Investigating the influence of operations management decisions on overall equipment effectiveness in an engineering company

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Mini-dissertation accepted in fulfillment of the requirements for the degree Master of *Business Administration* at the North-West University

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Graduation: June 2022
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ABSTRACT

The study investigating the influence of operations management decisions on overall equipment effectiveness in an engineering company. The company is based in Gauteng and 139 employees are involved in producing engineering solutions. The objective of this study was to find out what influence management decisions have on the over equipment efficiency, which currently stands at 46%, with the company improvement target set to 60%.

The literature was meant to give a theoretical understanding on the following principles such the definition of OEE, factors effecting OEE such as the elements of overall equipment efficiency, the calculations for overall equipment efficiency, overall equipment effectiveness, OEE benefits, a typical form of operational decisions in any business, and the decision challenges in operations management.

The population of the study design involved the manufacturing unit, which consists of 139 employees and over 20 CNC and other machines. A qualitative approach was used, and the sample was 6 CNC machines in the technical study analysis. The response rate was 33 from 139 employees. The data collection was done through a management questionnaire that was distributed in the company, and the technical data collection instrument was used to calculate the prior average OEE score. The OEE scores are from the company’s historical data (2019 -2021).

The results were obtained from factors that influence operations management decisions and included and discussed in the report and recommendations will addressed in the final chapter.

ACKNOWLEDGEMENTS

I want to start by thanking our Saviour who guided and provided me with this opportunity to study, who kept me going in these difficult times, and to gain from a self-learning experience that taught me a lot about self-discipline, motivation, and faith.

This research is dedicated to my employer and colleagues, including other industries who intend to drive continuous improvement by cultivating overall equipment effectiveness.

A study of this extend requires collaboration and support of diverse people who deserve to be acknowledged. Firstly, I would like to thank my wife and family for their support and encouragement during this research.

Mrs Wilma Pretorius for her continued supports to resolve clearance seeking questions related to MBA, Prof Manda Badnock for his great mentorship and guidance, especially during this research, Prof Christoff Botha and Prof Yvonne du Plessis for facilitating the mini dissertation, and lastly Prof Johan Jordaan for his role at the scientific committee.

Thank you to Ms Marieta Grundling for the editing and Dr Bothma (FC) for assisting with the data analysis.

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LIST OF ABBREVIATIONS

FMEA	Failure Mode Effective Analysis
iBPMS	Intelligent Business Process Management Software
MP	Maintenance Prevention
OEE	Overall Equipment Effectiveness
OEM	Operations Equipment Manufactures
SOP	Standard Operations Procedure
SPC	Statistical Process Control
TBM	Time-Based Maintenance
TC	Total Count
TPM	Total Productive Maintenance
TQM	Total Quality Management

CHAPTER 1: CONTEXTUALISATION OF THE STUDY

1.1 Introduction

This chapter introduces the study and presents the background to the study and the problem statement will be formulated. The aim of the study as well as the research objectives and questions formulated are presented. The theoretical and managerial significance of the study are presented. The chapter concludes with the format of the study, per chapter.

1.2 Background

Company A is a world-leading provider of engineering technology, and has been a leader in the field for more than 100 years. The company is headquartered in Chicago, Illinois. It is a global leader in applying advanced technologies for the safety and security sectors, contraband detection, energy, medical devices, communications, and engineered components. (Company A, 2020)

Company A is a well-organised global company that has a total of 54 branches and 4 manufacturing facilities across the globe. Company A employs more than 5,800 workers around the globe; Company A is both the supplier and service choice for products while in use. Company A's reputation for outstanding design and engineering of the highest quality, durability, and customised products and solutions allows them to retain their competitive advantage. One of the core focal points is to align partnerships with the customers and assist in meeting the latest environmental standards, whilst keeping their operations safe and controlled. (Klassen, R.D. and Vereecke, A., 2012)

Company A is in partnership with customers globally to deliver innovative solutions designed to improve the reliability of the equipment and the process through unrelenting focus on quality, a desire for best service with an uncompromising commitment to people, safety, the environment, and ethical business practices.

Overall equipment effectiveness (OEE) is a tool for assessing the efficiency of assets throughout the manufacturing process. The OEE can be equally successful in the investigation on equipment, processes, and tools that impact how assets operate. The OEE provides a great foundation for identifying areas of an operation that can be improved and a quantifiable way to measure progress.

Furthermore, the OEE is a tool to measure overall productivity using the three elements of performance, availability, and quality. It identifies potential losses and provides corrective actions that could be used to eliminate potential losses. As stated, Company A is global. However, this study is to focus on the South African-based unit situated in Gauteng. It uses numerical control machines (CNC) to make engineering products and solutions. There are about 20 CNC machines. The total number of employees are 120 all headed by a CEO.

The need for continuous improvement (CI) is one of the key fundamentals that cannot be overemphasised. Measuring OEE is a manufacturing best practice. OEE is the single best metric for identifying underlying losses and improving the productivity of manufacturing equipment (eliminating waste) and gaining insight on how to improve the manufacturing process. The operation's management team has embarked on a project namely "Apollo" to focus on all the manufacturing facilities to achieve a global standard of 60% OEE for the CNC machines.

Business is focused on optimisation and improvement of productivity to prevent unplanned production losses and eliminate defects. This not only improves the quality of the product, but also lowers manufacturing costs, which helps to meet customer specifications or demands, and remains competitive in the market. (Ross, 2017)

1.3 Problem statement

At Company A, the current machine operating capacity curve on the operating equipment efficiency shows that the company has an average of 40% of equipment operating efficiency. This is the average for all the 20 CNC machines. Management has set a target of 60% as an acceptable OEE. The global design standard is 60%.

(Lean Production, 2021) The concern is the OEE rate that does not meet the global standard of 60%.

Certain operations management decisions can influence the overall equipment effectiveness namely.

- Designing of goods and service
- Human Resources and Job design
- Inventory management
- Layout Strategy
- Location analysis and strategy
- Process and Capacity Design
- Process Maintenance
- Quality management
- Scheduling
- Supply chain management

The extent of how these affect the OEE is not known. Currently, the machine operating capacity curve on the operating equipment efficiency shows that the company has an average of 45% of equipment operating efficiency that can be improved.

Consequently, this research is to conduct an in-depth research study on the influence of operations management decisions on overall equipment effectiveness in computer numerical control machines. According to (Hill, 2017) in manufacturing industries, production machines are critical. They are required to be available for production if the company needs to stay competitive in the market. (Hill, 2017)

The research will be conducted through a quantitative method. Certain operations management decisions will have an impact on overall equipment effectiveness.

1.4 Core research question

The research question is "to what extent do operations management decisions influence the overall equipment effectiveness of CNC machines".

1.4.1 Aim of the study

The study aims to investigate the influence of operations management decisions on the overall equipment effectiveness.

1.5 Research questions

The specific research questions are:

1. What are the constraints in achieving the desired OEE value?

2. Which operations management decisions impact negatively and positively on the OEE?

3. What other alternatives are available and how can they be implemented to achieve an OEE global standard of 60%?

4. Is the current data collection system sufficient to quantify the OEE score on the CNC machines?

1.6 Research objectives

The main objective is to determine why the operations team is not reaching the OEE target in all the shifts.

1.6.1 Secondary objectives

The secondary objectives are:

1. To determine which OEE management decisions are least emphasised.

2. To determine which OEE operations management decisions impact negatively and positively.

3. To come up with a recommendation to improve the OEE.

1.7 Research Design

The population and sampling consist of theory and practice. The theory will be aimed at the OEE efficiency, and the sampling will be done through a questionnaire that will be addressing the outcome of the respondents.

1.7.1 The Target Population

The target population is the entire manufacturing unit situated in Springs, Gauteng, South Africa. The unit consists of 139 employees, and over 20 CNC and other machines. There are 34 managerial and supervisory workers, and 15 CNC operators. Out of 139 dedicated employees (population) at the Springs facility, the study is going to focus on six CNC machines. A draft of the questionnaire will be discussed and shared among the decisional managers, and includes three managers from operations, quality, and planning, with two operators on the CNC machines.

1.7.2 Sampling

The sample from 20 machines, 6 CNC machines will be used as a sample in the technical study analysis. These machines were selected as they are used to make the most critical components that generate 60% of the revenue. Out of the 139 employees, 12 managers and operators will be selected for the questionnaire.

The data sampling is involved under several continuities, which form part of master data capturing, computing production orders, material issuing, and production. One operations manager is overseeing the quality manager and the production manager, whereas the management team forms part of three managers and the specified equipment of 6 CNC machines with two operators. The research approach consists of quantitative research, where data from 2015 to 2020 to be retrieved and used, discussed, and revised.

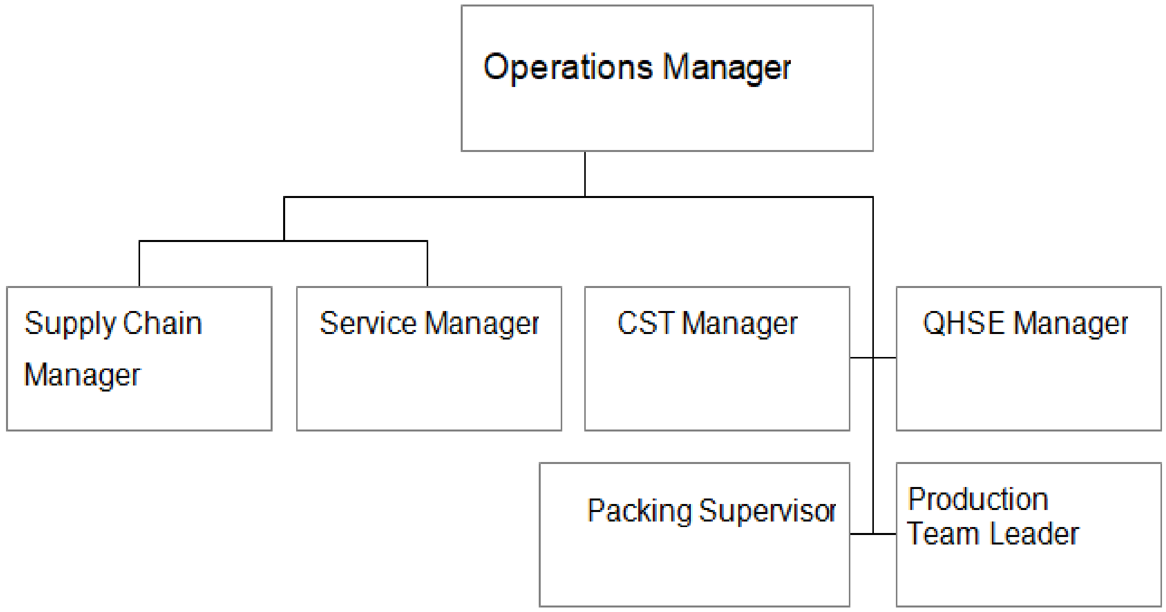

Figure 3.1: Organogram of Operations

The quantitative research will be conducted with the managers and employees within each department with a constructed questionnaire survey that reflects efficiency, available operator, and output quality to improve its overall operating equipment efficiency to meet an excellent standard of 60%. The target is to capture the data telemetry on installed CNC machines that will be used to collect data to conclude the analysis to determine its operating schedules, and overall capacity that would investigate the influence of operations management decisions on overall equipment effectiveness on six CNC machines.

The manual-operated machines will not be used during the research simply due to the technology and the company's vision for a technology upgrade in the future. The computer numerical control machines will be used for my sampling size, which is used for manufacturing and fine rounding during manufacturing such as machining. The production planning and quality pass will also be used.

1.7.3 Data collection

In this section, the data collection instruments used is presented.

1.7.4 Management Questionnaire

To the operations management part of overall equipment, effectiveness aligns with decisional aspects such as the task of designing, establishing, planning, and running, controlling, maintaining, and improving on overall equipment effectiveness systems. The planning, scheduling, and forecasting are assisted by developing the processes required for product realization. Planning of product realization shall be consistent with the requirements of the other processes, which form the Quality Management System.

The first instrument, namely a designed questionnaire, will be used to measure the management decisions to determine the influence it has on the current OEE score on the CNC machines. A questionnaire will be utilised to measure managers' decisions appended in Appendix C. The questionnaire was taken and approved by the company.

A few examples of operational decisions in the day-to-day operations of a business:

- How much tax should this customer pay?
- What are the products or services that can be offered to a customer?
- Is this transaction likely to be fraudulent?
- How do we handle exceptions in this claim process?
- Are we compliant with state regulations?

1.7.5 Technical Data collection instrument

The second instrument will be utilised to collect the computer-calculated data prior to the OEE percentage score. The quantitative data will be collected by using a machine-operated efficiency chart from 2019 to 2021. This includes the date when the equipment was used, the day on the date. The autonomous maintenance / preventative maintenance hours will be captured.

The machine housekeeping, in hours will be captured. Breakdowns such as the mechanical breakdown, electrical breakdown in hours will also be retrieved. The new program will be allocated to a certain type of work that is planned for manufacturing, followed by the setup time, tool change time, dimensional checking. The quality forms part of the next information capturing where quality decision delay is to be included, followed by the number of materials, metrication, number load, and electricity to be included that will provide a total time in minutes spent.

1.8 Research ethics

A letter of consent was supplied by Company A, which was selected for this research. The letter serves as proof and the understanding that the investigation in the organisation is permitted in terms of the field of study and research prospectus. The confidentiality of the data is guaranteed and only the combined results will be used for research and publication purposes.

No actual figures will be published due to competitor interest. All data gathered from the questionnaires will only be used for research purposes. Participation in the study is voluntary. The participants can withdraw from the study if they wish to do so.

1.9 Importance and benefits of the proposed study

The importance of this study is to identify the constraints, issues, to look for an alternative approach as management. To improve the efficiency on overall equipment effectiveness. The benefit of the research is based on improvement, the adoption capability within production, and the productivity that forms part of the company vision and mission. The study will identify the problem and will bring new ideas with the thought that will be discussed through management to capitalize, to meet the objective at a given time.

1.10 Delimitations and assumptions

The delimitations and assumptions of the study will be presented.

1.10.1 Delimitations (scope)

The study is established in an operations management environment, with the basic principles of availability, efficiency, and effectiveness of production machines, including computer numerical machines in a high volume-driven manufacturing environment. The research is limited to the subsidiary of Company A situated in Gauteng.

1.10.2 Assumptions

The participants will answer the questionnaire honestly. Secondly, the participants are experienced and subject experts in the field of CNC machines and throughout the organisation.

1.11 Structure of the study

The study has five chapters, starting with the introduction, literature review, research design, and methodology, results, discussions, and analysis and concluding with recommendations. The structure of the study will also give the reader different research areas where the impact of management decisions and the OEE effectiveness are discussed.

Chapter 1: Introduction: This chapter introduces the background and problem statement; followed by the aim, research questions and objectives, as well as a summary on the methodology used to conduct the research.

Chapter 2: A literature review: In this chapter, the history of overall equipment efficiency and the elements of overall equipment efficiency are presented, as well as the concept of total production management and operational decisions.

Chapter 3: Research design and methodology: This chapter gives an overview of the research methodology, design, research paradigm selected, and the population and sample selected. The data collection instrument and methods are justified, and ethical considerations are described.

Chapter 4: Results, Discussion, and Analysis: The chapter presents the data collected and analysed, the results from the data analysis in tables and figures, as well as discussions on the results.

Chapter 5: Conclusion and Recommendations: The last chapter presents the conclusions from the findings and presents recommendations and conclusions from the study.

1.12 Conclusion

In this chapter, a brief explanation on the study was provided, which explained with the objectives that this research aims to achieve in the field of operations. The problem statement and the core questions formulated were provided, including the significance of the study. Chapter 1 gave a structure on what the other chapters in the study will deliver regarding the impact of management decisions on the OEE in a manufacturing company. In the next chapter, the literature review conducted for the study is presented.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter presents the literature on the areas under study, explains the history of the OEE with a formulated equation of how the OEE are measured and calculated. The standards benchmark for a good OEE efficiency rate will be provided with the benefits of OEE in a manufacturing company. It then dwells on the management decisions that effect OEE.

2.2 History of Overall Equipment Efficiency

The OEE effectiveness was invented in the the1960s in Japan, where the pioneerand creator of the Total Productive Maintenance (TPM) system, Seiichi Nakajima, who was later hailed as the the father of TPM. (Parikh & Mahamuni, 2015) OEE primarily focuses on sub-components of the manufacturing process, which are listed as Availability, Performance, and Quality. (Noon, Jenkins & Lucio, 2000)

2.3 Elements of Overall Equipment Efficiency

OEE is mainly applied as a measuring tool to assess the efficiency of assets in the manufacturing process. The OEE is just as effective in the investigating of people, processes, and tools that might have an impact on the manner in which assets operate. In addiction OEE also provides a basis for the identification areas in an operation that could benefit from improvement, as it is a quantifiable way to measure progress.

2.4 Overall Equipment Effectiveness

OEE is the ultimate in measuring manufacturing productivity, and is referred to as the gold standard in the industry. OEE identifies the proportion of manufacturing time that is truly productive. The OEE score is counted out of 100%, and refers to manufacturing only. In short, the manufacturing of good parts in the fastest time possible with no stop time. According to Binti Aminuddin, Garza-Reyes, Kumar, Antony and Rocha-Lona (2015: 4431), “the OEE score means 100% Quality (only good parts), 100% performance (as fast as possible), and 100% availability (no stop time).”

Therefore, OEE measures manufacturing best practices as well as the underlying losses. Important insights can be gained by understanding how to improve the manufacturing process. OEE is the single best metric for identifying losses, benchmarking progress, and improving the productivity of manufacturing equipment (Bhadury, 2000). According to (Clarke, 2018), OEE is one of the most important performance measurements in modern manufacturing facilities.

As a manufacturing and cross-selling company serving as a global leader in its market, directors, stakeholders, and investors are eager to have a well-performed and accurate drive towards manufacturing and equipment efficiency including the quality of production to meet global score standards of 85% overall equipment efficiency. Furthermore, (Clark, 2018) states that overall equipment efficiency has the following problematic areas such as.

- **Availability:** Planned stops in production for setups and adjustments such as planned maintenance, cleaning, and quality inspections. Besides, unplanned stops in production, typically because of breakdowns, also negatively influence OEE. Shortstops and short periods are important too. These stops can occur for a range of different reasons including blocked sensors, misfeeds, and jams.

- **Performance:** This applies when production does not run at its full capacity. This could be because of worn-out equipment, poorly maintained equipment, environmental factors, or operator issues. Examples of the latter include operator errors, inexperience, or availability.

- **Quality:** Defective products as well as the reduced yield that occurs because of defective products. Examples include operator error, wrong settings, and inefficient batch changeover processes.

2.5 The calculation for overall equipment efficiency

The literature defines OEE as a hierarchy of standard measurement, which was developed to evaluate how high volume-driven manufacturing operations could be applied to effectively use machines and raw materials in manufacturing operations. (Binti Aminuddin et al., 2015) OEE is based on four factors namely, labour efficiency, availability, performance, and quality as presented in Figure 2.1 below.

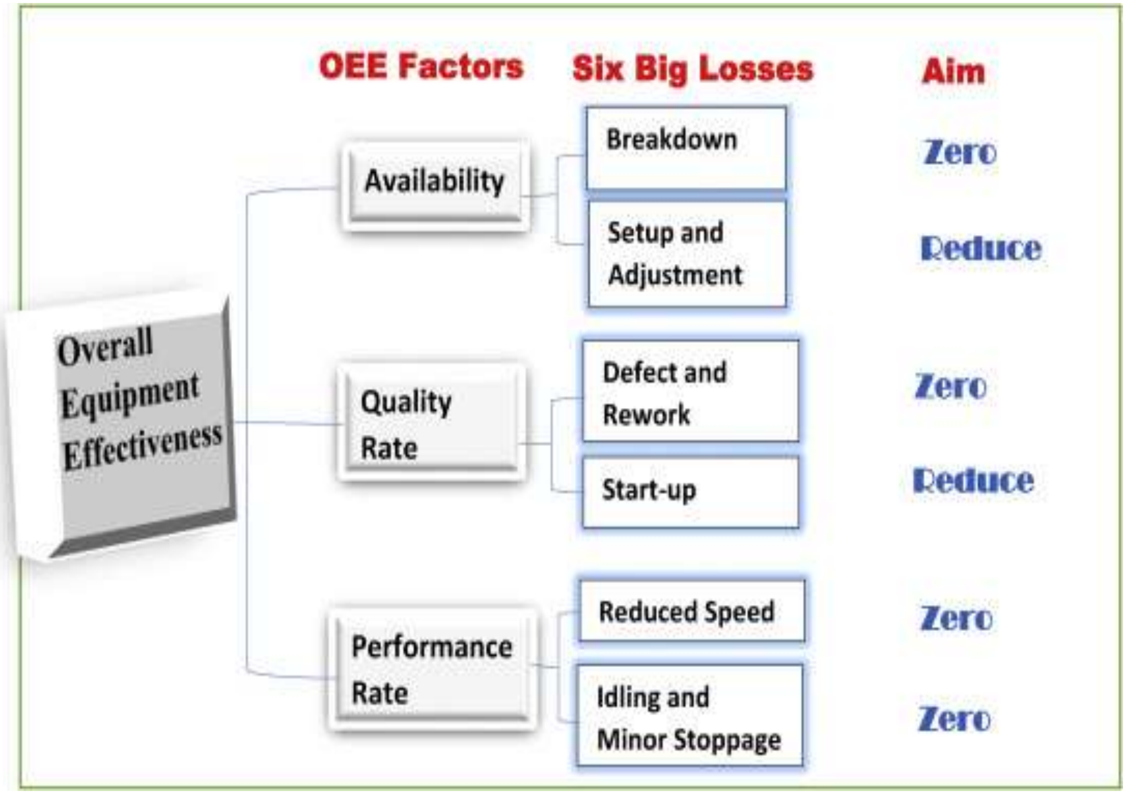

Figure 2.1: Overall Equipment Effectiveness (OEE) Factor Layout

Overall Equipment Effectiveness (OEE) is depicted in Figure 2.1 as a hierarchy of standard measurement. It is based on the labour efficiency, availability, performance, and quality. A detailed description of the formulas is presented below:

Overall Equipment Effectiveness (**OEE)** = Availability x Performance x Quality

Availability replicates to all events that stop planned production long enough where it makes sense to track a reason for being down.

Availability = Run Time / Planned Production Time

Run Time is Planned Production Timeless Stop Time, as for Stop Time is defined as all-time where the manufacturing process was intended to be running but was not due to Unplanned Stops such as breakdowns or Planned Stops like changeovers.

Run Time = Planned Production Time − Stop Time

Performance considers anything that motives the manufacturing process to run at less than the maximum possible speed. When it is running including both Slow Cycles and Small Stops. The performance is the ratio of Net Run Time to Run Time and is calculated as:

Performance = (Ideal Cycle Time × Total Count) / Run Time

The ideal cycle time is the fastest cycle time that a process can achieve in optimal settings. Hence, when it is multiplied by the Total Count, the result is Net Run Time which is (the fastest possible time to manufacture the parts. Since the rate is shared of time, Performance can also be calculated as:

Performance = (Total Count / Run Time) / Ideal Run Rate

The Performance should never be greater than 100%. If it goes beyond, it usually indicates that the Ideal Cycle Time is set incorrectly or is set is too high.

Quality = Good Count / Total Count

The quality considers manufactured parts that do not meet quality standards and parts that need rework. OEE Quality is like the First Pass Yield, in that it defines

Good Parts as parts that successfully pass through the manufacturing process the first time without needing any rework. A Standard Table for benchmarking OEE is presented in Table 2.1 below.

Table 2.1: A Standard Table for benchmarking OEE

Benchmarking OEE		
Ideal	**Normal**	**%**
Availability	90%	79%
Performance	95%	80%
Quality	99.90%	95%
OEE	85%	60%

The Standard table for benchmarking provides a standard bench-marking rate in OEE efficiency that involves the availability performance and quality, which forms part of a global standard. (Grenčík, J. and Legát, V., 2007)

2.6 Overall equipment effectiveness (OEE) benefits

Clark (2018) mentions that OEE has the following benefits:

- OEE carries a significant return on investment whether increasing capacity, driving efficiencies, launching new products, and more.
- OEE ensures existing equipment is used to its fullest capacity, reducing the need for investment in other areas.
- OEE provides better oversight of the production process.
- OEE helps maintain competitiveness in the market, particularly in competitive industries like pharmaceutical and medical device manufacturing.

- Enhanced process quality will save time and money, as well as helping maintain reputation in the market while also avoiding the risks and consequences of product recalls.

- OEE advances the scalability of the production line.

- OEE decreases machine maintenance and repair costs as you can put proper plans and schedules in place.

2.7 Total Productive Maintenance (TPM)

Total productive maintenance (TPM) is a “Japanese philosophy that focuses upon achieving zero breakdowns and zero defects by maintaining the equipment” throughout its use. (Parikh & Mahamuni, 2015) It is thus the process whereby machines, equipment, employees, and supporting processes are used to not only maintain, but also improve production integrity quality of the systems. Traditional total productive maintenance was developed by Seiichi Nakajima of Japan. The results of his work on the subject led to the TPM process in the late 1960s and early 1970s.

Nipponese became the leading company after implementing a TPM program. The company is now used as the international accepted benchmark for the implementation of TPM. It incorporates lean manufacturing techniques, and TPM is built on eight pillars based on the 5-S system. (Singh, Gohil, Shah & Desai, 2013)

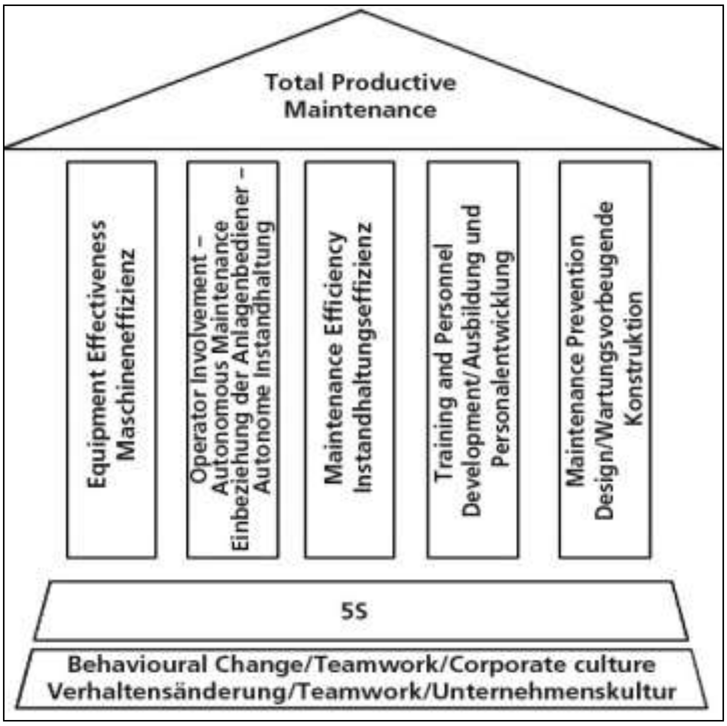

Figure 2.2: Typical 5 S -Total Maintenance Model

Source: Singh, Gohil, Shah and Desai (2013)

The 5 -S in the total productive maintenance consists of the following:

- Sort – To determine which items are used frequently or not.
- Systemize – The items should have a place for each.
- Shine – Housekeeping should always be obtained.
- Standardized – similar checks and balances applicable through the process.
- Sustain – To maintain efforts (continuous improvement).

2.8 The core elements of TPM

The operator Self-Maintenance Basic involves a program, lubrication, general inspection, and minor preventative maintenance to be completed by production operators. By conducting planned maintenance to develop and execute planned maintenance activities. (Venkatesh, Jindal. 2007)

2.9 Operations

Operations management is defined by (Bellgran & Säfsten, 2009; Galvin, 2009; Gunether, 2018; Stevenson, 2002; Kazi, 2010) As the management of systems or processes that create goods and provide services. It is an area of management concerned with designing and controlling the process of production and redesigning business operations in the productions of goods and services. Operations management involves the planning, organising, coordinating, and controlling all the resources needed to produce a company's goods and services, it also involves managing people, equipment, technology, information, and all the other resources needed in the production of goods and services. (Smit, P.J., Cronje, G.D., Brevis, T., and Vrba, M.J. eds., 2011)

The part of operation management in the company is the transformation role in the process of changing inputs. This includes changing raw materials into finished goods and services (Domingues & Machado, 2017; Fiorentino, 2018). It is directly responsible for many decisions inside the company including activities that give escalation to product design and delivery problems (Peinado et al., 2018). The operation's purpose is the doing part of the organization (Barnes 2008). No organization can hope to be successful unless its operations are well managed. The importance of operations is emphasised by Hill (2005), points out that it is the "function" that is responsible for 60-70 percent of costs, assets, and people. Operations management (OM) is the set of activities that creates value in the form of goods and services by transforming inputs into outputs (Waters, 2002)

Operations management decisions affect the inputs, operations, and outputs and operation managers use feedback on performance and additional information, which are relevant to update their decisions. Any firm, which is into business including wide variety of businesses, involving finance, consulting, marketing, and graphic design firms, is faced with 100 decisions that they must take in a day. Technology Developments is full of useful insights into today's technology that makes an impact based on how companies adapt to their operations. (Hill, 2005)

2.10 A typical form of Operational decisions in any business

A typical form of Operational decisions in any business is set in the following types:

2.10.1 Pricing

Pricing is important since it defines the value of a product. It is the tangible price point to let customers know whether it is worth their time and investment. (Bardakci, A. and Whitelock, J., 2003)

2.10.2 Promotions

Promotions involve a lot of operating decisions, like how to promote the product, and which areas or mediums will give the best ROI after promotions. Similarly, getting the promotional material ready and ensuring that the promotions are done properly in the market are all operational decisions that are to be taken from time to time. This is a task that is vast and can make a big influence on the overall running of an organisation. From the bottom level upwards, a lot of information are collected, which must be summarized through the operations management level and finally submitted at the director level. The major operational decisions must be taken every day and are mostly outsourced or are managed via a chain of command in between. There are other operational decisions also which are made in the day-to-day running of a business. (Banker, R.D., Kauffman, R.J. and Morey, R.C., 1990)

2.10.3 Maintaining Inventory

It allows for a variety of practical and financial benefits including consistently meeting the increases in demand without having to wait for a full production cycle to complete before receiving more products. It allows you to fill orders quickly and efficiently. Although there are a few problems when it comes to maintaining inventory such as inconsistent tracking, warehouse efficiency, inaccurate data, and changes, in demand, manual documentation, stock faulty, and supply chain complexity. There are several stock control methods to assist with maintaining inventory. The Just in Time (JIT) aims to reduce costs by cutting stock to a minimum. Items will be needed and used immediately. (Hiltrop, Jean M. 1992)

2.10.4 Customer management

Customer management is defined as the process of managing the relationship between an organisation, its people, and its customers over time. (Adhikari, Balaram, and Bibhav Adhikari, 2009) The company uses a CRM system that helps to capture leads, that systematizes messaging, to action daily tasks, to follow up on the task, to generate a weekly plan or action plan that is online with support if required. The CRM namely C4C referred to as customer for cloud was implemented in the 2000s.

2.10.5 Employee management

Employee management is the determination to help employees do their best work each day to reach the larger goals of the organisation. Some various tasks and duties fall under employee management. Most of them can fit into one of five categories namely. (Abrahamson, E. and Eisenman, M., 2008)

2.10.6 Logistical decisions

As defined earlier, logistics involves delivering the right product to the right customer at the right place, at the right time, and with the right cost and quality (Armington, Chen & Babbitt, 2021)

2.10.7 Sales and outreach

In general, calculating the time spent on operations is important for any organization as a manager you do not want to waste your resources. Operational decisions need to be managed through the day-to-day activities especially when the organization grows including daily activities. Henceforth the business needs to hire more employees, or an organization needs to hire managers to manage such operational decisions. (Hales, Colin, 2005)

2.11 Other operational decisions

Other known operational decisions in the day-to-day operations of a business are as follows:

2.11.1 Service product and design

Product requirements are clearly defined Contract or order requirements differing from those previously expressed are resolved the organization could meet the defined requirements. The overall responsibility for manufacturing process control lies with the company's Operations Manager. (Kumar, S.A. and Suresh, N., 2006) This responsibility is exercised in conjunction with local Team Leaders/Managers. All team members are responsible for the quality of the work they produce and for ensuring that only acceptable products are passed for further operations. The manufacture of components and the reconditioning of products are planned by each location and recorded on a routing document. (Juran, J.M. and De Feo, J.A., 2010)

2.11.2 Quality Management

Company A ensures that planning and development of the processes for product and service awareness are consistent with the requirements of other processes of the QMS. Management is responsible for adherence to and documentation of site quality requirements regarding product and service realization planning. Confirmation, proof, monitoring, and test activities and records as related to product and service acceptance have been established. These can take the form of standard operating procedures, work instructions, test frequency, sample, and product identification, as well as preservation of the product. Customer-specific requirements and references will be involved in the planning of product realization. Changes that affect product and service realization shall be controlled and reacted to through the change management processes. Documented information stating the results of a review of changes, the personnel authorizing change, and any necessary actions must be retained. (Board, B.A.C., 2014)

2.11.3 Process Capacity Design

To determine how company A will plan and develop the processes needed for product realization. Planning of product realization shall be consistent with the requirements of the other processes, which form the Quality Management System. In the planning of product realization, company A will determine, as appropriate, the following: Quality Objectives and requirements for the product. The processes, documents, and resources are specific to the products. (Pióro, M. and Medhi, D.,

2004) Records will be maintained to provide evidence of the realization process and that the resulting product meets the initial requirements

2.11.4 Location

Company A is situated in Springs, South Africa where it is central to most of its customers within its targeted markets. The manufacturing facility has the following equipment where some will be used in the research.

- 6 Braiding Machines
- 2 Bobbing winders
- 10 ton & 160ton press
- All common sizes and styles available Ex-stock
- Pre-cut rings available on request
- Technical support
- 24/7 service

2.11.5 Inventory Management

Storage areas/stores equipped with appropriate facilities are provided at all locations to prevent deterioration, loss of identity, or damage of materials, work-in-progress and finished products pending use, inspection/test, or delivery. Receipts and access to and from such areas are controlled. The organisation uses an inventory management system to optimise inventory turnover times. Consideration is given to storage conditions and climatic conditions. (Kolias, G.D., Dimelis, S.P. and Filios, V.P., 2011) All raw materials bought-out or manufactured components, subassemblies, and assemblies are identified at all stages from receipt to dispatch, to ensure correct items are being processed, and to provide the necessary traceability. Minimum identification is by the company’s part number through physical marking, labeling, or containment. In addition, all raw materials are supplied, identifiable to a purchase order item, and a cast/heat number with commonly used bar and strip colour coded for ease of identification. (Speight, J.G., 2014)

2.11.6 Scheduling

Scheduling develops aggregate level production plans into part-number level production schedules and associated production orders. Horizon is from 1 week to the longest cumulative product lead-time. (Tallon, W.J., 1987) Company A develops aggregate level production plans into part-number level production schedules and associated production orders.

2.11.7 Maintenance

Having accurate inventory and regular updates are vital. Collecting continuous improvement ideas at the site level to review and ensure the best one is rewarded. Communication regarding manufacturing updates should be communicated more often; perhaps a direct display on the manufacturing list can be more beneficial. (Coronado, R.B. and Antony, J., 2002)

Access from all branches to the manufacturing outlet is essential. Critical spares should be kept at a central place. Deploy waste elimination methodology, and develop and publish waste elimination site training plan. Housekeeping should be obtained regularly, and lastly, prestart machining inspection to followed and monitored frequently. By creating a safer working environment, the organisation can improve maintenance, especially secure that incidents will occur, resulting in loss of time in production and other value time to execute tasks. (Iverson, D.L., Martin, R., Schwabacher, M., Spirkovska, L., Taylor, W., Mackey, R., Castle, J.P. and Baskaran, V., 2012) Improving equipment effectiveness should be available when needed and producing as expected. Delight the customer. Moving from reactive to preventive and predictive maintenance assist by reducing operating costs.

2.12 Characteristics of Operational Decisions

Operational decisions are typically structured and are mostly repeated many times every day. The operational decisions can be exhibited once, and then reused and executed multiple times against many records and transactions, such as the calculation of tax for a portfolio of investments, or the calculation of a bill for a patient in a hospital.

A typical operational decision structure may be illustrated as shown below:

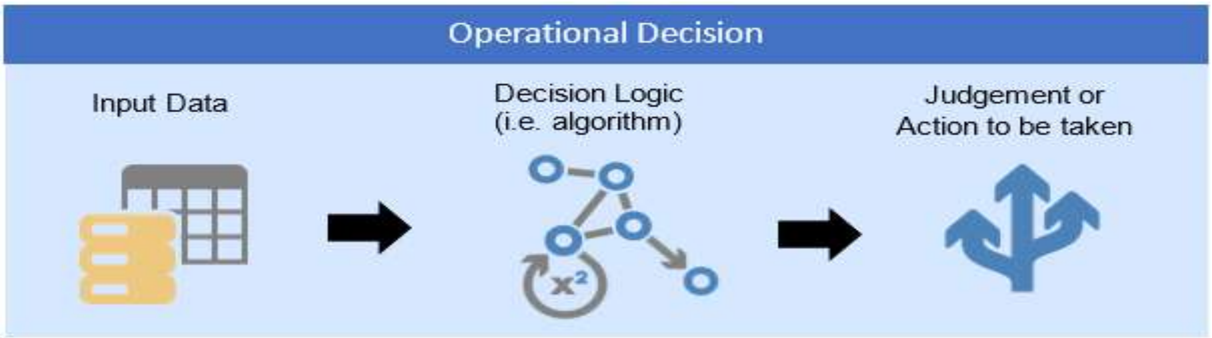

Figure 2.3: Operational Decision structure.

The operational decisions' conclusions can have diverse results or actions. The conclusion can be a meek value, list, or action that imposes a recommendation which has several positive influences such as.

- They can create configurations. i.e., the correct configuration of MRI equipment in a leasing process.
- They can guide a customer's journey. i.e., the best next action for students in achieving a specific goal.
- They can offer product bundling. i.e., the best options and price for up-selling and product bundling.
- They can provide a calculation. i.e., the billing calculation of a customer in the telecom industry.
- They can provide guidelines. i.e., the right criteria of a specific procedure for a patient in a particular situation.
- They can provide judgment. i.e., whether a pharmacist is certified to work in a pharmacy.
- They can provide options. i.e., the list of available treatments for a patient.

All these decisions require input to describe parameters, situations, and a case. The decision logic is run, and contrary to the situation, it produces a result. The effectiveness and efficiency of these operational decisions are critical to the success of a business in a rapidly changing and competitive environment. Up till now, the details of the decision and the decision logic are often concealed within the organisation. (Velasquez, M. and Hester, P.T., 2013)

As shown, a decision has both a conclusion such as an answer, and includes a method of deciding or processing, which we call the “decision logic”. Operational decisions are not excluded from this definition. There are many differences between operational decisions and other types of decisions, such as strategical and tactical, which makes operational decisions ideal candidates for systematization.

2.13 Maintenance schedules

The maintenance schedules have been constructed in a table format that involves prestart machining inspection. The table below provides the important aspect of the maintenance and the pre-start on machines to ensure that the important aspects on all machines are met before utilized. The maintenance schedule on machinery is done every six months depending on the hours in which they have been in operation. Maintenance schedules serves a purpose to keeps costs down and property function and appearance up. (Lim, J.H. and Park, D.H., 2007)

Table 2.2: The maintenance schedules

Company A	PRE-START MACHINING INSPECTION			Revision	1
				Prepared by	
				Date	
Pre-start criteria	**1st**	**2nd**	**3rd**	**4th**	**5th**
Was the correct material supplied as per BOM					
Is the drawing correct per the jobcard					
Is the drawing the correct revision					
Set up jaws to material - is IR mounted					
Select the correct toolig and probe all tools with correct off-set					
Verify that loaded program is correct					
Select and check measuring equipment with master ring					
Run first-off and check all sizes to drawing					
Confirm that sizes are to drawing specification					
Highlight any additional steps to inform the next operations					
Re-probe tool with every new shift					
Supervisor to sign off before it goes for final inspection					
Signature operator					
Supervisor sign-off:					
Signature					
Date					

2.14 Automation of Operational Decisions

While automation helps organisations to ensure the effectiveness and efficiency of operational decisions, companies often try to automate these using traditional approaches such as building applications using code, iBPMS, and other technologies. Companies use codes and low-code platforms to build applications and automate operational decisions. Companies have also been using Excel (and other spreadsheet applications) to help operators in these complex calculations, as well as other business-oriented solutions such as business rules management systems (BRMS), decision management solutions (DMS), and business process management (BPM) to build the automation for operational decisions. (Granell, V., 2007).

In the traditional approach of automating operational decisions (explained above), whether, through applications or traditional iBPMS (a more advanced flavor of BPM), all of these operational decisions are buried in process or code. When these are confronted with the required frequency of change and volume of data, it becomes critical to manage them independently. Otherwise, it makes it hard to understand the decisions, much less understand how to use and apply them. The problem with that is simply that organisations cannot keep up the pace.

As shown in the illustrated formula for operational decisions, these rely on data and have actions and/or judgment associated with them. Over time, the data, integration, and circumstances driving different decisions change for various situations. The actions are taken mature over time, based on the results of these operational decisions, as well as the decision logic itself. When automation of operational decisions is critical to the success of the business, hiding decisions, data, and required actions within processes and applications make it very difficult for the business to keep pace. It stretches the boundaries of technology platforms and business practices and leads to less effective results. (Von Halle, B. and Goldberg, L., 2009)

2.15 Conclusion

Most companies have complex operational decisions, they simply cannot scale with traditional approaches. Some have even tried to use one of the many decision management platforms to plug into data and processes. However, that approach creates a disconnected decision experience that often becomes unmanageable in complex and changing situations. That is where we need to take another approach. The impact of the disconnected decision experience is that it draws organisations back, when there is a need to balance the control between IT and business, which in turn leads organisations to implement these types of solutions in the first place.

CHAPTER 3: RESEARCH DESIGN

3.1 Introduction

In this chapter, the research design is discussed, including the type of method used to capture the data and the technical analysis. This chapter also covers the selection process of individuals involved in the research, as well as the research instrument, which was a questionnaire.

3.2 Description of overall research design

The research design includes a quantitative approach and technical data analysis. It is a combined approach. A questionnaire was used to collect data with the quantitative approach, while existing OEE data were analysed with the CNC machines.

3.2.1 The quantitative method

According to Cohen (1980), quantitative research is defined as social research that employs empirical methods and empirical statements. The quantitative method produces good results from the data collected in a group as stated by (Darmer and Freytag, 1995). Quantitative research is the numerical representation and manipulation of observations to describe and explain the phenomena that those observations reflect. It is used in a wide variety of natural and social sciences, including physics, biology, psychology, sociology, and geology.

Table 3.1: Quantitative Research Design

Quantitative Research	
Objective/Purpose	To quantify data and generalise results from a sample to the population of interest. ➢ Reduce sampling by the adequate size of the sampling ➢ Random Sampling

Sample	Usually, many cases representing the population of interest. ➢ Individual authorising access to premises/site ➢ Board review ➢ Individual
Data Analysis	Statistical data is usually in the form of tabulations. The findings are conclusive and usually descriptive. ➢ Checklist ➢ Instrument
Recording Data	Instruments with valid and reliable scores

3.3 Technical Analysis

Data on the identified CNC machines were collated over a period (2019 to 2021) and analysed for trends and gaps to evaluate the OEE. In this study, the quantitative data provided a good background for the problem statement and supported the quantitative approach by making the data more understandable (Rubin & Babbie, 2016).

3.4 Population/Sampling

The population and sampling method are detailed below.

3.4.1 The Target Population

The target population of the study was aimed at operational management and operators. The target population was selected at Springs, South Africa, which is the biggest operating facility that has the most impact on production in South Africa. It also contributes manufactured products across certain locations and regions all over the globe, such as the republic of Ceska.

The target population is the entire manufacturing unit situated in Springs, Gauteng South Africa. The unit consists of 139 employees, and over 20 CNC and other machines. There are 34 managerial and supervisory staff and 15 CNC operators.

3.4.2 Sampling

Out of the over 20 machines, 6 CNC machines were used as a sample in the technical study analysis. These machines were selected as they are used to make the most critical components that generate 60% of the revenue. Out of the 139 employees, 12 managers and operators were selected for the questionnaire.

The data sampling involved several continuities, which form part of master data capturing, computing production orders, material issuing, and production. One operations manager is overseeing the quality manager and the production manager, whereas the management team forms part of three managers and the specified equipment of six CNC machines with two operators. The research approach consists of qualitative research where data from August 2019 to May 2021.

The manual-operated machines were not used during the research, simply due to the technology and the company's vision for a technology upgrade in the future. The computer numerical control machines were used for the sampling size, which is used for manufacturing and fine rounding during manufacturing such as machining. The production planning and quality pass was be used.

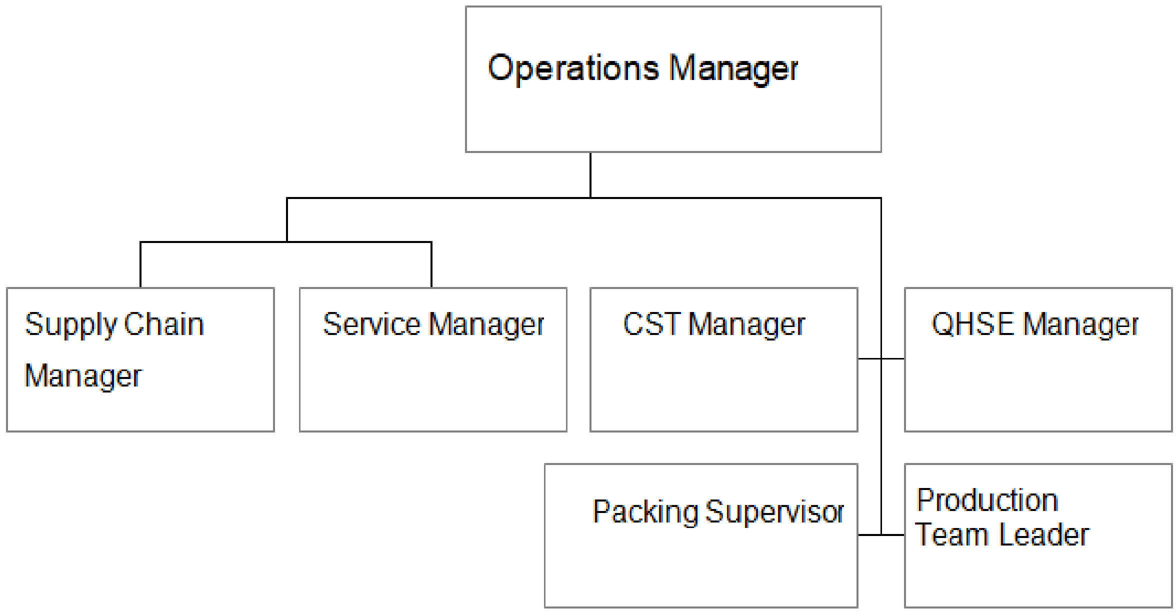

Figure 3.1: Organogram of Operations

Out of 139 dedicated employees (population) at the Springs facility, the study selected the managers and supervisors. A draft of the questionnaire was discussed and shared among the decisional managers that included three managers from operations, quality, and planning, and included two operators on the CNC machines.

The quantitative research was conducted with the managers and employees within each department, with a structured questionnaire survey, that reflects efficiency, available operator, and output quality to improve its overall operating equipment efficiency to meet an excellent standard of 60%. The target was to capture the data telemetry on installed CNC machines that was used to collect data to conclude the analysis to determine its operating schedules, and overall capacity that investigated the influence of operations management decisions on overall equipment effectiveness on six CNC machines.

3.5 Data collection

In this section, the instruments used to collect the data will be presented.

3.5.1 Management Questionnaire

The first instrument namely a designed questionnaire will be used to measure the management decisions to determine the influence it has on the current OEE score on the CNC machines. A questionnaire will be utilized to measure managers' decisions added in Appendix C.

3.5.2 Technical Data collection instrument

The second instrument will be utilized to collect the computer calculated date prior OEE percentage score. The quantitative data will be collected by using a machine-operated efficiency chart from 2019 - 2021. This includes the date when the equipment was used, the day on the date. The autonomous maintenance / preventative maintenance hours will be captured.

The Machine housekeeping in hours will be captured. Breakdowns such as the mechanical breakdown, electrical breakdown in hours will also be retrieved. The new program will be given to a certain type of work that is planned for manufacturing, followed by the setup time, tool change time, dimensional checking. The quality forms part of the next information capturing where quality decision delay is to be included, followed by the number of materials, metrication, number load and electricity to be included that will give us a total time in minutes spent.

3.6 Data analysis

Data analysis is a procedure of inspecting, cleansing, transforming, and modelling data with the goal of discovering useful information, informing conclusions, and supporting decision-making. The quantitative data collected with the research were analyzed with SPSS version 23 and was presented in two sections namely descriptive statistics and inferential statistical methods.

3.6.1 Descriptive statistics conducted

The purpose of descriptive statistics is to summarise collected quantitative data in tables and graphics the use and calculation of statistical measures e.g., mean and standard (Field, 2013). The mean is the sum of all the values in a data set, divided by the number of values and the standard deviation is a measure that indicated how far a set of numbers lay apart. (Mentz & Botha, 2012) The data collected were analyzed through SPSS descriptive methods, descriptive statistics, correlations, validity, and reliability.

3.6.2 Inferential statistics conducted

The primary purpose of inferential statistics is to draw conclusions and make predictions about the broader population. (Tabachnick & Fidell, 2007) The inferential statistics were used from the data from samples and to make generalizations about the population.

3.7 Data Validity and Reliability

Validity refers to the integrity and application of the methods undertaken and the precision in which the findings accurately reflect the data, while reliability describes consistency within the employed analytical procedure.

3.7.1 Validity

Validity refers to the degree to which the instrument measures what it is supposed to be measuring. (Field, 2013) The researcher mostly focused on content validity, which refers to the accuracy with which an instrument measures the factors under study. The validity refers to how well the results between the study participants represent true findings among similar individuals outside the study. It is important because it determines what survey questions to use and helps ensure that researchers are using questions that accurately measure matters of importance. In this section data validity and reliability will be presented.

3.7.2 Reliability

Reliability refers to how dependably a method measure something. If the same result can be consistently achieved by using the same methods under the same circumstances, the measurement is considered reliable. Reliability is important because it determines the value of a psychological test or study. (Sürücü, L. and MASLAKÇI, A., 2020) If test results remain consistent when researchers conduct a study, its reliability ensures value to the field of psychology and other areas in which it has relevance, such as education or business.

3.8 Ethical Consideration

Ethical issues are raised when the relationship in the research area leads to some degree of therapeutic communication for the participants. Thus, the researchers must be aware of the impact of the questioning on the participants, and to decrease such harmful effects on human subjects, the "reflexive approach" is recommended. (Eide, 2008)

Several recent studies and observations have described virtual modes of research and data collection that may move forward in the pandemic; to a limited extent, these have included qualitative methodologies. (Lobe et al., 2020; Marhefka et al., 2020)

3.9 Research Constraints

A minimum of 33 employees has responded during the research. The company had a restructuring phase twice within two years which means that the research could not be measured to a total of 139 employees.

3.9.1 Limitations of the study

Since the start of the Covid epidemic, Company was pushed into a position where the company did a civil restructuring phase twice since 2020 and 2021. This made it difficult to have a full respondent figure. The data collection process was not fully captured to change of organisation where employees were positioned in new roles whereas some employees left the organisation.

3.9.2 Delimitations of the study

The study is set in an operations management environment. It involves the principles of availability, efficiency, and effectiveness of production machines such as the computer numerical machines in a high volume-driven manufacturing environment. The research is limited to the subsidiary of Company A situated in Gauteng.

1.10 Conclusion

In this chapter, the description of the overall research design was explained through the type of research method that was used. The population and sampling were given to the respondents who participated in the questionnaire. A technical data collection instrument (questionnaire) was explained. Following the data analysis, an explanation of the descriptive statistics was announced. In the upcoming chapter, the analysis, discussion and results will be explained and displayed.

CHAPTER 4: RESULTS, DISCUSSION AND ANALYSIS

4.1 Introduction

In this chapter, the results from the questionnaire will be put in a statistical format and will be discussed and measured. This study was to investigate the influence of operations management decisions on the overall equipment effectiveness. To achieve this, a sample of 33 candidates was selected out of a population of 139. Questionnaires were sent to samples to measure managements decisions areas. These areas were identified in the literature to influence OEE in the company. These management decisions are Design of goods and services, Human Resources and Job design, Inventory management, Layout Strategy, Location analysis and strategy, Process and Capacity Design, Process Maintenance, Quality Management, Scheduling, and Supply chain management.

4.2 Response rate

31 out of 33 managerial and supervisory targets responded to the questionnaire. This represents 98% response rate~~.~~

4.3 Demographical Data

This section is providing an analysis of the demographics in the organization where several sections were used to have the gender, years' experience, department, years in current position, education, and department of the respondents. Each section will be discussed with the frequency percentage to have a better understanding of the dynamics from the responses.

4.3.1 Distribution by gender

The gender distribution of the respondents is presented in Table 4.1 below.

Table 4.1: Gender distribution of the respondents (*N* = 33)

	Frequency	Percent	Valid Percent	Cumulative Percent
Male	21	63,6	63,6	63,6
Female	12	36,4	36,4	100,0
Total	**33**	**100,0**	**100,0**	

The larger proportion of the respondents were males (*n* = 21, 63.6%) and the remainder were females (*n* =12, 36.4%).

4.3.2 Distribution by years of experience

The years of experience distribution of the respondents is presented in Table 4.2 below.

Table 4.2: Years of Experience distribution of the respondents (*N* = 33)

	Frequency	Percent	Valid Percent	Cumulative Percent
0-5	4	12,1	12,1	12,1
6-10	9	27,3	27,3	39,4
11-15	6	18,2	18,2	57,6
16-20	4	12,1	12,1	69,7
21-25	3	9,1	9,1	78,8
26 and more	7	21,2	21,2	100,0
Total	**33**	**100,0**	**100,0**	

Almost 40% of the respondents have a maximum of 10 years' experience in the industry, 0-5 years (*n* = 4, 21.1%) and 6-10 years *(n* = 9, 27.3%) respectively. Respondents with 11-20 years' experience equates to 30.3% of the sample with 11-15 years (*n* = 6, 18.2%) and 16-20 years (*n* = 4, 12.1%). The other 30.3% have 21-25 years' experience (*n* = 3, 9.1%), and more than 26 years' experience in the industry (*n* = 7, 21.2%).

4.3.3 Distribution by department

The department distribution of the respondents is presented in Table 4.3 below.

Table 4.3: Department distribution of the respondents (*N* = 33)

	Frequency	Percent	Valid Percent	Cumulative Percent
Operations	10	30,3	32,3	32,3
Sales and Marketing	10	30,3	32,3	64,5
Human Resources	4	12,1	12,9	77,4
Engineering	3	9,1	9,7	87,1
Procurement	1	3,0	3,2	90,3
Other	3	9,1	9,7	100,0
Total	31	93,9	100,0	
Missing	2	6,1		
Total	**33**	**100,0**		

With the given data, the frequency of the respondents within their departments was 31 out of 33. A frequency of (*n* = 10, 30.3%) in both operations including sales and marketing. A total of 4 respondents were human resources with a percentage value of 12.1%. The second-lowest frequency came from the engineering and other departments, at 9.1%. The lowest frequency was the procurement department, which had a percentage value of 3.0%.

4.3.4 Distribution by years current position

The years in the current position distribution of the respondents are presented in Table 4.4 below.

Table 4.4: Years in current position distribution of the respondents (*N* = 33)

	Frequency	Percent	Valid Percent	Cumulative Percent
0 – 5	15	45,5	45,5	45,5
6 –10	5	15,2	15,2	60,6
11 – 15	6	18,2	18,2	78,8
16 – 20	2	6,1	6,1	84,8
21 - 25	2	6,1	6,1	90,9
26 and more	3	9,1	9,1	100,0
Total	**33**	**100,0**	**100,0**	

The findings of years within the current position came from department one, where it held the highest score percentage of 45.5 % and 15 years, followed by department three that was six years or 18.2%.

4.3.5 Distribution by education

The education distribution of the respondents is presented in Table 4.5 below.

Table 4.5: Education distribution of the respondents (*N* = 33)

	Frequency	Percent	Valid Percent	Cumulative Percent
Matric	7	21,2	21,9	21,9
Certificate/Diploma	14	42,4	43,8	65,6
Degree	8	24,2	25,0	90,6
Postgraduate	2	6,1	6,3	96,9
Other	1	3,0	3,1	100,0
Total	32	97,0	100,0	
Missing	1	3,0		
Total	**33**	**100,0**		

In Table 4.5 above, most respondents held a certificate /diploma with a frequency of 42.4%, followed by a degree of 24.2%, and matric resulted in 21.2%. The remainder frequency was 6.1%, which were postgraduates.

4.3.6 Distribution by employment -level

The employment level distribution of the respondents is presented in Table 4.6 below.

Table 4.6: Employment level distribution of the respondents (*N* = 33)

	Frequency	Percent	Valid Percent	Cumulative Percent
Management/Supervisory	12	36,4	38,7	38,7
Employee	19	57,6	61,3	100,0
Total	31	93,9	100,0	
Missing	2	6,1		

Total	**33**	**100,0**		

Most respondents recorded were under “employee” who had a frequency percentage of 57.6%, followed by Management/ Supervisory entitlement that came to 36.4%.

4.4 Descriptive Statistics

In this section, the descriptive statistics of the research questionnaire (See Appendix C) will be presented. The statistical calculations used to describe the distribution of the collected quantitative data are the mean and standard deviation (*SD*). Mean refers to the sum of all the values in a data set, divided by the number of values in that data set (Mentz & Botha 2012). The standard deviation (*SD*) indicates how far a set of numbers are spread from the mean. A high *SD* score is an indication of a wide data spread from the mean, and a low *SD* score is an indication that the data is closely spread around the mean (Pallant, 2016:72-73). A mean score of < 3 will be an indication the respondents did not agree with the statement while a mean score of > 3 will be an indication the respondents agree with the statement.

4.4.1 Quality Management (OM)

The descriptive statistics for Quality Management is presented in Table 4.7 below.

Table 4.7: Descriptive statistics for Quality Management (*N* = 33)

QUALITY MANAGEMENT	N	1	2	3	4	5	Mean	Std
QM1: Company has a quality management system in place.	33	1	0	5	14	13	4.15	0.91
QM2: Company carries out studies to evaluate customer satisfaction.	33	4	1	5	11	12	3.79	1.32
QM3: Company welcomes and acts on customers’ complaints.	33		0	7	10	16	**4.27**	**0.80**
QM4: Quality is determined through acceptance sampling.	33	3	0	9	12	9	3.73	1.15
QM5: There is continuous improvement on handling of customers.	33	3	1	8	8	13	3.82	1.26
QM6: Staff are continuously trained and educated on quality programs.	33	3	3	5	12	10	3.7	1.26

Note: 5 is the highest score and 1 is the lowest score.

Quality Management the lowest mean was reported for QM5 stating: "Company relies on feedback from Pharmacy and Poisons board on quality of products" (mean = 2.52, *SD* = 1.66), indicating that respondents' average response regarding the statement were between Disagree and Neither agree nor disagree. The highest mean was reported for QM3 stating: "Company welcomes and acts of customers' complaints" (mean = 4.27, *SD* = 0.80), indicating that respondents on average agreed with the statement.

4.4.2 Location Strategy (LOS)

Access from all branches to the manufacturing outlet is essential. Housekeeping should be conducted regularly. Creating a clean and organised workplace that is a safe and healthy working environment is essential. Saving time looking for material, tools, equipment, and information and increasing overall efficiency can increase productivity. Making employees proud of their workplace, increasing employee accountability, and creating a visual impression of the professionalism of the company to reinforce the customer and employer brand could benefit the company.

The descriptive statistics for Location Strategy are presented in Table 4.8 below.

Table 4.8: Descriptive statistics for Location Strategy (*N* = 33)

LOCATION STRATEGY	Missing	N	1	2	3	4	5	Mean	Std
LS1: Location is close to customers.		33	4	0	4	12	13	3.91	1.28
LS2: Affordable rent and Leasing costs.		33	10	1	7	7	8	3.06	1.58
LS3: Labour easily available	1	32	6	3	6	9	8	3.31	1.45

Location Strategy, the lowest mean was reported for LS2 stating: "Affordable rent and Leasing costs" (mean =3.06, *SD* = 1.58), indicating that respondents' average responses regarding the statement were between Disagree and Neither agree nor disagree. The highest mean was reported for LS1 stating: “Location is close to customers” (mean = 3.91, *SD* = 1.28), indicating that respondents on average agreed with the statement.

4.4.3 Human Resources and Job Design (HR)

The descriptive statistics for Human Resources and Job Design are presented in Table 4.9 below.

Table 4.9: Descriptive statistics for Human Resources and Job Design (*N* = 33)

HUMAN RESOURCES AND JOB DESIGN	Missing	N	1	2	3	4	5	Mean	Std
HR1: There is a system for collecting employees' opinions.		33	5	4	4	6	14	3.61	1.52
HR2: There is a strong spirit of cooperation in the organization.		33	1	7	4	13	8	3.61	1.17
HR3: Employees fully understand the goals, policies, and objectives of this organization.		33	4	0	6	12	11	3.91	1.01
HR4: Supervisors provide feedback to employees on how well they are doing.	1	32	5	0	3	15	9	3.88	1.01
HR5: Management gives priority to employees' personal welfare.		33	3	4	2	14	10	3.73	1.28
HR6: Employees have access to all the training they need.		33	1	6	3	12	11	3.79	1.19
HR7: Employees understand their duties and are never idle.		33	1	1	5	16	10	4	0.94

Human Resources and Job Design, the lowest mean was reported for HR2 stating: " There is a strong spirit of cooperation in the organisation" (mean =3.61, *SD* = 1.17), indicating that respondents' average response regarding the statement were between Disagree and Neither agree nor disagree. The highest mean was reported for HR7 stating: "Employees understand their duties and are never idle" (mean = 4.00, *SD* = 0.94), indicating that respondents on average fully agreed with the statement.

4.4.4 Supply Chain Management (SCM)

The descriptive statistics for Supply Chain Management are presented in Table 4.10 below.

Table 4.10: Descriptive statistics for Supply Chain Management (*N* = 33)

SUPPLY CHAIN MANAGEMENT	N	1	2	3	4	5	Mean	Std

SCM1: Suppliers operate as separate entities with their own goals.	33	2	3	7	9	12	3.79	1.22
SCM2: The company deals with a few prequalified suppliers.	33	3	2	5	12	11	3.79	1.24
SCM3: Company gathers feedback from distributors and customers on how to improve the systems.	33	2	3	5	14	9	3.76	1.15
SCM4: The company provides technical assistance to suppliers, distributors and customers.	33	1	1	5	13	13	4.09	0.98
SCM5: The company can locate and track movement of items.	33	2	1	4	11	15	4.09	1.13

Considering the statements regarding the descriptive statistics for Supply Chain Management, the lowest mean was reported for SCM3, stating: "Company gathers feedback from distributors and customers on how to improve the systems" (mean =3.76, *SD* = 1.15), indicating that respondents' average response regarding the statement were between Disagree and Neither agree nor disagree. The highest mean was reported for SCM4 stating: "The company provides technical assistance to suppliers, distributors, and customers" (mean = 4.09, *SD* = 0.98), indicating that respondents on average fully agreed with the statement.

4.4.5 Inventory Management (IM)

The descriptive statistics for Inventory Management are presented in Table 4.11 below.

Table 4.11: Descriptive statistics for Inventory Management (*N* = 33)

INVENTORY MANAGEMENT	Missing	N	1	2	3	4	5	Mean	Std
IM1: Company uses computer software to manage its inventory		33	0	0	2	11	20	4.55	0.62
IM2: Goods are often disposed of without selling to customers.	1	32	4	13	9	3	3	2.63	1.13
IM3: Company orders at specific times in the year.		33	12	9	8	1	3	2.21	1.24
IM4: Company orders for goods randomly depending on demand.		33	5	5	5	8	10	3.39	1.46
IM5: Cost determines the amount of goods to be ordered.		33	4	4	10	10	5	3.24	1.23

IM6: Company considers discounts offered by various suppliers when ordering for goods.	1	32	5	4	7	7	9	3.34	1.43
IM7: Orders are placed depending on customer demand.		33	6	0	5	8	14	3.73	1.49
IM8: Orders are placed depending on prior agreements with suppliers.		33	1	4	10	7	11	3.7	1.16

Inventory Management, the lowest mean was reported for IM3, stating: "Company orders at specific times in the year" (mean =2.21, SD = 1.24), indicating that respondents' average response regarding the statement disagrees. The highest mean was reported for IM1 stating: "Company uses computer software to manage its inventory" (mean = 4.55, SD = 0.62), indicating that respondents on average fully agreed with the statement.

4.4.6 Maintenance (MT)

The descriptive statistics for Maintenance are presented in Table 4.12 below.

Table 4.12: Descriptive statistics for Maintenance (*N* = 33)

MAINTENANCE	N	1	2	3	4	5	Mean	Std
MT1: Maintenance services are done regularly	33	4	3	4	10	12	3.7	1.38
MT2: Maintenance services are done when there is less work or when equipment breaks down.	33	7	4	10	7	5	2.97	1.36
MT3: Company undertakes regular inspection of its products and facilities.	33	2	1	4	16	10	3.94	1.06

Maintenance, the lowest mean was reported for MT2, stating: “Maintenance services are done when there is less work or when equipment breaks down" (mean = 2.97, *SD* = 1.36), indicating that respondents' average response regarding the statement disagrees. The highest mean was reported for MT3 stating: "Company undertakes regular inspection of its products and facilities" (mean = 3.94, *SD* = 1.06), indicating that respondents on average agreed with the statement.

4.4.7 Scheduling (SC)

The descriptive statistic for Scheduling is presented in Table 4.13 below.

Table 4.13: Descriptive statistics for Scheduling (*N* = 33)

SCHEDULING	N	1	2	3	4	5	Mean	Std
SC1: Company maintains constant production and supply.	33	1	2	13	12	5	4	0.94
SC2: Company hires more workers when demand increases.	33	7	11	6	7	2	3	1.23
SC3: Increasing or decreasing working hours depending on demand.	33	8	7	8	6	4	3	1.35
SC4: Employees work overtime more often to clear backlogs.	33	9	7	9	6	2	3	1.25

Scheduling, the lowest mean was reported for SC2, stating: “Company hires more workers when demand increases" (mean =3.00, SD = 1.23), indicating that respondents' average response regarding the statement is neither agree nor disagree. The highest mean was reported for SC1 stating: "Company maintains constant production and supply" (mean = 4.00, SD = 0.94), indicating that respondents on average agreed with the statement.

4.4.8 Process and Capacity Design (PC)

The descriptive statistics for Process and Capacity Design is presented in Table 4.15 below.

Table 4.14: Descriptive statistics for Process and Capacity Design (*N* = 33)

PROCESS AND CAPACITY DESIGN	N	1	2	3	4	5	Mean	Std
PC1: Company does invest in systems that require a long time for benefits to be seen.	33	5	1	13	9	5	3	1.23
PC2: Company can respond to changes in demand quickly.	33	2	2	9	14	6	4	1.06
PC3: Subcontracts work to other firms when demand is high.	33	6	2	8	15	2	3	1.23
PC4: Company can forecast demand accurately.	33	4	4	11	9	5	3	1.22

Process and Capacity Design, the lowest mean was reported for PC4, stating: “Company can forecast demand accurately" (mean =3.00, *SD* = 1.22), indicating that respondents' average response regarding the statement neither agrees nor disagree. The highest mean was reported for PC2 stating: "Company can respond to changes in demand quickly" (mean = 4.00, *SD* = 1.06), indicating that respondents on average agreed with the statement.

4.4.9 Layout Strategy (LS)

The descriptive statistics for the Layout Strategy are presented in Table 4.16 below.

Table 4.15: Descriptive statistics for Layout Strategy (*N* = 33)

LAYOUT STRATEGY	N	1	2	3	4	5	Mean	Std
LS1: Departments are divided based on similarity of duties.	33	2	2	6	13	10	4	1.13
LS2: Divisions are grouped depending on products they deal with.	33	4	1	8	13	7	4	1.23
LS3: Divisions operate according to their geographical locations.	33	4	3	12	6	8	3	1.29
LS4: Designed for ease of future expansion and improvement.	33	4	3	9	10	7	3	1.27
LS5: To make it easy to move goods from one section to another.	33	3	2	5	14	9	4	1.21
LS6: It is easy for employees to communicate with one another.	33	0	0	1	17	15	4	0.56
LS7: To ensure safety of employees.	33	2	0	2	8	21	4	1.06

Layout Strategy, the lowest mean was reported for LS4, stating: “Designed for ease of future expansion and improvement" (mean =3.00, *SD* = 1.27), indicating that respondents' average response regarding the statement is neither agree nor disagree. The highest mean was reported for LS6 stating." It is easy for employees to communicate with one another" (mean = 4.00, *SD* = 0.56) indicating that respondents on average agreed with the statement.

4.4.10 Design of Goods and Services (DG)

The descriptive statistics for the Design of Goods and Services are presented in Table 4.16 below.

Table 4.16: Descriptive statistics for Design of Goods and Services (*N* = 33)

DESIGN OF GOODS AND SERVICES	N	1	2	3	4	5	Mean	Std

DG1: To comply with the legal requirements in the country.	33	2	0	0	14	17	4	0.99
DG2: Make the products easily acceptable in the market.	33	1	1	1	17	13	4	0.89
DG3: Make the products appealing to customers.	33		1	4	13	15	4	0.80
DG4: Make products that can satisfy customers’	33		1	3	15	14	4	0.76
DG5: To achieve competitive advantage	33		1	6	14	12	4	0.82
DG6: Company follows keenly on what competitor has in the market	33	1	0	10	8	14	4	1.02
DG7: To minimize the cost of the product.	33	2	1	10	12	8	4	1.08

Considering the statements regarding the descriptive statistics for Design of Goods and Services, the lowest mean was reported for DG7, stating: “To minimize the cost of the product" (mean =4.00, *SD* = 1.08), indicating that respondents' average response regarding the statement agrees. The highest mean was reported for DG4 stating: "Make products that can satisfy customers’" (mean = 4.00, *SD* = 0.76) indicating that respondents on average agreed with the statement.

4.4.11 Management decisions impact on OEE

A summary of the results of the importance of different management decisions on OEE is presented in Table 4.17 below.

Table 4.17: Impact of management decisions on OEE

Management Decisions	Mean	Std
Design of goods and service	4.00	0.91
Human Resources and Job design	3.79	1.16
Inventory management	3.35	1.22
Layout Strategy	3.71	1.11
Location analysis and strategy	3.43	1.43
Process and Capacity Design	3.25	1.19
Process Maintenance	3.54	1.27

Quality management	3.71	1.19
Scheduling	3.25	1.19
Supply chain management	3.90	1.14

The higher the mean value of the management decision the greater the impact it will have on OEE. Any management decision mean value of greater than 3.59 will have an impact on OEE.

The design of goods and services has scored a positive mean above 3.59 which states that management decisions have a great impact that contributes toward OEE. Following with supply chain management, the calculated mean has reached 3.90. Human resources and job design show an average mean of 3.79. With a mean of 3.71 both Quality management and the layout strategy score above the average mean of 3.59. These areas were more focused in management decisions.

The areas below 3.59 were not being emphasized, these were identified as process and maintenance which had a mean of 3.54. The Location analysis and strategy have scored 3.43. Inventory management has the second-lowest mean average of 3.35 and lastly, Process and Capacity Design and scheduling have set a mean rate of 3.25. The areas can be seen as for improvement that would improve overall the OEE value in the company.

4.5 Reliability analysis of questionnaire scales

Reliability analysis was conducted on the questionnaire scales with the view to determine if acceptable internal consistency reliability (Pallant 2016) is presented.

The results of the reliability analysis conducted on the different scales of the questionnaire are reflected in Table 4.19 below.

Table 4.18: Reliability analysis of the Questionnaire Scales

Construct	Question range	Cronbach's Alpha	Mean	Std
Quality Management	QM1 - QM7	.835	3.71	0.87

Location Strategy	LOS1 - LOS3	.796	3.43	1.21
Human Resources and Job Design	HR1 - HR7	.919	3.79	0.97
Supply Chain Management	SCM1 - SCM 5	.787	3.90	0.84
Inventory Management	IM1 - IM8	.788	3.35	0.79
Maintenance	MT1 - MT3	.659	3.54	0.98
Scheduling	SC1 - SC4	.688	2.85	0.86
Process and Capacity Design	PC1 - PC4	.393		
Layout Strategy	LS1 - LS7	.863	3.81	0.84
Design Of Goods and Services	DG1 - DG7	.827	4.13	0.64

Most of the reported Cronbach Alpha values are all above the guideline value of above 0.7 or 0.5 in the early stages of research, as recommended by Field (2009), which indicates that the resulting factors are reliable. The only exception is the "Process and Capacity Design" construct, which was not reliable (CA = 0.393); these questions will be analyzed individually going forward.

The resulting means ranged between 2.85 (*SD* = 0.86) - 3.43 (*SD* = 1.21) for the constructs Location Strategy, Inventory Management, and Scheduling, which indicate that respondents on average neither agree nor disagree with the statements within these constructs. The remainder of the constructs means ranged between 3.54 (*SD* = 0.981) - 4.13 (*SD* = 0.64), indicating that the respondents on average agreed with the statements within these constructs.

4.6 Quantitative inferential statistics for the study

Inferential statistical calculations were conducted on the data collected for the study, to make inferences about the company's population, based on the sample of data taken from the population. (Leedy & Ormrod 2015)

4.7 Inter-correlations between sub-scales

Correlation measures the degree to which two variables move with each other, or a correlation is a statistical measure of the relationship between two variables. The Spearmen correlations were conducted to measure the strength of association and direction between the four variables of this study. According to (Ratner, 2003), the strength of association or correlations ranging between values of r (*N*) = .1 and .3 pose a small effect, with no practical significant correlation; where r (*N*) > .3 to .5 poses a medium effect with a practically visible correlation and those greater than r (*N*) < .5 pose a large effect size with a practical significant correlation (Cohen 1988).

As the data was not drawn from a convenience sample instead of a random sample, the p-values are reported for completeness' sake, but will not be interpreted. Due to space constraints, the following abbreviations are used to identify the constructs: Quality Management (QM); Location Strategy (LOS); Human Resources and Job Design (HR); Supply Chain Management (SCM); Inventory Management (IM); Maintenance (MT); Scheduling (SC); Process and Capacity Design (PC); Layout Strategy (LS), and Design of Goods and Services (DG). The result of the Spearman Correlations is presented in Table 4.20 below.

Table 4.19: Inter-correlations matrix (Spearman Correlations) of the constructs (*N* = 33)

		OM	LOS	HR	SCM	IM	MT	SCM	PC1	PC2	PC3	PC4	LS	DG
OM	Correlation Coefficient	1.000												
	Sig. (2-tailed)													
LOS	Correlation Coefficient	0.239	1.000											
	Sig. (2-tailed)	0.180												
HR	Correlation Coefficient	**0.751**	0.260	1.000										
	Sig. (2-tailed)	<0,0001	0.143											
SCM	Correlation Coefficient	**0.523**	0.387	**0.778**	1.000									
	Sig. (2-tailed)	0.002	0.026	<0,0001										
IM	Correlation Coefficient	0.288	0.468	0.346	0.456	1.000								
	Sig. (2-tailed)	0.105	0.006	0.049	0.008									
MT	Correlation Coefficient	0.355	0.281	0.379	0.456	0.315	1.000							
	Sig. (2-tailed)	0.043	0.113	0.029	0.008	0.074								
SCM	Correlation Coefficient	0.203	**0.607**	0.167	0.265	**0.643**	0.396	1.000						
	Sig. (2-tailed)	0.256	<0,0001	0.351	0.136	<0,0001	0.023							
PC1	Correlation Coefficient	0.135	0.278	0.372	**0.596**	0.427	0.230	0.181	1.000					
	Sig. (2-tailed)	0.453	0.118	0.033	<0,0001	0.013	0.199	0.312						
PC2	Correlation Coefficient	**0.637**	0.247	**0.620**	0.497	0.244	0.197	0.242	0.316	1.000				
	Sig. (2-tailed)	<0,0001	0.166	<0,0001	0.003	0.172	0.272	0.175	0.073					
PC3	Correlation Coefficient	0.195	0.125	0.038	0.157	0.209	0.349	0.095	0.063	-0.058	1.000			
	Sig. (2-tailed)	0.276	0.487	0.833	0.384	0.243	0.047	0.598	0.728	0.747				
PC4	Correlation Coefficient	0.283	0.316	**0.517**	0.347	0.269	0.272	0.237	0.192	0.333	-0.165	1.000		
	Sig. (2-tailed)	0.111	0.073	0.002	0.048	0.130	0.126	0.185	0.285	0.059	0.360			
LS	Correlation Coefficient	**0.526**	0.470	**0.592**	**0.574**	0.370	0.405	0.424	0.362	**0.648**	-0.231	**0.523**	1.000	
	Sig. (2-tailed)	0.002	0.006	<0,0001	<0,0001	0.034	0.019	0.014	0.038	<0,0001	0.195	0.002		
DG	Correlation Coefficient	**0.680**	0.359	**0.608**	**0.501**	0.381	0.487	0.423	0.220	**0.632**	-0.021	0.463	**0.653**	1.000
	Sig. (2-tailed)	<0,0001	0.040	<0,0001	0.003	0.029	0.004	0.014	0.219	<0,0001	0.906	0.007	<0,0001	

Quality Management (QM): The correlations between Quality Management and the following constructs are all large or practically significant: Human Resources and Job Design (*r* = 0,751), Supply Chain Management (*r* = 0.523), Process and Capacity Design2 (*r* = 0.637), Layout Strategy (*r* = 0.526) and lastly Design of Goods and Services (*r* = 0.680). The correlations are positive, reflecting that as respondents tend to Strongly Agree with the statements within the Quality Management construct they will also tend to Strongly Agree with the statements within the other constructs.

Layout Strategy (LOS): The correlations between Layout Strategy and the following construct are large or practically significant: Supply Chain Management (*r* = 0.607). The correlations are positive, reflecting that as respondents tend to Strongly Agree with the statements within the Layout Strategy construct, the participants also tend to Strongly Agree with the statements within the Supply Chain Management construct.

Human Resources and Job Design (HR)

The correlations between Human Resources and Job Design and the following constructs are large or practically significant: Supply Chain Management (*r* = 0.778), Process and Capacity Design2 (*r* = 0.620), Layout Strategy (*r* = 0.592) and lastly Design of Goods and Services (*r* = 0.608). The correlations are positive, reflecting that as respondents tend to Strongly Agree with the statements within the Human Resources and Job Design construct they will also tend to Strongly Agree with the statements within the other constructs.

Supply Chain Management (SCM)

The correlations between Supply Chain Management and the following constructs are large or practically significant: Process and Capacity Design1 (*r* = 0.596), Layout Strategy (*r* = 0.574), and lastly Design of Goods and Services (*r* = 0.501). The correlations are positive, reflecting that as respondents tend to Strongly Agree with the statements within the Supply Chain Management construct they will also tend to Strongly Agree with the statements within the other constructs.

Inventory Management (IM)

The correlations between Inventory Management and the following construct are large or practically significant: Supply Chain Management (*r* = 0.643). The correlations are positive, reflecting that as respondents tend to Strongly Agree with the statements within the Inventory Management construct they will also tend to Strongly Agree with the statements within the other constructs.

Process and Capacity Design (PC2)

The correlations between Process and Capacity Design2 and the following constructs are large or practically significant: Layout Strategy (*r* = 0.648) and Design of Goods and Services (*r* = 0.632). The correlations are positive, reflecting that as respondents tend to Strongly Agree with the statements within the Process and

Capacity Design2 construct they will also tend to Strongly Agree with the statements within the other constructs.

Process and Capacity Design (PC4)

The correlations between Process and Capacity Design4 and the following construct are large or practically significant: Layout Strategy (r = 0.523). The correlations are positive, reflecting that as respondents tend to Strongly Agree with the statements within the Process and Capacity Design4 construct they will also tend to Strongly Agree with the statements within the other constructs.

Layout Strategy (LS)

The correlations between Layout Strategy and the following construct are large or practically significant: Design of Goods and Services (r = 0.653). The correlations are positive, reflecting that as respondents tend to Strongly Agree with the statements within the Layout Strategy construct, they will also tend to Strongly Agree with the statements within the other constructs.

4.8 Summary of descriptive statistical findings

A total of 21 of the participants are male and 12 are female that will give a balanced view from a gender perspective. The majority had more than 6 years of experience an indication the company employs an experienced workforce (not really- workforce relatively inexperienced) of which 13 works in the operations or engineering sections. Eighteen of the respondents are in the same position for more than 6 years an indication of a flat organisational structure. The majority of the participants possess a diploma or higher qualification an indication of a well-educated workforce. Twelve of the participants held management or supervisory roles and the other operational roles.

The company responds to customers –replace the word and do not rely on others to provide quality feedback. The facility is located strategically close to the customers which limits distribution challenges. Suppliers are regularly approached to provide feedback and when needed technical support and advice are rendered.

The company has adopted digitalization an indication that the affected information management system is in place. Maintenance on equipment is scheduled and conducted regularly and quality inspections are conducted by the company. Production and supply are maintained at a constant rate, and when a backlog occurs, the employees are prepared to work overtime. The company can respond to demand very quickly and have information systems in place to forecast demand effectively. The layout of the production area is well planned, segmented according to functions and there is room for future improvements. There is compliance with all government regulations. A positive relationship was found to exist between Quality Management with Human Resources and Job Design, Supply Chain Management, Process, and Capacity Design, Layout Strategy, and Design of Goods and Services. Based on this information this is a company with an effective business process that employs an experienced, educated, and committed workforce.

4.9 Technical Data on OEE

In this section, the data and telemetry on the equipment installed for manufacturing are normally used for measuring equipment effectiveness. The data capturing for the period 2019 - 2021 will be used to calculate the average OEE can be formulated through Productivity Percentage x Machine Availability percentage x Quality percentage. The Operating Equipment Effectiveness (OEE) Factor Layout goes with a flow diagram. Based on the OEE factor, the method in which the data analysis is conducted can be described through the following technique including a step-by-step clarification.

Regarding the data analysis, the OEE factor serves as the main focused area that has three different areas relating to the method approach. The starting point will be the divided sections namely the availability that is the effective time divided by the planned production time, followed by the affected downtime throughout the planned production time. Whereas it was deprived of the standard operating time, tea breaks, lunch break, and other planned machine stop.

The section of the OEE factor reveals productivity, which is the total actual output divided by the total planned output that is underlined under the total actual production. The third section is quality which is the good product produced divided by the total actual production. The good products and the rejected product are the key areas where the quality will be determined in percentage that is also listed under the total actual production. The machine production time can be aligned in all three sections from a starting point. To outline the main objectives of this study, the most important objective is to determine why the operations team is not reaching the production target in all the shifts. The secondary objective is to do a literature study that will show how to identify ways to improve the overall equipment efficiency of the machines and to identify the source of downtimes during production. To prescribe solutions to eliminate downtimes and reach production targets. With the current information, the following instruments were used to reach the objectives. Starting with the Operating Equipment Effectiveness (OEE) Factor Layout, the table below is used every month to determine the actual OEE score.

4.10 Operating Equipment Effectiveness (OEE)

The data capturing for the period Augustus 2019 to May 2021 will be used to calculate the average OEE can be formulated through Productivity Percentage x Machine Availability percentage x Quality percentage.

4.11 OEE technical analysis

Table 4.20: Summary of OEE values 2019 – 2021

Month	Average OEE %	Target OEE %
OEE August 2019	52	60
OEE September 2019	51	60
OEE October 2019	65	60
OEE November 2019	60	60
OEE December 2019	47	60
OEE January 2020	45	60
OEE February 2020	56	60
OEE March 2020	50	60

OEE January 2021	32	60
OEE February 2021	38	60
OEE April 2021	81	60
OEE May 2021	32	60

The table above presents the average OEE score obtained for each month from August 2019 to May 2021. Starting with the lowest OEE score, occurred in January 2021 which indicates an average score rate of 32% while the largest average score of 81% was achieved in April 2021.

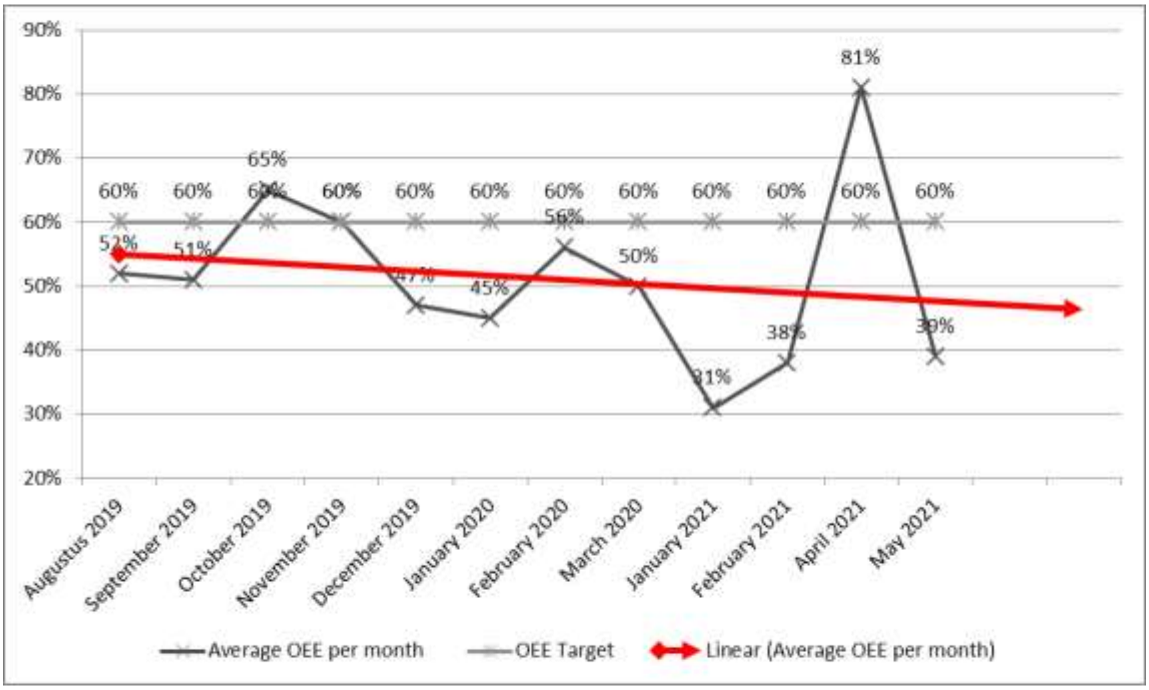

Figure 4.1 Summary of OEE Values August 2019 – May 2021

An individual statement for each Month's OEE average rate will be provided starting from August 2019 to May 2021.

4.11.1 OEE August 2019

The Actual OEE versus Target OEE for August 2019 is presented in Figure 4.1 below (See Appendix: August 2019 for detail).

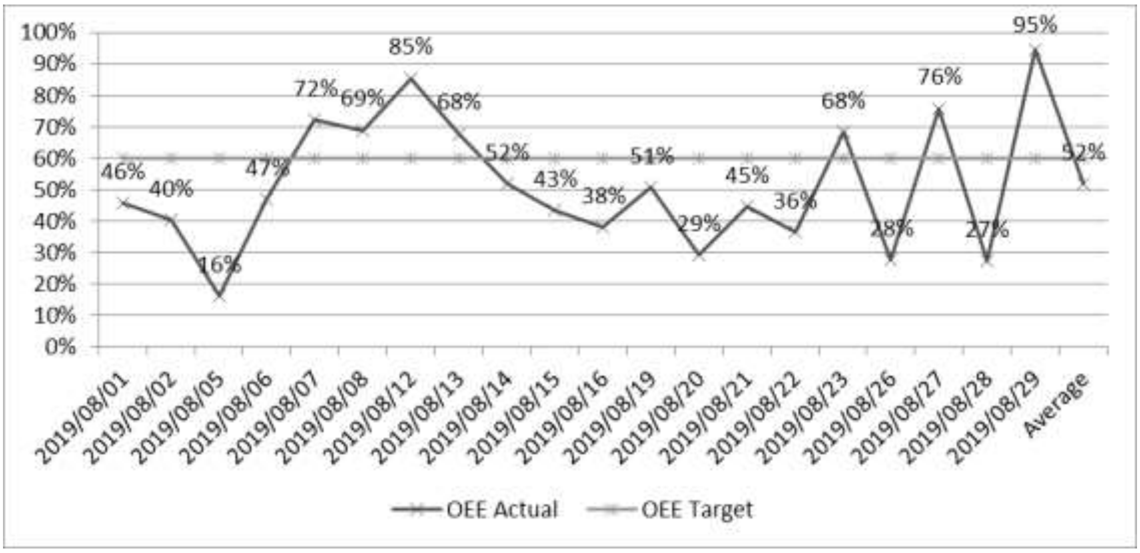

Figure 4.2: Actual OEE versus Target OEE for August 2019

During August 2019, the lowest actual OEE score is 16% and the machine availability was 71.4%. The productivity rate was 25.8%, with quality at 87.5%. From the six machines, three machines were reported that activity was visible. The highest OEE score was 95%. The average OEE for August 2019 was 52%, which is less than the target of 60%.

4.11.2 OEE September 2019

The Actual OEE versus Target OEE for September 2019 is presented in Figure 4.2 below (See Appendix: September 2019 for detail).

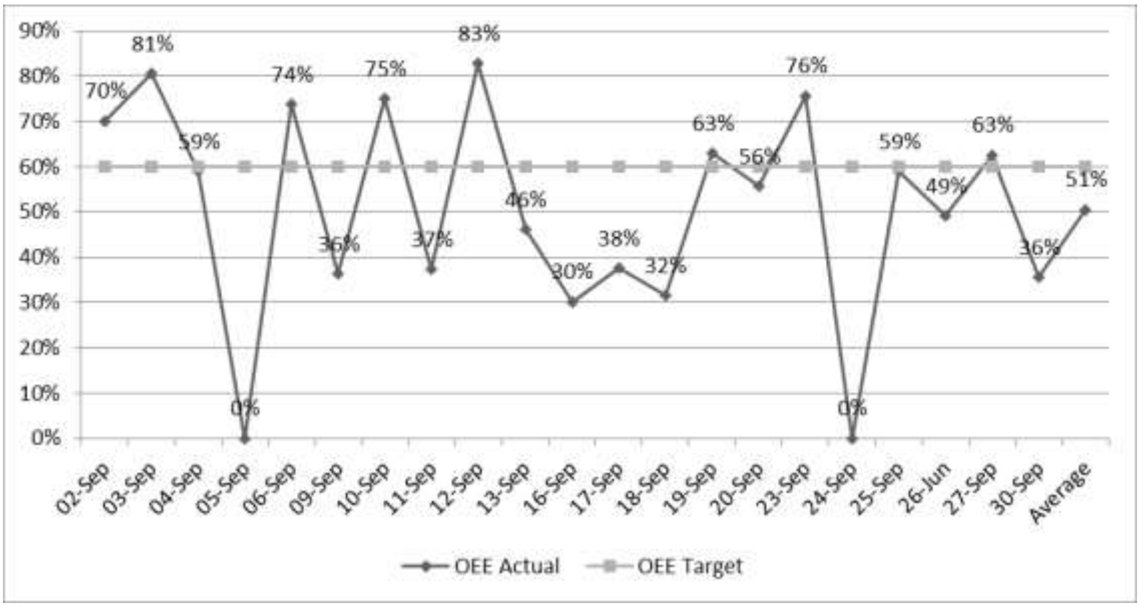

Figure 4.3: Actual OEE versus Target OEE for September 2019

In September 2019, the lowest actual OEE score was 30%; the machine availability was 81.5%. The Productivity was 37.0%, with quality 100%. The productive time available for an operator was 3800 min. The total number of units produced was 32 with no rework, which gave a 100% Quality score. The highest OEE score was 81%. The average OEE for September 2019 is 51%.

4.11.3 OEE October 2019

The Actual OEE versus Target OEE for October 2019 is presented in Figure 4.3 below (See Appendix: October 2019 for detail).

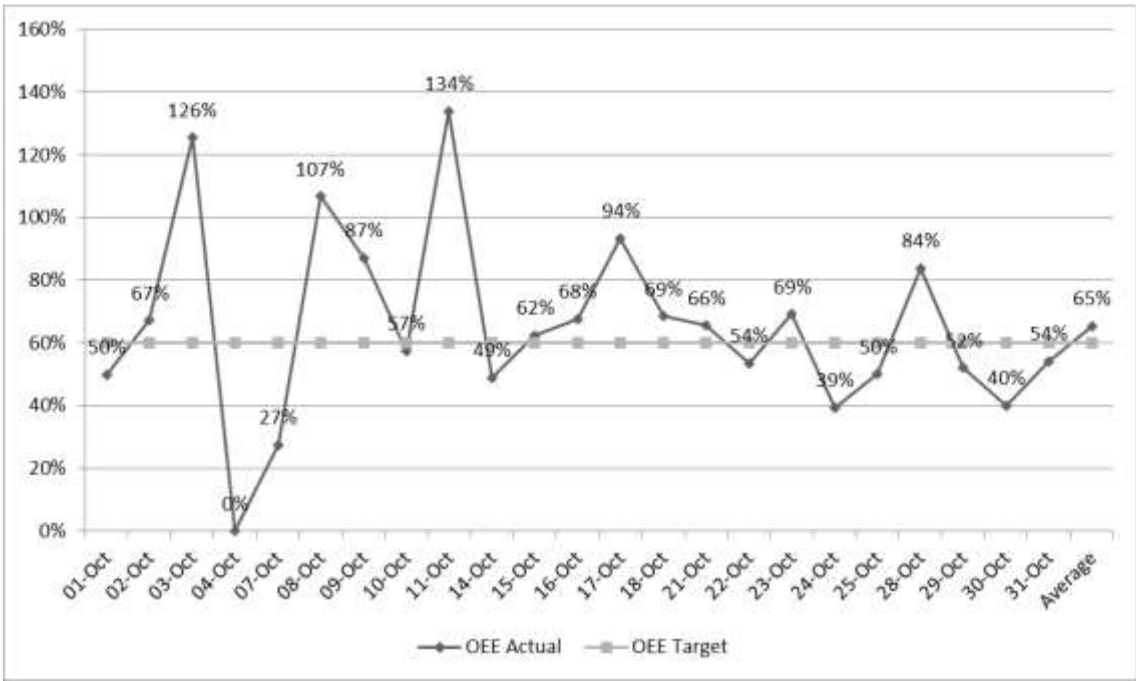

Figure 4.4: Actual OEE versus Target OEE for October 2019

In October 2019, the lowest actual OEE score was 27% and the machine availability was 78%. The Productivity was 35.2%, with quality at 100%. The highest OEE score was 134%. The metrication rate was 320 min, which had a total time of 830 min in consolidated downtime. The average OEE for October 2019 was 65%, which is above the target OEE of 60%.

4.11.4 OEE November 2019

The Actual OEE versus Target OEE for November 2019 is presented in Figure 4.4 below (See Appendix: November 2019 for detail).

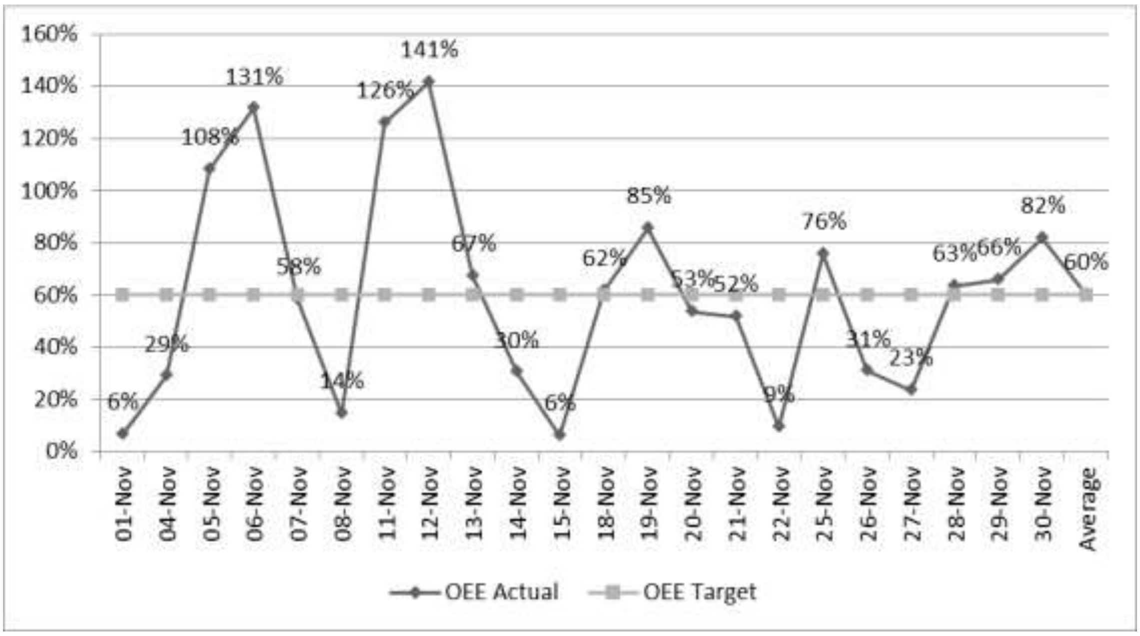

Figure 4.5: Actual OEE versus Target OEE for November 2019

November 2019, the lowest actual OEE score was 6% and the machine availability was 71.6%. The Productivity was 8.9% with a quality score of 100%. The productive time available for an operator was 12550 min. The highest OEE score was 141%. The average OEE for November 2019 was 60%, which is way above the target of 60%.

4.11.5 OEE December 2019

The Actual OEE versus Target OEE for December 2019 is presented in Figure 4.5 below (See Appendix: December 2019 for detail).

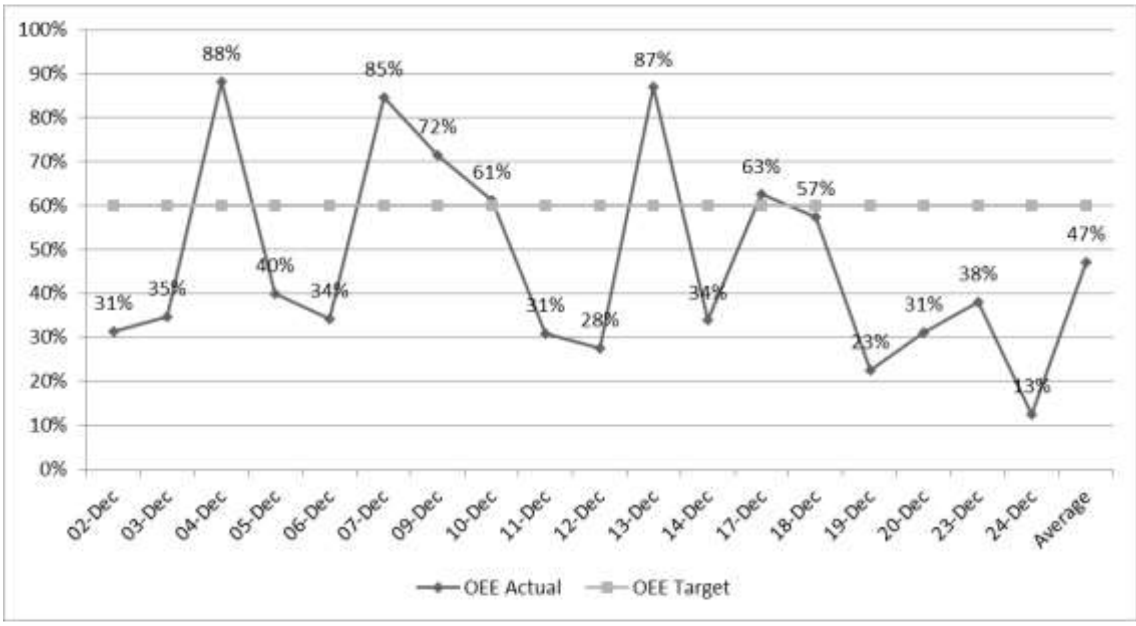

Figure 4.6: Actual OEE versus Target OEE for December 2019

December 2019, the average OEE for December 2019 was 47%, which is below the objective of 60%. The lowest actual OEE score was 13% and the machine availability was 32.2%. The Productivity was 39.2% with a quality score of 100%. The productive time available for an operator was 3325 min. The total number of units produced was 41 with no rework, which gave 100% Quality. From the six CNC machines, two machines were not in operation. The highest OEE score was 88%. The total unit produced was 47 with a rework figure of 0. Of the six CNC machines, the actual time in which the machines were in operation was 1630 min. A non-productive time of 280 min was obtained. The actual setup time was 2730 min. The total non-productive time was 280 min, which had a total time of 870 min in downtime consolidated.

4.11.6 OEE January 2020

The Actual OEE versus Target OEE for January 2020 is presented in Figure 4.6 below (See Appendix: January 2020 for detail).

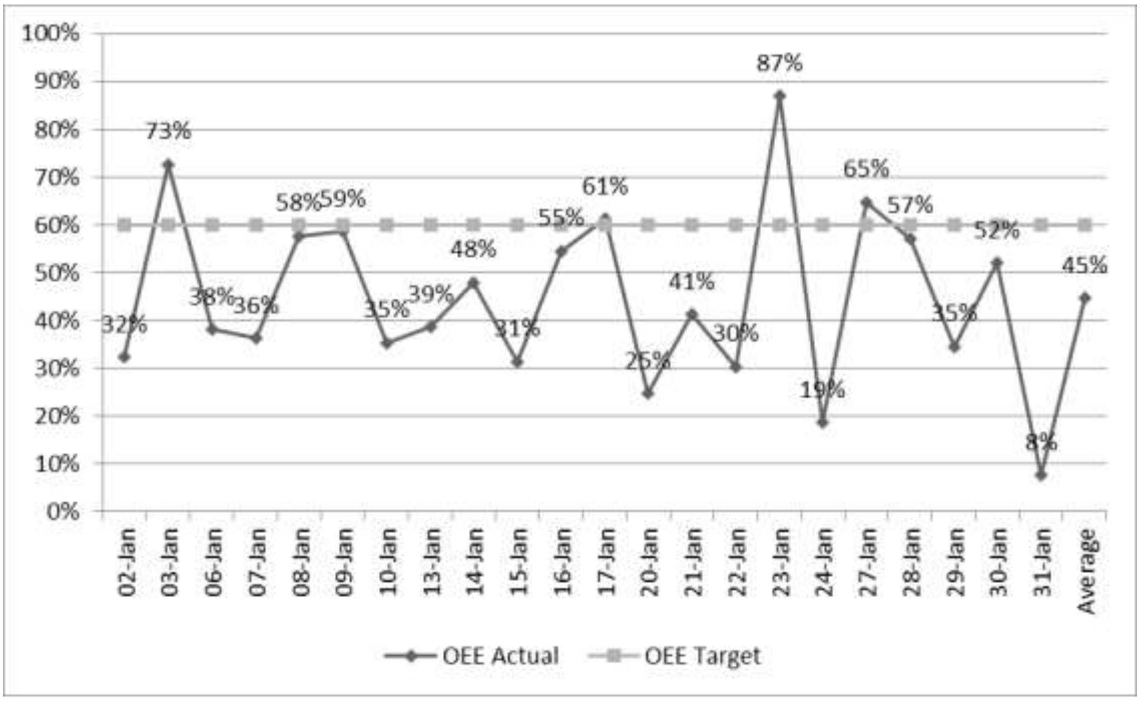

Figure 4.7: Actual OEE versus Target OEE for January 2020

The lowest OEE score was 8%. The highest OEE score was 87%. The total unit produced was 104 with a productivity rate of 126.3% The average OEE for January 2020 was 45%.

4.11.7 OEE February 2020

The Actual OEE versus Target OEE for February 2020 is presented in Figure 4.7 below (See Appendix: February 2020 for detail).

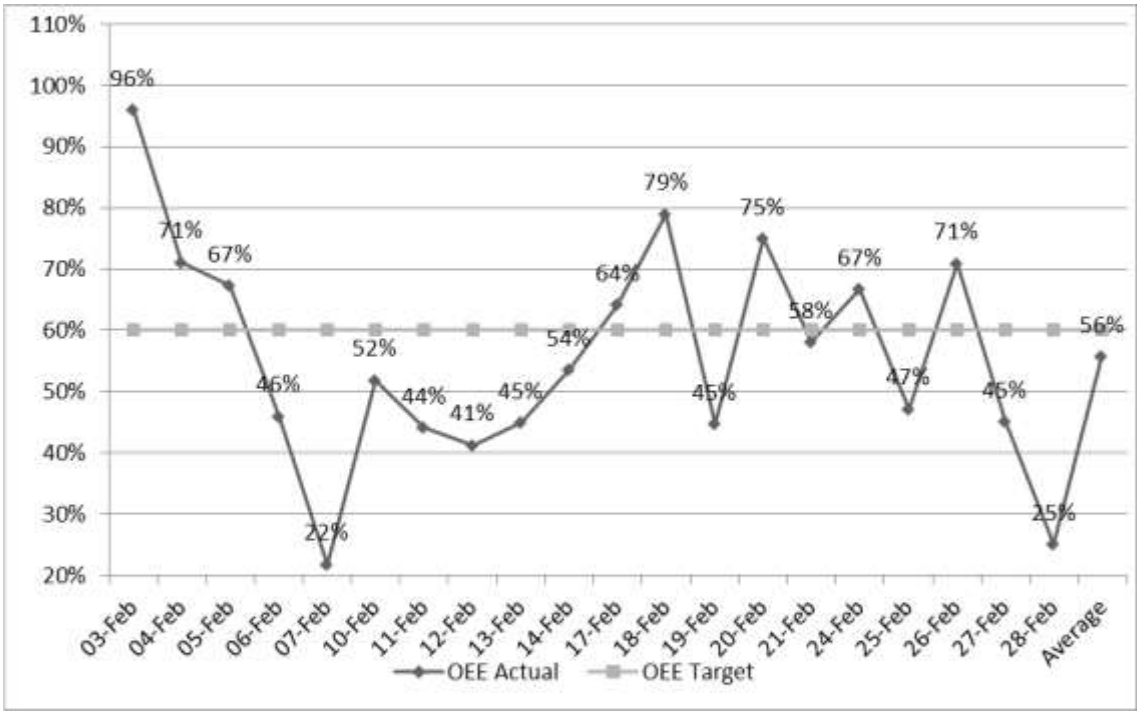

Figure 4.8: Actual OEE versus Target OEE for February 2020

February 2020, the lowest actual OEE score was 22% With the three main values of OEE, the machine availability was 56.1% followed by productivity of 38.9% and quality at 100%. The productive time available for an operator was 5278 min. The highest OEE score was 96% with a total unit produced at 19 with a rework figure of 0. With the highest score, the productivity rate was 123.9% and quality (FPY) was 100%. The average OEE for February 2020 gained an average score of 56%, which is near to the target of 60%.

4.11.8 OEE March 2020

The Actual OEE versus Target OEE for March 2020 is presented in Figure 4.8 below (See Appendix: March 2020 for detail).

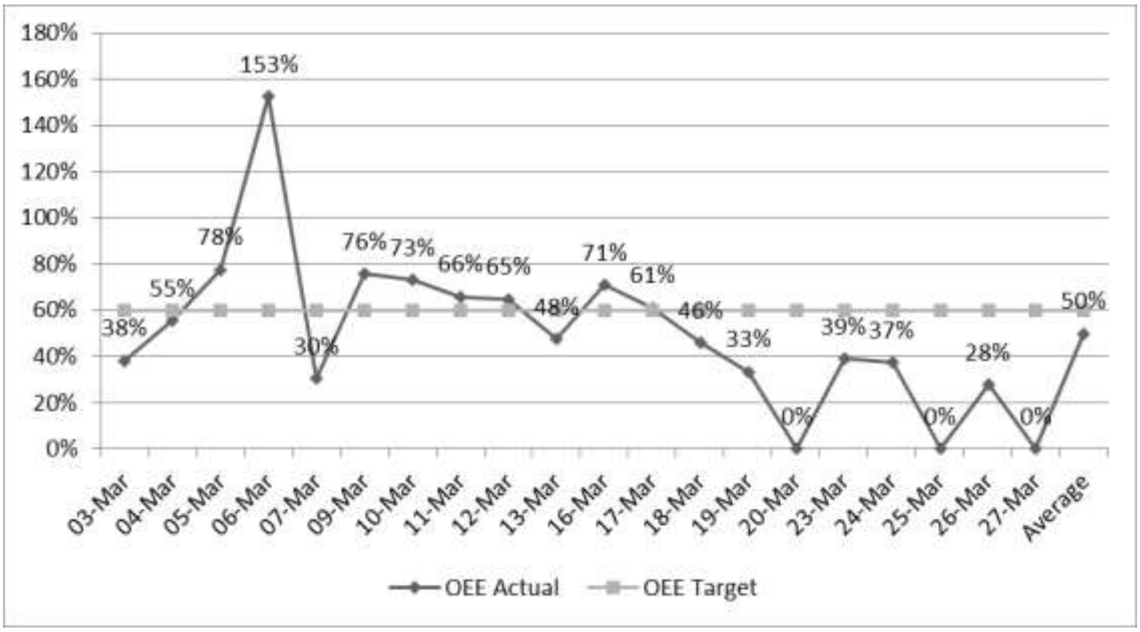

Figure 4.9: Actual OEE versus Target OEE for March 2020

In this month, the lowest actual OEE score was 28% The productive time available for an operator was 1765 min. The highest OEE score was 153%. which impressive that led to an average of 50%, which has improved but has not reached the target OEE of 60%.

4.11.9 OEE January 2021

The Actual OEE versus Target OEE for January 2021 is presented in Figure 4.9 below (See Appendix: January 2021 for detail).

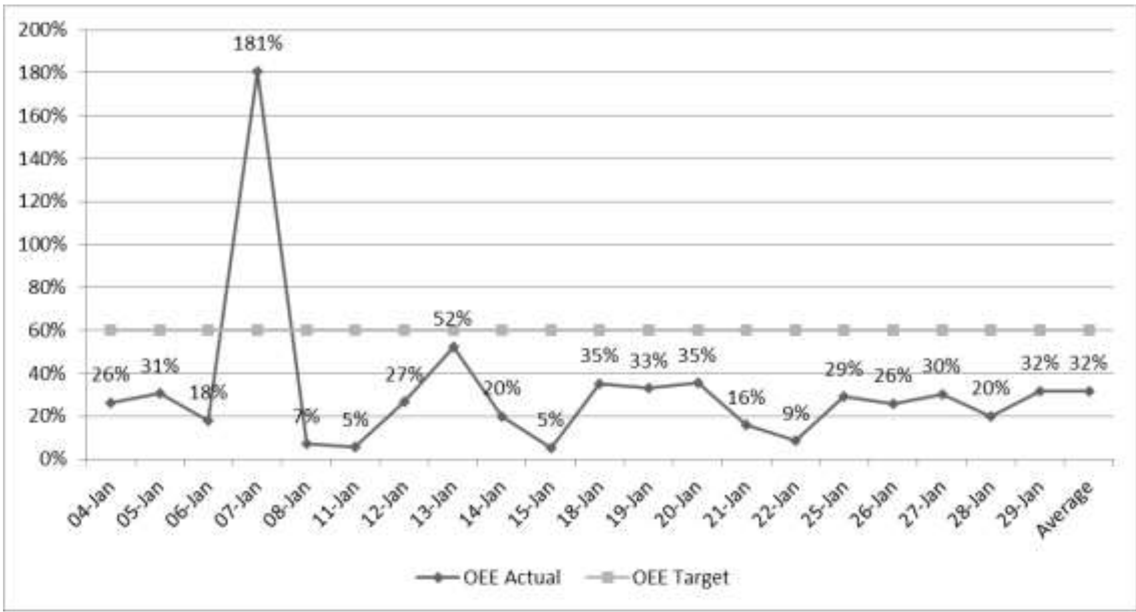

Figure 4.10: Actual OEE versus Target OEE for January 2021

January 2021 recorded the lowest actual OEE score of 5% with a machine availability of 45.1%. The highest OEE score was 181%. From this high score, the total unit produced was 19 with a rework figure of 1. The productivity rate was 202.2% and quality (FPY) was 94.7%. The average OEE for January 2021 was 32%.

4.11.10 OEE February 2021

The Actual OEE versus Target OEE for February 2021 is presented in Figure 4.10 below (See Appendix: February 2021 for detail).

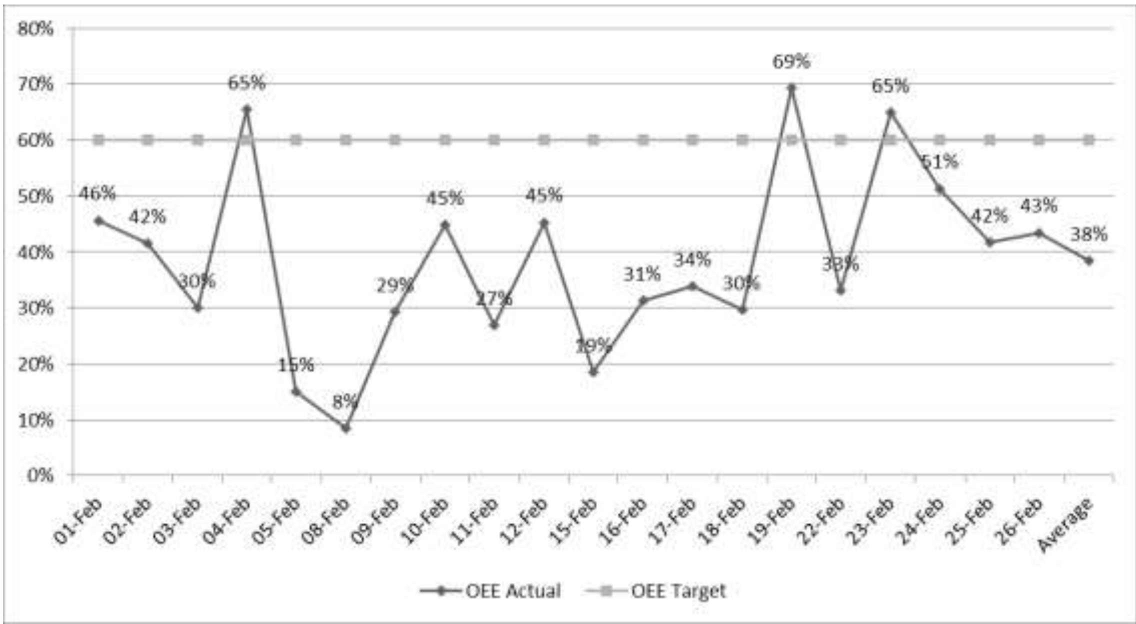

Figure 4.11: Actual OEE versus Target OEE for February 2021

February 2021 had a low actual OEE score of 8% and the machine availability was a low 43.8% including the Productivity of 19.2%. The quality however remains at 100%. The productive time available for an operator was 1900 min. The highest OEE reported in this month was an OEE score was 69%. The average OEE for February 2021 was 38%, which is below the objective of 60%.

4.11.11 OEE April 2021

The Actual OEE versus Target OEE for April 2021 is presented in Figure 4.11 below (See Appendix: April 2021 for detail).

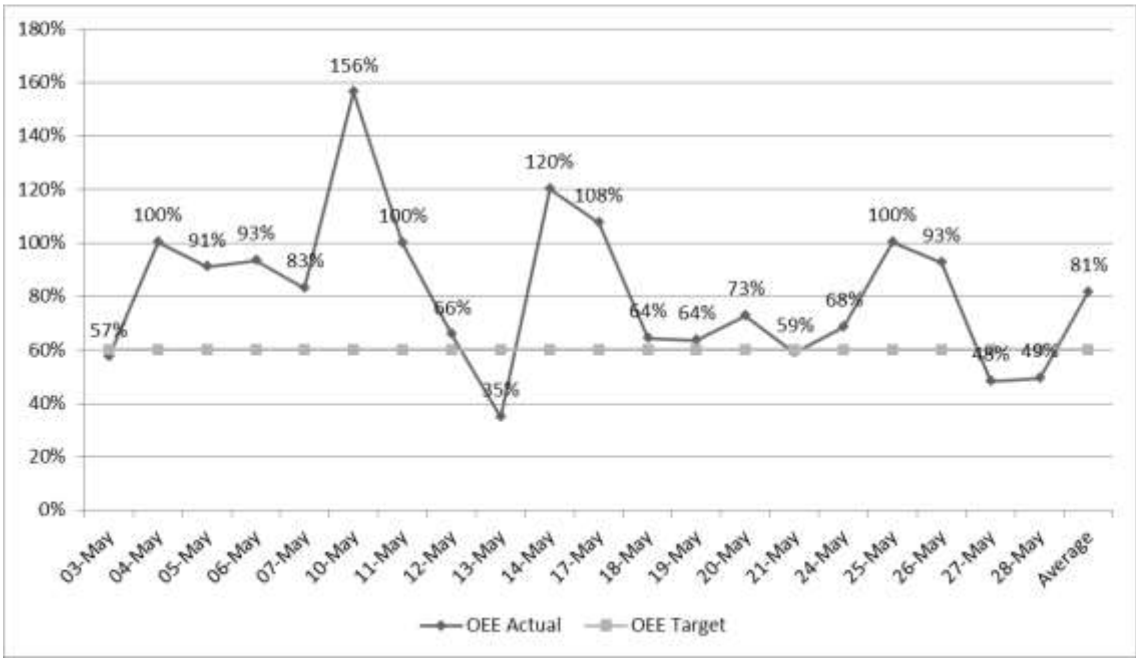

Figure 4.12: Actual OEE versus Target OEE for April 2021

In April 2021, the lowest actual OEE score was 35% and the machine availability was 100%. The Productivity was 34.8% with quality 100%. The highest OEE score was 156%. With a productivity rate of187.6% and quality (FPY) 83.3%. The average OEE for April 2021 was 81%.

4.11.12 OEE May 2021

The Actual OEE versus Target OEE for May 2021 is presented in Figure 4.12 below (See Appendix: May 2021 for detail).

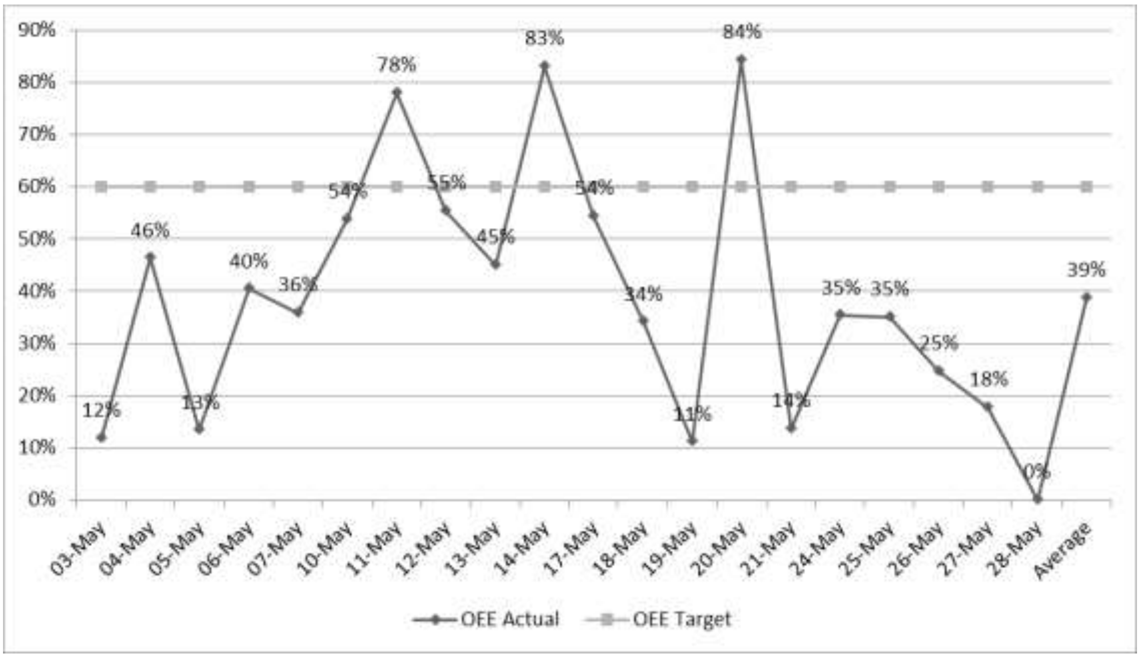

Figure 4.13: Actual OEE versus Target OEE for May 2021

The lowest actual OEE score was 0% for May 2021; Looking from the table in the Appendix, according to this month, the machine availability was 100%. The highest OEE score was 84%. The actual time in which the machines were in operation was estimated at 2000 min. With part of downtime, the actual setup time was 400 min. The productivity rate at 84.2% and quality (FPY) was 100%. The total non-productive time had a total time of 140 min in downtime consolidated. The average OEE for May 2021 was 32%.

4.12 Average OEE over the study period

The Actual Average OEE versus Target OEE for the period August 2019 to May 2021 is presented in Figure 4.13 below (See Appendix: May 2021 for detail).

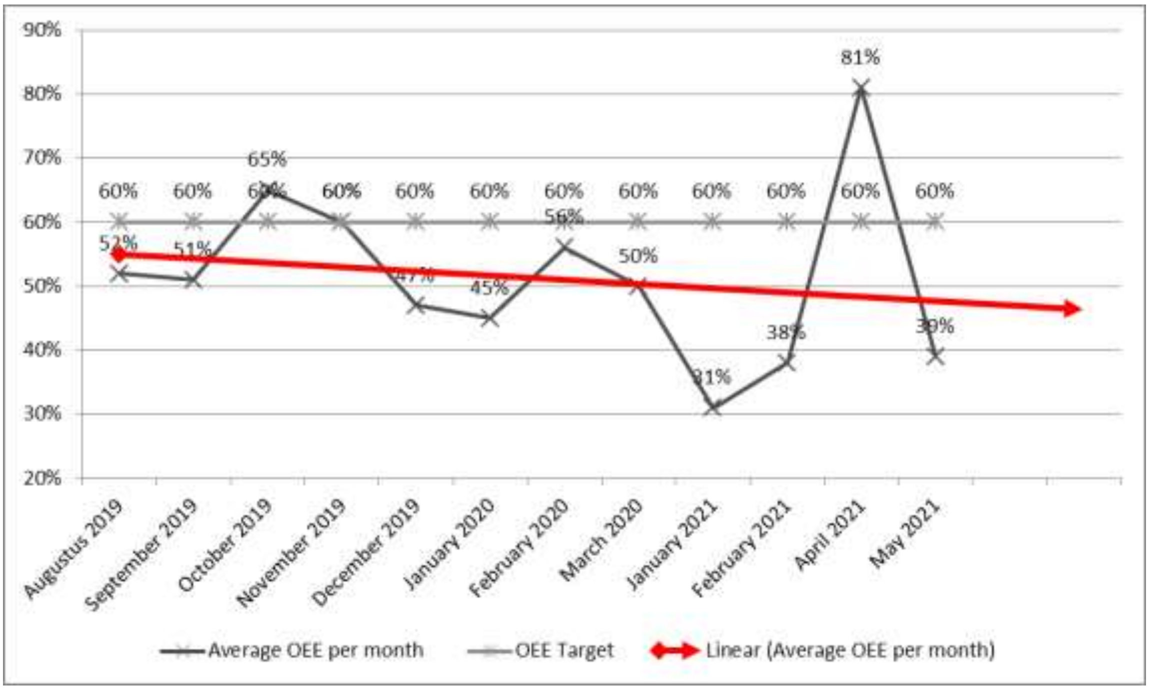

Figure 4.14: Actual Average OEE versus Target OEE for period August 2019 to May 2021

Based on the forecasting trend line for the period August 2019 to May 2021, the OEE is following a downward trend where August 2019 at 52%, September 2019 51%, October 2019 at 65% which was above the target. Following with November 2019 on par with 60%.

FY 2020, the OEE value remained below the target, wherein January 2020 scored 45%, February increased to 56%, March 50%. The lowest OEE score was reported in January 2021 with an average value of 31%. The highest value calculated was in April 2021. Out of the 12 months, January 2021, February 2021, and May 2021 OEE were below 40%. December 2019 and January 2020 remain below 50%August 2019 and October 2019 are below 60%. October 2019 and April 2021 were above the target of 60%. Still, we can see from the graph that the OEE value had a positive spike twice.

4.13 Conclusion

In this chapter, the results of the data analysis conducted on the data collected with the survey questionnaire were presented. The data were analyzed with both descriptive and inferential analyzing methods. Graphs and tables were used to present the data.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Introduction

In this chapter, the research objectives will be discussed with the findings from the study with recommendations and areas for further research. This chapter will give us the outcomes from the study with a recommendation approach.

5.2 Research objectives

The main purpose of this study is to determine why the operations team is not reaching the OEE target in all the shifts. The research objectives defined for the study in Chapter 1 are as follows:

- **Research Objective 1:** To determine which OEE management decisions are least emphasised.

- **Research Objective 2:** To determine which OEE operations management decisions impact negatively and positively.

- **Research Objective 3:** To come up with recommendation to improve OEE.

5.3 Findings from the study

In this section, the findings of the literature review and the primary research are presented with the statics based on the OEE data and the questionnaire.

5.3.1 Research findings from the literature review

Overall equipment effectiveness is furthermost seen as a tool for use in production operations. A major goal for overall equipment effectiveness programs is to reduce and/or eliminate namely the Six Big Losses, which are the most common causes of equipment-based productivity loss in manufacturing.

The processes, documents, and resources specific to the products and the methods of verification, validation, monitoring, measurement, and test activities specific to the product and the criteria are located for product acceptance. All records will be maintained to provide evidence of the realization process and that the resulting product meets the initial requirements. The output may be in the form of an engineering design review in quality, the project plan, and the customer-specific order process. The customer-related processes will determine the review/processing of customer inquiries/orders and the coordination of these activities with the internal/external parties.

The main goal for the operations management goes in three ways; the firm strategizes to meet its mission including differentiation, cost leadership, and response. Concerns to take into consideration when deciding on overall equipment effectiveness systems conclude that the system reveals as a metric and does it drive the right behaviour. In other essences, some companies use overall equipment effectiveness systems when they only look when its operation becomes a bottleneck.

Some overall equipment effectiveness systems have poor optimization capabilities it all comes at a price. So, operation managers should think very clear when obtaining or upgrading old machines with overall equipment effectiveness systems. Associates are often turned off by the system's complexity and unclear apportionments are typically part of the overall equipment effectiveness measurement system. The other fact allies that great figure do not mean anything to objectives of the value stream the overall equipment effectiveness is a local measure of a single piece of equipment.

The overall equipment effectiveness system can be difficult for some manufacturing entities especially when the results towards manufacturing in setting its goal can be miss achieved through overproduction, reducing changeover, and start-up losses by impacting the quality of the product. Furthermore, the overall equipment effectiveness system also influences the use of a general benchmark figure across machines and locations.

On the other hand, many companies have achieved better results when choosing the best fitted overall equipment effectiveness system with their manufacturing processes such as by resulting overall equipment effectiveness score of 60% that can be considered world-class for discrete manufacturers. However, an overall equipment effectiveness score of 60% can be typical for substantial improvement. Another key point for overall equipment effectiveness goes with maintenance including key performance indicators that measures an asset level of productivity. The overall equipment effectiveness score is calculated by multiplying the availability rate (utilization) by production rate (efficiency) by first-pass yield (quality). For me, this topic has a deeper thought based on the impact on decisions for operations management.

5.3.2 Findings from the primary research

The findings of the primary research are presented by the research objective.

5.3.3 Demographical findings

Gender - A larger proportion of the respondents were males (n=21, 63.6%) and the remainder were females (n-12, 36.4%) Thus 1 = Male, 2 = Female.

Years' experience - With the given data, most of the respondents had a frequency of 9, with a total of 27.3% having between 6 -10 years of work experience in the organisation

Departments - With the given data, the frequency of the respondents in their departments was 31 out of 33, a frequency of 10 (30.3%).

Years in position - The findings of years within the current position, came from department one, whereas it held the highest score percentage of 45.5 % and 15 years followed with department three that was six years or 18.2%.

Education - In the table which table, most respondents held a certificate /diploma of a frequency of 42.4% followed with a degree of 24.2% and thirdly had only matric resulting to a 21.2%. The remainder frequency was 6.1% which was postgraduates.

Employment level - Most respondents - were under “employee” who had a frequency percentage of 57.6% followed by management/ Supervisory entitlement that came to 36.4%.

A total of 21 of the participants are male and 12 are female that will give a balanced view from a gender perspective. The majority had more than 6 years of experience an indication the company employs an experienced workforce of which 13 works in the operations or engineering sections. Eighteen of the respondents are in the same position for more than 6 years an indication of a flat organisational structure.

The majority of the participants possess a diploma or higher qualification an indication of a well-educated workforce. Twelve of the participants held management or supervisory roles and the other operational roles.

5.3.4 Research objective 1

“To determine which OEE management decisions are least emphasised.”

The average mean score of management decisions was determined at 3.59 (see Table 5.2 below) In Table 5.1 the constraints identified for potential improvement are presented.

Table 5.1: Possible constraints in achieving the desired OEE value

Management Decisions	Mean	Comment - Decision Matrix
Inventory management	3.35	The company is not doing well
Location analysis and strategy	3.43	The company is not doing well
Process and Capacity Design	3.25	The company is not doing well
Process Maintenance	3.54	The company is not doing well
Scheduling	3.25	The company is not doing well

As reflected in Table 5.1 it was found that the management decisions inventory management; location analysis and strategy; process and capacity design; process maintenance and scheduling are the primary constraints that impact the achievement of OEE targets.

5.3.5 Research objective 2

"*To determine which OEE operations management decisions impact negatively and positively.*"

The operations management decisions that impact OEE are presented in Table 5.2 below.

Table 5.2: Impact of operations management decisions on the OEE

Management Decisions	Mean	Comment	Decision Matrix
Design of goods and service	**4.00**	Company is doing well	above mean 3.59
Human Resources and Job design	**3.79**	Company is doing well	above mean 3.60
Layout Strategy	**3.71**	Company is doing well	above mean 3.59
Quality management	**3.71**	Company is doing well	above mean 3.59
Supply chain management	**3.90**	Company is doing well	above mean 3.59
Inventory management	3.35	Company is not doing well	below mean 3.60
Location analysis and strategy	3.43	Company is not doing well	below mean 3.60
Process and Capacity Design	3.25	Company is not doing well	below mean 3.60
Process Maintenance	3.54	Company is not doing well	below mean 3.60
Scheduling	3.25	Company is not doing well	below mean 3.60
Average mean score	**3.593**		

The element in which the company has reached above 3.59 is doing well. The decision areas which are not doing well are not being emphasized. Despite the emphases, the OEE is going down as illustrated in (Figure 4.13).

5.3.6 Research objective 3

"To come up with recommendation to improve OEE."

By calculating the speed loss rather than the downtime, it will assist production effectiveness, thereby improving the OEE score. Speed loss has three areas namely, human-related, product-related, and technology-related that may have a possible area for improvement.

The human factors can be improved from knowing the steps of the process, with the right people in the right places, with the right tools, by using better tools such as electrical tools instead of manual. The design of tasks to be physically conformable will allow for performance to increase. The product factors involved with the quality of finished goods can create small stops as the line should be stopped to perform fixing. Technology factors such as equipment design weakness can portray speed loss. Looking into improved equipment such as motion control systems will create smoother and faster movement, especially on the CNC machines.

From the research, in figure 4.13, the data measured during the different periods provided accurate information. Based on the information the OEE rate went downwards. New OEE measuring programs can be looked into depending on the CAPEX availability and if the need is required to do so.

5.4 Research conclusions

The research conclusions are given by the research question based on the findings as defined in the research objectives.

5.4.1 Research question 1

It can be concluded that the management decisions inventory management; location analysis and strategy; process and capacity design; process maintenance and scheduling are the primary constraints that impact the achievement of OEE targets.

5.4.2 Research question 2

"Which operations management decisions impact negatively and positively on the OEE?

From the research results, it can be concluded that the design of goods and services, affected management's decisions positively. The human resources and job design also indicated a positive decision impact on the OEE. This is to say that the people who work on the equipment are trained and have the capabilities to utilise the equipment properly. The layout strategy has a positive effect on the management's decisions, as the equipment is aligned according to the manufacturing process that improves lean techniques.

It can be concluded that operations management decisions have a positive impact on the quality, to ensure that the product quality meets the global standards in which the company presents. It can be concluded that operations management should optimize its decisions towards scheduling to have all equipment prepared to eliminate improved downtime as this decision harms the data. The decisions on quality management are good; from the statistics, the mean over the standard rate is greater which has a positive impact on the OEE.

5.4.3 Research question 3

"*What other alternatives are available and how can they be implemented to achieve an OEE global standard of 60%?"*

It can be concluded that the alternative for speed loss is an option for the company that will be a benefit towards OEE improvement.

5.4.4 Research question 4

"*Is the current data collection system sufficient to quantify the OEE score on the CNC machines?"*

It can be concluded that the current OEE calculated system is on par based on the trends shown. The company may investigate new programs that will be more cost-efficient with new technology compatibility.

5.5 Recommendations

Based on the findings of this study the following recommendation can be made - these should come from the results.

The company should focus on the operations management decisions with means that were scored below 3.59. This does not state that the impact decisions were correct, but management can investigate these areas to focus and to improve their overall average OEE.

- Area 1: Inventory management
- Area 2: Location analysis and strategy
- Area 3: Quality management
- Area 4: Scheduling

The areas below 3.59 were not being emphasized, these were identified as process and maintenance which had a mean of 3.54. The Location analysis and strategy have scored 3.43. Inventory management has the second-lowest mean average of 3.35 and lastly, Process and Capacity Design and scheduling have set a mean rate of 3.25. The areas can be seen as for improvement that would improve overall the OEE value in the company.

Most operations decisions such as Design of goods and services, Human Resources and Job design, Layout Strategy, Quality management, and Supply chain management have contributed a positive effect on the OEE. However, with the decline in the OEE value towards the positive effect out of the research, the company can appoint a committee to investigate further why the OEE value declines based on the decisions.

Note: Additional unplanned measures due to breakdowns of machines might require preventive maintenance or vibration analysis. Upcoming research may be done to reconnoitre:

- Frequency studies on man-hours (Human OEE)
- Machine design or mechanical design
- Operation and production design
- Terms of cost
- The dynamics of translating equipment effectiveness or loss of effectiveness.

5.6 Areas for further research

An important aspect that might further improve the work now carried out in this dissertation would be qualitative research.

Some areas of difficulties were encountered during this work that included:

- The unavailability of data from some machines limiting the research
- Incomplete data from some machines
- Number of questionnaires received compared to the total which were sent to the participants.

Contact methods may gather information through mail, telephone, or personal interview. The questionnaire consists of a set of questions presented to the various industries to get their interpretation. This will support answers to some of the questions that might help solve the OEE problem in return. High quality can be established due to effectiveness and efficiency due to effort put by man, machine, method, and material.

Conducting frequent research on the latest equipment will be a guide towards upgrades or improvement on manufacturing and to eliminate areas that have a negative impact in the production line that may result to a low OEE rate.

Data from a build cross-functional teamwork possibly will help create more reliable and valuable data. Added unplanned measures due to breakdowns of machines might require preventive maintenance or vibration analysis. Future research may be done to explore.

- Frequency studies on man hours (Human OEE)
- Machine design or mechanical design.
- Operation and production design.

- The dynamics of translating equipment effectiveness or loss of effectiveness in terms of cost.

5.7 Conclusion

In this chapter, the research findings of the literature review and the primary findings by objectives were presented. Conclusions were presented by research questions based on the results from the study. The study concluded with recommendations and suggested areas for further research. The results of this study indicated that all the research objectives were achieved, and the research questions were answered by the data obtained from this study.

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APPENDIX A

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APPENDIX A: CONSENT FORM

NWU®

Ethics informed consent

INFORMED CONSENT

Dear Participant

This **Informed Consent Statement** serves to confirm the following information as it relates to the officially approved research project at the North-West University on *"your Research Topic"*.

1. The sole purpose of this study is to obtain information from customers like yourself to determine the nature of your everyday green buying behaviour experience related to the research topic.
2. Participation is completely voluntary and you may opt-out at any time. You may also decide not to answer specific questions.
3. The procedure to be followed is quantitative research design, which entails a questionnaire. Basic background information will be asked e.g. your age, function and related experience to the topic.
4. Confidentiality of the data is guaranteed and only the combined results will be used for research and publication purposes.
5. The data gathered from the questionnaires will only be used for research purposes.
6. Please note that there are four classifying variables in Section 5 (age, employment, gender and ethnicity) which will be used only to profile the respondents who partook in this study. It will be used in comparative analysis to distinguish green customer behaviour among different customer profiles. Note that only the combined results will be used and at no stage can any specific respondent or his/her data entry be isolated and analysed. (You may also select the option not to answer the specific question should you feel like it.)
7. Also note that this study does not have a correct or incorrect answer to any of the questions. This means that in comparing profiles of respondents, there is not a correct or incorrect behavioural profile. The study merely analyse green consumer behaviour as is.

Please indicate your consent

I hereby give my consent after having read the above information that my data may be used as stated	**YES**	**NO**

above.		
I hereby give my consent that my demographic data may be used to develop a profile for green consumer behaviour	**YES**	**NO**

Thank you for your time.

The researcher

APPENDIX B

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APPENDIX B: APPLICATION FOR ETHICAL CLEARANCE

NWU®

NWU Higher Degrees Administration

SOLEMN DECLARATION AND PERMISSION TO SUBMIT

1. Solemn declaration by student

I, **Wynand Jan Kleynhans**

declare herewith that the thesis/dissertation/mini-dissertation/article entitled **(exactly as registered/approved title)**,

INVESTIGATING THE INFLUENCE OF OPERATIONS MANAGEMENT DECISIONS ON OVERALL EQUIPMENT EFFECTIVENESS IN AN ENGINEERING COMPANY

which I herewith submit to the North-West University is in compliance/partial compliance with the requirements set for the degree:

SBE Q01 MBA

is my own work, has been text-edited in accordance with the requirements and has not already been submitted to any other university.

LATE SUBMISSION: If a thesis/dissertation/mini-dissertation/article of a student is submitted after the deadline for submission, the period available for examination is limited. No guarantee can therefore be given that (should the examiner reports be positive) the degree will be conferred at the next applicable graduation ceremony. It may also imply that the student would have to re-register for the following academic year.

Ethics number: NWU-00891-21-A4

ORCID: 0000-0002-7087-7495

Signature of Student: Wynand Kleynhans

University Number: 28327276

Signed on this 30 day of November of 2021

2. Permission to submit and solemn declaration by supervisor/promoter

The undersigned declares that the thesis/dissertation/mini-dissertation/article:

- [x] complies with the A-rules and the technical requirements provided for in the Manual for Master's and Doctoral studies and in faculty rules;
- [x] has been checked by me for plagiarism (by making use of Turnitin software for example) and a satisfactory report has been obtained;
- [x] and that the work was language edited before submission for examination.

Faculty specific requirements as per A-rules: 1.3.2, 433, 4.2.4, 4.10.4, 5.3.2

- [x] complies with regards to faculty rules on submission or acceptance by an accredited scientific journal;
- [x] complies with regards to faculty rules on peer reviewed conference proceedings;
- [x] the student is hereby granted permission to submit his/her article/mini-dissertation/ dissertation/thesis for examination.

Signatures of supervisor(s) and Promoter(s): (only compulsory in cases where there are co- or assistant- supervisor(s)/promoter(s))

Supervisor/Promoter	Co-Supervisor/Co-Promoter	Assistant -Supervisor Assistant-Promoter
10/12/2021		

Original details: [illegible] SOLEMN DECLARATION AND PERMISSION TO SUBMIT.docm 1 Oct 2018
File reference: 7.1.11.3.2.3

APPENDIX C

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APPENDIX C: QUESTIONNAIRE

Kindly answer the following questions by ticking in the appropriate box or filling the spaces provided.

Appendix ii: Questionnaire

Kindly answer the following questions by ticking in the appropriate box or filling the spaces provided.

PART A: GENERAL INFORMATION- DEMOGRAPHICS

1. Gender

Male	Female	Prefer not to indicate
1	2	3

2. Years of experience in Industry

0 – 5	1
6 –10	2
11 – 15	3
16 – 20	4
21 - 25	5
26 and more	6

3. Department

Operations	Sales and Marketing	Human Resources	Engineering	Procurement	Other
1	2	3	4	5	6

4. Years in Current Position

0 – 5	1
6 –10	2

11 – 15	3
16 – 20	4
21 - 25	5
26 and more	6

5. Highest level of Education

Matric	Certificate/Diploma	Degree	Post Graduate	Other
1	2	3	4	5

Level of employment

Management/Supervisory ☐

Employee ☐

PART B: Operations Management Practices

This section will be focused on the management practices, where each section will have a 1 -5 level of agreements scale will be used between strongly disagree to strongly agree.

Indicate on a scale of 1-5 to what extent you agree with the following about your company.

1 = Strongly disagree; 2 = Disagree; 3 = Neither agree nor disagree; 4 = Agree; 5 = Strongly Agree

QUALITY MANAGEMENT	**1**	**2**	**3**	**4**	**5**
QM1: Company has a quality management system in place.					
QM2: Company carries out studies to evaluate customer satisfaction.					
QM3: Company welcomes and acts on customers' complaints.					
QM4: Quality is determined through acceptance sampling.					
QM5: Company relies on feedback from Pharmacy and Poisons board on quality of its products.					
QM6: There is continuous improvement on handling of customers.					
QM7: Staff are continuously trained and educated on quality programs.					

LOCATION STRATEGY	**1**	**2**	**3**	**4**	**5**
LOS1: Location is close to customers.					
LOS2: Affordable rent and Leasing costs.					
LOS3: Labour easily available					

HUMAN RESOURCES AND JOB DESIGN	**1**	**2**	**3**	**4**	**5**
HR1: There is a system for collecting employees' opinions.					
HR2: There is a strong spirit of cooperation in the organization.					

HR3: Employees fully understand the goals, policies, and objectives of this organization.					
HR4: Supervisors provide feedback to employees on how well they are doing.					
HR5: Management gives priority to employees' personal welfare.					
HR6: Employees have access to all the training they need.					
HR7: Employees understand their duties and are never idle.					

SUPPLY CHAIN MANAGEMENT	**1**	**2**	**3**	**4**	**5**
SCM1: Suppliers operate as separate entities with their own goals.					
SCM2: The company deals with a few prequalified suppliers.					
SCM3: Company gathers feedback from distributors and customers on how to improve the systems.					
SCM4: The company provides technical assistance to suppliers, distributors and customers.					
SCM5: The company can locate and track movement of items.					

INVENTORY MANAGEMENT	**1**	**2**	**3**	**4**	**5**
IM1: Company uses computer software to manage its inventory					
IM2: Goods are often disposed of without selling to customers.					
IM3: Company orders at specific times in the year.					
IM4: Company orders for goods randomly depending on demand.					
IM5: Cost determines the amount of goods to be ordered.					
IM6: Company considers discounts offered by various suppliers when ordering for goods.					
IM7: Orders are placed depending on customer demand.					
IM8: Orders are placed depending on prior agreements with suppliers.					

MAINTENANCE	**1**	**2**	**3**	**4**	**5**

MT1: Maintenance services are done regularly					
MT2: Maintenance services are done when there is less work or when equipment breaks down.					
MT3: Company undertakes regular inspection of its products and facilities.					

SCHEDULING	**1**	**2**	**3**	**4**	**5**
SC1: Company maintains constant production and supply.					
SC2: Company hires more workers when demand increases.					
SC3: Increasing or decreasing working hours depending on demand.					
SC4: Employees work overtime more often to clear backlogs.					

PROCESS AND CAPACITY DESIGN	**1**	**2**	**3**	**4**	**5**
PC1: Company does invest in systems that require a long time for benefits to be seen.					
PC2: Company can respond to changes in demand quickly.					
PC3: Subcontracts work to other firms when demand is high.					
PC4: Company can forecast demand accurately.					

LAYOUT STRATEGY	**1**	**2**	**3**	**4**	**5**
LS1: Departments are divided based on similarity of duties.					
LS2: Divisions are grouped depending on products they deal with.					
LS3: Divisions operate according to their geographical locations.					
LS4: Designed for ease of future expansion and improvement.					
LS5: To make it easy to move goods from one section to another.					
LS6: It is easy for employees to communicate with one another.					
LS7: To ensure safety of employees.					

DESIGN OF GOODS AND SERVICES	**1**	**2**	**3**	**4**	**5**

DG1: To comply with the legal requirements in the country.					
DG2: Make the products easily acceptable in the market.					
DG3: Make the products appealing to customers.					
DG4: Make products that can satisfy customers’					
DG5: To achieve competitive advantage					
DG6: Company follows keenly on what competitor has in the market					
DG7: To minimize the cost of the product.					

APPENDIX: AUGUSTUS 2019

Date	Day	Normal Hours (CNC)	Normal Hours (Operator)	OT Hours	Resources (Machines)	Resources (Heads)	Scheduled Operating Time min (Operator)	Scheduled Operating Time min (CNC)	Non-productive time min	Spindle Downtime min	Productive time available (Operator)	Total Units Produced	Rework	Actual time min (set up)	Actual time min (run)	Machine Availability %	Productivity 95%	Quality (FPY%)	OEE Actual	OEE Target
01-Aug	Thur	9	8.50	0.84	7	8	4483.2	3780	280	0	4203.2	12	0	175	1750	100.0%	45.8%	100.0%	46%	60%
02-Aug	Fri	6	6.00	0.84	7	8	3283.2	2520	200	0	3083.2	30	0	220	1025	100.0%	40.4%	100.0%	40%	60%
05-Aug	Mon	9	8.50	0.84	7	8	4483.2	3780	280	1080	4203.2	16	2	365	720	71.4%	25.8%	87.5%	16%	60%
06-Aug	Tue	9	8.50	0.84	7	8	4483.2	3780	280	175	4203.2	20	0	280	1785	95.4%	49.1%	100.0%	47%	60%
07-Aug	Wed	9	8.50	0.84	7	8	4483.2	3780	280	100	4203.2	12	0	300	2820	97.4%	74.2%	100.0%	72%	60%
08-Aug	Thur	9	6.00	0.84	7	8	3283.2	3780	280	130	3003.2	13	3	755	2030	96.6%	92.7%	76.9%	69%	60%
12-Aug	Fri	6	6.00	0.84	7	8	3283.2	2520	200	0	3083.2	44	2	630	2130	100.0%	89.5%	95.5%	85%	60%
13-Aug	Mon	9	8.50	0.84	7	8	4483.2	3780	280	0	4203.2	17	0	535	2315	100.0%	67.8%	100.0%	68%	60%
14-Aug	Tue	9	8.50	0.84	7	8	4483.2	3780	280	0	4203.2	12	0	500	1675	100.0%	51.7%	100.0%	52%	60%
15-Aug	Wed	9	8.50	0.84	7	8	4483.2	3780	280	0	4203.2	5	1	380	1905	100.0%	54.4%	80.0%	43%	60%
16-Aug	Thur	9	8.50	0.84	7	8	4483.2	3780	280	0	4203.2	35	0	320	1280	100.0%	38.1%	100.0%	38%	60%
19-Aug	Fri	6	6.00	0.84	7	6	2462.4	2520	150	805	2312.4	5	0	405	1315	68.1%	74.4%	100.0%	51%	60%
20-Aug	Mon	9	8.50	0.84	7	6	3362.4	3780	210	780	3152.4	7	0	275	890	79.4%	37.0%	100.0%	29%	60%
21-Aug	Tue	9	8.50	0.84	7	7	3922.8	3780	245	390	3677.8	3	1	785	1955	89.7%	74.5%	66.7%	45%	60%
22-Aug	Wed	9	8.50	0.84	7	7	3922.8	3780	245	815	3677.8	12	0	395	1315	78.4%	46.5%	100.0%	36%	60%
23-Aug	Thur	9	6.00	0.84	7	7	2872.8	3780	245	375	2627.8	13	5	118	3120	90.1%	123.2%	61.5%	68%	60%
26-Aug	Fri	6	6.00	0.84	7	7	2872.8	2520	175	305	2697.8	33	0	70	780	87.9%	31.5%	100.0%	28%	60%
27-Aug	Mon	9	8.50	0.84	7	8	4483.2	3780	280	380	4203.2	7	0	345	3200	89.9%	84.3%	100.0%	76%	60%
28-Aug	Tue	9	8.50	0.84	7	8	4483.2	3780	280	660	4203.2	18	8	625	1870	82.5%	59.4%	55.6%	27%	60%
29-Aug	Wed	9	8.50	0.84	7	8	4483.2	3780	280	440	4203.2	3	1	3545	3200	88.4%	160.5%	66.7%	95%	60%
																90.8%	**66.0%**	**89.5%**	**52%**	**60%**

APPENDIX: SEPTEMBER 2019

Date	Day	Normal Hours (CNC)	Normal Hours (Operator)	OT Hours	Resources (Machines)	Resources (Heads)	Scheduled Operating Time min (Operator)	Scheduled Operating Time min (CNC)	Non-productive time min	Spindle Downtime min	Productive time available (Operator)	Total Units Produced	Rework	Actual time min (set up)	Actual time min (run)	Machine Availability %	Productivity 95%	Quality (FPY%)	OEE Actual	OEE Target
02-Sep	Mon	9	8.50	8	7	8	7920	3780	280	665	7640	3	0	3605	2900	82.4%	85.1%	100.0%	70%	60%
03-Sep	Tue	9	8.50	0	7	8	4080	3780	280	515	3800	12	0	345	3200	86.4%	93.3%	100.0%	81%	60%
04-Sep	Wed	9	8.50	0	7	8	4080	3780	280	1170	3800	33	0	475	2771	69.0%	85.4%	100.0%	59%	60%
05-Sep	Thur	9	8.50	0	7	8	4080	3780	280	930	3800	33	0	600	2115	75.4%	71.4%	0.0%	0%	60%
06-Sep	Fri	6	6.00	0	7	8	2880	2520	200	690	2680	7	0	550	2170	72.6%	101.5%	100.0%	74%	60%
09-Sep	Mon	9	8.50	0	7	8	4080	3780	280	535	3800	7	0	140	1470	85.8%	42.4%	100.0%	36%	60%
10-Sep	Tue	9	8.50	0	7	8	4080	3780	280	440	3800	7	0	680	2545	88.4%	84.9%	100.0%	75%	60%
11-Sep	Wed	9	8.50	0	7	8	4080	3780	280	520	3800	7	0	381	1260	86.2%	43.2%	100.0%	37%	60%
12-Sep	Thur	9	8.50	0	7	8	4080	3780	280	495	3800	7	0	775	2845	86.9%	95.3%	100.0%	83%	60%
13-Sep	Fri	6	6.00	0	7	8	2880	2520	200	405	2680	18	10	345	2970	83.9%	123.7%	44.4%	46%	60%
16-Sep	Mon	9	8.50	0	7	8	4080	3780	280	700	3800	32	0	300	1105	81.5%	37.0%	100.0%	30%	60%
17-Sep	Tue	9	8.50	0	7	8	4080	3780	280	685	3800	2	1	605	2885	81.9%	91.8%	50.0%	38%	60%
18-Sep	Wed	9	8.50	0	7	8	4080	3780	280	725	3800	2	1	555	2410	80.8%	78.0%	50.0%	32%	60%
19-Sep	Thur	9	8.50	0	7	7	3570	3780	245	610	3325	1	0	675	1820	83.9%	75.0%	100.0%	63%	60%
20-Sep	Fri	6	6.00	0	7	7	2520	2520	175	155	2345	6	1	310	1360	93.8%	71.2%	83.3%	56%	60%
23-Sep	Mon	9	8.50	0	7	4	2040	3780	140	370	1900	17	2	780	1025	90.2%	95.0%	88.2%	76%	60%
24-Sep	Tue	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0				0%	60%
25-Sep	Wed	9	8.50	0	7	8	4080	3780	280	790	3800	49	1	300	2820	73.3%	82.1%	98.0%	59%	60%
26-Jun	Thur	9	8.50	0	7	8	4080	3780	280	795	3800	12	1	755	2030	73.2%	73.3%	91.7%	49%	60%
27-Sep	Fri	6	6.00	0	7	8	2880	2520	200	520	2680	8	1	630	2130	69.4%	103.0%	87.5%	63%	60%
30-Sep	Mon	9	8.50	0	7	8	4080	3780	280	630	3800	21	1	300	1535	77.2%	48.3%	95.2%	36%	60%
																			51%	60%