a continuous processes environment are 5S, TPM, TQM, continuous improvement (Six sigma DMAIC, 5 Whys, root cause analysis and fishbone analysis) and recycling of resources. Based on the researcher's observations, standard operating procedures exist but are not fully practised in the case study environments.

Finding 7: The lean manufacturing techniques that are applied in continuous processes are TPM (preventative and corrective maintenance), continuous improvement (Six Sigma DMAIC, 5 Whys, root cause analysis and fishbone analysis), 5S, recycling and TQM.

Mourtzis, Papathanasiou and Fotia (2016) mentioned that where managers of companies are more knowledgeable about lean philosophy and its principles, the company derives more value, which results in greater lean results for the company. Lean theory should not concern only people from management levels, but workers should also be involved in and trained about lean (Marin-Garcia and Bonavia, 2015). Mourtzis et al. (2016) recommended that organisations provide training and a clear view of how companies can apply lean to all their organisational levels while monitoring ongoing progress. In addition to induction for new employees, workers should receive safety training, production and operations training, training as to how to operate different machines and equipment, lean principles and techniques and any other specialised training that pertains to their specific job function. Leadership training is not available for all workers but becomes available on the merit of individual performers. Where external providers have been contracted to provide training, staff become responsible for their own development, and progress is not driven by the organisation.

Lean manufacturing is most successful when workers are involved. The challenge is that workers do not implement what they have been trained. If workers choose not to follow what they have been taught, it is no longer a training issue but a disregard for standard operating procedures. Nunes et al. (2017) mentioned that a trained task team that understands how lean can be applied within an organisation is optimal when deciding to introduce lean as a philosophy into an organisation. Improving employees’ skills and abilities is essential (Cardon and Bribiescas, 2015; and McLean et al., 2017), and creating opportunities for personal development for employees is key (Liker and Hoseus, 2008). Training programmes must build the necessary skill and develop knowledge and techniques that can be used in jobs. Participants stated their views regarding training as follows:

We'll train all of them on the production line, so that they can understand how production works, so that they can understand the safety and precautions of our machines and how to, things like, what you need to wear when you wish to go the plant, like the induction. When you go to the induction, then the induction will also give you a guide to say this is what we're expecting when you're coming here. Then, it will depend on the department that you're going to work, then we'll give you that training based on the product or the job responsibilities that you'll be carrying out. The only time whereby we don't train our guys is like when we, like on the leadership development. Then we've got partnerships through the UCT's, the UNISA's and we are able to send them in those, but when it comes to production, operational, then we got to train themselves for that. ***(Manager-1)***

it's training, technical training, management training maybe because we can source people from outside and that's what I'm saying, but technical training it's, it's a problem. According to what I see. Previously what we were doing, we were taking the guys and training them in students. We stopped that about seven years ago, meaning whatever we have, we learnt it seven years ago and the technology keeps on changing ***(Manager-3)***

Providing training is also small workshops and just make people understand exactly what they have to do here, because we've got old people here, that they don't, it's hard in that I don't know how to deal with it, but I think this way of assessing and providing training is just going to make them understand a little bit more of what is expected from them. ***(Supervisor-4)***

Based on the responses from the participants, training is provided for workers. They have compulsory training (safety training, production and operational training, job-specific training and induction when joining the company) for all new employees. Original equipment manufacturers also come to the plant to provide training regarding specific machines However, employees do not implement and use what they have been trained in all instances, which affects the production quality, number of defects, production output and profits. It is necessary for the leadership (managers) to play a more active role in monitoring that workers implement what they have been trained to do.

5.3 LEAN MANUFACTURING FRAMEWORK FOR CONTINUOUS PROCESSES

According to the findings of this study, not all lean manufacturing techniques are applicable to continuous processes. The data review indicates that the following lean techniques are used in continuous processes: TPM (preventative and corrective maintenance), continuous improvement (Six Sigma DMAIC, 5 Whys, root cause analysis and fishbone analysis), 5S, recycling and TQM. In addition to the lean techniques, the following lean manufacturing principles are applicable in continuous processes: the recycling of resources, leadership commitment and workers' involvement through the reporting of defects, communication, training and teamwork. Work standardisation procedures have been put into place but are not practised by workers.

During the recycling of resources, defects or waste are recycled for reuse of the same product or to be used for a different purpose, which leads to the implementation of circular economy concepts into the operations of the case study environments. Leadership is responsible for the monitoring and control of all operational activities and reporting of all production statistics and must communicate with workers in the production facility. Workers must be involved through the reporting of defects and communication among workers, supervisors and managers, and they must work together as a team across the different areas and processes to produce error-free products. Monitoring and control functions are integrated into all processes and are predominantly managed by managers, although these functions must form part of each worker's framework for execution as well. Therefore, leadership and workers should constantly monitor and control the production process and use lean manufacturing tools to minimise waste and optimise operational efficiencies.

Equipment and machines are used in the production facility by the production team who form part of the workforce, while the equipment and machines are maintained by the maintenance team, which also forms part of the workers but is different from the production team. The production and maintenance teams are often at loggerheads with each other but need to find ways to work together and optimise efficiencies for the entire production facility and not only for short-term wins.

Input resources are essentially converted into the outputs of glass and electricity through a series of processes as per the case study environments. All defects and other waste that are produced in the production process are recycled and reused as inputs into the production process. Various strategies may be used to minimise the amount of waste and defects produced, including lean techniques, using standard operating procedures correctly, and waste management procedures. Underpinning the entire production process, waste reduction techniques and principles are the organisational strategies, operational plans, and standard operating procedures. The ISO standards are also seen as an underpinning influencer, as these standards may be used as a guideline to draft the organisational strategies, plans and procedures. In addition, green manufacturing principles that govern environmentally safe processes, products and services are also viewed as a stimulant for the entire production capability.

Having considered the aforementioned discussion, Figure 5.1 has been compiled to demonstrate the relationship of all these constructs mentioned. The figure aims to outline the findings of the research and serves as a guide for the use of lean techniques within continuous processes.

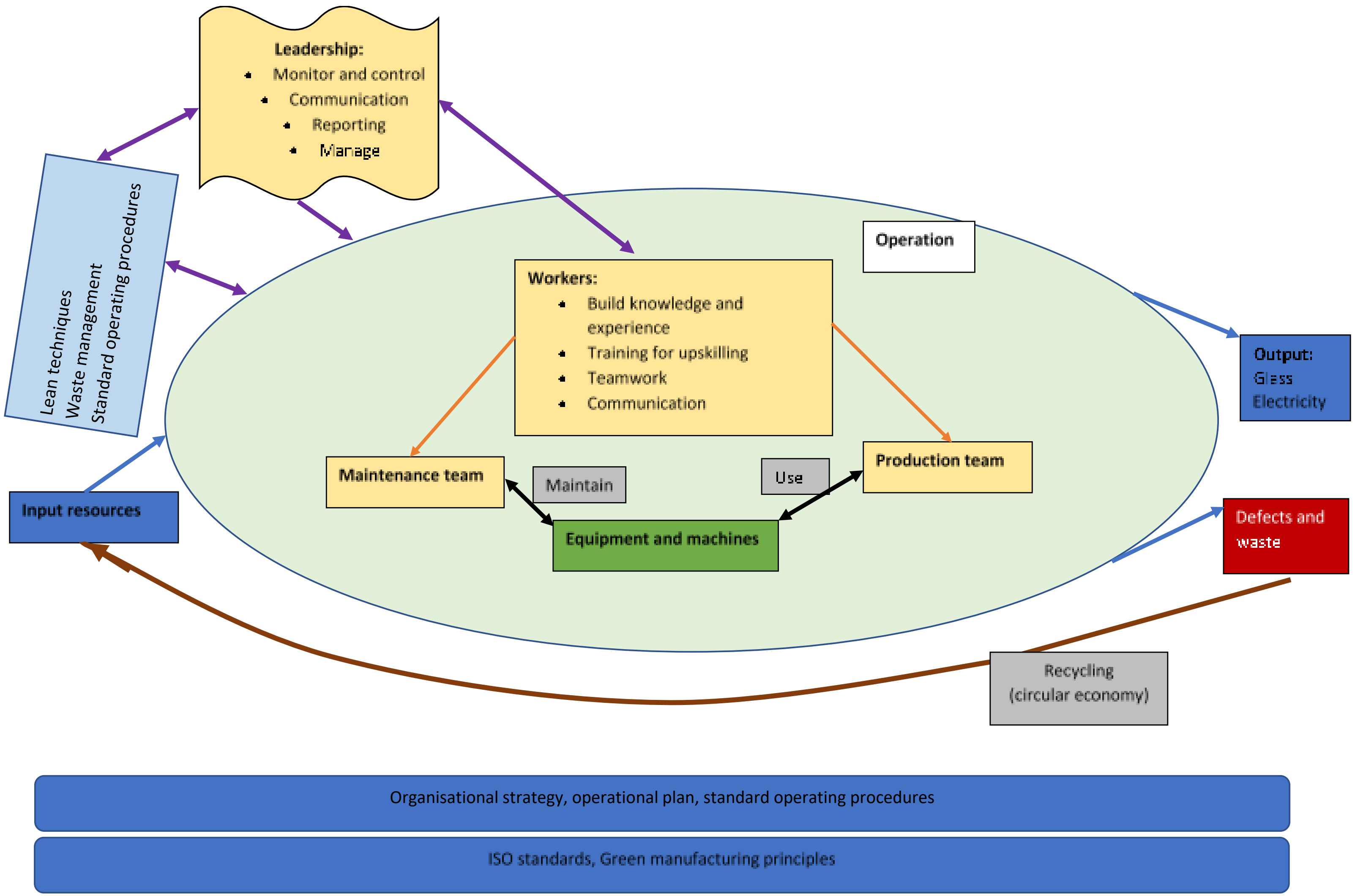

Figure 5. 1: A framework for the use of lean techniques in continuous processes

5.4 CONCLUSION

This chapter provided a discussion of the analysis of the data collected for this research, which comprised the literature, workplace observations and interview data. Implications of what the data presented were discussed. Seven findings resulted from the research. These findings were used to develop a framework (Figure 5.1) to show how lean techniques are used within the continuous process production environment for this study. The next chapter provides a summary of the findings, recommendations from the study, recommendations for future studies and conclusions that resulted from the study.

CHAPTER 6: SUMMARY OF THE FINDINGS, RECOMMENDATIONS AND CONCLUSION

6.1 INTRODUCTION

This research explored the lean manufacturing techniques that can be used within continuous process case studies in South Africa. The problem statement of this research was formulated as follows: There is a lack of application of lean manufacturing principles and techniques in continuous processes due to the high automation and inflexibility of machines and a lack of understanding of how to apply lean techniques, particularly from a South African perspective. The study used a qualitative approach and semistructured face-to-face interviews with workplace observations for a week in each case study environment. The data were analysed by using content analysis.

Chapter 1 provides a background to the study, the problem statement, research question, primary and secondary objectives and the research design, methodology used, expected impact and significance of the study, research ethical considerations and limitations.

Chapter 2 focused on the literature review for this study. It introduced the contingency theory that underpins this study. The literature covered areas about lean manufacturing principles, lean manufacturing techniques, the benefits of implementing lean principles and techniques into a manufacturing environment, challenges associated with the implementation of lean manufacturing techniques, global practices of lean manufacturing in manufacturing processes and the chapter concluded with lean manufacturing frameworks that have previously been developed.

Chapter 3 explains the research design, methodology and methods used in this study. The chapter outlines the research paradigm (interpretivism), research design (case study), research population (organisations that use continuous processes in South Africa), sample (two organisations that use continuous processes in two different provinces of South Africa) and sampling technique (purposive samples), data collection methods (workplace observations and twenty-four semistructured face-to-face interviews), and data analysis (content analysis). It also outlines the trustworthiness, dependability and credibility of the study, limitations and delimitations, and it concludes with a summary of ethical considerations that were applied in the research.

Chapter 4 presents the data collected from the literature, observations and semistructured interviews. As much as possible, interview data were presented in this chapter, as not all participants provided consent for the verbatim transcriptions to be used as addendums to the research document. Three themes that emerged from the data analysis were explained, namely, waste of resources (see section 4.3.1), people's involvement (see section 4.3.2) and continuous improvement (see section 4.3.3). Each theme had various subthemes that formed part of each main theme. The data were presented under each of the main themes. An interpretation of the workplace observation data was reported for each case study environment. An illustration of each case study environment accompanied the explanations for each of the case studies in the chapter.

Chapter 5 presented a discussion whereby the literature, observations and interviews that were collected were integrated to triangulate. The findings of the research were presented after a brief discussion of the various issues that were identified. The analysed information was used to construct a framework that demonstrates how the various actors and processes interact with each other within the case study environments of the study. It is a high-level interpretation of these relationships and does not pinpoint the respective areas where the identified lean techniques are being used within the case study environments.

This chapter provides an overview of the research in terms of the findings and results in relation to the problem and objectives. The chapter concludes with the contributions of the study and makes recommendations for future research.

The research objectives for the study will be presented next, and the findings of the study are grouped under each of the objectives to demonstrate that the objectives for this research have been achieved.

6.2 RESEARCH OBJECTIVES

The secondary research objectives for this study, as outlined in section 1.7, are as follows:

Secondary objective 1:

- To identify the various forms of waste that exist within two continuous process manufacturing environments in South Africa

Findings:

- The recycling of waste can also be viewed as a form of waste due to the additional employment of resources in the form of staff, energy, time, effort and money.

The specific types of waste that exist within the case study environments were identified as follows:

- **Staff**: Additional staff had to be employed to manually recover waste that could be recycled, sort the recovered glass waste according to colour, attend to oil spillages in the plant, and identify defects in the production process.
- **Energy**: Additional electricity is used to rework the same defects; manufactured electricity is lost and unable to be used if there is a unit trip.
- **Time**: Additional time is used to rework the same defects; recycling requires that time is spent to collect defects, spillages and dropped coal; time is spent on recruiting additional staff and training them; time is spent fixing equipment and machines that were not properly maintained.
- **Effort**: Additional effort is used to rework the same defects; recycling requires that effort is spent to collect defects, spillages and dropped coal; effort is spent on recruiting additional staff and training them; effort is spent fixing equipment and machines that were not properly maintained. And,
- **Money**: Additional workers require wages; additional training funds for extra staff employed, higher electricity bills to be paid; additional input resources (sand, soda ash, lime felt spa red oxide, powder, oil, water, coal) need to be purchased to replace defects; additional recycling facilities had to be put in place that need to be maintained on an ongoing basis; additional components and maintenance activities for equipment and machines that work to reproduce the same defective products.

Secondary objective 2:

- to determine the lean techniques that are used in two continuous processes in South Africa

Findings:

- There are various continuous improvement methods (Six Sigma DMAIC, Fishbone analysis, 5 Whys and root cause analysis) used in continuous processes to solve production problems.
- The lean manufacturing techniques that are applied in continuous processes are TPM (preventative and corrective maintenance), continuous improvement (Six Sigma DMAIC, 5 Whys, root cause analysis and fishbone analysis), 5S, recycling and TQM.

Lean manufacturing techniques are applied in the continuous process environment of the case study examples, even though the workers are not aware that they are applying them. TPM (preventative and corrective maintenance), continuous improvement (Six Sigma DMAIC, Fishbone analysis, 5 Whys and root cause analysis), 5S, recycling and TQM are practised in the case study environments. In addition, value stream mapping (VSM) can also be introduced to identify additional areas for waste to be minimised so that operational processes are optimised.

TPM is used to increase the reliability of the equipment and machines within each plant. Continuous improvement is also used in the continuous process environment. There are daily meetings done to discuss the performance of the plant. These meetings are attended by management, and actions are generated for improvement. Root cause analysis, fishbone analysis and 5 Whys are used to investigate incidents in the plant to prevent the reoccurrence of the same incidents.

5S is used in continuous processes in South Africa to maintain good housekeeping and cleanliness in the plant. Machines and equipment require daily maintenance of oiling and greasing. Six Sigma DMAIC is used to effect process improvements as identified by workers and managers. The steps that are followed include Define, Measure, Analysis, Improve, and Control. TQM is practised to enhance the quality of bottles manufactured to meet customer specifications.

Secondary objective 3:

- to identify how efficiencies can be improved within the two continuous process manufacturing environments in South Africa

Findings:

- Workers need to be involved in the decision-making capability of the production facility through the sharing of information, contribution to how work is performed and suggestions for continuous improvement and enhancement of production efficiency.
- Management has put standard operating procedures in place for workers, but workers do not follow those standard operating procedures.
- Maintenance staff prioritise maintenance to machines that prevent the complete stoppage of the production process in continuous process facilities.
- Maintenance staff mostly conduct reactive maintenance to avoid lengthy production downtime.

Workers are involved in the production process but do not seem to form part of the daily production meetings where the previous day's statistics are analysed, and improvement measures are identified. It also appears as if managers do not convey the information from these meetings to the workers. Workers may contribute to improvement initiatives. Workers communicate with each other throughout the production process and across the different shifts. Monitoring and control activities are executed from the control room to monitor losses and defects. Managers occupy external offices to the plant and may not appear to be as visible as needed.

The research identified that workers received various types of training for workers to be developed. However, workers do not always follow the procedures that they are taught.
The standardisation of work is crucial to the success of the manufacturing capability. Standard operating procedures have been developed by management for the different processes and departments, but workers do not seem to follow these guidelines. Although managers communicate with workers, their interaction with workers can be improved.

Preventative maintenance occurs according to a maintenance schedule. Preventative maintenance is often delayed due to pressure from the production staff. Corrective maintenance is scheduled according to the urgency of the required maintenance of equipment and machines in relation to how the production process is influenced by the maintenance that needs to occur.

In answering the secondary objectives that relate to the lean techniques that are being used, the types of waste that exist and how process efficiencies can be improved within manufacturing plants that use continuous processes, the primary objective has been answered as well. The **primary objective** of this research was as follows:

- To explore which lean techniques can be used to improve efficiencies in two continuous process case studies in South Africa

6.3 CONTRIBUTION OF THE STUDY

There is limited research on continuous processes and lean manufacturing in South Africa. This study contributes to the literature, industry and knowledge of lean manufacturing. The findings of this study confirm that various lean techniques are already being used in the case studies that formed part of this research, although workers were not aware that their methods were part of lean manufacturing. If workers can specifically be trained in lean techniques, they can be more effective in reducing waste and enhancing process efficiencies in the organisation. The study highlighted the various types of waste that managers can use to build strategies on how to reduce these wastes.

There is a need to formally implement lean manufacturing principles and techniques in continuous processes in South Africa to reduce waste and improve efficiencies, lead time, and productivity. Although workers recycle defects in a bid to reduce waste, there seems to be no impetus to reduce the number of defects, as recycling is seen as a means to rectify the wrongs. However, recycling also has cost implications that workers do not factor into their thinking and behaviour. This study highlights that there is, therefore, also a need for workers to be made aware of what the impact of increased defects to be recycled is and how that translates into waste of various forms.

If more organisations adopt lean as a philosophy, workers will be trained in lean manufacturing principles and techniques to be able to measure production efficiencies and help them to be more conscious about reducing waste. Management and workers should work together to implement lean manufacturing principles and techniques successfully.

Monitoring and control of the implemented lean manufacturing principles and techniques should be integrated into all processes. Adhering to standard operating procedures will help the organisation to be consistent with the product quality, minimise waste and control quality. Figure 5.1 provides an overview of how the various role players and processes work together within the case study environments.

6.4 RECOMMENDATIONS OF THE STUDY

Five recommendations for addressing and improving continuous process organisations in South Africa were formulated as follows:

Recommendation 1: **Managers must monitor adherence to standard operating procedures**.

Management should ensure that policies and set standard operating procedures are adhered to, and continuous monitoring takes place to ensure that workers do not regress again. The importance of following standard operating procedures must be explained to all employees to improve quality and product consistency, protect workers from knowledge loss, save on training and maintenance costs and simplify performance management.

Recommendation 2: It is recommended for a monthly forum to be established where workers can be taught and informed of the impact of the statistical data and number of defects and given an opportunity to provide input into how process efficiencies can be improved.

Management (leadership) and workers should work together as a team and constantly communicate about the challenges experienced during production processes for productivity to increase, misunderstandings between workers and management to be reduced, for creativity and innovation to increase, and for problems to be solved quickly. In addition, a monthly forum for workers and managers to exchange ideas as to how to solve pertinent issues. Training can be incorporated where specific issues are translated to workers that will help them to understand how what they are doing contributes to the issues being experienced in the production line. Over time, workers' behaviours and the culture of the production facility may change.

Recommendation 3: Management must facilitate proper maintenance execution through effective monitoring and control strategies.

Management, production staff and maintenance staff must ensure that proper maintenance (preventative and corrective maintenance) occurs to prevent the breakdown of machines and equipment. The implication of conducting scheduled preventative maintenance must be highlighted to staff in relation to long-term production losses and equipment failures. Effective maintenance will reduce waste and defects.

Recommendation 4: It is recommended that lean manufacturing be adopted as a philosophy within the case study examples.

By adopting lean manufacturing as a philosophy, workers will be trained in lean manufacturing principles and techniques, which will make them more conscious about minimising waste and maximising overall value to the customer.

6.5 RECOMMENDATIONS FOR FUTURE RESEARCH

This study explored how lean manufacturing principles can be applied in continuous processes within two case study examples. The sample can be enlarged for future studies to make the findings transferable. A future study can also conduct a comparative study of lean manufacturing in other countries.

6.6 CONCLUSIONS OF THE STUDY

Recycling is not cost-efficient because additional staff must be hired to sort the bottles into colours, an additional facility has to be constructed to cater to the recycling activities, and extra processes and logistical arrangements need to be put into place. Workers can help management reduce defects and enhance productivity if they are included in the production conversation and interpretation of the daily statistics. Following the standard operating procedures can help organisations reduce waste, minimise miscommunication and create consistency and uniformity in the organisation. However, the organisational plans, strategies and operating procedures must be amended to cater to and incorporate any changes that may have occurred to the organisation's technologies, processes, resources and strategies. Proper maintenance execution through effective monitoring and control strategies will reduce the breakdown of machines and equipment.

6.7 CHAPTER CONCLUSION

This chapter provided an overview of the study objectives, and the findings were grouped according to the secondary objectives. The primary research objective was to explore the lean techniques that can improve efficiencies in continuous processes in South Africa. The framework that was developed aims to highlight the relationships between the activities and actors that are involved in continuous processes in the case study examples. Lean manufacturing tools can be practised to reduce waste, increase value, improve quality and improve productivity. The chapter concludes with recommendations as well as recommendations for future studies and conclusions of the study.

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APPENDIX A: ETHICAL CLEARANCE CERTIFICATE

UNISA university of south africa

COLLEGE OF ECONOMIC AND MANAGEMENT SCIENCES
DEPARTMENTAL ETHICS REVIEW COMMITTEE
OPERATIONS MANAGEMENT

Date: 25 April 2019

NHREC Registration # : (if applicable)
ERC Reference # : OPS/2019/003

Name : Matshidiso Tsholetsane
Student #: 43808441

Dear Ms Matshidiso Tsholetsane

Decision: Ethics Approval from 7 March 2019 – 25 April 2024

Researcher(s): Matshidiso Tsholetsane
Department of Operations Management
College of CEMS
Email address: Etsholm1@unisa.ac.za

Supervisor: Dr A. Amidi-Echendu
Department of Operations Management
CEMS
E-mail Address: amadiag@unisa.ac.za
Tel number: 012 429 2627

Co-supervisor: N/A

Exploratory case studies on the implementation of lean manufacturing principles in continuous processes

Qualification: MCom in Business Management specialising with Operations Management

Thank you for the application for research ethics clearance by the Unisa Department of Operations Management Ethics Review Committee for the above mentioned research. Ethics approval is granted for 5 years (**see period mentioned above**).

*The **low risk application** was **reviewed** by the Department of Operations Management:*

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.

Open Rubric

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2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the Department of Operations Management Ethics Review Committee.
3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.

Note:

The reference number ERC Reference number ***OPS/2019/003*** *should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

Signature

Ethics Chair : Department : Operations Management

E-mail: cielact@unisa.ac.za

Tel: (012) 429 2497

Signature

Executive Dean : CEMS

E-mail: mogalmt@unisa.ac.za

Tel: (012) 4294805

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APPENDIX B: INTERVIEW QUESTIONS

Interview Questions

1. Which principles and activities are currently used in your organisation to reduce waste and optimise resources?
2. In your view, are there any other measures that may be introduced to reduce waste and optimise resources in your production processes?
3. How are staff members involved in reducing waste in the production processes in your organisation?
4. How regularly and meticulously are the activities in the production processes measured and reviewed in your organisation?

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APPENDIX C: CONSENT LETTER

CONSENT TO PARTICIPATE IN THIS STUDY

Dear Prospective Participant

My name is Matshidiso Tsholetsane, a master's student from the University of South Africa. My supervisor is Dr Anthea Amadi-Echendu. I am inviting you to participate in the study entitled: An exploratory case study on the implementation of lean manufacturing principles in continuous processes

Before you agree to participate in this study, you should know what is involved and this information leaflet is to help you decide. If you have any questions, which are not explained in this information leaflet, please feel free to ask me. You should not agree to participate in this research unless you are happy with all the aspects of this study that may affect your organisation.

WHY AM I CONDUCTING THE RESEARCH?

Studies in other parts of the world suggest that lean manufacturing principles has not been applied enough in continuous processes. The primary objective of this study is to explore how lean manufacturing principles can be applied in continuous production processes. Please see the following keywords of my studies and definitions

Keywords	Definition
Continuous production process/ Process industry	Manufacturing where the complete product are substances that cannot be discretely separated (e.g. chemicals, electricity, glass); in other instances, the complete items might be separated, yet their production calls for processes where the elements being worked on cannot be separated (e.g. steel, pharmaceuticals)
Lean manufacturing	A approach for refining business performance in many manufacturing, which removes unnecessary procedures, in order to increases productivity, improves quality and reduces lead times thereby, decreasing the overall costs,
Discrete manufacturing	Produces countable, distinguishable products and is identifiable in project-, jobbing-, batch- and mass process types

WHAT DOES THE STUDY INVOLVE?

This study will involve the following participants from your organisation: shop floor supervisors, managers and workers in your organisation. The researcher will conduct interview with each participant. The interview will take a one (1) hour with each participant and the study will last for entire year. Interview questions will be sent to participant in advance.

Selection criteria: Less than 3 years' experience in the focus area of the study and less than 3 years' operating on the job level.

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WHAT ARE THE RIGHTS OF THE PARTICIPANTS IN THIS STUDY?

Your organisation has signed a consent letter to take part in this study. You may refuse to take part at any time. You can also withdraw your consent at any time, before, during or at the end of the interview and discussions. Your withdrawal from the study will be without any adverse effect of any kind.

WILL ANY OF THE STUDY PROCEDURES RESULT IN DISCOMFORT OR INCONVENIENCE FOR THE ORGANISATION OR THE PARTICIPANTS?

Being part of an interview may make some participants feel uneasy as some of the questions deal with sensitive issues such as turnaround times and delays. If you feel unhappy with certain questions, you may refuse to answer them. A list of the research questions will be provided to participants to assist you in making an informed choice as to whether you would like to participate in the study or not.

WHAT ARE THE BENEFITS INVOLVED IN THIS STUDY?

This study seeks to identify strategies that are suitable for the adoption of lean principles in the continuous processes, which can be used to eliminate waste and improve productivity, reduce cost and improve profitability. Although this study cannot be transferable to other organisations, certain components of this study may be useful to other organisations that did not form part of this study but are using continuous process types. As such, the participants' awareness of lean principles may be enhanced. No gits or financial benefits will be given to any of the participant's.

HOW CAN YOU GET MORE INFORMATION FROM THE RESEARCHER?

You can contact Matshidiso Tsholetsane on 012 429 6012 if you need more information or would like to discuss this further. Alternatively, you may email her on etsholm1@unisa.ac.za. You can alternatively contact my supervisors at the University of South Africa:
Dr Anthea Amadi-Echendu
Email: amadiap@unisa.ac.za

CONFIDENTIALITY

The interviews will be held in private and all information gathered during the course of the study will be kept confidential. The written information and the audiotapes will be stored in a locked filing cabinet at the residence of the researcher when not in use. All forms will only be seen by the members of the research team. After five years, all audio tapes will be destroyed. We will write up on the study results in reports and journals. However, we will not include the name of the organisations where the research was carried out, nor will be include the names of any people who take part in this study. If you are happy to participate in the study, please read and sign the attached consent form.

INFORMED CONSENT

I ______________________________hereby confirm that I have been informed by the researcher Ms M. Tsholetsane about the nature, conduct, benefits and risks of the study. I have also received, read and understood the Participant leaflet and the Informed Consent regarding this study. I am aware that the results of the study, including any personal details, address and the name of the organisation in which the study will take place will not be stated in any study reports. I have also been informed that only relevant research team members will have access to the information.

I understand that I may at any time withdraw my consent and participation in the study, without having to give a reason. I am aware that I will not suffer any consequence if I withdraw my permission at any time. I have had sufficient opportunity to ask questions. I freely declare myself prepared to give permission for our organisation to be involved in this research.

I agree to the recording of the interview.

I have received a signed copy of the informed consent agreement.

Participant name & surname………………………………………… (please print)

Participant signature…………………………………………..Date…………………

Researcher's name & surname Matshidiso Tsholetsane

Researcher's signature………………………………………..Date…………………

Witness name & surname..(please print)

Witness's signature…………………………………...............Date…......................

APPENDIX D: PERMISSION LETTER TO CONDUCT THE STUDY FROM COMPANY A

[redacted]
Germiston
1401

Dear [redacted]

SUBJECT: REQUEST TO CONDUCT RESEARCH IN THE OPERATIONAL ENVIRONMENT

I am currently registered for the degree of a MCom in Business management (Operations Management) through the University of South Africa (UNISA), student number: 43808441 (Proof of registration is attached). I would like to request permission to conduct research within the [redacted] operational environment with specific emphasis on the [redacted]

The topic for my research study is "An exploratory case study on the implementation of lean manufacturing principles in continuous processes"

The purpose of the study "This study seeks to provide a review of lean manufacturing literature in a manner that will help to identify strategies suitable for the adoption of lean concepts in the continuous processes and develop a framework of how lean principles can be applied in continuous processes".

The **primary objective** of this study is to explore how lean manufacturing principles can be applied in continuous production processes.

The **secondary research** objectives of the study is to explore the following in support of achieving the primary objectives:

- to identify which lean principles are applicable to continuous production processes; and
- to identify when lean principles can be applied during continuous production processes

Open Rubric

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Methodology

The research will use qualitative approach.

Data collection method

The research will be conducted in three phases: Literature review, Qualitative observation and qualitative interview study.

Purpose of the interview

The researcher will conduct semi-structured, face-to-face interviews with participants. Open-ended questions will be asked so that the participants can share their views. Research interview questions will be developed based on the literature review and will aim to address the research question. The researcher will record the participants during the interview using voice recorder in order to obtain an unbiased record of the data collected

Include who will be involved - inclusion criteria

Sample and sample technique

This study will utilise non-probability sampling method and, in particular purposive sampling. The required participants will include two (2) shop floor supervisors, two (2) managers and two (2) workers in the respective case study environments.

Data analysis: The study will use content analysis to analyse data

Data Trustworthiness and credibility

This study will therefore triangulate by means of literature review, observation and interviews.

Ethical consideration

Should this request be approved, the researcher will sign a strict non-disclose agreement and the developed framework will be of good use to [redacted] The researcher will abide by the postgraduate policies of the University of South Africa. The researcher shall at all times demonstrate appropriate behavior in relation to the interest of the organization that forms part of the research interests.

Risk of the study

We do not foresee that the organization and will experience any negative consequences by completing the survey The researcher undertakes to keep any information provided herein confidential, not to let it out of our possession and to report on the findings from the perspective of the participating group and not from the perspective of an individual.

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We will request the following information from the organisation:
Examples: Email addresses, confidential reports and documents, documents that are not in the public domain, assistance with identification of participants.

The records will be kept for five years for audit purposes where after it will be permanently destroyed hard copies will be shredded, electronic versions will be permanently deleted from the hard drive of the computer and voice recorders will be destroyed. Participants will not be reimbursed or receive any incentives for their participation in the survey.

The research will be reviewed and approved by the Ethics Review Committee. The primary researcher, Matshidiso Tsholetsane, can be contacted during office hours at 012 429 6012. The study leader, Dr Anthea Amadi-Echendu, can be contacted during office hours at 012 429 2627

Matshidiso Tsholetsane
Lecturer –Office Management
Department of Operations Management

Approved: ____________ Not Approved ____________

[redacted]

Date: 19/10/2018

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APPENDIX E: PERMISSION LETTER TO CONDUCT THE STUDY FROM COMPANY B

UNISA university of south africa

[redacted]
Lephalale
0555

Dear [redacted]

SUBJECT: REQUEST TO CONDUCT RESEARCH IN THE OPERATIONAL ENVIRONMENT

I am currently registered for the degree of a MCom in Business management (Operations Management) through the University of South Africa (UNISA), student number: 43808441 (Proof of registration is attached). I would like to request permission to conduct research within [redacted]

The topic for my research study is "An exploratory case study on the implementation of lean manufacturing principles in continuous processes"

The purpose of the study "This study seeks to provide a review of lean manufacturing literature in a manner that will help to identify strategies suitable for the adoption of lean concepts in the continuous processes and develop a framework of how lean principles can be applied in continuous processes".

The **primary objective** of this study is to explore how lean manufacturing principles can be applied in continuous production processes.

The **secondary research** objectives of the study is to explore the following in support of achieving the primary objectives:

- to identify which lean principles are applicable to continuous production processes; and
- to identify when lean principles can be applied during continuous production processes

Open Rubric

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PO Box 392 UNISA 0003 South Africa
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Methodology

The research will use qualitative approach.

Data collection method

The research will be conducted in three phases: Literature review, Qualitative observation and qualitative interview study.

Purpose of the interview

The researcher will conduct semi-structured, face-to-face interviews with participants. Open-ended questions will be asked so that the participants can share their views. Research interview questions will be developed based on the literature review and will aim to address the research question. The researcher will record the participants during the interview using voice recorder in order to obtain an unbiased record of the data collected.

Include who will be involved - inclusion criteria

Sample and sample technique

This study will utilise non-probability sampling method and, in particular purposive sampling. The required participants will include two (2) shop floor supervisors, two (2) managers and two (2) workers in the respective case study environments.

Data analysis: The study will use content analysis to analyse data.

Data Trustworthiness and credibility

This study will therefore triangulate by means of literature review, observation and interviews.

Ethical consideration

Should this request be approved, the researcher will sign a strict non-disclose agreement and the developed framework will be of good use to [redacted] The researcher will abide by the postgraduate policies of the University of South Africa. The researcher shall at all times demonstrate appropriate behavior in relation to the interest of the organization that forms part of the research interests.

Risk of the study

We do not foresee that the organization and will experience any negative consequences by completing the survey. The researcher undertakes to keep any information provided herein confidential, not to let it out of our possession and to report on the findings from the perspective of the participating group and not from the perspective of an individual.

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We will request the following information from the organisation:
Examples: Email addresses, confidential reports and documents, documents that are not in the public domain, assistance with identification of participants.

The records will be kept for five years for audit purposes where after it will be permanently destroyed hard copies will be shredded, electronic versions will be permanently deleted from the hard drive of the computer and voice recorders will be destroyed. Participants will not be reimbursed or receive any incentives for their participation in the survey.

The research will be reviewed and approved by the Ethics Review Committee. The primary researcher, Matshidiso Tsholetsane, can be contacted during office hours at 012 429 6012. The study leader, Dr Anthea Amadi-Echendu, can be contacted during office hours at 012 429 2627

____
Matshidiso Tsholetsane
Lecturer –Office Management
Department of Operations Management

Approved: __________ Not Approved__________

[redacted]

Date: 2018/10/23

Acting Manager: Quality Assurance
[redacted]

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[redacted]	**TEMPORARY SIGNING AUTHORITY**	[redacted] Rev 1 Page 1/1

[redacted]	[redacted]	[redacted]
NAME	**UNIQUE NUMBER**	**COST CENTRE**
QUALITY ASSURANCE	SNR ADVISOR	[redacted]
DEPT / FUNCTION / SECTION	**DESIGNATION**	**SIGNATURE**

Is hereby delegated all "Organizational level" signing authority as per Management Signing Authority procedure - PS/014/001 normally held by:

[redacted]	ACTING QUALITY MANAGER	[redacted]
NAME	**DESIGNATION**	**SIGNATURE**

Please tick applicable Organizational level	HOS	HOF	HOD	GM

Please tick the applicable PROXY that has been assigned	[redacted]	YES ☐ NO ☒	[redacted]	YES ☒ NO ☐
	[redacted]	YES ☐	NO ☒	

The delegee shall ensure that any further delegation or sub-delegation is to a functionary with the appropriate seniority, skill, expertise and knowledge to exercise such authority in an effective manner, and shall ensure that such authorities are reviewed on a regular basis. (GGD0606 Rev 6)

		FOR THE PERIOD	
FROM	2018/10/22	TO	2018/11/09

UNLESS NOTED BY EXCEPTION.

This authority remains in force for the period stipulated and may only be extended by signature of the Departmental Manager.

EXCEPTIONS None

AUTHORISED BY HOF / HOD / GM			
	NAME	**SIGNATURE**	**DATE**

ACKNOWLEDGEMENT OF APPOINTMENT

I hereby acknowledge and accept the above mentioned appointment and declare that I am fully conversant with the relevant Procedure PS/014/001.

NAME	**SIGNATURE**	**DATE**