Factors influencing improvements of productivity at Ford Struandale Engine Plant

by

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Promoter: B. Heather

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DECLARATION

I, Zamandile Oscar Sundu, hereby declare that

- The work in this research paper is my original work;

- All resources used and referred to have been documented and recognised;

- This research paper has not been previously submitted in full or partial fulfilment of the requirements for an equivalent or higher qualification at any other recognised education institution;

- I hereby give consent for my dissertation, if accepted, to be available for photocopying and for interlibrary loan, and for the title and the summary to be made available to outside organisations.

Signature.............................................. Date.........................................
ACKNOWLEDGEMENTS

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ABSTRACT

This treatise investigates the underlying factors influencing productivity at Ford Struandale Engine Plant.

On 15 September 2009 Ford Motor Company of South Africa made an announcement about programme approval for the investment of more than R1.5 billion to expand operations for the production of Ford's next-generation compact pick-up truck and the PUMA diesel engine. The approval for this programme was on review for a year due to attempts by the decision-makers to find the least expensive way to launch the programme.

This investment is for the expansion to both vehicle assemble operations in Silverton for the production of 75 000 units pick-up trucks as well as engine operations in Port Elizabeth for 220 000 units of its new-generation PUMA diesel engines and component parts (http://www.autoblog.com/2009/09/15/ford-to-invest-209m-in-south-africa-for-new-ranger-pickup/).

Owing to the level of the global footprint of this programme given the locations where the vehicle, the engines and the components will be used, there are specific requirements for the sites which will be awarded the programme. From the list of requirements there were key elements, namely the cost at which the site can produce the parts, the quality history of the site and productivity performance of the plant. The plant has a good reputation for quality that has been built up over the years, including the level 8 quality award and in addition, the plant has made a number of sacrifices in the past to continuously reduce the cost structure.

The only area where the plant needs to make considerable changes is the level of productivity because this has not been satisfactory and there have been no significant improvements made. Because this a global programme there is a great deal at stake if the plant fails to deliver as the likes of Thailand, Argentina and South Africa depend on the Ford Struandale Engine Plant to supply their components. The Ford Struandale Engine Plant will also be the only plant which will have the I4 assembly, I5 assembly and 3C (Crank, Cylinder Block, and Cylinder Head) machining and the expectations of operating in a lean environment are high.
The management team at the Ford Struandale Engine Plant needs to understand what the factors are that influence productivity improvement and the recommended actions required to improve in order for the plant to be more competitive.

A literature review was conducted to determine what the theory reveals about productivity, focusing on the internal factors of productivity. The study looked at both aspects of the internal factors, namely the hard and the soft factors where the hard factors discussed were the equipment, particularly the overall equipment effectiveness (OEE) looking at (Availability, Performance Efficiency, and Quality) and material availability. On the other hand, as far as the soft factors are concerned, the study looked at employee skills availability to improve productivity. A Ford literature study was conducted to reveal the current literature being applied at Ford.

This was then followed by an empirical survey conducted within the Ford Struandale Engine Plant. Finally, the empirical survey, Ford Struandale Engine Plant literature survey and a general literature survey were amalgamated in order to draw conclusions relating to the Ford Struandale Engine Plant. These conclusions indicate what the factors are that influence productivity improvement of Ford Struandale Engine Plant facilities. Then recommendations are made as to how the Ford Struandale Engine Plant can improve the productivity of its facilities and equipment.
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<td>AM</td>
<td>Autonomous Maintenance</td>
</tr>
<tr>
<td>APQP</td>
<td>Advanced Product Quality Planning</td>
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<tr>
<td>BTS</td>
<td>Build To Schedule</td>
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<tr>
<td>CCAR</td>
<td>Concerns Corrective Action Report</td>
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<tr>
<td>CPU</td>
<td>Cost per unit</td>
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<td>DCP</td>
<td>Dynamic Control Plan</td>
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<tr>
<td>DMAIC</td>
<td>Define Measure Analyse Improve Control</td>
</tr>
<tr>
<td>ECPL</td>
<td>Energy Control and Power Lockout</td>
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<tr>
<td>FAR</td>
<td>Failure Analysis Report</td>
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<tr>
<td>FMC</td>
<td>Ford Motor Company</td>
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<td>FMCSA</td>
<td>Ford Motor Company of Southern Africa</td>
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<tr>
<td>FMEA</td>
<td>Failure Mode and Effect Analysis</td>
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<td>FPS</td>
<td>Ford Production System</td>
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<tr>
<td>FRACAS</td>
<td>Failure Reporting, Analysis and Corrective Action System</td>
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<tr>
<td>FSEP</td>
<td>Ford Struandale Engine Plant</td>
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<tr>
<td>FTPM</td>
<td>Ford Total Productive Maintenance</td>
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<tr>
<td>G8D</td>
<td>Global Eight Discipline</td>
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<td>GPDS</td>
<td>Global Product Development System</td>
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<td>ISPC</td>
<td>In Station Process Control</td>
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<td>IMT</td>
<td>Integrated Manufacturing Teams</td>
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<td>JIT</td>
<td>Just In Time</td>
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<td>MOS</td>
<td>Maintenance Operating System</td>
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<td>MP</td>
<td>Maintenance Prevention</td>
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<td>MP&amp;L</td>
<td>Material Planning and Logistics</td>
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<td>MTC</td>
<td>Manage the Change</td>
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<td>MRP</td>
<td>Material Replenishment Plan</td>
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<td>NWG</td>
<td>Natural Work Group Meeting</td>
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<td>OEE</td>
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<td>PD</td>
<td>Predictive Maintenance</td>
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<td>PM</td>
<td>Planned Maintenance</td>
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<td>POS</td>
<td>Production Operating System</td>
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<td>PPAP</td>
<td>Production Part Approval Process</td>
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<tr>
<td>PQCDSM</td>
<td>Product; Quality; Cost; Delivery; Safety, health and environment; Morale</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>PTO</td>
<td>Power Train Operations</td>
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<td>QM</td>
<td>Quality Maintenance</td>
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<td>QOS</td>
<td>Quality Operating System</td>
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<td>R&amp;M</td>
<td>Reliability and Maintainability</td>
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<td>SGA</td>
<td>Small Group Activities</td>
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<td>SMED</td>
<td>Single Minute Exchange of Dies</td>
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<td>SPC</td>
<td>Statistical Process Control</td>
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<td>SQDCME</td>
<td>Safety Quality Delivery Cost Morale Environment</td>
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<td>STA</td>
<td>Supplier Technical Assistance</td>
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<td>TEM</td>
<td>Total Equipment Management</td>
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<td>TOPS</td>
<td>Team Oriented Problem Solving</td>
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<td>TPM</td>
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<td>TQM</td>
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<td>VSM</td>
<td>Value Stream Maps</td>
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<td>WRP</td>
<td>Warranty Reduction Programme</td>
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CHAPTER ONE

PROBLEM DEFINITION AND KEY CONCEPTS

1.1 INTRODUCTION

In manufacturing industries productivity measures can be used to track the performance of the organisation over time. Productivity measures can also be used to judge the performance of an entire industry and the productivity of the country as a whole (Stevenson, 1996: 42). In essence, productivity measurement serves as scorecards for the effective use of the resources.

South African producers are constantly facing pressure from both foreign and local organisations in their domestic markets. Many business leaders are concerned about productivity as is relating to competitiveness. Firms that have high levels of productivity earn a competitive advantage over those with low productivity (Stevenson, 1996: 42). The adverse effects of this competition stem, in part, from the low levels of productivity which characterise South African industry and which is well documented by the National Productivity Institute of South Africa.

The Ford Motor Company South Africa (FMCSA) Struandale Engine Plant (SEP) is not immune to the level of competition that impacts on businesses in South Africa. They are not only competing with the local manufacturers in terms of a high level of productivity but also with other Powertrain organisations within Ford Motor Company (FMC) globally. In Ford Motor Company (FMC) all Powertrain Operations (PTO) are benchmarked against each other in terms of productivity levels, quality levels, cost and delivery levels. This benchmark information is used as the key determinant as to where the next generation of Powertrain products will be manufactured.

This competition forces all plants within the Ford Motor Company South Africa (FMCSA) to continuously work towards improving productivity in order to be better than the next plant producing the same product. Competitiveness is defined as how effectively an organisation meets the needs of customers relative to others that offer similar goods and services (Stevenson, 1996: 45). Most of the Struandale Engine Plant (SEP) customers are Ford Motor Company (FMC) internal assembly plants from South Africa, Europe, South America and Asia, therefore they are facing a very big challenge
of making sure that they are competitive in all spheres of their business, including productivity.

The overall productivity performance of the plant is the key to the plant’s ability to supply the customers with the low cost products on time at the right quality. Productivity in the Ford Motor Company (FMC) is not just the internal matrix but the benchmark measurement used to source the next generation of engines for the new vehicle models. The purpose of this study is to find a method of improving productivity at the Ford Motor Company South Africa (FMCSA) Struandale Engine Plant (SEP) (Port Elizabeth) by investigating issues affecting productivity in the plant.

1.2 PROBLEM STATEMENT AND SUB-PROBLEMS

In April 2008 the Ford Motor Company (FMC) made a formal announcement about the plans to invest about R1.6 billion for the expansion programme to build the next generation of compact pick-up trucks for the global markets. Included in the investment was the manufacturing of the Puma diesel engines for the pick-up truck that will be assembled by the Silverton Assembly Plant in Pretoria, as well as components such as cylinder blocks, cylinder heads and crank shafts that will be exported to South America, Europe and Asia. The global engine manufacturing programme will be carried out on four different continents, namely Europe, Asia, South America and Africa (w:\engine plant\cascade\management).

This engine programme will be made up of two derivatives: the I4 and the I5. The SEP will be responsible for making both derivatives. The number of parts to be manufactured in SEP will be 220 000, of which 75 000 will be the complete engine assembly for the Silverton Vehicle Assembly Plant and the balance will be machined cylinder cranks, cylinder blocks and cylinder headed for Turkey, Thailand and Argentina (w:\engine plant\cascade\management). The programme is expected to adopt a leaner environment where there will be high levels of predictability and stability in the processes for the manufacturing of these components.

The important thing for the Struandale Engine Plant (SEP) is to achieve the world-class productivity levels in order to continue with the programme throughout its life cycle.
The manufacturing team are required to make sure that the productivity operating system employed allows them achieve the expected levels of productivity. As a result of the high productivity expectations for the programme, the researcher has come up with the following problem statement:

**Problem Statement**

What are factors that influence productivity improvements at the Struandale Engine Plant (SEP)?

**Sub-Problem**

In order to solve the main research problem, the following sub-problems need to be solved:

1. What does the literature reveal about the importance of productivity in the manufacturing industry for the long-time survival of the organisation?

2. What is the impact of OEE on the organisation’s productivity improvements:
   - Performance efficiency?
   - Quality rate?
   - Availability?

3. What is the impact of other limiting factors in productivity improvements:
   - Material availability?
   - Skills level?

4. What is the impact of OEE at the Ford Struandale Engine Plant on productivity performance with regard to:
   - Availability?
   - Performance efficiency?
   - Quality rate?

5. What impact do employees skill and material availability have on the Ford SEP productivity improvements?
o What are the Ford Struandale Engine Plant (SEP) leadership views on them?
o What has the Stuandale Engine Plant Leadership (SEP) done about employee skill and material availability?

1.3 DELIMITATIONS OF THE RESEARCH

According to Leedy and Ormrod (2001), in the delimitation the reader needs to know precisely what the researcher intends to do. Here the researcher explains how the study focuses on one particular area.

1.3.1 The organisation

The research will only be limited to the Ford Motor Company of South Africa Struandale Engine Plant in Port Elizabeth. There are two production processes in the plant, namely the engine assembly and machining processes. This research will only concentrate on the assembly line.

1.3.2 Infrastructure

The research will also only be limited to the engine-assembly area as the plant’s productivity is measured on the ability to meet customer demand on delivery, cost and quality.

1.3.3 Motivation

Owing to the new engine programme awarded to the plant the levels of motivation in the plant are very high, therefore the researcher will not consider employee motivation as a limiting factor to productivity improvements at Struandale Engine Plant (SEP). Employee motivation will not be part of the research study.

1.4 KEY ASSUMPTIONS

Assumption One

The prerequisite for the Ford Motor Company South Africa Struandale Engine Plant is to keep the new engine programme by launching the new programme successfully. As they were competing with other power train plants within the Ford
world, everybody in the organisation is now looking to see whether they will be able to succeed, because the success of the whole new vehicle programme depends on the successful launch of the new engine. The expectation is high for the SEP to achieve high levels of productivity throughout the duration of the programme. The assumption is that the management of the plant are aware of this and are expected to put measures in place that will enable them to launch this programme successfully.

**Assumption Two**

The management of the SEP and employees do realise the importance of the new programme, they are motivated and committed to take necessary steps that will help achieve the productivity improvements required by the programme assumptions.

**Assumption Three**

It is assumed that FMCSA Struandale Engine Plant - management and the readers have a level of knowledge and understanding of the Productivity Operating System (POS).

1.5 METHODOLOGY

The methodology to be used for a particular research problem must always take into account the nature of the data that will be collected in the resolution of the problem (Leedy & Ormrod, 2001: 100).

1.5.1 Research Paradigm

According to Webster (1985), to research is to search or investigate exhaustively. It is a careful or diligent search, a studious inquiry or examination or experimentation aimed at the discovery and interpretation of facts, the revision of accepted theories or laws in the light of new facts or the practical application of such new or revised theories or laws and it can be the collection of information about a particular subject.

Many researchers categorise research studies into two broad categories (Leedy & Ormrod, 2001: 100): quantitative research and qualitative research. The quantitative research is sometimes called a positivist approach and the qualitative research is known as the post- positivist approach.
One of the focuses for the qualitative research are the phenomena that occur in natural settings and qualitative research involves studying those phenomena in all their complexity (Leedy & Ormrod, 2001:147). It is believed that the researcher’s ability to interpret and make sense of what he or she sees is critical for an understanding of any social phenomenon. The goal of the quality study might be to reveal the nature of these multiple complex perspectives (Creswell, 1998: Guba & Lincoln, 1998).

Therefore qualitative researchers discover the problems that exist within the phenomenon and the researcher is also allowed to test the validity of certain assumptions, claims, theories, or generalisation within real world context (Leedy & Ormrod, 2001:148).

Quantitative research is used to answer questions about the relationships among measured variables with the purpose of explaining, predicting, and controlling phenomena (Leedy & Ormrod, 2001:101). Quantitative research involves either identifying the characteristics for an observed phenomenon or exploring possible correlations among two or more phenomena. In every case, descriptive research examines a situation as it is (Leedy & Ormrod, 2001: 191).

Quantitative research is used to answer questions about relationships among measured variables and it usually ends with confirmation or disconfirmation of the hypotheses that will be tested. Quantitative researchers seek explanations and predictions that will generalise to other persons and places (Leedy & Ormrod, 2001: 102). The intent is to establish, confirm, or validate relationships and to develop generalisations that contribute to theory.

According to Remenyi, Williams, Money and Swartz (1998), there is claimed that qualitative research is “soft” research, and therefore can only add little to the real body of knowledge except in so far that it suggests new directions for quantitative or hard research. They further emphasised that it is important to remember that qualitative research and the construction of narratives that embrace the essential features of the problem can contribute substantially to the body of knowledge even if one hopes eventually to go beyond this with the use of quantitative techniques.
According to Leedy and Ormrod (2001), making the distinction between quantitative and qualitative research does not mean to imply that the two approaches are mutually exclusive or that the researcher must choose to use one or the other of them for any particular study. It is often found that researchers combine elements of both approaches.

The purpose of the study is to improve productivity levels in Struandale Engine Plant by investigating the factors that influence effective implementation of productivity operating system.

1.5.2 Sampling Design
A sample is a finite part of a statistical population whose properties are studied to gain information about the whole (Webster, 1995). A population is a group of individual persons, objects, or items from which samples are taken for measurement. Sampling is the act, process, or technique of selecting a suitable, or a representative part of the population for the purpose of determining parameters or characteristics of the whole population. Successful statistical practice is based on focused problem definition.

Sampling may be more or less appropriate in different situations and can fall into two major categories. These are probability sampling and non-probability sampling. One of the most important purposes of using sampling is to draw conclusions about the population from the samples and use inferential statistics which enable the researcher to determine the population’s characteristics by directly observing only a portion of the population. Because there is very rarely enough time or money to gather information from everyone or everything in a population, the goal becomes to find a representative sample (or subset) of that population (http://en.wikipedia.org/wiki/Sampling). A sample may provide the researcher with the needed information quickly.

The researcher in this particular study will use two types of purposeful sampling: stratified and snowball sampling. Stratified purposeful sampling illustrates the characteristics of particular subgroups of interest and facilitates comparison between the different groups. Snowball or chain sampling process is the one that identifies case of interest from people who know people who know what case are information rich, which is good example for study, good interview subjects (Patton, 1990:169).
The sample to be used for the study will only come from the middle management, junior management and the first line supervision. The stratified sampling in this study will be used as sampling that consists of the management team, production coordinators, production team leaders, maintenance supervisors and electronic specialists. The population will consist of five managers, five production coordinators, 23 team leaders, four maintenance supervisors, three electronic specialists and five production-quality engineers.

1.5.3. Data collection
The data for the study will be targeting only the Ford Motor Company Struandale Engine Plant personnel. The research will be targeting the leadership team in the manufacturing areas as they have a direct influence on the productivity performance levels in their production lines. The primary data was collected by formatting according to the five-point Likert Scale ranges from (1) Strongly Disagree to (5) Strongly Agree. Secondary data was obtained from a number of different sources within the plant and various literature sources.

1.5.4 Data Analysis
Data analysis is a process of gathering, modelling, and transforming data with the goal of highlighting useful information, suggesting conclusions and supporting decision making. Data analysis has multiple facets and approaches, encompassing diverse techniques under a variety of names, in different business, science and social science domains (http://en.wikipedia.org/wiki/Data_analysis). The data collected by the questionnaires will be analysed using Excel Spreadsheet.

1.5.5 The Final Step
From the data collected during the research study an analysis will be conducted that allows conclusions to be drawn about the study and recommendations to be made and indicates any further research that can be conducted.

1.6 DEFINITION OF TERMS

- *World Class Manufacturing:* This refers to the use of production or manufacturing techniques that aim to maximise productivity, create flexibility and
facilitate a culture of continuous improvement (Sharma, 2005).

World Class Manufacturing is a process-driven approach where implementations usually involve the following philosophies and techniques: Make-to-order; Streamlined flow; Small lot sizes; Families of parts; Doing it right the first time; Cellular manufacturing; Total preventative maintenance; Quick changeover; Zero Defects; Just-in-time; Variability reduction; High employee involvement; Cross-functional teams; Multi-skilled employees; Visual signalling and Statistical process control (http://rockFordconsulting.com/world-classmanufacturing.htm).

- **Productivity**: This denotes the ratio of manufacturing output to manufacturing input (Lawlor, 1985: 8). According to Stevenson (1996: 29), productivity relates to how effective an organisation is in the use of its resources.

- **Lean Manufacturing**: This manufacturing technique focuses on the elimination of waste, maximisation of product quality and increased flexibility, inherent in the process (http://www.gemba.com/consulting.cfm?id=201).

- **Value stream mapping**: this refers to the identification of all the specific activities occurring along a value stream for a product or a product family (Womack & Jones, 1996: 311).

- **Continuous improvement**: This is one of the principles of total quality management – the objective is to improve processes while increasing the quality of the production output (Womack & Jones, 1996: 345).

- **Productivity Operating system**: It is a standardised approach to ensure that the productivity levels are maintained and continuously improved (https://p5-ford-com/ERoom/private35/PTOmansfirmaungcouncil_Productivity Operating System Guide).
• **Best practices**: These refers to the set of activities that are applied in a manufacturing environment that ensure consistent and regular practice by the employees in an organisation (Faull, 1998: 45).

• **Overall Equipment Effectiveness**: OEE is the primary metric of TPM. It indicates the actual contribution a single piece of equipment as a percentage of its potential to add value to the value stream. The calculation is: % availability × % standard run rate (performance efficiency) × % first pass quality (Bernstein, 2005:66).

• **Total Productive Maintenance**: Total Productive Maintenance is a Japanese approach to maximising the effectiveness of the facilities used within a business. It not only addresses maintenance but all aspects of the operation and installation of these facilities, and at its very heart the motivation and enhancement of the people who work in the company (Davis, 1995:1).

• **Questionnaire**: A questionnaire is a method of collecting data in which a selected group of participants are asked to complete a written set of structured questions to find out what they do, think or feel. It is a list of carefully structured questions, chosen after considerable testing, with a view to eliciting reliable responses from a chosen sample (Collis & Hussey, 2003:173).

• **Autonomous Maintenance**: Autonomous Maintenance involves the participation of every operator, each maintaining his or her own equipment and conducting activities to keep it in the proper condition and running correctly. It is a process by which equipment operators accept and share responsibility (with maintenance) for the performance and health of their equipment (Robinson & Ginder, 1995:57).

### 1.7 OUTLINE OF THE STUDY

The study will consist of six chapters.
Chapter One will cover the introduction to Ford Motor Company, the problem statement, the objective of the study, key assumptions, methodology, the definition of terms and the proposed chapter headings of the research treatise.

Chapter Two will provide literature review on the productivity operating system and other related concepts including productivity, value stream map, constraint management, availability, first time through and overview of FPS.

Chapter Three will give a holistic overview of the Ford Struandale Engine Plant with regards to current production performance, looking at production line productivity levels in terms of efficiencies, quality and the systems currently in place.

Chapter Four will describe how the research has been conducted. The instrument of data collection and the measurement technique will be presented.

In Chapter Five the results of the data collection will be reported. An analysis of the results will be conducted and an explanation of the conclusions and the implications there-of will be given. This will be done by including the results from data collection, drawing the tables from the results and analysing the results.

Chapter Six will consist of conclusions and recommendations.

1.8 SUMMARY
In this chapter the research problem to be investigated was introduced and the objective for the research was outlined. The organisation, the geographic areas where the organisation is situated was covered in the limitation discussions in this chapter. This chapter also outlined the research methodology which includes the sampling size and the measuring instrument for the study. Key assumptions were also discussed and the definitions of the key terms that will be used in the research were defined.

Chapter Two will provide a literature review on the productivity operating system and other related concepts including productivity, the factors affecting productivity improvements, Overall Equipment Efficiency, performance efficiency, availability, quality, skills and material availability.
CHAPTER TWO
LITERATURE REVIEW

2.1 INTRODUCTION

In Chapter One the researcher gave an outline of the research paper. The primary objective and the secondary objectives needed to be resolved were also stated in the same chapter.

In this chapter the researcher will review the literature available on productivity by investigating the elements of productivity. The researcher will also investigate the role played by the Overall Equipment Effectiveness (OEE) in productivity improvements by discussing performance efficiency, availability and quality. The researcher will also review the impact that skills and material availability have in productivity improvements. The chapter will begin with the introduction and conclude with the summary.

Many people still associate the word 'productivity' with production and labour productivity. In a world where energy and material costs have soared, competition has become fiercer and budgets are drained by welfare-oriented societies (Lawlor,1985:4). The need for a more effective management of resources has never been higher (Lawlor,1985:4). Productivity should therefore be a number one priority in every country and all its organisations.

2.2 PRODUCTIVITY

2.2.1 What is productivity?

Productivity is the relationship between goods produced and sold or services provided and the output and the resources consumed in doing it – the input (Lawlor,1985:8).

\[
\text{Output/Input} = \text{Productivity}
\]

In the current economic conditions companies have no choice because survival and prosperity depend upon a continuous attack on the productivity issues. Therefore the task of top managers is the productive use of all resources at the disposal of their organisations.
Prokopenk, (1987:3) also defines productivity as the relationship between the results and the time taken to accomplish them. Time is always a good demonstrator since it is a universal measurement and it is beyond human control. It is obvious that the less time taken to achieve the desired results, the more productive the system is.

Regardless of the type of production, economic or political system measured, the definition of productivity remains the same. Productivity may mean different things to different people, but the basic concept is always the relationship between the quantity and quality of goods or services produced and the quantity of resources used to produce them (Prokopenko, 1987:3).

Sometimes productivity is viewed as a more intensive use of such resources as labour and machines which should reliably indicate performance or efficiency if measured accurately. It is important to separate productivity from intensity of labour, because while labour productivity reflects the beneficial results of labour, its intensity means excess effort is no more than work “speed-up” (Prokopenko, 1987:4). There are false conclusions out there being drawn from a single fact of productivity, namely that it is about only labour efficiency. Productivity is now much more than just labour productivity and the increase in the cost of energy and raw materials needs to be taken into account along with a growing concern about unemployment and the quality of work-life.

The second misconception is that there is a possibility to judge performance simply by output and can rise without an increase in productivity if input cost has risen disproportionately (Prokopenko, 1987: 4). This could be as a result in price increase and inflation influences where such approach is often the result of being process-oriented at the expense of paying attention to final results.

There is also confusion between productivity and profitability. In real life profits can be obtained through price recovery even though productivity may have gone down. High productivity does not always go with high profits since goods which are produced efficiently are not necessary in demand. This is one more misunderstanding that confuses productivity with efficiency.

Productivity is relative to any kind of organisation or system, including services and notable information. With the changing structure of occupations, information specialists have become a new target for productivity drives. Information technology itself gives
new dimensions to productivity measurement. The productivity of capital or other expensive scarce resources such as energy or raw materials is of more concern than labour productivity (Lawlor, 1985:20).

The concept of productivity is also increasingly linked with quality of output, input and the process itself. It has been recognised that rising productivity and improving quality of working life tend to go hand-in-hand. Productivity improvement is a never-ending journey. Many people never take the first step because they do not see the end of the road. Productivity improvement initiatives are often perceived as expensive, when one is not aware of the benefits that they achieve when executed with due diligence (Patra & Bartaki, 2009:3).

If the process improvement journey is carefully planned and executed, the painstaking investment in the initial cost, effort, and people may be rewarded with overwhelming results. Nothing worthwhile is ever achieved without persistence, and as the famous saying goes, “It takes effort to reduce effort.” There are several views on how breakthrough results can be achieved using process improvement principles (PIPs). These principles work well and help organisations translate transparent intentions into visible financial results. The key success factors for a process improvement programme are continuous improvement, commitment from top management, and a sustainable improvement organisation (Patra & Bartaki, 2009:3).

2.2.2 Factors that affect productivity improvements.

There are several ways to improve productivity in firms (Sink, 1985:37). Even the measurement of productivity as such is one way of increasing the level of productivity. Along with the method of productivity improvement there are also several factors that make them ineffective or even prevent improvement actions. These factors can be called limitations to productivity improvement. Examples of these limitations to productivity improvement are a lack of time and resources, a passive attitude, or a lack of know-how (Aggerwall, 1981: 460).

The productivity limitations can be classified into different categories, namely internal, external and general limitations. The internal limitations are factors that are inside the firm and it is possible to affect these actions performed inside the firm. The management and the workers can eliminate the internal restraints or they can weaken
the effects of these. Lack of knowledge and poor production methods are typical internal limitations (Hannula, 1998:98).

The external limitations are factors that are outside the firm. The firm cannot have an effect on these factors directly and the only way is to attempt to have an effect on them is via the unions or other similar interest groups. The firm must adapt to this kind of restraint. The external obstacles put up the limits within which the firm must operate. Legislation and the action of the trade unions are typical external restraints on productivity improvements (Prokompeko, 1987:11).

There are also some factors that are not so easy to categorise clearly in the above groups of limitations. They can belong to both of these groups or neither of them and they are called general limitations to productivity improvement. Examples of general restraints are theoretical problems, measurement problems and a lack of public information. This research will concentrate more on the internal limitations for productivity improvements. In the next section there will be discussions about the internal limitations on production methods.

2.2.2.1 Internal factors that limits productivity improvements

According to Prokopenko (1987:11), the internal factors that limit productivity improvements are classified into two groups: hard and soft factors. The hard factors include products, technology, equipment and the raw materials, while the soft factors involve the labour force, organisational systems and procedures, management style and work methods. Both the hard and the soft factors play a significant role in limiting productivity improvements with an organisation.

2.2.2.2 Hard factors

As mentioned above, the factors start with the product, specifically the extent to which the product meets output requirements. This means the product must have use value which is the amount that the customer is prepared to pay for the product of given quality and this can be improved by better design and specification. Product place value, time value and, price value refer to the availability of the product at the right place, at the right time and at a reasonable price. The value factor in particular gives a better notion of the economies of scale through increased volume of production. The cost benefit factor can be enhanced by increasing the benefit for the same cost or by reducing cost for the same benefit (Prokopenko, 1987:11).
According to Prokopenko (1987:11), plant and equipment play a central role in a productivity improvement programme through the following:

- good maintenance;
- operating the plant and equipment in an optimum process condition;
- increasing the plant capacity by eliminating bottle-necks and by corrective measures and
- reducing idle time and making more effective use of available machines and plant capacities.

Improved technology can contribute to high productivity when it brings increased volumes and quality of the goods and services (Prokopenko, 1987:12). New technology is introduced for productivity improvement programmes as a fight against obsolescence. Material is also a vital source of productivity improvement programmes as organisations are trying to reduce consumption to achieve positive productivity results. (Prokopenko1987:12) raises the following aspects of material that impact productivity:

- output of useful product per unit of material used;
- use and control of wastage and scraping;
- improving inventory turnover ratio to release funds tied up in inventories for more productive uses;
- improving inventory management to avoid running out of stock or holding excessive stock and;
- developing reliable sources of supply.

### 2.2.2.3 Soft factors

People are the principal resource and the central factor in productivity drives, as workers, engineers, managers and union members in an organisation all have a role to play (Prokopenko, 1987:12). The role played by each one of the above has two aspects, namely the application and effectiveness. Application is the degree to which people
apply themselves to their work and people differ not only in their ability but also in their will to work.

Motivation is basic to all human behaviour and thus to efforts in productivity improvement (Prokopenko, 1987:13). Increasing productivity must be reinforced immediately by reward not only in the form of money but also by improving recognition, involvement and learning opportunities and by complete elimination of negative rewards. It is possible to improve productivity by eliciting co-operation and participation from workers. Labour productivity can be tapped only if management encourage workers to apply their creative talent by taking a special interest in their problems and by promoting a favourable social climate.

The role played by the people involved in a productivity drive is determined by their effectiveness and the extent to which the application of human efforts brings the desired results in output and quality (Prokopenko, 1987:13). It is a function of method, technique, personal skill, knowledge, attitude and aptitude – the “ability to do”. The ability to do a productive job can be improved through training and development, job rotation and placements, systematic job progression and career planning. The following section will be the discussing the hard and soft factors of productivity improvements, as well as looking at plant and equipment processes, material availability, employee skills and processes.

2.3 PLANT AND EQUIPMENT PROCESSES

2.3.1 Total productive maintenance

Total productive maintenance (TPM) has been around for almost 50 years. To the ‘west’ it is a new way of looking at maintenance: to the Japanese, it is an established process. Like all processes, it has a host of acronyms and buzzwords. Some are obvious, many will require follow-up reading. The origin of TPM can be traced back to 1951 when preventive maintenance was introduced in Japan. However, the concept of preventive maintenance can be traced back to the USA.

Nippondenso was the first company to introduce plant-wide preventive maintenance in 1960. Preventive maintenance is the concept where, operators produced goods using machines and the maintenance group was dedicated with the task of maintaining those machines. However, with the automation of Nippondenso, maintenance became a
problem as more maintenance personnel were required. So the management decided that the routine maintenance of equipment would be carried out by the operators (This is Autonomous Maintenance, one of the features of TPM). Maintenance group took up only essential maintenance works.

Thus Nippondenso which already followed Preventive maintenance also added Autonomous maintenance done by production operators. The maintenance crew worked on the equipment modification for improving reliability. The modifications were made or incorporated in new equipment. This leads to maintenance prevention. Thus preventive maintenance along with Maintenance prevention and Maintainability Improvement gave birth to **Productive Maintenance**. The aim of productive maintenance was to maximise plant and equipment effectiveness to achieve the optimum life cycle cost of production equipment.

### 2.3.1.1 Why TPM?

TPM was introduced to achieve the following objectives:

- Avoid wastage in a quickly changing economic environment;
- Produce goods without reducing product quality;
- Reduce cost;
- Produce a low batch quantity at the earliest possible time and
- Ensure goods sent to the customers are non-defective.

### 2.3.1.2 World Class Targets for TPM:

- **P** - Obtain Minimum 80% OPE (Overall Performance Efficiency);
  - Obtain Minimum 90% OEE (Overall Equipment Effectiveness);
  - Run the machines even during lunch. (Lunch is for operators and not for machines!);
- **Q** - Operate in a such a manner, that there are no customer complaints;
- **C** - Reduce the manufacturing cost by 30%;
- **D** - Achieve 100% success in delivering the goods as required by the customer;
- **S** - Maintain an accident-free environment;
- **M** - Increase the suggestions by three times.
- Develop Multi-skilled and flexible workers.

In TPM, the machine operators are thoroughly trained to perform much of the simple maintenance and fault-finding. Eventually, by working in ‘Zero Fails’ teams that include a technical expert as well as operators, they can learn many more tasks – sometimes all (Nakajima, 1989).

TPM is a critical adjunct to lean manufacturing. If machine uptime is not predictable and if process capability is not sustained, the process must keep extra stocks to buffer against this uncertainty and the interruption of the flow-through the process. Unreliable uptime is caused by breakdowns or badly performed maintenance. If maintenance is done properly (Right First Time), uptime will improve - as will ‘OEE’ (Overall Equipment Effectiveness - basically how many ‘sellable’ items are actually produced as opposed to how many the machine ‘should’ produce in a given time) (Nakajima, 1989).

One way to think of TPM is ‘deterioration prevention’: deterioration is what happens naturally to anything that is not ‘taken care of’. For this reason many people refer to TPM as ‘total productive manufacturing’ or ‘total process management’. TPM is a proactive approach that essentially aims to identify issues as soon as possible and plans to prevent any issues before occurrence. One motto is "Zero error, zero work-related accident, and zero loss".

TPM is a maintenance process developed for productivity. The original goal of total productive management is to: “continuously improve all operational conditions, within a production system; by stimulating the daily awareness of all employees” (Nakajima.) TPM focuses primarily on manufacturing (although its benefits are applicable to virtually any ‘process’) and is the first methodology Toyota used to improve its global position (in the 1950s). After TPM, the focus was stretched, and suppliers and customers were also involved (Supply Chain).

An accurate and practical implementation of TPM, will increase productivity within the total organisation, where:
- a clear business culture is designed to continuously improve the efficiency of the total production system,
a standardised and systematic approach is used, where all losses are prevented and/or known;

- all departments, influencing productivity, will be involved to move from a reactive to a predictive mindset;

- a transparent multi-disciplinary organisation reaches zero losses and steps are taken as a journey, not as a quick menu.

Finally TPM will provide practical and transparent ingredients to reach operational excellence.

2.3.1.3 Operational elements/Pillars of TPM

Figure 2.1: Pillars of TPM

Source: Venkatesh (2005: 21)

- **Pillar 1 – 5S**:

TPM starts with 5S. Problems cannot be clearly seen when the work place is unorganised. Cleaning and organising the workplace helps the team to uncover problems. Making problems visible is the first step of improvement.
• **Pillar 2 - Jishu Hozen (Autonomous maintenance):**
This pillar is geared towards developing operators to be able to take care of small maintenance tasks, thus freeing up the skilled maintenance people to spend time on more value-added activity and technical repairs. The operators are responsible for the upkeep of their equipment to prevent it from deteriorating.

• **Pillar 3 - Kaizen:**
‘Kai’ means change, and ‘Zen’ means good (for the better). Basically kaizen is for small improvements, but carried out on a continual basis and involving all people in the organisation. Kaizen is the opposite of big spectacular innovations. Kaizen requires no or little investment. The principle behind it is that "a very large number of small improvements are more effective in an organisational environment than a few improvements of large value". This pillar is aimed at reducing losses in the workplace that affect efficiency. By using a detailed and thorough procedure losses are limited in a systematic method using various Kaizen tools. These activities are not limited to production areas and can be implemented in administrative areas as well.

• **Pillar 4 - Planned maintenance:**
The aim is to have trouble-free machines and equipment producing defect-free products for total customer satisfaction. This breaks maintenance down into four ‘families’ or groups which were defined in the TPM discussion:

1. Preventive Maintenance;
2. Breakdown Maintenance;
3. Corrective Maintenance and
4. Maintenance Prevention

With planned maintenance efforts evolve from a reactive to a proactive method and trained maintenance staff are used to help train the operators to maintain their equipment better.

• **Pillar 5 – Quality maintenance:**
Quality maintenance is aimed towards customer delight through highest quality from defect-free manufacturing. The focus is on eliminating non-conformances in a systematic manner, much like Focused Improvement. The organisations gain an
understanding of what parts of the equipment affect product quality and begin to 
eliminate current quality concerns, then move to potential quality concerns. The 
transition is from reactive to proactive (Quality Control to Quality Assurance). Quality 
maintenance (QM) activities are to set equipment conditions that preclude quality 
defects, based on the basic concept of maintaining perfect equipment to maintain 
perfect quality of products. The condition is checked and measured in time series to 
verify that measure values are within standard values to prevent defects. The transition 
of measured values is watched to predict possibilities of defects occurring and to take 
counter measures before hand.

- **Pillar 6 – Training:**

Training is aimed to have multi-skilled revitalised employees whose morale is high and 
who are eager to come to work and perform all the required functions effectively and 
individually. Operators are educated to upgrade their skills. It is not sufficient to only 
"Know-How" but they should also learn "Know-why". By experience they gain the 
"Know-How" to overcome a problem of what to be done. This they do without knowing 
the root cause of the problem and why they are doing so. Therefore it becomes 
necessary to train them on knowing "Know-why". The employees should be trained to 
achieve the four phases of skills. The goal is to create a factory full of experts. The 
different phases of skills are:

- Phase 1: Do not know;
- Phase 2: Know the theory but cannot do;
- Phase 3: Can do but cannot teach and
- Phase 4: Can do and can also teach.

- **Pillar 7 – Office TPM:**

Office TPM should be started after activating the four other pillars of TPM (JH, KK, 
QM, PM). Office TPM must be followed to improve productivity and, efficiency in the 
administrative functions and to identify and eliminate losses. This includes analyzing 
processes and procedures towards increased office automation. Office TPM addresses 
twelve major losses. They are:

1. Processing loss;
2. Cost loss including in areas such as procurement, accounts, marketing, sales leading to high inventories;

3. Communication loss;

4. Idle loss;

5. Set-up loss;

6. Accuracy loss;

7. Office equipment breakdown;

8. Communication channel breakdown, telephone and fax lines;

9. Time spent on retrieval of information;

10. Non-availability of correct on line stock status;

11. Customer complaints due to logistics and

12. Expenses on emergency dispatches/purchases

- **Pillar 8 - Safety, Health and Environment:**

  1. Zero accidents
  2. Zero health damage and

In this area the focus is on creating a safe workplace and a surrounding area that is not damaged by processes or procedures. This pillar will play an active role in each of the other pillars on a regular basis. A committee is constituted for this pillar which comprises representatives of officers as well as workers. The committee is headed by the Senior Vice-President (Technical). Safety is of the utmost importance in the plant. The Manager (Safety) looks after functions related to safety. To create awareness among employees various competitions like safety slogans, quizzes, drama and, posters related to safety can be organised at regular intervals.

**2.4 OVERALL EQUIPMENT EFFECTIVENESS**

Overall Equipment Effectiveness (OEE) is a ‘best practices’ way to monitor and improve the efficiency of the manufacturing processes (i.e. machines, manufacturing cells, assembly lines). OEE is simple and practical. It takes the most common and important sources of manufacturing productivity loss, places them into three primary
categories and distills them into metrics that provide an excellent gauge for measuring where the organization stands - and how it can improve. OEE is frequently used as a key metric in Total Productive Maintenance (TPM) and Lean Manufacturing (LM) programmes and provides a consistent way to measure the ‘What is OEE?’ OEE is a ‘best practices’ way to monitor and improve the efficiency of the manufacturing processes (i.e. machines, manufacturing cells, assembly lines). OEE is frequently used as a key metric in TPM and LM programmes and provides a consistent way to measure the Fast Track Roadmap (http://www.oee.com/world_class_oee.html).

OEE factors introduce Availability, Performance Efficiency, and Quality Rate, the metrics that are used to measure a plant's efficiency and effectiveness. A visual overview is provided of the key productivity losses that occur in the typical manufacturing environment. It starts with Plant Operating Time and ends up at Fully Productive Time, showing the sources of productivity loss that occur in between. Six big losses describe the most common causes for efficiency loss - almost always found in today's manufacturing environment. Six root causes of loss are presented, each directly related to an OEE Factor (http://www.oee.com/world_class_oee.html).

2.4.1 Factors included in OEE

As described in World Class OEE, the OEE calculation is based on the three OEE factors: Availability, Performance, and Quality.

OEE analysis starts with Plant Operating Time: the amount of time the facility is open and available for equipment operation.

From Plant Operating Time, a category of time called Planned Shut Down is subtracted, which includes all events that should be excluded from efficiency analysis because there was no intention of running production (e.g. breaks, lunch, scheduled maintenance, or periods where there is nothing to produce). The remaining available time is the Planned Production Time.

OEE begins with Planned Production Time and scrutinises efficiency and productivity losses that occur, with the goal of reducing or eliminating these losses. There are three general categories of loss to consider: Down Time Loss, Speed Loss and Quality Loss.
OEE takes into account all three OEE Factors, and is calculated as:

\[
OEE = Availability \times Performance \times Quality
\]

(a) Availability

Availability takes into account down time loss, which includes any events that stop planned production for an appreciable length of time (usually several minutes – long enough to log as a trackable event). Examples include equipment failures, material shortages, and changeover time. Changeover time is included in an OEE analysis, since this is a form of down time. While it may not be possible to eliminate changeover time, in most cases it can be reduced (www.vorne.com). The remaining available time is called operating time.

Availability takes into account Down Time Loss, and is calculated as:

\[
Availability = \frac{Operating Time}{Planned Production Time}
\]

Availability has various meanings and ways of being computed, depending upon its use. Availability is defined as “a percentage measure of the degree to which machinery and equipment is in an operable and committable state at the point in time when it is needed.” This definition includes operable and committable factors that are contributed to the equipment itself, the process being performed, and the surrounding facilities and operations. This statement incorporates all aspects of malfunctions and delays relating to equipment, process, and facility issues (www.mt-online.com).

If there is consideration of both reliability (probability that the item will not fail) and maintainability (the probability that the item is successfully restored after failure), then an additional metric is needed for the probability that the component or system is operational at a given time, \( t \) (i.e. has not failed or it has been restored after failure). This metric is availability. Availability is a performance criterion for repairable systems that accounts for both the reliability and maintainability properties of a component or system. This defined as “a percentage measure of the degree to which machinery and equipment is in an operable and committable state at the point in time when it is needed.” This definition includes operable and committable factors that are contributed
to the equipment itself, the process being performed, and the surrounding facilities and operations. It has various meanings and ways of being computed, depending upon its use (www.mt-online.com).

(b) Performance Efficiency

Performance efficiency takes into account Speed Loss, which includes any factors that cause the process to operate at less than the maximum possible speed, when running (www.vorne.com). Examples include machine wear, substandard materials, misfeeds, and operator inefficiency. The remaining available time is called Net Operating Time.

Documented Minor Stoppages and All other Idling & Minor Stoppages are losses resulting from interruptions in the process flow requiring operator or job setter intervention. Minor losses which are documented, belong in the Documented Stoppages category (Availability), except Starved and Blocked Time losses. (These belong in the Documented Stoppages Category (Performance Efficiency)). Losses which cannot be documented, belong in the All Other Idling & Minor Stoppages category and are classified as Performance Efficiency losses. It is not always practical to document all stoppages, and the plant should establish a decision rule for consistent documentation of minor stoppages (www.oee.com).

Effective decision rules for documentation of minor stoppages, are usually based on a minimum time threshold. For example, “All stoppages of duration more than x minutes will be documented (www.vorne.com).” As the documented stoppages are reduced, the threshold can be shortened. The use of Production Operating System (POS) Monitoring, or other automated data collection systems, enables increased documentation of minor stoppages. The plant should define equipment specific loss or cause codes that will be recorded by the automated data collection system before a machine is placed back into the automatic mode (Larsen, 2002).

In order to distinguish between documented minor stoppages and breakdowns, plants may wish to establish a downtime duration threshold. For example, all stoppages equal to or greater than x minutes will be classified as breakdowns, and all others will be
classified as minor stoppages. There is importance to establish clear definitions or rules that are simple to apply, so that the collection of downtime data is consistent across the plant and can be easily analysed for root causes.

For Idling and Minor Stoppages, the exact downtime per incident may not be recordable, but an effort should be made to categorise the number and total time duration of Idling and Minor Stoppages by type (such as jam location, manual adjustment type/location, or blockage cause). Pareto analysis of the number of occurrences of each type of minor stoppage, can lead to the identification and elimination of the root causes and the corresponding minimisation of losses associated with Idling and Minor Stoppages (Davis, 1995:96).

Examples of Minor Stops:

• Machine Jam
• Undocumented Manual Adjustment
• Material Misalignment
• Temporary Cleaning Requirement
• Machine Reset

**Blocked and Starved (Performance Efficiency)**

Blocked and Starved time losses are NOT subtracted from the equipment’s Availability. They reduce the Performance Efficiency of the equipment. Production losses due to Blocked and Starved conditions should be tracked whenever possible, and the plant should consider establishing plant-wide loss codes for specific blocked and starved conditions, e.g. ‘Blocked - Buffer Full’, or ‘Starved - No Stock from Supplier’. Where minimum or maximum-levels have been established with a pull system, blocked conditions may occur when all levels are at maximum. The equipment or process would then be considered blocked. This could be a good time to complete Operator Preventive Maintenance such as Cleaning to Inspect.

**Reduced Speed Loss (Performance Efficiency)**

Reduced Speed Loss is lost production due to the machine or line operating at an overall rate that is slower than ideal cycle time. The ideal cycle time of a machine, along with the product that is being produced, is the engineered design cycle rate. A faster cycle
time may be used, if it has been documented and proven-out by the plant, using the internal “Manage-the-Change” process. Reduced Speed Losses should be tracked and regularly reported.

Examples of Reduced Speed Losses include:
• Running at less than design speed to meet quality specifications,
• Running at less than design speed in order to stretch production runs to complete a scheduled shift,
• Running at customer demand rate. (i.e., the machine or line has the capability of running 1000 products per hour, but customer demand rate is only 500 products per hour.) By running at the customer’s rate, the performance efficiency on this particular machine would only be 50%. However, the plant would also have a 50% capacity for growth on this machine as customer demand increased.

*Performance* takes into account Speed Loss, and is calculated as:

\[
Performance = \frac{Ideal \ Cycle \ Time}{(Operating \ Time / Total \ Pieces)}
\]

Ideal Cycle Time is the minimum cycle time that the process can be expected to achieve in optimal circumstances. It is sometimes called Design Cycle Time, Theoretical Cycle Time or Nameplate Capacity.

Since Run Rate is the reciprocal of Cycle Time, Performance can also be calculated as:

\[
Performance = \frac{(Total \ Pieces / Operating \ Time)}{Ideal \ Run \ Rate}
\]

*Performance* is capped at 100%, to ensure that if an error is made in specifying the Ideal Cycle Time or Ideal Run Rate the effect on OEE will be limited.

(c) Quality

Quality takes into account Quality Loss, which accounts for produced pieces that do not meet quality standards, including pieces that require rework. The remaining time is called Fully Productive Time (www.vorne.com). The goal is to maximise Fully Productive Time.
Quality Losses (Quality Rate)

A Quality Loss is associated with the production of products that do not meet Quality Standards (unable to pass quality control). The following Quality Losses must be included in the calculation of an OEE for a piece of equipment or a process (Maimela, 2009):

- all product requiring either in-line or off-line rework,
- all products that are rerun in order to meet Quality Standards and
- all products that are scrapped.

Only Quality Losses directly related to the equipment or process, should be included in the calculation of the equipment OEE. These Quality Losses should be carefully reported and categorised for root cause analysis and prevention of recurrence.

Examples of Quality Losses include:
- Product rerun through testing operations,
- Scratched or discolored glass,
- Broken injection moulded pieces
- Missing or dislocated screw and
- Re-machined products.

Start-up Losses

A Start-up Loss is defined as a loss that occurs between the equipment time or process start-up until the time that a product is produced meeting all Quality Standards. This loss is usually a result of the time it takes for the equipment to stabilise in terms of temperature, pressure, and speed, during start-up. The goal in minimising Start-up Losses has two factors. The first is to minimise the number of start-ups by stabilising equipment reliability, production schedules, and overall machine operation.

The second is to minimise the lost time for each start-up by bringing the equipment to stability in a shorter time. This may require equipment modification to control temperature, pressure, and speed, prior to pushing the start button. All losses that occur during the start-up period should be indicated by checking ‘Start-up’ on the data collection sheet. Some of the start-up losses are not used in the OEE calculations, but
can be used for reporting purposes. Organisations should strive to reduce both the number of start-ups and the time required to bring the operation to stability.

Examples of Start-up Losses include:
- Pre-heating time before using an oven;
- Cleaning out material before using a machine;
- Dirty paint and
- Cleaning out lines.

‘Start-up’ losses are recorded differently than the other ‘Major loss’ categories. ‘Start-up’ should be indicated for every type of loss which occurs during the ‘Start-Up’ period. For example, changing tooling to make a new product should be recorded as a ‘Set-up and Adjustment’ loss, but should also be recorded as a ‘Start-up’ loss on the data collection sheet. An ‘Equipment Breakdown’ which occurs during start-up, should be recorded under the Equipment Breakdown category; and the ‘Start-up’ box should also be checked.

Quality takes into account Quality Loss, and is calculated as:

\[
Quality = \frac{Good\ Pieces}{Total\ Pieces}
\]

2.4.2 OEE Conclusion

OEE takes into account all three OEE Factors, and is calculated as:

\[
OEE = Availability \times Performance \times Quality
\]

It is very important to recognise that improving OEE is not the only objective the organisation must concentrate on to improve productivity. The researcher will examine how total quality as one element can influence productivity improvements in an organisation. In addition, the researcher will also illustrate that either of the two factors mentioned already material availability and skills levels in the organisation plays a very critical role in either limiting or improving productivity in an organisation.

2.4.3 Total Quality Management

According to (Dale:1999), total quality management (TQM) is the management approach of an organisation centered on quality, based on the participation of all its
members and aimed at long-term success through customer satisfaction and benefits to all members of the organisation and to society.

Total Quality Management (TQM) is an approach that seeks to improve quality and performance which will meet or exceed customer expectations. This can be achieved by integrating all quality-related functions and processes throughout the company. TQM looks at the overall quality measures used by a company, including managing quality design and development, quality control and maintenance, quality improvement and quality assurance. TQM takes into account all quality measures taken at all levels and involving all company employees (Dale, 1999:9).

(a) Origins Of TQM

Total quality management has evolved from the quality assurance methods that were first developed around the time of the First World War. The war effort led to large-scale manufacturing efforts that often produced poor quality. To help correct this, quality inspectors were introduced on the production line to ensure that the level of failures due to quality was minimised (Lessem, 1991:3).

(b) Principles of TQM

TQM can be defined as the management of initiatives and procedures that are aimed at achieving the delivery of quality products and services. According to Lascelle and Dale (1990:67) number of key principles can be identified in defining TQM, including:

- Executive Management – Top management should act as the main driver for TQM and create an environment that ensures its success;
- Training – Employees should receive regular training on the methods and concepts of quality;
- Customer Focus – Improvements in quality should improve customer satisfaction;
- Decision-Making – Quality decisions should be made based on measurements;
- Methodology and Tools – Use of appropriate methodology and tools ensures that non-conformances are identified, measured and responded to consistently;
• Continuous Improvement – Companies should continuously work towards improving manufacturing and quality procedures;
• Company Culture – The culture of the company should aim at developing the employees’ ability to work together to improve quality and
• Employee Involvement – Employees should be encouraged to be pro-active in identifying and addressing quality-related problems.

(c) The Cost of TQM

Many companies believe that the costs of the introduction of TQM are far greater than the benefits it will produce. However, research across a number of industries has indicated that costs involved in doing nothing, i.e. the direct and indirect costs of quality problems, are far greater than the costs of implementing TQM (Pursglove & Dale, 1996: 567).

The American quality expert, Phil Crosby, wrote that many companies choose to pay for the poor quality in what he referred to as the ‘Price of Nonconformance’. The costs are identified in the Prevention, Appraisal, Failure (PAF) Model (Dale, 1999:148).

Prevention costs are associated with the design, implementation and maintenance of the TQM system. They are planned and incurred before actual operation, and can include:

• Product Requirements – The setting specifications for incoming materials, processes, finished products/services;
• Quality Planning – Creation of plans for quality, reliability, operational, production and inspections;
• Quality Assurance – The creation and maintenance of the quality system and
• Training – The development, preparation and maintenance of processes.

Appraisal costs are associated with the vendors’ and customers’ evaluation of purchased materials and services to ensure they are within specification (Carson, 1986: 54). They can include:

• Verification – Inspection of incoming material against agreed upon specifications;
• Quality Audits – Checking that the quality system is functioning correctly and;
Vendor Evaluation – Assessment and approval of vendors.

Failure costs can be split into those resulting from internal and external failure. Internal failure costs occur when results fail to reach quality standards and are detected before they are shipped to the customer. These can include:

- Waste – Unnecessary work or holding stocks as a result of errors, poor organisation or communication;
- Scrap – Defective product or material that cannot be repaired, used or sold;
- Rework – Correction of defective material or errors and
- Failure Analysis – This is required to establish the causes of internal product failure.

External failure costs occur when the products or services fail to reach quality standards, but are not detected until after the customer receives the item (Dale, 1999: 149). These can include:

- Repairs – Servicing of returned products or at the customer site;
- Warranty Claims – Items are replaced or services re-performed under warranty;
- Complaints – All work and costs associated with dealing with customers’ complaints and
- Returns – Transportation, investigation and handling of returned items.

### 2.4.4 Similarities and differences between TQM and TPM:

The TPM programme closely resembles the popular Total Quality Management (TQM) programme (Dale, 1999: 78). Many of the tools such as employee empowerment, benchmarking and documentation, used in TQM are used to implement and optimise TPM. Following are the similarities between the two:

1. Total commitment to the programme by upper level management is required in both programmes;
2. Employees must be empowered to initiate corrective action, and
3. A long-range outlook must be accepted as TPM may take a year or more to implement and is an on-going process. Changes in employee mind-set toward their job responsibilities must take place as well.

Table 2.1: The difference between TQM and TPM is summarised below:

<table>
<thead>
<tr>
<th>Category</th>
<th>TQM</th>
<th>TPM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Object</strong></td>
<td>Quality (Output and effects)</td>
<td>Equipment (Input and cause)</td>
</tr>
<tr>
<td><strong>Means of attaining goal</strong></td>
<td>Systematise the management. It is software oriented</td>
<td>Employees’ participation and it is hardware oriented</td>
</tr>
<tr>
<td><strong>Target</strong></td>
<td>Quality for PPM</td>
<td>Elimination of losses and wastes.</td>
</tr>
</tbody>
</table>

Source: Venkatesh (2005: 21)

2.5 MATERIAL AVAILABILITY

Material is one of the most important factors in relation to productivity improvements in any organisation. In this section the research will show how material inventory affects productivity improvements by explaining the basic elements of inventory management and control.

The inventory of an organisation is the amount and type of raw material, parts, supplies, and unfinished goods an organisation has on hand at any one time (Hellriegel et al, 1999: 736). Inventory control is concerned primarily with setting and maintaining minimum, optimum and maximum levels of inventory.

In part, such controls are achieved by obtaining feedback about changes in inventory levels that signal the need for action to avoid going above or below the predetermined levels. The amount of inventory may have an enormous effect on a firm’s capital requirements and the productivity of its capital (Hellriegel et al., 1999: 736).
The manufacturing firms carry supplies of raw materials, purchased parts, partially completed items, finished goods, as well as spare parts for machines, tools, and other supplies. Inventory management is driven by the demand for the material and there are two types of demands for material, namely the independent and the dependent demand (Stephenson, 1996: 528).

According to Stephenson (1996: 528) the dependent demand is the demand for items in an inventory that are sub-assemblies or component parts to be used in the production of finished goods. The demand for sub-assemblies and component parts is derived from the number of finished units that will be produced. The independent demand items are the finished goods or other end items. These items are sold or at least shipped out rather than used in making another product (Stephenson, 1996: 529).

2.5.1 Inventory Goals

According to Hellriegel et al. (1999: 736), inventories are maintained to achieve some independence in transformation where input material, components, and partially complete goods sometimes are stocked at each work station to provide some independence of operation. An inventory allows flexibility in the production schedule because stockpiling the finished goods lessens the pressure to produce a certain amount by a particular date and provides for shorter lead times.

According to Stephenson (1996: 528), an inventory safeguards against problems caused by variations in the delivery of input material. Without a backup inventory of input materials, even slight delays can shut down an entire operation and have a considerable impact on the productivity performance of the plant. Inventories also help meet the variation in market demand for the firm’s output. Due to these variations the common practice is to maintain a safety, or buffer, inventory to meet unanticipated market demand.

Inventories enable management to take advantage of economic order quantities. Purchasing material and carrying those materials in inventory costs money. These costs along with any offset supplier discount for quantity ordering are factors in determining the most economical size of an order (Hellriegel et al. 1999: 738). These costs will be discussed in the next section.
2.5.2 Inventory Cost

Inventory costs are the expenses associated with maintaining inventory, including ordering cost, carrying costs, shortage costs and set-up costs (Hellriegel et al. 1999: 738). The ordering costs are the expenses associated with placing the order and/or preparing the purchase order. The carrying costs are the expenses of holding goods in inventory.

On the other hand, the shortage costs are the losses that occur when there is no stock in inventory to fill the customer order and this can result in a customer’s decision not to place an order or to place future orders elsewhere. Lastly, the set-up costs are the expenses incurred in changing over to make a different product. They include the time required to get the new input materials, make equipment changes, make changes in the sequence of transformation processes and clear out inventories of other items (Hellriegel et al, 1999: 738).

2.5.3 Inventory Systems

Two systems that have significantly affected inventory management and control are the material resource planning (MRP) system and the just-in-time (JIT) system. The MRP system appears to have the greatest application with process-focus and intermediate positioning strategy while the JIT system provides tighter inventory control with the product-focus strategy (Hellriegel et al, 1999: 738).

The MRP system helps meet three basic information requirements of operations management: (1) What is needed? (2) How much is needed? (3) When is it needed?

The following components provide this information:

- A master production schedule shows which goods are to be produced, when and in what quantities;
- The bill of materials describes the inputs, raw materials, parts, or sub-assemblies for each goods or components to be produced and
- An inventory-status file shows inventory on hand and an order for each stock item by time period, including information on lead time, order size and supplier.

The MRP also calculates gross and net financial requirements for inputs and outputs by time period.
2.5.4 Just-in-time System

The delivery of finished goods just-in-time to be sold, sub-assemblies just-in-time to be assembled into finished goods, parts just-in-time to go into assemblies and the purchased material just-in-time to be transformed into parts is called JIT (Hellriegel et al. 1999: 740). The JIT system affects more than just the purchasing department because it requires a fundamental change in the relationship between a manufacturer and its suppliers. The JIT system has major implications for the quantities purchased and produced, quality expectations and the suppliers used. It requires high levels of communication, coordination and cooperation. With the JIT system, buffer inventories, idle time and other forms of slack are drastically reduced. All the above material availability elements impact on productivity improvements of an organisation.

2.6 EMPLOYEE SKILLS

The productivity of individuals may be reflected in employment rates, wage rates, stability of employment, job satisfaction or employability across jobs or industries. An increase in productivity at any level can be attributed to various factors, for example, new capital equipment, organisational changes or new skills learned on or off the job. Productivity is affected by factors at the individual level, such as health, education, training, core skills and experience as well as by factors at the enterprise level, such as management, investment in plant and equipment and occupational safety and health (ILO, 2005a, pp. 2–3).

There is an importance to recognise that skills development and other investments in human capital comprise only one set of factors necessary for productivity growth. Skills development alone cannot raise enterprise and national productivity. Other factors and policies are likewise insufficient if they are implemented in isolation of skills development. One of the messages of this research is that skills development must be an integral part of broader development strategies if the company is to deliver on its substantial potential to contribute to overall productivity and profit growth (Schumpeter, 1942: 45).

Skills are critical in the structural adjustment of economies. As economies move from relative dependence on agricultural production to manufacturing and service industries, workers and enterprises must be able to learn new technical, entrepreneurial, and social
skills. An inability to learn new skills because of inadequate basic education or a lack of opportunity slows the transfer of all factors of production from lower to higher value added activities (ILO, 2002; ILO, 2005a; Ghose et al., 2008).

In the long term, productivity is the main determinant of income growth. Productivity gains increase real income in the economy, which can be distributed through higher wages. A low-wage, low-skill development strategy is unsustainable in the long term and incompatible with poverty reduction. Investment in education and skills helps to ‘pivot’ an economy towards higher value added activities and dynamic growth sectors (Tan & Batra, 1995:95).

There is an importance that both enterprises and workers benefit from improved productivity. Improved productivity can enable enterprises to make new investments and fuel the innovations, diversifications and expansions into new markets that are needed for future growth. Improved productivity can result in higher earnings for workers, better working conditions, improved benefits and reduced working hours: these in turn can improve workers’ job satisfaction and motivation.

Productivity growth reduces production costs and increases returns on investments, some of which turn into income for business owners and investors and some of which are turned into higher wages. Prices may go down, consumption and employment grow and people move out of poverty. The virtuous circle is also fed through the investment side of the economy when some productivity gains are reinvested by a firm into product and process innovations, plant and equipment improvements and measures to expand into new markets, which spurs further output growth and productivity (McArdle, 2007) meet skills demand in terms of relevance and quality.

An enterprise has to employ skills policies that seek to develop relevant skills, promote lifelong learning, deliver high levels of competences and a sufficient quantity of skilled workers to match skills supply with demand. Furthermore, equal opportunity in access to education and work is needed to meet the demands for training across all sectors of society. According to Oxenham (2000) policies designed to meet skills demand contribute to productivity, employability and decent work because of the following reasons:
enterprises can use technologies efficiently and fully exploit productivity potentials;

young people acquire employable skills which facilitate their transition from school to work and smooth integration into the labour market;

workers build up and improve competences, and develop their careers in a process of lifelong learning; and

disadvantaged population groups have access to education, training and the labour market.

2.7 SUMMARY

The literature reveals that productivity improvements are the core element of the business that result in higher profitability. In this chapter it has been made clear that management and the employees have control over internal and external factor affecting productivity improvements. Productivity is much more than just labour productivity and needs to take into account the increase in the cost of raw material and energy. There is a direct link between productivity and quality of output, input and the process itself.

In addition, the study supports the fact that the purpose of measuring OEE is to drive improvement in the production process. For OEE to meet this goal it is crucial that people using OEE, or any measure for that matter, understand why they are making the measurement and what is going to happen with the information collected. The leadership must understand it, too, and clearly communicate their expectations and intentions to operators. If this very critical step is not taken, the measure could impair improvement effort instead of driving it (Bernstein, 2005:105).

Today, with competition in industry at an all-time high, TPM may be the only factor that stands between success and total failure for some companies. It has been proven to be a programme that works. Employees must be educated and convinced that TPM is not just another ‘programme of the month’ and that management is totally committed to the programme and the extended time frame necessary for full implementation. If everyone involved in a TPM programme does his or her part, an unusually high rate of return compared to resources invested may be expected (TPM100-SG-001-00.doc).
It remains the responsibility of organisational leaders to ensure that quality is improved. This will increase productivity, and enable officials to provide more efficient service to their customers. Leadership is needed to improve quality. It is germane at this point for an article to include a scenario of an inspired quality management champion thus:

Not a blue-sky dreamer, nor an intellectual giant. The champion might even be an ideal thief. But, above all, he’s the pragmatic one who grabs onto someone else’s theoretical construct if necessary and bull headedly pushes it to fruition… Champions are pioneers, and pioneers get shot at. The organizations that get the most from champions, therefore, are those that have rich support networks so their pioneers will flourish. This point is so important it’s hard to overstate. No support system, no champions. No champions, no innovations (Hunt, 1993).

This should be noted that quality management depends on people more than anything else, and people lead or are led; they are not managed. Thus, quality management depends on effective leadership, and leadership must be provided. Taking the initiative, providing an example, and showing the way can inspire subordinates and inspire peers to follow the example.

This can be argued that as more and more firms participate in enterprise training and as more funds become available for training, lower level staff invariably gain greater access to skills training programmes and so increase their chances of securing higher-level employment. It will also need a greater commitment from employers to view training as an asset that can contribute to increased productivity and growth, and not simply as a burden which negatively impacts on cost structure, which is how the current training dispensation is commonly perceived amongst many employers. It will also need a greater commitment from employers to view training as an asset that can contribute to increased productivity and growth, and not simply as a burden which negatively impacts on cost structure, which is how the current training dispensation is commonly perceived amongst many employers (Badroodien,2005:156).

Chapter Three will provide an overview of the Ford Struandale Engine Plant with regard to Productivity performance, Overall Equipment Effectiveness, availability,
performance effectiveness, quality rate, Ford Total Productive Maintenance, Total Quality Management, Material availability and employee Skills
CHAPTER THREE

LITERATURE REVIEW ON FORD STRUANDELE ENGINE PLANT

3.1 INTRODUCTION

In Chapter Two the literature revealed that there are internal, external and other factors that can limit productivity improvements in an organisation. The literature also identified that plant and equipment (OEE), availability, performance efficiency, quality rate, material availability and employee skills can limit productivity improvements in an Organisation.

In this chapter the researcher will discuss productivity performance at the Ford Struandale Engine Plant and the systems they employ to achieve productivity improvements. The discussion will look at OEE performance at the SEP compared to the world standards and will also look at the material availability issue and employee skills. The chapter will start with a brief introduction to Ford’s background and the history of the organisation with regard to the experiences it has in implementing best practices.

Since its formation in 1901 Ford Motor Company has initiated and developed productivity improvement processes. Henry Ford is known as the father of modern assembly lines used in mass production. Ford is credited with “Fordism”, that is the mass production of large number of inexpensive motor cars using the assembly line coupled with high wages for his workers. Ford had adopted the concept of lean manufacturing before it became popular because its founder, Henry Ford, had an intense commitment to lowering costs which resulted in many technical and business innovations including the franchise system that put a dealership in every city in North America.

Early in 2000 Ford introduced Ford Production Systems (FPS) in all its plant and theses were the key characteristics of the system. It is a unified system that integrates Ford’s worldwide manufacturing, design and development, order to delivery, supply, and management functions. It aims to have ZERO waste, injuries, accidents, defects and breakdowns and is targeted to assist in the improvement process at the shop floor level. Eliminating waste (defects, waiting, excess motion, over processing, inventory over
supply and inefficiency) is the primary goal. The ultimate goal is to make sure that Ford produces components that will satisfy the customer's needs.

3.2 FORD PRODUCTION SYSTEMS (FPS)

The Ford Production System (FPS) is based on the Lean Manufacturing Principle which is one of the paradigms for operations, and its influence can be found in a wide range of manufacturing and servicing strategies. The FPS consists of ten elements meant to create a lean, flexible and disciplined common production system defined by a set of principles and processes that employ groups of capable and empowered people learning and working safely together in the production and delivery of products that consistently exceed customers' expectations in quality, cost and time.

Lean operations management design approach focuses on the elimination of waste and excess and represents an alternative model to that of capital-intense mass production. Ford had to make distinction between Lean thinking at the strategic level, and Lean production at the operational level as it is crucial to understanding Lean as a whole, in order to apply the right tools and strategies to provide customer value (Shirouzu, 2000:4).

Ford’s objective for the introduction of the FPS 2000 programme was to build a Lean, flexible and disciplined production system, but it seems in a quest for Lean system, the concept of flexibility was lost. Today, markets are more demanding and new product introduction speed is crucial for maintaining the leadership position. This necessitates flexibility coupled with speed, better known as agility. Agility means being able to reconfigure operations, processes, and business relationships efficiently in an environment of continuous change (Chopra & Sodhi, 2004: 53).

All Ford plants must cooperate to achieve the overall goal of improving manufacturing, which requires their employees to expand their horizons by continuous learning in order to achieve greater creativity and flexibility in the way they perform their jobs. Agile organisations are flexible and quick to respond to fast-moving market conditions, which necessitate the creation of strategic alliances and virtual organisations.
To become a truly agile organisation, Ford had to rethink the way they conduct their business. This involved embracing the latest information technology in order to conduct electronic commerce and facilitate information flow. Also business processes needed to be re-evaluated and reconstructed in order to increase overall organisational efficiency and effectiveness, and employees had to accept the challenges presented to them by agile manufacturing, by being more creative and more open to challenges when performing their jobs, and by being more receptive to the concept of life-long learning.

Ford standardised the manufacturing operations around the globe, and this certainly had some benefits in the form of economies of scale in equipment purchases, reduced inventory of spare parts and moreover the production can be shifted to other plants whenever there is a surge in demand in any particular region. Ford is trying to source materials from the same suppliers for all its plants.

In the recent times Ford announced a R1.6 billion investment for South Africa to build engine assemblies and components for the engines that will be built in various countries in the Asia Pacific and Africa region. This investment includes the production of the new pick-up T6 truck to be exported to various parts of the world.

3.3 FORD TOTAL PRODUCTIVE MAINTENANCE (FTPM)

Total Productive Maintenance (TPM) is a well-defined and time-tested concept for maintaining plants and equipment. TPM can be considered the science of machinery health.

The objective of FTPM is to maximise the overall effectiveness of the plant facilities, equipment, processes and tooling through the focused efforts of Small Group Activities directed at the elimination of the Seven Major Losses (Equipment Breakdowns, Setup and Adjustments, Idling and Minor Stoppages, Reduced Speed, Start-up Losses, Quality Defects in Process and Tooling Losses) associated with manufacturing equipment. The five necessary pillars for sustaining FTPM performance are (1) Work Groups separate FPS Element, (2) Training separate FPS Element, (3) Planned Maintenance (4)
Improving Equipment Effectiveness and (5) Early Equipment Management Section 4.5 of Manufacturing Engineering

**Five major integrated elements of FTPM**

*Fig 3.1: FTPM five major integrated elements*

1. Small group activity
2. Early Equipment Management
3. Training in Operation and Equipment
4. Conduct Planned Maintenance
5. Improve Equipment Effectiveness

**Source:**

Figure 3.1 above indicates the five elements of FTPM and the sequence in which they are implemented. The sequence starts with the small group activities as all other elements depends on how effective the work groups are.

**3.3.1 Small group activities**
The focus of this study is on the first three steps of “Small Group Activities” which are:

1. Cleaning is Inspection
2. Cleaning, Lubricating, and Safety – Procedures
3. Eliminating the Sources of – Contamination

Small Group Activities complement planned maintenance activities.

The results of doing Small Group Activities are:

– Measuring and Eliminating Forced Deterioration
– Restoring Equipment to its Ideal Level of Operation
Elimination of Problems that Affect Productivity

The Small Groups maintain the improved levels through visual controls and increased process awareness (http://hub.fmcsa.Ford.com/pe/FORD/FordStructure/ASPPages/FTPMpackages.asp).

3.3.2 Early equipment management

Ford uses early equipment management to minimise the life cycle costs of new equipment and this done for the following reasons:

- Data collection and feedback to equipment suppliers, can avoid buying equipment with design problems.
- There is a need to inform suppliers of “Things gone right” and “Things gone wrong” along with the expectations for the new equipment.

The early equipment process in the FTPM element is also called the Reliability and Maintainability (R&M) process. The intention of the process is to extract R&M information from data, create knowledge, and apply the knowledge to improve equipment performance. In FTPM the successful implementation of an R&M process provides the following:

- Higher machinery and equipment availability;
- Reduced unscheduled downtime;
- Reduced maintenance costs;
- Stabilised work schedule;
- More consistent part/product quality and
- Increased equipment reusability.

FTPM requirement means that the supplier has to have a data-driven understanding of historical equipment performance; continuous improvement of equipment performance through design changes; integration of sub-suppliers into the R&M process; maintenance strategy based on data; and design decisions based on the total cost of ownership of the equipment. The facility has to have an infrastructure to support the R&M process on new and rehabbed machinery and equipment. The infrastructure consists of processes to capture equipment performance data and support continuous improvement tools and processes at the work group level.
The acquisition activity ensures that the suppliers are compliant with the process and work with suppliers to identify and eliminate historical failures. R&M information includes the Reliability and Maintainability Specification Statement and the 5-Point Process.

- In FTPM the R&M process is applied in the acquisition of product and support equipment where improvements in the reliability and maintainability are key enablers to lean manufacturing;
- Work groups participate in the buy-off of equipment. Experienced work group members are allowed to participate with suppliers in identifying equipment issues before the equipment is released to production. The buy-off can be conducted at the supplier or on the plant floor. Safety, ergonomics, maintainability, part quality and uptime could be included in the buy-off.
- Performance data is fundamental to the R&M process. Facilities must be able to provide performance data to the supplier for newly acquired equipment. The data provides a common focus to eliminate immediate concerns and establishes historical baseline for future acquisitions.
- The collection of equipment historical data is vital to the R&M process. Machine performance data of downtime, repairs, and improvements made on existing equipment needs to be available to the acquisition activity.
- Failure Reporting, Analysis and Corrective Action System (FRACAS) is the activity that targets the components to be included in contract participation of the selected suppliers. This system is meant to target the very first part that fails to meet the reliability target. This process does not replace warranty but it is determined by the cost of the part or lost of production when it fails.

### 3.3.3 Training in operation and management

The purpose of training the existing workforce is to make “Each Ford Employee the best there is.”

- FTPM training is fundamental and provides basic understanding and specific skill improvements required by each employee.
- There are other types of training offered such as Constraint Identification and Analysis, Reliability and Maintainability, Constraint Identification Work Group (CIWG), Team-Oriented Problem Solving (TOPS ), Small Group Leader Training and Basic Equipment Wellness II (BEW II).
• Small Group Activities (SAG) training includes such topics as:
  – Seven steps for SGA;
  – Visual Inspection Techniques;
  – Data Collection and Analysis of Major Losses;
  – A knowledge of:
    - ECPL
    - Lubrication and
    - Machine Component Functionality and Abnormalities

Versatility training for skilled trades may also include such topics as:
• Preventive maintenance techniques;
• Vibration analysis;
• Infrared;
• Laser alignment;
• Ferrography;
• Reliability maintainability (R&M) and
• Ultrasound.

3.3.4 Planned maintenance

Planned Maintenance is foundational for FTPM and FPS continued success. Planned Maintenance is about structuring activities required to restore and improve facilities, equipment, processes and tooling through routine, periodic and predictive maintenance. It is the focus of the Maintenance organisation to manage maintenance activities and resources required to restore and improve facilities, equipment, processes and tooling.

There is a focus on the development of necessary maintenance tasks to be scheduled in the facility through FTPM coordinator and maintenance personnel, with appropriate emphasis on the development of PM task schedules prior to facility, equipment, process or tooling being put into service. It is the duty of the maintenance supervisor and his team to ensure that they adhere to the PM schedules and that corrective measures are taken for the behind schedule. SEP reviews the maintenance schedules on a weekly basis in the maintenance meetings and the focus of the meeting is the following:

• Identifying all “key” equipment;
• Developing appropriate PM task descriptions and frequencies;
- Identifying and quantifying appropriate Industrial Materials requirements;
- Establishing a predictive/conditioned maintenance plan;
- Focusing on Corporate and governmental regulatory requirements for safety and environmental and
- Involving work groups in the PM process (i.e. equipment and process checks)

*Figure 3.2 PM Completion Report Plant Wide 2010YTD*

The maintenance scheduling process should complement the facilities maintenance planning process, to ensure that all planned and unplanned maintenance tasks are scheduled and completed in a timely fashion. The above graph shows planned maintenance status at SEP up to the month of July 2010. It also indicate that although some areas in the plant have high levels of PM completion, there are areas that are not adhering to the schedules and as a result they have low PM completion. This is the kind of performance that can lead to increased downtime due to breakdowns.

These are the elements identified from these plans:
- Identify priorities, based on safety, environmental, product quality and throughput and
- Identify timing, roles and responsibilities and other resource requirements.
The purpose is to ensure that all maintenance tasks are performed effectively (i.e., safely, timely, cost-consciously, consistently to a documented standard), through a regular task review process:

- Regularly scheduled task review by an appropriate cross functional work group;
- Defined verification of maintenance task completion process;
- Emphasis on completion and review of safety, environmental and quality tasks and
- Consideration of effective utilisation of resources, adequacy of tools, cost effectiveness, work group input, and increased throughput opportunities.

### 3.3.5 Improve equipment effectiveness (OEE)

OEE is one of the key matrices in FTPM implementation to measure equipment effectiveness. The question is always asked as to why measure the OEE. **Overall Equipment Effectiveness (OEE)** is a measure of the ability of a piece of equipment to consistently produce product, which meets Quality Standards, at the designed cycle rate without disruption.

It measures the Availability, Performance Efficiency, and Quality Rate of a machine. From the FTPM the objective of monitoring and improving OEE is to increase the effective utilisation of the equipment resulting in increased throughput (revenue), decreased cost, lower inventories (required working capital), and lower net fixed assets (improved investment efficiency). This will increase the health of the Company which benefits employees, customers, creditors and shareholders (http://www.fps.ford.com).

As indicated above, an increase in the OEE performance will mean an increase in the health of an organisation as a result of an increase of the Returns on Assets. This will benefit all stakeholders i.e. the employees in the form of job security or increase in pay, customers which means reduced price or increased level of quality and delivery service, creditors because of the ability to pay the loan, and finally the shareholders due to the increase in the share price.

**(a) Availability**

Availability is the amount of time the machine or the process is available to run compared to the amount of time it is scheduled to run. Availability can be affected by
equipment failures and breakdowns, setup and adjustment losses, tooling, documented minor stoppages, and start-up losses. In FTPM when availability is calculated all the losses are include even those that are normally excluded, like the blocked and starved.

Availability = Operating Time / Net Available Time

It has been indicated above that one of the elements of availability is Equipment. Breakdowns are losses resulting from any equipment malfunction that requires maintenance intervention. Equipment Breakdown loss is defined as the time between when the equipment is stopped, due to malfunction, until the equipment is repaired, checked out, and ready to operate.

That includes response time to equipment malfunction, time to diagnose and identify the cause and/or result of the failure, time to repair the equipment, and any test time to insure that the failure has been corrected. Information on the cause, duration, effects, and actual repairs made to the equipment should be recorded for all breakdown incidents to enable analysis and prioritisation of opportunities for improvement (http://www.fps.ford.com/learningeventslearningbew.html).

Equipment Breakdown loss is one of the major losses for SEP due to the lack of urgency in fixing the breakdown where there is no proper system to measure the time when the machine actually went down, when the artisan stated working on the machine and when the machine actually started running. The current tendency is that after the operator has reported the machine to an artisan, he or she feels it is acceptable for him or her to wander around and by the time the machine is ready to run, he or she is not available and more time is lost. This is a discipline issue the SEP management have to deal with if they want to be able to separate machine breakdown for corrective action.

Examples of Equipment Breakdowns include the following:

- Wear Product Failure
- Equipment Jam
- Transfer Line or Conveyor Belt Failure
- Lubrication Failure
- Operator Error
- Utility Failure
- Component Fatigue
- Misalignment
- Controls Failure
- Equipment Design Misapplication.
The second element of availability are the Set-up and Adjustment Losses. These are losses resulting from downtime while the equipment or process is being prepared to run a different product or altered to meet end-product specifications. The time recorded must include both changeover time and setup time following equipment overhaul or maintenance. In FTPM all set-up and adjustment times are recorded, tracked, and analysed to identify opportunities to make the set-up and adjustment process more efficient.

Examples of Set-up & Adjustment Losses include the following:

- Calibration
- Machine fixture setting
- Limit Switch Adjustment
- Set Point Adjustment

Figure 3.3 represents the SEP assembly line availability vs downtime YTD.

Source: W:\GROUP\FPS\2. FPS Department\09. Department Information\Production\2010\J. Downtime

The graph above show the SEP assembly line downtime versus the availability for the top fifteen categories. The downtime is the combination of machine breakdowns and
material availability. The other downtime is the planned downtime such as the team meetings. In the Ford world there are good systems in place to ensure that breakdowns do not repeat themselves although it is not always possible to achieve this objective due to people not following the system properly. The Failure Analysis Report (FAR) is a very comprehensive system used at the SEP to resolve machine breakdown issues.

In a small team approach where maintenance and production teams come together in an effort to find permanent solutions to the problems. In this process they use the five Why process to determine the root cause of the problem. The teams also use the ishikawa diagram to pinpoint whether the problem is machine, method, processes, product, material, systems or the people that cause the problem and then come up with the resolution to the problem. This is not always used properly as some of the teams use this as the paper exercise where it is seen as something management demands for every breakdown but it is a very good system for issue resolution.

(b) Performance efficiency
In FTPM Performance Efficiency determines how closely a piece of equipment or a process runs to its ideal cycle time. This can be affected by speed losses and losses associated with undocumented idling or minor stoppages resulting from blocked or starved upstream and downstream equipment. 
(http://www.fps.ford.com/learningeventslearningbew.html).

Performance Efficiency = (Ideal Cycle Time x Total Products Run) / Operating Time. These losses that cannot be documented, belong in the All Other Idling & Minor Stoppages category and are classified as Performance Efficiency losses. It is not always practical to document all stoppages, and the plant should establish a decision rule for consistent documentation of minor stoppages. However, effective decision rules for documentation of minor stoppages are usually based on a minimum time threshold.

As the documented stoppages are reduced, the threshold can be shortened. The use of the Productivity Operating System (POS) monitoring, or other automated data collection systems, enables increased documentation of minor stoppages. All Ford plants should define equipment specific loss or cause codes that will be recorded by the
automated data collection system before a machine is placed back into the automatic mode.

Examples of Minor Stops include the following:

- Machine Jam
- Undocumented Manual Adjustment
- Material Misalignment
- Temporary Cleaning Requirement
- Machine Reset.

**Blocked and Starved**

Blocked and Starved time losses are not subtracted from equipment’s Availability. They reduce the Performance Efficiency of the equipment. Production losses due to Blocked and Starved conditions should be tracked whenever possible, and the plant should consider establishing plant-wide loss codes for specific blocked and starved conditions, e.g. ‘Blocked - Buffer Full’, or ‘Starved - No Stock from Supplier’.

Where minimum or maximum levels have been established with a pull system, blocked conditions may occur when all levels are at maximum. This can also happen to the production areas that are down the stream when one area experiences long down time as a result of a breakdown. The equipment or process would then be considered blocked. This could be a good time to complete Operator preventive maintenance such as Cleaning to Inspect.

**Reduced Speed Loss**

Reduced Speed Loss is lost production due to the machine or line operating at an overall rate that is slower than ideal cycle time. The ideal cycle time of a machine, along with the product that is being produced, is the engineered design cycle rate. A faster cycle time may be used, if it has been documented and proven-out by the plant, using the FPS “Manage-the-Change” process. Reduced Speed Losses should be tracked and regularly reported. One of the challenges that SEP faces is the reduction of the cycle by the machine tool setters to avoid quality issues on the line and when permanent corrective action implemented do not put the machine to its original design cycle time. This is as a result of not following the Manage-the-Change process.
Figure 3.4 below shows assembly line efficiency performance for the year to date and it only depicts the top five efficiency issues. According to the graph, the top five issues show that there are three issues of significance that affect efficiency performance on the line. The three items in the top five are the material availability (clearly waiting for heads is the number one factor) as well as quality issues on the line and the machine downtime. There other issues but this research will concentrate only on these top five issues.

**Figure 3.4 Assembly performance efficiency graph**

![Assembly performance efficiency graph](source)

(c) **Quality Losses**

A Quality loss is associated with the production of products that do not meet Quality Standards. In FTPM Quality Losses include the calculation of an OEE for a piece of equipment or a process:

- all product requiring either in-line or off-line rework;
- all product that is rerun in order to meet Quality Standards and
- all product that is scrapped.

Only Quality Losses directly related to the equipment or process should be included in the calculation of the equipment OEE. The SEP reports and categorises all types of quality losses for root cause analysis and the prevention of recurrence. Currently the assembly line First Time Through (FTT) is about 93% on average so far, including the
first half of October. That can be seen in the FTT graph which is figure 3. in the lower sections.

Table 3.1 Percentage internal daily reject from the machining lines to assembly

<table>
<thead>
<tr>
<th>Description</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crank shafts</td>
<td>0.07</td>
<td>0.31</td>
<td>0.03</td>
<td>0.05</td>
<td>0.15</td>
<td>0.07</td>
<td>0.15</td>
<td>0.05</td>
<td>0.17</td>
<td>0.05</td>
<td>0.65</td>
<td>0.16</td>
</tr>
<tr>
<td>Cyl Blocks</td>
<td>7.60</td>
<td>1.74</td>
<td>2.43</td>
<td>1.08</td>
<td>0.99</td>
<td>1.03</td>
<td>0.94</td>
<td>1.01</td>
<td>1.22</td>
<td>0.52</td>
<td>0.55</td>
<td>1.74</td>
</tr>
<tr>
<td>Cylinder Heads</td>
<td>3.19</td>
<td>10.70</td>
<td>3.41</td>
<td>4.14</td>
<td>4.08</td>
<td>3.33</td>
<td>5.48</td>
<td>2.11</td>
<td>2.16</td>
<td>3.74</td>
<td>1.35</td>
<td>3.97</td>
</tr>
<tr>
<td><strong>TOTAL REJECTS</strong></td>
<td><strong>10.86</strong></td>
<td><strong>12.76</strong></td>
<td><strong>5.87</strong></td>
<td><strong>5.26</strong></td>
<td><strong>4.43</strong></td>
<td><strong>6.56</strong></td>
<td><strong>3.17</strong></td>
<td><strong>3.55</strong></td>
<td><strong>4.31</strong></td>
<td><strong>2.54</strong></td>
<td><strong>5.87</strong></td>
<td></td>
</tr>
</tbody>
</table>

Included in the FTT figure is the 5.87 percent contribution from various departments supplying assembly with parts rejects ranging from incorrectly machined parts to the smallest rejects such as surface damages filtering through to assembly. The other 1.13 percent is the contribution from the assembly line where parts are fitted to an engine incorrectly or defective parts are not picked up early enough.

**Start-up Losses**

In FTPM Start-up Loss is defined as a loss that occurs between the time of equipment or process start-up until the time that a product is produced, meeting all Quality Standards. This loss is usually a result of the time it takes for the equipment to stabilise in terms of temperature, pressure and, speed, during start-up. The goal in minimising Start-up Losses has two factors.

The first is to minimise the number of start-ups by stabilising equipment reliability, production schedules, and overall machine operation. The second is to minimise the lost time for each start-up by bringing the equipment to stability in a shorter time. This may require equipment modification to control temperature, pressure, and speed, prior to pushing the start button. The SEP strives to reduce both the number of start-ups and the time required to bring the operation to stability.
3.3.6 Key Ford Total Productive Maintenance (FTPM) requirements for stabilising and improving OEEs are:

- Sound maintenance practices;
- Reliable and maintainable tooling/equipment;
- Stable/controlled processes;
- Strong FTPM processes;
- Lean changeover processes and
- Highly-skilled team-oriented workforce.

The goal of the OEE is to provide the shop floor workgroups with a process that will enable them to collect data on the “Major Equipment Losses,” analyse that data, and use it for continuous improvement. OEE is a measure of the ability of a piece of equipment or a process to consistently produce products, which meet Quality Guidelines without disruption, at the designed cycle rate. It measures the availability, performance efficiency, and quality rate of a machine.

*Figure 3.5 FTPM Measures*

*Table 3.2 World Class OEE vs SEP OEE Performance*

<table>
<thead>
<tr>
<th>OEE Factor</th>
<th>World Class</th>
<th>SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>90.0%</td>
<td>83.24%</td>
</tr>
<tr>
<td>Performance</td>
<td>95.0%</td>
<td>74.57%</td>
</tr>
</tbody>
</table>
This chart shows that on the SEP assembly line OEE performance is lower than the world class performance by almost 27 percent, mostly due to poor availability and performance efficiency. Even though the quality levels are also low, the gap is not that significant. The assembly team should focus more on availability and performance.

3.3.7 Total Quality Management (TQM)

In Ford Motor Company (FMC) quality of the product is the second priority after the safety of every employee throughout the organisation. Quality at Ford Motor Company is not just the use of quality check sheets but a way of life in everything they do. Every employee is held accountable for the quality of the work or product they make. Ford has a global quality office that is responsible for making sure that quality systems are standardised in every Ford plant throughout the world. The function of the quality office is to continuously review the quality process within the organisation to ensure that they address customer concerns.

(a) Customer supplier relation

During the launch of a new product, Ford has a global process in place to ensure that the suppliers have the capability and the capacity to supply the product required at the required quality and quantities. This process is called the Global Product Development System (GPDS) that ensures during the development stage that the product specification is met by engaging the suppliers early in the development process. This is to engage the suppliers early in the launch process right after the sourcing is done to ensure supplier success and sharing of responsibility. The cross functional teams from Ford will visit the supplier key manufacturing premises a number of times per year.

The GPDS Supplier Engagement process describes a disciplined set of activities performed throughout a GPDS programme to ensure that critical parts delivered by Ford's supplier partners achieve the desired quality and capacity levels at Job #1.
Working on the principle that supplier success is a shared responsibility among the different Ford organisations, the process is focused around a core cross-functional team made up of representatives from Ford PD, buyers, STA, MP&L and the supplier. This team will form shortly after sourcing and continue working together through the successful completion of component Production Part Approval Process (PPAP) (http://www.purchasing.Ford.com/prch_sta/index.htm).

The roles and responsibilities within this process are structured around ownership of the key elements of the industry standard Advanced Product Quality Planning (APQP) and Production Part Approval Process (PPAP). APQP and PPAP are existing Ford processes and are both fundamental building blocks of GPDS (http://www.purchasing.Ford.com/prch_sta/index.htm). This is a structured method used in Ford to ensure that Ford and the suppliers are collectively building products or material that will allow them to meet customer specification.

All Ford plants develop the Supplier APQP/PPAP Readiness Assessment (Schedule A), a structured method for defining and executing the necessary steps required to ensure a product satisfies the customer. The objective of involving suppliers in APQP/PPAP Readiness is to facilitate communication between all individuals and activities involved in a programme and to ensure that all required steps are completed on time, at a high level of accuracy and at acceptable cost and quality levels (http://www.purchasing.Ford.com/prch_sta/index.htm).

The changes in the warranty costs are generally measured by comparing the warranty cost-per-unit CPU of the Goods used on the model year of the vehicle line being evaluated with a specified baseline, which is either:

- the warranty CPU of the goods (or similar goods) on the prior model year of the vehicle line; or
- an agreed fixed warranty CPU.

The Supplier Technical Assistance (STA) department is responsible for the monitoring of the relationship between the Ford Motor Company and the suppliers. Every supplier that supplies material to any of the Ford manufacturing plants after certain period of time has to be in possession of the Q1 certificate where STA department based on the
points achieved during the evaluation process to continue doing business with Ford Motor Company (http://www.purchasing.Ford.com/prch_sta/index.htm).

(b) Early quality planning through dynamic control plan (DCP)
The DCP is the process which the SEP uses to make sure that customer product specification is available and known by everybody in the organisation. This is also used on the shop floor as the reference for operators regarding the sampling measurements during production. From the DCP a quality process sheet (QPS) is developed and posted in each station as the shortened version of the DCP file. The DCP process is also driven through small teams in all production areas (http://www.purchasing.Ford.com/prch_sta/index.htm).

The teams meet once a month to discuss the quality performance of their respective lines. In these meetings the production manager for each area is the champion and the other members of the team are the process engineers, production supervisors, maintenance supervisors, quality engineers, production team leaders and one or two operators. In these meeting the teams discuss quality issues like line rejects, scrap and the customer quality concerns.

(c) Corrective action

From the DCP process a resolution of issues in the form of Concern Corrective Action Report (CCAR) is developed allocating responsibilities and the expected completion date for all concerns raised during the DCP meeting. The CCAR is used to resolve both the customer and the internal quality problems where the status is reviewed weekly in the quality meeting lead by the quality manager. It is common in these meeting that where issues are repeatedly raised, the team responsible is required to come up with error-proofing devices for the common problems.

For customer quality problems Ford uses the Global 8 D (G8D) process to resolve the problem. This is a team focused approach where all relevant parties are involved in the resolution of the problem. This system requires a champion who is the process owner to respond to the customer complaint within five days at least with the interim corrective action to protect the customer. Then within fifteen days permanent corrective action is implemented or identified with the time frame for the date of implementation. This process has also been extended to the suppliers training manual for the resolution process.
(d) Quality Operating System (QOS)

To ensure TQM entrenchment in the organization, Ford recently launched the Quality Operating System that involves every level of the organisation. The objective of the Quality Operating System is to have a standardised quality improvement process with common cadence to enable quality fundamentals at all levels in manufacturing.

This process is user-friendly with analysis methods that are easily understood. It utilizes common data feed mechanisms that generate standardised analysis and reporting; with a common follow-up process that requires minimal preparation work, while allowing manufacturing personnel to concentrate more on quality solutions or corrective and preventive actions. This is a process based on team structure to drive quality initiatives and concentrate more on the commodity that is a quality constraint in the plant. The quality data for a specific commodity is collected and the quality trends are analysed for corrective actions. The area manager for a specific line is required to lead the teams to ensure that First Time Through (FTT) for his respective line improves.

Figure 3.6 Assembly FTT for the YTD

The figure above is the FTT analysis for the first ten months of 2010 where it is evident that the plant struggled to meet the internal quality target for that year. The plant is
currently achieving only an average of 93 percent in comparison with the target of 98 percent set for the plant.

(e) Process improvement

In QOS the teams come together to look at various issues that can help improve the current production processes for improved quality standards. The initiation and review of Statistical Process Control charts ensure all processes are running within the acceptable tolerances. The continual review of the warranty report and quality trends and the implementation of preventive and corrective actions are the key aspects of the business. Ford has embarked on many continuous improvement processes where Kaizen programmes were implemented, starting with the training of production team leaders by using the DMAIC process to raise green belt projects. These projects are the means of resolving quality problems in their areas of responsibility.

SEP continued the quest for being a continuous improvement organisation by making sure they are not treated differently to their counter-parts from around the globe. In 2009 Ford’s quality office in Europe conducted a quality audit at the SEP and the plant was awarded level eight which is the highest level to be achieved by the Power Operation plants within the Ford world.

The plant also registered the third highest score in terms of percentage achieved from the ten power train plant in existence throughout the organisation. This was as a result of the work the SEP put in during the previous years that ensured that quality is one of the top priorities in the plant (http://www.at.ford.com/news/cn/Pages/FordengineplantinSouthAfricagetsworldclassstampforqualitymanagement.aspx).

Ford has also been training the engineers in six sigma where they go on black belt training to learn about continuous improvement techniques. These projects are used either to drive quality improvements or to drive cost improvements in the organisation. The Ford Motor Company of Southern Africa (FMCSA) Engine Plant in Struandale has achieved a significant milestone by becoming one of the first plants in South Africa to attain the latest ISO 9001:2008 Quality Management System certification (http://www.at.ford.com/news/cn/Pages/FordengineplantinSouthAfricagetsworldclassstampforqualitymanagement.aspx).
3.4 MATERIAL AVAILABILITY

Material availability is one of the most important elements in a manufacturing plant and plays a very big role in improving or limiting productivity improvements in an organisation. It is important for the organisation to keep records of the levels of inventory for all types of raw materials required to run production lines. Different organisations have different views about the inventory on their premises. However, Ford and the founder of Ford Motor Company had the same view about inventory:

"Ordinarily...money put into raw materials or finished stock is thought of as live money. It is money in the business, it is true, but having a stock of raw materials or finished goods in excess of requirements is waste - which like every other waste, turns up in high prices and low wages." Henry Ford

Because of the increasing pressure for the plants to be cost competitive, inventory levels have become the one of the key performance indicators under spotlight as there are taxes or interest charged for carrying high levels of inventory. But on the other hand, the facility reliability puts pressure on the manufacturing plant: due to the high levels of machine breakdowns the plants are struggling to make production schedules as a result of low productivity levels. SEP is treated as a cost centre, not a profit-making centre, therefore they need to make every part on schedule in order for them to meet the expected financial results and continue to exist.

3.4.1 Inventory management

(a) Dock-to-Dock

Dock-to-Dock is a FPS Measure that helps identify waste that occurs in the manufacturing process. It focuses on the non-value-added activities between the time raw materials are brought into the process and the time they are shipped out as products. Whenever parts stop and wait in the process, costs that do not add value begin to build up. The following are some examples from the plants:

- Space and storage systems for Work In Progress (WIP) are accepted as necessities;
- Inventory builds parts are moved to unused areas and when needed, can be difficult to locate and
• Parts must be disposed of when they become obsolete by production or design changes.

When many parts are involved, the problems can become hard to see. Vast amounts of money are tied up in inventory!

The SEP, like all other Ford plants, does keep some level of inventory between the processes as a result of facility reliability issues and poor performance of the facilities. In some cases these areas are used as a hiding place for nonconforming products. As a result the amount of stock in these areas is limited to a certain number of parts because of the quality risk associated with the WIP.

(b) Build to Schedule (BTS)

Build to Schedule (BTS) reveals how well a plant executes plans to build the right number of products, on the right day, and in the right sequence. In order for a plant to define the right products to build, the plant’s production schedule must reflect the daily demands of its customers. Measured in this way, BTS will help plants monitor and support the FPS Principle of ‘Aligning Capacity with Market Demand’. Build-to-Schedule measures the percentage of products that are built in the right volume, the right mix, and the right sequence. The Ford Production System BTS Measurable includes a measurement of Volume Performance with some new important aspects:

• Scheduled Volumes are developed from daily customer requirements rather than plant Requirements and
• Benchmark Schedules used in the calculation of BTS performance are fixed in advance. These schedules are not adjusted by the plant on a daily basis.

3.4.2 Just-in-time (JIT)

SEP is running a just-in-time system with some of the local suppliers where one day stock is available between SEP and the supplier. This poses challenges of its own due to the fact that suppliers have the similar performance that SEP has due to facility reliability. When these problems arise, the build-to-schedule system followed by SEP is affected and the plant has to reschedule in order to accommodate the supplier problem at a very high cost. Ford is running two hourly milk run deliveries with the local supplier to support their just-in-time strategy.
3.5 SKILLS

In the previous chapter literature revealed the importance of individual skills development to enhance the productivity performance of the individuals. The productivity of individuals is reflected in the employee rates of pay and the stability of employment in the specific industry. Since the large intake of employees during the launch of the Rocam engine in 2002, labour stability at the SEP has been the best throughout the years which is an indication of the level of satisfaction the employees have in their jobs right from the operator level.

One of the critical skills for the SEP due to the nature of the equipment they have is the technical skill that requires continuous enhancement to ensure that the artisans are up to date with current changes. Generally in South Africa there is a large shortage of artisans in the country therefore organisations are doing everything they can to retain them some by offering out of the market wages or salaries. The SEP is also affected by the level of the turnover of technical people because of the high demand for their skills.

The SEP has initiated the task team concept as a result of the very low level of skills among the trade people in the organisation. There has always been a problem where breakdowns are extended because of the low level of knowledge on the type of machine available in the plant. A breakdown that should take five minutes to fix sometimes takes up to about thirty to forty minutes as artisans are not well equipped in fault-finding skills and as a result productivity suffers. Fault-finding is not skill that can be learnt at school but continuous practice using fault-finding techniques enhances fault-finding skills.

The other aim for the task team is to teach the trades people how to use the continuous improvements technique to increase productivity performance at the SEP. During the duration of the programme when the trades-people are in the task team they are required to identify constraint machines in conjunction with the production teams. Through this process they are taken through the practical way of conducting root cause analysis when dealing with breakdowns. From the task team the artisans are also trained on how to open an A3 project for continuous improvement in order to resolve issues that affect the productivity performance of the plant.
The operators are trained in FPS principles like autonomous maintenance and 5S as the basic training in understanding the machines they operate. They are also trained in problem-solving tools like the failure analysis reports (FAR) for permanent resolution of the machine breakdowns. The basic pillar for the FPS process is the work group concept for all aspects of the business and in these work groups the continuous improvement process are being used.

3.6 SUMMARY

In this chapter there is a clear demonstration that by introducing the FPS in Ford Motor Company is making sure that lean manufacturing is the way of life. This has been demonstrated recently by the current Ford CEO, Mr Allan Mullaly, driving the lean principles through the One Ford One Plan One Goal strategy where through consolidated effort all employees in the organisation have one goal. That One Goal is “to build products that the customers want”.

One of the key elements of FPS is FTPM with its key objective being to improve the productivity of the plant by making sure that there are high levels of plant overall equipment effectiveness through small group activities, early equipment management, training in operation and maintenance, planned maintenance and equipment effectiveness. The other objective of FTPM is to improve availability, performance efficiency and quality from the plant facility.

Ford utilises the Supplier Engagement manual which is intended to define the internal Ford process for working with the supply base to launch quality parts. Advanced Product Quality Planning (APQP) is the tool by which external suppliers perform planning in accordance with the Ford Customer Specific requirements. APQP/PPAP Readiness Assessment reporting is a requirement for all external suppliers to Ford Motor Company. The G8D process that is used internally within Ford for permanent corrective actions regarding external customer concerns has also been extended to the suppliers to help them resolve quality problems encountered in Ford plants.

Internally the DCP and QOS are also used by small work group teams to measure and drive quality issues in the plant. The use of continuous improvements initiatives like green belt projects, six sigma black belt projects and A3 projects to improve quality has
contributed towards productivity improvements at the SEP. The SEP also demonstrated the importance of material scheduling and availability to ensure high levels of productivity.

The next chapter will outline research methodology to be followed in conducting the study in an attempt to address the problems as outlined in Chapter One.
CHAPTER FOUR

RESEARCH DESIGN AND METHODOLOGY

4.1 INTRODUCTION

In Chapter Two the researcher discussed the theory on productivity highlighting the internal and the external factors that impact on productivity improvements. The third chapter linked the systems and process used at the Ford Motor Company to the elements discussed in Chapter Two. This chapter will describe the research method that will be followed in conducting the empirical study. The discussion will consist of the research design, research paradigm, sampling, data collection, validity and reliability measures implemented.

The research problem has already been mentioned in Chapter One: **What are the factors that limit productivity improvements at the Ford Struandale Engine Plant?**

The primary objective is to identify factors impacting on productivity performance at the Ford Struandale Engine Plant and what can the plant do to improve.

In order for the primary objective to be resolved the following secondary objectives have to be investigated:

I. What is the importance of productivity in the manufacturing industry for long-term survival?

II. What is the impact of Overall Equipment Effectiveness on the organisation’s productivity improvements with regards to availability, performance efficiency and quality rate?

III. What is the impact of other limiting factors like material handling and skills level on the productivity improvements?

IV. What is the impact of Overall Equipment Effectiveness on the Ford Struandale Engine Plant’s current productivity performance with regards to availability, performance efficiency and quality rate?

V. What is the impact of material availability has on the Ford Struandale Engine Plant’s productivity improvements?

VI. What level of skills are required for such processes?
The above secondary objectives were discussed in the second and third chapters, Chapter Two describing the importance of productivity. OEE with its elements as productivity measure was also discussed in Chapter two, and the impact of material availability and the skills levels required for these systems.

In Chapter three the secondary objectives number four to six were dealt with, by discussing the impact on Ford Production Systems (FPS) in implementing FTPM processes for the improvement of productivity.

4.2. RESEARCH DESIGN

According to Leedy and Ormrod (2001:91) research design is the complete strategy of attack on the central research problem. It provides the overall structure for the procedure that the researcher follows, the data that the researcher collects and the data analyses that the researcher conducts. A research design is a set of logical procedures that, if followed, enables one to obtain the evidence to determine the degree to which one is right or wrong (Labovitz & Hagedorn, 1981:42).

Research design is the “science (and art) of planning procedures for conducting studies so as to get the most valid findings” (Vogt, 1993:196). Research design provides a detailed plan which is used as a guide and focuses the research (Collis & Hussey, 2003:113).

4.3 RESEARCH METHODOLOGY

According to Leedy (1997:3), research is “the systematic process of collecting and analysing data in order to increase our understanding of the phenomenon with which we are concerned or interested.”

Rozakis (1999:3) agrees that research is the gathering and presenting of reliable information. The research paper is the medium used to communicate this research, that is, it argues the thesis. Rozakis (1999:4) states that research is an analytical way of arguing a point using facts, details, examples and opinions as support.

According to Leedy and Ormrod(2001:100), many researchers tend to categorise research studies into two broad categories, namely quantitative research and qualitative research.
4.3.1 Qualitative Research

Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that makes the world visible. These practices turn the world into a series of representations including field notes, interviews, conversations, photographs, recording and memos to the self. It involves an interpretive, naturalistic approach to the world. This means that qualitative research studies elements in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them (Denzin & Lincoln, 2000:3).

There is importance to recognise that there is no single, accepted way of doing qualitative research. The qualitative method investigates the why and how of decision-making, not just what, where, when. Hence, smaller but focused samples are more often needed, rather than large samples. The data collection methods usually involve close contact between the researcher and the research participants, which are interactive and developmental and allow for emergent issues to be explored (Ritchie & Lewis, 2003:3).

4.3.2 Quantitative Research

Quantitative research is used to answer questions about relationships among measured variables with the purpose of explaining, predicting and controlling phenomena. This approach is sometimes called the traditional, experimental or positivist approach (Leedy & Ormrod, 2001:101).

The quantitative researchers usually start with a specific hypothesis to be tested. They separate and isolate the variables they want to study, control for extraneous variables, use a standardised procedure to collect some form of numerical data and use statistical procedure to analyse and draw conclusion from the data. Quantitative research usually ends with confirmation or disconfirmation of the hypotheses that were tested (Leedy & Ormrod, 2001:101).

4.3.3 Distinction between Qualitative and Quantitative approaches

There are distinguishing characteristics of the quantitative and qualitative research approaches which can clearly be demonstrated by means of a table (See table 4.1).
In qualitative research cases can be selected purposefully, according to whether or not they typify certain characteristics or contextual locations (Becker, 1996:53). The quantitative research refers to the systematic empirical investigation of quantitative properties and phenomena and their relationship (Hunter & Erin, 2008:290). Qualitative means an inquiry process of understanding based on distinct methodology traditions of inquiry exploring a social or human problem. The research builds a complex, holistic picture, analyses words, reports a detailed view of informants, and conducts the study in a natural setting (Creswell, 2003).

On the other hand, quantitative research is used to test the hypotheses and some consider the quantitative method to provide more representation, reliable and precise measures through focused hypotheses, measurement tools and applied mathematics (http://en.wikipedia.org/wiki/Quantitative_research). Qualitative research may use different approaches in collecting data, such as the grounded theory practice, narratology, storytelling, classical ethnography or shadowing. These methods are also loosely presented in other methodological approaches, such as action research or actor-network theory (http://en.wikipedia.org/wiki/Qualitative_research).

According to Leedy and Ormrod (2001:103), the distinction between quantitative and qualitative research does not necessary imply that these approaches are mutually exclusive or that a researcher must use one or the other for a particular study. It is acceptable for the researcher to combine certain elements of both approaches.

Also important to note that there is a range of flexibility among the methods used in both quantitative and qualitative research and the flexibility is not an indication of how scientifically rigorous a method is. Rather the degree of flexibility reflects the kind of understanding of the problem that is being pursued using the method. Since this research endeavours to understand the underlying factors the affect productivity improvements at the Ford Struandale Engine Plant (FSEP), the study will be conducted in an attempt to find out what can be done to improve productivity.
Table 4.1: Comparison of quantitative and qualitative research approaches

<table>
<thead>
<tr>
<th>Quantitative Research</th>
<th>Qualitative Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Seeks to confirm hypotheses about phenomena</td>
<td>• Seeks to explore phenomena</td>
</tr>
<tr>
<td>• Instrument uses more rigid style of eliciting and categorising responses to questions</td>
<td>• Instruments used more flexible, iterative style of eliciting and categorising responses to questions.</td>
</tr>
<tr>
<td>• To quantify variation</td>
<td>• To describe variation</td>
</tr>
<tr>
<td>• To predict causal relationships</td>
<td>• To describe and explain relationship</td>
</tr>
<tr>
<td>• To describe characteristics of a population</td>
<td>• To describe individual experience</td>
</tr>
<tr>
<td>• Closed-ended questions</td>
<td>• To describe group norms</td>
</tr>
<tr>
<td>• Assign numerical values to responses</td>
<td>• Open-ended</td>
</tr>
<tr>
<td>• Study design is stable from beginning to end</td>
<td>• Textual</td>
</tr>
<tr>
<td>• Participant responses do not influence or determine how and which questions researchers ask next</td>
<td>• Some aspects of the study are flexible</td>
</tr>
<tr>
<td>• Study design is subject to statistical assumptions and conditions</td>
<td>• Participant responses affects how and which questions researcher ask next</td>
</tr>
<tr>
<td></td>
<td>• Study design is iterative, that is data collection and research questions are adjusted according to what is learned</td>
</tr>
</tbody>
</table>


### 4.4 RESEARCH METHODS FOR THIS STUDY

In conducting the study the researcher tried to ensure that the primary problem and the secondary problems highlighted earlier in the first chapter are answered satisfactorily. This was done through a literature study from books, journals and the Internet. The rest of the study was based on the literature from Ford’s internal processes like policies, work instruction, quality operating systems, production operating systems, local intranet and the various reports generated within the organisation.
4.4.1 Literature study
The literature study conducted was discussed in Chapter Two, revealing factors that limit productivity improvements FSEP. It was also revealed how OEE as the productivity measure, material availability and skills level impact on productivity improvements in a manufacturing organisation.

This literature was further tested in Chapter Three by the study that was conducted in FSEP on the processes used by the company to improve productivity. In that chapter the FSEP literature revealed that the plant uses OEE through FTPM internal policies, processes and procedures, systems like quality operating systems and production operating systems, as well as management reports as productivity improvement measures for the plant.

4.4.2 Empirical Study
The empirical study was conducted in the form of questionnaires that were distributed among a sample of employees working in production areas. The questionnaires were distributed to five managers, five production/quality engineers, 23 production team leaders, nine production coordinators/IMTs and three electronic specialists.

Section A of the questionnaire is the biographical information of the sample study and section B addresses the importance of productivity performances. Then in section C, D, E, F and G the research is directed at the participant’s understanding of the effectiveness of productivity measurement systems being used within FSEP. The understanding of the level of alignment with FSEP to the academic literature discussed in Chapter Two is also dealt with. Sections H and I seek to address material availability issues and skills levels respectively as factors that also limit productivity improvements. And the last section asks open-ended questions from the participants on the issues that they think need to be addressed to improve productivity at FSEP.

4.4.3 Sample design
A sample is a finite part of a statistical population whose properties are studied to gain information about the whole (Webster, 1995). A population is a group of individual persons, objects, or items from which samples are taken for measurement. Sampling is the act, process, or technique of selecting a suitable, or a representative part of the
population for the purpose of determining parameters or characteristics of the whole population. Successful statistical practice is based on focused problem definition.

Sampling may be more or less appropriate in different situations and can fall into two major categories. These are probability sampling and non-probability sampling. One of the most important purposes of using sampling is to draw conclusions about the population from samples and use inferential statistics which enable the researcher to determine the population’s characteristics by directly observing only a portion of the population. Because there is very rarely enough time or money to gather information from everyone or everything in a population, the goal becomes finding a representative sample (or subset) of that population (http://en.wikipedia.org/wiki/Sampling). A sample may provide the researcher with the needed information quickly.

The researcher in this particular study will use two types of purposeful sampling: stratified and snowball sampling. Stratified purposeful sampling illustrates the characteristics of particular subgroups of interest and facilitates comparison between the different groups. Snowball or chain sampling is particularly the one that indentifies cases of interest from people who know what case are information rich, that is good example for study, good interview subjects (Patton,1990 :169).

The sample to be used for the study will only come from the middle management, junior management and the first line supervision. The stratified sampling in this study will be used as sampling that consists of the management team, production coordinators/IMTs, production team leaders and electronic specialists). The population will consist of five managers, nine production coordinators/IMTs, 23 team leaders, three electronic specialists and five production-quality engineers.

4.4.4 Data collection design

There will always be a combination of quantitative or qualitative inputs into one’s data generating activities. The balance depends on one’s analytical requirements and the overall purpose of the research. Quantitative and qualitative approaches to data collection present a collection of both advantages and disadvantages. A main advantage of a quantitative approach to data collection is the relative ease and speed with which the research can be conducted (Collis & Hussey, 2003:162). The research instrument
that was used in the study was the questionnaire. The use of the questionnaire is best served when conducting descriptive or analytical research (Saunders et al, 2000:279). The questionnaire was the sole data collection method for the research findings.

The data for the study will target only the Ford Motor Company Struandale Engine Plant personnel. The research will target the leadership team in the manufacturing areas as they have direct influence on the productivity performance levels in their production lines. The primary data was collected by formatting according to the five-point Likert Scale ranging from (1) Strongly Disagree to (5) Strongly Agree and the questionnaires will include the combination of quantitative and qualitative approach. Secondary data was obtained from a number of different sources within the plant and various literature sources.

I. Questionnaires
A questionnaire is a series of questions asked to individuals to obtain statistical useful information about a given topic. Leedy and Ormrod (2001:202) suggest that clear instructions must be provided and this should be achieved by communicating exactly how the researcher wants the respondents to respond. To make sure that this is achieved, a pilot study must take place, as this will highlight items that are difficult to understand.

The questionnaire developed for this research was simple and easy to understand by the respondents. Close-ended questions with a five-point scale were utilised. The most appropriate box was ticked by the research respondent and a theoretical lean manufacturing model was attached to the questionnaire as a visual aid to eliminate any confusion when answering the questionnaire (Annexure 1 shows the complete questionnaire). The questionnaires are developed to answer the secondary problem that has not been satisfactorily answered by the literature study.

II. Questionnaire Design
Collis and Hussey (2003:177) reason that questionnaires rely heavily on the type of questions asked for extracting the primary research data. Consequently it is of vital importance that the questions are structured correctly in order to elicit the responses needed for the investigation.
The questions in section A address biographical information of the sample and section B addresses the main objective on productivity then in sections C, D, E, F and G the questionnaires are directed at the secondary objective. Sections H and I seek to address material availability issues and skills levels respectively as the factors that also limit productivity improvements. And the last section asks open-ended questions from the participants on the issues that they think need to be addressed to improve productivity improvements at FSEP.

In sections C to I the respondents were required to indicate a degree of agreement or disagreement with each of the five scale points below.

The five scale points were labelled as follows.
1. Strongly agree
2. Agree
3. Uncertain
4. Disagree
5. Strongly disagree.

In compiling the statements for the questionnaire the researcher kept the following criteria in mind:
- To use short simple statements;
- To be as objective as possible in the evaluation of the results;
- To use a variety of statements under each heading or each section in order to improve consistency and accuracy of evaluation and
- To ask open-ended questions in section J to give respondents an opportunity to voice their opinions.

III. Questionnaire cover letter

The covering letter and accompanying questionnaire (annexure A) are the assurance from the researcher to the respondent that the content of the questionnaire would be treated with the utmost confidence and that there would not be any form or way of sharing the information supplied by the respondent without his or her consent as indicated in annexure A. The covering letter was sent out attached to the questionnaire to the participants at the Ford Struandale Engine Plant.
4.4.5 Data analysis

Data analysis is a process of gathering and transforming data with the objective of highlighting useful information, coming up with conclusions and supporting decision-making. Data analysis has multiple facets and approaches, encompassing diverse techniques under a variety of names, in different business, science and social science domains.

Data analysis is more than number crunching. It is an activity that permeates all stages of a study. Concern with analysis should (1) begin during the design of a study, (2) continue as detailed plans are made to collect data in different forms, (3) become the focus of attention after data are collected, and (4) be completed only during the report writing and reviewing stages (Collis & Hussey, 2003:165).

The basic hypothesis of this paper is that successful data analysis, whether quantitative or qualitative, requires (1) understanding a variety of data analysis methods, (2) planning data analysis early in a project and making revisions in the plan as the work develops; (3) understanding which methods will best answer the study questions posed, given the data that have been collected; and (4) once the analysis is finished, recognising how weaknesses in the data analysis affect the conclusions that can properly be drawn. The study questions govern the overall analysis.

But the form and quality of the data determine what analyses can be performed and what can be inferred from them. The data collected by the questionnaires will be analysed using histograms, pie charts and tables generated from Excel Spreadsheet.

4.4.6 Validity and Reliability

According to Leedy and Ormrod (2001:103), validity encompasses the entire experimental concept and establishes whether the results obtained meet all of the requirements of the scientific research method. There must have been randomisation of the sample groups and appropriate care and diligence shown in the allocation of controls.

- Internal validity –This dictates how an experiment design is structured and encompasses all of the steps of the scientific research method. Even if results are
good, sloppy and inconsistent design will compromise integrity in the eyes of the scientific community. Internal validity is at the core of any experimental design.

- **External validity** – This is the process of examining the results and questions whether there are any other possibly causal relationships. Control groups and randomisation will lessen external validity problems but no method can be completely successful. This is why the statistical proofs of hypothesis are called significant not absolute truth. Any science research design only puts forward a possible cause for the studied effect. There is always a chance that another unknown factor contributes to the results and findings.

Leedy and Ormrod (2001:99) confirm the idea behind reliability is that any significant results must be more than one-off finding and be inherently repeatable. Other researchers must be able to perform exactly the same experiment under the same conditions and generate the same results. This will reinforce the finding and ensure that the wider scientific community will accept the hypothesis. Without this replication of statistically significant results, the experiment and research have not fulfilled all of the requirements of testability. This prerequisite is essential to a hypothesis establishing itself as an acceptable scientific truth.

**4.6 SUMMARY**

In this chapter the research methodology being followed for this research was described in depth. This chapter laid the framework for the study and documented all the steps followed in this study.

The data collected by means of questionnaires will be analysed using deductive analysis and discussed in greater detail in Chapter Five.
CHAPTER FIVE

EMPERICAL STUDY RESULTS ANALYSIS AND DISCUSSIONS

5.1 INTRODUCTION

In Chapter Four the researcher explained the different ways that have been used to conduct research, starting with a literature study, the Ford Motor Company literature and the empirical study that was conducted to determine the views of the internal employees on productivity in the company. A set of questionnaires was distributed to the leadership and maintenance team consisting of 45 people to test their feelings about productivity levels in the company. In this chapter the results of the survey will be consolidated and presented as follows:

Section A: The demographic information of the study
Section B: Productivity
Section C: Overall Equipment Effectiveness
Section D: Availability
Section E: Performance Efficiency
Section F: Quality
Section G: Total Productive Maintenance
Section H: Material availability
Section I: Skills

This is followed by open-ended questions integrating all other information from the literature study and the information acquired from the FPS systems and processes.

5.2 RESPONSE RATE

The respondents that participated in the research were employees from the Ford Struandale Engine Plant located in Port Elizabeth, South Africa. There are two key areas this section will focus on, namely the response rate and the results of the questions from the sample used in the study.

The sample group that was given questionnaires consisted of 45 members and only 36 were returned which amount to 80 per cent of the total questionnaires distributed. Below is the graphical representation of the response rate:
The response rate to the total sample of questionnaires that were distributed to the various leadership members at the Ford Struandale Engine Plant was 80 percent of the total sample. All levels responded well to questionnaires except the electronics specialists where there is not a single response with the excuse that they had been attending electronic training for the new machines they were busy installing. Below is a table (Table 5.1) that shows the level of response for each position:

### Table 5.1: Response rate by position

<table>
<thead>
<tr>
<th></th>
<th>Number of Responses</th>
<th>Number of responses by the position in the company</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Manager</td>
</tr>
<tr>
<td>Issued</td>
<td>45</td>
<td>6</td>
</tr>
<tr>
<td>Received</td>
<td>36</td>
<td>6</td>
</tr>
<tr>
<td>Outstanding</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td><strong>Percentage</strong></td>
<td><strong>80%</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

### 5.3 BIOGRAPHICAL ANALYSIS

#### 5.3.1 Questionnaires

The questionnaires for the empirical study consist of ten sections with Section A the biographical information for the sample used at the Ford Struandale Engine Plant. This
information concerns the gender, age, position in the company, highest qualification and years of service of each other respondent.

The next set of questions from Sections B to I are designed on the Likert Scale model and cover productivity, OEE, availability, performance efficiency, quality rate, TPM, material availability and skills level. Section I contains open-ended questions whereby the respondents were asked their own opinion on how the Ford Struandale Engine Plant can improve Sections B, D, G, F, H and I. In order to analyse the Likert-Scaled response a decision was taken to group all the “strongly agree” and “agree” responses together. The same was done with the “strongly disagree” and “disagree” data.

5.3.2 Biographical Information

The biographical information in this section is represented in the form of a chart depicting the gender, age, current position, highest qualification and the number of years the respondents has been working for the company.

Table 5.2: Biographical Information

<table>
<thead>
<tr>
<th>What is your gender?</th>
<th>Number of responses</th>
<th>Percentage of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>29</td>
<td>81%</td>
</tr>
<tr>
<td>Female</td>
<td>7</td>
<td>19%</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What is your age?</th>
<th>Number of responses</th>
<th>Percentage of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 - 39 years</td>
<td>30</td>
<td>56%</td>
</tr>
<tr>
<td>40 + years</td>
<td>16</td>
<td>46%</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What is your position?</th>
<th>Number of responses</th>
<th>Percentage of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manager</td>
<td>6</td>
<td>17.00%</td>
</tr>
<tr>
<td>IMT</td>
<td>5</td>
<td>14%</td>
</tr>
<tr>
<td>Production - Quality Eng.</td>
<td>5</td>
<td>14%</td>
</tr>
<tr>
<td>Electronic Specialist</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Production Team Leader</td>
<td>20</td>
<td>56%</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What is your highest qualification?</th>
<th>Number of responses</th>
<th>Percentage of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>High school</td>
<td>6</td>
<td>17%</td>
</tr>
<tr>
<td>Diploma</td>
<td>25</td>
<td>70%</td>
</tr>
<tr>
<td>Degree</td>
<td>5</td>
<td>14%</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year of Service at Ford</th>
<th>Number of responses</th>
<th>Percentage of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The table shows that 81 percent of the respondents were males and only 19 percent were female respondents. This is an indication that there is still a high domination of male employees at the Ford Struandale Engine Plant, with a gender ratio of four to one.

There is also a high level of maturity in the group of respondents selected for the study. All of the respondents were older than thirty and the majority are between 30 and 39 years of age. Normally at the age of 30 and above people are starting to settle in their career choices with little desire to move around as many of them at this age are already married (Campbell, 2007:1).

The questionnaires for the positions show a 100 percent response rate from the manager group and that accounts for 17 percent of the total responses. The IMT response rate is 63 percent and accounts for 14 percent of the total response. The production/quality engineers’ 100 percent response rate represents 14 percent of the total response, whereas the production team leaders had an 87 percent response rate and make up 56 percent of the total response rate. The electronic specialists had a zero percent response rate since they did not have enough time to complete the questionnaires owing to training.

The majority of the respondents hold diplomas and degrees, accounting for 70 percent and 14 percent respectively. This is as result of the internal individual development plan process used in the company to encourage leaders to develop themselves. But there are still 17 percent from this group whose highest level of education and training is high school and this is something to which the company needs to pay attention.

All the respondents in this section have been with the company for more than five years and this re-affirms the level of experience the respondents have in terms of the company processes and procedures. This also demonstrates the ability of the
respondents to respond to the questionnaires with high level of confidence as they are aware of all the programmes involved in the company.

5.3.3 Section B – Productivity

In the productivity section the questions are directed to the respondents in order to test the respondents’ understanding of productivity levels in their areas. The questionnaires were structured to highlight the understanding of productivity performance measurements in the areas. The questions also check the understanding of the factors that affect productivity performance in the plant. The table below (5.3) depicts the respondents understanding of productivity in their areas:

Table 5.3: Section A - Productivity

<table>
<thead>
<tr>
<th>Number</th>
<th>STATEMENT</th>
<th>Strongly agree/Agree</th>
<th>Uncertain</th>
<th>Strongly disagree/Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>In the company productivity performance levels are viewed as one of the most important measurables.</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>Productivity performance data is collected and trended daily.</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>3</td>
<td>We all know and understand our company productivity performance in comparison to the best in the world.</td>
<td>89%</td>
<td>3%</td>
<td>8%</td>
</tr>
<tr>
<td>4</td>
<td>I am aware of the productivity operating system introduced by the company to improve productivity in the company.</td>
<td>92%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>5</td>
<td>Productivity levels are discussed and communicated to all levels of the organisation.</td>
<td>83%</td>
<td>8.33%</td>
<td>8.33%</td>
</tr>
<tr>
<td>6</td>
<td>We all know and understand factor that affect productivity performance both internal and external.</td>
<td>89%</td>
<td>5.50%</td>
<td>5.50%</td>
</tr>
<tr>
<td>7</td>
<td>Productivity losses are identified and root causes analyses conducted for corrective actions in all departments.</td>
<td>92%</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>8</td>
<td>Equipment effectiveness is one of the most important factors that affect productivity improvements in the plant.</td>
<td>92%</td>
<td>5%</td>
<td>3%</td>
</tr>
</tbody>
</table>

Below is the detailed graphical analysis of the responses:
Looking at the chart, it appears that 100 percent of the respondents are aware of the productivity levels in the plant and agree that productivity performance data is collected and trended daily. About 92 percent of the respondents are aware of the productivity operating system introduced by the company to improve productivity in the plant. In addition, 92 percent of the respondents also know production losses that are identified for corrective measures.

Furthermore 92 percent of the respondents believe that equipment effectiveness is one of the most important factors that affect productivity improvements. There seem to be some concerns on the part of some 8 percent of the respondents about effective communication of the productivity level in the plant. Also 5 percent of the respondents are uncertain about the existence of the productivity operating systems and 5 percent are uncertain whether they know and understand factors that affect productivity performance.

The majority of the team leaders (92 percent) agree as to whether they know the productivity performance in comparison to the best in the world and whether productivity levels are discussed and communicated to all levels of the organisation. About 8 percent of the respondents disagree with these statements. The respondents also disagree (5 percent) with both the statements that all understand factors that affect
productivity performance and productivity losses are identified and root causes analysed for corrective actions.

The significant reason for this is the fact that although the company’s intention and objective is to make sure that positive progress made in the company is communicated throughout the company, there is a feeling from the team leader level that this is not happening as it should happen. Also team-leaders believe that even though the company has processes and systems in place as stipulated in the FPS to identify productivity losses and conduct root cause analysis to resolve them, this is not happening owing to a lack of discipline.

5.3.4 Section C - Overall Equipment Effectiveness

In this section of the questionnaire on OEE the understanding and the knowledge of the respondents on the subject and how engaged are they in the subject is reflected.

Table 5.4 below demonstrates the respondents, knowledge of and their involvement in the elements of OEE in their area:

Table 5.4: Overall Equipment Effectiveness

<table>
<thead>
<tr>
<th>Number</th>
<th>STATEMENT</th>
<th>Strongly agree/ Agree</th>
<th>Uncertain</th>
<th>Strongly disagree/ Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I know what the daily OEE rate is for my department by 14h30.</td>
<td>55.50%</td>
<td>30.50%</td>
<td>14%</td>
</tr>
<tr>
<td>2</td>
<td>The company uses small group activities to improve equipment effectiveness from all production areas.</td>
<td>80.50%</td>
<td>14%</td>
<td>5.50%</td>
</tr>
<tr>
<td>3</td>
<td>In the company losses are identified and corrective measures are implemented resulting in productivity improvements.</td>
<td>89%</td>
<td>8%</td>
<td>3%</td>
</tr>
<tr>
<td>4</td>
<td>Employees in the company understand that a high level of OEE has a positive impact on the productivity performance of the company.</td>
<td>89%</td>
<td>5.50%</td>
<td>5.50%</td>
</tr>
<tr>
<td>5</td>
<td>Plant leadership respond quickly to OEE issues that affect productivity improvements.</td>
<td>75%</td>
<td>16.67</td>
<td>8.33%</td>
</tr>
<tr>
<td>6</td>
<td>All OEE improvement actions implemented in the company are directed at improving productivity performance of the plant</td>
<td>92%</td>
<td>8%</td>
<td>0%</td>
</tr>
</tbody>
</table>

This table is converted to a form of graphic representation and discusses in greater depth in chart 5.2 below:
In this section chart 5.1 shows that 92 percent of the respondents understand that OEE improvement actions implemented in the company are directed at improving productivity. The same chart shows that the 89 percent of the respondents agree that OEE losses are identified and corrective actions taken. The chart also shows that 89 percent of the respondents understand that high levels of OEE make positive contribution to the productivity improvements in the company. About 80 percent of the respondents agree that the company uses small group activities to improve productivity.

Only 75 percent of the respondents agree with the statement that plant leadership quickly respond to OEE issues. About 25 percent of the respondents believe leadership response to OEE issues is not as quick as it is expected to be or are uncertain about leadership response. Only 55 percent of the respondents know their daily OEE performance just after the end of their shift. This is an indication that 45 percent of the respondents do not know the OEE levels at the end of their shift. These are mostly the team leaders and managers owing to the fact that there is no real time measurement process for OEE in the company. The process of measuring OEE in the company is manual and the time to respond to the OEE issues is very long, resulting in a delay in issuing resolutions.

5.3.5 Section D: Availability

In this section the questionnaires are designed to understand the machine availability and the contributing factors to machine availability. It also tests whether appropriate
actions are taken to reduce all types of down time. The table below (5.5) depicts the knowledge of the respondents on the availability levels in their areas:

**Table 5.5 Section D - Availability**

<table>
<thead>
<tr>
<th>Number</th>
<th>STATEMENT</th>
<th>Strongly agree/ Agree</th>
<th>Uncertain</th>
<th>Strongly disagree/ Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I know the availability percentage for my area by 16h00.</td>
<td>66.67%</td>
<td>16.67%</td>
<td>16.67%</td>
</tr>
<tr>
<td>2</td>
<td>The company measures machine availability and takes corrective actions to improve productivity.</td>
<td>80.56%</td>
<td>14%</td>
<td>5.5%</td>
</tr>
<tr>
<td>3</td>
<td>All unscheduled downtime is recorded and there are plans to reduce it.</td>
<td>92%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>4</td>
<td>There is a change over process set for all equipments where change over is conducted and there is an improvement process in place.</td>
<td>86%</td>
<td>11%</td>
<td>3%</td>
</tr>
<tr>
<td>5</td>
<td>The plant records and trends tooling down time.</td>
<td>94%</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>6</td>
<td>All setting and adjusting downtime is recorded and trended for corrective actions.</td>
<td>80.50%</td>
<td>11%</td>
<td>8%</td>
</tr>
<tr>
<td>7</td>
<td>There is a unique process used by the company to permanently eliminate machine breakdowns.</td>
<td>63.89%</td>
<td>22.22%</td>
<td>13.89%</td>
</tr>
<tr>
<td>8</td>
<td>The company records and trends total machine breakdown and the time taken to repair the machine.</td>
<td>80.50%</td>
<td>13.89%</td>
<td>5.56%</td>
</tr>
</tbody>
</table>

Below is the detailed graphical analysis of the responses:

**Chart 5.4: Section D - Availability**

Chart 5.3 shows the respondents’ understanding of machine availability and the different types of downtimes contributing to machine availability. The chart shows that 94 percent of the respondents understand that tooling down time is recorded and trended. Also 92 percent of the respondents agree that unscheduled down time is
recorded and plans put in place to reduce downtime. The chart also indicates that 86 percent of the respondents understand that the company has a changeover process in place for all equipments where changeover is conducted. It indicates that the 80.5 percent of the respondents know that all setting and adjustment downtime is collected and trended.

About 33 percent of the respondents, the majority being the team leaders, disagree or are uncertain that they know the level of availability of their areas at 16h00. This also includes managers and 32 percent are uncertain of or disagree about having knowledge about the unique process used by the company to permanently eliminate machine breakdown. Some feel that similar breakdowns keep coming up and are not permanently resolved.

The company is in the process of resolving maintenance issues permanently. An FAR process is used but in some areas of the company this is just seen as a paper-exercise and not as a tool to resolve issues that the process or system is in place but is not followed properly.

5.3.6 Section E – Performance Efficiency

During the theory research it was discovered that losses which cannot be documented belong in the All Other Idling & Minor Stoppages category and are classified as Performance Efficiency losses. In this section the questionnaire was designed to test the understanding of the respondents on the performance efficiency in their areas. Table 5.6 below shows the respondents’ view on performance efficiency: (http://www.fps.ford.com/learningeventslearningbew.html).

Table 5.6: Section E – Performance Efficiency

<table>
<thead>
<tr>
<th>Number</th>
<th>STATEMENT</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Strongly disagree/ Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>In my area idling and minor stoppages are measured and trended for every shift.</td>
<td>77.78%</td>
<td>11.11%</td>
<td>11.11%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>The company uses POS as a tool to understand and reduce minor stoppages.</td>
<td>52.78%</td>
<td>33.33%</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>The company uses a process confirmation process to review machine cycle time to improve performance efficiency.</td>
<td>86.11%</td>
<td>8.33%</td>
<td>5.56%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>In my area start-up losses are measured and improvement plans are developed to reduce start-up losses.</td>
<td>77.78%</td>
<td>11.11%</td>
<td>11.11%</td>
<td></td>
</tr>
</tbody>
</table>
In our area we periodically review the machine speed and make sure they are running at the design speed. 

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>In our area we periodically review the machine speed and make sure they are running at the design speed.</td>
<td>80.56</td>
</tr>
<tr>
<td>6</td>
<td>In my area we periodically review the idling and minor stoppages.</td>
<td>69%</td>
</tr>
</tbody>
</table>

Below is the detailed graphical analysis of the responses:

*Chart 5.5: Section E – Performance Efficiency*

![Performance Efficiency Chart](image)

In this section 86 percent of the respondents agree that the company uses process confirmation process to review machine cycletime to improve performance efficiency. Also 80 percent of the respondents agree that machine speed is reviewed periodically and 77 percent agree that idling and minor stoppages are measured and trended for every shift.

There is also a level of uncertainty amongst the respondents where 33 percent and 17 percent of the respondents respectively do not know the use of the POS system to improve performance efficiency. This is as a result of management failure to popularise POS amongst the team members. And 14 percent of respondents disagree with the statement that idling and minor stoppages are reviewed periodically because chart 3.4 in Chapter Three shows efficiency on the target line but there are inexplicable efficiency losses to the 100 percent level.

**5.3.7 Section F – Quality**

As indicated in the theory in Chapter Two, quality losses are associated with the production of products that do not meet quality standard. There are two types of quality losses, namely production losses like scrap and rejects or start-up losses. In this section
the researcher is trying to test how much the respondents know about the quality issues in their areas.

**Table 5.7: Section F - Quality**

<table>
<thead>
<tr>
<th>Number</th>
<th>STATEMENT</th>
<th>Strongly agree/ Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Strongly disagree/ Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All areas in the company measure quality rate and take corrective actions.</td>
<td>97%</td>
<td>0%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>The company uses Quality Operating Systems to track all quality issues in their areas.</td>
<td>97%</td>
<td>3%</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>When customer quality problems are measured in the company there is a process in place to resolve the issues.</td>
<td>83%</td>
<td>0%</td>
<td>17%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>In my area all start-up losses are recorded and trended for corrective actions.</td>
<td>75%</td>
<td>14%</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>All scrap and rejects in my area are recorded and trended.</td>
<td>92%</td>
<td>6%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>I know that the company reduces early supplier quality losses through early supplier involvement during product launch.</td>
<td>80%</td>
<td>17%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>I am aware of the customer problems in my area.</td>
<td>94%</td>
<td>6%</td>
<td>0%</td>
<td></td>
</tr>
</tbody>
</table>

Below is the detailed graphical analysis of the responses:

**Chart 5.6: Section F – Quality**

Most of the respondents in this section, an average percent of 88 percent, are in agreement with the statement that most of the measures to control quality levels are in place. There is a 14 percent uncertainty and 11 percent disagreement about the existence of these measures or processes except the statement that the start-up losses are recorded and trended.
This is as a result of a lack of discipline where the process is clear the after every start-
up or machine set-up the machine setter is required to check the quality of the first five
parts and record them on the operator hourly sheet. This does not always happen where
it supposed to happen, resulting in defective parts sent through to the next process.
There are also 17 percent of the respondents who disagree that customer quality
problems are measured and there is process in place to resolve them. Currently the
company has containment procedures in place. However, and the teams are not adhering
to these procedures and as a result quality issues are transferred to the customers.
Another reason is that there are repetitive customer quality issues picked up at the
assembly line from the machining lines.

5.3.8 Section G – Total Productive Maintenance

TPM is a critical adjunct to lean manufacturing. If machine uptime is not predictable
and if process capability is not sustained, the process must keep extra stocks to buffer
against this uncertainty and flow-through the process will be interrupted. The table
below is meant to test the understanding by the respondents of the TPM processes
implemented in their areas.

Table 5.8: Total Productive Maintenance

<table>
<thead>
<tr>
<th>Number</th>
<th>STATEMENT</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Strongly disagree/ Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>There is a 5s standard implemented in all the production areas throughout the plant.</td>
<td>97%</td>
<td>3%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Maintenance Operating System has been communicated to plant employees.</td>
<td>75%</td>
<td>19%</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Operators conduct daily checks on machinery and equipment they operate.</td>
<td>94%</td>
<td>3%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Maintenance artisans do preventive maintenance checks as per schedule.</td>
<td>77%</td>
<td>17%</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Employees are encouraged to initiate continuous improvement projects.</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Operators are trained to conduct autonomous maintenance on the machines they operate.</td>
<td>94%</td>
<td>6%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Operators do autonomous maintenance on the machines they operate.</td>
<td>92%</td>
<td>8%</td>
<td>0%</td>
<td></td>
</tr>
</tbody>
</table>

Below is the detailed graphical analysis of the responses:
According to the chart above, 100 percent of the respondents strongly agree that management encourages employees to initiate continuous improvement projects. The table also shows that 97 percent of the respondents agree that there is a 5s standard implemented throughout the plant. In addition, 94% of the respondents know that operators conduct daily checks and autonomous maintenance in their areas.

There are also 19 percent of the respondents that are uncertain whether the maintenance operating systems have been communicated to all. This is critical to the improvement of productivity in the organisation as all the Maintenance Operating system (MOS) elements are the pillars of TPM. Therefore the implementation of MOS communication to the employees and the knowledge about MOS would mean that TPM is entrenched in the organisation.

Furthermore, 17 percent are uncertain about the level of maintenance work conducted by the artisans. There are also 6 percent of the respondents who disagree with the same statements. In figure 3.4 it is clear that even though the company does have schedules for planned maintenence, not every area’s artisans adhere 100 percent to the schedule and machine downtime increase.

5.3.9 Section H – Material Availability

Material is one of the most important factors in relation to productivity improvements in any organisation. Lean manufacturing believes in Just In Time, therefore if the company
is using the JIT system for material supply, then it is a key measure in ensuring that machine uptime is always high.

Table 5.8 below depicts a summary of the respondents by question on how they feel about material availability in their work areas:

**Table 5.9: Section H – Material Availability**

<table>
<thead>
<tr>
<th>Number</th>
<th>STATEMENT</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Strongly disagree/ Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Material availability is measured and recorded daily.</td>
<td>89%</td>
<td>8%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>The company has a WIP process in place and the levels for each production area in clearly visible areas for proper control.</td>
<td>81%</td>
<td>19%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>There is always an adequate amount of raw material available to avoid production stoppages.</td>
<td>75%</td>
<td>11%</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>The company has an effective JIT system in place that supports productivity improvements.</td>
<td>62%</td>
<td>19%</td>
<td>19%</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>The daily raw material cycle counts are used in the company to avoid raw material shortages that could lead to production stoppages.</td>
<td>86%</td>
<td>14%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>The plant schedules production according to customer orders.</td>
<td>97%</td>
<td>3%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>The capacity of the plant is aligned to the market demand</td>
<td>86%</td>
<td>14%</td>
<td>0%</td>
<td></td>
</tr>
</tbody>
</table>

This table is converted to a form of graphic representation and discussed in more depth in chart 5.7 below:

**Chart 5.8: Section H – Material Availability**

In the chart above it is clear that the respondents agree 97 percent that the plant schedule production is according to customer orders. It is also evident from the respondents that there is 89 percent response in agreement with the statement that material availability is measured and recorded daily.
About 86 percent of the respondents agree with the statement that the capacity of the plant is continuously aligned to the market demand.

The chart also depicts that about 81 percent of the respondents agree that the company has a WIP process in place and the levels for each production area in clearly visible areas for proper control.

About 75 percent of the respondents agree that there is always adequate amount of raw material available to avoid production stoppages. And 62 percent of the respondents agree that the company has an effective JIT system in place that supports productivity improvements. There are about 19 percent of the respondents who are not certain about the WIP process employed by the company as in some areas the levels of WIP exceed the target levels owing to breakdowns in certain operations. This is sometimes the source of quality problems because people see this as a place to hide their quality problems.

On the other hand, 19 percent of respondents in the company are uncertain and disagree that the JIT process in place supports productivity improvements in the company. There are various reasons for the system to fail: one closer to the line is that the people are not posting the smart cards to call parts from the warehouse as part of the JIT system. The second reason is when the parts have been delayed from the sea freight due to unforeseen circumstances, the scheduling process is not flexible enough to cater for these changes.

Another reason is the shortage of material from the internal machining lines, especially the cylinder blocks and the cylinder heads. This is also as a result of poor performance from these lines as demonstrated in figure 3.3 where of the top ten downtimes in assembly, the numbers one and two highest downtime issues are these two areas.

**5.3.10 Section I – Skills Levels**

There is an importance to recognise the fact that skills development and other investments in human capital comprise only one set of factors necessary for productivity growth. One of the messages of this research is that skills development must be an integral part of broader development strategies if it is to deliver on its substantial potential to contribute to overall productivity and profit growth.
Table 5.9 and chart 5.8 below depict a summary of the respondents’ answers to the question on what they feel Ford has done to take care of all the human factors in design for maintenance:

**Table 5.10: Section I – Skills Availability**

<table>
<thead>
<tr>
<th>Number</th>
<th>STATEMENT</th>
<th>Strongly agree/Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Strongly disagree/Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The company ensures that employees have the necessary skills to perform effectively in their jobs.</td>
<td>88%</td>
<td>6%</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>People with adequate qualifications are appointed in positions where they contribute to the productivity improvements in the company.</td>
<td>53%</td>
<td>25%</td>
<td>22%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>When new technology is introduced employees working with the new equipment are given skills to ensure the equipment continues performing at high levels of productivity.</td>
<td>69%</td>
<td>25%</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>The company pays its employees in line with the skills they acquire.</td>
<td>50%</td>
<td>31%</td>
<td>19%</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>The critical skills like those of artisans are continuously enhanced to ensure that they are up-to-date with changes taking place out there.</td>
<td>42%</td>
<td>33%</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>There is an individual development plan for each employee for the development of their skills.</td>
<td>47%</td>
<td>17%</td>
<td>36%</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Adequately skilled employees can contribute to the productivity improvements in the company.</td>
<td>89%</td>
<td>11%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Employees are adequately trained to do the jobs for which they are appointed.</td>
<td>63%</td>
<td>31%</td>
<td>6%</td>
<td></td>
</tr>
</tbody>
</table>

**Chart 5.9: Section I – Skills Level**

About 88 percent of the respondents agree that company ensures that the employees have the necessary skills to perform effectively in their jobs. By the same token 89
percent of the respondents agree that adequately trained employees can contribute to productivity improvements in the plant.

In addition, 69 percent of the respondents agree with the statement that when new technology is introduced, employees working with the new equipment are given skill to ensure the equipment continues performing at high levels of productivity.

About 63 percent of the respondents agree that the employees are adequately trained to do the jobs for which they are appointed. But only 53 percent respondents agree that people with adequate qualifications are appointed in positions where they contribute to the productivity improvements in the company. When the study was conducted with the trade people with lower levels of qualifications in the organisation, it was discovered that during the initial intake the trade certificate was not a prerequisite. Now that there is a significant need for skills like trouble-shooting and root cause analysis, these people are struggling to fulfil these requirements, resulting in their feeling incompetent to do their jobs.

There is a very low level of agreement from the respondents with the statement that the company pays its employees in line with the skills they acquire: only 50 percent of the respondents are in agreement. There is also about a 42 and 47 percent level of agreement with the statements firstly, that the critical skills like those of the artisans are continuously enhanced to ensure that they are up-to-date with changes taking place out there and secondly, that there is an individual development plan for each employee for the development of their skills.

There is significant evidence that the respondents feel that at Ford artisans skills are not enhanced and that there is no individual development plan for all the employees in the company (http://www.clearconnection.ford.com/en/professional-development/individual-dev-planning/index.htm).

5.3.11 Section J – Respondents’ Opinions

In this section the respondents are given the opportunity to voice their personal opinions about the way they feel things need to be done in Ford to improve productivity and how to go about doing that. In this section the researcher will summarise responses from the questions covering sections B, D, G, F, H and I.
Table 5.10 to table 5.15 below are the summaries of the respondents on how to improve productivity.

Table 5.11: The opinions of the respondents on how productivity can be improved:

<table>
<thead>
<tr>
<th>How can the company improve the levels of productivity?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Improving machine spares buying system for spares availability.</td>
</tr>
<tr>
<td>2. Prompt response of both artisans and operators to the problems.</td>
</tr>
<tr>
<td>3. By making sure that all production parts are available.</td>
</tr>
<tr>
<td>4. By giving training to the people.</td>
</tr>
<tr>
<td>5. By taking steps in improving small group activities, giving ownership to the shop-floor employees, training all employees in small group activities.</td>
</tr>
<tr>
<td>6. Getting artisans involved in production.</td>
</tr>
<tr>
<td>7. Giving training to operators on regular bases and taking advice from them.</td>
</tr>
<tr>
<td>8. Focusing the attention on people needs and toning down on systems.</td>
</tr>
<tr>
<td>9. Conducting PMs and following-up on the issues raised.</td>
</tr>
<tr>
<td>10. Proper tracking for the job per hour.</td>
</tr>
<tr>
<td>11. Removing organisational red tape.</td>
</tr>
<tr>
<td>12. Holding shop-floor employees accountable for their productivity performance.</td>
</tr>
<tr>
<td>13. Making sure that all machines are available at all times.</td>
</tr>
<tr>
<td>14. Improving minor losses like early leaving for breaks, late start-ups from breaks.</td>
</tr>
</tbody>
</table>

The above table is related to the levels of productivity and the feeling of the respondents on productivity levels of the company. What the respondents clearly feel is that people have a very big role to play in productivity improvements. There are many aspects on people highlighted by the respondents: one that keeps coming to the fore is the training of the people in doing their job, especially artisans.

The second item concerning people that become more evident in the respondents’ opinions is the discipline of the people in doing their work: people not adhering to the start-up time for breaks, before and after. Artisans delay in attending to the machine breakdowns resulting in a delay in fixing the machines. There is also a lack of proper cooperation in the work groups where artisans are reluctant to engage in the production issues.

Machine spares availability is one of the biggest causes for delays in fixing the problems quickly and properly. Temporary fixes are conducted and as a result, machine problems repeat themselves.
Table 5.1 below is about summary of performance efficiency, the reasons why the lines are not performing well and the suggested solutions from the respondents. The respondents believe that the main reasons for the lines not performing well are poor planning for tool changes, a lack of data capturing and analysis, a lack of discipline as well as quick fixes. They also suggest that the company should start making people accountable for their jobs. They should start collecting data and have a history of their equipment.

Table 5.1: Respondents’ opinions on how the company can improve OEE:

<table>
<thead>
<tr>
<th>How can the company improve overall equipment effectiveness in support of productivity?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Training of OEE should focus on the benefits to the operators as an effective tool.</td>
</tr>
<tr>
<td>2. Machine preventive maintenance should be done on time.</td>
</tr>
<tr>
<td>3. Promote ownership of the equipment by the people working on the equipment including artisans.</td>
</tr>
<tr>
<td>4. By doing scheduled maintenance that is relevant to life span of machine and doing away with no value check lists.</td>
</tr>
<tr>
<td>5. Spare parts availability during the time PMs are conducted.</td>
</tr>
<tr>
<td>7. Employ more technically qualified people.</td>
</tr>
<tr>
<td>8. Adherence to the PM schedule.</td>
</tr>
<tr>
<td>9. Eliminate quick fixes and put in place permanent corrective action.</td>
</tr>
<tr>
<td>10. Identify constraint on machines in all the areas.</td>
</tr>
<tr>
<td>11. Quick reaction the breakdowns and proper communication between production and maintenance.</td>
</tr>
<tr>
<td>12. Proper collection and presentation of maintenance data.</td>
</tr>
<tr>
<td>13. Ensure that there is a robust Maintenance Operating System in place.</td>
</tr>
</tbody>
</table>

The findings on table 5.10 are related to overall equipment effectiveness, the cause of equipment losses and how the company can improve it. The main factors that stand out are quick fixes, lack of skills for both supervisor planning and artisans and processes that are not followed properly.

The respondents feel that the quick fixes are a major cause of the poor machine uptime because the artisans will then have to keep on doing temporary fixes that will not last and the machine will stop again. The planning is also not done properly because whenever there is a quick fix done, there should be a plan to go back and correct the quick fix.

This indicates that there is no follow-up process or the follow-up process is not adhered to by the maintenance supervisors and artisans to ensure that all corrective maintenance
and planned maintenance issues are completely closed and there will be no comebacks. The respondents also feel that skills are an issue due to a high influx of new artisans as a result of the expansion to the new programme and this is compounding the OEE problems.

The respondents suggest that the company should do more preventive and predictive maintenance. The production team should be made part of the maintenance planning so that they can highlight the concerns that are randomly causing breakdowns. The artisans and production employees also need training on the problem-solving tools and on new machinery. The artisan turnover in the plant for the past year alone was 8 percent and due to the level of shortages of qualified artisans, it takes a very long time to replace them.

Table 5.13 below is a summary of total productive maintenance, the reasons why the lines are not performing well and the suggested solutions from the respondents. The respondents believe that the main reasons for the lines not performing well are firstly because even though there are well-established work-group teams in the company, communication is still not as effective as it should be. They also suggest that the company should start making people accountable for their jobs.

Table 5.13: Respondents' opinions on how the company can improve TP:

<table>
<thead>
<tr>
<th>How can the company improve total productive maintenance?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Improve communication in the small groups and encourage team work in all aspects of the business.</td>
</tr>
<tr>
<td>2. Involved in making sure that the machines are kept in good condition.</td>
</tr>
<tr>
<td>3. Implement up to date reporting system to identify negative trends.</td>
</tr>
<tr>
<td>5. Effective implementation of the 5s standard throughout the company.</td>
</tr>
<tr>
<td>6. Proper control of machine spares</td>
</tr>
<tr>
<td>7. Planning and scheduling cleaning, inspection before the equipment downtime occurs.</td>
</tr>
<tr>
<td>8. Scheduled machine deep cleaning.</td>
</tr>
<tr>
<td>9. Conducting PMs and follow-up on the issues raised.</td>
</tr>
<tr>
<td>10. Involvement of the operators in minor maintenance.</td>
</tr>
<tr>
<td>11. By implementing “small business units” where teams are responsible for the up – keep of their area.</td>
</tr>
<tr>
<td>12. Putting clear maintenance measurable</td>
</tr>
<tr>
<td>13. Make effective use of autonomous maintenance process.</td>
</tr>
<tr>
<td>14. Create a feedback loop to OEMs on component failures and equipment performance.</td>
</tr>
</tbody>
</table>
TPM is a maintenance process developed for productivity and the original goal of total productive management is to continuously improve all operational conditions within a production system by stimulating the daily awareness of all employees. The respondents in table 5.11 share the same view that the involvement of people in TPM is crucial where people have to follow 5s standards.

From the above responses there is a clear message that there is a general belief that no regular feedback from supervisors and management when things go well or badly is given to employees. There should be a process of monitoring effectiveness of work done by artisans. The respondents also feel that there are processes and programmes in place but these are not implemented properly. Therefore they recommend that the company should enforce the implementation of the current processes.

Table 5.14 below is the summary of the respondents’ opinions about quality in their workplace. There are also suggestions on how the company can improve its product quality.

Table 5.14: Respondents’ opinions on how the company can improve quality:

<table>
<thead>
<tr>
<th>How can the company improve the levels of quality?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The continuous training of people on quality issues.</td>
</tr>
<tr>
<td>2. Adherence to containment procedure for the parts out of specification.</td>
</tr>
<tr>
<td>3. The effective use of the dynamic control plan (DCP).</td>
</tr>
<tr>
<td>4. Raise the level of alertness for quality problems that have a potential of going through to the customer.</td>
</tr>
<tr>
<td>5. Maintain the OEM standard on tooling</td>
</tr>
<tr>
<td>6. Avoid making compromise at the expense of quality.</td>
</tr>
<tr>
<td>7. Strict adherence to the company quality procedures.</td>
</tr>
<tr>
<td>8. Always ensure that the machines are running within the acceptable levels of capability.</td>
</tr>
<tr>
<td>9. The setting process must be adhered to and the setters must always do five piece checks.</td>
</tr>
<tr>
<td>10. It is crucial to involve suppliers in all quality initiatives.</td>
</tr>
<tr>
<td>11. Gauge process confirmation issues must be recorded and corrective actions be implemented.</td>
</tr>
<tr>
<td>12. Formalising the show and tell areas.</td>
</tr>
<tr>
<td>13. Automatic quality data collection from each process.</td>
</tr>
<tr>
<td>14. Effective use of the global 8D process.</td>
</tr>
</tbody>
</table>

Preventive maintenance should be done on time and regular cleaning schedules should be introduced in order to ensure cleanliness of the machines. When the machines are not cleaned regularly they can contribute to poor quality: for instance, when there is swarf (metal chips) between the clamps it could cause machines to cut skew. Therefore by
keeping the machines clean, quality can be improved. The autonomous process is in place to overcome this problem but not every operator is conducting autonomous maintenance as required.

They also believe that there are different quality standards being followed in the company. They believe that they are not properly followed when dealing with the issues. They also believe that there is a need to re-enforce the importance of people adhering to quality standards by ensuring that every part that comes out of the line is fit to be used by the customer and where defects are identified, the existing process of separating defective parts should be followed. During the gauge process confirmation conducted by management one of the findings is that gauging frequency is not adhered to by some operators in many areas of the plant.

Table 5.15 below is the summary of the respondents’ views about material availability and how the company can improve it:

**Table 5.15: Respondent’s opinions on how the company can improve material availability.**

<table>
<thead>
<tr>
<th>What is the impact of material availability in the productivity performance of the plant?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Late deliveries from the suppliers lead to production stoppages.</td>
</tr>
<tr>
<td>2. Poor performance on machining lines affects assembly performance.</td>
</tr>
<tr>
<td>3. Spares availability can minimise machine downtime.</td>
</tr>
<tr>
<td>4. If raw materials are not available this could cause machine idle and can cost money.</td>
</tr>
<tr>
<td>5. The ineffective JIT system can cost the company too much money due to production stoppages</td>
</tr>
<tr>
<td>6. Material unavailability could lead to not supplying the customer with required volumes.</td>
</tr>
<tr>
<td>7. Not meeting the production schedule</td>
</tr>
</tbody>
</table>

In the above table the respondents indicate that there are also allegations of late deliveries from their suppliers that affect the plant’s level of productivity. Also one of the common problems that lead to material shortages is the machining lines’ performance that leads to short supply to assembly line.

There is also a feeling from the respondents at Ford that material availability is one of the biggest problems, resulting in failure to supply the customers with the required products. There is also evidence from the respondents’ statements that machine spare parts availability is another contributing factor to the material availability as machines are not repaired on time resulting in longer breakdowns.
Table 5.16: Respondents’ opinions on how the company can improve skills

<table>
<thead>
<tr>
<th>Is the training you have received in the company adequate for the job you are required to do?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Can do better with more training.</td>
</tr>
<tr>
<td>2. More training is required.</td>
</tr>
<tr>
<td>3. Unfortunately not – and is one area where I feel strongly that the company has been lacking.</td>
</tr>
<tr>
<td>4. The company needs to focus on training operators on minor tool changes.</td>
</tr>
<tr>
<td>5. Almost every year there is something new I learn from the company.</td>
</tr>
<tr>
<td>6. Most definitely.</td>
</tr>
<tr>
<td>7. When it comes to training there is always room for improvement</td>
</tr>
<tr>
<td>8. No, Formal training is needed for continuous upgrade but not specialised.</td>
</tr>
<tr>
<td>9. Yes but need a plan for the next five years.</td>
</tr>
<tr>
<td>10. Need more cross-skill training</td>
</tr>
</tbody>
</table>

In this chart the respondents have indicated that there is a need for more training. In short, those that have received training are positive that the training is good and has helped them to do their jobs better and more efficiently. There are still those who believe that for them there is not enough training taking place.

According to some of the statements, there are those that have received training that are positive that the training is good and has helped them to do their jobs better and more efficiently. It was also recommended that most training should be on-the-job training rather than classroom training and the training material should be updated regularly.

5.4 TEST FOR RELIABILITY

When testing for reliability, questions are asked of the same people, but on two separate occasions. Responses for the two occasions are correlated, thus providing an index of reliability (Collis & Hussey, 2003:186).

In order to test the reliability of the feedback from the questionnaire, a group of people was brought together to discuss what they consider the cause of the low machine availability to be and suggestions on how can it be improved. The following statements were included in the questionnaire (ref. table 5.5):

- The company measures machine availability and takes corrective actions to improve productivity.
- The company records and trends total machine breakdown and the time taken to repair the machine.
This is basically the same question as the one in the Table 5.5. For both questions 80.5 percent of the respondents answered positively.

Similarly, the following questions were asked in table 5.8:

- Operators conduct daily checks on machinery and equipment they operate.
- Operators do autonomous maintenance on the machines they operate.

The respondents’ response rate was exactly the same: 94 percent of the respondents strongly agreed. Based on these qualitative findings it was concluded that the data collected was consistent and therefore useable.

The respondents were also asked to comment on what they think could be done to improve productivity, overall equipment effectiveness, total productive maintenance, quality, material availability and skills level understanding in section J of the questionnaire. This question was also used to test whether the answers correlated.

Finally, a group of people was brought together to discuss what they feel the cause of low machine availability is and how they believe it can be improved. The group consisted of one IMT, a manager and the team leader. These people were strategically selected in order to represent the targeted sample for the questionnaires. The responses indicated that they had given the matter some serious thought and therefore the scale was considered to be reliable.

**5.5 SUMMARY**

In this chapter, the empirical results were reported. More specifically, the general perceptions of productivity and other productivity measurement factors like the OEE, Total Productive Maintenance, material availability and the importance of skills levels for the employees in the company were highlighted.

In Chapter Six, the summary, conclusions and recommendations will be presented. Managerial implications of these empirical findings for Ford Struandale Engine Plant will also be discussed.
CHAPTER SIX
CONCLUSION AND RECOMMENDATIONS

6.1 INTRODUCTION

In Chapter Two the researcher conducted an in-depth review of literature about the factors that impact on productivity improvements. The third chapter dealt with processes used in the Ford Struandale Engine Plant in measuring productivity improvements. In Chapter Four the research design and methodology for the empirical study were discussed. Chapter Five presented the findings from the empirical study. In Chapter Six a combined analysis of the data discussed in Chapters Two to Five will be done in order to addresses the sub-problems and ultimately the main problem.

6.2 SUMMARY OF THE STUDY

6.2.1 Reasons for the Research

South African producers are constantly facing pressures from both foreign and local organisations in their domestic markets. Many business leaders are concerned with productivity as it relates to competiveness. Firms that have high levels of productivity earn a competitive advantage compared to those with low productivity (Stevenson, 1996:42). The Ford Struandale Engine Plant is under pressure to improve productivity levels so that they can be competitive with the world class levels. This pressure is as a result of a R1.6 billion investment made by the company.

One of the critical success factors in productivity improvements within manufacturing organisations is the measurement of productivity. Along with the method of productivity improvements there are also several factors that render them ineffective or even prevent improvement actions. These factors are called limitations to productivity improvements. This research is about the internal factors that are limitations to productivity improvements. They are also classified as soft and hard limitation factors (Prokopenko, 1987:11).

Several elements of the hard and soft factors were reviewed in the literature study, as well as how these elements or the systems are applied in the Ford Motor Company Struandale Engine Plant. In this chapter the researcher will draw conclusion on how the soft and hard factors like technology, equipment, raw materials, labour skills and internal company systems limit productivity improvements and hence have a negative...
impact on the profitability of the organisation and its ability to compete successfully in the global arena.

6.2.2 The problem statements
With the abovementioned challenges in mind, various factors to resolve the main problem had to be considered. The following factors that influence productivity improvements were identified. These were considered as sub-problems which need to be addressed in order to address the main problem: What are the factors that influence productivity improvements at the Struandale Engine Plant (SEP)?

The following five sub-problems were identified in order to find a solution to the main problem:

Sub-problem one

- What does the literature reveal about the importance of productivity in the manufacturing industry for the long term survival of the organisation?

This sub-problem was addressed in Chapter Two by a literature review of the importance of productivity performance in the manufacturing industry, factors effecting productivity improvements in the company’s internal factors that effect productivity improvements as well as how these factors play a significant role in productivity improvements. This was followed by discussions on the productivity measurements.

According to the FSEP literature review, the level of productivity has not been comparable to the world class levels. As a result most of the areas in the plant struggled to build to customer demand as required by the FPS process of building to schedule. The engine assembly line achieved only 88.47 percent of building to schedule in comparison to the plant’s target of 100 percent. It is important for the plant to calculate the level at which they build in relation to customer orders.

Productivity calculation shows that there is a relationship between input and output in production activities. Input consists of labour, machines and materials, while output comprises production (P), quality (Q), cost (C), delivery (D), safety, health and environment (S), and morale (M) (Nakajima, 1988:12). During the FSEP literature review the productivity measures were discussed by an in-depth evaluation of how FSEP performs against these performance measures. Productivity performance and the
factors that affect productivity programmes in the organisation have to be made known to everyone in the organisation.

In the empirical studies 100% of the respondents agreed that the company productivity levels are viewed as one of the most important measurable and also that productivity performance is collected and trended. About 8 percent of the respondents disagree with the two statements, namely (1) everybody knows and understands the company productivity performance in comparison to the best in the world, and (2) productivity levels are discussed and communicated to all levels of the organisation.

The respondents made some recommendations as to how productivity can be improved in the company. Amongst these are the prompt response of all personnel in the plant to productivity problems; proper tracking of job per hour recording at all stations as well as long-term and ongoing productivity improvements being vital to international/multinational company survival.

Sub-problem two

- What is the impact of OEE on the organisation?

This OEE was researched in chapter two. This information will be used to answer sub-problem two. Firstly the TPM seven pillars will be discussed as one section of the OEE and how they influence productivity improvements. Secondly, the three OEE elements which is availability, performance efficiency and quality rate will be discussed. Finally, a comparison between total quality management and total preventive maintenance will be made as to what kind of impact they have on productivity improvements.

The original goal of TPM is to continuously improve all operational conditions within a production system by stimulating the daily awareness of all employees (Nakajima, 1989). The literature reveals accurate and practical implementation of TPM will increase productivity within the total organisation where:

- A clear business culture is designed to continuously improve the efficiency on the total production systems;
- A standardised and systematic approach is used where all losses are prevented and/or known;
• All departments influencing productivity will be involved to move from a reactive to a pro-active mindset;
• A transparent multidisciplinary organisation will reach zero losses.
• Steps are taken as a journey, not as a quick menu.

OEE begins with planned production time and scrutinises efficiency and productivity losses that occur with the goal of reducing or eliminating these losses. The research revealed that OEE factors like availability that takes into account downtime losses of any events that stop planned production for an appreciable length of time have a significant influence on productivity improvements of an organisation.

The second OEE factor discussed in the literature study is performance efficiency. That takes into account speed losses which include any factors that cause the process to operate at less than the maximum speed when running. This includes other idling and minor stoppages resulting from interruptions in the process flow requiring operator or job setter intervention influencing productivity improvements.

Quality, on the other hand, takes into account quality losses which account for produced pieces that do not meet quality standards, including pieces that require rework. The second element for quality rate is the start-up loss that occurs between the time of equipment or process start-up until the time that a product is produced meeting all quality standards.

The respondents confirm that the above elements of OEE have a significant influence on productivity improvement activities in the manufacturing business. It also impacts on the profitability of the organisation as the plant fails to supply the customers with the required products.

**Sub-problem three**

• What is the impact of other limiting factors in productivity improvements?

In Chapter Two when the literature review was conducted the items which affect this sub-problem were discussed in order to demonstrate what impact these elements have on the productivity of an organisation. Material availability was one of the elements
discussed in this section. The literature study reveals that material availability is one of the important factors regarding productivity improvements.

The literature also revealed that the inventory of an organisation is the amount and the type of raw material, parts, supplies and unfinished goods an organisation has on hand at any one time (Hellriegel et al., 1999: 736). The research study also demonstrated the importance of the inventory systems to ensure material availability, the importance of making sure that there is a robust just-in-time material supply system to avoid material stock cost.

Additionally in this sub-problem the role played by employee skills levels to enhance productivity improvements was discussed as the second element. Productivity is also affected by factors at the individual level such as health, education, training, core skills and experience (ILO, 2005a, PP2-3). In Chapter Two the literature review reveals that it is important to recognise the fact that skills development and other investments in human capital are one set of factors necessary for productivity growth.

**Sub-problem four**

- What is the impact of Overall Equipment Effectiveness on the Ford Stuandale Engine Plant’s current productivity performance regarding the following:
  1. availability
  2. performance efficiency
  3. quality rate?

The results from the general literature, the FSEP literature and the empirical survey on OEE have been amalgamated to draw conclusions. Both the general literature and the FSEP literature reveal that the equipment effectiveness plays a central role in promoting productivity improvements in an organisation (Prokopeko, 1987: 11). Plant and equipment play a central role in a productivity improvement programme.

During the FSEP literature review, a benchmark exercise was conducted between what the world best OEE performance is against the current engine assembly OEE performance. The world best performance in OEE is 85 percent and the current performance at the FSEP is 57.73 percent which is about 27 percent lower that the world's best (http://www.oee.com/world_class_oee.html). OEE is one of the
productivity measures therefore at this level there is a clear indication that the plant is not performing well against the best in the world.

Currently the assembly has a target OEE of 75 percent: that is 10 percent below the world class OEE and it is still not achieving this target (W:\GROUP\FPS\5.Management\2010 Policy Deployment). The plant has no chance of achieving the same levels of OEE as the world best because they set themselves a very low target. Also the empirical survey indicates that 30 and 14 percent of the respondents are uncertain and disagree respectively they know their daily OEE rate at a certain time of the day.

About 92 percent of the respondents agree that all OEE improvements actions implemented in the company are directed at improving productivity performance in the plant. At the same time only 75 percent of the respondents agree that the plant leadership responds quickly to OEE issues that affect productivity improvements. There are 17 and 8 percent who are uncertain and disagree with this statement respectively. This is an indication that the small group activities are not used effectively to communicate performance issues in the organisation. These activities are meant to discuss and develop improvement activities for productivity improvements in the organisation.

**Availability**

FSEP literature survey conducted and discussed in Chapter Three reveals that availability is one of the equipment effectiveness elements. Availability is the amount of time the machine or the process is available to run compared to the amount of time it was scheduled to run. The type of availability they are talking about in FTPM is the equipment failures and breakdowns, set-up and adjustment losses, tooling, minor stoppages and start-up losses.

FSEP current availability is sitting at 83.24 percent for the assembly line. That is 6.7 percent lower than the world class availability benchmark but also 1.8 percent lower that the plant's target. The plant set itself a target of 85 percent lower that the world benchmark of 90 percent. They should strive for the world class availability levels but will have to improve productivity to the world class productivity levels. This is an
indication that the company is not driving the system hard enough to be globally competitive.

The empirical study conducted in the company from a group of leadership teams like the team leaders, managers and supervisors shows that there are still people in the leadership positions who are uncertain and do not know the availability levels of their area at the end of each day. Only about 67 percent of respondents agreed with the statement that they know the availability percentage for their areas by 16h00; 16.67 percent are uncertain and 16.67 respondents disagree.

Also there are only 63.89 percent of the respondents who agree that there is a unique process used in the company to permanently eliminate machine breakdowns whereas 22.22 percent of the respondents are uncertain while 13.89 disagree with the statement. Table 3.2 shows that the plant is performing 6.8 percent in availability less than the world class level therefore it should be a priority for everyone in the plant to eliminate factors that can lead to poor availability. There are 94 percent and 92 percent of the respondents who agree unscheduled and tooling downtime data is recorded and trended but not all respondents agree that there is action (is this the 92%?) Please refer to my previous comment about this statement – the two percent is confusing.

**Performance Efficiency**

In Chapter Three the FSEP literature survey registers two losses as elements of performance efficiency. These are the reduced speed losses and blocked and starved. Performance efficiency is (Ideal Cycle Time x Total Products Run) / Operating Time) (http://www.fps.ford.com/learningeventslearningbew.html). According to the FSEP literature survey, the efficiency losses are those losses that cannot be documented and that belong to all other idling and minor stoppages categories.

These other minor stoppages that are coded in Ford plants are stoppages like machine jam, material misalignment, machine-reset, undocumented manual adjustments and temporary cleaning requirements. These are the losses that are missing in the assembly performance efficiency figure 3.4 where up to 80 percent of the line can account for the amount of efficiency and there are 20 percent of inexplicable losses.
This is supported by the empirical study results where there are 11 percent of the respondents who disagree with the statement that idling and minor stoppages are measured and trended and there are also 11 percent of the respondents who are uncertain about the same statement. This is repeated in statement 6 of the empirical study results where 17 percent of the respondents and 14 percent of the respondents are uncertain and disagree respectively with the statement that in their areas they periodically review the idling and minor stoppages.

One of the most common efficiency losses at the FSEP is the reduced speed loss: when there are quality problems the machine setters tend to reduce the speed of the machines. When the quality problem is fixed there is no system in place to ensure that the machine is put back to its original speed. This was indicated in Chapter Three when the FSEP literature study indicated that reduced speed losses are as a result of tool setters trying to resolve quality concerns but not following the proper MTC process to ensure that after the quality issues have been resolved the machines are put back to their normal operating speed.

Currently the FSEP has set itself a target of 80 percent efficiency: lower that the world class benchmark of 95 percent. It is currently achieving 74.57 percent, which is 5.43 percent lower that the plant's target and 15.43 percent lower than the world benchmark. This will have a significant impact on the productivity performance of the plant.

**Quality**

In most of the empirical study statements on quality except one, the respondents responded overwhelmingly - above 80 percent - in agreement with all the statements. There still seem to be a concern in the plant about how the relevant people deal with start-up losses as they make a significant contribution to the quality performance of the plant. Only 75 percent of the respondents agree that start-up losses are recorded and trended for corrective actions.

The second concern on quality is the 17 percent of the respondents who disagree that there are effective processes to resolve customer quality issues even though in Chapter Three there is a G8D process that FSEP literature study mentions to be used to resolve customer quality issues. But the respondent opinions from the empirical study
questionnaires reveal that this process is not used effectively in the plant. Also in this section the respondents feel that there is a need to raise the awareness of quality problems that have the potential of going through to the customers.

Also the current quality levels at the FSEP are an area of concern as they contribute to the low levels of OEE in the plant. The plant’s quality rate is 93 percent 5 percent lower than the plant’s target and is also 6.9 percent lower than the world class benchmark. At this level of quality performance the plant will struggle to reach the targeted OEE levels, much less the world class levels. One of the major concerns shown by the FSEP literature study from assembly line figure 3.4 is that the quality issue is the third highest concern regarding the assembly line and it affects both quality and efficiency.

Containment of the quality issues in the areas that supply assembly with parts has been one of the reasons for poor quality in the assembly line as these problems are picked up in assembly. As demonstrated in table 3.1, there is a significant amount of defect coming through to assembly from the machining lines where table shows 5.87 percent of assembly defects are coming from the machining lines.

The literature study from the FSEP shows that assembly line on availability, performance efficiency and quality rate performs poorly, hence poor OEE performance levels. In addition, table 3.1 shows that regarding the assembly line, OEE is far lower than the world class levels, hence poor productivity levels. The empirical study through the analysis in Chapter Five reveals various reasons for poor availability, performance efficiency and quality rate.

Sub-problem five

- What impact do material availability and employee skills have on FSEP productivity improvements?
  1. What are the processes in place to drive the process of material availability and employee skills requirements?

Material Availability

According to the general literature survey conducted in chapter two of this research, material availability is one of the most important factors in relation to productivity
improvements. The study also show two ways by means of which the manufacturing company can protect it self from material shortages - by employing the inventory strategy that is more cost effective for their operations or a just-in-time system that allows minimum or no inventory.

According to Stephenson (1999: 528), inventory safeguards against problems caused by variations in the delivery of input material. Without a backup inventory of input material, even slight delays can shutdown an entire operation and have a significant impact on the productivity performance of the plant. The FSEP uses a build-to-schedule process that requires a high level of accuracy in the number of parts required to be built per day.

The just-in-time system used in the plant poses some challenges due to the problems created by the internal and external suppliers because of their machine reliability issues. It is clear in figure 3.3 depicting assembly line availability versus downtime, that amongst the 15 top items affecting assembly are the availability of cylinder heads and cylinder blocks during the time they are required for production.

The other issues that are included in this graph are the changeover issues where the line has to conduct unscheduled changed due unavailability of parts as a results of late arrival of cargo ships. This is also supported by the respondents’ opinions that the late deliveries from the suppliers lead to production stoppages.

The respondents also believe that the JIT system is not very effective and is costing the company too much money. According to the empirical study, 19 percent of the respondent disagree that the company has an effective JIT system in place that supports productivity improvements. One of the key elements of material availability is the strategy of having a daily count of available inventory of available raw material for all the production processes.

In this case the respondents believe this process is not adequately adhered to as it sometimes happens that the assembly production line stops because of a shortage of parts. About 14 percent of the respondents disagree that there is always adequate amount of raw materials available to avoid production stoppages.
The respondents also feel that the availability of the machine spare parts leads to extended breakdowns resulting in the machining lines failing to deliver parts to the assembly line and this result in production stoppages. Figure 3.3 in the FSEP literature study shows that of the top 15 downtime causes on the assembly line, number one and number six are the times when the assembly line is waiting for cylinder heads and cylinder blocks. This shows that they contribute more to low productivity levels at the FSEP.

**Employee skills**

A considerable number of the respondents believe that people are appointed in certain positions are not contributing to the productivity improvements of the company because they do not have the adequate qualifications. In the empirical study 22 percent of the respondents disagree with the statement that people with adequate qualifications are appointed in positions where they contribute to the productivity improvements in the company and 25 percent of the respondents are uncertain.

The company is not enhancing the critical skills, according to 25 percent of the respondents and 33 percent are also not certain that the company does everything in its power to enhance critical skills. About 36 percent of the respondents also believe that not all employees in the company have individual development plans to develop their skills. One of the common points raised by the respondents in the respondent opinion section is that the company should implement multi-skilling for the artisan group and also equip operators with some technical skills.

Based on the FSEP literature and the empirical study it appears that material availability has an impact on assembly line productivity performance. Both internal and external suppliers influence productivity improvements. In addition, the company has not done enough to equip employees with the necessary skills that will assist them to permanently resolve their problems. The respondents also believe that the company can benefit more by multi-skilling the artisans to have both electrical and mechanical skills and by equipping the operators with technical skills so that they conduct minor maintenance.
6.3 CONCLUSION OF THE RESEARCH

Based on the available literature and the respondents to questions in the questionnaires, the researcher has found that personnel at the FSEP know the importance of ongoing productivity improvements and are aware of the shortcomings presented to the company by the research study conducted. The researcher also discovered that in order for the FSEP to achieve high levels of productivity, there have to be improvements in the OEE levels for engine assembly.

Currently the discussion above in section 6.2.2 indicates that OEE at the FSEP is very poor and leads to poor productivity levels at the plant as a result of poor machine availability, poor performance efficiency and unacceptable quality standards. Below is the table showing the OEE targets and performance levels at the Ford Struandale Engine plant in comparison to the world class standards. The table shows that the targets set for the plant are lower than the world class standard and the plant is performing poorly against these targets.

Table 6.1: Ford Struandale Engine Plant Assembly line OEE Performance

<table>
<thead>
<tr>
<th></th>
<th>World class</th>
<th>Assembly Target</th>
<th>Actual Assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>90.00%</td>
<td>96.00%</td>
<td>83.24%</td>
</tr>
<tr>
<td>Performance</td>
<td>95.00%</td>
<td>80.00%</td>
<td>74.57%</td>
</tr>
<tr>
<td>Efficiency</td>
<td>99.90%</td>
<td>98.00%</td>
<td>93.00%</td>
</tr>
<tr>
<td>Quality Rate</td>
<td>85.00%</td>
<td>75.00%</td>
<td>57.79%</td>
</tr>
</tbody>
</table>

Source: [http://www.oee.com/world_class_oee.html](http://www.oee.com/world_class_oee.html)

Clearly from chart 6.1 below FSEP there is a needs to reduce the amount of breakdowns for the machines to be available, reduce minor stoppages and improve quality coming from the line. The OEE for the assembly line is lower than the target OEE as a result the productivity levels are low.
Material availability and employee skills levels also contribute heavily to the poor performance as the literature revealed that two of the top six contributors to poor productivity are the material availability. FSEP literature study in Chapter three through figure 3.3 indicates that material availability contributes about 23 percent of the total top ten downtime factors to assembly downtime as a result this impact productivity negatively. The literature study in chapter three also reveals that artisans are taking longer than expected to fix breakdowns due to lack of skills.

The extended time taken to resolve these breakdowns result in poor delivery of parts by the machining line to assemble and subsequently result to poor productivity performance on the assembly line. Management, the trade union and the employees have to come up with creative ideas in order to improve these performances. Below are a number of recommendations the company managements and employees can put in place to overcome these problems.

6.4 RECOMMENDATIONS
The productivity of the manufacturing company is measured by the effectiveness with which the company utilises its resources to transform the raw materials into a saleable product. The following recommendations were made based on the data collected through the FSEP literature survey and the empirical survey:
6.3.1 Productivity

- It is recommended that managers should have a process in place that will allow them to hold the shop-floor employees accountable for their productivity performance. This can be done by the team-leaders through hourly checks to ensure that the job per hour for every operation has been achieved and that there is a valid reason why it has not been achieved.

- The line management should eliminate the early departure to breaks and late returns after breaks by installing alarms that will alert the line leadership when the machine or operation has stopped long before time or started long after the time.

6.3.2 Overall equipment effectiveness (OEE)

The current performance of the assembly line on OEE is at 57.73 percent which is very poor compared to the target, and worse still, to the world class benchmark. The availability is at 83.24 percent, the performance efficiency 74.57 percent and the quality rate 93 percent: hence poor OEE, resulting in poor productivity.

- One of recommendations is that the company, through the FPS department, introduces an automated system to measure OEE to ensure that the OEE results are live and quick to retrieve. This will ensure that line leadership have information early enough for to take corrective measures to improve OEE in their areas.

- The official launch by senior management of the Productivity Operating System (POS) in all production areas in the plant will force managers to react quickly to OEE issues that affect productivity. Line managers will be forced to have weekly discussions with the senior management team about the performance of their areas, including those issues that affect productivity performance in their areas.

- For availability it is recommended that the maintenance department, through the spares coordinator, ensures that a machine spare availability strategy is developed. This includes the re-instatement of the spares coordinator. There is also a recommendation that all production spares should be in the spares workshop, closer to the point of use and must be closely controlled.

- The maintenance supervisors should have a level of accountability for machine failures that occur more than two times in a specific period. One of the reasons
for poor availability is that machine breakdowns are not fixed properly because the artisans do quick fixes.

- From the availability questionnaires and the respondents’ opinion it is clear that the maintenance operating system (MOS) is not fully implemented in the plant or not implemented robustly enough. The key elements of MOS are the machine spares strategy, predictive maintenance, the FTPM elements, reliability and maintainability of the equipment and use of failure in reporting analysis and corrective action (FRACAS). It is therefore recommended that the MOS has to be fully implemented by the line management throughout the organisation to improve productivity in assembly line.

- There is also recommendation that the plant link all the machines to an electronic system (SCADA system) that will enable the plant to collect machine data automatically. The current manual system used is time-consuming and the reports cannot be made available conveniently early. It is recommended that the Ford Struandale Engine Plant management should look at adopting the TRS system currently being used by Ford Australia for automatic reporting system. TRS is the Ford Australia locally developed Total Equipment Management Reporting System used to improve the current reporting of the reports from the TEM system. This will eliminate delays on information translation from the TEM system.

- The main issue that affects performance efficiency for the assembly line is the operator discipline: arriving late at the beginning of the shift, leaving early and returning late from tea and lunch breaks and leaving early at the end of the shift. It is recommended that a management process to control the movement of operators must be implemented by introducing the access system on the assembly line entrances.

- The process engineering department in conjunction with production leadership should also increase the frequency for the review of cycle time in each operation to three months compared to the current six months.

- The team leaders should ensure that all machining operators are trained on who and what their customers are, including assembly and that they are as important as the external customers by making sure that all repeat quality issues picked up at assembly are thoroughly investigated through the G8D process where permanent corrective actions are initiated by the use of work groups.
The line leadership should also ensure that the containment of quality issues is entrenched and this should be a compulsory training programme for all new and old employees through the training department. Each employee running an operation must report to the management team how many parts there were that had the potential of going to the next process with a defect.

From process confirmation process findings, the five-piece check and adhering to the gauging frequency by the tool setters and operators appear to be the main contributors to the poor quality levels in the plant. Management should introduce a review process for all process confirmation issues to ensure that there are corrective actions taken to rectify process confirmation issues.

6.3.3 Material availability

The company orders most of the parts used in assembly from overseas suppliers which makes scheduling difficult as parts are ordered long before the time to avoid shortages. Sometimes shortages are as a result of circumstances beyond human control due to bad weather at sea or vessel delay. The recommendation is that the company should look at localising the majority of the parts through the material planning and planning (MP&L) department.

The other recommendation is that the material planning and logistic department (MP&L) should always make sure that there is minimum number of a day’s worth of stock to build alternative product to the one being built to avoid production stoppages. The cost of production losses is higher than the cost of carrying additional day’s worth of production parts and this will improve productivity in the plant.

The smart card just-in-time system used between the assembly line and the warehouse is a very good system but there is human interference to such an extent that some of the respondents believe that it is not effective. In many cases the line stops because the operator does not post the smart card at the right time, resulting in delayed deliveries of the parts to the line and the line stops, waiting for the parts. It is recommended that the assembly and the warehouse leadership connect the smartcard system to the operating system of the line to ensure they automatically calculate the number of parts processed through the station and there is a need to deliver the parts.
6.3.4 Skills level

- There is a tremendous need for the operators to be trained in conducting minor maintenance, not just checking as most of the time the line looses time in conducting minor adjustments on the scanners, for example. Therefore it is recommended that the company conducts basic technical training for operators.

- There is also recommendation that the production leadership, in collaboration with the training department should launch a multi-skilling programme for the artisans. This will equip them with both electrical and mechanical skill as a result reduces delays in the resolution of breakdowns on the lines because there will be no waiting of the artisan with a specific skill.

- Management needs to sustain the task team concept because it allows exposure for the artisans in different areas of the plant and enhances the continuous improvement of the artisans’ skills through A3 projects and PM review process.

6.4 FURTHER RESEARCH OPPORTUNITIES

Below is an outline of issues that can be researched further to address some of productivity improvement factors:

- What is the impact of labour productivity on South African manufacturing companies in improving productivity or reducing productivity improvements compared to other developing economies?

- What type of culture exists in the plants where Productivity Operating Systems (POS) have been fully implemented and what are the benefits?

- Investigate the main reasons for the poor availability, performance efficiency and quality in the plant.

6.5 SUMMARY

The study has shown that there is not only one factor that affects productivity improvement for the assembly line at the FSEP. The empirical study has shown that the OEE and material availability, whether internal or external supply, both contribute heavily to poor productivity performance.

Assembly OEE is currently at 57.47 percent and besides quality rate being the closest to the target, all the elements of OEE in the assembly line are poor. Material availability
has also been identified as one of the contributing factors to poor productivity levels of
the line. Lastly, the skills needed by the artisans has been identified as requiring
attention because of the impact they have on productivity improvements in the
organisation.

The FSEP can only survive in future by improving productivity and this can be done by
making sure that the OEE performance is at the world class level by firstly, targeting 85
percent instead of 80 percent, secondly, improving material availability and thirdly,
improving the skills levels.
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http://en.wikipedia.org/wiki/Sampling


w:\engine plant\cascade\management
ANNEXURE A : QUESTIONNAIRE COVER LETTER

QUESTIONNAIRE COVER LETTER

Research title: THE FACTORS THAT INFLUENCE PRODUCTIVITY IMPROVEMENTS AT FORD STRUANDALE ENGINE PLANT

Researcher: Zamandile Oscar Sundu

Operations Manager: Ford Struandale Engine Plant.

Dear Participant

I am currently doing my MBA through Nelson Mandela Metropolitan University here in Port Elizabeth. I am also working as an Operations Manager at Ford Struandale Engine Plant. My research is to investigate the factors that limit productivity improvements at Ford Struandale Engine Plant.

I am doing research on Overall Equipment Effectiveness, material availability and skills levels as productivity measures. I have developed a questionnaire to observe the performance of the plant in the elements involved in these three measurements of productivity. The questions are directed at the current programme observing productivity performance of the plant in the machining and assembly areas. The research is limited to the production, maintenance and quality performance of the plant. I would like you to answer the questions with a high degree of honesty as to how you see the plant. Your honest answers will assist me to compile the findings of the research and they will be treated with absolute confidence. Under no circumstances will these answers be shared with anybody in the plant without your consent.

Can you kindly complete the questionnaire and return it before 13 November 2010. I thank you in advance. Your contribution is highly appreciated.

Regards
## ANNEXURE B QUESTIONNAIRES

### SECTION A: BIOGRAPHICAL INFORMATION

Please fill in an x in the box that applies to you

**What is your gender?**

<table>
<thead>
<tr>
<th>Male</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td></td>
</tr>
</tbody>
</table>

**What is your age?**

<table>
<thead>
<tr>
<th>20 - 29 Years</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>30 - 39 Years</td>
<td></td>
</tr>
<tr>
<td>40 - and above years</td>
<td></td>
</tr>
</tbody>
</table>

**What is your current position?**

<table>
<thead>
<tr>
<th>Manager</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>IMT</td>
<td></td>
</tr>
<tr>
<td>Production – Quality Engineer</td>
<td></td>
</tr>
<tr>
<td>Electronic Specialist</td>
<td></td>
</tr>
<tr>
<td>Production Team Leader</td>
<td></td>
</tr>
</tbody>
</table>

**What is your highest qualification?**

<table>
<thead>
<tr>
<th>High school</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diploma</td>
<td></td>
</tr>
<tr>
<td>Degree</td>
<td></td>
</tr>
</tbody>
</table>
What are your years of service?

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 5 Years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 – 10 Years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 – 15 Years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 – 20 Years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 Years and above</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PLEASE TICK RELEVANT BOX FOR EACH ITEM APPLICABLE TO YOU

SECTION B: Productivity

Please tick with an X the extent to which you agree or disagree with each of the statements below in an appropriate box.

1. In the company productivity performance levels are viewed as one of the most important measurables.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

2. Productivity performance data is collected and trended daily.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

3. We all know and understand our company productivity performance in comparison to the best in the world.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

4. I am aware of the productivity operating system introduced by the company to improve productivity in the company.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

5. Productivity levels are discussed and communicated to all levels of the organisation.
6. We all know and understand factors that affect productivity performance, both internal and external.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

7. Productivity losses are identified and root causes analyses conducted for corrective actions in all departments.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

8. Equipment effectiveness is one of the most important factors that affect productivity improvements in the plant.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

**SECTION C: Overall Equipment Effectiveness**

Please tick with an X the extent to which you agree or disagree with each of the statements below in an appropriate box.

1. I know what the daily OEE rate is for my department by 14h30.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

2. The company uses small group activities to improve equipment effectiveness in all production areas.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

3. In the company losses are identified and corrective measures are implemented resulting in productivity improvements.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>
4. Employees in the company understand that a high level of OEE has a positive impact on the productivity performance of the company.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

5. Plant leadership responds quickly to OEE issues that affect productivity improvements.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

6. All OEE improvement actions implemented in the company are directed at improving productivity performance of the plant.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

**SECTION D: Availability**

Please tick with an X the extent to which you agree or disagree with each of the statements below in an appropriate box.

1. I know the availability percentage for my area by 16h00.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

2. The company measures machine availability and takes corrective actions to improve productivity.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

3. All unscheduled downtime is recorded and there are plans to reduce it.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

4. There is a change-over process set for all equipments where change-over is conducted and there is an improvement process in place.
5. The plant records and trends tooling down time.

6. All setting and adjusting downtime is recorded and trended for corrective actions.

7. There is a unique process used by the company to permanently eliminate machine breakdowns.

8. The company records and trends total machine breakdown and the time taken to repair the machine.

**SECTION E: Performance efficiency**

Please tick with an X the extent to which you agree or disagree with each of the statements below in an appropriate box.

1. In my area idling and minor stoppages are measured and trended for every shift.

3. The company uses POS as a tool to understand and reduce minor stoppages.
4. The company uses a process confirmation process to review machine cycle time to improve performance efficiency.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

5. In my area start-up losses are measured and improvement plans are developed to reduce start-up losses.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

6. In our area we periodically review the machine speed and make sure they are running at the designed speed.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

7. In my area we periodically review the idling and minor stoppages.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

**SECTION F: Quality**

Please tick with an X the extent to which you agree or disagree with each of the statements below in an appropriate box.

1. All areas in the company measure quality rate and take corrective actions.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

2. The company is using Quality Operating Systems to track all quality issues in their areas.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

3. When customer quality problems are measured in the company and there is process in place to resolve the issues.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>
4. In my area all start-up losses are recorded and trended for corrective actions.

5. All scrap and rejects in my area are recorded and trended.

6. I know that the company reduces early supplier quality losses through early supplier involvement during product launch.

7. I am aware of the customer problems in my area.

**SECTION G: Total Productive maintenance**

Please tick with an X the extent to which you agree or disagree with each of the statements below in an appropriate box.

1. There is a 5s standard implemented in all the production areas throughout the plant.

2. Maintenance Operating System has been communicated to plant employees.
3. Operators conduct daily checks on machinery and equipment they operate.

4. Maintenance artisans do preventive maintenance checks as per schedule.

5. Employees are encouraged to initiate continuous improvement projects.

7. Operators are trained to conduct autonomous maintenance on the machines they operate.

8. Operators do autonomous maintenance on the machines they operate.

SECTION H: Material Availability

Please tick with an X the extent to which you agree or disagree with each of the statements below in an appropriate box.

1. Material availability is measured and recorded daily.
2. The company has a WIP process in place and the levels for each production area in clearly visible areas for proper control.

3. There is always an adequate amount of raw material available to avoid production stoppages.

4. The company has an effective JIT system in place that supports productivity improvements.

5. The daily raw material cycle counts are used in the company to avoid raw material shortages that could lead to production stoppages.

6. The plant schedules production according to customer orders.

7. The capacity of the plant is aligned to the market demand

SECTION I: Skills
Please tick with an X the extent to which you agree or disagree with each of the statements below in an appropriate box.

1. The company ensures that employees have the necessary skills to perform effectively in their jobs.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

2. People with adequate qualifications are appointed in positions where they contribute to the productivity improvements in the company.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

3. When new technology is introduced employees working with the new equipment are given skills to ensure the equipment continues performing at high levels of productivity.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

4. The company pays its employees in line with the skills they acquire.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

5. The critical skills like those of the artisans are continuously enhanced to ensure that they are up-to-date with changes taking place out there.

<table>
<thead>
<tr>
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<th>Agree</th>
<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

6. There is an individual development plan for each employee for the development of their skills.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
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<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>
7. Adequately skilled employees can contribute to the productivity improvements in the company.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
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<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

8. Employees are adequately trained to do the jobs for which they are appointed.

<table>
<thead>
<tr>
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<th>Neither Agree Nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

SECTION J: RESPONDENTS OPINION

Please write down your own opinion with regards to these sections indicated below. Please print when you write, keep it sort and clear.

SECTION B: PRODUCTIVITY

How can the company improve levels of productivity?

________________________________________
________________________________________

SECTION D: OVERALL EQUIPMENT EFFECTIVENESS

How can the company improve overall equipment effectiveness in support of productivity improvements?

________________________________________
________________________________________
________________________________________

SECTION G: TOTAL PRODUCTIVE MAINTENANCE

How can the company improve total productive maintenance?

________________________________________
________________________________________

SECTION F: QUALITY

How can the company improve its quality?
SECTION H: MATERIAL AVAILABILITY

What is the impact of material availability on the productivity performance of the plant?

SECTION I: SKILLS

Is the training you have received in the company adequate for the job you are required to do?