S.P Govender
Student No. 8813906
8 Speyers Road
Walmer Downs
Port Elizabeth
6000

Dr J.J Pieterse
Port Elizabeth Technikon
MBA Unit
Summerstrand

Re: Modification to dissertation

Sir,

I have modified my dissertation in line with the requirements of the evaluator / moderator. Modifications to the dissertation includes, amongst others, the following:

- A detailed interpretation of the literature study.
- An explanation of Ford in-house terminology so as to facilitate ease of understanding.
- An in-depth explanation of the instruments used for data collection and recording. The summary thereof is also clearly explained. Method study and work measurement is also explained clearly.
- The analysis, descriptions and explanations of the findings are clearly defined and described.
- The removal of emotive and colloquial language.

Hoping this meets your approval.

S.P Govender

DECLARATION

This work has not been previously accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed …….
Date …….

STATEMENT 1
This dissertation is being submitted in partial fulfilment of the requirements for the degree of Masters in Business Administration.

Signed …….
Date …….

STATEMENT 2
The dissertation is the result of my own independent work/investigation, except where otherwise stated.
Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

Signed …….
Date …….

STATEMENT 3
I hereby give consent for my dissertation, if accepted, to be available for photocopying and for interlibrary loan, and for the title and summary to be made available to outside organisations.

Signed …….
Date ……...

ACKNOWLEDGEMENTS

I hereby wish to express my gratitude to the following individuals who enabled this document to be successfully and timeously competed.

- Dr J.J Pieterse, my promoter, for his professional and constructive guidance during the course of my research efforts.

- The Management at Ford Motor Company (Engine Plant), for their undivided time and cooperation.

- My wife, Saras and the children Sachin and Sarika, for their love and understanding.

ABSTRACT

Ford Motor Company embarked on a new engine programme, called the Rocam Engine Programme, in the year 2001. This engine was developed specifically for the European market. The customer demand rate was small initially, but ramped up slowly over time. During the low production volume period, this engine was introduced into the local market to test the publics' response. The response was overwhelmingly positive. The local market grew considerably in a short space of time. During the same time-period, the European customer demand increased, unexpectedly, by approximately 60 percent.

The additional production volume placed an enormous amount of pressure on the Engine Plant facility. Two of the production lines in particular, were taking huge strain. These lines were not producing the demand quantities, and the product quality levels were dropping quickly.

The research project is based purely on the lean manufacturing principles and philosophies. The aim of the study is to identify the deficiencies on these two production lines, thereby allowing corrective action to be taken.

The research methodology comprised of the following steps:

- A literature study was performed to give the reader a better understanding of the principles and philosophies of lean manufacturing.
- A second literature study was also performed to get a better understanding of the continuous improvement philosophies of lean manufacturing.
- A current state map, which depicts the existing situation on the line, was developed for both production lines. The existing situation was then compared to the fundamental principles and philosophies of a lean

manufacturer. In this way the deficiencies were highlighted to management.

Several recommendations were made regarding the data obtained in the study. The key ones are as follows:

- First-line management needs to be trained and coached into managing their business by using quality, cost and delivery as the key performance metrics. They also have to be trained in team dynamics. This will promote cross-functional brainstorming and problem solving sessions.

- The accurate collection and processing of base-measurement data should be treated as cardinal, and road shows by production personnel should be presented every week to top management. This will ensure that data is regularly collected and corrective action is continually taken to improve the current situation. Operating personnel needs to be trained in this discipline. Management needs to be serious about implementing lean production principles by enforcing these road shows.

- The objectives of Kaizen, production management and the supporting departments (including maintenance and MP&L) ought to be the same in the interest of maximum productivity i.e. leaning towards world class.

- First-line management must develop formal structured plans that will rectify the current on-line situation. Plans must include medium to long-term objective setting. Senior management need to coach the first-line management in this discipline.

- Few production systems can be implemented without the necessary infrastructure conducive to supporting it. An infrastructure where production gets involved and takes ownership (policy deployment with

regards to lines of communication and responsibility between Area Managers, Production Coordinators, Team Leaders and contractors) is what is required.

Lean manufacturing deficiencies on the two production lines have been identified. A detailed implementation plan, which needs to be developed by the Ford Production System department, needs to be given to management. This plan needs to address the identified deficiencies in a timely manner that will assist in the Engine Plant meeting their production targets.

TABLE OF CONTENTS

		PAGE
Declaration		(i)
Acknowledgements		(ii)
Abstract		(iii)
Table of Contents		(vi)
List of Figures		(xiii)
List of Tables		(xv)
1	INTRODUCTION, PROBLEM STATEMENT AND RESEARCH METHODOLOGY	2
1.1	INTRODUCTION	2
1.2	MAIN PROBLEM	2
1.3	SUB-PROBLEMS	3
1.4	DEFINITION OF KEY CONCEPTS	4
1.4.1	Lean Manufacturing	4
1.4.2	Lean Manufacturing Control Systems	4
1.4.3	World Class Manufacturing	5
1.5	DELIMITATION OF THE RESEARCH	5
1.5.1	The Organisation	5
1.5.2	Geographic Delimitation	5
1.6	THE RESEARCH METHODOLOGY	5
1.7	KEY ASSUMPTIONS	6

1.7.1 Assumption One 6
1.7.2 Assumption Two 6
1.7.3 Assumption Three 6

1.8 CHAPTER HEADINGS 7

1.9 CONCLUSION 8

2 CHAPTER 2 - LITERATURE STUDY OF LEAN MANUFACTURING PHILOSOPHIES 10

2.1 INTRODUCTION 11

2.2 PRINCIPLES OF LEAN MANUFACTURING 11
2.2.1 Clear goals 12
2.2.2 Low down authority for decision making 12
2.2.3 Learning new skills 12
2.2.4 No buffers of safety stock 13
2.2.5 Work teams 13
2.2.6 New material handling systems 13
2.2.7 Customer satisfaction 14
2.2.8 New model development time 14
2.2.9 Demand fulfilment 14
2.2.10 Make to order 15
2.2.11 Customer involvement 15
2.2.12 Shop floor involvement 15
2.2.13 Idea stimulation 16

2.3 PHILOSOPHIES OF LEAN MANUFACTURING 16
2.3.1 Total Quality Management 18
a. Commitment 21

b. Scientific knowledge 32
c. Involvement 33

2.4 CONCLUSION 34

3 CHAPTER 3 - KAIZEN – CONTINUOUS IMPROVEMENT 37

3.1 INTRODUCTION 37

3.2 APPLYING TOOLS OR METHODS FOR CONTINUOUS IMPROVEMENT 38
3.2.1 The Seven Mudas 38
3.2.2 Housekeeping and Workplace Organisation (Five S's) 41
3.2.3 Visual Management 43
3.2.4 The Five whys 44
3.2.5 The Five W's and the One H 45
3.2.6 Brainstorming 47
3.2.7 Statistical tools 47
3.2.8 Checklists 47
3.2.9 Benchmarking 48
3.2.10 Focused Factory Networks 48

3.3 ESSENTIAL CHARACTERISTICS OF LEAN MANUFACTURING 49

3.4 CUSTOMER FOCUSED, EMPLOYEE DRIVEN, DATA-BASED PERFORMANCE PRINCIPLES 50
3.4.1 General 50
3.4.2 Design 51
3.4.3 Operations 51
3.4.4 Human Resources 51

3.4.5 Quality and Process Improvement 51
3.4.6 Information for Operations and Control 51
3.4.7 Capacity 52
3.4.8 Promotion and Marketing 52

3.5 CONCLUSION 52

4 CHAPTER 4 - BACKGROUND OF RESEARCH ENVIRONMENT AND RESEARCH METHODOLOGY 54

4.1 INTRODUCTION 54

4.2 ROCAM CUSTOMER DEMAND HISTORY 54

4.3 MANUFACTURING PLANT AND PROCESSES 56
4.3.1 Manufacturing Assembly Plant 58
a) Shift Pattern and Schedule 58
b) Labour 58
c) Complexity 59
d) Organisation Structure 59

4.3.2 Manufacturing Machining Process 62
a) Shift Pattern and Schedule 62
b) Labour 63
c) Complexity 63
d) Organisation Structure 63

4.4 RESEARCH METHODOLOGY 64

4.5 CONCLUSION 66

5 CHAPTER 5 - ANALYSES OF FORDS' MANUFACTURING PROCESS – PRESENTATION OF RESULTS 69

5.1 INTRODUCTION 69

5.2 BLOCK MACHINING PROCESS 69
5.2.1 Current State Map 69
a) Quality 72
b) Equipment Effectiveness and Stock Holding 72
c) Build-to-schedule 73

5.2.2 People Aspects 73
a) Production Coordinator and Team Leader Interview 74
b) Observations 75
i) Overall Equipment Effectiveness 75
ii) Operator Effectiveness 83

5.3 CONROD MACHINING PROCESS 89
5.3.1 Current State Map 89
a) Quality 91
b) Equipment Effectiveness and Stock Holding 91
c) Build-to-schedule 92

5.3.2 People Aspect 92
a) Production Coordinator and Team Leader Interview 93
b) Operating Personnel Interviews 94
c) Production Coordinator and Team Leader Relationship 98

5.4 BLOCK AND CONROD MACHINING SIX SIGMA 102
5.4.1 What is Six Sigma? 102
5.4.2 Deployment 105

5.5 CONCLUSION 105

6 CHAPTER 6 - ANALYSES OF FORDS' MANUFACTURING PROCESS – INTERPRETATION OF RESULTS 108

6.1 INTRODUCTION 108

6.2 BLOCK MACHINING PROCESS 108
6.2.1 Current State Map – Interpretation of Results 108
a) Quality 108
b) Equipment Effectiveness and Stock Holding 109
c) Build-to-schedule 110

6.2.2 People Aspects 111
a) Production Coordinator and Team Leader Interview 111
b) Observations 111
i) Overall Equipment Effectiveness 111
ii) Operator Effectiveness 112

6.3 CONROD MACHINING PROCESS 114
6.3.1 Current State Map –Interpretation of Results 114
a) Quality 114
b) Equipment Effectiveness and Stock Holding 115
c) Build-to-schedule 116

6.3.2 People Aspect 116
a) Production Coordinator and Team Leader Interview 116
b) Operating Personnel Interviews 117
c) Production Coordinator and Team Leader Relationship 121

6.4 BLOCK AND CONROD MACHINING SIX SIGMA 124

6.5 CONCLUSION 125

7 CHAPTER 7 - SUMMARY, CONCLUSIONS AND RECOMMENDATIONS 128

7.1 SUMMARY 128

7.2 CONCLUSIONS 128

7.3 RECOMMENDATIONS 132

LIST OF FIGURES

		PAGE
Figure 2.1	The TQM triangle	21
Figure 3.1	Five WHYS	45
Figure 4.1	Layout of Engine Assembly Plant	61
Figure 5.1	Layout of Cylinder Block Machining Line	71
Figure 5.2	Downtime recording correlation	76
Figure 5.3	Machine utilisation summary	78
Figure 5.4	Recorded downtime summary	78
Figure 5.5	Recorded downtime – Impactability summary	80
Figure 5.6	Hidden downtime – Impactability summary	81
Figure 5.7	Total downtime – Impactability summary	83
Figure 5.8 (a)	Individual activity sampling summary	86
Figure 5.8 (b)	Total activity sampling summary	86
Figure 5.9	Layout of Connecting Rod Machining line	90
Figure 5.10 (a)	Operator assessment questionnaire	94

Figure 5.10 (b)	Completed operator assessment questionnaire	95
Figure 5.11	Operating personnel experience and training summary	96
Figure 5.12	Quality control check frequencies	97
Figure 5.13	First-line management observation summary	99
Figure 5.14 (a)	Team Leader activity summary	101
Figure 5.14 (b)	Production Coordinators expectations of the team leader	101
Figure 5.15	Statistical definition of Six Sigma	103

LIST OF TABLES

		PAGE
Table 3.1	Fives W's and One H	46
Table 5.1	Potential overall equipment effectiveness	82
Table 5.2	Operator observation study	85
Table 5.3	The goal of Six Sigma	104

CHAPTER 1

INTRODUCTION, PROBLEM STATEMENT AND RESEARCH METHODOLOGY

		PAGE
1.1	INTRODUCTION	2
1.2	MAIN PROBLEM	2
1.3	SUB-PROBLEMS	3
1.4	DEFINITION OF KEY CONCEPTS	4
1.4.4	Lean Manufacturing	4
1.4.5	Lean Manufacturing Control Systems	4
1.4.6	World Class Manufacturer	5
1.5	DELIMITATION OF THE RESEARCH	5
1.6.1	The Organisation	5
1.6.2	Geographic Delimitation	5
1.7	THE RESEARCH METHODOLOGY	5
1.7	KEY ASSUMPTIONS	6
1.8.1	Assumption One	6
1.8.2	Assumption Two	6
1.8.3	Assumption Three	6
1.9	CHAPTER HEADINGS	7
1.9	CONCLUSION	8

CHAPTER 1

INTRODUCTION, PROBLEM STATEMENT AND RESEARCH METHODOLOGY

1.1 INTRODUCTION

To remain competitive, prospective companies are developing strategies to achieve performance transcendence as they move towards the year 2003 and beyond. At present the South African motor industry is inefficient and unproductive compared to “world players” such as Japan, Germany and the United States of America. This is mainly due to the fact that the South African motor vehicle industry developed largely in an era of protectionism. (Womack, Jones & Roos, 1990:11).

Ford Motor Company will be briefly discussed, depicting the problem that they are now facing. The main problem will be identified and addressed by this study. This will be done by identifying the sub-problems, establishing and confirming the key assumptions, conducting literature studies and then deploying the philosophies and principles, identified in the literature study, to the current situation at Ford Motor Company.

1.2 MAIN PROBLEM

South African businesses are facing unforeseen opportunities and threats following the country’s remarkable political transformation that culminated in its first non-racial, democratic elections in April 1994 (Kruger, 1997:138).

Ford Motor Company has recently (June 2000) acquired SAMCOR, an engine manufacturing and component machining facility situated in Struandale, Port Elizabeth. Prior to the acquisition, SAMCOR only produced products for the local

market. This meant that most of its competitors were resident within South African boundaries. The opportunity that came with the acquisition was that of increased production volumes of a new high technology engine, which predominantly is for the export market. The associated threat is that of global competition.

Taubate engine plant, situated in Brazil, is the only other manufacturer of the Rocam engine. Should the Port Elizabeth based plant succeed in conforming to the quality, cost and delivery specifications, their volumes will increase from an existing 17000 units per annum to 240 000 units per annum in the year 2003. However, should they not meet the requirements they will lose the production volumes to the Brazilian plant.

This leads to the following problem, which will be addressed by this research:

Achieving successful implementation of lean manufacturing control systems, to achieve world-class status, at Ford Motor Company of Southern Africa.

1.3 SUB-PROBLEMS

In order to develop a research strategy to deal with and solve the main problem, the following sub-problems have been identified:

(a) What does the literature reveal about the nature of a strategy of lean manufacturing?

(b) What does the literature reveal about the nature and strategies of world-class manufacturers?

(c) What are the control systems of lean manufacturing and how does it compare to the manufacturing control systems of Ford Motor Company?

1.4 DEFINITION OF KEY CONCEPTS

1.4.1 Lean Manufacturing

Lean manufacturing may be seen as a coherent, composite management concept geared to avoiding waste in the inputs and outputs of production (lean production and beyond, 1993: 3)
It uses half the factor inputs compared with mass production – half the human effort, half the manufacturing space, half the investment in tools and half the engineering hours to develop a new product in half the time. Also, it requires keeping less than half the needed inventory on site, results in vastly fewer defects, and produces a greater and ever-growing variety of products (Womack et al, 1990: 13).

The strategic concepts underlying lean manufacturing are just–in-time; short product cycles based on simultaneous engineering; continuous improvement; multi-skilled workers organised in teams; and symbiotic relationships with supplier firms.

1.4.2 Lean Manufacturing Control System

Lean manufacturing control systems are systems that are introduced into a manufacturing concern to ensure the long-term sustainability of lean manufacturing concepts and strategies. It ensures that lean manufacturing systems are adhered to.

1.4.3 World class manufacturer

A world–class manufacturer employs some or all aspects of Just-In-time (JIT), or the likes of, in order to reduce inventories plant wide; specialise manufacturing and/or assembly; and encourage continuous one-piece flow.

1.5 DELIMITATION OF THE RESEARCH

Delimiting the research makes the research topic manageable.

1.5.1 The Organisation

This research will be conducted at Ford Motor Company of Southern Africa, an engine manufacturing plant, located in the Port Elizabeth. Attention will be focused on the manufacturing of a Rocam 1,3 litre engine.

1.5.2 Geographic Delimitation

The research will be limited to the Ford engine manufacturing plant, located in Port Elizabeth. This does not include the vehicle assembly plant, which is located in Pretoria. Reference will be made to the engine manufacturing plant in Taubate, but this is purely for comparison purposes.

1.6. THE RESEARCH METHODOLOGY

In this section the broad methodology that will be followed in the study is described.

- The researcher will initially conduct a study of the literature. This will assist the researcher in understanding the concepts of lean manufacturing control systems and world class strategies.

- An analysis will then be done on the existing manufacturing control systems at Ford Motor Company. A current state map, which will focus on the key success factors of lean manufacturers, will then be developed for the identified areas.
- The current state of the identified areas will be compared to what the literature reveals on lean manufacturing control systems. This will highlight the deficiencies, upon which corrective action can be taken.

- Recommendations will then be made, to the management at Ford Motor Company, to rectify the situation.

1.7 KEY ASSUMPTIONS

a) Assumption one

Assuming Ford Motor Company needs to compete internationally, it will have to reduce costs and improve overall quality on a permanent basis. This is the only way that they can achieve world class status.

b) Assumption two

It is assumed that Ford Motor Company's management wishes to optimise the potential that the successful implementation of a strategy of lean manufacturing control systems will deliver.

c) Assumption three

The Japanese motor industry has achieved lean manufacturing or world-class status. Assuming Ford Motor Company follows these Japanese

principles; the same results can be achieved in terms of productivity and quality.

1.8 CHAPTER HEADINGS

The research has been planned to consist of the following chapters:

Chapter 1 Introduction to Ford Motor Company, the problem statement, the definition of key concepts, research methodology and proposed chapter headings.

Chapter 2 Literature survey of prior research into lean manufacturing control systems, as well as world class manufacturing strategies.

Chapter 3 Further literature survey, specifically focusing on continuous improvement strategies that lean manufacturers have adopted and deployed.

Chapter 4 A holistic overview of Ford Motor Company, with specific regards to increased product demand from inception of the Rocam engine programme to the current situation. The research methodology will also be described in detail.

Chapter 5 An analysis of the existing manufacturing control systems at Ford Motor Company. A current state map, which will focus on the key success factors of lean manufacturers, will be developed for the identified areas.

Chapter 6 The current state of the identified areas will then be compared to what the literature reveals on lean manufacturing control systems. This will highlight the deficiencies, upon which corrective action can be taken.

Chapter 7 Summary and conclusions. In this section the researcher plans to make recommendations, based on the study, to the management of the company.

1.9 CONCLUSION

A literature survey will be conducted on the principles and philosophies of lean manufacturing. This will provide the reader with a better understanding of the concept of lean manufacturing. This will then be compared to the existing situation at Ford Motor Company, thereby highlighting any deficiencies that may exist so that corrective action can be taken. Recommendations will then be made to the management at Ford Motor Company to rectify the situation.

CHAPTER 2

LITERATURE STUDY OF LEAN MANUFACTURING PHILOSOPHIES

		PAGE
2.4	INTRODUCTION	10
2.5	PRINCIPLES OF LEAN MANUFACTURING	11
2.5.1	Clear goals	12
2.5.2	Low down authority for decision making	12
2.5.3	Learning new skills	12
2.5.4	No buffers of safety stock	13
2.5.5	Work teams	13
2.5.6	New material handling systems	13
2.5.7	Customer satisfaction	14
2.5.8	New model development time	14
2.5.9	Demand fulfilment	14
2.5.10	Make to order	15
2.5.11	Customer involvement	15
2.5.12	Shop floor involvement	15
2.5.13	Idea stimulation	16
2.6	PHILOSOPHIES OF LEAN MANUFACTURING	16
2.3.1	Total Quality Management	18
d.	Commitment	21
e.	Scientific knowledge	32
f.	Involvement	33
2.4	CONCLUSION	34

CHAPTER 2

RESEARCH OF LEAN MANUFACTURING PHILOSOPHIES

2.1 INTRODUCTION

Lean manufacturing is defined as providing a way to do more and more with less and less – less human effort, less equipment, less inventories, less time and less space – while coming closer and closer to providing customers with exactly what they want when they want it (Womack & Jones, 1996: 46).

Jackson (1996: 33) defines lean companies as follows:

> Lean companies pursue zero waste relentlessly in all processes and operations. It is about operating the most efficient and effective organization possible, with the least cost and zero waste. Lean means no waste and no fat.

In this chapter the principles and philosophies, such as Total Quality Management, of lean manufacturing will be discussed.

2.2 PRINCIPLES OF LEAN MANUFACTURING

Womack et al (1990: 14) states that a lean organisation's main goals, within a manufacturing process, are the elimination of waste and continued effort to:

- Provide world class customer service
- Reduce manufacturing lead-times
- Increase labour efficiencies
- Improve product quality
- Increase market flexibility
- Reduce inventories
- Lower the cost of overheads

Lean manufacturing addresses all aspects of business from strategic planning, to maintenance, engineering, work culture, information management and production systems. Its broad philosophies are opposite from those of the traditional systems of mass production.

Mass production is focused on maximising production efficiencies by extending run lengths, increasing levels of inventory, making to stock, having low product flexibility and dictating to the customer what and when they can have the product. Lean manufacturing focuses on only producing what the customer wants, when they want it and only in the quantities that they want.

According to the Massachusetts Institute of Technology (MIT) researchers, a lean organisation relies on several lean principles. These are:

2.2.1 Clear goals

2.2.1 Low down authority for decision making

2.2.2 Learning new skills

2.2.3 No buffers of safety stock
2.2.4 Work teams
2.2.5 New material handling systems
2.2.6 Customer satisfaction
2.2.7 New model development time
2.2.8 Demand fulfilment
2.2.9 Make to order
2.2.10 Customer involvement
2.2.11 Shop floor involvement
2.2.12 Idea stimulation

2.2.1 Clear Goals

"Lean producers … set their sights explicitly on perfection: continually declining costs, zero defects, zero inventories, and endless product variety" (Womack et al, 1990: 14).
An organisation has to have clear goals, which their employees all have to understand, to ensure its sustainability.

2.2.2 Low Down Authority For Decision Making

A key objective of lean manufacturing is to push responsibility far down the organisational ladder. Operators need to make decisions on the shop floor.
"Responsibility means freedom to control one's work – a big plus" (Womack et al, 1990: 13).
"Instruct workers to stop the whole assembly line immediately if a problem emerged that they couldn't fix" (Womack et al, 1990: 57).

2.2.3 Learning New Skills

Lean manufacturing calls for learning far more professional skills and applying these creatively in a team setting rather than in a rigid hierarchy (Womack et al, 1990: 13).

Workers need to be taught a wide variety of skills, in fact, all the jobs in their work group so that tasks can be rotated and workers can fill in for each other. Workers then need to acquire many additional skills: simple machine repair, quality checking, housekeeping and materials ordering.

Operator versatility is key to ensuring consistent acceptable product quality levels. Management has to consider the impact of absenteeism on their organisation.

2.2.4 No Buffers Of Safety Stock

The authors point out that making only a few parts before assembling them into a car caused mistakes to show up almost instantly (Womack et al, 1990: 53). This suggests that not retaining buffer stocks is beneficial. Shop floor operators produce quality products when they work in a fixed routine. Any thing other than the routine adds complexity, which negatively impacts quality.

2.2.5 Work Teams

An important aspect is to group workers into teams with a team leader rather than a foreman (Womack et al, 1990: 56). This supports the concept of decision-making at the lowest levels of the organisation. Management are not always on the shop floor. Operating personnel have to be empowered to make decisions on the shop floor.

2.2.6 New Material Handling Systems

New ways are sought to co-ordinate the flow of parts within the supply system on a day-to-day basis. These include the famous just-in-time system; called KANBAN at Toyota (Womack et al, 1990: 62).
Continuous production flow is a key attribute of lean manufacturers. It enhances product quality by keeping production operators in their work routine. It also reduces complexity management on the shop floor.

2.2.7 Customer Satisfaction

Womack et al (1990:64) cites an example of the importance of customer satisfaction:

> Consumers began to report that the most important feature of their car or truck was reliability. Because the Toyota system could deliver superior reliability, soon Toyota found that it no longer had to match exactly the price of competing mass-production products.

High customer satisfaction levels always results in high sales, which enhances the business long-term sustainability.

2.2.8 New Model Development Time

To change production and model specifications in mass-production firms takes a long time and is very expensive. By contrast a pre-eminent lean manufacturer such as Toyota needs half the time and effort required by a mass-producer such as General Motors to design a new car. This means that Toyota can offer twice as many vehicles with the same development budget (Womack et al, 1990:64).
In the ever-changing competitive environment, one has to beat ones competitor in almost every category to stay on the top. By developing new models in less time, an organisation develops an edge over its competitor.

2.2.9 Demand Fulfilment

All of the variety available from lean manufacturing would be for nought if the organisation could not build what the customer wanted (Womack et al, 1990: 66). Satisfying the customer is a lean manufacturers number one priority. The customer needs to be satisfied at all times if the organisation wants to survive. An organisation cannot effectively sustain over the long term if the customer is not kept happy.

2.2.10 Make To Order

At Toyota, the dealer became part of the production system as the organisation gradually stopped building cars in advance for unknown buyers and converted to a build-to-order system (Womack et al, 1990: 67).
Build-to-stock is an outdated practice, which adds no value to the bottom line of an organisation. Finished stock only adds value to the organisation once it is sold to the customer.

2.2.11 Customer Involvement

The system also incorporated the buyer into the product development process. In a very direct way, Toyota focused relentlessly on repeat buyers, going directly to its existing customers in planning new products (Womack et al, 1990: 67). The customer has to be involved at all times. His feedback has to be taken into account. If the customer is not entirely happy with the product, then the manufacturer has to change it accordingly. This is key to the success of the organisation.

2.2.12 Shop Floor Involvement

Womack et al (1990:99) has this to say on the importance of shop floor involvement:

> All information – daily production targets, cars produced so far that day, equipment breakdowns, personnel shortages, overtime requirements and so forth – are displayed on andon boards (lighted electronic displays) that are visible from every work station.

The operating personnel on the shop floor have to be involved at all times. They are the ones producing the products therefore they should be involved at all times. They need to know the status of the organisation at all times.

2.2.13 Idea Stimulation

There is also an emphasis on obtaining suggestions from employees.

"Then they need encouragement to think actively, indeed pro-actively, so they can devise solutions before problems become serious" (Womack et al, 1990: 99).

In summary there are three main issues that are constantly repeated throughout the MIT findings. They are an emphasis on:

- Good leadership with the necessary authority at all levels.
- A good team with members that support each other and cross training.
- Good communication between all stakeholders to create the required synergy.

2.3 PHILOSOPHIES OF LEAN MANUFACTURING

Organisations can use many different strategies and approaches to achieve the objectives of Lean manufacturing. An example of this is the adoption of the principal of reducing inventory and work-in-progress as advocated in the Just-in-time production philosophies. "Kaizen" or the "Continuous Improvement"

concept, which forms the cornerstone of Toyota's manufacturing philosophy, is also a fundamental aspect of Lean manufacturing.

Lean thinking is a conceptual approach towards manufacturing that adopts a broad range of principles that are continually striven towards. It does not prescribe a specific approach or method of attaining these goals. Over the past three decades, many different manufacturing techniques and philosophies have become popular and are used to assist organisations to work towards the goals of Lean manufacturing. Some of these have included:

- Total Quality Management
- MRP and MRP II (material resource planning)
- Theory of Constraints
- Just-in-time
- Kanban
- Kaizen
- Simplification
- Customer Care
- Enterprise Resource Planning
- Quality Circles
- Visual Management
- Bench Marking

This research aims to achieve successful implementation of lean manufacturing control systems on the manufacturing process of the Rocam 1,3 litre engine. The quality, cost and timeous delivery of this product to the customer is mandatory if the Engine Plant wants to retain the business. Failure to conform to any of those requirements will result in the loss of the Rocam export contract. Ford of Southern Africa has the cost advantage over the other competing Ford engine plants throughout the world. This is mainly due to the weak Rand. This was the main contributor, thus far, to the acquisition of the export contract.

Quality and delivery of the product has to be improved upon to ensure the sustainability of the export contract.

"Quality is the single most important weapon in the achievement of competitive advantage. The customer demands it, and the company that cannot provide it loses to the competitor that can" (Logothetis, 1992: 448).

It is thus essential that Total Quality Management, as well as Kaizen (continuous improvement), be introduced to the reader to give a more in-depth understanding of some of the fundamental philosophies of Lean manufacturing.

2.3.1 Total Quality Management

Logothetis (1992: 1) states that it is increasingly being recognized that a high quality of product and service, and their associated customer satisfaction, is the key to survival for any enterprise. The nature of the current worldwide competition generally demands from any corporation the following four types of ability characteristic:

- To understand what the customer wants and to provide it, immediately on demand, at the lowest cost.
- To provide products and services of high quality and reliability consistently.
- To keep up with the pace of change, technologically as well as politically and socially.
- To be one step ahead of the customer's needs; that is, to predict what the customer will want one year or ten years from now.

Logothesis (1992: 1) states:

> Of course, as Deming says: 'You don't have to do this; survival is not compulsory!' But the fact is that any company, which lags behind in terms of any of the above characteristics, will inevitably be overtaken by a competitor.

Logothetis (1992: 1) further states that the attainment of those abilities requires an organised approach to management – an approach of managing for total quality, of managing for effectiveness and competitiveness, involving each and every activity and person at all levels in the organisation.
"This is the total quality management (TQM) approach" (Logothetis, 1992: 1).

This approach usually demands a total transformation of the existing management culture. There is no room for complacency or half-hearted measures. There is no alternative. If the quality revolution is to take root and succeed, a brand new culture will be required. TQM is such a culture – a culture advocating a total commitment to customer satisfaction through continuous improvement and innovation in all aspects of the business.

Logothesis (1992: 2) has this to say about the customer:

> The customer in the TQM culture is not intended to mean only the final recipient of the corporation's end-product or service. The customer is also every individual or department within the organisation, which is now viewed as a chain of which only the final part is the external customer.

This makes everyone a customer of, and a supplier to, someone else, with quality inputs and outputs demanded and expected at every part of the supply chain.

Having as a basis the above definition of a customer, the actions required for the achievement of customer satisfaction now becomes the everyday duties of every individual or division within the organisation. Some of those routine duties could be as follows:

- To monitor performance and customer satisfaction levels.
- To identify improvements necessary in the customer interface.
- To deliver improved customer products and services at the lowest cost.
- To assess and agree to the customer's requirements.

- To tailor output to the customer's demand.

When appropriate company policies have firmly been established so that activities such as above, and the TQM definition of the customer, becomes second nature for every employee in the company then the TQM culture will have been established (Logothetis, 1992: 2).

Logothetis (1992: 2) further states that:

> Major achievements include cost reduction and corporate success. But removal of waste, reduction of cost, improvement of reputation and increased market share are not the objectives; they are simply the natural consequences. Continuous improvement and innovation are the objectives, if, that is, one can give such a name to a non-static, updating and never-ending process. It is an objective without a completion date, because nothing can ever be immune from further improvement; new technologies, methods and attitudes or the presence of innovators and advocates of change will make sure of that.

In a TQM culture, the top managers are themselves the advocates of change. They must be, because no improvement can ever materialise without a change in the old management attitudes (Logothetis, 1992: 3).

Logothetis (1992: 3) has this to say about a company's success:

> Progress and success for a company, therefore, can materialise only when a committed management accepts the challenge of change, and becomes the leader in defining a (new) total quality policy and in creating the conditions to enable everybody to fit into this policy.

TQM provides an environment where employee fear is eliminated, where all the employees take pride in their work, where they feel respected and accepted, where they feel part of the same team, and where they strive not only for their own interests, but also for the interest of the whole organisation. TQM needs the establishment of the following three fundamental characteristics:

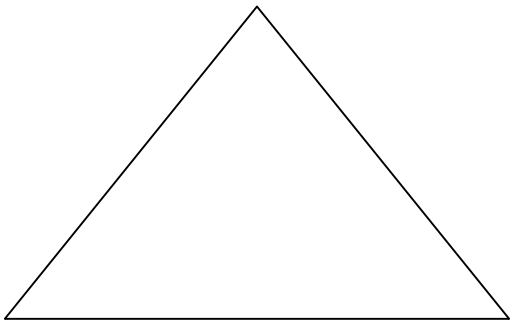
a) Commitment (to never-ending quality improvement and innovation).

b) Scientific knowledge (of the proper tools and techniques for the technical change).
c) Involvement (all in one team, for the social change) (Logothetis, 1992: 3).

The above characteristics are the axioms of the TQM culture. They are of equal significance, something that can be expressed by putting them on the corners of an isosceles triangle, as Figure 2.1 below reflects.

Figure 2.1: The TQM triangle

Axiom 1: Commitment



Axiom 3: Involvement Axiom 2: Scientific Knowledge

Source: Adapted from (Logothetis, 1992: 4)

a) <u>Commitment</u>

A management commitment to continually improve the quality of products and services sounds an obvious necessity, but it is not an easy commitment to adhere to. For some organisations this might require a complete shift from the old style of management, a total cultural transformation in the company. There is no alternative, no easy way out. Quality is the major determining factor in the choice of the customer, who is not prepared any more to accept second best, however attractive the price (Logothetis, 1992: 5).

"The customer's ever-increasing expectations demand the urgent reconsideration of current practices and the development of a new strategy driven by a management-led focus on total quality" (Logothetis, 1992: 5).

Senior managers should be the ones to plan, initiate and coordinate the quality improvement process and keep up the momentum when the initial enthusiasm dies down. This requires appropriate and adequate training and education, not just for the workforce but also for the managers themselves, who should be the first to demonstrate their commitment by active participation in quality improvement projects (Logothetis, 1992: 5).

William Edwards Deming was one of the quality gurus who achieved great success throughout the world with regards to improvements in quality. The successful implementation of his statistical approach by Japanese industry has been the main contributor to Japan's attainment of its worldwide reputation for quality products and services (Logothetis, 1992: 26).

Logothetis (1992:28) summarises the respect that the Japanese industry has for W.E Deming:

> Each year since 1951, the Japanese industry has awarded the highly valued Deming Prize to a company or individual that or who has actively contributed to the spread and development of statistical techniques for quality improvement.

Doctor Deming provides a framework for action with his fourteen points for management, which if properly appreciated and accepted, can lead to a permanent change (for the better) in the thinking of top management, and to a beneficial transformation of the whole company culture (Logothetis, 1992: 26).

Doctor Deming's fourteen points, which will be discussed, are as follows:

- <u>Deming's Fourteen Points for Management</u>

i) Create constancy of purpose for continual improvement of product and service.
ii) Adopt the new philosophy for economic stability.
iii) Cease dependence on inspection to achieve quality.
iv) End the practice of awarding business on the basis of price tag alone.
v) Improve constantly and for ever the system of production and service.
vi) Institute training on the job.
vii) Adopt and institute leadership.
viii) Drive out fear.
ix) Break down barriers between departments and individuals.
x) Eliminate slogans, exhortations, and targets for the workforce.
xi) Eliminate work standards and numerical quotas.
xii) Remove barriers that rob the hourly worker of the right to pride in workmanship.
xiii) Encourage education and self-improvement for everyone.
xiv) Take action to accomplish the transformation.

i) <u>Create constancy of purpose for continual improvement of product and service</u>

Your customers, your suppliers, your employees need your statement of constancy of purpose – your intention to stay in business by providing products and services that will help man live better, and that will have a market (Deming, 1986: 26).

Long-term constancy of purpose for continuous improvement and innovation is an obligation that management should accept as a number one priority. Resources have to be allocated for long-term planning with the faith that there will be a future. This faith has to be demonstrated continuously on a day-to-day basis by top management in order to motivate employees and convince them of the seriousness of their efforts.

ii) Adopt the new philosophy for economic stability

A change is necessary in the old management methods, which are no longer effective for today's business environment. Without innovation you can never lead. If you try to meet the competition, you will not survive in the new economic age. We can no longer live in the days when quantity was more important than quality; but what has to be realized is that higher quality costs less (Logothetis, 1992: 31).

Management must fully appreciate the challenge and accept the obligation to change; accept change in order to become economically stable.

iii) Cease dependence on inspection to achieve quality

Routine 100% inspection to improve quality is equivalent to planning for defects, acknowledgement that the process has not the capability required for the specifications. Inspection to improve quality is too late, ineffective and costly (Deming, 1986: 28).

Quality comes not from inspection, but from improvement of the production process. Build quality into the product at the development/design stage through off-line quality control, and maintain it or improve further during normal production through on-line quality control of the process that produces the product.

iv) End the practice of awarding business on the basis of price tag alone

We can no longer leave quality, service, and price to the forces of competition for price alone – not in today's requirement for uniformity and reliability.

Price has no meaning without a measure of the quality being purchased. Without adequate measures of quality, business drifts to the lowest bidder, low quality and high cost being the inevitable result. The aim in purchase of tools and other equipment should be to minimize the net cost per hour of life. This requires long-term thinking, not just cheapest price tag for purchase today (Logothetis, 1992: 33).

Price should not be the sole reason for awarding business. Many things have to be taken into account before a decision can be made. One has to take the overall impact on the business into account before making a decision

v) Improve constantly and for ever the system of production and service

Search continually for problems in order to constantly improve quality and productivity and decrease costs. Always try to reduce the variability of products and services, in order to achieve the highest quality at the lowest cost. Never be satisfied with simply meeting current standards or specifications.

Logothetis (1992: 34) states:

> "It is management's job to work continually on the system (design, research and development, incoming materials, maintenance, process improvement, training, communication and supervision) and not turn a blind eye to chronic problems or let things ride until they become problematic, by which time it is usually too late. Always anticipate trouble and never be content. Seek out potential problems and solve them before they cause harm. Prevent rather than firefight."

Continuous improvement, in all aspects, has to be promoted by management. The organization has to delight the customer with its product. This is the only way to retain and grow the existing business.

vi) Institute training on the job

"Training must be totally reconstructed. Management needs training to learn about the company, all the way from incoming material to the end customer" (Deming, 1986: 52).

If top managers make themselves subject to education and training, they can provide an example for the rest of the employees to emulate. Efficient and modern methods of training allow a company better use of all its employees. Training and education are the corner stones of greater consistency.

vii) Adopt and institute leadership

Deming (1986: 54) states:

> The job of management is not supervision, but leadership. Management must work on sources of improvement, the intent of quality of product and of service, and on the translation of the intent onto design and actual product. The required transformation of Western style of management requires that managers be leaders.

Efforts should be focused on helping people and machines to do a better job. Supervisors must ensure that immediate action is taken on reports of defects, poor tools and conditions detrimental to quality. Leadership and supervision should concentrate on making the workers take more interest in their work. An interested worker will want to do the job well and will accept advice, training and help towards doing it better. If this is achieved, the worker's interest will increase even further.

viii) Drive out fear

No one can put in his best performance unless he feels secure. Secure means without fear, not afraid to express ideas not afraid to ask questions. Fear takes on many faces. A common denominator of fear in any form, anywhere, is loss from impaired performance and padded figures. (Deming, 1986: 59).

Two-way communication should be encouraged so that fear is driven out of the organization. In this way everybody may work more effectively and more productively for the company. Management by fear does not serve the best interests of the company. It leads to a reduction in efficiency and in decision quality.

ix) Break down barriers between departments and individuals

The performance of any individual department should be evaluated in terms of its contribution to the company as a whole, not for its individual profit or to any other measure that promotes competitiveness. Lack of proper communication inhibits the company-wide development of the innovative idea, which thus remains just an idea. The common language of simple statistical techniques is extremely effective in enabling people to appreciate each other's problems and contribute to their solution. Everybody is a customer of somebody else along the process line, and the sooner this is fully appreciated, the better the chance for team spirit to flourish (Logothetis, 1992: 39).

All departments within an organisation must work towards the corporate objective, and not towards its departmental objective. All departmental objectives should be developed from the corporate objective. This will ensure that everyone works as a team, and not in isolation. This fosters team work, and in so doing promotes quality.

x) Eliminate slogans, exhortations, and targets for the workforce

What is wrong with posters and exhortations? They are directed at the wrong people. They arise from management's supposition that the production workers could, by putting their backs into the job, accomplish zero defects, improve quality, improve productivity, and all else that is desirable. The charts and

posters take no account of the fact that most of the trouble comes from the system (Deming, 1986: 65).

Eliminate slogans, exhortations, and targets for the workforce that urges them to increase productivity. Posters and slogans have never helped anyone to do a better job.

xi) Eliminate work standards and numerical quotas:

Eliminate management by objectives (MBO), by numbers and by numerical goals. Focus on quality not quantity. The attainment of a target must not be viewed as the ultimate success, because there is always room for further improvement. MBO neglects the variation in the processes and it is an invitation to short-term thinking. The only way to increase quality and productivity (and joy in work) is to replace work standards with competent leadership (Logothetis, 1992: 41).

MBO must be replaced by MBIO: management by improvement objectives. If there is an objective to be set, it should be that of constancy of purpose for continuous quality improvement of products, processes and services, an objective that is not specific in detail in the form of a numerical target in isolation. This objective should always be a real consensus rather than a top-down mandate, and should be supported by continuous training and sustained cooperation involving everybody from the top management down (Logothetis, 1992: 42).

Work standards and numerical quotas mean nothing to workers if they cannot realistically achieve it. Also, it sets the mindset for the workforce that they should only achieve a specific amount. This does not focus on continuous improvement, and therefore is not in line with the attributes of a lean manufacturer.

xii) Remove barriers that rob the hourly worker of the right to pride in workmanship

It is widely accepted that eliminating physical and mental obstacles facilitates communication, encourages cooperation and improves the overall morale of employees. The most serious of mental obstacles are those that do not allow pride in workmanship. MBO is one of them; the annual merit rating (performance appraisal) is another. Indeed, one cannot expect workers to be proud of their output when it consistently turns out to be defective because of faulty purchased materials, faulty equipment or poor working environment, the provision of which is a management responsibility (Logothetis, 1992: 42).

The appraisal procedure should be replaced by proper leadership and communication and by a counseling and development procedure, whose main purpose would be to identify, sustain or develop further the employee's contributions towards the continuous improvement of the organization as a team (Logothetis, 1992: 43).

Operators must be proud of their work place, and have pride in what they do. It is the responsibility of management to provide such an environment.

xiii) Encourage education and self-improvement for everyone

Deming (1986: 86) states:

> What an organization needs is not just good people; it needs people that are improving with education. People require in their careers, more than money, ever-broadening opportunities to add something to society, materially and otherwise

Encourage continual training to keep up with new developments, changes in product design and machinery, and innovative techniques. Re-education must

be treated as an investment, not an expense, and the people must be treated as an asset, not a commodity (Logothetis, 1992: 45).

An educated workforce will produce quality products on time every time. Management must be committed to educating their employees.

xiv) Take action to accomplish the transformation:

Management should immediately take action to accomplish the transformation by implementing all the preceding thirteen points. All employees must understand and be committed to the new philosophy. Senior managers must lead the way by fully committing themselves to continuous quality improvement and innovation, and by practicing whatever they preach (Logothetis, 1992: 45).

Leadership in statistical methodology must predominate in any attempt to achieve the transformation. This is simply because quality is what counts these days, and proper implementation of statistical techniques always leads to quality improvements and innovations (Logothetis, 1992: 46).

- Overview

Deming's fourteen points can be developed into five concepts for an effective TQM program:

i) Continuous improvement
ii) Employee empowerment
iii) Benchmarking
iv) Just-in-time (JIT)
v) Knowledge of TQM tools

i) Continuous improvement:

Total Quality Management (TQM) requires a never-ending process of continuous improvement that covers people, equipment, suppliers, materials, and procedures. The basis of the philosophy is that every aspect of an operation can be improved and that total perfection is sought, but never achieved.

ii) Employee empowerment:

This means involving employees in every step of the production process. Techniques for building employee empowerment include: building communication networks that include employees; developing open, supportive supervisors; moving responsibility from both manages and staff to production employees; building high-morale organizations and creating such formal organizational structures as teams and quality circles.

iii) Benchmarking:

Benchmarking involves selecting a demonstrated standard of products, services, costs, or practices that represent the very best performance for processes or activities very similar to your own. The idea is to develop a target at which to shoot and then to develop a standard or benchmark against which to compare your performance.

iv) Just-in-time (JIT):

JIT systems are designed to produce or deliver goods just as they are needed. Therefore, JIT reduces the amount of inventory that a firm has on hand by establishing quality and purchasing controls that bring inventory to the firm just-in-time for use. Scrap, rework, inventory investment and damage costs are

reduced; lead time shrinks and keeps evidence of errors fresh; no more poor production performance resulting from unreliable quality.

v) Knowledge of TQM tools:

To empower employees and implement TQM as a continuing effort, everyone in the organization must be trained in the techniques of TQM.

b) Scientific knowledge

There is no excuse any more for passing the responsibility for quality to others. Tools do exist; tools for the manager, tools for the technician, tools that can be utilised by both the manager and the technician. There is a scientific theory supporting each of those tools, something that validates them beyond doubt. Their value has already been proved in practice, in a way that convinces even the most difficult unbeliever. There is no excuse any more not to use them (Logothetis, 1992: 7).

"Apart from providing … they help in the assignment of responsibilities; they provide exact boundaries which fairly separate everybody's duties and obligations concerning quality" (Logothetis, 1992: 7).

The workers now know where responsibilities for quality end, and where those of management begin; this knowledge is not contaminated by meaningless slogans, unjustified opinions, emotions or unrealistic expectations.

"What is needed is emphasis on continuously improving the process that produces the product, perhaps from as early on as its design stage" (Logothetis, 1992: 7).

The role of the TQM quality department should be that of coordination, education and support of scientific quality tools throughout the organisation. Its best role

should be that of the source of scientific knowledge and the advocate of the belief that everybody should be responsible for quality (Logothetis, 1992: 7).

"Given the necessary scientific tools, every individual can pinpoint a cause of bad performance and take care of it as soon as possible, thus … probably too late" (Logothetis, 1992: 7).

Everyone needs to be trained to be able to apply scientific tools within the organisation.

c) Involvement

If Axiom 1 and Axiom 2 are concerned respectively with structural and technological aspects, Axiom 3 is concerned with the social aspect. No TQM initiative has any chance of bringing about a TQM culture unless the social factor is properly addressed, because total quality is not about a particular quality manager. It concerns everybody in the company and it requires a new social attitude and a new network of relationships (Logothetis, 1992: 8).

Logothetis (1992: 8) on quality pursuit:

> Involving everybody in the common pursuit of quality will ensure that all interdependent processes can function to their maximum capacity, and can be seen to do so right the way through.

The capability for solving problems increases many times when there is a common effort. When problems are discussed in brainstorming sessions, they are more likely to be examined critically and in detail. Team members help each other to rule out mistakes and to provide many potential solutions. A team brings together a vast amount of skill in problem solving and idea generation. In the end, there is a greater chance for a right solution to emerge from averaging out many potential solutions.

2.4 CONCLUSION

The principles of Lean Manufacturing have been discussed so as to give the reader a good understanding of the basic disciplines of Lean Manufacturing. Lean Manufacturing focuses on providing the customer with exactly what he requires. This is provided at the required quality level, at the required time, and in the required quantities. The manufacturing concern utilises minimal resources to produce the products.

Total Quality Management has also been discussed so as to give the reader a full understanding of what TQM really means, as well as what companies have to do to successfully implement TQM. TQM focuses on building quality into the product. It aligns all employees to the corporate objective, thereby eliminating misaligned departmental objectives.

Kaizen, and the principles thereof will be discussed in chapter 3. This will give the reader a further understanding of the philosophies of lean manufacturing, specifically with regards to continuous improvement.

CHAPTER 3

KAIZEN – CONTINUOUS IMPROVEMENT

		PAGE
3.5	INTRODUCTION	37
3.6	APPLYING TOOLS OR METHODS FOR CONTINUOUS IMPROVEMENT	38
3.6.1	The Seven Mudas	38
3.6.2	Housekeeping and Workplace Organisation (Five S's)	41
3.6.3	Visual Management	43
3.6.4	The Five whys	44
3.6.5	The Five W's and the One H	45
3.6.6	Brainstorming	47
3.6.7	Statistical tools	47
3.6.8	Checklists	47
3.6.9	Benchmarking	48
3.6.10	Focused Factory Networks	48
3.7	ESSENTIAL CHARACTERISTICS OF LEAN MANUFACTURING	49
3.8	CUSTOMER FOCUSED, EMPLOYEE DRIVEN, DATA-BASED PERFORMANCE PRINCIPLES	50
3.8.1	General	50
3.8.2	Design	51
3.8.3	Operations	51
3.8.4	Human Resources	51
3.8.5	Quality and Process Improvement	51
3.8.6	Information for Operations and Control	51

3.8.7 Capacity 52
3.8.8 Promotion and Marketing 52

3.5 CONCLUSION 52

CHAPTER 3

KAIZEN – CONTINUOUS IMPROVEMENT

3.1 INTRODUCTION

Womack, Jones and Roos (1990: 149) has this to say on the definition of Kaizen:

"Improvements in lean-production companies should, in fact, come much faster – that is, learning curves should be much steeper because of *Kaizen*, the continuous incremental improvement in the production process."

"In a working environment, *Kaizen* means continuous process improvement involving everybody" (Logothetis, 1992: 90).

Masaaki Imai (1986: xx) has this to say about Kaizen:

> KAIZEN means improvement. Moreover it means continuing improvement in personal life, home life, social life, and working life. When applied to the workplace KAIZEN means continuing improvement involving everyone – managers and workers alike.

KAIZEN is generally accepted to mean continuous small improvements without substantial capital outlay (Imai, 1986: 4).

In this chapter Kaizen (the second philosophy of lean manufacturing), the essential characteristics of lean manufacturing, and a way of measuring the organisation's closeness to being a lean manufacturing enterprise as a strategy are discussed.

3.2 APPLYING TOOLS OR METHODS FOR CONTINUOUS IMPROVEMENT

Ten checkpoints, which will be discussed, have been identified as a means of becoming lean and each should be used when necessary in the continuous improvement process.

The ten checkpoints are as follows:

3.2.1 The Seven Mudas

The seven mudas, the first checkpoint, is the most important tool of all because it makes one aware of all possible waste. Only once a problem is identified can corrective action be taken. These wastes must be eliminated before true standard operation is possible.

“Muda” is the Japanese word for waste. Suzaki (1987: 8) describes waste as anything other than the minimum amount of equipment, materials, parts, space, and worker’s time, which are absolutely essential to add value to the product.

Taiichi Ohno, the man who pioneered the Toyota Production System, classified the waste incurred in the production process into the following categories:

i) Waste from overproduction
ii) Inventory waste
iii) Waste of waiting time
iv) Transportation waste
v) Waste from defect making
vi) Waste of motion
vii) Processing waste (Imai, 1986: 89).

i) Waste from Overproduction

The Toyota Production System concluded that overproduction is one of the worst wastes commonly found in factories. Producing goods over and above the amount required by the market creates this waste (Suzaki, 1987: 12).

Taiichi Ohno felt that overproduction was the central evil that led to waste in other areas. To eliminate the problem of waste, Ohno devised a production system based on a “just-in-time” and “autonomation” concept (Imai, 1986: 89).

ii) Inventory Waste

Excess inventory increases the cost of a product. It requires extra handling, extra space, extra interest charges, extra people and extra paperwork. We should consciously try to reduce inventory levels at all times. As we begin to reduce inventory levels, we may find more problems that need to be addressed before the inventory level can be reduced further (Suzaki, 1987: 17).

iii) Waste of Waiting Time

While waste from overproduction is not always easy to identify because the operators appear to be busy, waste of waiting time is usually easy to identify. Waste in the form of waiting should be exposed, so that corrective action can be taken. Supervisors can thus better assess the capacity and control the situation more readily (Suazaki, 1987: 14).

iv) Transportation Waste

Transportation waste and double or triple handling is also commonly observed wastes in most factories. Ill-planned layouts may make long-distance transportation necessary. In order to eliminate this waste, improvement in layout, coordination of processes, methods of transportation, housekeeping, and workplace organisation need to be considered (Suzaki, 1987: 15).

v) Waste from Defect Making

When defects occur at one station, operators at subsequent stations waste time waiting, thereby adding cost to the product and adding to production lead-time. Furthermore, rework may be required or the defective products are scrapped. If a defect has occurred in the assembly, operation, additional labour is required to disassemble the product, and additional parts are required for reassembly. Schedules must then be adjusted to accommodate these changes (Suzaki, 1987: 18).

vi) Waste of Motion

Whatever time is not spent in adding value to the product should be eliminated as much as possible. One thing to constantly bear in mind is that “move” does not necessarily equal “work”. An operator may keep “busy” for hours looking for tools all around the factory without adding any value to the product. Instead, he has increased the cost of the product by his idle hours (Suzaki, 1987: 14).

vii) Processing Waste

The processing method itself may be a source of problems, resulting in unnecessary waste. When fixtures are not well maintained or prepared, operators may have to use extra effort in processing the materials (Suzaki, 1987: 16).

3.2.2 Housekeeping and Workplace Organisation (Five S’s)

If one takes pride in the workplace, he/she is more likely to produce the necessary quality. Accordingly a clean, well organised plant tells one more than any financial statement can (Suzaki, 1987: 26).

Housekeeping ties in closely with many important aspects of management, including operator's morale, management-labour relationships, and level of improvement activities. One should understand the linkage between the level of housekeeping and the amount of defective products produced, the number of machine breakdowns, routing of material flow, inventory level, number of suggestions, level of absenteeism, and so on (Suzaki, 1987: 26).

Housekeeping is closely tied to better workplace organisation. The ultimate goal is to reduce the cost of the product. Clean surfaces exposes problems such as oil leaks and cracks so that corrective action can be taken as early as possible (Suzaki, 1987: 27).

The five S's are:

i) Seiri (Simplification)

Dispose of unnecessary goods and simplify the work environment (Imai, 1986: 233). Sift out what is not needed. Often as time progresses and operators feel the pressure of the moving line, objects of no use collect in their work areas and can only cause chaos. These items must be removed because they create wasted space and confusion.

ii) Seiton (Store)

Designate location by address, line and colour coding (Suzaki, 1987: 30). Things must be kept in order so that they are ready for use when needed (Imai, 1986: 233).

Suzaki (1987: 25) states the definition of store:
"A place for everything, and everything in its place."

In this way time spent looking for things is eliminated, and visual management is exercised by instantly determining whether a tool is being correctly stored, used or is missing.

iii) Seiso (Sparkle)

Suzaki (1987, 30) defines sparkle as to sweep, wash and maintain the best conditions starting with personal appearance.

iv) Seiketsu (Support)

Support is the most important of the five S's as it ensures that the above three conditions are constantly maintained. The hardest part of any system seems to be sustenance. Adherence by the operator shows that he/she is serious about his/her work. As stated by Suzaki (1987: 30):
"Safety and ease of operation are tied to respect for the individual".

v) Shitsuke (Self Discipline)

This refers to the individual following procedures, standards and rules, as decided by management and unions as being in the best interest of the company and individual.

Suzaki (1987: 30) aptly sums up this point:
"Make incorrect practices visible to everyone so correct practices are learned right away".

3.2.3 Visual Management

This is a tool using sense of sight to exercise control. Before this can be done there must be standardisation so that if something goes wrong simply looking at

it easily identifies it. Standardisation is established using a process over a certain time frame.

Suzaki (1987, 94) presents the following as the definition of “andon” and visual management:

> On the …, in a well-managed factory, improvement projects are pursued actively and problems are exposed quickly so that corrective action can be taken. This is fundamental to good management. But abnormal conditions and problems need to be obvious enough to catch people’s attention. Andon is used as a tool to do this. *Andon* means ‘lantern’ in Japanese. Just as a lantern may guide people walking in the dark, an andon light helps expose abnormal condition in the factory. Because of the emphasis on visual methods for quick information transfer, the practice is called *‘management by sight’* or *‘visual control*.

Andon lights, buzzers, and video cameras facilitate information transfer without delay. When factory operations are linked by these means, the factory functions similar to our reflexive muscle system. Corrective action is taken immediately, just as our muscles pull our hand away when we touch a hot plate (Suzaki, 1987: 95).

Whenever an abnormal condition exists, the system will give a signal requiring that timely corrective action be taken. In order to develop such a system, andon, kanban (just-in-time material replenishment system), production control boards (used to visually convey actual production activities), and the likes are used to facilitate the transfer of important information as quickly as possible. These are, in effect, forms of just-in-time information transfer in the factory. Because of their visual nature, these means are called visual control tools (Suzaki, 1987: 107).

Suzaki (1987: 109) gives the following examples of visual controls:

- Identification of operating conditions: meters, gauges, valves, and the like may be marked to indicate the normal operating conditions so that anyone can understand them.
- Housekeeping: When tools are stored in different locations according to individual preference, confusion and associated loss of time will result when several people have to use them.
- Kanban, parts storage area: inventory levels may be controlled by using kanban cards and / or a maximum height indicator in the storage area.
- Recognition / information feedback: The idea is to develop an open management system which is self-explanatory even for visitors who are unfamiliar with plant activities.

3.2.4 The Five whys

One of the most simple tools to use when faced with a problem is to ask the question “Why am I having this problem?” and then to answer your own question. Then ask “why” again to your first answer and repeat this a total of five times to try and reach the root cause of the problem.

Suzaki (1987, 116) summarises the five whys as follows:

> “The process of questioning should be persistent, so that problems do not recur. As Taiichi Ohno of Toyota comments, if we ask “why” five times, we may be able to capture the true cause of the problem.”

Figure 3.1: Five Whys

Problem: Malfunction of digital controller for NC machine

Why → Defective printed circuit board
Why → Lack of cooling
Why → Lack of air
Why → Lack of pressure
Why → Dust on filter

Solution: Clean filter every month

Source: Adapted from (Suzaki, 1987: 116)

Figure 3.1 is an example of the five why approach. By asking the question five times, the root cause of the problem becomes evident.

3.2.5 The five W's and the One H

This is another simple questioning tool, which can be applied to any situation by almost anyone. Imai (1986: 235) developed the following table, which incorporates the five W's and one H:

Table 3.1: Five W's and One H

Who	What	Where
1. Who does it? 2. Who is doing it? 3. Who should be doing it? 4. Who else can do it? 5. Who else should do it? 6. Who is doing 3-Mus?	1. What to do? 2. What is being done? 3. What should be done? 4. What else can be done? 5. What else should be done? 6. What 3-Mus are being done?	1. Where to do it? 2. Where is it done? 3. Where should it be done? 4. Where else can it be done? 5. Where else should it be done? 6. Where are the 3-Mus being done?
When	**Why**	**How**
1. When to do it? 2. When is it done? 3. When should it be done? 4. What other time can it be done? 5. What other time should it be done? 6. Are there any time 3-Mus?	1. Why does he do it? 2. Who does it? 3. Why do it there? 4. Why do it then? 5. Why do it that way? 6. Are there any 3-Mus in the way of thinking?	1. How to do it? 2. How is it done? 3. How should it be done? 4. Can this method be used in other areas? 5. Is there any other way to do it? 6. Are there any 3-Mus in the method?

Source: Adapted from (Imai, 1986: 235)

3.2.6 Brainstorming

Brainstorming is based on the principle that more heads are better than one. When there is a problem and a solution needs to be found, all the affected people gather together to have a brainstorming session.

Imai (1986: 96) states that brainstorming sessions are frequently held by small-group activities. He believes that small-group activities should be deployed throughout organisations that want to become lean or world-class.

3.2.7 Statistical Tools

Statistical tools are tools that can be deployed to solve problems when the data is available for analysis. The seven statistical tools used for such analytical problem solving are:

1. Pareto diagrams
2. Cause-and-effect diagrams
3. Histograms
4. Control Charts
5. Scatter diagrams
6. Graphs
7. Checksheets

These tools are used widely by QC circles, small goups, managers and engineers for identifying and solving problems (Imai, 1986: 239).

3.2.8 Checklists

The “4 M” checklist refers to man, machine, material and method. There are 10 check questions with regard to each of the 4 M’s. Each question requires only a

yes or a no answer, and if the answer is not desired action can be taken to correct it.

Man refers to the operator, Machine refers to the facilities, Materials is straightforward, and Method refers to the operation. A typical question from each heading is taken to demonstrate the effect:

Man	-	Does the operator follow standards?
Machine	-	Do the facilities meet production requirements?
Material	-	Is the inventory level adequate?
Method	-	Is the sequence of work adequate? (Imai, 1986: 238)

3.2.9 Benchmarking

Benchmarking starts with competitive analysis, but goes far beyond it. Benchmarking looks beyond products to the operating and management skills that produce the products. Benchmarking studies are free to search out the 'best of a breed' of a process or sill, wherever it may be found (Hines, 1994: 200). Benchmarking is the process of measuring an organisation's performance on a key customer requirement against the best in the industry. Its purpose is to establish a standards against which performance is judged, and to identify a model for learning how to improve.

3.2.10 Focused Factory Networks

This is also referred to as the outsourcing of operations that are non-core to the business.

Colenso (2000: 42) states:

"Part of the vogue for structural change in the past few years has been the drive to outsource non-core activities".

Large vertically integrated organisations were characteristics of early structures. The modern thinking tends to favour smaller, more tightly focused operating units that are more responsive to their customers. Companies continue to get bigger but operating units tend to get smaller (Colenso, 2000: 42).

3.3 ESSENTIAL CHARACTERISTICS OF LEAN MANUFACTURING

Hines (1994:15) quotes Jones as saying that the essential characteristics of lean manufacturing as demonstrated in the motor vehicle assembly industry are:

- It is customer driven – not by production.
- Activities are arranged on product lines with champions managing them and with functional areas playing a secondary role.
- All activities are team based.
- There are fewer, more integrated role-players.
- There is a high level of information exchange.
- There is team orientation, the success of the whole is more important than one area alone.
- A system functioning on the disciplines of JIT and Total Quality allows for exposure of problems and performance evaluation.
- The key to lean manufacturing is moving responsibility as low down the organisation as possible.
- There are stable production volumes with a great deal of flexibility.
- Employees, suppliers and dealers are treated as fixed costs.

Hines (1994: 15) further states:

> "As a result all employees are highly valued, especially for their ability to contribute to solving of problems and improvement in productivity. In

> the same way that the employees are seen as long-term assets, the suppliers are viewed as a source of competitive advantage and not a millstone to be removed when the going gets tough."

In the automotive industry the assemblers are totally dependent on the ability of the supplier base. If the suppliers are not party to these efforts, the assembler has little chance of achieving world-class status and being a truly lean organisation.

"Of course, no lean producer has ever reached this promised land – and perhaps none ever will, but the endless quest for perfection continues to generate surprising twists" (Womack et al, 1990: 14).

This argument goes further by stating that it is only realistic to note progression towards these lean targets. Suppliers are key elements in the Lean Manufacturing chain. They should be viewed as partners in the business. Organisations have to realise that they can only succeed if they make their suppliers part of their daily business.

3.4 CUSTOMER FOCUSED, EMPLOYEE DRIVEN, DATA-BASED PERFORMANCE PRINCIPLES

Schonberger (1996: 23) developed 16 databased performance indicators, which an organisation could use to measure whether it is customer focused, and employee driven. These should be an indication of how close the organisation is to be a lean enterprise. They are:

3.4.1 General

- Team up with customers; organise by families of customers or products.
- Capture and apply customer information, competitive information, and best practice information.

- Dedicate to continual, rapid improvement in quality, response times, flexibility, and value.
- Frontline employees should be involved in change and strategic planning to achieve unified purpose.

3.4.2 Design

- Lean organisations cut to the few best components, operations and suppliers.

3.4.3 Operations

- They cut flow time, distance, start-up, and changeover times all along the chain of customers.
- Such companies operate close to customers' demand.

3.4.4 Human Resources

- They aim to continually enhance human resources through cross training, job and career-path rotation, and improvements in health, safety and security.
- The varieties of rewards, recognition, pay, and celebration – to match the expanded variety of employee contributions – are expanded.

3.4.5 Quality and Process Improvement

- Lean companies continually reduce variation and mishaps.
- Frontline teams record and process their own data at the workplace.

3.4.6 Information for Operations and Control

- The root causes of cost and performance are controlled thereby reducing internal transactions and reporting and simplifying external communications.
- Lean organisations align performance measures with universal customer wants: quality, speed, flexibility and value.

3.4.7 Capacity

- They improve present equipment and human work before considering new equipment and automation.
- They seek simple, flexible, movable, low-cost, readily available equipment and work facilities – in multiples, one for each product/customer family.

3.4.8 Promotion and Marketing

- Successful companies promote, market, and sell the organisation's increasing capability and competence – which are the results of the other fifteen principles.

Schonberger (1996: 23) concludes by saying that the strategic change towards lean manufacturing or world-class status is an outcome of all sixteen principles. If the organisation does not measure itself on a regular basis the focus on improvement will be lost. A co-ordinated step-by-step improvement process towards this goal is the responsibility of all stakeholders (Womack et al, 1996:49).

3.5 CONCLUSION

In this chapter the emphasis was to arrive at a better understanding of the term "lean manufacturing". In essence lean manufacturing is focused on the reduction of all forms of non-value added activities. Processes and procedures alone cannot achieve this, what is required is a culture of continuous improvement.

CHAPTER 4

BACKGROUND OF RESEARCH ENVIRONMENT AND RESEARCH METHODOLOGY

		PAGE
4.1	INTRODUCTION	54
4.2	ROCAM CUSTOMER DEMAND HISTORY	54
4.3	MANUFACTURING PLANT AND PROCESSES	56
4.3.2	Manufacturing Assembly Plant	58
a)	Shift Pattern and Schedule	58
b)	Labour	58
c)	Complexity	59
d)	Organisation Structure	59
4.3.2	Manufacturing Machining Process	62
e)	Shift Pattern and Schedule	62
f)	Labour	63
g)	Complexity	63
h)	Organisation Structure	63
4.4	RESEARCH METHODOLOGY	64
4.5	CONCLUSION	66

CHAPTER 4

BACKGROUND OF RESEARCH ENVIRONMENT AND RESEARCH METHODOLOGY

4.1 INTRODUCTION

The aim of this chapter is to outline the Rocam customer demand history, provide an overview of the existing manufacturing and plant processes at Ford Motor Company, as well as provide a framework for the research methodology to be adopted.

4.2 ROCAM CUSTOMER DEMAND HISTORY

Ford Motor Company's Port Elizabeth (PE) Engine Plant has manufactured the Rocam 1.3 litre (and 1.6 litre) engine, since June 2001, predominantly for the export market. The export market consumes 95 percent of all production, with the remaining 5 percent allocated to the domestic market. All Rocam engines are fitted to Ford Ikons and Ford Fiestas (locally and abroad). Customer feedback has been extremely positive with regard to engine performance, quality, cost and delivery. This resulted in an unexpected increase in customer demand.

Production volume at the beginning of the year, January 2002, was approximately 75 engines per day. At this point in time only one production shift was required. Increased customer demand, approximately April 2002, created a need for an additional production shift.

Ford of Europe in Germany and Spain also produces 1,6 litre Fiestas and Ikons. The engines for these vehicles are produced in Spain and the United Kingdom. The PE Plant was requested by Europe to develop and ship a 1,6 litre Rocam prototype engine. Ford of Europe subjected this engine to a series of rigorous

performance tests. The test results were extremely positive with regards to product performance. Ford of Europe (FOE) was also pleased with the total cost (manufacturing and supply) of this engine. FOE placed further production orders with the PE Plant for the new 1,6 litre Rocam engine.

The domestic market responded very well to the new 1,6 litre engine, which also resulted in an increased customer demand rate. This meant that production capacity had to be optimised much earlier than scheduled.

The initial scheduled agreement was that the PE Plant, should they be successful in securing the business, would produce a 1000 engines per day towards the end of December 2003. This meant that three full production shifts had to be operational by August 2003. This would allow enough time for the training of the newly appointed production personnel, thereby ensuring their familiarity with the machining and assembly operations.

The new revised schedule now meant that the PE Plant had to produce 1000 engines per day at the beginning of the second quarter of 2003. To produce 1000 engines per day, three shifts had to be deployed by October 2002 the latest. This meant that the PE Plant had to pull the production plan ahead by almost one full year.

Currently, the daily volume stands at 650 engines. The Engine Plant has ramped up the daily production volume almost tenfold in a mere space of ten months. It is imperative that the PE Plant is in a position to comfortably produce 1000 engines per day prior to commencement of the contract. This will ensure that they supply low cost quality engines on time to their customers; thereby retaining the contract. It is therefore vitally important to the longevity of the PE Plant to become a world-class manufacturer as soon as possible.

4.3 MANUFACTURING PLANT AND PROCESSES

At present date, the Engine Plant produces two different engines. They are:

- B-Series engine, produced only for local use. There are two B-Serie engine derivatives, and they are both fitted to the Bantam and Rustler 1,3 and 1,6 litre light delivery vehicles. Production volumes are at approximately 98 engines per day. The Rocam engine will shortly replace the B-Series engine. It outperforms the B-Series in both cost and performance.
- The Rocam engine. This engine will be the star product of the Engine Plant. By the middle of 2003, the Engine Plant will only manufacture this specific engine. There are two Rocam engine derivatives, which are produced for both the export and domestic markets. The new contract with Europe ensures that the PE Plant will produce this engine, including additional derivatives, for the next five to seven years.

The PE Plant employs approximately 970 personnel including administration and warehousing. The equipment in the plant varies from modern to relatively old and unsophisticated machinery. Most of the machining processes are manually operated and not of a high level of automation. The inverse is true for the assembly process.

The Rocam engine manufacturing process is relatively straightforward and is made up of only five stages. These are:

- Production Scheduling. The Master Production Schedule (for the entire year) is broken down into monthly schedules and issued on a monthly basis to the relevant personnel. This informs all the concerned personnel of exactly what needs to be produced for that specific month.
- Logistics / Receiving. This is the process of acquiring all the necessary components to produce and assemble an engine. Components are

sourced locally as well as internationally. There is a high level of complexity involved in this process. Internationally sourced parts have to arrive timeously, along with the locally sourced parts, to ensure that production needs are always met on time, every time without fail.

- Manufacturing machining process. All components, apart from the intake manifold, is machined at the Engine Plant. This includes all the larger components such as the cylinder block, cylinder head, crankshaft, connecting rod, and etcetera.
- Manufacturing assembly process. This entails the sub-assembly as well as the complete assembly of the entire engine. This process also includes the engine hottest (functionality check) operation.
- Shipping / Warehousing. This is the process of shipping components and engines to the customer. It also entails the storage of components that are shipped only a few times a month.

The PE Plant has been in existence for more than 70 years. This is the first time ever that they have been subjected to such high production volumes. They are currently struggling to consistently produce 650 engines per day. They have to be in a position to consistently produce and supply 1000 engines per day at the end of March 2003.

4.3.1 Manufacturing Assembly Process

a) Shift Pattern and Schedule

The Rocam assembly plant operates 24 hours per day, five days a week. Three production shifts operate back to back to cover the 24-hour period. This plant consists of two production assembly lines, which are:

- Cylinder head sub assembly: There are only three operators that work on this highly automated production line. The longest cycle time on this line

is 45 seconds, which means that this line can produce one and a half cylinder heads per minute.

- Main engine assembly: There are a total of 74 operators that work on this production line. The longest cycle time is 60 seconds, which means that this line can produce 440 engines per shift. There are 480 minutes in a shift, but 30 minutes are allocated to a lunch break and 10 minutes are allocated to a tea break. The remaining 440 minutes is used for production.

The assembly plant, based on production cycle time per station, can easily produce 1000 engines per day. A target of 350 engines per shift has been set, which means that three shifts will produce in excess of 1000 engines per day. This target, based on the largest cycle time, allows 90 minutes for machine breakdowns per shift.

b) Labour

The Rocam engine assembly process is fairly labour intensive, yet highly automated. All production stations on the assembly line require operator interaction. Operators have to fit engine parts onto the short-block assembly (cylinder head and cylinder block assembly) in order to complete an engine assembly.

Operators are fairly young and they conform easily to change. The average age of all assembly production hourly personnel is approximately 25 years. Approximately 66 percent of the assembly production plants labour force was recruited in June 2002. These employees were trained off-site in the disciplines of lean manufacturing, teamwork and basic engine assembly. The total training content was completed in just one week. Not much time was spent on training due to the unexpected increase in customer demand. These employees have, however, progressed very quickly and are now fairly comfortable in performing their duties on a daily basis.

c) Complexity

A huge amount of time has been spent on the development of process sheets and visual aids to simplify the engine assembly process for the employees. It is not uncommon, due to absenteeism levels, for operators to change working stations on a daily basis. They perform different jobs at acceptable levels due to the detail contained in the visual aids and process sheets that are displayed directly above the working station.

d) Organisation Structure

The organisation structure is fairly simple. There is one area manager per shift that is responsible for production, quality and maintenance. He has a production coordinator, a Quality Coordinator and a Maintenance Specialist that reports to him.

The production coordinator has five team leaders that report to him. He is purely responsible for production. He communicates with the maintenance and quality personnel to ensure that production progresses as planned. His function also includes production administration.
The team leader is responsible for approximately 10 to 12 operators. He has to coordinate the activities of his team to ensure that they, as a group, achieve their production targets. The team leader is the equivalent of a Production Foreman. There are several teams on one production line. Each team has their own team leader.

It is critical that the production coordinator and the team leader works well together. The team leader has to clearly understand what the production coordinator requires. A breakdown in communication between these two individuals will definitely result in non-achievement of production targets.

The PE Plant has spent a huge amount of time and money on developing these team leaders. They are, in the eyes of management, the production coordinators of the future

In summary, the team leader reports to the production coordinator who in turns reports to the area manager.

On several occasions the assembly plant has produced in excess of 1000 engines per day. There are no production volume concerns associated with the assembly plant. The concern lies with the machining plant. On the occasions that the assembly plant produced in excess of its target, it consumed all the machining plants' components as well as the machining plants' buffer stock.

(Layout of Assy Plant Required !!!)

4.3.2 Manufacturing Machining Process

a) Shift Pattern and Schedule

The Rocam machining plant operates 24 hours per day, seven days a week. This plant only produces products for 21 hours of the day. The remaining three hours are utilised for preventative maintenance.

Three production shifts operate on a swing-shift basis to cover the 21-hour period. Production shift “A” operates from 06h00 to 16h30. A maintenance crew then performs preventative maintenance over the next three hours, followed by production shift “B” starting up at 19h30 and finishing at 06h00. Production shift “C” is officially off work for that specific week. Production shifts work 10,5 hours per day for four consecutive days, and are then off work for three consecutive days.

This plant consists of several machining centres and four main machining production lines. The four main production machining lines are:

- Cylinder block machining
- Connecting rod machining
- Crankshaft machining
- Cylinder head machining

The machining plant, based on production cycle time per station, can definitely produce 1000 engines per day. A target of 580 engines per shift has been set, which means that two shifts will produce in excess of 1000 engines per day. This target, based on a machining efficiency of 71 percent, allows ample time for crisis maintenance (actual breakdowns) per shift.
The longest cycle time in the machining plant is 60 seconds. All bottleneck operations (cycle times close to 60 seconds) are continuously run for the entire shift. These operations run through tea and lunch times, by tag relief hourly

personnel. Excess stock is stock piled just after the bottleneck operations. This process ensures that products are produced, on average, every 50 seconds. This ensures that the 1000 engine objective can be met over the two-shift period.

b) Labour

The Rocam machining process is highly automated, yet is requires at least one operator per workstation. All production stations require operator interaction. Operators have to initiate the machining run cycle for every component. Operators are not as young as the assembly operators, and they do not conform easily to change. The average age of all machining production hourly personnel is approximately 36 years. Employees ages ranges from 22 years to 57 years. Most of these employees have worked, on average, at the PE Plant for 12 years.

c) Complexity

A huge amount of time has been spent on the development of process sheets and visual aids to simplify the machining process for the employees. Employees are not comfortable at changing jobs on a daily basis to offset absenteeism levels. The machining process is more complex than the assembly process. Operators become skilled in their area of work over a period of time. A huge emphasis is placed on the gauging of components. Special gauging stations are set up to verify the quality levels of components. Operators perform all gauging themselves. The learning curve is a long one, and as it improves so does production capability.

d) Organisation Structure

The organisation is very similar to the assembly plant. The only difference is that the machining plant has only one team leader per production line per shift reporting to a production coordinator. The workload, per line, is basically split up

between the production coordinator and the team leader. These two individuals have to operate as one. In this plant, it is even more important that roles and responsibilities are clear.

4.4 RESEARCH METHODOLOGY

4.4.1 Motivation for the study

The management of the PE Plant are fairly comfortable with the performance of the assembly plant. Management are more than confident that they will achieve their target with great ease. Management firmly believe that they have excess capacity in the assembly plant.

Management have, however, expressed their concerns at the performance of the machining plant, specifically with regards to the cylinder block and connecting rod machining lines. Management knows that these two machining lines have the capacity to produce in excess of 1000 engines per day, but they are not sure why it cannot consistently produce its current target of 650 engines per day. It has occasionally achieved its daily production volume target, but has yet to achieve its weekly target. The other machining lines, in their opinion, do not pose a problem for them at this point in time.

In August, this year, a group of Powertrain engineers visited the PE Plant to perform an audit on the production capacity. Management were pleased with the assembly plants installed capacity, but were extremely apprehensive about the machining plants installed capacity. This resulted in them downgrading the machining plants capacity to 895 units per day as they were of the opinion that the PE Plant could only produce 895 units per day. This resulted in a reduction of production volume per annum originally allocated to the PE Plant. The plant

will now produce, in total, 215 000 engines per annum – and not 240 000 engines per annum as planned.

This immediately threw the PE Plant into the spotlight of the Ford international arena. They absolutely have to comfortably produce 895 units per day, and more, if they want to regain the full contract of 240 000 units per annum.

It is with this view that all research analysis at the PE Plant will be performed on the cylinder block and connecting rod machining lines. Emphasis will be focused on the bottleneck operations, which have been identified by the management at the PE Plant.

4.4.2 Methodology

Two issues will be addressed in this research:

a) People
b) Processes

a) People

Discussions will be held with the production coordinators and team leaders to identify the constraints that are responsible for the non-achievement of production targets. They are the first line of management on the production floor, and therefore they should have a good idea of what the problems are. Their views will be investigated and validated.
Method study and work measurement will be utilised to collect data on the production personnel. This will assist in identifying the production operators' workload, as well as their efficiencies.

b) Processes

The existing process, for both the block and connecting rod machining lines, will be analysed with specific regard to the philosophies of lean manufacturing, which were discussed in chapters 2 and 3. A current state map will be developed to collect data and to better understand the existing process. Emphasis will be focused on certain points from Deming's fourteen points of management, which was discussed in chapter two, as well as on continuous improvement. The existing process will be analysed to identify constraints that physically impact on the non-achievement of daily and weekly production targets.
A questionnaire on quality will be presented to the production personnel. Production personnel will, through answering the questionnaire, provide feedback on the focus of quality within the production environment.

4.5 CONCLUSION

The focus of attention will be placed on the machining facility, specifically with regards to the cylinder block and connecting rod machining lines. Management has identified these two production lines as the production lines with the biggest opportunity for improvement.
The research methodology will focus on the analyses of people and processes. First-line management will be interviewed, and their claims will be investigated. The existing processes will be compared to that of a lean manufacturer. In this way the deficiencies will be identified, upon which corrective action can be taken.

CHAPTER 5

ANALYSES OF FORDS' MANUFACTURING MACHINING PROCESS – PRESENTATION OF RESULTS

		PAGE
5.1	INTRODUCTION	69
5.4	BLOCK MACHINING PROCESS	69
5.2.1	Current State Map	69
d)	Quality	72
e)	Equipment Effectiveness and Stock Holding	72
f)	Build-to-schedule	73
5.2.2	People Aspects	73
c)	Production Coordinator and Team Leader Interview	74
d)	Observations	75
iii)	Overall Equipment Effectiveness	75
iv)	Operator Effectiveness	83
5.5	CONROD MACHINING PROCESS	89
5.3.1	Current State Map	89
d)	Quality	91
e)	Equipment Effectiveness and Stock Holding	91
f)	Build-to-schedule	92
5.3.2	People Aspect	92
d)	Production coordinator and team leader Interview	93
e)	Operating Personnel Interviews	94
f)	Production coordinator and team leader Relationship	98

5.4 BLOCK AND CONROD MACHINING SIX SIGMA 102

5.4.1 What is Six Sigma? 102

5.4.2 Deployment 105

5.5 CONCLUSION 105

CHAPTER 5

ANALYSES OF FORDS' MANUFACTURING MACHINING PROCESS – PRESENTATION OF RESULTS

5.1 INTRODUCTION

In this chapter the focus of attention will be based on the analysis of the manufacturing control systems of the Rocam engine manufacturing machining process, specifically with regard to the cylinder block machining and connecting rod (Conrod) machining lines. The existing process (people and machining process) will be examined and discussed. This will be performed through the development of current state maps, as well as through on-line interviews and observations.

5.2 BLOCK MACHINING PROCESS

5.2.1 Current State Mapping

Current State Mapping provides a snapshot overview of an area by focusing on quality, cost and delivery. The level of quality is reflected in the levels of scrap and rejects, cost is determined by equipment effectiveness and stock holding, and delivery reflected in the production line's build-to-schedule (Ford Production Systems, Ford Motor Company).

The cylinder block machining line consists of 39 computer numerically controlled machines set up in series. The first machine is defined as operation 10, and the last machine is defined as operation 390. A raw casting is loaded into operation 10 (start of the line), then goes through all the machining operations and is finally offloaded, as a completed product, at the final buy-off station. Operator interaction is minimal, probably accounts for 10 percent of the total allowed cycle

time, with a huge emphasis on automation. At least one cylinder block has to be produced per minute in order to meet the daily production target. The total capital investment for this machining line was R140 million.

Layout of Block Line Required !!!

a) Quality

Average machining scrap over a five month period was 0,7 percent. Average machining rejects, for the same time period, was two percent. Foundry scrap, also for the same time period, was 2,3 percent. Total scrap and rejects for that specific time period, accounted for five percent of total product input. Scrap and rejects are measured as a percentage of stock input into the machining line operation 10. Stock that is sold at the end of the line is not taken into account.

First time through (FTT) is a qualitative measure that depicts how many parts went through first time the entire machining process without being reworked or repaired (Ford Production System, Ford Motor Company). The average FTT, for the same time-period, was 92 percent.

b) Equipment Effectiveness and Stock Holding

Overall equipment effectiveness is a measure of a machines operating uptime (Ford Production System, Ford Motor Company). Overall equipment effectiveness, for the same time period, was approximately 78 percent. This means that, on average, production machinery was down for 22 percent of the time. Ford Motor Company works on a production efficiency of 71 percent. The management at the Engine Plant were pleased with the fact that the production machinery was 78 percent effective. This meant that additional production volume could be produced. This would result in more profit for the company.

Stock holding of finished goods, for the same time period, was minimal. A maximum of 200 blocks were housed in the final storage area. Non-achievement of the daily schedule was the main reason for this. In-process stock storage was extremely high. Bottleneck areas had huge amounts of blocks stored. This was deliberately performed so that theses bottleneck machines could run continuously during tea and lunch breaks. Raw casting storage was excessively

high. There were, on average, more than seven days worth of castings in the plant, excluding the castings on the production line.

c) Build-to-schedule

Build-to-schedule (BTS) is a measure of what production actually produces versus what the production schedule calls for (Ford Production System, Ford Motor Company).

If production is scheduled to produce 100 units per day, and production actually produces 100 units then the build-to-schedule is 100 percent. The build-to-schedule for the same time period, averaged at 73 percent.

The Engine Plant monitors production volume produced on an hourly basis, they call it jobs-per-hour (JPH). The average JPH for the same time period was 31, which is 73 percent of the required 42,6 JPH. To achieve 1000 engines per day, the block line has to produce a 42,6 JPH. The calculation is as follows:

42,6 * 21hrs * 20 days * 12 months = 240 000 engines

Total scrap and rejects accounted for five percent, and the overall equipment effectiveness was above the required target. Taking this into account, this production line should produce a 95 percent build-to-schedule or a JPH of 40,47. This was definitely not the case hence further investigation was required. The people aspect of the plant had to be reviewed.

5.2.2 People Aspects

The block machining line has one production coordinator and one team leader per shift. These two employees, in management's opinion, have to work closely

together to ensure that production targets are achieved. Good coordination between these two employees is critical.

a) Production Coordinator and Team Leader interview

This interview was conducted with the production coordinators and the team leaders. Both employees per shift were interviewed together. The interviews were conducted over all shifts, which ensured that one shifts employees were not influenced by what the other shifts employees said. The aim of the interview was to identify the constraints to achieving production volume on a regular basis.

The interview was very informal, and lasted a maximum of 15 minutes. The only question posed was "What are the factors that prevent you from achieving your production target on a daily basis?" The factors mentioned were numerous, and ranged from a continually changing production schedule to inexperienced operating personnel on the production line. The common factors mentioned in all three interviews were machine downtime and carefree operating personnel. All three shifts were adamant that these were their biggest problems. They were confident that machine downtime accounted for approximately 80 percent of production non-achievement, with the carefree operators accounting for the remaining 20 percent. The production coordinators and team leaders firmly believed that the operating personnel physically worked for only 75 percent of the day.

They knew that overall equipment effectiveness (OEE) was being monitored, but were not sure what the current status of OEE was. Obviously communication was poor between the maintenance department, who was ultimately responsible for OEE, and the production department. Also, it highlighted that both the production coordinator and the team leader were not familiar with OEE as a measurable, even though their operators were the ones that were collecting the

data. It was also evident that they did not use this measurable to manage their business.

With regard to the carefree operating personnel, it was also clear that both the production coordinator and the team leader did not manage their subordinates in a manner that was conducive to achieving their production targets.

Further investigation was required on the data integrity of OEE. Also, an investigation was necessary on the working pattern of the operators to identify whether or not the production coordinator and team leaders' claims were true.

b) Observations

i) Overall Equipment Effectiveness

The purpose of this observation was to identify a correlation between what the production operator actually recorded versus what the consultant had recorded. The author is referred to as the "consultant" wherever analysis is performed.

A positive correlation would imply that the OEE data integrity was good, whilst a negative correlation would imply that the data integrity was not good.

The production coordinators and the team leaders were convinced that machine uptime could not be 78 percent. They were of the opinion that machine uptime / OEE was probably 60 percent, which meant that machine downtime was approximately 40 percent.

Historical OEE data, as previously discussed, averaged at 78 percent. This meant that there was machine downtime of only 22 percent, which was acceptable to the management of the Engine Plant. The management allowed for a 29 percent machine downtime.

An observation was conducted on the bottleneck operations over a full production week. The author conducted a production study on five operators, one per full day, recording downtime. Figure 5.2 below, an example of the study, displays the difference between what the author observed and what the operator observed and recorded. This was part of the study performed on one of the operators during the production week.

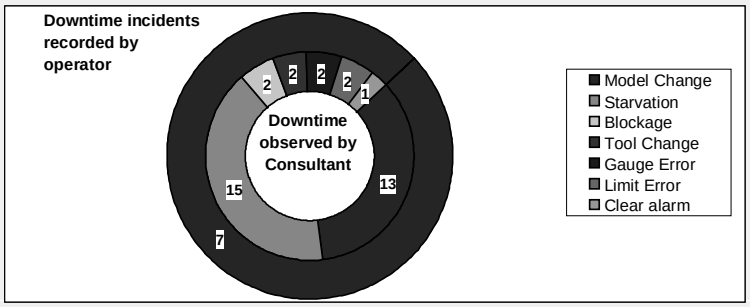
FMC Struandale Plant - Block Line OP280 to 320
Downtime Recording Correlation

DAY:
Thursday, 15 August 2002

AREA:
Block line, Crew A
Operation 280-320: Andre

CYCLE TIME KEY

- **Within specification**
- **Low cycle time**
- **Machine Stopped**



Time	CONSULTANT Model Change	Starvation	Blockage	Tool Change	Gauge Error	Limit Error	Clear alarm	Downtime	Cycle Time	Downtime (s)	OPERATOR Model Change	Starvation	Blockage	Tool Change	Gauge Error	Limit Error	Clear alarm
08: 05								0	##	0							
08: 10								2	##	0							
08: 15		ST						4	##	0							
08: 20		ST						2	##	0							
08: 25		ST						2	##	0							
08: 30			BL					3	##	0							
08: 35			BL					0	##	0							
08: 40								0	##	0							
08: 45								0	##	0							
08: 50								1	##	0							
08: 55					GE			0	##	0							
09: 00								2	##	0							
09: 05							CA	1	##	0							
09: 10					GE			5	#	0							
09: 15		ST						5	#	0							
09: 20						ZR		4	##	0							
09: 25		ST						2	##	0							
09: 30		ST						0	##	0							
09: 35								2	##	0							
09: 40						ZR		5	#	0							
09: 45				TC				4	##	0							
09: 50		ST						0	##	0							
09: 55								4	##	0							
10: 00		ST						5	#	0							
10: 05		ST						1	##	0							
10: 10		ST						2	##	0							
10: 15		ST						3	##	0							

Comments

The observation started with OP 280 being starved. Andre said "I don't know where the on loader is, I'll do it myself to keep the machines running" Shortly thereafter a blockage developed at OP330 as no off loader was available. OP290 developed a gauge error caused the blockage to clear again. Andre commented "these conveyors are **** designed and **** assembled" and called to the Graham to adjust some rollers as his machines were being starved due to blocks getting stuck on the conveyor. Andre battled to clean some swarf out on OP300. The consultant questioned the artisan about the source of the starvation and received the reply "f**k knows"

It turns out that a model change was started during the previous shift to 1300's. 1600's were still being fed into the line at OP130 to complete reworks prior to tool changes being affected. Brendon started loading 1300's at OP210 commenting "this change over is already taking two hours". Aspro came running and shouted " Whoa, whoa, there is still 1600's on the line". The PCO and area manager arrived to assist in the change over. Aspro commented "too many bosses", shook his head and retreated. Later he attempted to manually correct a machine, the operation got stuck and Andre had to rectify the problem. On loading of 1300's started at 270. The consultant questioned the setter about his apparent lack in preparation upon which he commented "Nobody told me, now I'll have to work through tea, but that is quite normal in this place, I'm not getting paid for it though" Upon the

Figure 5.2: Downtime recording correlation

From the figure 5.2 above, it is evident that there is a marked discrepancy between what the operator recorded and what the consultant recorded. The correlation was therefore negative.

The analysis of the figure 5.2 is as follows:

- Incorrect recording prevails:
  - Downtime symptoms are recorded rather than causes.
  - Recording is irregular and inaccurate.
  - No action plans or feedback is provided to the operator if any wrongdoing is noted.

- Communication and co-ordination is haphazard and wholly ineffective:
  - Model changeovers are completely uncoordinated – team leaders, setters and foremen are all running different models on the line at the same time.
  - Model changeovers are not communicated and planned.
  - Model changeovers methodology is not established – there are no clear procedures.
  - Model changeovers are executed as seen fit – team leaders, setters and foremen individually do their own things.
  - Costly model changeovers have non-critical activities interrupt progress.

- Only major downtime is reported – fire fighting dominates the daily routine:
  - No downtime is recorded when hourly targets are achieved
  - Production starvation and blockages on the block line are not recorded.

It must be noted that all five operators observed displayed exactly the same behaviour. Based on these observations, one could assume that the data integrity of the historical downtime was not good. No assumptions could be made on the historical data. All assumptions had to be based on the data that

was recorded by the author over the full production week. Further observations, over a six-week time period, were performed to ascertain the actual OEE.
All operators, team leaders and production coordinators were trained by the author to record all forms of downtime. Operators were then assessed and certified by the author. Only certified operators were utilised for data collection purposes. The focus, this time, was placed more on uptime than downtime.

The figure below summarises overall equipment effectiveness data recorded over the six-week period.

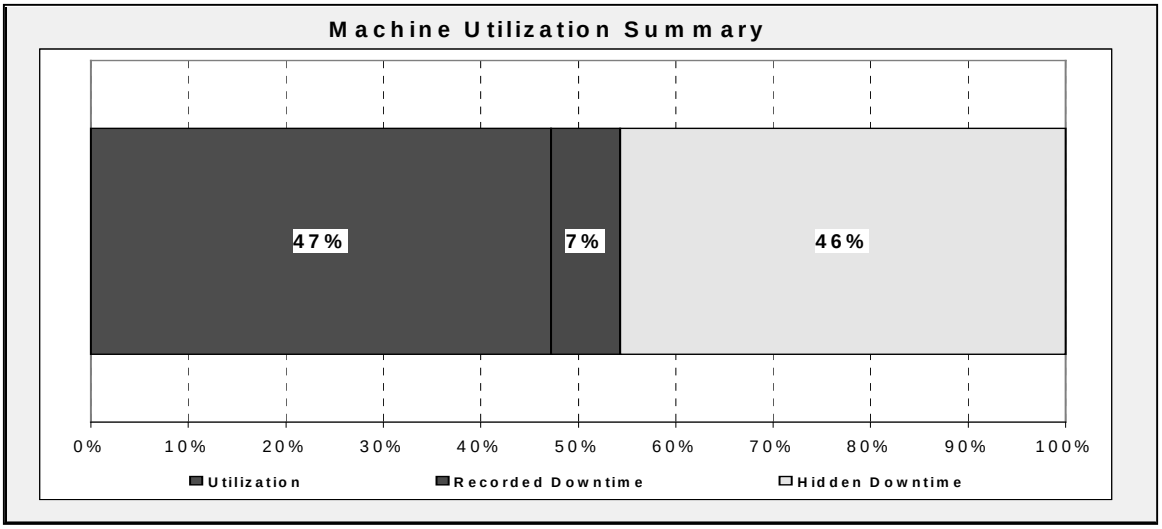


Figure 5.3: Machine utilisation summary

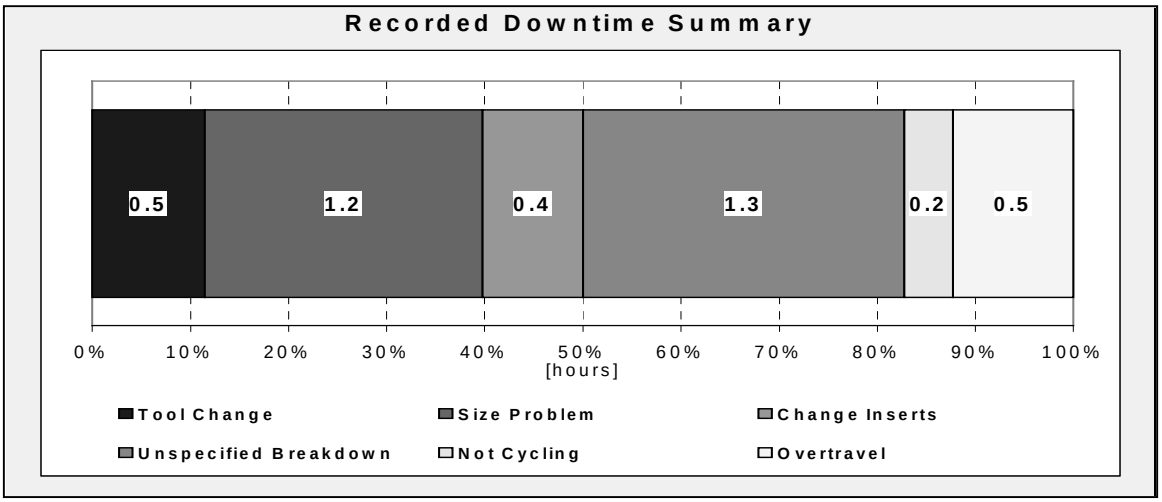


Figure 5.4: Recorded downtime summary

Overall equipment effectiveness, a measure of a machines up-time, for the bottleneck operations was 47 percent for the period analysed. Recorded downtime accounted for seven percent and hidden downtime for 46 percent of the available time for production.
From figure 5.4, it can be seen that tooling issues contributed to more than half of the recorded downtime, and unspecified breakdowns accounted for more than 30 percent of downtime. The majority of stoppages were not recorded. Those stoppages that were recorded mostly lacked downtime durations. Some of the operators, the team leader and the production coordinator commented that they considered the recording of downtime unnecessary when hourly targets were achieved. Machine starvation and blockage problems were under reported, rarely mentioned and no periods were specified.

Overall equipment effectiveness was not 78 percent; in fact it was 47 percent. Management was under the impression that OEE was at an acceptable level, but this was not the case. The data proved that OEE was definitely a huge factor for the non-achievement of the production targets. It was physically impossible to achieve this target when machine downtime was higher than machine uptime.

To achieve the set production target, machine uptime had to be immediately improved. Recorded downtime, as well as the non-recorded downtime had to be reviewed to identify the percentage of total downtime that could immediately, without great effort, affect uptime.

The following figure summarises the recorded downtime into two categories; namely impacted and non-impacted downtime.

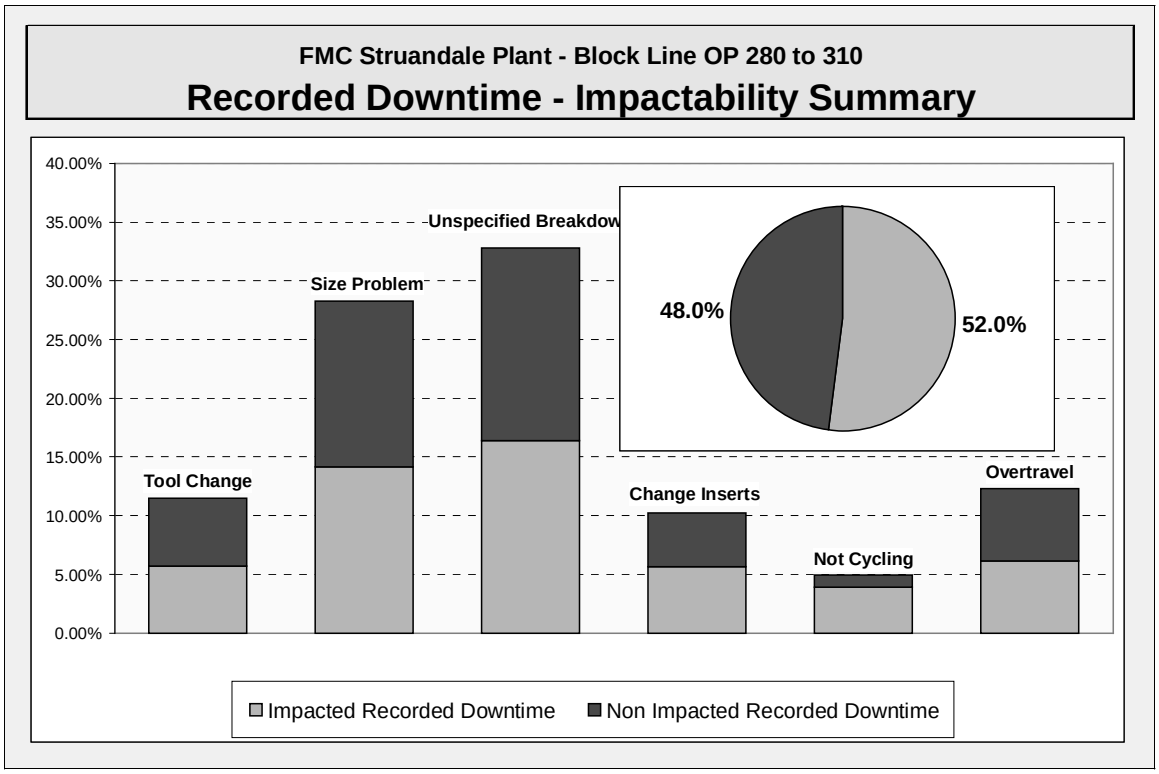


Figure 5.5: Recorded downtime – Impactability summary

The analyses of the recorded downtime, as seen in figure 5.5 is as follows:

- Machine tooling was not properly prepared and assembled by first-year tooling supplier, prior to delivery to production machining. This resulted in unnecessary tooling problems (tool change, size problem). This accounted for approximately 50 percent of total downtime.
- Tooling inserts required a minimum of two changes per shift. This accounted for 10 percent of total downtime.
- Machine gauge and tooling change and setting procedures do not deliver timely changes and results in unreliable and erroneous performance. There is a huge build up of machining swarf, which hinders the actual machining process, resulting in unnecessary stoppages. This accounted for approximately 33 percent of total downtime.

➢ By working on these issues immediately, recorded downtime can be improved by 52 percent.

Hidden downtime was also analysed. The following figure summarises the hidden downtime into the same two categories:

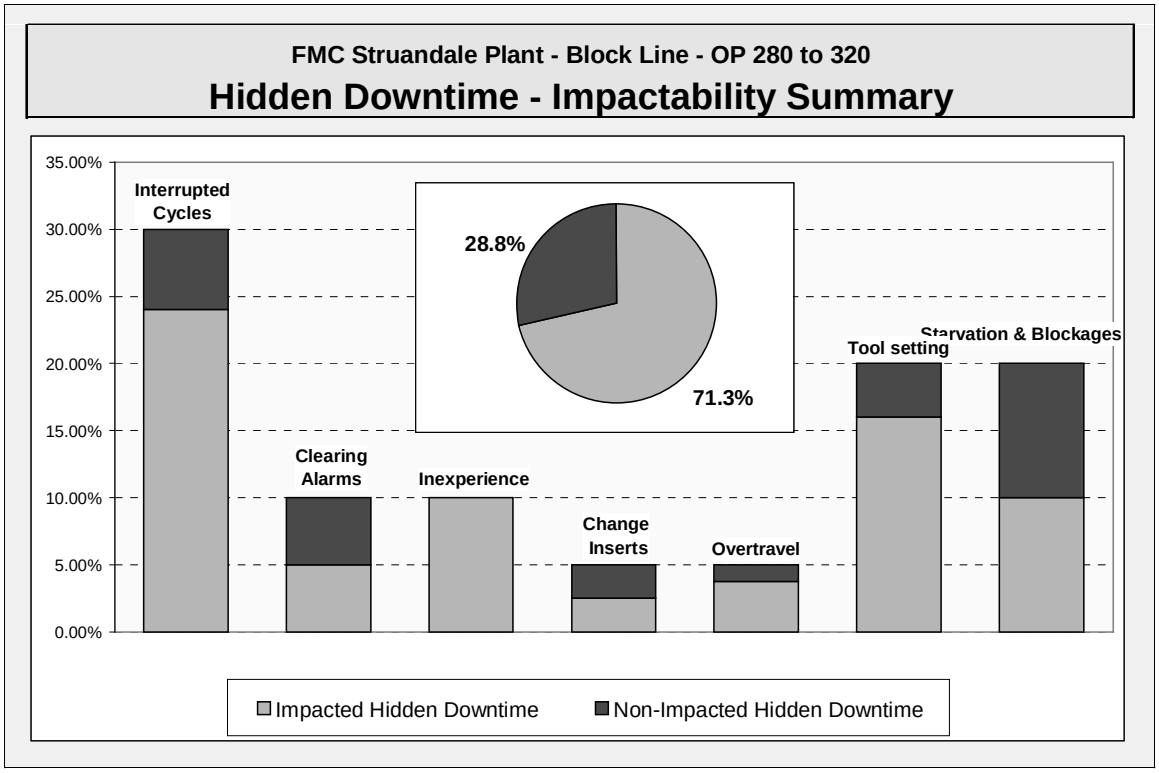


Figure 5.6: Hidden downtime – Impactability summary

The analyses of the hidden downtime, as can be seen in figure 5.6, is as follows:

- Swarf related short period downtime was not reported.
- Poor operator and setter skills resulted in problems not being identified timeously (inexperience).
- Machine automation continually required intensive programming adjustments. It was not problem-free, as initially claimed to be (interrupted cycles).
- Poor co-ordination and communication resulted in starvation and blockages not being addressed (starvation and blockages).
- Machine alarms caused processes to halt half way through requiring manual correction (machine alarms).

➢ Hidden downtime can be improved by 71% by addressing these issues.

- Inadequate communication
  - team leaders don't plan or control, they are reactive, bypassed in decision-making by superiors and uninvolved in troubleshooting.
  - Zero effective interfacing was noticed between team leaders and other members/ contractors on the Block Line.
  - Activities like model changeovers have no formalised nor clearly agreed methodologies.

In summary, total OEE can be increased from 46 percent to 83 percent as is reflected in the table below.

OEE	Existing	Minutes	Impacted	Minutes	Potential
Utilisation	46 %	266,8			481,45
Recorded d/time	7 %	40,6	52%	21,11	19,49
Hidden d/time	47 %	272,6	71%	193,54	79,06
TOTAL AVAIL.	100%	580			580

Table 5.1: Potential overall equipment effectiveness

Total machine downtime (recorded and hidden) can be improved by 68,5 percent as can be seen in figure 5.7.

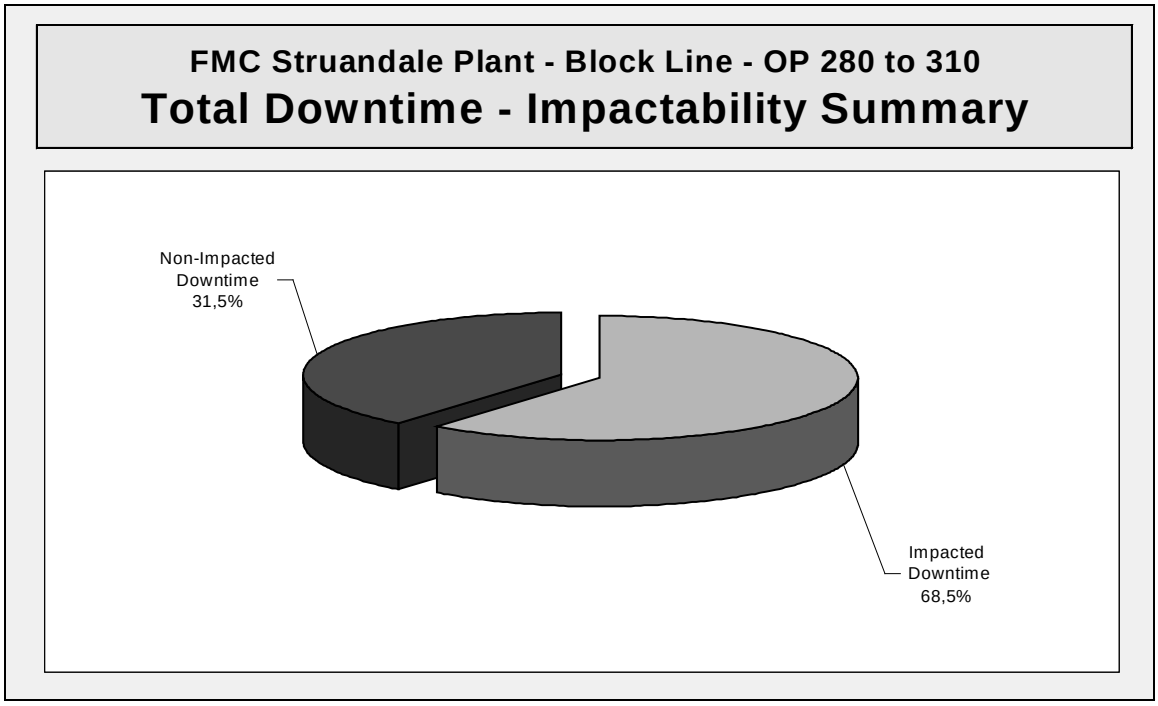


Figure 5.7: Total downtime – Impactability summary

OEE, at present, negatively impacts the achievement of production targets. Production coordinators and team leaders have a valid point with regards to machine uptime. Line operating personnel will now be investigated.

ii) <u>Operator effectiveness</u>

The production coordinators and team leaders were adamant that operators had a totally carefree attitude towards work, and that they only worked 75 percent of the day. They were confident that all operators worked slowly for the first two hours at start-up, then worked at a fair pace for the rest of the production day but slowed down tremendously during the last hour of the day. The jobs-per-hour (JPH) totals, taken over a period of six weeks, were extremely low for the first two hours, as well as the last hour of the working day, which validated the claim. Both the production coordinator and the team leader could not pinpoint any operator as the culprit, and did not have a plan in place to rectify the situation.

Their comments were that they were too busy fire fighting to look at this problem. They believed that this concern was secondary to the OEE. They also believed that if they had more machine setters on the production line, they would not have an operator problem, as there would then be more supervision on the line.

An activity sampling exercise was developed and deployed to identify the approximate time actually worked by operators. A group of 11 plant operators and four machine setters (artisans) were observed over a full production week. Machine setters were included to ascertain their workload. Observations were not random, but were taken at 15-minute intervals. Observations began at 06h00 and continued through to 10h00. This accounted for the first four hours of the day. Observations were then continued from 15h30 to 16h30. This accounted for the last hour of the day.
Operators were either working or not working. No questions were asked as to where an operator was if he was not present, he was merely recorded as not working.

Table 5.2 below illustrates the method deployed to observe and record operators' activities. There is a summarised version below Table 5.2.

Time	Worker 1	Worker 2	Worker 3	Worker 4	Worker 5	Worker 6	Worker 7	Worker 8	Worker 9	Worker 10	Worker 11	Setter 1	Setter 2	Setter 3	Setter 4
06:00	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a
06:15	a	w	a	w	w	w	w	w	w	a	w	w	w	w	w
06:30	u	w	w	w	w	w	w	w	w	w	u	w	u	w	u
06:45	w	w	w	w	w	w	w	w	u	u	u	u	u	u	u
07:00	u	u	u	w	a	w	w	u	u	u	u	u	u	u	w
07:15	w	w	u	w	a	w	w	u	u	w	a	w	u	u	w
07:30	w	u	w	w	a	w	w	u	u	u	u	u	u	u	w
07:45	w	u	w	w	a	w	w	w	w	w	u	u	u	a	u
08:00	Tea Time														
08:15															
08:30	w	w	w	w	a	w	w	u	u	u	a	u	u	u	u
08:45	w	w	w	w	a	w	u	w	w	w	a	u	u	w	u
09:00	w	w	w	u	a	w	w	u	u	w	a	w	w	a	w
09:15	w	w	u	w	w	w	u	u	w	w	u	w	u	a	u
09:30	w	w	u	a	w	w	u	w	u	u	w	u	a	a	u
09:45	u	u	u	u	w	w	w	u	u	u	u	a	u	w	w
10:00	a	a	a	a	w	w	a	a	w	u	a	w	u	a	a
	No Sampling														
15:30	w	w	u	w	a	w	w	u	u	u	w	u	u	u	w
15:45	w	w	w	w	a	w	w	w	u	w	u	u	u	u	u
16:00	u	u	w	w	u	w	a	u	u	u	u	u	a	u	w
16:15	w	w	w	w	w	w	a	u	u	u	u	u	u	a	u
16:30	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a

	12	12	10	14	8	18	12	7	6	7	3	6	2	4	8
Green	60%	60%	50%	70%	40%	90%	60%	35%	30%	35%	15%	30%	10%	20%	40%
Away	4	3	4	4	11	2	5	3	2	3	7	3	4	8	3
Unproductive	4	5	6	2	1	0	3	10	12	10	10	11	14	8	9
	8	8	10	6	12	2	8	13	14	13	17	14	18	16	12
Red	40%	40%	50%	30%	60%	10%	40%	65%	70%	65%	85%	70%	90%	80%	60%
Total	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Check	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.2: Operator observation study

A green block identifies an operator as working, hence the "w" within the block. A red block identifies an operator as either unproductive (u) or away (a). Unproductive operators are always present at their working stations, but they are not physically working. Away operators are missing from their stations.

The following figure is a summary of the activity sampling for the individual operators (workers) and setters, performed over the entire production week.

Figure 5.8 (a): Individual activity sampling summary

The following figure is a combination of the operators and setters. It identifies the percent of time actually worked, as well as the percent of time not worked and away.

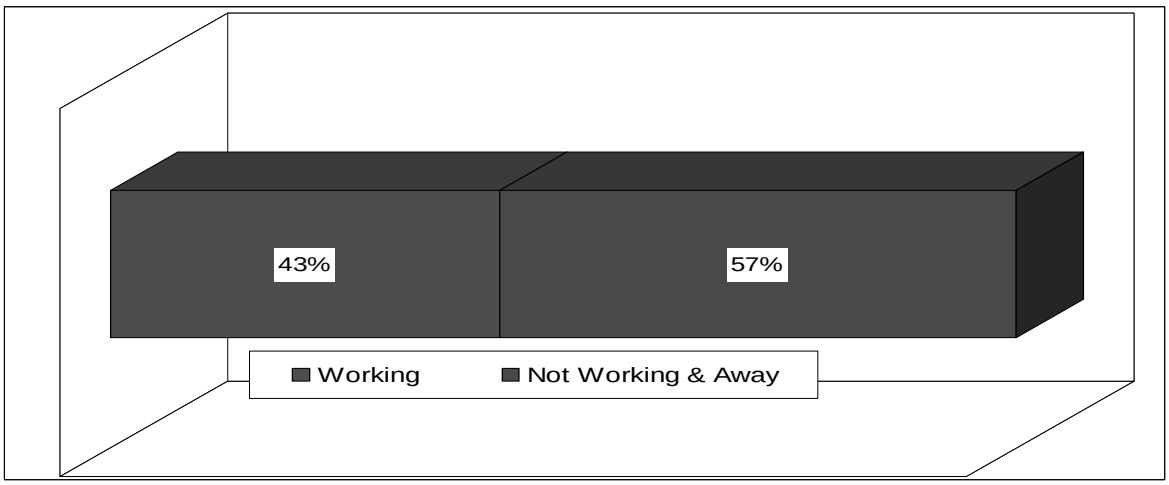


Figure 5.8 (b): Total activity sampling summary

The findings of the activity sampling is as follows:

- Workers (operators and setters) are generally unproductive:
  - A lack of experience generated too much finger pointing, and not much doing at all.
  - A lack of plant knowledge forced workers to call for assistance for even the most trivial of issues.
  - There were no pro-active trouble shooting sessions (excepting one instance) and this was not managed well by the supervision.
  - Everyone waits for a cue to do productive work – no one takes the initiative.
  - Information on problems is not communicated to workers, which negatively impacts the mean time to repair (MTTR). Machine breakdown trends are not recorded or displayed. Setters commented that certain artisans (specialists) could only fix certain problems. If they were not on shift when the problem occurred, they would have to be called out from home.

- No feedback from management (production coordinator and area manager):
  - Workers record production data but the information is not fed back for pro-active problem resolution.
  - Data is not reduced to information. The commitment is reduced to only the gathering of accurate data.
  - Reported problems are not addressed, resulting in multiple occurrences of the same problem.
  - Problems are seen by workers but not reported (especially generic problems). These problems are seen as minor; therefore they are not significant to the operator for him to report it.
  - Workers are uninvolved in decision-making and problem resolution – no brainstorming sessions were witnessed.

- Conflicting instructions throw production into disarray:
  - Operators receive instructions from too many managers.
  - Different instructions are given at different points in the line by different managers creating more even more confusion.
  - The team leader is excluded from all decision-making, as well as from the issuing of instructions. This robs him of his pride and desire to improve, which ultimately results in a total lack of motivation to succeed.

- Outsourced tooling bypasses team leader and operator controls:
  - Carbide Insert Products (CIP), the first year tooling supplier, simply takes over, bypassing setters and operators. They are responsible for the setting up of tools prior to tool fitment to the machinery. Their line of responsibility was not clearly communicated to the workers.
  - The team leader does not feature in the reporting structure of CIP. They view him as an operator, not as a supervisor on the line.
  - CIP settings are considered haphazard and fluently re-worked.

The authors findings is that the production coordinators and the team leaders are justified in claiming that their workforce is unproductive. The workforce is 43 percent of the time productive, as opposed to the claim that they were 75 percent productive. This highlights another negative attribute of the production coordinator and team leaders' management style. They are not in control of their workforce, and they certainly do not manage them properly.

5.3 CONROD MACHINING PROCESS

5.3.1 Current State Map

The connecting rod (Conrod) machining line consists of 9 machines set up in series. A raw casting is loaded into Operation 10 (start of the line), then goes through all the machining operations and is finally offloaded, as a completed product, at the final buy-off station. All operations require physical part input by the operator. When a part, per machine, is finished machine it exists the machine and falls into a stock holding bin. Operators then manually remove these parts and load it into the next operation. Operator interaction is minimal, although it is much higher than that of the block machining line. There is an emphasis on automation, but not anywhere as close to that of the block line. This machining line is one of the older machining facilities, but is also one of the most capable as far as process capability is concerned.

There are four conrods produced for every engine, which means that the Engine Plant has to produce at least 4000 conrods per day to meet the production target of 1000 engines. A huge emphasis has been placed on machine cycle time, to ensure that at least four conrods per minute are produced.

The quality, cost and delivery aspects of the conrod line will now be discussed.

LAYOUT OF CONROD MACHINING LINE

a) Quality

Average machining scrap over a five month period was 4,9 percent. Average machining rejects, for the same time period, was 3,2 percent. Foundry scrap, also for the same time period, was 2,9 percent. Total scrap and rejects for that specific time period, accounted for 11 percent of total product input. Scrap and rejects are measured as a percentage of stock input into the machining line operation 10. Stock that is sold at the end of the line is not taken into account. First time through (FTT), a qualitative measure that depicts how many parts went first time through the entire machining process without been reworked or repaired, averaged at 86 percent for the same time-period, was.

b) Equipment Effectiveness and Stock Holding

Overall equipment effectiveness, a measure of a machines operating uptime, was approximately 71 percent for the same time period. This means that, on average, production machinery was down for 29 percent of the time. Management at the Engine Plant were pleased with this level of machine uptime.

Stock holding of finished goods, for the same time period, was minimal. A maximum of two hours worth of stock were housed in the final storage area. Non-achievement of the daily schedule was the main reason for this. In-process stock storage was extremely high. Bottleneck areas had huge amounts of conrods stored. This was deliberately performed so that theses bottleneck machines could run continuously during tea and lunch breaks. There were approximately four thousand in-process parts that needed sorting. No one could say whether these parts were good or bad. The production coordinator and the team leaders' comments were that they were too busy fire-fighting to sort the stock out. Raw casting storage was excessively high. There were, on average, more than five days worth of castings in the plant, excluding the castings on the production line.

c) Build-to-schedule

Build-to-schedule (BTS), a measure of what production actually produces versus what the production schedule calls for averaged at 89 percent for the same time period.

The average JPH for the same time period was 37, which is approximately 87 percent of the 42,6. To achieve 1000 engines per day, the conrod line has to produce a 42,6 JPH. The calculation is as follows:

42,6 * 21hrs * 20 days * 12 months = 240 000 engines

Total scrap and rejects accounted for 11 percent, and the overall equipment effectiveness met the required target. Taking this into account, this production line should produce an 89 percent build-to-schedule or a JPH of 38. This was not the case. Data integrity, even though there was only a difference of one JPH, was once again questionable. Although the data integrity was questionable, it was much better than that of the block line.

A decision was taken, by all the team players, not to perform any further investigation on the integrity of the data because of the small difference. Rather, the emphasis would shift to improvements in JPH. To make improvements in the JPH levels, an investigation would have to be performed on the scrap and reject rate. A reduction in the scrap and reject rates would automatically result in an increased production yield.

5.3.2 People Aspect

The conrod machining line has one production coordinator and one team leader per shift. These two employees, in management's opinion, have to work closely

together to ensure that production targets are achieved. Good coordination between these two employees is critical.

a) Production Coordinator and Team Leader interview

A structured questionnaire was used to interview the production coordinators and the team leaders. Both employees per shift were interviewed together. The interviews were conducted over all shifts, which ensured that one shifts employees were not influenced by what the other shifts employees said. The aim of the interview was to identify the constraints to achieving production volume on a regular basis.

The interview was very informal, and lasted a maximum of 20 minutes. The first question posed was "What are the factors that prevent you from achieving your production target on a daily basis?" All three shifts unanimously agreed that the high levels of scrap and rejects were the cause for the non-achievement of production targets.

The second question posed was “What is the cause of these high levels of scrap and rejects?” Answers were numerous, with the two common factors being a fairly new and poorly trained workforce, and poor tool settings by the first-year tooling supplier. The workforce, in their opinion, were deficient in quality control techniques as well as basic tool setting procedures.

Numerous conflicting opinions between the production coordinator and the team leader became apparent during the interview, which led the consultant to assume that these two employees were not working together.

An investigation was required on the training levels of the operators on the line, as well as on the tool setting procedures and gauge checking frequencies. The production coordinator and the team leader relationship had to be investigated.

b) Operating personnel interviews

A questionnaire was developed, with the assistance of the production coordinators and the team leaders, which would be answered by the operators. The questionnaire would address the concerns raised by the production coordinators and the team leaders, and would verify whether or not their claims were valid. The questionnaire would be split up into two categories. The first section would focus on quality assurance, with the second section focusing on tool controls.

Figure 5.10a below is the operator assessment questionnaire.

FMC Struandale Plant - Crew C Block and Conrod Lines

On-Line Quality Assurance System Study

QUALITY ASSURANCE	1	How long have you been on this machine (months)?
	2	Do you have written QC procedures with you?
	3	Have you been given training on QC procedures for this specific machine prior to commencing work on it?
	4	Have you been evaluated/ given additional QC training after commencing work on this machine?
	5	Do you have all the necessary gauges to properly check the quality of this machine's product?
	6	Can you recall anybody having checked/calibrated any of your gauges within the last month?
	7	How frequently do you actually quality check this machine's parts [Jobs checked per hour] (samples randomised)
	8	Do you keep a written record of these checks?
TOOL CONTROLS	9	Do you check tool settings or set tools in this machine at any time?
	10	Have you been given formal training prior to commencing these tool checks and set-ups?
	11	Do you keep a written record of these tool setting/checks/changes
	12	Do you have a written tool setting procedure with you?

Figure 5.10 (a): Operator assessment questionnaire

A sample of 18 operators over all three shifts was interviewed. Six operators per shift (50 percent of the workforce) were interviewed, thereby ensuring that the results would be representative of all three shifts.

Figure 5.10 (b) is the completed questionnaire, answered by all 18 operators, which was then analysed.

FMC Struandale Plant - Conrod Line

On-Line Quality Assurance System Study - Raw Data

		QUESTIONS	Conrod Machining Line																	
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
QUALITY ASSURANCE	1		1.0	0.1	3.0	1.0	1.0	0.5	1.0	1.0	1.0	2.5	0.0	3.5	4.0	0.8	4.0	7.0	3.5	4.0
	2		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	3		N	N	Y	Y	Y	N	N	Y	N	N	N	Y	N	N	N	N	N	N
	4		N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N
	5		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y	N	Y	Y	Y
	6		N	Y	N	N	Y	N	N	Y	Y	Y	N	N	N	Y	N	Y	Y	Y
	7		1.0	1.0	1.0	1.0	1.0	2.0	2.0	6.0	6.0	180.0	0.5	0.5	0.6	1.0	1.0	6.0	6.0	60.0
	8		Y	Y	Y	Y	N	Y	N	Y	N	N	N	Y	N	N	N	Y	Y	N
TOOL CONTROLS	9		Y	Y	Y	N	Y	N	N	N	Y	Y	Y	N	Y	N	Y	N	Y	N
	10		N	N	Y	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N
	11		N	N	N	N	Y	N	N	Y	Y	Y	N	N	Y	N	N	Y	N	N
	12		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Figure 5.10 (b): Completed operator assessment questionnaire

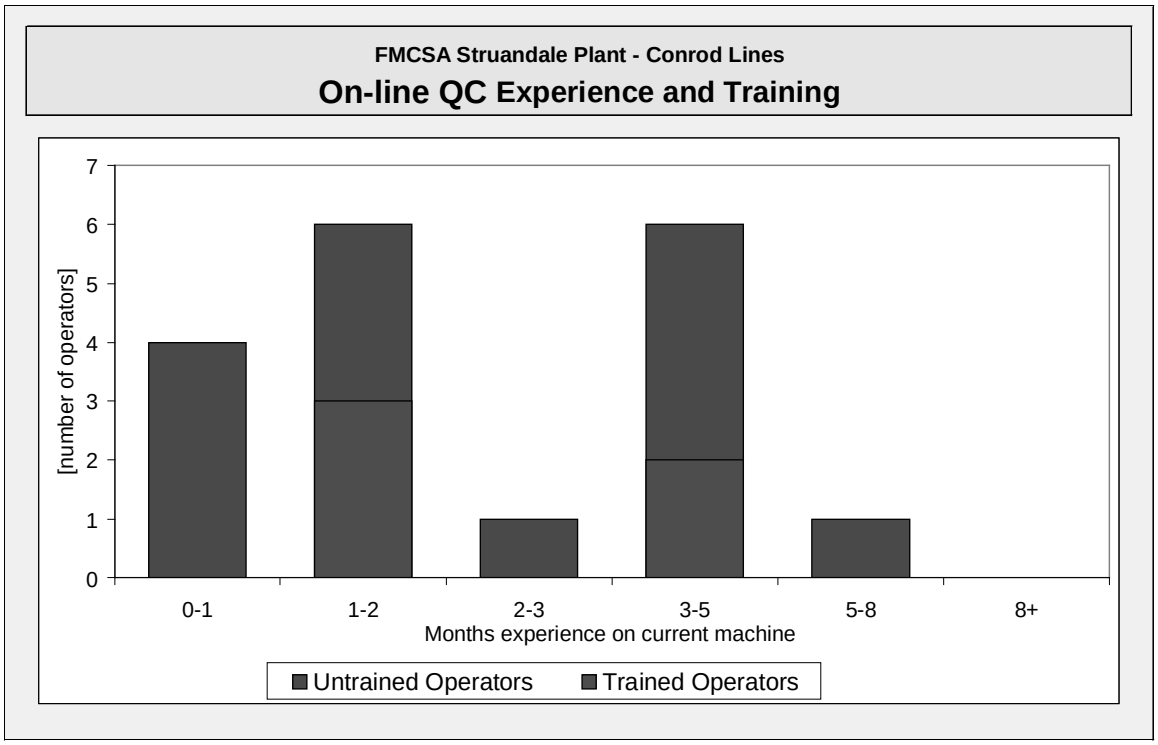


Figure 5.11: Operating personnel experience and training summary

The results of the quality control (QC) questionnaire, summarised in figure 5.11 above, is as follows:

- None of the interviewed operators had a written quality procedure.
- Only 28 percent of the operators had received quality training prior to commencing work on their current machines.
- Only six percent of the operators received quality training after commencing work on their current workstations.
- 17 percent of the operators felt that they did not have all the required gauges to properly check their work.
- 56 percent of the operators could not recall whether their gauges had being calibrated in the last month.

The quality control checking frequency is summarised in the following figure:

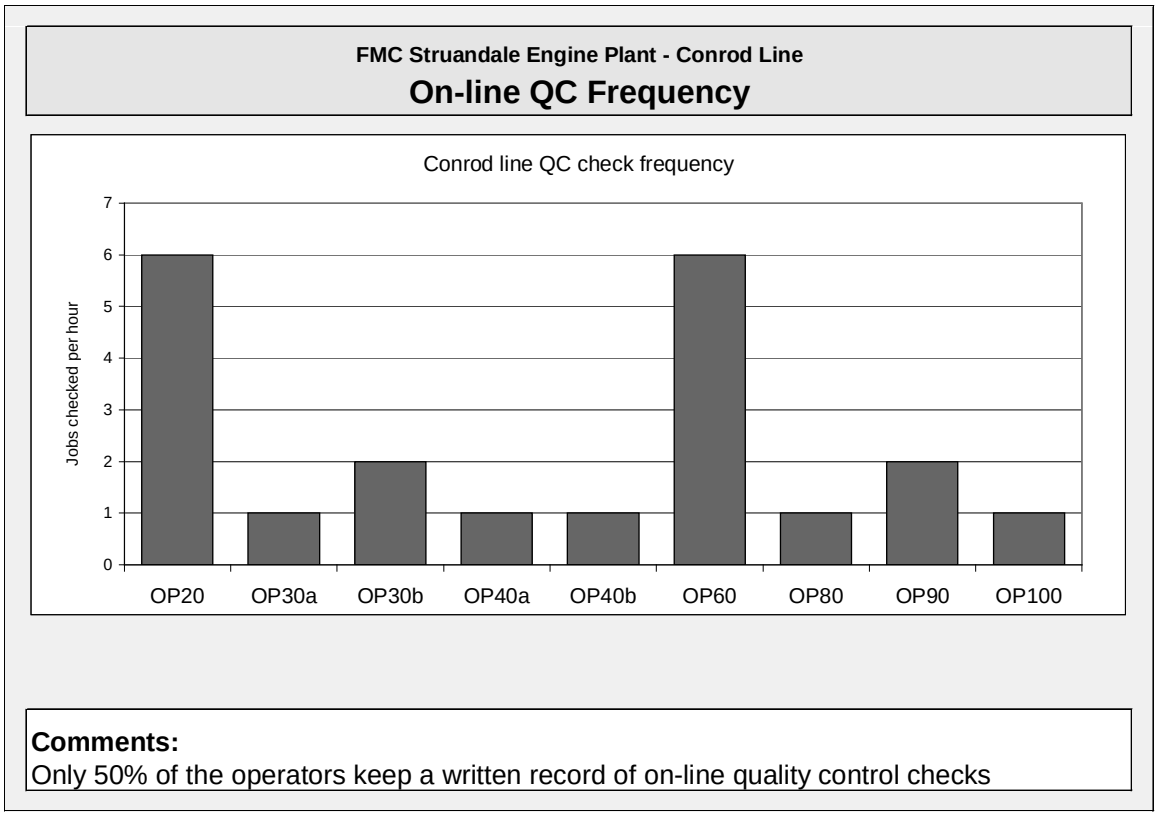


Figure 5.12: Quality control check frequencies

Quality control check frequencies are not been adhered to. High levels of scrap and reject occur because operators are not checking their components at the correct frequency. The process sheets call for a 1:50 checking frequency. In other words, one conrod should be gauged after every 50 components are produced. The conrod machining line produces four conrods per minute, which means that the operators should be checking a component almost every 13 minutes. This means that they have to gauge at least four times per hour. Operators, on average, are only checking their components once per hour, which is not in line with the required gauge frequency.

Also, only 50 percent of the operators keep a record of the on-line quality control checks. This does not enable the supervision to determine breakpoints between the good and the defective stock produced on the production line. It is not clear when the defect occurred. This results in a marked amount of time being spent on stock sorting on the production line.

The following is an analyses of the on-line tool control system:

- Only 56 percent of the operators perform checks or change and set tools on their machines.
- Only 20 percent of the operators that check, change and/or set tools have received training prior to working on their respective machines.
- Only 40 percent of the operators that check, change or set tools keep a written record of these tool checks, changes and/or settings.
- Zero percent of the operators had written tool-setting procedures.

c) Production Coordinator and Team Leader working relationship

Managements view was that these two employees spend at least 85 percent of their day on the production floor itself. The remaining time should be spent, in the office, on planning.

During the initial interview with these two employees, it became apparent that there were many conflicting opinions. For production to achieve its target, these two employees have to work extremely close. They are the first line of management on the production floor, and they have to deal directly with any issues that arise on the production line. This means that their presence has to be felt at all times by the operating personnel.

It must be noted that both the production coordinators and the team leaders were new to this production line. They were recently appointed to this production line. The production coordinators were employed from other companies, whilst the team leaders were all employed from within the Engine Plant.

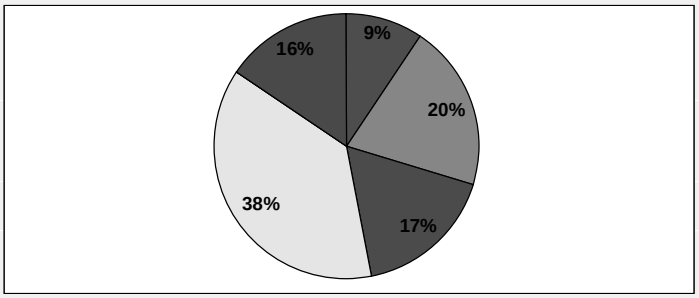
The production coordinator and team leader were observed over a full production shift. The team leader spent most of his day on the production floor attending to production issues. Figure 5.13 is a summary of the observations performed on

the production coordinator and the team leaders' activities. Observations began at 06h00 and ended at 16h30.

Ford Motor Company - Conrod Line
T/Leader Observation Study

DAY: TUESDAY, 13 AUGUST 2002
SUPERVISOR: RICCO
AREA: Conrod Line

= ACTIVE
= PASSIVE
= MANUAL
= ADMIN
= TRAINING
= UNPRODUCTIVE



Time	Activity						Comments
	Active	Passive	Manual	Admin	Training	Unprod/Away	
06:00 AM		1 1					**The day started of with Andile's Daily Briefing meeting where issues from the previous shift were discussed with the Team Leaders and the Operators. This meeting covered general housekeeping issues and team gripes. Very little time was spent on actioning operating problems reported from the previos shift. After the meeting one Team Leader went to count the stock on the line that was WIP and the other, Ricco, went to the Final Assembly to count what production took place from the previous shift. Upon his return, Ricco was angered that the night shift had produced 38 rejected sets of conrods that would have to be reworked on his shift. He explained to me that Crew C often had rejected parts that had to be reworked and that the crate of rejects was building up and up. He said that they were pressurised to fulfill other orders and that there was no time to rework the ever increasing crates that were building up. Ricco then handed out guage sheets to the operators for recording spec's.**
06:10 AM		1 1					
06:20 AM				1			
06:30 AM				1 1			
06:40 AM				1 1			
06:50 AM				1 1 1			
07:00 AM				1 1 1			
07:10 AM				1 1			
07:20 AM		1 1					
07:30 AM		1 1					
07:40 AM				1 1			
07:50 AM				1 1			
08:00 AM						1 1 1	
08:10 AM						1 1 1	
08:20 AM						1 1 1	
08:30 AM		1 1 1					
08:40 AM		1 1 1					
08:50 AM		1 1 1					
09:00 AM				1 1 1			
09:10 AM				1 1 1			
09:20 AM				1 1 1			

Figure 5.13: First-line management observation summary

The summary of the day included the following: -

- The production coordinator only made 3 brief visits to the production floor for the entire day. He spends most of the day in the office.
- The team leader spent 62 percent of his day on the production floor attending to production issues.
- team leaders only overlook the recording of hourly JPH and downtime figures and don't react on the variances highlighted.

- The team leader style is reactive and problems are either not being solved or it takes an hour and 15 minutes for a setter to address a key machine that is manufacturing over and under specification.
- Operators lack skills and there is very little on the job training. This is one of the responsibilities of the team leader.
- team leaders lack accountability and are not empowered to address problems. The area manager bypasses the team leader and instructs the operators of operations 30a & b to continue running a sub-standard part as they needed the output.
- Perception of the team leader is that all the administration of updating controls and documentation is for senior management only. They do not see that this information is there for them to take timeous corrective action. There is a fire-fighting style of supervision.
- team leaders are very busy without actually impacting production.
- The operators are not recording downtime accurately as they often fill out the controls after the hour has already passed (for the sake of satisfying managers' demand). Part of the team leaders responsibility is to ensure that accurate data collection occurs at all times.
- The Quality Controller spends most of his time in the meeting room than on the production floor. He was only on the floor for about 30 minutes during the entire shift, hence the high levels of scrap and rework. The production coordinator keeps the Quality Controller busy with presentations that he has to give to management on the production lines performance.
- Crews do not support each other. Only the last six machines, from 15h45, were actively working to achieve output.

Figure 5.14 (a) illustrate the team leaders' actual activities (from figure 5.13), whilst figure 5.14(b) portrays the production coordinators' expectations.

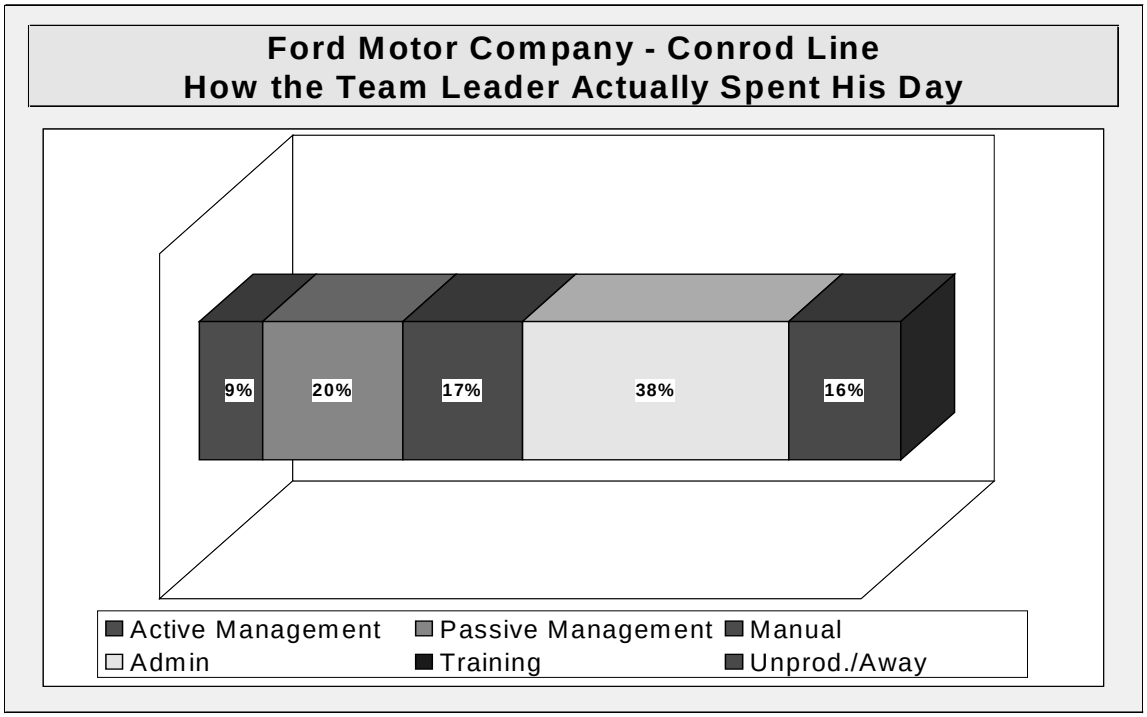


Figure 5.14 (a): team leader activity summary

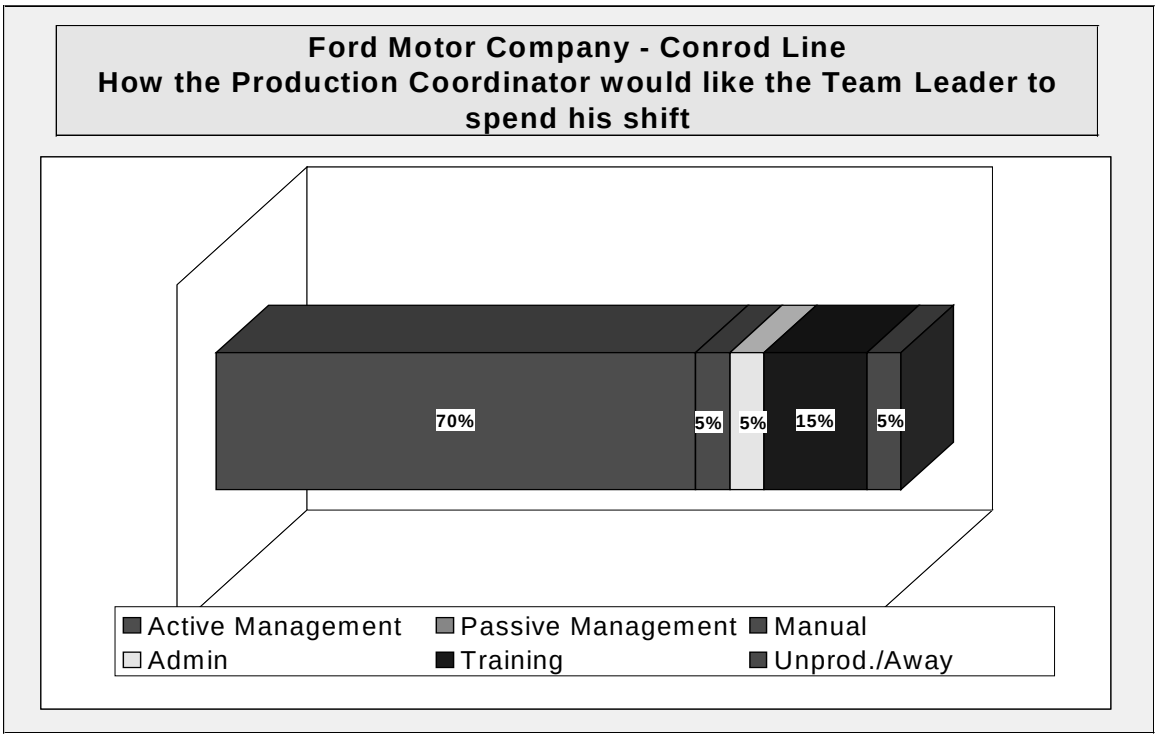


Figure 5.14 (b): Production coordinators' expectations of the team leader

It is clear that the communication between these two individuals is lacking.

The team leaders activities are not in-line with what the production coordinator requires. They don't spend enough time on actively managing their production lines.

The production coordinator does not assist the team leader at all with production activities.

High scrap and reject rates occur because of the lack of management on the production line. The production coordinator is hardly ever there, and the team leader spends too much time on administration. This results in operators doing as they please.

Employee management, a basic production discipline, is not in place on this production line.

5.4 BLOCK AND CONROD MACHINING – SIX SIGMA

Six Sigma (6σ) Breakthrough Strategy, a statistical approach to problem solving, has been deployed on both the block machining and conrod machining lines. Ford, globally, has deployed this strategy to focus on continuous improvement. It is their phase-in strategy of Total Quality Management (TQM) and thus a new approach to TQM (Ford Production System, Ford Motor Company).

5.4.1 <u>What is Six Sigma</u>

It is a statistical measurement. Sigma is a letter in the Greek alphabet. The term "sigma" is used to designate the distribution or spread about the mean (average)

of any process or procedure. For a business or manufacturing process, the sigma value is a metric that indicates how well that process is performing. The higher the sigma value, the better the performance of the process. Sigma measures the capability of the process to perform (Breyfogle, 1999: 3). This can be seen in the following figure:

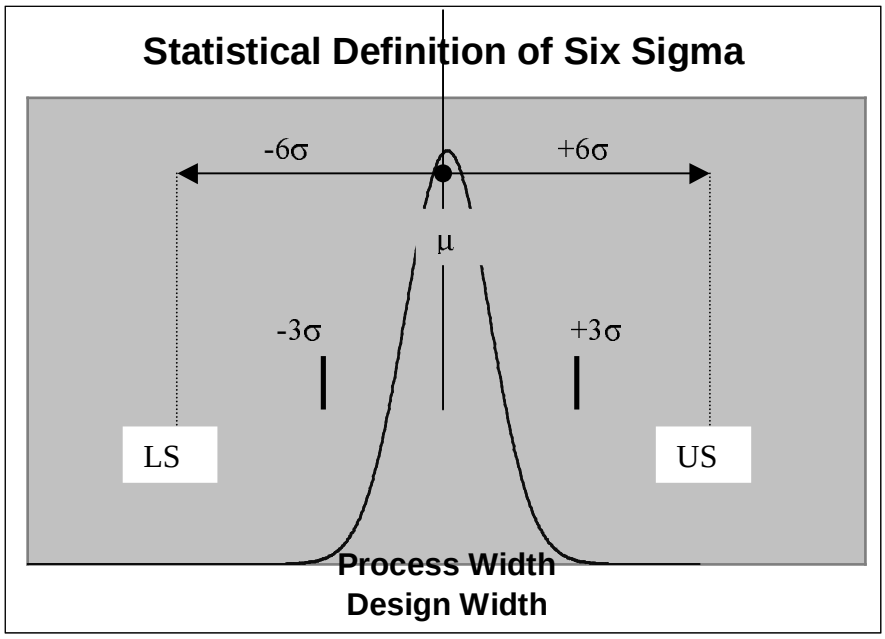


Figure 5.15: Statistical definition of Six Sigma

With Six Sigma, the common measurement index is ‘defects-per-unit’, where a unit can be virtually anything – a component, piece of material, line of code, administrative form, time frame, distance, etc. The sigma value indicates how often defects are likely to occur. The higher the sigma value, the less likely a process will produce defects (Breyfogle, 1999: 4).

σ	PPM
2	308 537
3	66 807
4	6 210
5	233
Process Capability	Defects per Million Opportunities

Table 5.3: The goal of Six Sigma

The Six Sigma method enables one to draw comparisons to other similar or dissimilar products, services, and processes. In this manner, it can be seen how far ahead or behind it is. Most importantly, it shows where one needs to go and what must be done to get there. In other words, Six Sigma helps to establish a course and gauges the pace in the race for total customer satisfaction. For example, when a process is 6 sigma, it is best in class. Such a level of capability will only yield about three instances of nonconformance out of every million opportunities for nonconformance. On the other hand, when a process is at a 4 sigma level, it is regarded as average. This translates to about 6200 nonconformities-per-million-opportunities for nonconformance. In this sense, the sigma scale of measure provides a “goodness micrometer” for gauging the adequacy of products, services, and processes (Breyfogle, 1999: 9).

Six Sigma is also a business strategy and philosophy. It assists a company in gaining the competitive edge by growing customer satisfaction. It is also a smarter way of doing business. Working smarter, not harder, becomes the norm.

5.4.2 Deployment

Six Sigma is only applied to the biggest problems on the lines. These are the problems that even the specialists cannot permanently fix. Six Sigma certified specialists, called Black Belts, are the key drivers of this process. Their function is to pull all the key personnel together to firstly brainstorm the concern for potential solutions. Hypotheses are then developed for all potential solutions. Black Belts then deploy the Six Sigma methodology, which statistically proves whether these hypotheses were significant, or not. All these problems are logged onto a global network as projects. This allows for a rapid replication of solutions.

The concern with this approach is that the basic data collection systems would have to already be in place. This, however, is not the case on both of the machining lines as the integrity of the existing data is questionable.

5.5 CONCLUSION

Current state maps for both the cylinder block and the connecting rod machining lines have been completed. This gives the reader a good understanding of the existing situation on the respective production machining lines. Interviews and observations have also been deployed, which gives the reader a deeper understanding of the underlying concerns within the machining lines. Brief explanations for the on-line concerns have been given thus far.

Six Sigma has been discussed to highlight Fords' continuous improvement initiative. All Black Belt projects completed thus far at the Engine Plant had to begin with the establishment of a data collection system. The existing data that had been collected was not good enough.
A more detailed interpretation of the results will now be portrayed in chapter six.

CHAPTER 6

ANALYSIS OF FORDS' MANUFACTURING MACHINING PROCESS – INTERPRETATION OF RESULTS

		PAGE
6.1	INTRODUCTION	108
6.2	BLOCK MACHINING PROCESS	
6.2.1	Current State Map – Interpretation of Results	108
d)	Quality	108
e)	Equipment Effectiveness and Stock Holding	109
f)	Build-to-schedule	110
6.2.2	People Aspects	111
c)	Production coordinator and team leader Interview	111
d)	Observations	111
iii)	Overall Equipment Effectiveness	111
iv)	Operator Effectiveness	112
6.3	CONROD MACHINING PROCESS	114
6.3.1	Current State Map –Interpretation of Results	114
a)	Quality	114
b)	Equipment Effectiveness and Stock Holding	115
c)	Build-to-schedule	116
6.3.2	People Aspect	116
a)	Production coordinator and team leader Interview	116
b)	Operating Personnel Interviews	117
c)	Production coordinator and team leader Relationship	121

6.4 BLOCK AND CONROD MACHINING SIX SIGMA 124

6.5 CONCLUSION 125

CHAPTER 6

ANALYSIS OF FORDS' MANUFACTURING MACHINING PROCESS – INTERPRETATION OF RESULTS

6.1 INTRODUCTION

In this chapter the focus will be on the interpretation of the results described in chapter five. The existing process (people and machining process) will be discussed and compared to that of a lean manufacturer. The inefficiencies within the existing process will be identified so that recommendations can be made to bring the existing process in-line with that of a lean manufacturing process.

6.2 BLOCK LINE MACHINING

6.2.1 Current State Map – Interpretation of results

a) Quality

Average scrap and rejects for the five month period was 2,7 percent. Foundry scrap for the same time period was 2,3 percent. Total scrap and rejects accounted for five percent of total product input. That equated to approximately 50 blocks scrapped per day, based on a target of 1000 blocks per day. At a cost of R900, 00 per block, the block machining line generated approximately R45 000,00 worth of scrap per day, excluding process and production costs (fixed and variable).

Foundry scrap has to be incorporated into the first time through calculation, as they are only physically identifiable after the block has completed 30 percent of the line processing. All foundry defective blocks are replaced by the customer. The hidden costs (process and production) are not charged back to the supplier,

which does little to pressurise the supplier into improving his process immediately.

Housekeeping was poor. The line was dirty, there were numerous oil leaks, machines were not cleaned, and parts (process and production) were lying all over.

First time through (FTT) averaged at 92 percent for the five-month period. If total scrap and rejects were five percent, then FTT should have been 95 percent. The data integrity was definitely questionable. Somehow, three percent of total input was not accounted for. This equated to 30 cylinder blocks per shift, or 150 blocks per week.

There were no control systems in place to ensure that all the operators were collecting qualitative data. Some operators collected data, whilst others did not. A standard data collection system has to be implemented as soon as possible. Also, too much focus was placed on part inspection (input, in-process and final) instead of the building of quality into the product. Inspection is non-value added because it increases head count and does absolutely nothing for quality. Scrap and rejects can only be identified in this way, which is totally reactive. No proactive measures can be introduced in this way.

b) Equipment Effectiveness and Stock Holding

The data integrity for OEE was, as is the case with quality, poor. Incorrect numbers were been reported into management. This allowed them to believe that they had a good maintenance system in place. The inverse was true. It was only after the operators were trained up to correctly record data, did the true OEE level become apparent. Average OEE for a six week time period was at 47 percent. This implied that machine downtime was in excess of machine uptime.

A standard data collection system for OEE is in place, however all the operators are not familiar with this process. Operator training is immediately required to rectify the situation.

Stock holding of finished goods was minimal due to the constant non-achievement of the daily schedule.
In-process stock storage was excessive due to the stock pile-up prior to the bottleneck operations. These operations ran continuously to maximise production volume. Stock identification was non-existent, as well as the setting of minimum and maximum stock levels. Some in-process stock was approximately two weeks old, and had already begun to corrode. These blocks were always reworked and then sold to the assembly line. These corroded blocks almost always turned out to be rejected on the assembly line (only after it had been loaded and sub assembled).
Raw casting stock storage was too high, which consumed too much storage space. There were no clear signs of a first-in-first-out system in place. Some blocks had date codes of the year 2000 on them. This caused a considerable time delay when castings had to be inspected due to supplier related concerns. Communication links needs to be improved between Ford and the casting supplier.

c) Build-to-schedule

The build-to-schedule for the five-month period was 71 percent. This equated to a JPH of 31. This line should have produce a 95 percent build-to-schedule if one takes into account that total scrap and rejects accounted for five percent. This was evidently not the case.

Data integrity was once again questionable.

6.2.2 People Aspects

a) Production Coordinator and Team Leader Interview

These employees firmly believed that machine downtime and the carefree attitude that operators had negatively impacted on them achieving their daily production targets.

These employees did not use OEE to manage their business. They knew that the data was been recorded, but they were not sure what the figures were. All that they were interested in was getting the production totals out at the end of the line. These employees had adopted a fire-fighting management style.

They were also not team players, as they had no forms of communication with the other departments, other than alerting them when there was a breakdown on the line. No brainstorming sessions were held to solve recurring problems on the line.

b) Observations

i) Overall Equipment Effectiveness

Actual OEE was at 47 percent. This meant that the machinery was operational for less than half the available time. Total machine downtime, split up into recorded and hidden downtime, could immediately be improved with a little effort.

Recorded downtime, accounting for seven percent of total downtime, could be improved by 52 percent. Attention has to be placed on:

- The capability process of the first-year tooling supplier,
- Tool life change frequencies (this must be monitored and recorded)

- Tooling and gauge change and setting procedures (needs to be more specific and user friendly so that the operators fully understand them).

Hidden downtime, accounting for 46 percent of total downtime, could be improved by 71 percent. Attention has to be placed on:

- Operator and setter training to identify the cause of concerns quickly,
- CNC programming integrity
- Improving effective communication and coordination between production coordinators, team leaders, area managers and operators. Everyone needs to know what the status of the production line is. All concerns should be communicated to everyone, as they are part of the team.

team leaders need to be empowered to make decisions. They need to be part of the decision making process. They do not plan or control at all. They need to be trained in these aspects, thereby empowering them to take the initiative.

Activities, like model changeovers, need to be formalised between the production coordinator and the team leader. This will eliminate confusion on the machining production line when this occurs.
OEE can be improved from 46 percent to 83 percent if these points are actively worked on. That is already in excess of managements' target of 71 percent OEE.

ii) <u>Operator effectiveness</u>

The workforce is 43 percent of the time productive, as opposed to the claim that they were 75 percent productive. The team leader and production coordinator are not in control of their workforce.

Operators are generally unproductive. No matter what they do, they cannot achieve their daily production targets because of the poor OEE. JPH is the only

performance measurable that their supervisors use. JPH means nothing if it is not achievable. Operators have little, if any, motivation to achieve the JPH targets.

Operators are also not skilled to perform basic tool setting activities. A tool setter has to be summoned each time a machine stops. Training is direly required.

Proactive brainstorming sessions need to be implemented so that everyone feels part of the team. Operators need to feel important, and they have every right to.

Feedback from production coordinators and team leaders are minimal. Reported problems are not addressed, which motivates the operators not to report any future problems.

Operators receive instructions from too many managers. They don't entirely know what the responsibility of the team leader is. Workers are only productive when senior managers are present on the production lines.

The first-year tooling supplier creates more problems on the production line. They bypass everyone, excluding the production coordinator, when they want to make changes on the machines (due to their initial poor tool settings). The operating personnel don't see themselves as the process owners any more, and subsequently lose interest in their jobs.

6.3 CONROD MACHINING PROCESS

6.3.1 Current State Map – Interpretation of Results

a) Quality

Total scrap and rejects (machining and foundry) for the five-month time period accounted for 11 percent of total product input. That equated to approximately 440 conrods scrapped per day, based on the daily production target of 4000. At a cost of R45, 00 per conrod, the conrod machining line generated approximately R19 800,00 worth of scrap per day, excluding process and production costs (fixed and variable).

Foundry scrap has to be incorporated into the first time through calculation, as they are only physically identifiable after the conrod has completed 70 percent of the line processing. All foundry defective conrods are replaced by the customer. The hidden costs (process and production) are not charged back to the supplier, which does little to pressurise the supplier into improving his process immediately.

Housekeeping was poor. The line was dirty, there were numerous oil leaks, machines were not cleaned, and parts (process and production) were lying all over.

The current housekeeping situation was similar to that of the block line.

First time through (FTT) averaged at 86 percent for the five-month period. If total scrap and rejects were 11 percent, then FTT should have been 89 percent. The data integrity was definitely questionable. Somehow, three percent of total input was not accounted for. This equated to 120 conrods per shift, or 1200 conrods per week (based on two shifts per day).

There were no control systems in place to ensure that all the operators were collecting qualitative data. Some operators collected data, whilst others did not. A standard data collection system has to be implemented as soon as possible. Also, too much focus was placed on part inspection (input, in-process and final) instead of building quality into the product. Inspection is non-value added because it increases head count and does absolutely nothing for quality.

b) Equipment Effectiveness and Stock Holding

Overall equipment effectiveness averaged at 71 percent for the same five-month period. Management at the Engine Plant viewed this level of machine uptime as acceptable.

Stock holding of finished goods was minimal due to the constant non-achievement of production targets. A maximum of two hours worth of stock were housed in the final storage area.

In-process stock storage was extremely high. Bottleneck areas had notable amounts of conrods stored. This was deliberately performed so that theses bottleneck machines could run continuously during tea and lunch breaks. There were approximately four thousand in-process parts that needed sorting. No one could say whether these parts were good or bad. The production coordinator and the team leaders' comments were that they were too busy fire-fighting to sort the stock out.

Raw casting storage was excessively high. There were, on average, more than five days worth of castings in the plant, excluding the castings on the production line.

c) Build-to-schedule

Build-to-schedule (BTS), a measure of what production actually produces versus what the production schedule calls for averaged at 89 percent for the same time period.

The average JPH for the same time period was 37, which is approximately 87 percent of the 42,6.

Total scrap and rejects accounted for 11 percent of the total input. OEE met the required target of 71 percent. This meant that the BTS should be 89 percent. This was not the case. All the team players took a decision, that further investigations into the data integrity were not necessary due to the small discrepancy.
It was decided that the emphasis would shift to making improvements in the JPH levels. This would automatically result in an increase in production yield.

6.3.2 People Aspect

a) Production Coordinator and Team Leader interview

Both employees agreed that the non-achievement of their daily production target was due to the high levels of scrap and rework. They firmly believed that operator deficiencies in quality control techniques and basic tool setting were the root cause of the high scrap and reject levels.

These employees had adopted a fire-fighting management style. They did not have a structured plan in place to solve the existing problem. They were of the opinion that they had no time to train the operators, as they were too busy trying to achieve their production targets. Their initial solution to the problem was that

the team leader spends time with the operators, on a one-on-one basis, to train them in the required disciplines. This, however, proved fruitless, as time constraints, in their opinion, did not allow this to materialise.

No brainstorming sessions were held to solve this problem on the line. The Human Resources departments' assistance was also never requested to solve this issue. Conflicting opinions between the production coordinator and the team leader, during the interview became apparent which led the consultant to the conclusion that these two employees were not working together. This probably accounted for the absence of brainstorming sessions or formalised plans to solve their problems.

An investigation was performed on the training levels of the operators on the line, as well as on the tool setting procedures and gauge checking frequencies. An investigation was also performed on the working relationship between the production coordinator and the team leader to establish whether or not these two individuals were in fact working as a team. It was evident that training was required. It was also clear that the communication between the production coordinator and the team leader was poor.

b) Operating personnel interviews

A questionnaire was developed, with the assistance of the production coordinators and the team leaders, which was answered by the operators. The questionnaire addressed the concerns raised by the production coordinators and the team leaders, and verified their claims. The questionnaire was split up into two categories. The first section focused on quality assurance, with the second section focusing on tool controls.

A sample of 18 operators over all three shifts was interviewed. Six operators per shift (50 percent of the workforce) were interviewed, thereby ensuring that the results would be representative of all three shifts.

The results of the quality assurance questionnaire was as follows:

- None of the interviewed operators had written quality procedures. This was definitely one of the main reasons for the high scrap and reject rates. Operators were scrapping and rejecting components that should not have been scrapped or rejected. They were also passing components that should have been scrapped or rejected. This skewed the figures, and also gave management an incorrect idea of the true production yield on the machining line. Clear, concise quality procedures were available, but were never posted on the production line by the production coordinator or the team leader. These procedures were located in the mini business areas on the production line.
- Only 28 percent of the operators received quality training prior to commencing work on their current machines. The bulk of the operators were new employees. Ford employed an additional 66 percent headcount earlier on in the year. These employees received training, but not quality-specific training. This training was supposed to be administered on-line by specialist training coordinators prior to the production volume increase. There was a comprehensive training plan for this purpose, which was located in the training department. This plan did not materialise due to the unexpected production volume increase. It was fairly difficult to produce high volume products and train operating personnel at the same time.
- Only six percent of the operators received quality training after commencing work on their current workstations. This was due to the unexpected production volume increases. Six percent of the conrods' workforce received training prior to the unexpected volume increase. No operators were trained after the volume increase. The six percent that had been trained were the ones that were recording the data correctly.

They also rejected and scrapped fewer components than their counterparts.

- A total of 17 percent of the operators felt that they did not have all the required gauges to properly check their work. This was, in fact, not true. There were adequate gauges on the line to gauge all the significant and critical characteristics. These gauges were not clearly identified to all the operating personnel. Certain characteristics had to be measure by means of three-dimensional measuring machines. Operators were not familiar with these machines; therefore they did not use them. This promoted scrap and rejects because the parts were not gauged. This specific characteristic was only identifiable towards the end of the production line. Once a reject was identified, parts had to be traced back to the station where the characteristic was machined. All these parts were then either rejected or scrapped, depending on the severity of the reject.
- A total of 56 percent of the operators could not recall whether their gauges had being calibrated in the last month. All gauges had been calibrated timeously. A calibration sticker on the gauge table reflected the date when the gauge was last calibrated. The quality layout department verified this. Operators were not using their gauges frequently; otherwise they would have known this.

Quality control check frequencies were also not being adhered to. High levels of scrap and rejects occurred because operators were not checking their components at the correct frequency. The process sheets specified a 1:50 checking frequency. In other words, one conrod should be gauged after every 50 components are produced. The conrod machining line produces four conrods per minute, which meant that the operators should be checking one component almost every 13 minutes. This meant that they had to gauge at least four times per hour. Operators, on average, were only checking once per hour, which was not acceptable.

Also, only 50 percent of the operators kept a record of the on-line quality control checks. This did not enable the supervision to determine breakpoints between the good and the defective stock produced on the production line. It was not clear when defects actually occurred as opposed to when they were first noticed. This resulted in a huge amount of time being spent on stock sorting on the production line, which was non-value added as well as costly.

The following was an analyses of the on-line tool control system:

- Zero percent of the operators had written tool-setting procedures. Tool setting procedures were not available to the operators. The engineering process sheets specified that all tool-setting procedures be displayed at the machining station. The process sheets were obviously not being adhered to, which was in contravention of their quality system, QS9001. Tool setting was performed by unskilled personnel, hence the high rate of rejects and scrap.
- Only 56 percent of the operators performed checks or changed and set tools on their machines. Most of the operators were not skilled enough to perform tool setting. The majority of the operators that received tool setting training were often moved to other machining lines because of the high absenteeism rate. This negatively impacted on the scrap and reject rate. Majority of the operators were not aware of the tool change frequency. They believed that the machine tool setters were responsible for identifying when a tool had to be changed. Often tool change frequencies were not adhered to, resulting in sub-standard parts being machined. This increased the scrap and reject rate.
- Only 20 percent of the operators that performed checks, changed and/or set tools had received training prior to working on their respective machines. Tool setting training was extremely informal. All training was performed on-line by the machine tool setters. No formal evaluation of the operators was performed after the training was completed. There was no

evidence of a structured training plan to train operators in the discipline of tool setting.

- Only 40 percent of the operators that performed checks, changed or set tools kept a written record of these tool checks, changes and/or settings. Training was definitely required for the operating personnel.

c) Production Coordinator and Team Leader working relationship

During the initial interview with these two employees, it became apparent that there were many conflicting opinions. For production to achieve its target, these two employees had to work extremely close. They were the first line of management on the production floor, and they had to deal directly with any issues that arose on the production line. This meant that their presence had to be felt at all times by the operating personnel. Management was of the view that these employees spend at least 85 percent of their day on the shop floor.

These employees were new to Ford Motor Company. They were recently employed. The production coordinators were employed from external companies, whilst the team leaders were employed from within Ford. The production coordinators were definitely not familiar with the culture at Ford. This caused several problems for them, with regard to their relationship with their subordinates.

The production coordinator and team leader were observed over a full production shift to ascertain whether or not these employees were actually working closely together.

The findings was as follows: -

- The production coordinator only made 3 brief visits to the production floor for the entire day. He spent most of the day in the office preparing

presentations and attending meetings. The production coordinator did not believe that he had to spend most of his time on the shop floor. He firmly believed that he only had to manage the team leader and the operating personnel. This was specified in his job description. His job description did not clearly indicate to him that he had to spend most of his day on the shop floor. Most of the production coordinators were new to this type of job, and were struggling to settle into the job. Their previous jobs were not as demanding as this one, and obviously an adjustment was necessary.

- The team leader spent 62 percent of his day on the production floor attending to production issues. All the team leaders were previously operators on the machining and assembly lines. They were comfortable with the idea of spending the majority of their days on the shop floor.
- The team leader only overlooked the recording of hourly JPH and downtime figures and did not react to the variances highlighted. The team leaders' behaviour was that of a clerk, and not as that of production management. They did not take any proactive measures to rectify out of specification situations. They believed that this was the responsibility of the production coordinator.
- The team leader style was totally reactive. Problems are hardly ever solved. No reasons are given when machine tool setters take excessive time to address a key machine that is manufacturing over and under specification.
- Operators lack skills and there is very little on the job training. This is one of the responsibilities of the team leader that he hardly ever performs. This is one of the main reasons for the lack of versatility amongst the operators on the shop floor.
- team leaders lack accountability and are not empowered to address problems. Area managers and production coordinators bypass the team leader and instruct the operators to perform duties that the team leader is not aware of. Area managers and production coordinators overrule team leaders decisions, and do not involve them in decision-making.

- Team leaders are very busy without actually impacting on production. The team leader never starts and finishes a concern. He starts with one thing and then starts with something else. He hardly ever completes something from start to finish.
- The operators are not recording downtime accurately as they often fill out the controls after the hour has already passed (for the sake of satisfying managers' demand). Part of the team leaders responsibility is to ensure that accurate data collection occurs at all times. Team leaders are comfortable with the fact that operators are collecting data, even though the data may be incorrect. They cannot see the value of data collection.
- The Quality Controller spends most of his time in the meeting room instead of on the production floor. He was only on the floor for about 30 minutes during the entire shift, hence the high levels of scrap and rework. The production coordinator keeps the Quality Controller busy with presentations that he has to give to management on the production lines performance. The Quality Controllers' presence on the shop floor is extremely important. A lack thereof sends out the incorrect message, with regard to quality, to the workforce.
- Crews do not support each other. Only the last six machines, from 15h45, were actively working to achieve output. The bottleneck machine operators were not productive at their stations, resulting in a shortage of work in progress for the following shift. This type of behaviour does not foster teamwork, but actually results in the demoralisation of the workforce. The different production shifts ended up working against each other instead of working for each other.

There were no clear lines of communication between these two individuals. The team leaders' activities were not in-line with what the production coordinator required. The production coordinator wanted the team leader to spend most of his time (70 percent) on active management, followed by training (15 percent), and then administration. The team leader, however, spent most of his time (38

percent) on administration, only nine percent spent on active management, and no time at all on training.

The team leaders' formal job description, obtained from the Human Resources department, was not in line with the requirements of the production coordinator. The production coordinator did not clearly explain his requirements to the team leader. He was under the impression that this had already been explained to the team leader by the Human Resources department.

The production coordinator never assisted the team leader with production activities. He believed that it was the team leaders' responsibility to manage the shop floor, whilst he coordinated the integration of the service departments into production.

High levels of scrap and rejects occurred because of the lack of management presence on the production line. The production coordinator was hardly ever present, and the team leader spent most of his time on administration. There was no control exercised over the operators, which resulted in them walking off the job when they pleased. Employee management, a basic production discipline, was not in place on this production line.

6.4 BLOCK AND CONROD MACHINING – SIX SIGMA

Six Sigma has only been deployed to the major problem areas on the block and conrod machining lines. The intention is good, but the timing is not good at all. Six Sigma can only work if a sound data collection process is in place. Historical data is used to identify potential Six Sigma projects. A Pareto chart is then developed using the historical data, and the largest concern is selected as the Six Sigma project. If the data were not true, then people would be working on

issues that were not really a concern to the company. Incorrect measurements foster inappropriate behaviour.

6.5 CONCLUSION

The block line first-line management team were not managing their business according to the principles of lean class manufacturing. Quality, cost and delivery were not their key drivers of performance. Housekeeping was also terrible.

The data collection system for first time through; overall equipment effectiveness; scrap and rejects; and build-to-schedule, was not enforced by the first-line management team. The integrity of the data was definitely questionable.

Policy deployment, in the form of roles and responsibilities, was not clearly explained to all, resulting in poor communication and inefficient operators. First-line management were also not in control of their workforce.

The Conrod line experienced similar concerns to that of the block line. The additional concerns were poorly trained operators with regard to quality assurance and basic tool setting, and unclear lines of authority and responsibility between the production coordinator and the team leader. These concerns, on both the conrod and the block line, needs to be immediately resolved if management wants to grow the JPH figures. Similar to the block line, housekeeping was not good at all.

Focusing on the improvement of the value stream, as well as by adopting and deploying Demings' philosophies can solve most of these concerns. The philosophies to deploy immediately would be:

- Cease dependence on inspection to achieve quality

- Improve constantly and for ever the system of production and service
- Institute training on the job
- Adopt and institute leadership
- Break down barriers between departments and individuals
- Eliminate slogans, exhortations, and targets for the workforce
- Eliminate work standards and numerical quotas
- Remove barriers that rob the hourly worker of the right to pride in workmanship
- Encourage education and self-improvement for everyone
- Take action to accomplish the transformation

Employees need to take responsibility for their actions. They all have to buy into the corporate goals and objectives. This is the only way to make quick improvements to the current situation.

CHAPTER 7

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

		PAGE
7.1	SUMMARY	128
7.2	CONCLUSIONS	128
7.3	RECOMMENDATIONS	132

CHAPTER 7

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 SUMMARY

It was the intention of the study to, firstly, introduce Ford Motor Company (Engine Plant) and its current state holistically; secondly to investigate the philosophies and principles of lean manufacturing; thirdly to map the current process at identified production lines at Ford Motor Company; and fourthly to compare the existing state, based on the research methodology to that of the philosophies and principles of lean manufacturing. In this way, the deficiencies were identified upon which first-line management could react.

7.2 CONCLUSION

Several conclusions can be drawn on completion of the study of related literature, investigations and evaluation. They are as follows:

- Several companies, including Ford Motor Company's Engine Plant, are trying to move quickly to a world class status because of the increasingly competitive industry (Engine Plant holistically explained with regards to increased customer demand).

- World class manufacturers adhere to three main factors:
    1. Quality
    2. Cost
    3. Delivery

- First-line management did not manage their business the way a lean manufacturer would. Quality, cost and delivery were not their key drivers of performance. These personnel were also not team players as there was no evidence of cross-functional brainstorming and problem resolution sessions. Production personnel, in isolation, addressed all problems and concerns. Supporting departments were only called in when problems could not be resolved. This resulted in huge production losses, which severely affected the JPH figures.

- Methods and tools for reaching world class status need to be identified and deployed, but needs to be modified to suit each individual company. This also applies to different production lines within a company. There could be an existing system in place that only needs to be slightly modified to achieve an improvement in quality and volume levels.

There were data collection systems in place on both the cylinder block line and the conrod line, but it was better deployed, even though it has to be improved, on the conrod line.

- Housekeeping in general was not good at all, with plenty of unnecessary parts (process and production) lying around. Machines were not cleaned regularly and floors were covered with oil leaks from the machinery.

- Data collection systems for first time through, build-to-schedule, overall equipment effectiveness, scrap and rejects were not fully deployed. The systems were in place, but adherence thereto was minimal. Not all the operating personnel were collecting data, and those that did were not doing a good job. Operator training, with regard to data collection, was non-existent and was required.

- Material Planning and Logistics (MP&L) was not fully integrated into production. Raw and in-process stock levels were exceedingly high, resulting in huge stock carrying costs as well as unnecessary stock holding areas. There was no evidence of a first-in-first-out (FIFO) stock rotation system, which resulted in old (more than one month old) in-process stock still lying around on the machining lines. There were marked amounts of in-process stock that still needed to be sorted, stock which had been present on the line for more than two months. This was obviously not highlighted by the MP&L department, which meant that they were definitely not in control of their process.

- Production personnel were not adhering to the quality systems (Q1 and QS9000). Gauging of components were not performed regularly, in-process and final stock was not properly identified (product status identification) and procedures, for both quality and tool setting, were not available to the shop floor personnel.

- The Quality department did not rigidly control suppliers. There was a high rate of foundry scrap. Foundry scrap, over the five-month period, did not decline at all. Suppliers were not pressurised to improve on their current performance. This was so because quality personnel focused more on in-process improvement rather than on supplier improvement. Suppliers are not managed in line with Q1 and QS9000 requirements.

- Overall equipment effectiveness, first time through, and build-to-schedule figures were below the required levels consistently for more than five months. First-line management had no formal structured plans in place to rectify the situation. There was no evidence of medium to long term planning. First-line management were continually in a fire-fighting mode, which was definitely counterproductive.

- Policy deployment (roles and responsibilities) was not clearly explained to all personnel, which included the first-year tooling supplier. Lines of communication amongst the production personnel were not clear. Operators were not sure of the first-year tooling suppliers responsibilities. Production coordinators did not formally inform the team leaders of their requirements. The team leaders job description, obtained from Human Resources, was also substantially different to the expectations of the production coordinators. There was definitely a mismatch, which needed to be remedied immediately.
- Operators were not motivated to achieve their production targets due to poor OEE performance. Lines of communication were also poor between the first-line management and the shop floor operating personnel.

- Shift crews were not supporting each other. They only worked to meet the shift production target, and not the daily production target. One shift would almost deplete the work-in-progress to try to achieve the shift production target. This resulted in product starvation on the next shift. In other words, the second shift would have to firstly prime the production line before selling any components at all. This negatively affected the JPH figures.

- Management do not spend enough time on the shop floor. This indicates that they are not interested in the problems that the shop floor personnel are experiencing.

- Continuous improvement is non-existent on the shop floor. Six Sigma is an excellent tool, but it requires that the basic systems be in place prior to deployment. This is definitely not the case. At present, Six Sigma is only applied to the biggest concerns on the production line. This is not always effective because the biggest concerns often turn out to be smaller concerns because of the integrity of the data collection system.

- When lean manufacturing systems and philosophies are adopted and implemented by a company, there are usually teething problems because most South African factories are brownfield sites.

- These teething problems have to be addressed and there seems no better way than with continuous improvement (Kaizen). Ford Engine Plant is not ready for Six Sigma implementation.

7.3 RECOMMENDATIONS

From the above conclusions there are certain fundamental principles pertaining to lean manufacturing that Ford Motor Company need to investigate in order to achieve world class status. The recommendations are as follows:

- Companies should realise that for a brownfield site, continuous improvement teams (Kaizen) in production are essential for keeping costs down, throughput up and reducing operator fatigue.

- First-line management needs to be trained and coached into managing their business by using quality, cost and delivery as the key performance metrics. They also have to be trained in team dynamics. This will promote cross-functional brainstorming and problem resolution sessions.

- The seven mudas (as per chapter 2) needs to be deployed immediately. Housekeeping and workplace organisation (as per chapter 3) also needs to be focused on. Regular audits need to be performed by cross-functional teams.

- The accurate collection and processing of base-measurement data should be treated as cardinal and road shows, by production themselves, should be presented every week to top management. This will ensure that data is regularly collected and corrective action is continually taken to improve the current situation. Operating personnel needs to be trained in this discipline. Management needs to be serious about implementing lean production principles by enforcing these road shows.

- The objectives of Kaizen, production management and the supporting departments (including maintenance and MP&L) ought to be the same in the interest of maximum productivity i.e. leaning towards world class.

- A full quality audit (Q1 and QS9000) needs to be performed immediately to identify any shortcomings. All deficiencies should be placed into a concern corrective action request (CCAR) format identifying the responsible persons and the completion dates for all the concerns.

- The Quality department needs to become more aggressive with the supply base. The Supplier Technical Assurance (STA) department needs to work closely with the Quality department. Suppliers must be managed in line with Q1 and QS9000 requirements.

- First-line management must develop formal structured plans that will rectify the current on-line situation. Plans must include medium to long-term objective setting. Senior management need to coach the first-line management in this discipline.

- Few production systems can be implemented without the necessary infrastructure conducive to supporting it. An infrastructure where production gets involved and takes ownership (policy deployment with regards to lines of communication and responsibility between area

managers, production coordinators, team leaders and contractors) is what is required.

- Incentives (reward and recognition) are needed to drive the system especially where the shop floor employees are concerned. This will definitely improve operator effectiveness on the line.

- Senior and middle management need to manage by improvement objectives (as per chapter 2), and not by objectives. Their presence will assure the shop floor personnel of their commitment.

- The physical layout of supporting departments around production management is critical, as more interrelationships between these departments will prevail. The maintenance department in particular should be located fairly close to the production lines. They should not be summoned when a problem arises, but they should know of the problem when it occurs. This will greatly assist in improving the uptime of machinery (OEE).

- Lean manufacturing deficiencies on the two production lines have been identified. A detailed implementation plan, developed by the Ford Production System department, needs to be given to management.

REFERENCE LIST

Breyfogle, F.W (1999). *Implementing Six Sigma*. New York: John Wiley & Sons, Inc.

Deming, W.E. (1986). *Out of the Crisis, MIT Center for Advanced Engineering Studies*., Cambridge, Massachusetts: Productivity Press.

Dimancescu, D., Hines, P. & Rich, N (1997). *The lean enterprise*. New York: Amacom.

Fandel, G. & Zapfel, G. (1991). *Modern production concepts*. Heidelberg: Springer-Verlag Berlin.

Ford Production Systems. Ford Motor Company.

Goldrat, E. (1986). *The goal*. New York: North River Press.

Heller, E.D. (1971). *Value management*. Philippines: Addison-Wesley.

Imai, M. (1986). *Kaizen*. New York: McGraw-Hill.

International Institute for Labour Studies. (1994). *Lean production and Beyond*. Geneva: International Labour Office.

Jackson, T. (1996). *Implementing a lean management system.* Productivity Press.

Kruger, L.P. (1997). Strategic manufacturing priorities for South African manufacturers: the need to shift emphasis and improve on current performance levels. *South African Journal of Business Management*, pp. 138 - 146.

Logothetis, N. (1992). *Managing For Total Quality.* Prentice Hall International.

Maskell, B. (1991). *Performance measurement for world class manufacturing*. *A model for American companies*. Massachusetts: Productivity Press.

Ohno, T. (1988). *Toyota production system. Beyond large-scale production*. Massachusetts: Productivity Press.

Sboros, M. (1996). Intellectual minds on the move. *The Star*, 25 March.

Schonberger, R.J. (1996). *World class manufacturing: The next decade*. New York: The free press

Schonberger, R.J. & Knod, E.M. (1988). *Operations management*. Texas: Business publications.

Scheer, A.W. (1990). *Computer integrated manufacturing*. *Towards the factory of the future*. Heidelberg: Springer-Verlag Berlin.

Shingo, S. (1989). *A study of the Toyota production system*. *From an industrial engineering viewpoint*. Massachusetts: Productivity press.

Suzaki, K. (1987). *The new manufacturing challenge*. London: Collier Macmillan.

Todd, J. (1994). *World class manufacturing*. Great Britain: University Press.

Womack, J.P., Daniel, T., Jones, T. (1996). *Lean thinking*. Great Britain: The bath press.

Womack, J.P., Jones, D.T. & Roos, D. (1990). *The machine that changed the world*. New York: Rawson Associates.