

# **Guidelines for successful implementation of total productive maintenance in a chemical plant**

**JP Mahlangu**

**23232757**

Mini dissertation submitted in partial fulfilment of the  
requirements for the degree *Master in Business Administration* at  
North-West University Potchefstroom campus

Study Leader      **Ms K Nell**

November 2014



## DECLARATION

I, Jethro Padya Mahlangu, hereby declare that the mini dissertation, "Guidelines for successful implementation of total productive maintenance in a chemical plant", which I herewith submit to the North-West University, Potchefstroom Campus, in compliance with the requirements set for the Master in Business Administration is my work, has been language edited and has not been submitted to any other institution.

I understand and accept that the copies submitted are the property of the university.

---

Signature : 23232757

---

November 2014  
Signed at Sasolburg

# ACKNOWLEDGEMENTS

I would like to acknowledge and thank the following people for their support and patience in the completion of this dissertation. It has been a long and trying road but without your support it might have not been possible to complete this.

- To my family, my deepest gratitude for being so patient with me over the years
- To my friends, thank you all for the inspiration that you have been over the years
- Karolien Nell, thank you helping me put this document together
- The staff of North-West University, my deepest gratitude for the guidance that you offered

## **ABSTRACT**

With the world economy becoming unpredictable, it has become a necessity for businesses to relook at the way they do business. The world has become competitive and companies that aim to become profitable have seen the need to find ways to improve efficiencies and increase productivity to stay relevant. There has been an adoption of strategies that are aimed at improving the efficiencies in companies such as Total Productive Maintenance (TPM). The strategy is aimed at improving equipment efficiencies and increase productivity through the transfer of certain skills from maintenance personnel to operators. The aim is that the operators perform some of the activities that the maintenance people used to do and they do the more complex tasks. By transferring these skills to operators there is constant cleaning, inspections and lubricating of equipment. This frees up time for maintenance people to do planning and other jobs that require time and higher skills levels. The implementation of these activities allows companies to tap into unused capacity that was always hidden by breakdowns and unplanned stops. The process however requires commitment from management and all stakeholders involved in the organisation. There are prescribed implementation processes that can be followed or companies can follow their own processes but the fundamentals of involving people from the onset must be followed. The involvement of stakeholders creates commitment at all levels and in order to sustain this initiative people must be committed to it. The inclusion of the activities transferred from maintenance people to operators, will reinforce the knowledge and habits required from operators and perhaps sustain the initiative.

## **KEY WORDS**

Total Productive maintenance, Overall equipment efficiency, TPM Deployment, Autonomous maintenance, Plant maintenance, Preventative maintenance, Planned maintenance, Quality maintenance, Focused improvement, Early equipment management, Training and education, Safety, Health and Environment, TPM in administration, Zero defects, Zero waste, Zero downtime, 5S, Breakdown maintenance, Preventative maintenance, Corrective maintenance, Maintenance prevention, Downtime losses, Speed losses, Defect losses, Quality defect losses, Normal production loss, Abnormal production losses, Maintenance schedules, Prescribed TPM deployment, Equipment failure, Function failure, Function reduction, Reprocessing losses, Factors of successful TPM deployment

# TABLE OF CONTENTS

DECLARATION .....	ii
ACKNOWLEDGEMENTS .....	iii
ABSTRACT .....	iv
KEYWORDS .....	v
LIST OF TABLES .....	xiv
LIST OF FIGURES .....	xv

---

---

<b><u>CHAPTER 1</u></b>	<b>INTRODUCTION.....</b>	<b>1</b>
1.1	INTRODUCTION.....	1
1.2	BACKGROUND TO THE STUDY (MOTIVATION).....	2
1.3	PROBLEM STATEMENT .....	3
1.4	OBJECTIVES OF THE STUDY .....	3
1.4.1	Primary objective.....	3
1.4.2	Secondary objectives.....	4
1.5	SCOPE OF THE STUDY .....	4
1.6	RESEARCH METHODOLOGY .....	4
1.6.1	Literature/theoretical study.....	4

1.6.2	Empirical study.....	4
1.7	LIMITATIONS OF THE STUDY .....	5
1.8	LAYOUT OF THE STUDY .....	5
<hr/>		
<b><u>CHAPTER 2</u></b>	<b>LITERATURE REVIEW .....</b>	<b>7</b>
2.1	INTRODUCTION.....	7
2.2	DEFINITION OF TPM .....	8
2.3	HISTORY AND ORIGIN OF TPM .....	9
2.4	OBJECTIVES OF TPM .....	9
2.5	5 S.....	10
2.6	TPM PILLARS.....	11
2.6.1	Focussed Improvement.....	12
2.6.2	Autonomous Maintenance .....	13
2.6.3	Planned Maintenance .....	15
2.6.4	Quality maintenance .....	16
2.6.5	Early Equipment management .....	17
2.6.6	Education and Training pillar.....	17
2.6.7	Safety Health and Environment .....	17
2.6.8	TPM in administration .....	17

2.7	THE 6 BIG LOSSES .....	18
2.7.1	Downtime Losses.....	18
2.7.2	Set-up and adjustment.....	18
2.7.3	Short stops.....	19
2.7.4	Rework.....	19
2.7.5	Speed losses .....	19
2.7.6	Start-up losses/yield losses.....	19
2.8	PROCESS LOSSES .....	19
2.8.1	Shutdown Losses.....	20
2.8.2	Production adjustment loss .....	20
2.8.3	Equipment failures .....	20
2.8.3.1	Function failure .....	20
2.8.3.2	Function reduction.....	21
2.8.4	Process Failure loss.....	21
2.8.5	Normal Production loss .....	21
2.8.6	Abnormal Production Losses .....	21
2.8.7	Quality Defect Losses .....	22
2.8.8	Reprocessing Losses.....	22
2.9	PRESCRIBED TPM DEPLOYMENT PLAN .....	22

2.9.1	The preparatory stage.....	23
2.9.1.1	Announce top management’s decision to introduce TPM .....	23
2.9.1.2	Launch educational campaign .....	24
2.9.1.3	Create organisations to promote TPM .....	24
2.9.1.4	Establish basic TPM policies and goals .....	25
2.9.1.5	Formulate a master plan for TPM development .....	26
2.9.2	The Preliminary implementation stage .....	26
2.9.2.1	Hold kick-off meeting.....	26
2.9.3	TPM Implementation .....	26
2.9.3.1	Improve equipment effectiveness .....	27
2.9.3.2	Establish an autonomous maintenance program .....	27
2.9.3.3	Develop schedules for maintenance .....	27
2.9.3.4	Conduct training for teams involved.....	27
2.9.3.5	Development of early equipment management.....	28
2.9.4	Stabilisation.....	28
2.9.4.1	Master TPM and raise targets.....	28
2.10	MEASURES IN TPM.....	29
2.11	STATE OF DEPLOYMENT IN COMPANY X.....	30
2.12	FACTORS OF SUCCESSFUL DEPLOYMENT IN OTHER COMPANIES .....	35

---

<b><u>CHAPTER 3</u></b>	<b>RESEARCH METHODOLOGY .....</b>	<b>38</b>
3.1	INTRODUCTION.....	38
3.2	RESEARCH INSTRUMENT .....	38
3.3	POPULATION .....	41
3.4	DATA ANALYSIS: MANAGEMENT COMMITMENT .....	41
3.4.1	Management Commitment.....	41
3.4.2	Operator Involvement.....	51
3.4.3	Sustainability.....	61
3.5	CONCLUSION .....	69
<b><u>CHAPTER 4</u></b>	<b>DISCUSSION OF THE RESULTS OF THE EMPRICIAL STUDY .....</b>	<b>70</b>
4.1	INTRODUCTION.....	70
4.2	MANAGEMENT COMMITMENT .....	70
4.2.1	Question 1: Was kick off meeting held .....	70
4.2.2	Question 2: Were unions consulted by management before implementation?.....	71
4.2.3	Question 3: Were employees consulted by management before implementation?.....	71
4.2.4	Question 4: Does management inspect pilot areas regularly? .....	72

4.2.5	Question 5: Is management involved in the process of rolling out TPM? .....	72
4.2.6	Question 6: Was there a clear link between company objectives and implementing TPM? .....	73
4.2.7	Was training on the benefits of TPM conducted with all stakeholders? .....	73
4.2.8	Were pillar champions appointed? .....	74
4.2.9	Were pillar champions trained on their role in TPM implementation? .....	74
4.2.10	Was a TPM officer appointed for the site? .....	74
4.3	OPERATOR INVOLVEMENT .....	75
4.3.1	Was operator training held in the implementation process? .....	75
4.3.2	Was there by in by operators? .....	76
4.3.3	Are small teams formed to solve problems? .....	76
4.3.4	Are plant operators a part of small groups? .....	77
4.3.5	Were team structures overlapping with leaders in lower teams being part of a team higher than the team they belonged to? .....	77
4.3.6	Is downtime measured and analysed according to the 6 big losses? .....	77
4.3.7	Are tags raised by operators repaired? .....	78
4.3.8	Does management involve operators in decision making? .....	78

4.3.9	Are suggestions from operators implemented?.....	79
4.3.10	Are operator areas clearly defined? .....	79
4.3.11	Are roles and responsibilities clearly defined? .....	79
4.4	SUSTAINABILITY OF TPM.....	80
4.4.1	Do standards for cleaning, inspecting and lubricating exist?.....	80
4.4.2	Are operators trained on cleaning, inspection, lubricating & tightening standards?.....	80
4.4.3	Are TPM standards included in operator KPI's? .....	81
4.4.4	Do TPM concepts form part of the operator training manuals? .....	81
4.4.5	Is there time set aside for TPM sessions or training?.....	81
4.4.6	Does the gap between operations and maintenance still exist?.....	82
4.4.7	Are skills being transferred from maintenance personnel to operators? .....	82
4.4.8	Are operators rewarded for achieving set targets?.....	82
4.5	CONCLUSION .....	83

---

**CHAPTER 5 CONCLUSION AND RECOMMENDATIONS.....84**

5.1	INTRODUCTION.....	84
-----	-------------------	----

5.2 CONCLUSION ..... 84

5.3 RECOMMENDATIONS..... 86

---

---

**REFERENCES .....89**

---

---

**APPENDIX A RESEARCH QUESTIONNAIRE .....92**

**APPENDIX B RESULTS OBTAINED FROM THE RESPONDENTS.....98**

# LIST OF TABLES

<b><u>CHAPTER 2</u></b>	<b>LITERATURE REVIEW .....</b>	<b>7</b>
Table 2.1:	The 12 steps of TPM implementation (Nakajima, 1988: 55).....	22



Figure 3.9:	Were pillar champions trained on their role in TPM implementation? .....	50
Figure 3.10:	Was a TPM officer appointed for the site? .....	51
Figure 3.11:	Was operator training held in the implementation process? .....	52
Figure 3.12:	Was there buy in by operators?.....	53
Figure 3.13:	Are small teams formed to solve problems?.....	53
Figure 3.14:	Are plant operators a part of small groups?.....	55
Figure 3.15:	Were team structures overlapping, with leaders in lower teams being part of a team higher than the team they belonged to?.....	56
Figure 3.16:	Is downtime measured and analysed according to the 6 big losses? .....	56
Figure 3.17:	Are tags raised by operators repaired? .....	57
Figure 3.18:	Does management involve operators in decision making?.....	58
Figure 3.19:	Are suggestions from operators implemented? .....	59
Figure 3.20:	Are operator areas clearly defined? .....	60
Figure 3.21:	Are roles and responsibilities clearly defined?.....	61
Figure 3.22:	Do standards for cleaning, inspecting and lubricating exist? .....	62

Figure3.23: Are operators trained on cleaning, inspection, lubricating & tightening standards? .....63

Figure 3.24: Are TPM standards included in operator KPI's? .....64

Figure 3.25: Do TPM concepts form part of the operator training manuals? .....65

Figure 3.26: Is there time set aside for TPM sessions or training? .....66

Figure 3.27: Does the gap between operations and maintenance still exist? .....67

Figure 3.28: Are skills being transferred from maintenance personnel to operators? .....68

Figure 3.29: Are operators rewarded for achieving set targets? .....69

# CHAPTER 1

## INTRODUCTION

### 1.1 INTRODUCTION

After the Second World War, Japan industries imported and improved ways of managing and manufacturing from the United States of America. This way of doing things was improved to such a point that the quality of goods produced in Japan improved to superior levels compared to those in the USA and Europe. This led to the Japanese style of doing things to become a focal point for western countries (Nakajima 1988: 7). Robinson & Ginder (1995: 11) also state that over the past three decades, the Japanese have copied and improved American concepts, with a lot of success. Amongst these was the Lean Production System, which was later renamed Toyota Production System. Its main objective was to increase profitability and productivity (Baluch, Abdullah & Mohtar, 2012: 850). The Japanese Motor industry, together with its suppliers realised the importance to improve on machine efficiencies, by eliminating breakdowns, (Baluch *et al* 2012: 851).

Total Productive Maintenance (TPM) was introduced in order to improve maintenance management in the fabrication and assembly industries (Suzuki, 1994: 2). Suzuki states that the concept of TPM is a form of productive maintenance that involves employees at all levels in the organisation. The Japan Institute of Plant Maintenance (JIPM) indicate that it must be strongly supported by the leaders of the organisations to be successful. In order for companies to be cost effective, Baluch *et al* (2012: 851), states this concept is achieved by involving shop-floor workers in the cleaning, inspecting, lubricating and maintaining the equipment in a good condition. TPM aims to improve processes by empowering the operators to help maintain the equipment so as to increase mean time between failures and maximise Overall Equipment Efficiency (OEE) (Haddad & Jaaron, 2012: 148). According to Ramesh, Prasad & Srinivas (2008: 47), TPM involves the transfer of knowledge and skills from

the maintenance teams to the operators who will then operate and maintain the machines.

Companies are aiming to become world class and TPM is being used as a means to become competitive and improve organisation behaviour in companies that implement it (Baluch *et al* 2012: 851). Most companies operate at low efficiencies and TPM helps tap into these low efficiencies to improve overall productivity and equipment performance. Continuous improvement, which is the critical aspect of TPM, is adopted as companies aim to increase efficiencies (Robinson *et al* 2005: 2). The increased efficiencies are achieved by the elimination of breakdowns thereby increasing equipment effectiveness, elimination of waste, elimination of quality defects and elimination of accidents in the factories. TPM is a new way of tackling problems, it moves away from the old reactive way of doing maintenance to a proactive and preventative approach (Micietova, 2011: 214). This is done by creating shared responsibility for the machines between operators and maintenance. It focuses on a systematic way of eliminating losses, which are categorised into Availability Loss, Performance Loss and Quality Loss (Kenedy, 2011: 10). TPM involves using any tools or processes to identify, quantify, eliminate and monitor the sustainability of reduction of these losses.

## **1.2. BACKGROUND TO THE STUDY (MOTIVATION)**

Companies are adopting TPM as it is seen as a way of changing organisational cultures, it delivers tangible results and work places are changed into clean dirt free environments (Suzuki, 1994: 3). TPM, a concept which has its roots in Japan, is now being adopted by companies throughout the world. It aims at transforming the peoples' way of thinking and doing things – culture change (JIPM-Solutions, 2002: 184). Traditionally, industry norms are that the operator only operates the equipment and maintenance only fixes but TPM aims to bridge this gap by transferring knowledge to the operator (Womack & Jones, 2003: 60). Operator skills on operating equipment is standardised according to Womack *et al* (2003: 60). In implementing TPM all employees are involved in cleaning, inspecting and

maintaining machinery, thereby increasing the skills level of the operators (Liker, 2004: 33). This process involves setting standards for the operators and everyone alike to ensure that tasks are carried out in the same manner.

### **1.3. PROBLEM STATEMENT**

TPM has been implemented in many Asian companies with major successes in especially the Japanese automotive industry (Robinson *et al* 1995: 5). There have been a number of companies in South Africa which have tried to implement the TPM concept with success but many have struggled with the process. Research has been done into implementing such initiatives in high volume single product industries, namely automotive, rubber and steel but little research has been done into the failures of TPM implementation in the high volume multiple product chemical industry.

It is my perception that if TPM is properly implemented the benefits may be enormous for both the company and employees at all levels of the organisation. Companies have been impatient and looking for a quick fix in implementing TPM as a business tool to improve efficiencies and outputs. The implementation of TPM will differ from industry to industry. An important aspect to remember is that what worked in the automotive industry may not necessarily work in other industries. If businesses are to benefit from such initiatives there should be a willingness to exercise patience, invest resources and ensure sustainability of such tools in their day to day operations.

### **1.4 OBJECTIVES OF THE STUDY**

#### **1.4.1 Primary objective**

The TPM concept has been used successfully in many companies but the implementation took several years to accomplish. The primary objective of this study will be to determine the factors that lead to the successful implementation of TPM in the chemical processing industry.

## **1.4.2 Secondary objectives**

The secondary objective will be to determine if such concepts can be sustained in the South African context.

## **1.5 SCOPE OF THE STUDY**

The study will be done within the discipline of Operations Management as it concerns the implementation of TPM in the chemical process industry in the Sasolburg area. It will include some parts of Change Management, as the process of implementation requires organisations and its employees to go through some process of change in order to reach the desired outcome. Some industries in the food, manufacturing and automotive sectors will be looked at to determine the sustainability of their TPM initiatives. The study will also contain lessons learnt by other organisations during the process of implementing TPM.

## **1.6 RESEARCH METHODOLOGY**

### **1.6.1 Literature/theoretical study**

A literature study will be conducted to determine the extent of research already done on TPM implementation and its sustainability. Little research has been done on the factors for sustainable implementation of TPM in chemical processing industry.

### **1.6.2 Empirical study**

This research paper will take the form of a quantitative and qualitative study. A questionnaire will be designed as far as possible from existing and tested questions from earlier research. There will however be a supplement of my own questions to test the sustainability of TPM programs. The sample will consist of the whole population of operator level employees and their immediate supervisors of a chemical company within the Sasolburg region. Statistical analysis will be used to

determine the extent to which the factors can be used to sustainably implementing TPM.

The questionnaire will be administered manually within the organisation still implementing TPM and electronically within the organisations that have sustainably implemented TPM.

## **1.7 LIMITATIONS OF THE STUDY**

Because the sample will consist out of employees from only one company, it may not be a representative study for South Africa and might not be broadly generalizable for all organisations.

This study will be limited to the implementation of TPM and the factors that may affect its sustainability within organisations.

## **1.8 LAYOUT OF THE STUDY**

Below is the layout of this document:

### **Title page**

Including:           Dissertation title

                          Student name

                          Student number

                          Course

                          Study group leader

**Acknowledgements**

**Abstract**

**Table of contents**

**List of figures**

**Chapter 1 : Introduction**

**Chapter 2 : Literature review**

**Chapter 3 : Research methodology**

**Chapter 4 : Discussion**

**Chapter five : Conclusion and Recommendations**

**Bibliography**

**Appendices**

## CHAPTER 2

# LITERATURE REVIEW

### 2.1 INTRODUCTION

With the global market becoming very competitive, it has become inherent for businesses to ensure they change the way of doing things. The main aim of businesses is to become profitable and for this they need to be cost efficient and ensure they meet customer needs which have evolved over time. Today's customers have become quality conscious and require goods to be delivered within the agreed time. With many organisations positioning themselves to serve the global market, consumers and organisations are able to choose who they do business with; this has forced companies to adapt to the changing global market or lose business.

Total Productive Maintenance (TPM) objectives are to strive for productivity (P), quality (Q), delivery (D), costs (C), safety (S) and morale (M). (McCarthy & Rich, 2004:37). These objectives are meant to ensure organisations become profitable by ensuring machines are used efficiently, thereby increasing product output and online time through reduction of stoppages. In wanting to increase profitability, organisations need to ensure they maintain and increase their customer base by ensuring they offer them products which conform to their requirements. Quality standards have increased over the years and consumer tastes have also changed. Customers are now demanding the best quality. In pursuit of these objectives organisations have realised the importance of ensuring their employee morale is maintained and increased. The outputs are driven by the employees and they require to be engaged and up skilled in order to maintain and meet the high demands from the market. In adopting TPM, organisations have to put all measures in place in order to monitor and improve their performance and to meet their targets. These objectives are achieved through the measuring and classification of losses and

eliminating the major losses in the process. The elimination of these losses are achieved through a team based effort and skills transfer from the maintenance personnel to the operators who then do cleaning, inspection, lubrication and tightening activities through autonomous maintenance. The reduction of forced deterioration on machinery ensures that companies get value for their money as machine life is extended through focused improvement projects. The work environment is standardised in the process and accidents are reduced by ensuring clutter is removed. Waste reduction is attained by creating a culture which aims at improving and maintaining work areas in neat condition.

## **2.2 DEFINITION OF TPM**

Japan Institute of Plant Maintenance, formerly known as Japan Institute of Plant Engineering, refer to the main aim of Total Productive Maintenance as the elimination of losses and waste which reduce the efficiencies of equipment. This is achieved through aiming for zero defects, zero accidents and zero waste. Howell (2012: 18), describes TPM as a way of managing that aims to bring together equipment maintenance and the manufacturing process, meaning the operators of equipment become the owners of the equipment. As the system matures and skills are transferred to the operators, they will eventually do some of the maintenance jobs on the machines. Kocher *et al* (2012: 42) also mention the people that normally do maintenance on the equipment are relieved of lower skill tasks like inspection, tightening, lubricating and cleaning. These tasks are done by the production personnel and the maintainers only do high skill level tasks and improvements on equipment. The transfer of skills therefore increases the level of responsibility amongst operators and maintainers.

Seiichi Nakajima combined the American concepts of maintenance and total quality control and employee involvement to form TPM to aim for a system that has changed plant maintenance and aiming for world class production (Nakajima 1988: 11). TPM is defined by Seiichi Nakajima as: “plant improvement methodology which enables continuous and rapid improvement of the manufacturing process through the use of

employee involvement, employee empowerment and closed loop measurements”, (Nakajima 1988: 11). Ahuja and Kumar (2009: 243) define TPM as: “structured equipment based continuous improvement process that aims to optimise equipment effectiveness by identifying and eliminating equipment and production efficiency losses through active team-based participation of employees across all levels of the operational hierarchy.”

Robinson and Ginder (1995: 4) described the aspects of TPM as follows:

“Plant improvement methodology is a method of bringing about change with a set of structured activities that lead to improved management of plant equipment.”

## **2.3 HISTORY AND ORIGIN OF TPM**

Preventive maintenance, according to Ramesh, Prasad & Srinivas (2008: 46), was introduced in Japan in the 1950’s from the USA and in 1960 the concept was first introduced to the whole plant by Nippondenso, a part of Toyota. According to the Planned Maintenance (PM) philosophy the operators operate the machines to produce goods and maintenance department does repairs on the machines. As a highly automated plant, Nippondenso maintenance became a problem as the requirements of maintenance personnel increased. Nippondenso management took a decision, which meant operators started carrying out routine maintenance on equipment and thereby leave the maintenance team to focus on upgrades. (Ramesh *et al* 2008:46).

## **2.4 OBJECTIVES OF TPM**

The aim of TPM, as described earlier, is to attain zero defects, zero accidents and zero waste. The main objective in achieving these is to maximise plant and equipment effectiveness and achieve the optimum life cycle cost of production equipment. The optimum life cycle cost of equipment is achieved by ensuring the operators take care of the equipment as the process run.

The concept is derived from Total Quality Management which is aimed at eliminating defects and the application of the concept on equipment with the aim of eliminating breakdowns and production losses (Kocher, Kumar, Singh & Dhillon, 2012: 42). TPM is aimed at increasing efficiencies by tapping eliminating breakdowns and waste. TPM is designed to optimise equipment reliability and ensure efficient management of plant equipment by involving and empowering all employees through linking production, maintenance and engineering functions (Ahuja & Khamba, 2008: 125). It is aimed at increasing product output and employee morale and attitudes are improved in the process. The creation of a safer work environment is critical in ensuring zero accidents occur (Ahuja *et al* 2009: 243). Ahuja *et al* (2009: 244) also indicate that the goals of TPM are expressed in productivity, cost, delivery, quality, safety and morale which are the main drivers for any business.

## **2.5      5 S**

5S basically stands for 5 words which are spelt in the Japanese context and start with “S”. The five words according to Nakajima (1988: 73) are:

Seiri (Sort) – this means removing items that are required or not used in a particular area. The purpose for sorting is to reduce clutter and only have items that are really necessary for the jobs and tasks that are carried out in the area, for example cleaning, tightening or lubricating.

Seiton (Organising) – this means placing the items in the area in such a way that they are easily accessible when needed. The purpose of placing these items in such a manner ensure there is no time wasted while looking for items. Each item can be marked such that it is easily noticed if it is not in its place.

Seiso (Cleaning) – this refers to the initial clean up and the daily clean up. The removal of dirt makes it easier to identify defects and fix them. During this initial clean up, sources of contamination are identified and fixed or tagged if they cannot be fixed immediately.

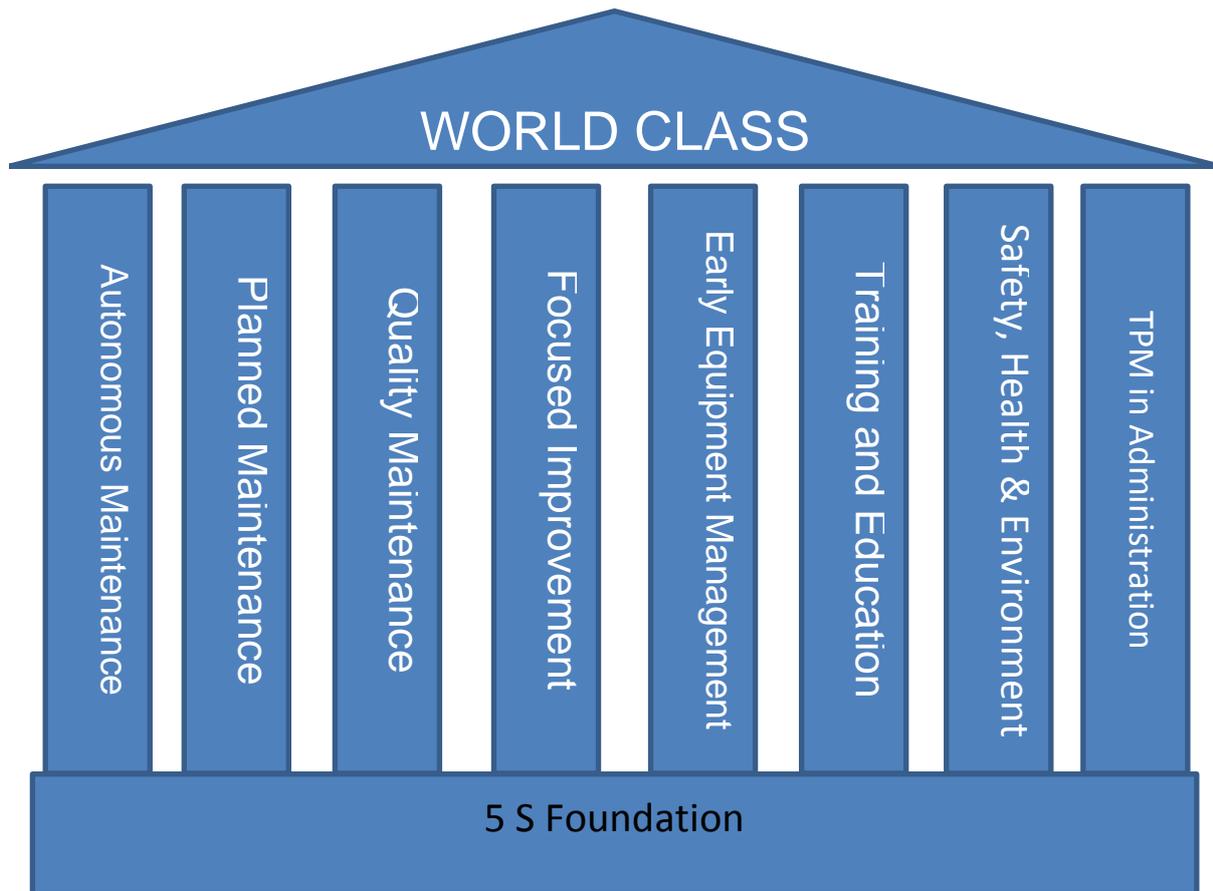
Seiketsu (Standardising) – this involves the standardisation of spares and tools used to perform tasks in the organisation.

Shitsuke (Self-discipline) – this indicates self-discipline amongst the operators. The following of simple rules like wearing of the correct personal protective equipment, using the correct tools; house-keeping is what is used to validate the existence of self-discipline.

The 5S is the basis of the TPM implementation process (Gupta & Garg, 2012: 115). It improves safety as it reduces clutter in work areas and reduces the causes of minor accidents. Work efficiency is increased as time wasting is reduced when looking for tools to perform tasks. Cleaning time is reduced because sources of contamination are fixed and areas have less dirt in them. Productivity is supposed to increase as equipment on line time is increased and breakdowns are reduced. The clean work area is supposed to have a psychological impact on the operators resulting in increased team morale according to Gupta *et al* (2012: 115).

## **2.6 TPM PILLARS**

In figure 2.1 the 8 pillars of TPM deployment are shown. The order of implementation is not prescribed but it is determined by what the organisation intends to achieve in process. The foundation of implementation is 5S and the rest of the pillars are built from it, as depicted in figure 2.1 below.



**Figure 2.1: The 5 S Foundation pillars (Source: Ahuja and Kumar: 2009)**

In the next section the different pillars in figure 2.1 will be discussed. These 8 pillars of TPM are autonomous maintenance, focused improvement, planned maintenance, early equipment management, quality maintenance, training and education, TPM in administration and Safety, Health and Environment all of which share 5S as a foundation. Each of these pillars has a focus area that will lead to the achievement of the overall objective of improving equipment efficiency and output.

### **2.6.1 Focussed Improvement**

This pillar is aimed at making improvements in the process in order to reduce targeted losses. All activities are aimed at maximising overall equipment effectiveness, activities and plants through the reduction of major losses that are incurred in the operation of plants (Gupta *et al* 2012: 117). Cross functional teams

are made up of operators, maintenance personnel and production engineers (Suzuki, 1992: 13). The team looks for problems that are recurring and they choose which project to work on, based on their impact on the process or operational costs (Micietova, 2011: 215). The Japanese word Kaizen is used to describe this pillar which means change for the better.

## **2.6.2 Autonomous Maintenance**

According to Gupta *et al* (2012: 115) this pillar is the main objective of TPM. The aim is to have the operators perform some of the functions of the maintenance department in maintaining the equipment to ensure the efficient performance thereof. Autonomous maintenance involves activities performed by operators in the production department, according to Suzuki (1992: 87); these activities have a maintenance function to them. Autonomous maintenance is implemented according to the following 7 steps:

Step 1: The initial clean up involves putting machines off line and opening covers and guards and it is aimed at eliminating and exposing defects and sources of contamination (Suzuki,1992: 102). The safety of personnel should be put first whenever the equipment is taken off line and all equipment must be isolated and locked out before cleaning begins. According Nakajima (1988:76), operators learn and ask questions why their machines accumulate so much dust and get a better understanding of their machines. This type of cleaning ensures the operators get to all parts of the equipment. Suzuki (1992: 101) mentions that the clean-up may be slow due to operators not having a clear understanding of the purpose for the clean-up. As the process of clean-up continues, operators will get to appreciate the purpose of removing dirt from the machines as it prevents unexpected breakdowns. Suzuki attributes this to being of inspection which leads to the exposure of all abnormalities.

Step 2: Elimination of sources of contamination: TPM is aimed at increasing efficiencies and this includes labour efficiencies. This is also achieved by reducing

the amount of product spills and leaks from equipment and processes. This according to Nakajima (1998: 76) is meant to reduce cleaning times and free up the operator to perform other duties in the process. The work areas are kept clean and free of clutter and in areas where the causes of dirt and clutter cannot be completely eliminated, cleaning and inspection methods must be put in place to reduce accumulation of dirt (Nakajima 1988: 76).

Step 3: Establishment of cleaning and checking standards - The work performed by all operators should be according to a work procedure which must be standardised amongst all the operators (Suzuki, 1992: 102). These standards ensure the cleaning, lubricating, inspection and tightening is done in the same way by all operators. Operators need to identify the areas that need to be cleaned on machines. Decisions on the plan of action are taken by the team of operators and the role of the supervisor is to guide them the process. The inspections must be visual to ensure easy identification of deviations, flow directions must be marked, gauges must be labelled to indicate safe operating parameters and levels must be easily identified if low (Nakajima 1988: 77).

Step 4: Perform general inspection – operators need to become experts in identifying equipment deviations but for them to become experts they need to be skilled through training on how their machines are set up and work. This enables the operators to pick up problems before they cause breakdowns. Nakajima (1988: 78) recommends that operators are trained in one schedule at a time and the first step must be skills development. The process is taken through the PDCA cycle in which operator effectiveness is checked and corrected if required. Like the whole concept of TPM introduction this step must not be rushed as it requires the operators to be at the same level of expertise and it forms the core of autonomous maintenance. Technical skills of operators need to be increased as they will require this to perform proper inspections and if the inspections are not yielding the desired results, the operators may require up skilling in this regard.

Step 5: Autonomous Inspection – boundaries must be drawn to eliminate work overlap between maintenance and production teams. Developed standards for production personnel must be compared to those prepared by maintenance people to ensure all the inspection aspects are covered and included (Nakajima 1988: 79).

Step 6: Organisation and Tidiness - The operator will require training on the activities that are normally done by the maintenance team, for example tightening, inspecting and lubricating. Standards need to be set however to ensure uniformity especially in areas where there are more than one operator. Suzuki (1992: 14) states that the operators will start taking responsibility for their machines and are involved in routine maintenance and improvement processes. Autonomous maintenance according to Enaghani, Arashpour & Karimi (2009: 17) eliminates the root causes of most problems and operators become more knowledgeable in their work as they have more skills in terms of maintaining the equipment. The transferring of these tasks such as tightening, lubricating and visual inspection from the maintenance department to the operators will ensure that the maintenance department concentrates on specialised tasks aimed at improving equipment. Nakajima (1988: 72) describes autonomous maintenance as the unique part of TPM and it will take time to change the operators' mind set to become operators/maintainers of equipment. The challenge in changing these mind sets is the main reason it takes more than a long time to implement AM according Nakajima (1988: 72).

### **2.6.3 Planned Maintenance**

The main objective of planned maintenance is to apply correct maintenance techniques to ensure effectiveness of equipment at all times, Gupta *et al* (2012: 115). When equipment is effective there are minimal breakdowns and the quality of the product is always guaranteed. This fulfils the zero breakdown and zero defects aimed for in the implementation of TPM. Planned maintenance is aimed at reducing or maintaining optimal cost of maintenance by increasing the availability and

reliability of machines, Enaghani *et al* (2009: 18). Enaghani *et al* (2009: 18) also state that there are four types of planned maintenance, namely:

- **Breakdown maintenance:** this happens when equipment is run until it fails and only then maintenance will be done on it.
- **Preventive maintenance:** these are actions put in place in order to prevent failures from occurring. There are two types namely, **periodic maintenance** which is also known as time based maintenance and this is done at specific times in the operation of the process. **Predictive maintenance** also known as condition based monitoring; these are tests done on the equipment to determine if there is any changes in operation or deterioration in condition whilst the plant is in operation.
- **Corrective maintenance:** this maintenance is when the actual cause of a failure has to be determined in order to prevent a failure from recurring.
- **Maintenance prevention:** this is when ideas developed in productive maintenance are used in the design of new plants or equipment. The concept is such that equipment is designed not to breakdown or is easy to maintain. JIPM-Solutions (2002: 7) state that this requires the current maintenance data of machines that are in use to be accurately recorded and available so as to be used in the designs of new equipment.

#### 2.6.4 Quality maintenance

This pillar is there to focus on sections of the process that affect product quality so as to ensure that products with zero defects are being produced. Equipment must be maintained in such a way that it produces zero defects. This is a proactive approach to prevent quality defects from occurring in the final product through inspections and monitoring the process and taking preventive action before quality defects occur (JIPM-Solutions, 2002: 147).

## **2.6.5 Early Equipment management**

Early Equipment management is a process in which all problems experienced during start-up or commissioning of new plants are dealt with before production can commence. Howell (2012: 20) describes that the problems could be caused by wrong selection of material or equipment as well as the malfunction of equipment.

## **2.6.6 Education and Training pillar**

The main objective of TPM is to ensure operators are given the correct skills in order for them to perform some of the maintenance functions like inspection, lubrication and tightening. The purpose of this pillar is to ensure that the knowledge of the operators and all other employees is increased, to better enable them to perform their duties efficiently. As the operators take over some of the maintenance jobs they will need to be up skilled and given knowledge on how to perform these new tasks (Howell, 2012: 19). All stakeholders of the organisation need to be taught about TPM and the training and education pillar is tasked with educating people on TPM so as to create a clear understanding of the direction in which the organisation is heading.

## **2.6.7 Safety Health and Environment**

One of the TPM objectives is to ensure there are zero accidents. The targets are attained by ensuring improvements are made to the work environment to eliminate accidents. The improvement of equipment and regular cleaning ensures the housekeeping standards are increased and clutter is removed from the workplace.

## **2.6.8 TPM in administration**

The improvement process also takes place in the administration department by eliminating processes that waste time and decrease efficiencies. This processes aims at ensuring that all processes are stream lined to ensure the production facilities are equipped and resourced fully to produce the required product.

## **2.7 THE 6 BIG LOSSES**

There are 6 big losses that are measured and used to calculate overall equipment efficiency. The main objective of measuring is to ensure the loss is quantifiable and can be tracked and monitored. The big losses are grouped into three categories (Nakajima, 1988: 14)

- Downtime losses
- Speed losses
- Defect losses

The six big losses will be defined in the following sections according to Nakajima (1988: 98).

### **2.7.1 Downtime Losses**

Equipment is meant to run when it is planned to run. Downtime is the time when the equipment is off instead of running. The two types of downtime in this category are equipment failures and set-up and adjustment losses. These are sudden failures which result in loss of operating time. These kinds of failures are normally due to deterioration that goes by unnoticed and results in a sudden failure and the effect is worsened by the non-availability of spares to carry out the repairs.

### **2.7.2 Set-up and adjustment**

Set-up and adjustment loss is incurred when a change in the type of product has to be done. The change in type of product at times requires processes to be stopped in order to change pieces of equipment in the process. Some processes require different raw materials and because one of the aims of TPM is zero defects, some changes may need to be made to prevent mixing of product and raw materials.

### **2.7.3 Short stops**

Short stops are normally small interruptions that are sorted out quickly and the process is back on line within no time.

### **2.7.4 Rework**

Rework loss is experienced when the product is off spec and has to be reprocessed again for it to conform to the product specification.

### **2.7.5 Speed losses**

Speed losses are incurred when the equipment or processes are being run below the set targets or design capacity, in the case that the process or equipment normally runs at design capacity. Processes or equipment is normally run at reduced rates because of problems experienced when certain levels of production are reached or certain standards of quality product can only be achieved at a given rate.

### **2.7.6 Start-up losses/yield losses**

These losses are due to processes not being run efficiently on start-up; this causes a difference in yield as full production capabilities may not have been reached.

## **2.8 PROCESS LOSSES**

Suzuki (1992: 23) describes eight major plant losses in the process industry which can increase plant effectiveness if prevented. These losses are however linked to the six major losses described by Nakajima and other advocates of TPM. These losses are shutdown losses, production adjustment losses, equipment failures, process failures, normal production losses, abnormal production losses, quality defect losses and reprocessing losses. These losses, according to Suzuki, will now be discussed in detail:

## **2.8.1 Shutdown Losses**

Most processes are operated continuously and are stopped once a year to do maintenance. The entire plant is shutdown as per plan in order to do statutory inspections and to do repairs to parts of the plant to prevent deterioration. In order to maximise productivity and plant effectiveness, Suzuki (1992: 2) maintains these shutdown periods need to be minimised. These losses arise from the servicing of machines while the plant is in operation. Some sections of the plant can be put off line for this type of maintenance to take place but they require careful planning.

## **2.8.2 Production adjustment loss**

Production time is lost when supply and demand varies and it is required to adjust supply and demand accordingly. If demand was constant and increasing there will be constant production which would mean production lines are utilised fully. Though these facilities are planned to operate the whole year, changes in the market may lead to temporary shutdown of production facilities. Companies can however minimise this kind of production losses by maintaining their quality in the market which will ensure there is demand for their product. According to Suzuki (1992: 24), this will ensure that the production facilities are utilised effectively.

## **2.8.3 Equipment failures**

This is loss due to equipment failures which lead to plant stoppages. Suzuki (1992: 24) describes two types of equipment loss, function failure and function reduction.

### ***2.8.3.1 Function failure***

This loss occurs when equipment stops functioning totally causing the plant to stop completely. It will impact on the availability of the plant as a whole and especially if it is a piece of equipment on the critical path of product flow where there is no standby equipment available (Suzuki, 1992: 24).

### **2.8.3.2 Function reduction**

This loss is when certain parts of the plant stop functioning but the plant can be run at reduced capacity. This could also be due to other factors causing the equipment to underperform. The availability of standby equipment can normally avert such problems in the process. (McCarthy et al 2004: 80).

### **2.8.4 Process Failure loss**

This is time lost when plants shutdown due to factors other than equipment failure. The cause of such shutdowns may be due to changes in properties of raw materials or faults caused by the operators. These kinds of process failures may be reduced if the sources are removed (Suzuki, 1992: 24).

### **2.8.5 Normal Production loss**

These are losses incurred due to change in production rate when the plant is being ramped up especially on start-up, during run changes and ramping down for shutdowns. The production rate varies considerably during start up as full production is not accomplished on start up. As operators prepare to shutdown plants they reduce production rates gradually as they cool down the plant until the rates and plant conditions, for example temperature are low enough for shut down. Suzuki (1992: 25) mentions that most continuous processes need to be warmed up on start-up and cooled down before shutting them down.

### **2.8.6 Abnormal Production Losses**

This type of loss is normally caused by poor plant performance. Suzuki (1992: 25) describes abnormal production losses as the difference between the normal operating rate and the actual reduced rates the plant is being operated at. There is production capacity lost during this time and it is what is related to the abnormal production loss.

## 2.8.7 Quality Defect Losses

This is the time lost through reworking of off spec product, time used in producing the product and the monetary loss incurred in the process. The time spent producing the out of specification product is also classified as a loss according to Suzuki (1992: 25). This loss is caused by contamination, raw material problems and perhaps wrong specification settings.

## 2.8.8 Reprocessing Losses

This is the production time lost in the process of reworking a product that does not meet the quality specifications. Some processes have to rework this material as it cannot be used if it does not meet the quality requirements (Suzuki, 1992: 26).

## 2.9 PRESCRIBED TPM DEPLOYMENT PLAN

Nakajima (1988: 54) describes the deployment method to be used when TPM is being implemented. The 12 steps of TPM implementation steps are summarised in table 2.1 below.

**Table 2.1: The 12 steps of TPM implementation (Nakajima, 1988: 55)**

STAGE	STEP
Preparatory	Announce top management decision to introduce TPM
	Launch an educational campaign to introduce TPM
	Create organisational structure to promote TPM
	Establish basic policies and goals of TPM
	Form master plan for implementing TPM

STAGE	STEP
Preliminary Implementation	Kick off TPM
TPM Implementation	Improve effectiveness of each critical piece
	Set up and implement autonomous maintenance
	Establish a planned maintenance system in the maintenance department
	Provide training to improve operator and maintenance skills
	Develop an early equipment management program
Stabilisation	Perfect TPM implementation and raise TPM

The 12 steps are divided into 4 groups/categories. Each of these groups will now be discussed in order to get an understanding of the implementation process which was proposed by Nakajima (1988: 53).

## 2.9.1 The preparatory stage

In the preparatory stage there are 5 steps that need to be followed in preparation of TPM implementation. Nakajima (1988: 54) describes this as the stage at which the right environment is created for the implementation of TPM.

### 2.9.1.1 *Announce top management's decision to introduce TPM*

The first step is the formal announcement by top management on the decision to implement TPM. Nakajima (1988: 56) states that there should be an explanation as to why the decision has been made to choose TPM. Like in any strategy, people will support what they understand and for them to make this decision they need all the information they can receive. Suzuki (1994: 8) points out that once the decision is

made by top management, all stakeholders need to be informed and there must be an indication that top management understands the value added by implementing TPM. According to Robinson *et al* (1995: 23) training and skilling of the operators must begin once the announcement has been made but the style of leadership must not be authoritarian in this early stage. The process of implementing TPM is long and management need to ensure that the employees understand this as it involves changing peoples' way of thinking.

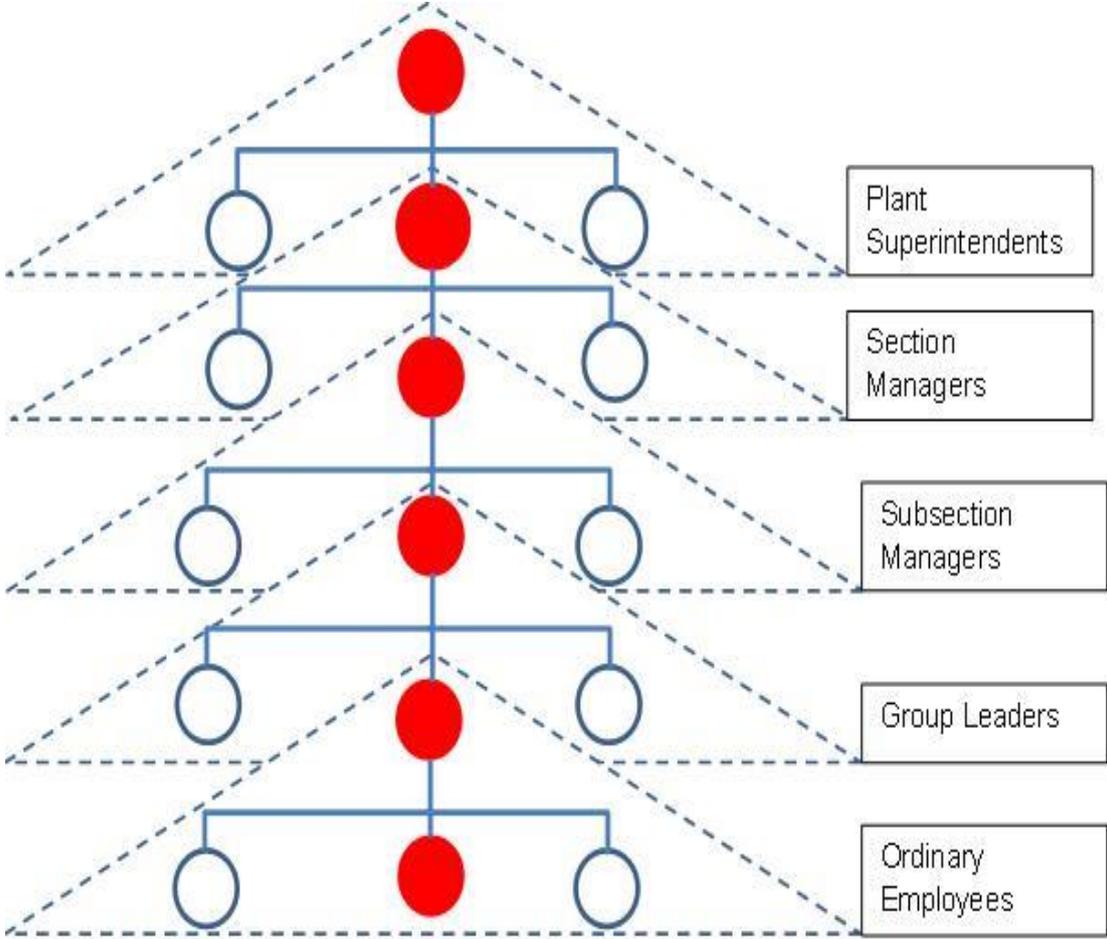
### ***2.9.1.2 Launch educational campaign***

The second step is the launching of an educational plant to introduce TPM. As mentioned above, the type of leadership needs to be accommodating, as there will be resistance to change from employees according to Nakajima (1988: 58). In this step Nakajima (1988: 58) and Suzuki (1994: 10) suggest people visit other plants where TPM has been implemented so that they can learn and talk to the people in these companies. This will enable them to get an understanding of the issues they came across in the process. Robinson *et al* (1995: 28) also agree with Nakajima, that training sessions to educate people about TPM and its benefits must or can be carried out in order to answer questions and reduce resistance to the implementation process.

### ***2.9.1.3 Create organisations to promote TPM***

Step three is the creation of structures that promote TPM in the organisation. There is a requirement to form groups or project teams that will include the operators with an overlapping network at each level. This requirement according to JIPM is to ensure there is a connection between levels to enable two way communications, which is both upward/downward and sideways. Nakajima (1988: 59) and Suzuki (1994: 10) suggest that it is essential that the TPM office be staffed by professional people who are able to run campaigns on the implementation of TPM.

Figure 2.2 below shows the recommended team or small group structure. The leaders in each team are part of a higher level group. This structure according to Suzuki (1994: 10) is meant to enable effective dissemination of policies and goals.



**Figure 2.2: TPM team structure (Source: Suzuki: 1994: 10)**

**2.9.1.4 Establish basic TPM policies and goals**

Step four of the process is the establishment of TPM policies and goals. The TPM policy must support the business goal in such a way so that the actions to reach the goals can be set. The goals and actions must be communicated to everyone in the organisation, although they must be challenging according to Suzuki (1994: 11), they also must be achievable. The aim of TPM is to improve business processes and

ultimately make organisations profitable. The gains must be translated to a monetary value (Nakajima, 1988: 63), in order to enable the employees to better understand the need for TPM.

#### **2.9.1.5 *Formulate a master plan for TPM deployment***

A master plan must be formulated in step five. The plan must contain which pillars must be focussed on to enable the accomplishment of the organisations TPM goals (Suzuki; 1994: 12). Robinson *et al* (1995: 38) indicate that the plan must have all actions, timelines for start to finish, resources, a measure of completion and the people responsible for the action.

### **2.9.2 The Preliminary implementation stage**

The implementation stage involves the stating of activities involved in TPM implementation. The stakeholders are informed of the activities in kick off meetings.

#### **2.9.2.1 *Hold kick-off meeting***

In step six the TPM initiatives are kicked off. Suzuki (1994: 12), Nakajima (1988: 45) and Robinson *et al* (1995: 38) all agree that the involvement of all stakeholders is essential. The stakeholders not only include all the employees in the organisation, but suppliers, customers, contractors and representatives of companies affiliated to the organisation. The kick off must be set in such a way that it promotes inspiration and enthusiasm amongst all involved and creates commitment.

### **2.9.3 TPM Implementation**

Steps seven through to eleven are the TPM implementation stages. In these stages the organisation basically focuses on setting up of teams and processes to be followed in the implementation stage and these must link to the master plan. The steps will now be discussed in the following section.

### **2.9.3.1 Improve equipment effectiveness**

The aim at this point is to improve equipment effectiveness by selecting the machines that have the highest downtimes and forming teams which are tasked to improve the effectiveness of such machines. The downtimes and delays on the machines must be recorded and reviewed in the teams to ensure there is reduction or not. Preventative maintenance may be implemented to ensure there is a reduction in the amount of downtime as a starting step (Robinson *et al* 1995: 47).

### **2.9.3.2 Establish an autonomous maintenance program**

The formation of operator teams that will ensure the equipment is looked after by the implementation of autonomous activities. These activities are linked to the preventative maintenance activities. The autonomous activities will include activities and skills transferred from the maintenance teams. (Robinson *et al* 1995: 59).

### **2.9.3.3 Develop schedules for maintenance**

The schedules must be used to counter breakdowns by ensuring there are predictive maintenance activities that are built into the schedules. The checking of spares and acquiring must also be done to ensure there will be no extended downtimes because of spare shortage. Proper and correct tools must be supplied to the maintenance teams. If there is requirement for diagrams for use when doing maintenance or inspections, these must also be supplied and stored in an easily accessible place. The supplying of correct tools and diagrams ensures time for maintenance and inspection is reduced because there is no time wasted looking for tools or trying to figure out equipment layout. (Robinson *et al* 1995: 63).

### **2.9.3.4 Conduct training for teams involved**

Teams which are involved in the implementation process will require training on activities that they are going to be doing. The training can either be given to the operators by the maintenance teams or given to the leaders who will be tasked to

train and coach the other operators. This forms the critical part of implementation as it is the basis of TPM.

#### ***2.9.3.5 Development of early equipment management***

At this point there must be processes that measure life cycle costs of equipment for new equipment that has just been installed. The cost analysis can also be done for old equipment to identify improvement opportunities. The implementation of maintenance prevention systems must be done at this point to enable the reduction of downtime. New equipment commissioning must be controlled to prevent forced deterioration of equipment due to improper commissioning or start-up (Robinson *et al* 1995: 83).

### **2.9.4 Stabilisation**

This point of implementation is concerned with ensuring adherence standards set to enable meeting of targets set. The final step must also be used to ensure new and higher targets are set and achieved. The next paragraph will give insight to stabilisation of TPM.

#### ***2.9.4.1 Master TPM and raise targets***

The final step is the stabilisation of the TPM process. This step involves the adherence to routines that set out for TPM activities to ensure master the activities and they can obtain good results from the process. Suzuki (1994: 20) states that there should a good foundation set and improvement must be recorded in order to show the operators there is progress. The sharing of results on progress should in a way motivate the operators want to achieve more.

## 2.10 MEASURES IN TPM

There need to be measures which can be monitored in order to evaluate the effectiveness of TPM on the business and plant machinery. The maintenance performance measure of overall equipment effectiveness is directly linked to the equipment and plants where the initiatives have been implemented (Wang, 2006: 657). One of the objectives of TPM is to increase the overall equipment efficiencies and effectiveness and this can be related to the overall performance of the plant and the on line times that are achieved.

Overall Equipment Efficiencies and Effectiveness?? (OEE) = availability X performance efficiency X quality rate

According to Nakajima (1988: 28) and Wang (2006: 657), OEE is calculated by multiplying the availability of the plant by the performance and quality rate achieved in the plant.

- Availability is the actual time that the machine or plant is available to run. Availability is calculated by dividing the time by the planned time for the plant to run. Planned downtime and downtime caused by other factors outside of the environment where availability is being measured are excluded in this calculation according to Kocher, Kumar, Singh & Dhillon, (2012: 42).
- Quality rate is a measure of the amount of the product that is of right quality out of the total product produced. Quality rate is calculated by subtracting the defects from the total amount of product and dividing this amount by the total output. The defects is a total of all product reworked, rejected product, scrap from the process and all product that is shipped back to the organisation (Robinson *et al* 1995: 135).
- Performance efficiency can be measured using the set targets or the design capacity of the plant. It is used to measure how far from design capacity or target the equipment is running (Robinson *et al* 1995: 129). The calculation

according to (Robinson *et al* 1995: 129) is the ideal cycle multiplied by total parts run and the product is divided by operating time.

The 3 ratios multiplied by each other will give the OEE of the process, which is the measure of how efficient the plant or equipment is being utilised as mentioned earlier. An OEE of 85% is considered an industry bench mark.

## **2.11 STATE OF DEPLOYMENT IN COMPANY X**

Company X is a medium size company which produces ammonium nitrate based fertiliser and other chemical products, to service the farming community and mining industry. TPM was introduced in the year 2007, with the help of consultants, as a means to improve equipment efficiency; this is in line with what Ahuja *et al* (2008: 125) state. TPM is aimed increasing efficiencies by eliminating breakdowns and increasing reliability of machines. Several pilot areas were picked in one of the plants on the basis that it would make a big and noticeable difference. The plant had been running for just over 20 years when the initiative was introduced. Maintenance and inspections were being carried out by the mechanical department on a breakdown basis and scheduled shutdowns. Production teams did minimal inspections and they relied on the maintenance teams to pick up problems with components on pieces of equipment before they broke down. There was a distinct line between the operator and maintenance duties, which led to blame shifting whenever there was a problem on the plant. Problem solving was done individually and there was no teamwork or small groups that were tasked to solve problems. There were no cleaning schedules in place and cleaning was done on equipment if there was going to be repair work that required to be carried out. Most of the cleaning on the platforms and around equipment was done on instruction of the supervisors or shift supervisors. Some of the equipment was only maintained to ensure it runs to keep the process on line. Even though there were visible contamination sources in the form of leaks, cracks or loose parts, the plant was kept on line and seldom were these fixed. It was as if the operators and maintenance personnel were used to the plant to be in a rundown state as it was.

The implementation was announced to the management team as per recommendation according to Nakajima (1988: 56). There was awareness that was created by management on the benefits of TPM for the organisation and the reasons for choosing this strategy. There was resistance from operators and unions alike when the announcements were made. The main concern was that it was extra work for the operators and this would not come with any compensation in terms of monetary value. Management on the other hand argued that the new strategy would have soft motivation rather than tangible ones. The strategy would ensure cleaner work places and reduced cleaning times as sources of contamination would reduce and thereby dirt in work areas would minimise. Management was also tasked with answering questions on job redundancy for maintenance personnel as some of the tasks are transferred to the operators. All these are questions which Suzuki (1994: 11) identifies need to be answered by management in order to create an understanding of the process and choice of such strategy. The pillars of TPM were allocated to different managers as the pillar champions. The teams were set up in such a way that there was an individual who was a member one and a team higher. As proposed by Suzuki (1994: 10), the team member will be tasked with conveying the message to the team they led from the team one level above. For example the pillar champion of each of the pillars would be on management and they lead the executing team which was formed by supervisors and they in turn formed the leadership part of the operational teams. The concept was announced to the supervisors who in turn were trained as facilitators because they were going to take on the function of facilitators for the shop floor personnel. According to Nakajima (1988: 56), the announcement was supposed to be made to all involved and get a clear understanding of the requirements or expectations from each employee. Pilot areas were set up and kick off sessions were held per area. The teams that were involved on kick off did not include the operators for certain pieces of equipment because there wasn't operators appointed to run these pieces of equipment or work in the areas that these machines were located. The teams had a set day and time in the week on which they would come to the pilot plant and areas do their cleaning and then leave the area. The cleaning of the area was tasked to the operators who worked on the plant full time. This created a big gap between the time the activities

were carried out by the teams and the operators were overloaded in terms of the duties they had to carry out. The problem arose in that operators did not take ownership when it came to cleaning the areas outside of their work areas. Activity boards, called 5S boards, were set up and there were graphs, area maps, team photos, source of contamination maps, graphs of tags raised and dirt collected. Teams had to co-ordinate the repairing of tags raised with the mechanical department. Training of the shift supervisors was also carried out as the activities were meant to be carried out over the weekends too and the shift workers had to do the cleaning and recording of dirt collected.

The implementation stage carried on for a while in that state until a team was set up to fix the tags raised which were increasing with each clean up and tagging sessions. The involvement of the team helped separate the pilot areas from the rest of the plant and repair most of the tags raised. The pilot areas were rolled to the rest of the factory and targets to get the whole site to have TPM implemented were set for the year. There was support from top management in terms of financing the repairs and training the people. Top management was also involved in the 5S activities and this was to ensure there is visible support from top management. As Robinson *et al* (1995: 6) stated there has to be support from top management and the involvement of top management in the initial cleaning and kick off stages was aimed at showing this commitment. There was a consulting firm that was used to train and help implement TPM. The consultants were also involved in the 5S activities to ensure everyone on the teams in the plant was following the set rules and recording all information that was required to measure the progress of the process. Top management visited other plants that had or were implementing TPM to observe and ask questions on implementation problems encountered in the process.

Loss time systems were set up in order to monitor downtime on pieces of equipment and whole process. The six downtime categories were as follows:

- Breakdowns > 1 hour;
- setup and adjustment loss;

- short stops < 1 hour;
- reduced speed;
- rework; and
- start-up and yield losses.

The operators were trained on the loss time systems and review meetings are held every week to identify major losses. The autonomous maintenance pillar continued to meet in sessions each week to go through training and do practical learning in pilot areas. This team was also tasked with reducing the losses that were encountered due to operation of the equipment and issues that required major changes were referred to the focussed improvement teams. These included losses where the autonomous maintenance teams did not have the capacity to resolve like equipment upgrade or installation of new equipment.

The Focussed Improvement pillar, like the AM pillar, was rolled out throughout the factory; each department had to identify their losses and categorise them according to the 6 big losses. The FI pillar was tasked with running the loss tree systems and the data collected from these systems was used to identify potential problem areas in the form of major losses. Improvement projects were identified based on the following:

- Biggest losses from the loss tree.
- Activities that had a potential saving on operational costs.
- Safety and environmental impact on the factory.

There were review meetings to monitor progress and share Kobetsu Kaizen initiatives amongst the technical team. The activities were put on activity boards to show the whole factory what progress was being done in the factory.

The Training and Education pillar was also set up. It was to be run together with the help of the Human Resources department. Each department had to draw up a plan for the personnel training and identify skills required for the operators and employees as a whole. The involvement of the human resources department was not effective as the course or training requirements were not carried forward to an extent of obtaining service providers for the required training. As time went on, a technical training centre was set up where operators were trained in some of the basic skills to enable them to perform their jobs.

The safety pillar was assigned to the safety manager. This was also done with the help of each department manager and the safety officers. Targets were set for the whole site and were communicated throughout the whole factory.

Quality maintenance was incorporated into the quality programmes that were being run in the factory. The methodology of the quality maintenance programme was the only change realised, in that the biggest problems were isolated and plans were put in place to tackle these. There was a big change in the way product from one section of the factory was released for distribution. The laboratory would analyse the chemical composition of the product and it was released based on weighted average but this caused a problem as huge adjustments had to be made to get the weighted average within the limits. This caused a problem in that the actual analysis would run either way higher or lower than the upper and lower control limits. The new way of releasing products is now based on the percentage of actual analysis that is within the specification limits.

Planned maintenance (PM) was applied in planning of shutdowns mainly. The plan was to use the PM pillar to train and transfer skills to the operators when the implementation of TPM had reached a mature stage.

Early equipment management was not focussed on as it applied to newly installed equipment rather than old equipment. TPM in administration was applied but only up

to the 5S stage and application of it. The concepts of being efficient and reduction of waste were not applied.

Review meetings for each of the pillars were set up weekly and these rotated between the pillar champions. The purpose was to give feedback to other pillar champions on the progress being made in the different environments and obstacles which were encountered in the process.

The consultants got the management of Company X in contact with different companies that had initiated TPM activities and in the process a TPM club South Africa was formed. The club basically shares information and help each other with the deployment of TPM. They convene once in every 3 months and focus on pillars that the organisations are implementing. The organisations in the club play host at different times of the meetings and plant tours are arranged in the process with presentations on the progress of certain pillars.

## **2.12 FACTORS OF SUCCESSFUL TPM DEPLOYMENT IN OTHER COMPANIES**

Each business has unique plans and goals. Ahuja *et al* (2009: 242) suggest that TPM goals and objectives must be integrated into the strategic and business goals for the organisation. For the successful deployment of TPM, organisations need to focus on certain pieces of equipment or areas that will enhance the business to achieve its set objectives. Production teams have to drive the implementation of TPM and the maintenance department supporting them in the process (Bamber, Sharp & Hides 1999: 167). The support from the maintenance departments is mainly to transfer skills and train the production teams in all lubrication, tightening and inspections. Bamber *et al* (1999: 167) suggest that the implementation must be gradual, as mentioned above and not implemented on too many machines. Most importantly however is the support of top management (Ahuja & Khamba 2008: 124). Ahuja *et al* (2008: 126) also advocate that organisations should manage the change process such that there is minimal to no resistance from the employees. Employee

fears of losing their jobs due to the processes becoming more efficient should be addressed and management must ensure there is clarity on the future of all individuals' concerned. Top management should show their commitment in establishing TPM by ensuring there is a support system to facilitate learning and the application of the learning into the process. The process of implementing TPM is not supposed to be rushed as it involves the changing of peoples' mind-set through establishment of a learning culture (Eti, Ogaji & Probert 2004: 393). This is in agreement with Nakajima (1988: 2) who states there should be at least three years before an organisation can fully implement TPM activities. However there should be alignment between maintenance and production objectives. Planning and the establishment of direction are essential to the success of creating commitment of the employees in the organisation. According to Howell (2012: 21) training should be split between leadership training, training of the employees in the pilot areas and then the rest of the employees of the organisation. Howell also explains that the training of the managers and supervisors is important in that leadership buy in, will be viewed as commitment by the operators and rest of employees. Training of the production staff and supervisors as facilitators are seen as crucial by Bamber *et al* (1999: 168). This is due to the fact that the supervisors will be in charge of operators on a daily basis and they will therefore be able to better answer questions from the operators and help train the operators in TPM.

This is in agreement with Howell (2012: 19), who states that operators would be taking a much bigger responsibility as machine operators and they require training for this. Training needs analysis needs to be done in order to ensure each of the pillar teams has the correct skills required to ensure equipment is operated optimally and safe. It is suggested by Chan, Lau, Ip, Chan & Kong (2005: 78) that a TPM office must be established with the main function being setting up of targets and policies which must be aligned to the organisation's goals. According to them the office should come up with the master plan for the establishment of training processes for the operators and TPM promotion activities. The author is of the view that TPM activities should form part of the operator or workers routine activities; this will remove the notion that it is extra work which is normally formed by the operators. The

activities must form part of the individuals Key Performance Indicators to ensure they carried out to the right standard and not rushed. However, the individuals must be trained and deemed competent in terms of carrying out the inspections, lubrications, tightening and cleaning.

## CHAPTER 3

# RESEARCH METHODOLOGY

### 3.1 INTRODUCTION

For TPM implementation to be successful there are several factors that need to be in place. The successful implementation of this concept according to Eti *et al*, (2004: 391) requires the commitment of top management as the main driving force. Management will ensure there are policies that drive the implementation of TPM to ensure there are enough resources to help operators and all other stakeholders to perform their duties. This study seeks to establish if the key success factors for implementation of TPM are being followed by the companies that are adopting this concept.

This chapter deals with the research design and methodology that the researcher followed in the development of the questionnaire. The method used in the selection of the sample is also outlined in this chapter. The method used to analyse the data is also outlined in the last part of this chapter.

### 3.2 RESEARCH INSTRUMENT

The research instrument seeks to evaluate the implementation methodology used by South African companies and compare this to the prescribed methods. It seeks to establish to what extent the prescribed methods are being used or adhered and to what extent organisations are ensuring the sustainability of the initiative. The questions in the measuring instrument were developed from previous studies and some questions which were developed by the author of this document.

The questions are aimed to assess how respondents perceive the implementation methods. The perceptions of the respondents are important in evaluating what they perceive to be the process followed in the implementation of TPM. These

perceptions will then be compared to what is contained in previous literature as the proposed way to implement TPM. The measuring instrument does not take things like age, gender, race or position into account as these were perceived not to have any influence on what people thought to be the way TPM was implemented. The research instrument can be seen in Appendix A.

The research instrument was in 3 sections, namely:

1. Management commitment
2. Operator involvement
3. Sustainability of TPM

Section 1 deals with the commitment of management in the implementation process. There are a number of issues which this section aims to ascertain and the questions were based on what is recommended by other authors. This section will amongst other things try to ascertain:

- If management informed all stakeholders of the reason for implementing TPM?
- If management explained and reassured employees that their jobs will not be lost?
- If management made the official announcement about the implementation of TPM?

All the questions in this section are based on all actions that required management decisions in the implementation process. The questions were derived from literature that indicates the responsibilities of management in the implementation process.

The 2<sup>nd</sup> section of the instrument was aimed at establishing to what extent the operators were involved in the implementation process. The implementation of TPM is aimed at bridging the gap between operators and maintenance departments and the involvement of operators from the onset will be essential to ensure the gap is bridged. The questions are aimed at ascertaining the degree to which companies follow the recommended way to implement TPM in terms of involvement of all stakeholders. The questions were formulated by looking at the key success factors of implementing TPM and how much these are perceived by the operators to be applied in their respective areas.

The instrument will try to ascertain amongst others:

- If operators were involved in the implementation of TPM?
- If training was given to the operators?
- If cross functional teams were formed?
- If development opportunities were offered to operators as they start to perform new duties in the AM pillar?

The 3<sup>rd</sup> part of the research instrument is aimed at establishing the sustainability of such initiatives in a South African context. The questions to establish this are unstructured and the respondent's views will be used to establish both relevance and sustainability of TPM in a South African context. The views of the respondents will also be used as recommendations for the implementation of TPM or other programs that may be seen as relevant in the South African context.

One hundred copies of the instrument were handed out to the operators and assistance was given when answering the questions. Despite the assistance, though only 51 copies were returned.

The instrument will gather quantitative and qualitative data which will be analysed in this chapter and will be further discussed in Chapter 4.

### **3.3 POPULATION**

The population was made up of all operators and their immediate supervisors in one section of the company where the implementation of TPM has been happening for the past seven years. The operators consist of people that have been with the company from the beginning of the implementation process and new people that joined the company at various points that preceded the inception of TPM.

The operators included the lowest position in the section to the immediate supervisor. The operators' level of understanding of the TPM implementation process was varied as the level of education also varied from tertiary diploma to first school level according to the South African education system. The positions of the operators were not considered for the purpose of this research, as the levels that were asked to fill in the questionnaire were up to first line supervisor level, the highest level was shift supervisors.

### **3.4 DATA ANALYSIS: MANAGEMENT COMMITMENT**

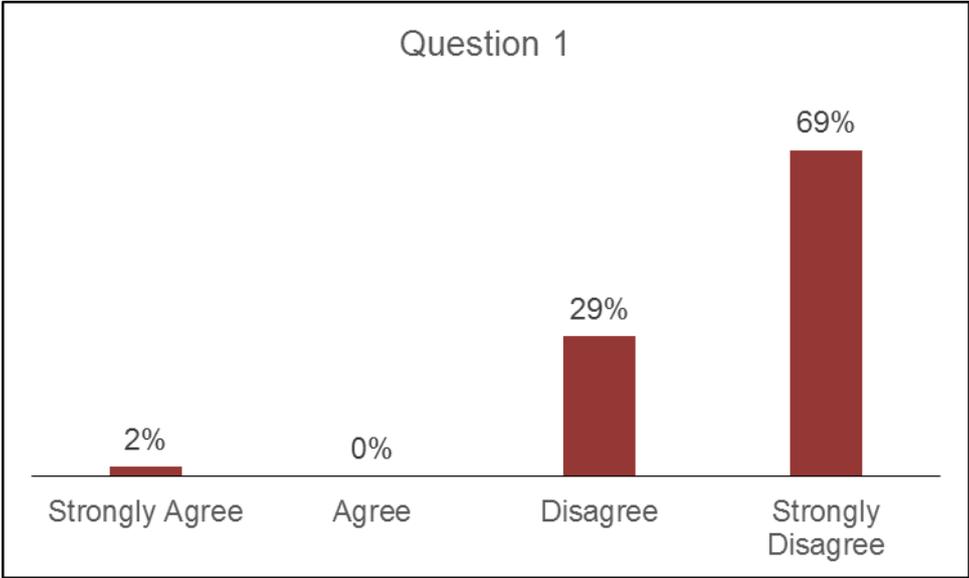
In this section we will look at the questions that were meant to measure how employees perceived management commitment.

#### **3.4.1 Management Commitment**

##### **QUESTION 1: Was kick off meeting or announcement held?**

This question was meant to find out if sensitisation of the implementation of TPM was done. These meetings have the purpose to ensure that people are made aware of the intention of management to implement TPM. It is during these meetings that management answers questions raised by employees and all other stakeholders.

As stated by Nakajima (1988: 56) management must explain the reasons for choosing the TPM strategy to the stakeholders. These sessions are used to clarify everyone's responsibility and the benefit of implementing TPM. Figure 3.1 shows the responses from the operators for question 1.



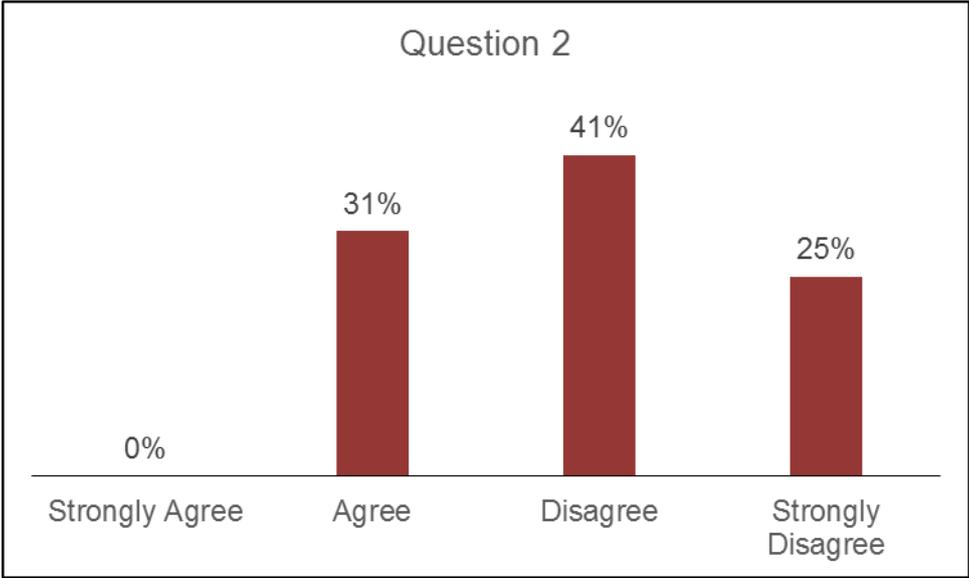
**Figure 3.1: Was kick off meeting or announcement held?**

The response to question 1 suggests that 98% of the respondents disagree that a kick off meeting or announcement was made to the operators. The announcement might have been made to certain positions as suggested by the 2% that strongly agrees that an announcement on the implementation was made. Most organisations do not invite all operators to these meetings and supervisors and team leaders that are invited are tasked with taking the information to the rest of the operators. The responses to this question seem to suggest that the information was not cascaded down to the lower levels.

**QUESTION 2: Were unions consulted by management before implementation?**

Suzuki (1994: 8) encourages the fact that all stakeholders must be consulted when the decision to implement TPM has been taken. The involvement of stakeholders ensures that people are committed from inception. The unions have power over the

members and they consult them when new initiatives are implemented. If unions are not consulted there is a big chance that the information given to consulting workers may be different to that which management intends to achieve. Unions are there to ensure the workers' wellbeing and rights are upheld and they need to ensure there are no job losses due to the implementation of TPM. Figure 3.2 shows the responses to this question.



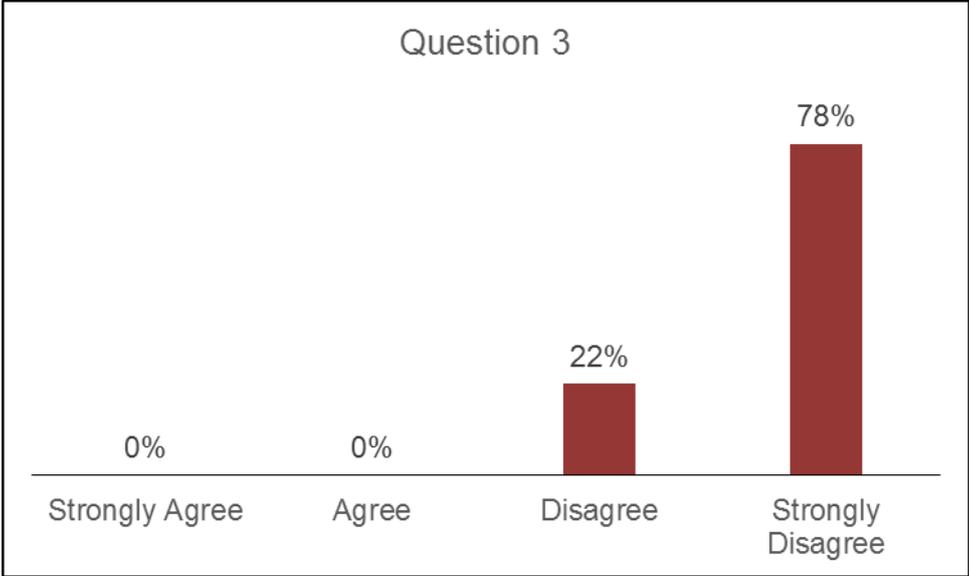
**Figure3.2: Were unions consulted by management before implementation?**

The responses seem to suggest some consultation was done with the unions as there are 31% of the respondents that agree with the statement. 41% percent disagree and 25% strongly disagree, this could be attributed to the poor dissemination of information amongst workers and their unions.

**QUESTION 3: Were employees consulted by management before implementation?**

This question links to the two questions above. It is aimed at creating awareness of new initiatives that are going to be implemented. The aim of these sessions is to ensure that the same information is given to all those involved and that all the

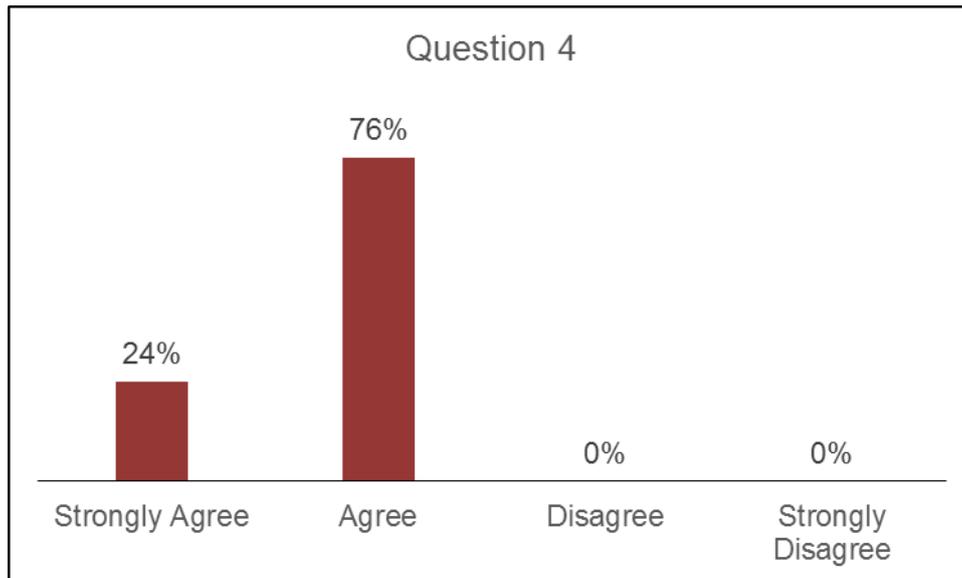
concerns are addressed. Figure 3.3 indicates the responses to this question. The results clearly show that there was no consultation, as the respondents either disagree or strongly disagree. However the consultations may not have been held as management relied on the unions and first line supervisors to sensitise the employees on the decision implement TPM.



**Figure 3.3: Were employees consulted by management before implementation?**

**QUESTION 4: Management inspect pilot areas regularly?**

The question aims to establish if management were committed in the process by inspecting and ensuring that the pilot areas are inspected on a regular basis. It aims to also establish whether management guided and walked the road with the operators. Certain initiatives fail because management implement and leave the area but do not follow up on the progress being made. The checking of the areas shows the operators the level of commitment shown by management. Figure 3.4 shows the responses from the operators.

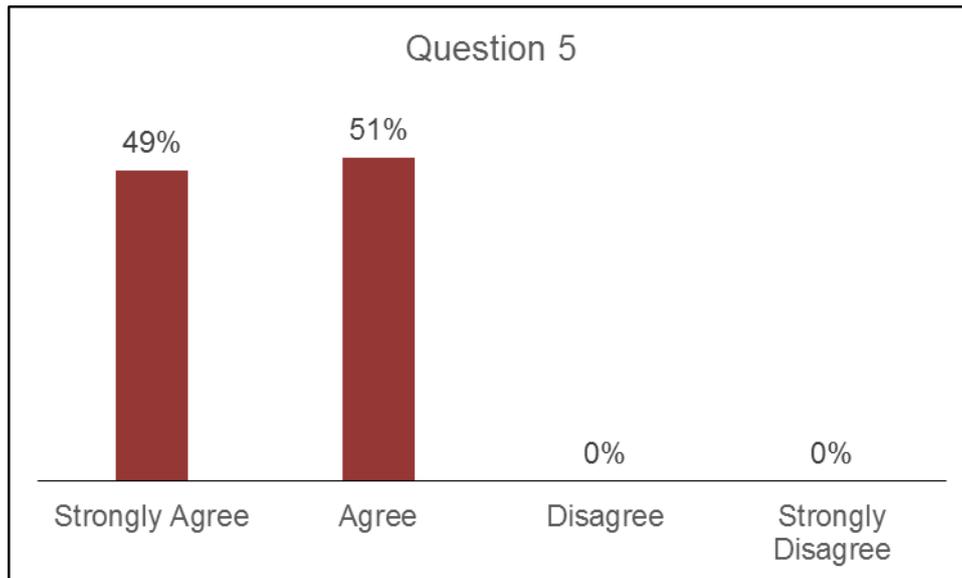


**Figure 3.4 Management inspect pilot areas regularly?**

The results show the operator’s perceptions of whether management were checking the areas on a regular basis. This result shows that they perceived management’s willingness to guide and ensure they were involved in the process.

**QUESTION 5: Is management involved in the process of rolling out TPM?**

This question is linked to the previous question and it is mainly aimed at establishing whether management were involved in the process. It also shows what level of commitment operators perceived management to have in the process. The result can be seen in figure 3.5.

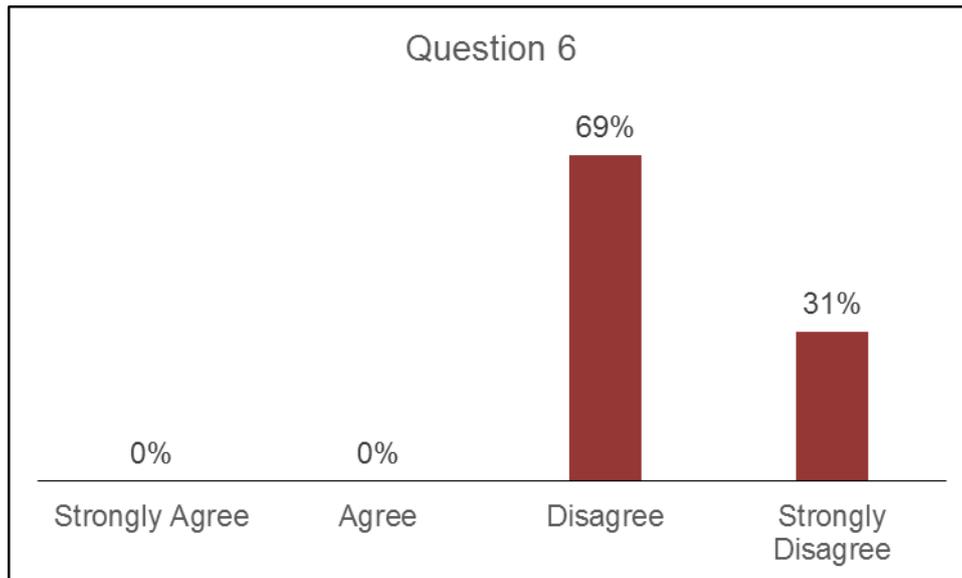


**Figure 3.5: Is management involved in the process of rolling out TPM?**

The results show that management were perceived to be involved in the implementation process. The respondents either strongly agree or agree with the statement that management were involved in the implementation process. As mentioned previously this is an indication to the operators that management do not just leave things to them, it shows that they are willing to walk the road with them and guide them in the process.

**QUESTION 6: Was there a clear link between company objective and implementing TPM?**

TPM is aimed at improving productivity by ensuring reduction of breakdowns, improved efficiencies and strengthening the link between production, maintenance and engineering functions (Ahuja *et al* 2009: 243). The objective for many companies that implement TPM is to ensure increased productivity and this was no different to Company X. The question was however aimed at establishing if the operators were aware of the link between implementing TPM and the company objectives. Figure 3.6 shows the responses from the operators.

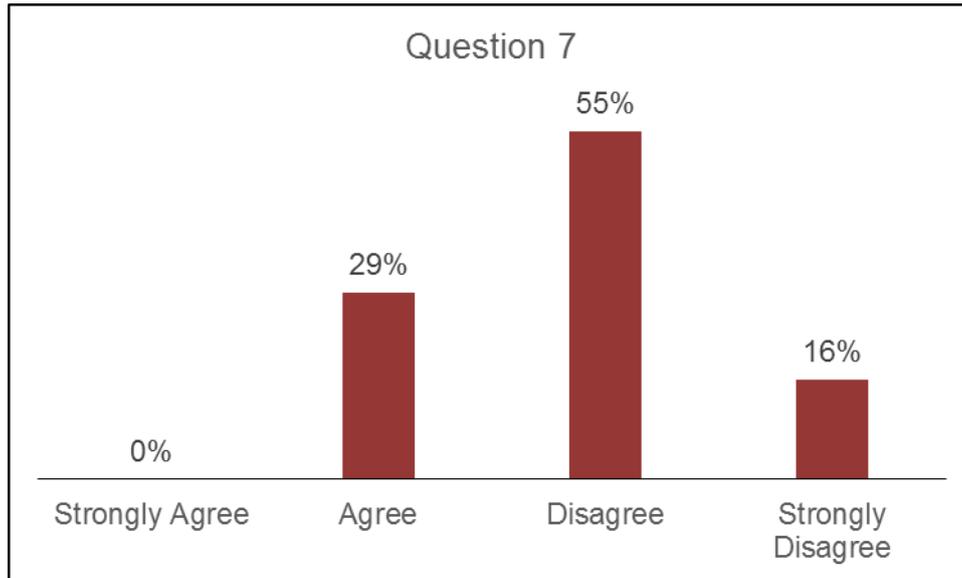


**Figure 3.6: Was there a clear link between company objective and implementing TPM?**

The results show the respondents were not aware of the link between company objectives and TPM implementation. This could be due to a lack of explanation or the absence of consultation sessions with the operators as this would be the place to ensure the company objectives are explained and the link to TPM is defined.

**QUESTION 7: Was training on the benefits of TPM implementation given to all stakeholders?**

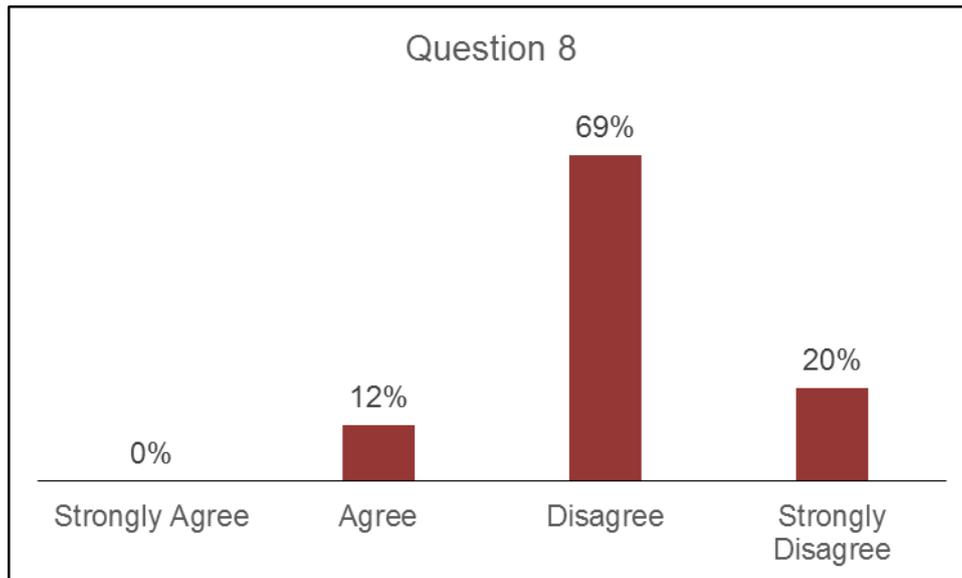
The question aimed to establish if the operators were trained or informed of the benefits of TPM. Figure 3.7 shows the responses to the question and it shows that 29% of the operators agree they received training or was informed of the benefits of implementing TPM. However 55% and 16% disagree and strongly disagree respectively to the statement of being trained on the benefits of TPM. The discrepancy could be attributed to either misunderstanding amongst the operators during training or information was distorted when it was given to the operators.



**Figure 3.7:** Was training on the benefits of TPM implementation given to all stakeholders?

**QUESTION 8: Were pillar champions appointed?**

The proposed implementation of TPM suggests that pillar leaders must be appointed by management to ensure there is consistent application of the concepts across all the areas. Suzuki (1994: 10) suggests that the pillar champions must be part of a higher level team so they can ensure the same information is shared upward or downward in the organisation.



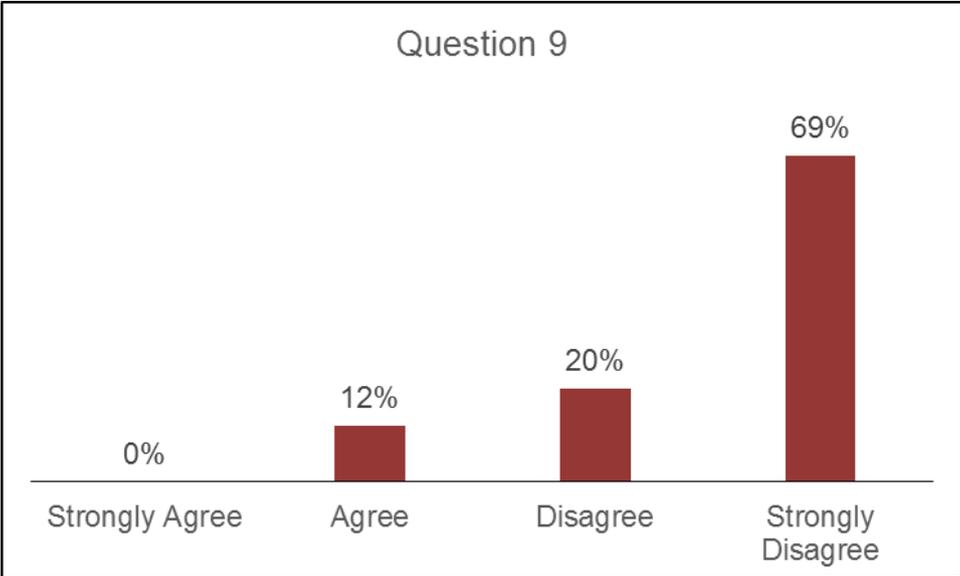
**Figure 3.8: Were pillar champions appointed?**

Figure 3.8 shows the responses to the question whether pillar champions were appointed. Only 12% agreed to the statement that pillar champions were appointed, 88% disagreed to the statement. The organisations implementing TPM normally appoint these pillar champions but because they do not always communicate with the operator, through their team leaders, some operators will not be aware of their existence. This may be a problem with communication and sharing of information.

**QUESTION 9: Were pillar champions trained on their role in TPM implementation?**

This question is also linked to the previous question. The pillar champions need to be trained in the responsibilities and actions required of the pillar champions. Adding on to what was said above; they drive the implementation of the respective pillars across the organisation and ensure there is regular feedback to all the stake holders involved in the process. Figure 3.9 shows the results obtained for this question; it also shows a similar kind of trend as the question above. 12% of the respondents agree that the pillar champions were offered training on the implementation of the pillars. 88% of the respondents disagreed to the statement. The organisation offered

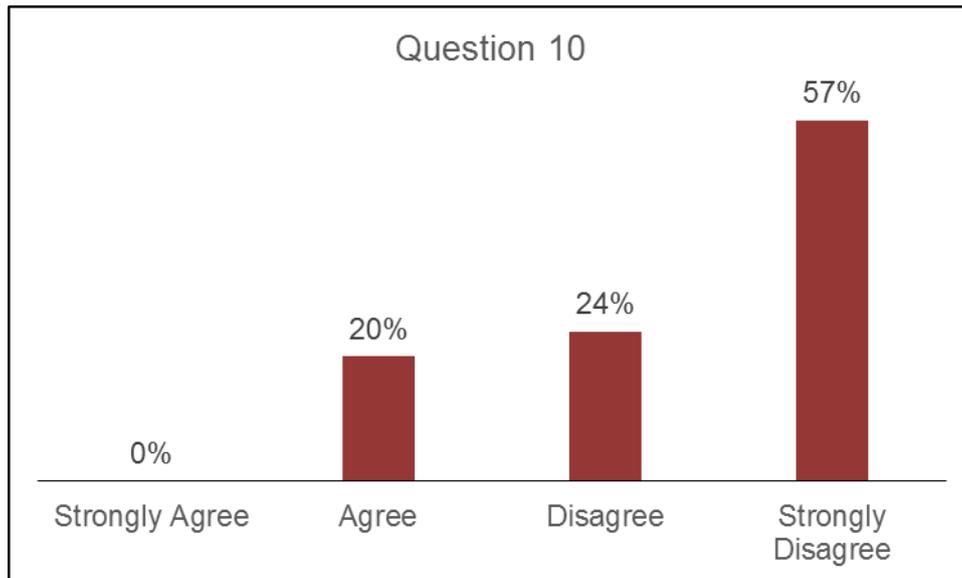
a facilitator course which gave an overview of the pillars and what they were intended to achieve. The course which was run over 5 days covered all 8 pillars in the introduction but it mainly concentrated on 5S and putting together the boards for 5S.



**Figure 3.9: Were pillar champions trained on their role in TPM implementation?**

**QUESTION 10: Was a TPM officer appointed for the site?**

The responses for this question are shown below in Figure 3.10. There were 20% who responded that there was a TPM office established and 24% and 57% disagreed and strongly disagreed as to whether there was a TPM office. Some organisations have a TPM office that performs this function but others choose to give the responsibility to the pillar champions. The pillar champions co-ordinate with the team leaders and get consistency on implementation of TPM. The argument is that it adds a lot of unnecessary resources to the organisation and thereby slows down the process due to a lot of consultation between the office, pillar champions and the team leaders. It is believed to be easier to have pillar champions and team leaders who co-ordinate the implementation of TPM.



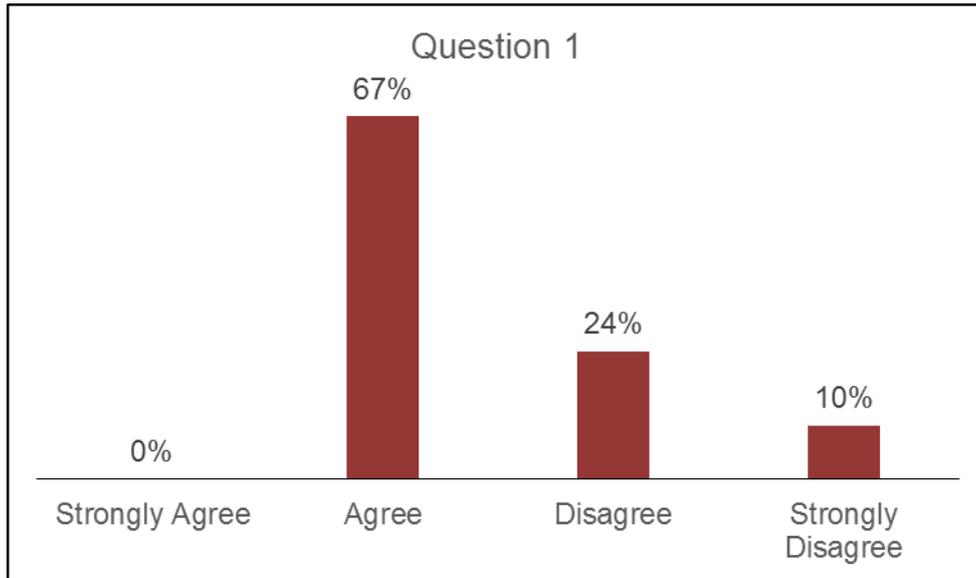
**Figure 3.10: Was a TPM officer appointed for the site?**

### 3.4.2 Operator Involvement

This sections aims to establish to what extent the operators were involved in the implementation process. The aim of TPM is to ensure that operators are empowered and that all employees in the production, maintenance and engineering functions are linked. (Ahuja & Khamba, 2008: 125).

#### **QUESTION 1: Was operator training held in the implementation process?**

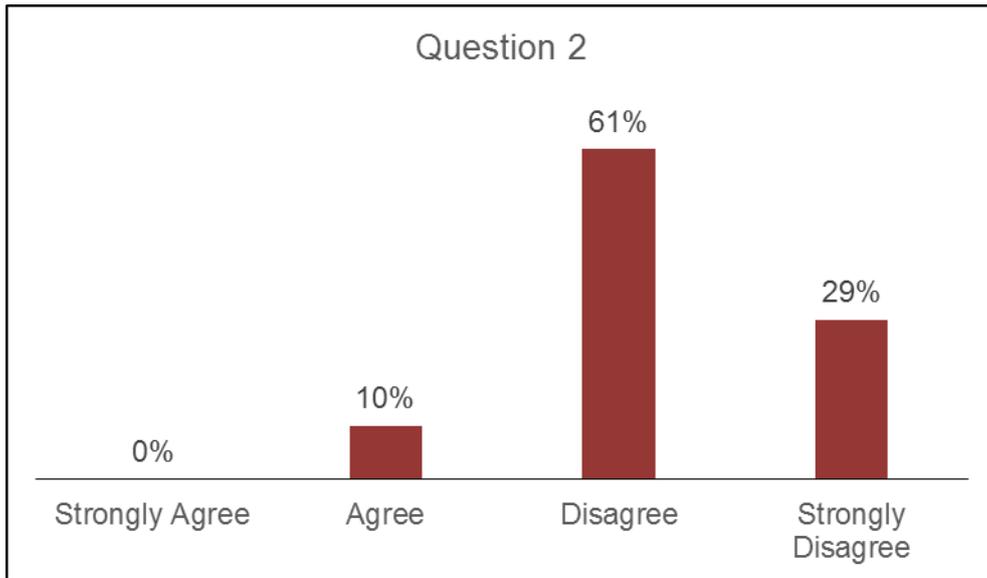
This question is to measure the perception of employees as to what they believe their involvement in the implementation process must be? As it is the operators who will run with the fully implemented TPM programme, it should be apparent that they are involved from the onset. The chart below shows the responses to this question; the results show that 67% of the operators believed they were involved in the implementation process. 24% and 10% disagree and disagree strongly about involvement in the implementation process. They were however exposed to some of the concepts like 5S, cleaning standards and training processes.



**Figure 3.11: Was operator training held in the implementation process?**

**QUESTION 2: Was there buy in by operators?**

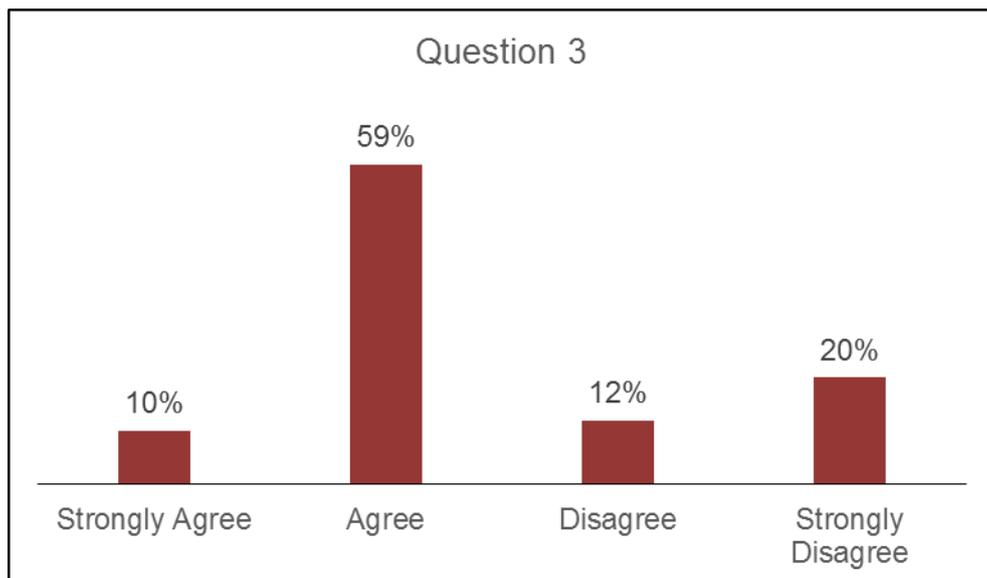
The question was aimed at evaluating what the level of buy in the operators perceived they had to the concept of TPM. This is the real measure of what the operators thought or perceived TPM to be, as this question really talks to the operators and what they believe. The results in the figure 3.12 below show that only 10% of the operators believed there was buy in by the operators. 61% and 29% disagree and disagree respectively that there was no buy in from the operators. It could be in this case that, because there were so many unanswered questions and people saw it as extra, they did not buy in to the concept. Question 3 in the management commitment section can be used to justify this, there were consultation sessions held with the employees. It could mean that the operator concerns were not addressed by management or that they were but they probably were not convinced.



**Figure 3.12: Was there buy in by operators?**

**QUESTION 3: Are small teams formed to solve problems?**

The formation of small teams ensures focus is given to the areas that are being piloted. The individuals will have defined responsibilities and it is within these small teams that work is carried out and information is shared upward or downward. The chart below shows the response received for this question.

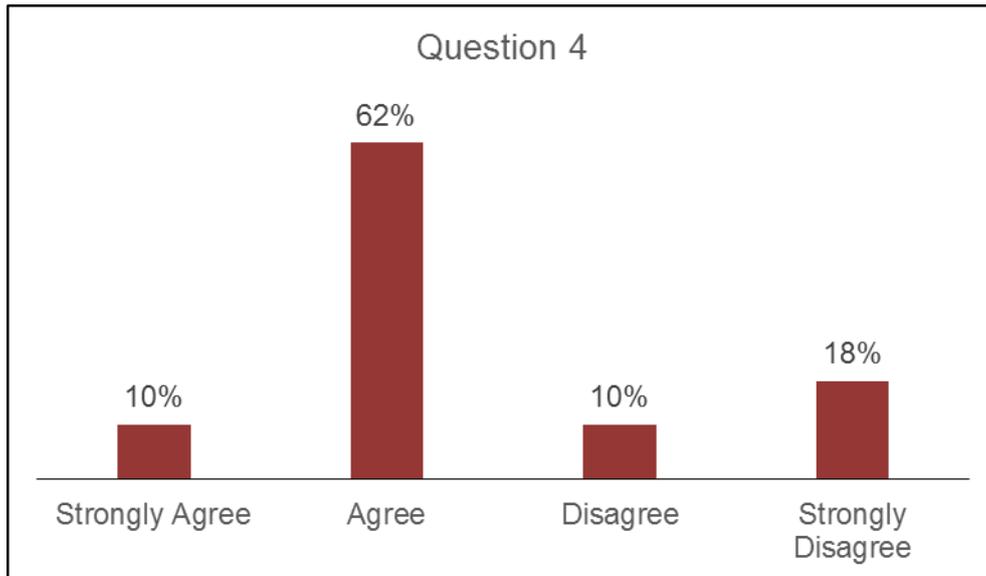


**Figure 3.13: Are small teams formed to solve problems?**

The results are wide spread; 10% and 59% strongly agree and agree to the question. This may be attributed to their involvement in the first clean up sessions which involved operators and other employees from other departments. 12% and 20% of the operators believed there were no teams that were formed because initially the cleaning up process was in only one of the plants and operators that were not working in that piloted plant, were not aware of teams being formed.

**QUESTION 4: Are plant operators a part of small groups?**

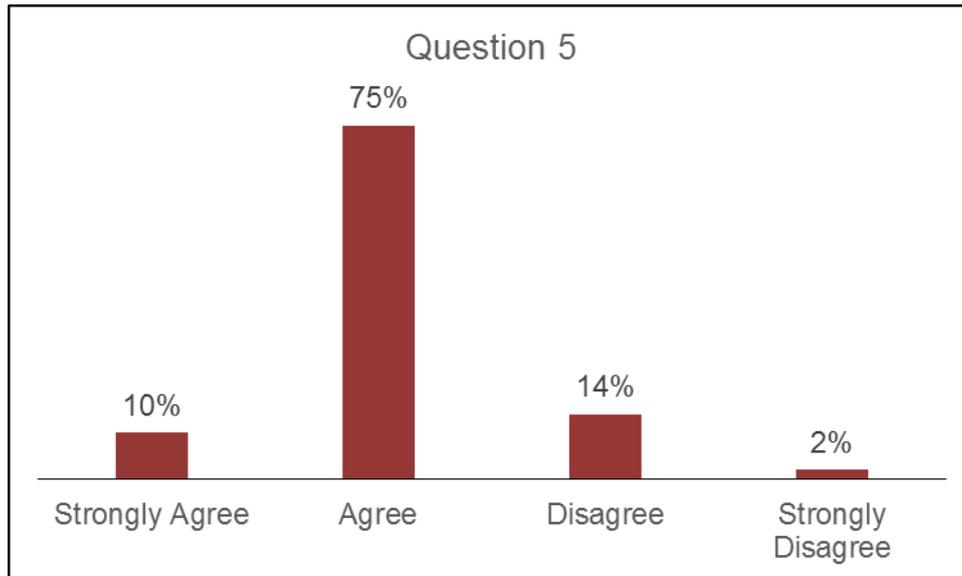
This question is linked to the previous question; it seeks to establish if operators were part of the small groups formed in the implementation process. The teams formed must contain the operators as they will be running with TPM even when the rest of the group is done. The operator involvement or inclusion in the small groups formed is paramount in the implementation process. The results shown below are almost similar to those of question 3 of the operator involvement section. 10% and 62% strongly agreed and agreed respectively that plant operators formed part of the small groups; this according to Howell (2012: 19) will help with the transfer of skills within the small groups between operators and other members. This forms the most critical part of the implementation process as skills transfer will determine the effectiveness of TPM in the long run. 10% and 18% of the operators did not believe the operators were part of the teams that were formed. As mentioned above, the other operators worked in a different plant and were not exposed to the formation of teams and operator involvement.



**Figure 3.14: Are plant operators a part of small groups?**

**QUESTION 5: Were team structures overlapping, with leaders in lower teams being part of a team higher than the team they belonged to?**

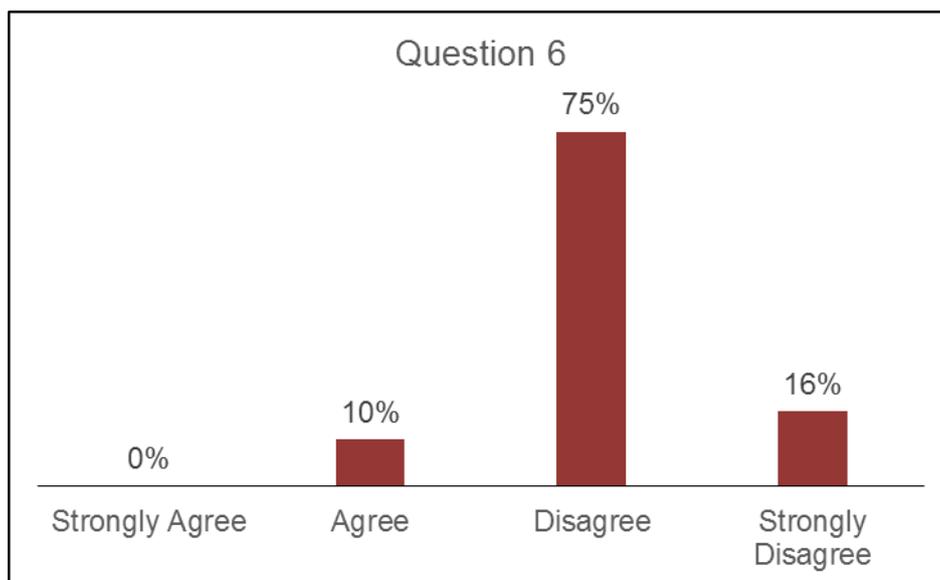
The proposed team structure ensures that there is an exchange of information upwards/downwards and sideways as the team leaders is part of a higher level team. This according to Suzuki (1994: 10) ensures that there is proper dissemination of information and goals. The chart below shows the results of the question and show that operators believed that the team leaders were part of the higher team. This is shown by the 10% and 75% who strongly agree and agree respectively with the statement. The rest of the operators were not aware of the involvement of their leaders in teams that were higher than their team.



**Figure 3.15:** Were team structures overlapping, with leaders in lower teams being part of a team higher than the team they belonged to?

**QUESTION 6:** Is downtime measured and analysed according to the 6 big losses?

The results to this question somehow reveal there was no measuring that was being done.

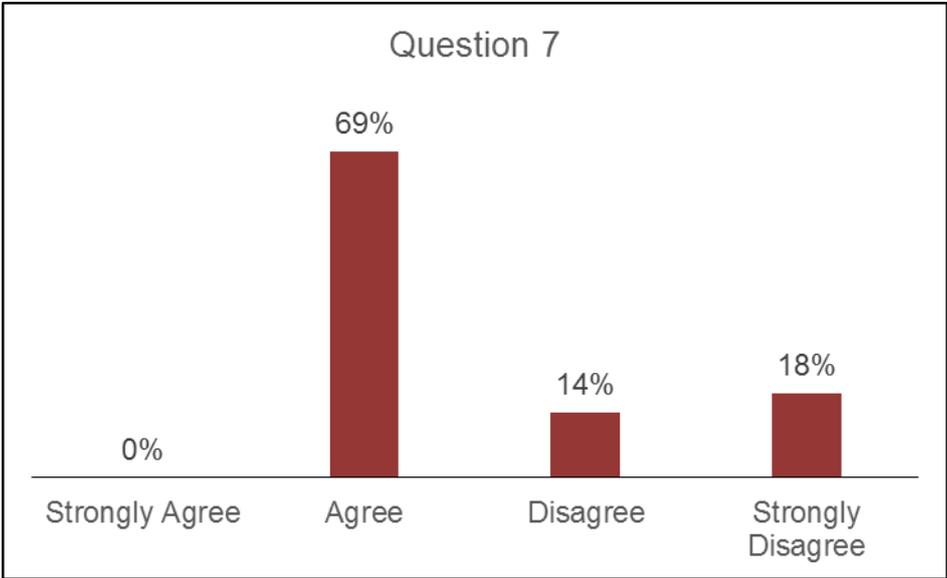


**Figure 3.16:** Is downtime measured and analysed according to the 6 big losses?

Only 10% believed there were measurements of downtime according to the 6 big losses. 75% and 16% disagreed and strongly disagreed that there were measurements according to the 6 big losses. This may be due to the lack of communication with the operators on the downtime categories or a lack of understanding of the categories.

**QUESTION 7: Are tags raised by operators repaired?**

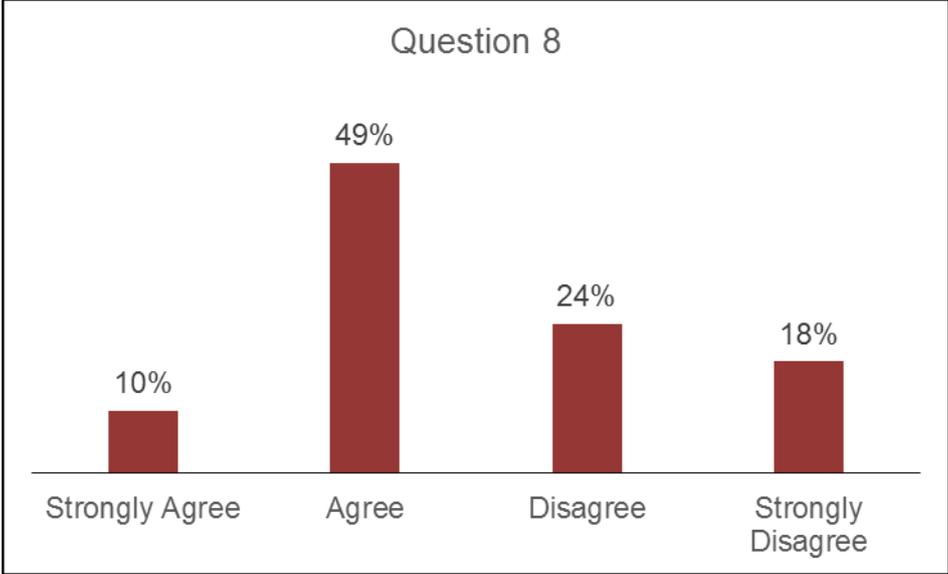
The tags used to pick up defects must be tracked and most importantly they must be fixed, as this will lead to demotivated operators if they are not repaired. It is important to increase the number of people who repair and close out raised tags in the initial stages as there will be a lot of tags raised. Doing this ensures that the operators' perception management are serious about implementing TPM. The results suggest that 69% of the operators agree the tags raised were being repaired. 14% and 18% disagree and strongly disagree respectively. This could be due to the fact that the concept of tagging was eventually rolled out to the rest of the plant but the focus was mainly in the pilot areas and some of the tags raised in the plant did not receive urgent attention.



**Figure 3.17: Are tags raised by operators repaired?**

**QUESTION 8: Does management involve operators in decision making?**

The question was aimed to measure how much operators believe they are involved in making decisions. The chart below shows that 10% and 49% of the respondents strongly agree and agree respectively that management involved operators in decision making. 24% and 18% disagree and disagree strongly that management do not involve operators in decision making. This may be the portion of operators that do not normally meet with management on a regular basis.

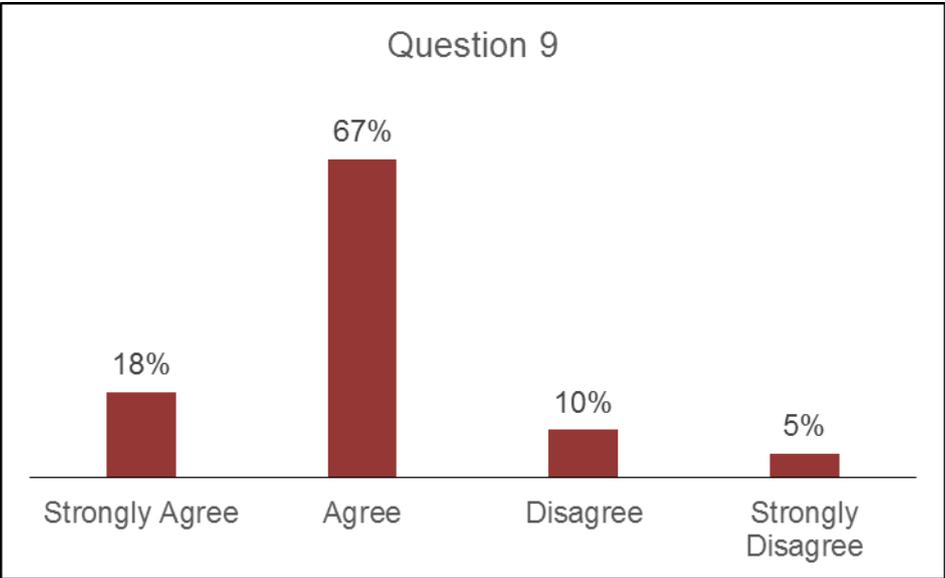


**Figure 3.18: Does management involve operators in decision making?**

**QUESTION 9: Are suggestions from operators implemented?**

This question and question 9 of operator involvement section aim to establish how much operators perceive that they are part of the team and how much their input is valued. The implementation of suggestions requested by operators gives the operators a sense that they are valued and their input is important. The operators are the ones who run the equipment and chances are that they know how to improve the machines they use. The responses for this question show that 85% of the operators agree that their suggestions are implemented. There is however 10% and 5% who seem to disagree and strongly disagree, respectively. The amount of suggestions from operators increases exponentially and the rate at which they were

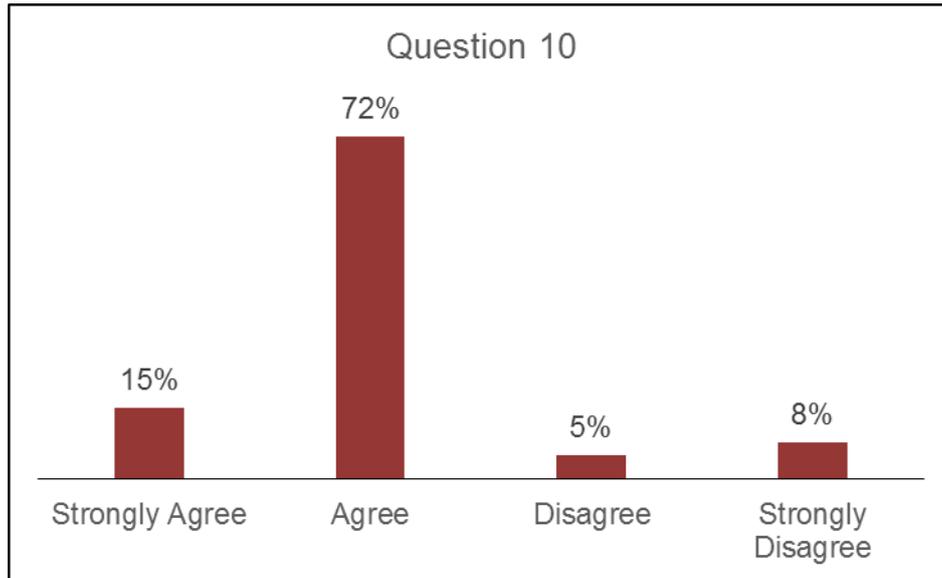
being implemented sort of declined; that could be the cause of the 15% believing their suggestions are not implemented.



**Figure 3.19: Are suggestions from operators implemented?**

**QUESTION 10: Are operator areas clearly defined?**

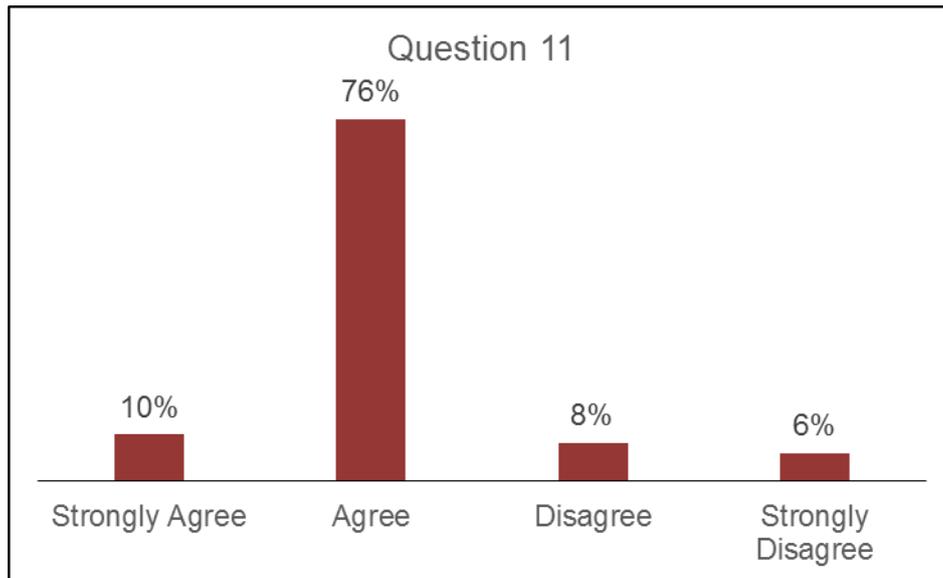
The plant in which TPM was implemented has a huge manpower requirement and workplaces are integrated as it is a continuous process. There were 13 positions per shift and each operator had a clear work area they were responsible for. The operator areas were defined clearly and this is reflected in the responses to this question. As can be seen in the chart below, there is 87% of the operators that agree their areas are clearly defined. The operators were made up of groups of cleaners who were used at times to cover for absent operators; these could be the fraction that responded their work areas were not clearly defined.



**Figure 3.20: Are operator areas clearly defined?**

**QUESTION 11: Are roles and responsibilities clearly defined?**

The roles of each operator must be defined to ensure that there is clarity in terms of what is required of them. The aim of this question was to test if the roles and responsibilities of operators in the implementation process of TPM were defined and communicated to them. This would have ensured that the operators are aware of the role they play in the implementation of TPM. The response to the question was that 86% of the operators agreed they had their roles and responsibilities clearly defined to them and the 14% disagreed they had their roles defined. However there may have been some misunderstanding with some of the operators on this question; it was meant to measure the perception during implementation not day to day operation of the plants.



**Figure 3.21: Are roles and responsibilities clearly defined?**

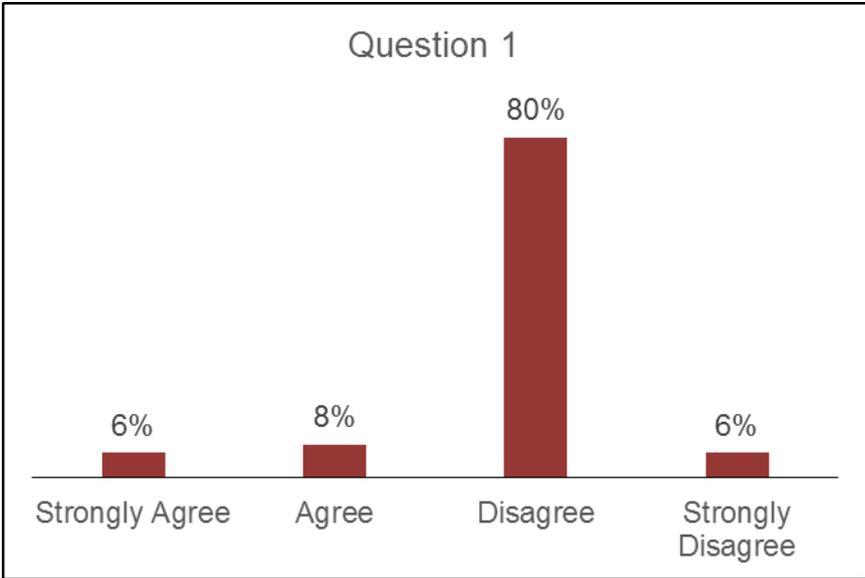
### 3.4.3 Sustainability

This section of the measuring instrument was meant to measure to what extent the initiative would be sustainable. The questions were formulated based on actions the author thought could be done that would ensure sustainability of the initiative; some of the questions are based on the prescribed process to implement TPM. It meant to measure what was being put in place to lay a strong foundation for the program to be sustainable, even after the people that were implementing it have left this section. This section does not dwell on the implementation process it looks at post implementation as to what is being put in place to sustain the process.

#### **QUESTION 1: Do standards for cleaning, inspecting and lubricating exist?**

The implementation process requires that there are standards that are formulated and implemented to ensure there is standardisation of operator actions. These standards are meant to guide operator actions and direct them in what has to be done. Operator responses to this question were as shown in the chart below. Only 14% agreed there were standards and the rest, 86% did not agree. The absence of

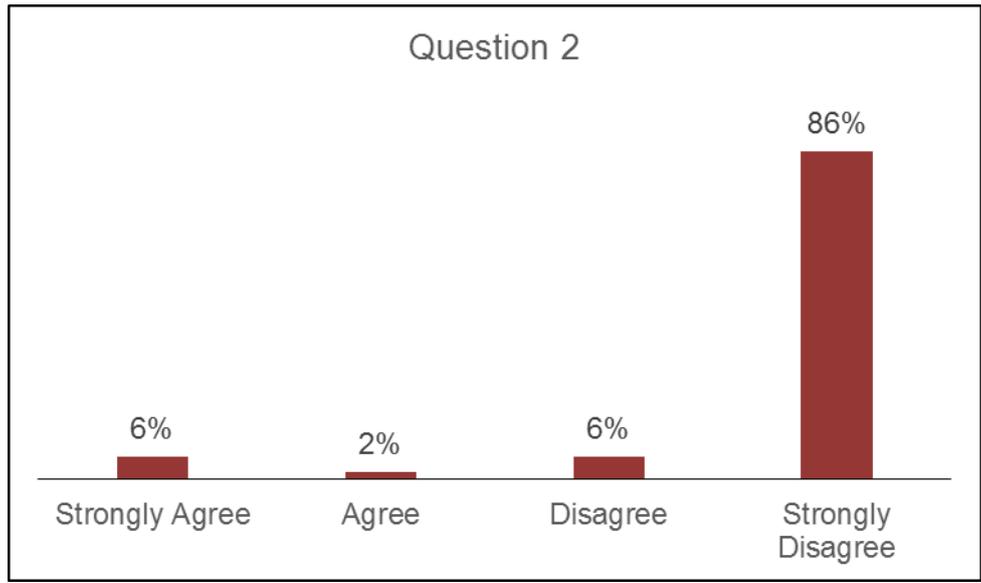
standards means the operators approach the same job differently and this could mean the results achieved vary widely.



**Figure 3.22: Do standards for cleaning, inspecting and lubricating exist?**

**QUESTION 2: Are operators trained on cleaning, inspection, lubricating & tightening standards?**

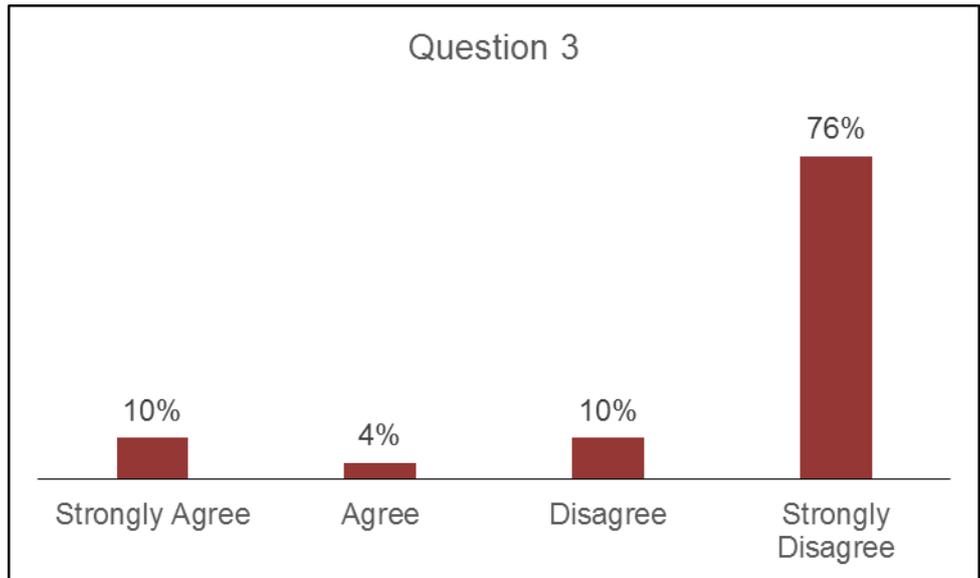
The previous question ties up into this one in that it seeks to determine how many operators were trained in the standards that were available. The responses indicate that there was little to no training done on the standards that were available. 92% of the respondents replied that they did not receive training on any of the standards; this response fits in well with the response to Question 1. The number of people disagreeing is evidence of perhaps the absence of standards. 8% of the respondents agreed they had been trained in standards that were available.



**Figure3.23:** Are operators trained on cleaning, inspection, lubricating & tightening standards?

**QUESTION 3: Are TPM standards included in operator KPI's?**

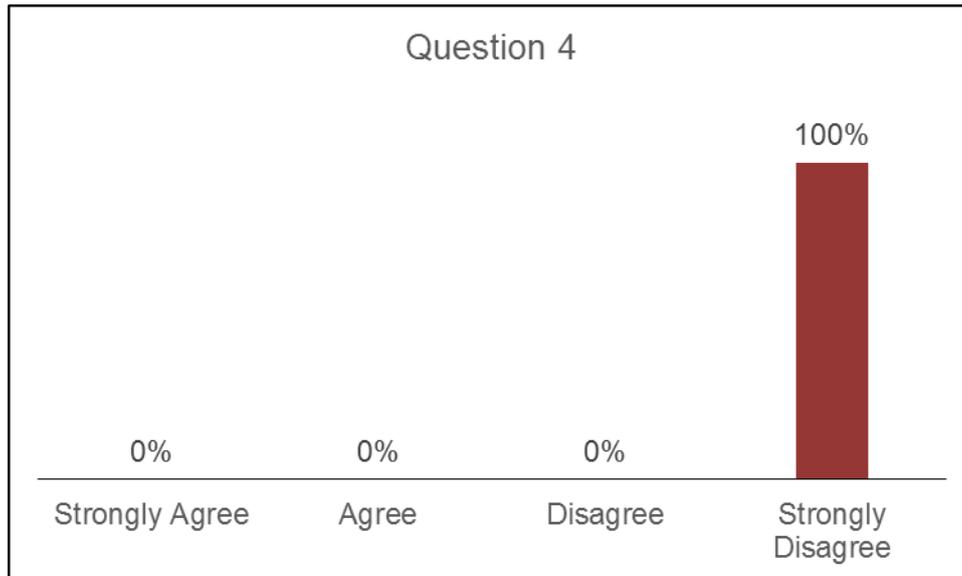
In order to ensure standards are upheld, the author believes they must be put into the operator KPI's and they must be measured on their contribution towards the attainment of entrenching the standards in the work place. This also ensures there is continuity in the day to day activities of the operator including the standards that are being established and more importantly all new employees are trained in the standards as they form part of their daily actions. The operator responses however suggest the standards are not part of their KPI's as 86% of the respondents did not have standards forming part of their KPI's. 14% of the respondents agreed there were KPI's that included the standards; 10% of these strongly agreed with the statement. This, as mentioned earlier, ensures the continuity and strong entrenching of the standards on the operators.



**Figure 3.24: Are TPM standards included in operator KPI's?**

**QUESTION 4: Do TPM concepts form part of the operator training manuals?**

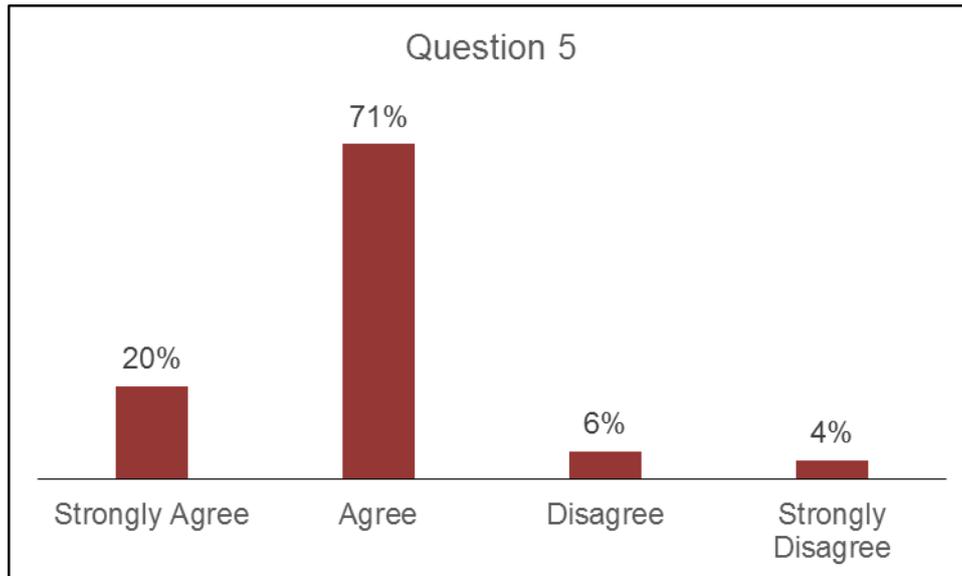
The concept of TPM once introduced, must then be made “the way things are done in an organisation”, however for this to happen all new employees must be trained in the concepts of TPM. This is achieved by making the concepts and standards part of the operator training manuals which ensures that the new employees are exposed to the concept before entering the plant environment. The responses however show the operators strongly disagree that the concepts have been made part of their training manuals.



**Figure 3.25: Do TPM concepts form part of the operator training manuals?**

**QUESTION 5: Is there time set aside for TPM sessions or training?**

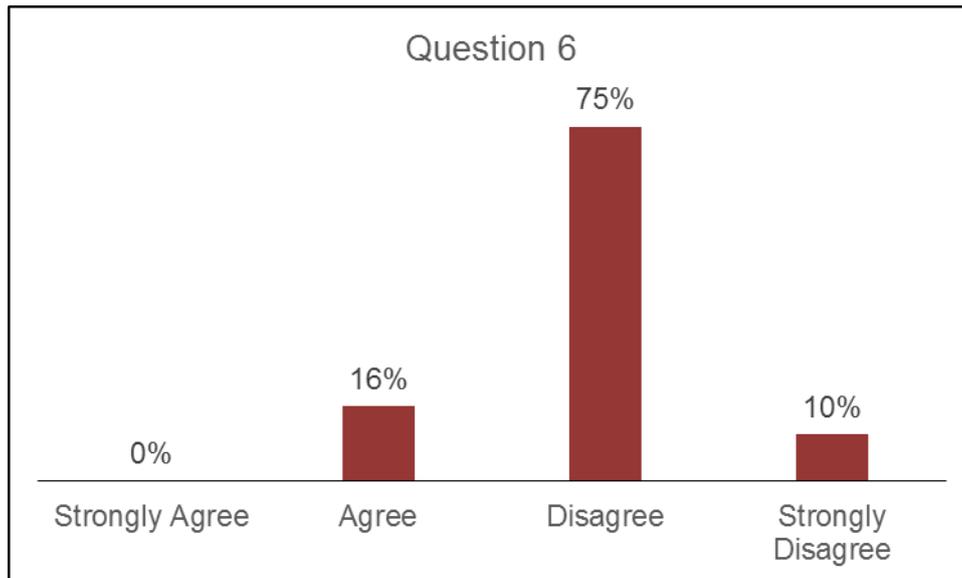
The concepts of TPM will not generate results overnight. It is a long process that requires training of operators and stakeholders. The process requires training sessions to be held until the concepts become second nature to the operators. 91% of the respondents to this question agreed there was time set aside to have TPM sessions and training. The 9% of responses disagreed there was time set aside for training on TPM as shown in the chart below.



**Figure 3.26: Is there time set aside for TPM sessions or training?**

**QUESTION 6: Does the gap between operations and maintenance still exist?**

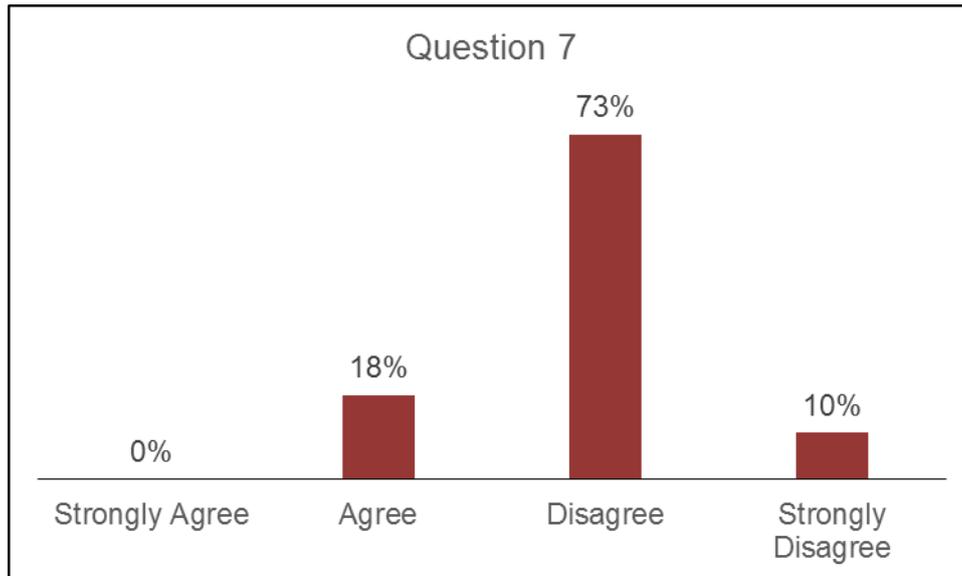
The concept of TPM is to bridge the gap between maintenance and operators. It aims to have skills transferred from maintenance to operators. The transfer of skills will however take some time as the operators must be trained in the use of tools that are used by the mechanical people. Figure 3.27 shows 85% of the respondents seem to believe that the gap between maintenance and operators still exist. 15% perceive there is no gap between the two departments; the comments made by some of the respondents were there is a strong relationship when it comes to solving problems on the plant.



**Figure 3.27: Does the gap between operations and maintenance still exist?**

**QUESTION 7: Are skills being transferred from maintenance personnel to operators?**

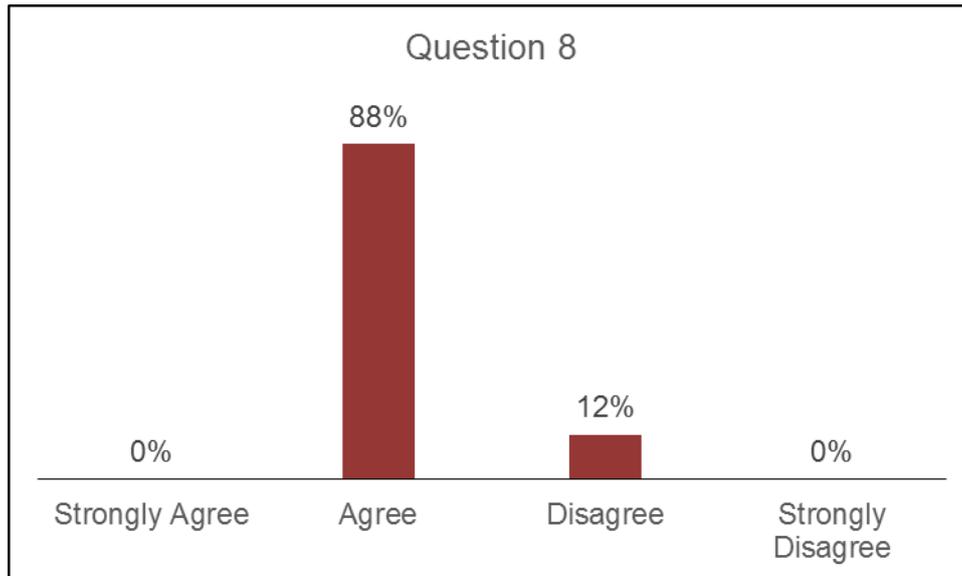
One of the aims of TPM is to ensure skills are transferred from maintenance to operations people and this is achieved mainly by the bridging the gap between the two disciplines. When maintenance work on the same floor as the operators that is when practical skill transfer takes place, the theory can be done in training sessions but the practical will only happen on the floor. The response to this question and question 6 of the sustainability show some similarities in that the existence of the gap will hinder the transfer of maintenance skills to the operators. Figure 3.8 shows 83% of the respondents disagree with the statement, they feel that there are no skills being transferred from maintenance and 18% agree there are skills being transferred from maintenance to operators. The same comments were also made saying that during problem solving when operators spend time with maintenance people a considerable amount of knowledge will be transferred.



**Figure 3.28: Are skills being transferred from maintenance personnel to operators?**

**QUESTION 8: Are operators rewarded for achieving set targets?**

The responses in figure 3.29 below show that operators agree there is reward for attaining the targets. There are however, 12% of the operators that seem to disagree with the statement that there are no rewards. This could be because they feel the reward does not equate to the targets reached. The reward could be smaller compared to what they are expecting.



**Figure 3.29: Are operators rewarded for achieving set targets?**

### 3.5 CONCLUSION

The results obtained from the research shows there are some differences from the prescribed methods based on the responses that were given by the operators. Some companies however follow processes that work for their organisation and not necessarily what is prescribed. The results obtained will be discussed to some degree in Chapter 4 and compared to what is prescribed in some instances

**CHAPTER 4**  
**DISCUSSION OF THE RESULTS OF THE  
EMPRICIAL STUDY**

**4.1 INTRODUCTION**

The aim of the research was to establish how companies are implementing TPM in their processes. The questionnaire which had 3 sections was intended to test the people perceptions as to what their views were on the implementation process. The questionnaire was aimed at comparing the implementation process followed by management and the prescribed methods of implementation in section 1 and 2. The third section was aimed at determining, based on the operator responses if the concept will be sustainable in the long run. As mentioned previously the questions were based on previous studies and information from literature.

In the following sections the results from respondents will be discussed.

**4.2 MANAGEMENT COMMITMENT**

The section was aimed to measure the operator perceptions on management commitment in the implementation process. The questions in this section ranged from decision making, involvement of all stakeholders and the establishment of support systems. Seng, Jantan and Ramayah, (2010: 2) reckon top management have the duty to ensure there is conducive environment that will enable a smooth implementation process.

**4.2.1 Question 1: Was kick off meeting held**

Most of the respondents reckon a kick off meeting was not held. The aim of holding a kick off meeting is to ensure awareness is created before the implementation of

TPM. Nakajima (1988: 56) states that it is important to hold this meeting as it creates an environment where people understand the aim of introducing TPM and prepare all stakeholders for the change process. It is in these meetings that management answer questions raised by employees and not holding these kick off meetings. The concerns of the employees may not be fully addressed and this will create issues during implementation and running phase of TPM. Suzuki (1994: 8) believes it is at these kick off meetings that management pledge their commitment and their reasons for choosing to implement TPM. These meetings are of utmost importance and if there are disagreements on issues raised, it may be wise to postpone the implementation or kick off.

#### **4.2.2 Question 2: Were unions consulted by management before implementation?**

Ahuja *et al* (2008: 126) say unions are established to represent employee needs in organisations. They also state when new strategies like TPM are implemented, employees always have fears of becoming redundant as the production efficiencies increase. It is for this reason that unions need to be consulted to ensure the employee fears are put to rest. Employees will always listen to their union representatives and if the information sent out by management differs from what the unions know and understand this may jeopardise the implementation process. It is then equally important that unions are consulted before the implementation process begins. In the case of Company X there seems to have been some consultation with the unions because of the 31% of responses that agreed with the statement.

#### **4.2.3 Question 3: Were employees consulted by management before implementation?**

The responses to this question suggest that no consultation was held with the employees as all the respondents disagreed with the statement. This question is linked to the first two questions as it is during these consultations that management

will understand the concerns of the employees and give answers to them. In some instances companies consult with unions and immediate supervisors in the hope that information will be distributed amongst the operators. It must however be noted that this type of communication in some instances distorts information and creates misalignment to some point. Information should be put on slide shows and standardised if the consultation is done with supervisors only; this helps with the standardisation of information passed on.

#### **4.2.4 Question 4: Does management inspect pilot areas regularly?**

Arca *et al* (2008: 255) reckon the involvement of management in the implementation process ensures that there is supervision of the process and that guidance is always offered. This makes the process move forward in a uniform manner and mistakes are easily picked up in the process of checking and inspecting. It also gives management the opportunity to identify the areas which could cause the process to slow down. This must not be used as way to discipline operators or employees because at this point they also need guidance and help in carrying out the activities stipulated in the implementation process. It should be used to judge the effectiveness of the implementation process and obviously put in place corrective actions to help the process move forward.

#### **4.2.5 Question 5: Is management involved in the process of rolling out TPM?**

The involvement of management reassures the operators that there is commitment by management. This involvement by management in the roll out process is key to ensure operators understand management want to make the whole initiative work and it is not one the initiatives that is started and left to the operators to see it through. Their involvement ensures there is guidance of the operators and all involved in the implementation process. This guidance will eventually lead to everyone moving in the right direction with regards to implementing TPM. The

answering of questions raised by employees will be easily addressed as the process moves along and not wait for another time where operators meet with their management. It helps in reducing the time taken to address concerns and management can get exposed to the issues that operators are confronted with.

#### **4.2.6 Question 6: Was there a clear link between company objectives and implementing TPM?**

The objectives of the company were to become competitive in the environment in which they do business and become a world class producer. The main objectives of the company were to eliminate losses and improve efficiencies and productivity. These objectives are similar to what Ahuja *et al* (2009: 248) state as to what TPM is meant to achieve. The attainment of higher productivity is linked to the improvement of equipment efficiency and the reduction of unforeseen breakdowns through the activities that operators embark on such as cleaning, inspection, lubrication and tightening. Companies should however inform the operators about the objectives they hope to be achieved through the implementation of TPM. These must be linked to the organisation's objectives, though.

#### **4.2.7 Was training on the benefits of TPM conducted with all stakeholders?**

The explanation of benefits would ensure the operators buy in to the concept and thereby ensuring the full support in the implementation and sustaining the process. According to Gupta *et al* (2012: 115) the benefits of implementing TPM amongst others include a safe work environment, reduced cleaning times and increase in operator knowledge as maintenance skills are transferred to operators. If these benefits are communicated properly, there will be enormous buy in from the operators. The training of the operators also creates alignment and ensures their actions are focused on attaining the most of the benefits of implement TPM. The premise is that all operators would like a clean, safe and breakdown free

environment and if it means TPM activities will help to achieve this, the operators would then most probably work towards this.

#### **4.2.8 Were pillar champions appointed?**

The appointment of pillar champions is important in cases where the implementation of TPM is going to be carried out on a full scale or company wide basis; their primary job is to ensure there uniformity of processes being carried out. The pillar champions together with the TPM office or co-ordinator must map out process flows and source tools that will be used in the implementation process.

#### **4.2.9 Were pillar champions trained on their role in TPM implementation?**

The training of pillar champions is of utmost importance as these are the people that will eventually ensure that there is a link between the pillars involved. According to the author the link between the pillars is at times not understood. Each function somehow works in its own silo without a clear link to the other pillar. The ultimate goal is to ensure there is an increase in productivity by ensuring high equipment efficiencies. That being said, the pillars must then find this as their common goal and strive to align all actions to it. Each pillar must be able to show what they are doing in order to attain the main goal of the company.

#### **4.2.10 Was a TPM officer appointed for the site?**

There was no TPM office established in the case of Company X, based on the responses received. Nakajima (1988: 59) and Suzuki (1994: 10) suggest there be a TPM office established to ensure that the link between all pillars is established. The TPM office has the duty amongst others to run campaigns and communicate upwards/sideways and ensure that there are adequate resources for the pillars to function without disruption. They ensure, together with pillar champions that there is consistency in the introduction and running of the pillars across the organisation.

Chan, Lau, IP, Chan & Kong, (2003: 78) also say that the duties of the TPM office are to set guidelines and define the policies which will be followed within the organisation during the implementation stage. The master plans for TPM implementation are set-up by this office as well.

### **4.3 OPERATOR INVOLVEMENT**

The main aim of TPM is to ensure overall equipment efficiency is increased in order to increase productivity. This is achieved by ensuring the operators are trained in some maintenance tasks and they take on these roles on a day to day basis. Seng *et al* (2010: 2) reckon operators have to be empowered to an extent where they start running and maintaining machines like they are the owners. This attained by involving the operators from the first step of implementation and ensuring that they understand the intention of management in the implementation of TPM. The whole process of involving operators will ensure that there is understanding between management and operators in terms of expectations and the direction in which the company is going.

#### **4.3.1 Was operator training held in the implementation process?**

The training given to operators must ensure that they understand the role of TPM and activities within it. This training must be aimed at ensuring that people do not resist change and to raise the morale of the people involved (Nakajima, 1988: 58). It is within this time that management gives employees all the benefits associated with the implementation of TPM. It can be used to answer all the questions that operators have about the strategy the company has chosen and to outline how it links to company objectives. The training must not be given to operators alone; their supervisors can be invited to the same training sessions to create reassurance for the operators. Ahuja *et al* (2009: 249) also indicate that operators require a lot of training to improve the competencies which they require to carry out the new tasks that will be handed down to them.

### **4.3.2 Was there buy in by operators?**

This may create resistance against the implementation of TPM from the operators and in a way prolong the implementation process. Arca *et al* (2008: 255) sites the lack of commitment as a hindering factor in implementation of TPM. They propose the involvement of all the people in the implementation process including management to supervise and guide the operators. This ensures that there is a support system for operators should they require it. The access to information by operators and all involved must not be restricted in order to ensure that there is transparency on all activities being carried out. It also ensures that questions are raised and answered by management to reduce or remove any doubts that may be raised in the process. The author is of the view that in order to create buy in, the basis of implementation must be established through transparent sharing of information. The operators must be taken to environments where TPM has been implemented and allowed the chance to discuss with operators that have been through the process. There will always be suspicion when new strategies are implemented and the use of living proof has not been explored for lower level employees.

### **4.3.3 Are small teams formed to solve problems?**

Most of the responses to this question agreed that small teams were formed. Eti *et al* (2004: 389) are of the opinion that small group activities within the organisation leads to the development of problem solving oriented individuals. The formation of the teams in the start of the implementation process was meant to impart the concept of TPM on all the senior employees in the factory; however these were not put in place to solve problems. The responses received referred to these teams which were responsible for pilot areas within the plant and teams that were formed to solve problems. However the small groups would have to eliminate certain problems which were encountered in the pilot areas and this was done with the help of the maintenance teams.

#### **4.3.4 Are plant operators a part of small groups?**

Operators were part of the small groups formed in the implementation based on the response to the question. The inclusion of operators in the small groups ensures operators are guided by different disciplines within the teams. This ensures skills transfer between operators, management, maintenance and other disciplines within the group (Chan *et al*, 2003: 74). The concept of all inclusive teams is what TPM advocates the total inclusion of all people in the organisation. The inclusion of operators also ensures that a standardised way of doing things is maintained as the standards set in the beginning are what the operators are going to use and improve on.

#### **4.3.5 Were team structures overlapping with leaders in lower teams being part of a team higher than the team they belonged to?**

The response to this question was linked to the previous one as it aimed to establish if teams were made up of different disciplines within the organisation. Chan *et al* (2003: 74) state these small groups must be made up of manager, supervisors, team leaders, maintenance and operators. This, they say, enables the easy transfer of skills and habits within the group. It also ensures that there is alignment of group activities as information is transferred from higher to lower groups and lower to higher groups.

#### **4.3.6 Is downtime measured and analysed according to the 6 big losses?**

One of the main aims of TPM is to reduce downtimes and increase the overall equipment efficiencies. The best place to start will be to measure the downtimes and track if they are reducing or not. Nakajima (1988: 24) says the information kept must reflect the true state of affairs. The information according Nakajima must also be linked the true operating times of the equipment in the plants and these losses must

be categorised into the big losses as defined to ensure focus is directed to the right place.

#### **4.3.7 Are tags raised by operators repaired?**

The process of tagging is a way of establishing the operators are able to identify defects on their machines. In the clean-up process the operators must rigorously trained on how to pick up defects and identify potential problems with their machines. The tags must however be repaired and operator concerns must be looked into as this will give them a sense of being heard in the process. As time goes by the operators must be able to do all the activities that maintenance used to do on their machines; this will help them understand their machines better and put them in a place where they are able to prevent potential breakdowns on their equipment. Some companies have a flow process for tags raised and a way to give feedback to the operators in case there are problems with the raised tags. There should never be a big ratio between raised tags and completed/fixed tags as this will demoralise the operators and may lead to them not raising new tags. Teams that resolve tags must be available from the maintenance teams and some tags that the operator can fix must be fixed by them.

#### **4.3.8 Does management involve operators in decision making?**

Eventually operators should take responsibility of the operation of the plant and this includes taking decisions that would have been taken by senior people. The involvement of operators ensures that they are guided through the process and they eventually make decisions on their own. The operator decision making process will have to be guided in the beginning and importantly so they must be given guiding principle/questions in terms of prioritising their activities and making decisions. The importance of involving operators in making of decisions also helps management model the kind of thinking that is expected from the operators and it will give the operators an understanding that is required by management.

#### **4.3.9 Are suggestions from operators implemented?**

Operators in most cases know how they can get machines to perform better and they have all these ways in which to reduce downtime on machines. There must be a system in place to ensure this knowledge is tapped into and formalised/documentated into operating manuals. The suggestions must not be shot down but taken through a decision process where the operators are involved to explain their ideas. If there is a reason for not implementing suggestions, the operators must be given feedback in order for them to understand or improve their suggestion. Suggestion schemes can be linked to some sort of reward process for best suggestions given by the operators; this will help increase the number of suggestions operators hand in. The easiest way of killing operator morale is not to implement and give feedback to the originator of such suggestions.

#### **4.3.10 Are operator areas clearly defined?**

Operator areas ensure that there is specialisation on the activities that the operators do in these areas. It also ensures the KPI's are directed to certain areas or responsibility where operators work in. The operator areas must be clearly defined to ensure the overlapping areas are noted and assigned to a particular area. This will make sure that there is attention given to the whole plant area and all defined activities are being carried out.

#### **4.3.11 Are roles and responsibilities clearly defined?**

The roles of the people involved in the implementation process must be defined as this removes the confusion of who has to do what in the process. The defining of roles and responsibilities is closely linked to the defining of operator areas and setting up of KPI's. The roles and responsibilities of operators will help in ensuring that the operators are aware of what is expected of them in the whole implementation and running process of TPM. As activities are shifted from maintenance to operators

there will be a need to clarify what the new operator duties and maintenance duties will be.

## **4.4 SUSTAINABILITY OF TPM**

The following questions were considered by the author to be aspects that create a sustainable implementation of TPM. These questions touch on what is thought to be ways of ensuring the activities that operators do are entrenched into habits of new and old employees all together.

### **4.4.1 Do standards for cleaning, inspecting and lubricating exist?**

The existence of standards ensures activities are being carried the same way across the board. This is the way in which results can be attained if all operators are going to ensure they look after their machines the same way. If they are meant to lubricate or stop and clean at a particular time which is defined and this is done according to a set standard, they all need to these activities to ensure the efficiency of equipment is achieved.

### **4.4.2 Are operators trained on cleaning, inspection, lubricating & tightening standards?**

Daily inspection of equipment according to Nakajima (1988: 33) is the responsibility of the people operating the equipment and by carrying out daily equipment maintenance (cleaning, inspecting, lubricating and tightening), unexpected equipment failures and forced deterioration of equipment can be prevented. The operators have to be deemed competent in carrying out these duties if the full value of the process is going to be realised. The transfer of skills from the maintenance people is vital and the training must form part of the new employee skills matrix. The inclusion of these activities in the operator training should ensure there is constant training on them and thereby ensuring continuity and sustainability of such activities.

#### **4.4.3 Are TPM standards included in operator KPI's?**

The teams created at all levels ensure the promotion of organisations that complement daily activities with TPM aspects. Suzuki (1992: 20) mentions results need to be locked in and this is achieved by systematic repetition of activities. By so doing, operators are forced to remember what needs to be done on a daily basis and this helps create sustainability of the TPM activities.

#### **4.4.4 Do TPM concepts form part of the operator training manuals?**

The inclusion of TPM activities into operator training manuals ensures the retraining and training of old and new employees alike and entrenches the activities into their minds. In areas where operators are supposed to be retrained annually it will eventually become the operator's second nature to carry out these activities. This also removes the notion of extra work as it is already defined as operator activities from the onset especially for new operators and more so in newly commissioned plant or projects.

#### **4.4.5 Is there time set aside for TPM sessions or training?**

The setting aside of time to train operators, shows commitment by the organisation to the operators. This training will help to improve the level of understanding of TPM concepts and its activities. In companies where the concept is introduced, there is un-learning of old habits that need to happen and learning of new ways of doing things. This will not happen overnight but it will take time and literature says at least 3 years must be considered to be when results will be generated. These training sessions must not all be class room based; there must be practical training that is done as some of the operators will need to be shown what is being talked about and how it is done, especially in places where the level of understanding technical terms is low. The introduction of practical sessions also places the operators into their work environment and the activities that are trained in this way will be those that perhaps

become entrenched because whenever the operators go back to their work areas it is easier to remember.

#### **4.4.6 Does the gap between operations and maintenance still exist?**

The existence of the gap between operations and maintenance is an indication that the TPM implementation process has not matured yet. The premise of implementing TPM was based on bridging the gap between operators and maintenance so as to remove the notion, “I operate, you fix”. The two disciplines need to work together to ensure the transfer of skills takes place and ultimately to get results from the implementation of TPM. As the implementation process carries on the transfer of skills should be emphasised and measured so as to meet established deadlines and increase productivity and line efficiencies.

#### **4.4.7 Are skills being transferred from maintenance personnel to operators?**

Suzuki (1992: 14) indicates operators, in their autonomous maintenance teams, will become responsible for scheduled maintenance and improvement activities on equipment. This implies that it is apparent that the operators have to be trained in some of the maintenance activities to ensure they can carry out what is required of them. There must however be a direct line that distinguishes what the operators must do and what the planned maintenance people must do. This helps in reducing delays and creates clarity for everyone involved.

#### **4.4.8 Are operators rewarded for achieving set targets?**

Reward for reaching or attaining a target will motivate the operators and chances are they may be motivated to keep attaining the targets set for them. This however must be done on a contribution basis to ensure everyone is rewarded equally according to the amount of effort put into the achievement of the targets. This can be achieved by

ensuring the KPI's are measured or based on operator daily activities, which are linked to certain deliverables or outputs. What must be made clear though are the hidden rewards which include new skills, safe, clean and problem free work environment.

## **4.5 CONCLUSION**

The implementation of TPM has to take into account a lot of factors but amongst these there must be an understanding from all parties involved. The creation of a positive environment depends on the information that management are willing to share with the operators and how they clarify the concerns raised in the interactions they have with everyone. An all-inclusive approach ensures there is understanding and clarity of all the people involved in the implementation process. For operators to sustain the activities there is a need to ensure these activities are made part of their daily way of functioning and for this extensive training will ensure it is attained.

## CHAPTER 5

# CONCLUSION AND RECOMMENDATIONS

### 5.1 INTRODUCTION

TPM is aimed bridging the gap between maintenance and production and to ensure increased equipment efficiencies. The following of the processes laid out in TPM will ensure the OEE of equipment is increased by ensuring operators do the daily inspections, cleaning, lubrication and tightening. The involvement of the operators is the key, as they spent the most time with machines and they must to get to a point where they understand their machines. This will enable them to pick up or anticipate breakdowns on their machines. Maintenance personnel are freed up and able to do other critical tasks on the plants and plan for major shutdowns. The involvement of everyone in the workplace enables teamwork and removes silos that people might be working within.

### 5.2 CONCLUSION

The primary objective to determine the factors that lead to the successful implementation of TPM was met as the prescribed methods were compared to the current methods used by companies. The research established the pitfalls that many companies fall into when implementing TPM based on the perceptions of the respondents. Some of the prescribed activities like management involvement and the answering of operator questions on implementation will ensure there is buy in and commitment from all stakeholders. The importance of not rushing the process and expecting results to be achieved in the first year of implementation is considered as setting up for failure because it will take at least 3 years to start seeing the benefits. The secondary objective to determine the sustainability of such initiatives was also met. This is based on the responses obtained in the sustainability section of the questionnaire which was designed to determine how TPM activities are being managed in the workplace.

The implementation process of TPM could be a cumbersome process as it involves changing the mind sets of the people on any particular site. It is mentioned that the results of implementing such strategies will only start coming through a couple of years down the line and depending on the culture in organisations it may even take up to 10 years. The implementation process prescribed has been structured in such a way that it follows a structured change management process which ensures everyone is on board from the beginning.

In order to get buy in from the people involved, it is important for the organisation not to rush and start implementing programs before they get buy in from their workforce. For any strategy to work there has to be the right foundation laid and the culture has to be conducive to nurture and grow new strategies. It is important for companies to therefore spend time on getting employees concerns answered and even taking shop floor employees to places where these initiatives have been implemented so they can get first-hand information from fellow shop floor workers who have experienced the implementation of TPM. The notion that workers may not trust management may be put to rest by following this simple step. The commitment of management must be seen from the time the decision is made to follow TPM strategies and in the process they must ensure they involve the operators and everyone in the factory. As mentioned the word, “total”, must include all the employees in the organisation. Management are also included in this word and they must lead by example and be involved in the initial clean up and be there to guide the operators and people involved in the process.

There should be alignment of company objectives to implementing TPM and these objectives must be communicated to all people in the organisation to ensure they also align their activities to the objectives of the company. If there is no link between the two then the process must not be continued as this will create different impressions on people and may end up creating a disengaged workforce.

Any company would like implemented strategies to continue as long as they bear good results from them. TPM, as mentioned, is a way of ensuring the high

productivity through increased equipment efficiencies. If implemented properly it will bear good results but there must be means to ensure it is sustainable. This is achieved by making all TPM activities part of the day to day running of businesses. All applicable concepts within TPM must somehow be used as tools to ensure that they are entrenched in the people's minds. Transfer of skills must be made part of training matrices for operators and it must be followed on to ensure it is being carried out.

### **5.3 RECOMMENDATIONS**

TPM is a concept that many companies or countries have imported from Japan because of the successes that the Japanese have achieved. It is a concept that requires the total involvement of the whole organisational structure from top management through to the lowest position within the organisation. The reason for this is to ensure that there are enough resources to carry out all the activities that are required in both the implementation and the running phase of TPM.

The implementation of such strategies must be from the onset especially in newly formed organisations or commissioned projects. The scenario has been that many companies do not do the correct maintenance on equipment or cut costs when installing new plants, which then leads to the forced deterioration of equipment and work environments. If TPM is implemented from the inception of such projects, it will reduce the costs involved in the implementation phase, compared to if it is implemented sometime after the plants have been running. The pillar of early equipment management will then be utilised fully if it is implemented on inception of such projects.

In an environment where the plants have been running for some time, it is recommended that the training material used in such environments be amended to include TPM activities. The basic jobs of any operator must include cleaning, inspection, lubricating and tightening. The example given on this is that the owner of a car is the one that ensures the coolant is checked, oil is checked and petrol is

refilled on a regular basis. The operator must ensure their machines are operating optimally and they must know when they require maintenance. The amending of training manuals will however lead to intensive training of operators on the new tasks and this has to involve the maintenance departments to ensure there is correct transfer of skills taking place. Many organisations set time aside for TPM and this is where the question of extra work and extra pay come in from the operators. It is advised that TPM must be incorporated into the daily functions of all operators to ensure the reinforcement of the behaviours and activities. If there are KPI's in the organisation the TPM activities must form part of those KPI's. The bridging of the gap between maintenance and production is paramount in the running of TPM. There must be teams that include both functions, to ensure that there is transfer of skills between operators and maintenance.

Many organisations have a TPM office that is supposed to co-ordinate the implementation process but this creates an extra layer in the system. Implementation may become a time consuming process as there needs to be sync between all areas implementing pilot areas. Some companies still use the TPM office route but others get the responsibility to the plant managers or area managers to implement TPM. The reason for this is because areas will differ and what is required in one area may not necessarily be required in other areas.

It is also advisable to look at the education level of employees before implementing strategies like TPM, as this may become a hindering factor in the implementation process. Most companies use operators that have a lower level of education, thus cause a problem for people to understand the concepts involved and prove to be a time consuming process in trying to get operators to grasp new concepts. The level of education in countries like Japan is completely different from that which is found in many countries across the world and in South Africa.

The other concern is what role societal culture plays in organisations. The Eastern culture, especially Japan, is that of obedience and discipline; this may make it easy

for them to implement this strategy and perhaps the fact that it is grown in their country there is buy in from the employees.

It could be advisable, as a way to ensure the operators push for transfer of skills, to relook at the operator levels within the organisation. If operators acquire new maintenance skills and they apply these continuously, they must be recognised or perhaps regarded to a level higher with a slightly increased remuneration. This will address the issues of extra work not being paid for but it is up to organisations to do what works for them.

Companies must look at their environment and implement what works for them rather copying and pasting what other companies have done and even within organisations it will not be a copy and paste situation.

The Japanese use their own words to describe the activities of TPM. It is advisable for people to use local names that the operators and everyone can identify with. The use of the original names makes the whole TPM process foreign to the operators and those involved. It is recommended companies use their own words that are easier for the operators to understand and familiarise with. It may be a good idea to get the operators to come up with the words to describe these activities. This helps create ownership from the onset as the operators feel they have helped create the concept of TPM. Some companies have rebranded TPM to suit their own company culture because that is what works for them.

There are eight pillars in TPM and it does not mean all of them have to be implemented. It is recommended that companies look at what needs to be achieved and based on that decide on what pillars are going to be implemented. If companies choose to implement all eight pillars, it must be done in phases and priority is given to the major area of concerns, rather than trying to implement all eight pillars, which might spread resource thinly and result in a prolonged implementation process.

## REFERENCES

Ahuja, I. & Khamba, J. 2008. Strategies and Success Factors for Overcoming Challenges in Total Productive Maintenance Implementation in Indian Manufacturing Industry. *Journal of Quality in Maintenance Engineering* Volume 14, Number 2.

Ahuja, I., & Kumar, P. 2009. A case study of total productive maintenance implementation at precision tube mills. *Journal of quality maintenance engineering*. Volume 15, number 3.

Arca, J. & Prado, C. 2008. Personnel participation as a key factor for success in maintenance program implementation. *International Journal of productivity and performance Management*. Volume 57, Number 3

Baluch, N., Abdullah, C. & Mohtar, S. 2012. TPM and Lean Maintenance – A Critical Review. *Interdisciplinary Journal of Contemporary Research in Business* Volume 4, Number 2.

Bamber, C., Sharp, J. & Hides M. 1999. Factors affecting successful implementation of Total Productive Maintenance: AUK manufacturing case study. A UK case study perspective. Volume 5. Number, 3.

Chan, F., Lau, H., Ip, R., Chan, H. & Kong, S. 2005. Implementation of total productive maintenance: A case study. *International journal of production economics*.

Enaghani, M., Arashpour, M. & Karimi, M. 2009. The relationship between Lean and TPM. University of Boras. *Science for the professions*.

Eti, M., Ogaji, S.& Probert, S. 2004. Implementing total productive maintenance in Nigerian manufacturing industries. *Applied Energy*. Volume 79.

Gupta, A. & Garg, R. 2012. OEE improvement by Total Productive Maintenance implementation. *International Journal of IT, Engineering and Applied Sciences Research*. Volume 1. Number 1.

Haddad, T. & Jaaron, A. 2012. The Applicability of Total Productive Maintenance for Health Care Facilities: an Implementation Methodology. *International Journal of Business, Humanities and Technology*. Volume 2: Number 2.

Howell, V. 2012. *Total Productive Maintenance: A strategy for your Lean Journey*

JIPM Solutions. 2002. *TPM Encyclopaedia Key Word Book*. Tokyo

Kocher, G., Kumar, R., Singh, A. & Dhillon, S., 2012. An Approach for Total Productive Maintenance and Factors Affecting its Implementation in Manufacturing Environment. *International Journal on Engineering Technologies* 3(1): 41-47.

Kenedy, R. 2011. Examining The Process of RCM and TPM: What do they ultimately achieve and are the two approaches compatible: Article

Liker, J. 2004. *The Toyota Way: 14 Management Principles from the world's Greatest Manufacturer*. New York: McGraw-Hill.

McCarthy, D. & Rich, N. 2004. *Lean TPM: A Blue Print for Change*. Elsevier Butterworth-Heinemann. Burlington

Micietova, M. 2011. Lean Production, Lean vs Mass Production, TPM as a tool of Lean Production. Number 5, Volume VI

Nakajima, S. 1988. Introduction to TPM: Total productive maintenance. Portland. Productivity Press.

Ramesh, V., Prasad, K., Srinivas, T. 2008. Implementing Total Productive Maintenance with Reference to Lean Manufacturing in a Processing Industry in Myrose: A Practical Approach. The Icfai University Journal of Operations Management. Volume VII, No. 4.

Robinson, C & Ginder, A. 1995. Implementing TPM: The North American Experience. Portland. Productivity Press. Suzuki, T. 1994. TPM in Process Industries. New York: Productivity Press.

Seng, O., Jantan, M. & Ramayah, T. 2010. Implementing Total Productive Maintenance in Malaysian manufacturing organisation: An operational strategy study.

Wang, F. 2006. Evaluating the efficiency of implementing Total Productive Maintenance. Department of Industrial Management, National Taiwan University of Science and Technology. Total Quality Management. Volume 5.

Womack, J. & Jones, D. 2003. Lean thinking: Banish waste and create wealth in your corporation. Free Press. New York

**APPENDIX A**  
**RESEARCH QUESTIONNAIRE**

Research questionnaire used is attached below. As mentioned previously, the questionnaire was in three sections, management commitment, operator involvement and sustainability.

**SECTION 1: Management commitment**

1. Was kick off meeting or announcement held?

Strongly Agree	Agree	Disagree	Strongly Disagree

2. Were unions consulted by management before implementation?

Strongly Agree	Agree	Disagree	Strongly Disagree

3. Were employees consulted by management before implementation?

Strongly Agree	Agree	Disagree	Strongly Disagree

4. Does management inspect pilot areas regularly?

Strongly Agree	Agree	Disagree	Strongly Disagree

5. Is management involved in the process of rolling out TPM?

Strongly Agree	Agree	Disagree	Strongly Disagree

6. Was there a clear link between company objective and implementing TPM?

Strongly Agree	Agree	Disagree	Strongly Disagree

7. Was training on the benefits of TPM implementation given to all stakeholders?

Strongly Agree	Agree	Disagree	Strongly Disagree

8. Were pillar champions appointed?

Strongly Agree	Agree	Disagree	Strongly Disagree

9. Were pillar champions trained on their role in TPM implementation?

Strongly Agree	Agree	Disagree	Strongly Disagree

10. Was a TPM officer appointed for the site?

Strongly Agree	Agree	Disagree	Strongly Disagree

SECTION 2: Operator Involvement

1. Was operator training held in the implementation process?

Strongly Agree	Agree	Disagree	Strongly Disagree

2. Was the buy in by operators?

Strongly Agree	Agree	Disagree	Strongly Disagree

3. Are small group teams formed to solve problems?

Strongly Agree	Agree	Disagree	Strongly Disagree

4. Are plant operators a part of small groups?

Strongly Agree	Agree	Disagree	Strongly Disagree

5. Were team structures overlapping, with leaders in lower teams being part of a team higher than the team they belonged to?

Strongly Agree	Agree	Disagree	Strongly Disagree

6. Is downtime measured and analysed according to the 6 big losses?

Strongly Agree	Agree	Disagree	Strongly Disagree

7. Are tags raised by operators repaired?

Strongly Agree	Agree	Disagree	Strongly Disagree

8. Does management involve operators in decision making?

Strongly Agree	Agree	Disagree	Strongly Disagree

9. Are suggestions from operators implemented?

Strongly Agree	Agree	Disagree	Strongly Disagree

10. Are operator areas clearly defined?

Strongly Agree	Agree	Disagree	Strongly Disagree

11. Are roles and responsibilities clearly defined?

Strongly Agree	Agree	Disagree	Strongly Disagree

SECTION 3: Sustainability of the TPM

1. Do standards for cleaning, inspecting and lubricating exist?

Strongly Agree	Agree	Disagree	Strongly Disagree

2. Are operators trained on cleaning, inspection, lubricating & tightening standards?

Strongly Agree	Agree	Disagree	Strongly Disagree

3. Are TPM standards included in operator KPI's?

Strongly Agree	Agree	Disagree	Strongly Disagree

4. Do TPM concepts form part of the operator training manuals?

Strongly Agree	Agree	Disagree	Strongly Disagree

5. Is there time set aside for TPM sessions or training?

Strongly Agree	Agree	Disagree	Strongly Disagree

6. Does the gap between operations and maintenance still exist?

Strongly Agree	Agree	Disagree	Strongly Disagree

7. Are skills being transferred from maintenance personnel to operators?

Strongly Agree	Agree	Disagree	Strongly Disagree

8. Are operators rewarded for achieving set targets?

Strongly Agree	Agree	Disagree	Strongly Disagree

## APPENDIX B

### RESULTS OBTAINED FROM THE RESPONDENTS

The results obtained from the respondents are shown below. The aim was to measure the population perceptions of the way TPM was being implemented and compare the process followed to what is the prescribed process.

	Strongly Agree	Agree	Disagree	Strongly Disagree
<b>Section 1: Management commitment</b>				
1. Was kick off meeting or announcement held?	2%	0%	29%	69%
2. Were unions consulted by management before implementation?	0%	31%	41%	25%
3. Were employees consulted by management before implementation?	0%	0%	22%	78%
4. Management inspect pilot areas regularly?	24%	76%	0%	0%
5. Is management involved in the process of rolling out TPM?	49%	51%	0%	0%
6. Was there a clear link between company objective and implementing TPM?	0%	0%	69%	31%
7. Was training on the benefits of TPM implementation given to all stakeholders?	0%	29%	55%	16%
8. Were pillar champions appointed?	0%	12%	69%	20%
9. Were pillar champions trained on their role in TPM implementation?	0%	12%	20%	69%
10. Was a TPM officer appointed for the site?	0%	20%	24%	57%
<b>Section 2: Operator Involvement</b>				
1. Was operator training held in the implementation process?	0%	67%	24%	10%
2. Was the buy in by operators?	0%	10%	61%	29%
3. Are small group teams formed to solve problems?	10%	59%	12%	20%
4. Are plant operators a part of small groups?	10%	62%	10%	18%
5. Were team structures overlapping, with leaders in lower teams being part of a team higher than the team they belong to?	10%	75%	14%	2%
6. Is downtime measured and analysed according to the 6 big losses?	0%	10%	75%	16%
7. Are tags raised by operators repaired?	0%	69%	14%	18%
8. Does management involve operators in decision making?	10%	49%	24%	18%
9. Are suggestions from operators implemented?	18%	67%	10%	5%
10. Are operator areas clearly defined?	15%	72%	5%	8%
11. Are roles and responsibilities clearly defined?	10%	76%	8%	6%
<b>Section 3: Sustainability of the TPM</b>				
1. Do standards for cleaning, inspecting and lubricating exist?	6%	8%	80%	6%
2. Are operators trained on cleaning, inspection, lubricating & tightening standards?	6%	2%	6%	86%
3. Are TPM standards included in operator KPIs?	10%	4%	10%	76%
4. Do TPM concepts form part of the operator training manuals?	0%	0%	0%	100%
5. Is there time set aside for TPM sessions or training?	20%	71%	6%	4%
6. Does the gap between operations and maintenance still exist?	0%	16%	75%	10%
7. Are skills being transferred from maintenance personnel to operators?	0%	18%	73%	10%
8. Are operators rewarded for achieving set targets?	0%	88%	12%	0%