THE IMPACT OF THE ABSENCE OF A TOTAL PRODUCTIVE MAINTENANCE (TPM) PROGRAM AT A PLASTIC PAINTING PLANT.

By

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DECLARATION

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

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ABSTRACTS

This research was concerned with investigating “the absence of Total Productive Maintenance (TPM)” at a plastic painting plant. TPM is a combination of operations and maintenance activities and is performed by operators under their own authority and is called “autonomous maintenances”. The author has tested the degree of implementation of TPM by using a seven-step TPM implementation model this highlighted an absence of TPM in the organisation investigated.

TPM is a relatively new concept in the South African automotive industry and has not been fully accepted by management as a solution to the maintenance problems in the organisation. Due to a long implementation period and the difficulty in measuring the benefits of the TPM program for the organisation TPM tends not to be implemented by companies.

The research studies several maintenance philosophies each with its own advantages and disadvantages. The benefits that arise from the implementation of an effective TPM philosophy were explored. The development of an effective improved model for the implementation of TPM was investigated. Maintenance engineers and managers in any organisation can use this model to implement an effective TPM program.

The seven-step TPM implementation model formed the basis for the compilation of a questionnaire. A survey was conducted to determine if an absence of TPM existed in a plastic painting plant. The results from the survey were drawn up and recommendations to further develop a model for the implementation of TPM was put forward.

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LIST OF COMMONLY USED ACRONYMS.

Cp:	**Capability index if less than one then this is not good**
MTBF:	**Mean time between failures**
MTTR:	**Mean time to repair**
OEE:	**Overall equipment effectiveness**
PM:	**Preventative maintenance**
RMC:	**Reliable cantered maintenance**
TPM:	**Total productive maintenance**
TQM:	**Total Quality Management**

REFERENCE LIST

CHAPTER 1

PURPOSE AND SCOPE OF THE STUDY

1.1 INTRODUCTION

Since the beginning of the manufacturing era and the invention of machinery for the use in production facilities, the users of the machinery have been investigating ways to improve the reliability of machinery by improving maintenance techniques. The philosophy of the past was to operate on breakdown or reactive maintenance mentality “if it breaks down it is repaired”. This is an expensive method of maintaining equipment, as it will normally break at the most inconvenient times causing lose of production, poor quality and expensive repairs in some cases. A maintenance philosophy that operates on a breakdown mentality can be minimized or avoided by the implementation of a well-designed maintenance program

This has lead to the implementation of a different maintenance philosophy known as Total Productive Maintenance (TPM) that originated in the United States of America in the early 1950 Japanese engineers and managers came to America to study manufacturing plants and systems that had successfully supplied the American war effort, and they noticed that American companies were experimenting with preventive maintenance as an alternative to breakdown maintenance. By 1960’s Nippondenso, a Toyota parts supplier, had developed a maintenance initiative that involved all the people in the organization in maintenance activities. In 1971 Nippondenso was the first Japanese plant to receive the distinguished plant award from the Japanese institute of plant maintenance for successfully developing and implementing TPM (Rubrich and Watson, 2000: 210)

The statement by Rubrich and Watson (2000: 210) is reinforced by the following important fact. Suzuki (1992:x) stated that TPM as a maintenance philosophy has as much to do with attitude of employees as it does with maintenance skills. It also gives the production people a new sense of ownership and pride in the

equipment as they learn the importance of cleaning and inspecting the equipment. Also a partnership develops between the maintenance employees and equipment operators, so together they can detect early warnings of failure and take corrective action.

The above partnership results in TPM as a concept improving the quality of the employees and the culture of organizations. TPM can also be used in conjunction with Reliable Centered Maintenance (RCM) as both these concepts complement each other and are central to the improved reliability of machinery and equipment and the reduction of maintenance costs (Ben-Daya, 2000:82).

The use of a TPM philosophy results in the reduction and hopefully the eventual elimination of waste and associated cost. This should be a major goal of any manufacturing organisation. TPM will lead to the maximization of manufacturing productivity with a modest investment in machine and equipment maintenance. The concept is simple provided people at all levels support the concept (*Strategic direction*, 2003:17).

The maintenance function must work efficiently to increase profitability and completeness of organisations. The maintenance division must contribute to the success of the factory and aim to introduce a methodology for a soft and tenable application of the principals of TPM in Italian factories this also applies to South African factories. The first step of the study is an explanation of the actual situation, usually based on traditional or productive maintenance. (Farrari, Pareschi, Regattri & Persona, 2000: 350).

1.2 MAIN PROBLEM.

Taking into account the cost of downtime in the plastic hang on parts painting industry for example lost production due to downtime on robotic paint lines can cost an estimated four thousand five hundred Rand (R4, 500.00) per minute. Considering the above statement the following main problem has been developed.

The absence of a Total Productive Maintenance (TPM) program at a plastic painting plant.

This problem results in excessive machine breakdowns and loss of production due to the absence of TPM at Venture SA East London plant.

1.2.1 Sub-problems.

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

1. A lack of Total productive maintenance (TPM) knowledge and awareness.
2. Unsatisfactory plant availability without Total productive maintenance (TPM).
3. Low level of implementation of Total Productive maintenance (TPM).
4. Ref to Annexure C why-why problem analysis.

1.3 DEFINITION OF KEY CONCEPTS

Total productive maintenance (TPM): - A maintenance concept that implements continues improvement of production equipment reliability by the involvement of all the people in the organisation (Rubrich and Watson, 2000:209)

Benefits: - advantage or profit. Benefits are the advantages and improved availability of machinery after the implantation of total productive maintenance (Soenes, 2003:73)

Absence: - The non-existence or lack of (Soanes ,2003:3).

Program: - A planned series of events (Soanes,2003:713).

1.4 DELIMITATIONS OF RESEARCH.

The delimitations of research serves the purpose of making the research topic manageable from a research point of view.

The study will be restricted to four managers, seven supervisors, nine maintenance technicians, five quality inspectors, four production planners, four graduate trainees and 37 machine operators employed at Venture SA East London plant. The reasons for the absence of total productive maintenance (TPM) due to the low level of implementation of a TPM program over the past three years will be researched in order to establish the disadvantages of the absence of implementation of total productive maintenance (TPM) and also the disadvantages of low-level implementation at Venture SA.

The research will be confined to a specific plastic hang on parts painting company called Venture SA and conducted at the East London plant in South Africa.

1.5 ASSUMPTIONS

It is assumed that the managers, maintenance manager, engineer and maintenance technician who are the users of this information have the skills and knowledge to analyse the inputs to the model.

Most of the literature on TPM has been written by international authors (not South African). It was thus necessary to assume that the relevant research literature would also be applicable to South African organisations.

1.6 THE SIGNIFICANCE OF THE RESEARCH

The fixed assets in the plastic hang on parts painting industry is a large portion of the investment of a company, thus the effectiveness of a maintenance plan can extend the working life of the equipment and machinery. The benefits to management will be lower operating costs, as machinery will run more efficiently. The cost of unscheduled downtime in this industry leads to an estimated loss of four thousand five hundred Rand (R4,500.00) per minute and the reduction of this downtime has financial benefits for Venture SA.

The maintenance system in place at the Venture SA East London plant is a planned preventative maintenance system using time based schedules, the success of this method has now reached its full potential. A low level of TPM has been implemented using autonomous small groups, which include the operator. The implementation of a full-blown TPM system is now being implemented.

TPM in the workplace empowers employees and provides them with skills and confidence. It enables employees to use those skills for the benefit of the customers, the company and themselves.

The benefits of TPM include less reliance on key individuals, more motivated staff, more confident individuals who respond resourcefully to situations and staff who remain with a company, because they feel valued.

The objective of the research is to establish effective TPM implementation strategies that can be used by organisations for their benefit.

1.7 RESEARCH DESIGN (PROPOSED RESEARCH METHODOLOGY)

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

1.7.1 Research methodology

The following procedures will be adopted to solve the main and sub-problems:

1.7.2 Literature survey

The study is based on a literature review investigation that covers all aspects, principals and key success factors for the benefit, development and implementation of Total productive maintenance (TPM).

1.7.3 Development of a questionnaire

A questionnaire will be developed using the TPM framework as the basis for the analysis of the questionnaire to determine the extent of the absence TPM. The data will be gathered using open-ended questions using quantitative and qualitative methods of analysis. The sample will be consist of four managers, seven supervisors, nine maintenance technicians, five quality inspectors four production planners, four graduate trainees and 37 machine operators.

1.7.4 The research method to be adopted

A quantitative research method was followed in this study.

1.7.5 Literature study

The information gained from the literature study was used to determine various approaches to TPM and which TPM strategies are effective within organisations.

1.7.6 Empirical study

Sources of information were obtained from primary and secondary data.

- **Primary data**
  This will be in the form of:

  Postal questionnaire: This method was used to survey the staff within the Venture SA East London plant. This established the TPM methods being used within the organisation and the effectiveness. This method was preferred as it is reasonably inexpensive to use within a large sample size (Collis and Hussey, 2003 : 175).

- **Secondary data**

  This was in the form of:

  - books
  - articles in journals and magazines
  - newspapers
  - electronic databases
  - the internet

- **Measuring instrument**

  The researcher developed a comprehensive questionnaire to determine effective TPM implementation strategies that can be used by organisations.

- **Sample**

  The target population in this study is very large and therefore could not be covered in its entirety. Stratified sampling was used; the strata included senior managers, middle managers and general workers. Stratified sampling ensures that each identified strata of the population is taken into account and prevents the under or over represent action of curtain groups (Collis and Hussey, 2003 : 157).

1.7.7 Development of a model

The results of the literature survey and the empirical survey were integrated to develop a model to determine the most effective means of undertaking TPM implementation within organisations.

1.8 STRUCTURE OF DISSERTATION

The research has provisionally been planned to include the following chapters:

Charter 1: Purpose and scope of the study.

Chapter 2: Literature review.

Chapter 3: Overview of Total productive maintenance (TPM) at a plastic painting plant.

Chapter 4: Empirical findings.

Chapter 5: Summary, conclusions and recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

A great deal has been written about maintenance philosophies. Methods such as planned preventive maintenance (PPM), condition based maintenance (CBM) or predictive maintenance which is also referred to as reliable centred maintenance (RCM) and total productive maintenance (TPM) has been developed and applied in industry.

Maintenance management in some industries is at a low level of effectiveness. This is due to the fact that maintenance is viewed as a technical activity, rather than a management discipline.

This misconception is reinforced by several factors. The first is that the maintenance department is most visible when involved in emergency repairs to malfunctioning machines. Production management is so grateful when the machine is running again they neglect to ask why the breakdown was not anticipated before production was disrupted. Secondly maintenance managers are accustom to and proud of their image as fire fighters and enjoy the perceived glory that accompanies this title. Thirdly maintenance departments are accused of unpredictable response times and erratic priorities.

The journal *Strategic direction* (2003:17) stated that the behaviors mentioned in the previous paragraph that the maintenance department should be more visible when involved in emergency repairs and maintenance managers being proud of the image of being a fire fighter are costing industry. Total productive maintenance (TPM) has the potential to organize manufacturing productivity with a modest investment in equipment and machinery maintenance. The concept of autonomous maintenance sounds simple and is relatively easy to implement in an organisation with an ethic of learning, provided people at all levels support the concept.

To elaborate on information the research literature reveals in connection with the benefits of Total productive maintenance (TPM) in industry as a whole, that there are benefits to having a fully functioning TPM system and the absence or low level implementation of a TPM system will have a negative impact on the organisation.

Farrari et al (2000: 350) stated in their journal that the maintenance function must work efficiently. Also the maintenance division must contribute to the success of the factory and aim to introduce a methodology for a soft and tenable application of the principals of TPM in Italian factories and this also applies to South African factories. The first step for the implementation of a TPM strategy is an explanation of the actual situation, usually based on traditional or productive maintenance. After a brief introduction the focus is on TPM links with productive maintenance in order to suggest a method or TPM. It Concludes with a real application of TPM in a big factory, with a description of a world leader in plant manufacturing for the ceramic tile industry.

Van der Wal and Lynn (2002: 359-366) stated in their journal article that the implementation of Total productive maintenance (TPM) at a South African mill and attempts to establish the influence that this journey has had on productivity, employee development, quality improvement and organisational change within the manufacturing unit. A literature survey was undertaken by Van der Wal and Lynn into the methodologies, including a look at the so-called soft issues to evaluate the values of adopting a TPM strategy. Questionnaires were sent out to a sample of selected people at all levels of the organisation to find out their views on the methodology being used. Van der Wal and Lynn (2002: 359-366) Concluded that this journey has been successful in spite of difficulties specific to South Africa. The final objective of this research was to establish whether the implementation of this process has resulted in a change within the mill. Increased productivity, quality and reduction of cost of producing the product resulting in the mill winning a gold award from the national productivity institute.

This shows that there are definite benefits to the implementation of TPM in any industry and will not only be limited to one industry.

Ki-Young and Phillips (2001 1404-1416) stated in their journal that the accurate estimation of equipment utilisation is very important in capital-intensive industry since the identification and analysis of hidden time losses are initiated from these estimates. Thus the measurement of overall equipment effectiveness as discussed in Nakajima (1988:27) is an integral part of equipment utilisation and time losses.

Ireland and Dale (2001 183-192) in their journal. focused on a study of TPM in three companies. The companies implemented TPM because of the business difficulties they faced in all three companies. Senior management supported TPM and set up suitable organisational structures to facilitate its implementation. The companies had followed Nakajima's seven steps of autonomous maintenance, although different TPM pillars had been adopted, with common ones being improvements, education and training, safety and quality maintenance. The main difference in TPM implementation related to the use of ABC machine classification system and the role of facilitators.

The implementation of TPM has benefits when companies face difficulties, as it saves costs, improves quality and productivity, will lead to machinery reliability and improved uptime of equipment. Costs savings can be achieved by eliminating the six big losses caused by an inefficient maintenance system. Shirose (1992: 37) stated that there are six big losses, which are obstacles to efficient operation of equipment, they are.

1 Breakdown losses.
2 Setup and adjustment losses.
3 Idling and minor stoppage losses.
4 Reduced speed losses
5 Quality defects and rework.
6 Setup – yield losses (reduced yield between machines setup and stable production).

The above statement is reinforced by Nakajima, Takebe, Ichekawa, Yamazaki, Izumi and Shinozuku (1996:16) who stated that the six big losses lower equipment efficiency, caused productivity slumps and equipment problems drain which productivity.

The implementation of a TPM philosophy is not easy. Fang (2000 1003-1016) stated in his journal article that the implementation of Total productive maintenance (TPM) is by no means an easy task, which is heavily burdened by political, financial, departmental and inter occupational barriers.

The barriers to TPM are important when considering the implementation of TPM as these barriers can lead to the failure of implementation. This will also undermine any benefits of TPM that will be achieved by the implementation.

2.2 THE CONCEPT OF TOTAL PRODUCTIVE MAINTENANCE (TPM)

TPM is a maintenance philosophy developed in Japan to optimise machinery and equipment reliability and availability to production and promote operator involvement in the maintenance of the machinery they operate. TPM was developed and introduced in Japan in 1971 by Seiichi Nakajima.

TPM combines preventative maintenance with the total involvement of the whole work force by using small group activities. This empowers the operator to undertake maintenance activities such as lubrication of their own equipment and frees the maintenance personal to concentrate on preventative maintenance activities. The awareness of potential breakdowns is improved and allows the maintenance department to focus on difficult breakdown problems.

Suzuki (1992:17) stated that TPM is a team approach that improves people. Years before maintenance management existed, workers looked after their own equipment. This custom almost completely disappeared when maintenance management was introduced in Japan and speciality maintenance groups were formed. This resulted in a culture of “I run it you fix it” being established. TPM tries to correct this culture.

Pieterse (2005:29) states that Nakajima developed the principal of TPM in Japan along the same lines as Total quality management (TQM). TPM involves everybody in the organisation so it is not the sole responsibility of the maintenance department to carry out all maintenance tasks as operators of machinery also undertake some of the maintenance tasks. This raises the awareness of potential breakdowns and frees the maintenance department to focus on the intractable breakdown problems.

A proactive team approach is encouraged by TPM and all team members are responsible for the repair of machinery and equipment. This improves overall equipment efficiency allowing the maintenance team to focus on finding root causes of maintenance problems.

Pieterse (2005:30) states that TPM is proactive. It focuses on all aspects of shop floor arrangement condition, by following a team approach. The whole team is responsible for repair of the equipment. It aims to improve overall equipment efficiency by improving its uptime. This leads to products of better quality and productivity. The production team who continually operate the equipment are trained to diagnose technical problems and if possible repair them. If the scope of the repair is too large the maintenance team is called. This reduces the time to find the fault resulting in less equipment downtime.

For the production team TPM has the advantage of cleaner work areas and has the ability to solve some equipment problems, thus the production team have more control over their work area and can work more effectively with the machinery. This allows the maintenance team to focus on finding root causes of breakdown and not waste time on unskilled jobs.

There are four development stages to total productive maintenance (TPM). Nakajima (1988:8) lists the following four development stages of TPM showing the growth of preventative maintenance (PM) in Japan:

Stage 1 Breakdown maintenance.

Stage 2 Preventative maintenance.

Stage 3 Productive maintenance.

Stage 4 Total productive maintenance.

Total productive maintenance is defined by Nakajima (1988:10) by using the following five elements.

1 TPM aims to maximise equipment effectiveness.
2 TPM establishes a thorough system of preventative maintenance (PM) for the equipments entire life span.
3 TPM is implemented by various departments (engineering, operations, maintenance).
4 TPM involves every employee, from top management to workers on the floor.
5 TPM is based on the promotion of PM through motivational management autonomous small group activities.

Total productive maintenance is defined by Nakajima Takebe Ichekawa Yamazaki Izumi Shinozuku (1996:11) using the following five elements:

1 Setting the goal of maximising equipment effectiveness.
2 Establish a total PM system focusing on the entire equipment life cycle.
3 Coordinate all departments, including those that design, maintain and use the equipment.
4 Involving everyone, from top executive to shop floor employees.
5 Managing through team based activities aimed at plant wide goals of zero losses.

Nakajima (1988:11) stated the word “total” in “total productive maintenance” has three meanings. These are listed below:

1 **Total effectiveness** is the pursuit of economic efficiency or profitability.
2 **Total maintenance system** includes maintenance prevention and maintainability improvement as well as predictive maintenance.
3 **Total participation of all employees** includes autonomous maintenance by operators through small group activities.

Nakajima (1988:36) states that preventative maintenance alone cannot eliminate breakdowns. According to the principal of reliability engineering, the cause of equipment failure changes with the passing of time.

Nakajima (1988:40) states that to eliminate failure or hidden defects they must be identified and treated before machine breakdown. These are counter measures that assist to eliminate failures:

- Maintain well regulated basic conditions (cleaning, lubricating and bolting)
- Adhere to proper operating procedures.
- Restore deterioration.
- Improve design weaknesses.
- Improve operation and maintenance skills.

Breakdowns often occur because people fail to implement simple measures. The main reasons for the success of TPM are its pursuit of zero breakdowns and zero defects.

Nakajima et al (1996:50) concurred with the statement above that to come to grips with zero breakdowns these are the activities that assist in eliminating failures.

- Provide daily basic cleaning checks (cleaning, lubricating and bolting).
- Stick to rules (use and operate the machine correctly).
- Restore deterioration (eliminate or control factors that cause deterioration).
- Sharpen operations and maintenance skills.

Nakajima (1988:49) recommends that in order to successfully implement TPM the following five steps are required:

1. Eliminate the six big losses to improve equipment effectiveness.
2. An autonomous maintenance program.
3. A scheduled maintenance program for the maintenance department.
4. Education and training in operations and maintenance techniques.
5. Set up initial maintenance program.

Nakajima et al (1996:50) concurred that in order to implement TPM the following eight similar steps are required:

1. Focused improvement (Kaizen) to make equipment more efficient.
2. Autonomous maintenance activities.
3. Planned maintenance for the maintenance department.
4. Technical training in equipment maintenance for operation.
5. An early equipment management program.
6. Quality maintenance activities.
7. A system to increase the efficiency of administration and support options (a TPM office).
8. A system for management of safety and environmental issues.

2.3 THE DIFFERENT MAINTENANCE AND ENGINEERING ANALYSIS TECHNIQUES

The introduction of TPM techniques and engineering analysis, has led to the role of the maintenance department changing from a reactive to a proactive department. Thus this section discusses the maintenance techniques and engineering analysis that can be introduced to improve the utilisation of maintenance resources.

2.3.1 Breakdown maintenance.

Breakdown maintenance is a philosophy of reacting to equipment faults only once they fail or breakdown, thus the fault will be an unscheduled unplanned failure. This is an irresponsible approach to maintenance as equipment will breakdown at the most inconvenient time and place the business at risk or lead to non delivery of goods to clients.

The run to failure strategy of maintenance can be economically viable when an unplanned failure will not result in production delays

Coetzee (1995:7) gives the following definition for breakdown maintenance: “all the work done during an unforeseen functional failure to return the plant to an acceptable functional level with little or no prior planning.” Takahashi and Osada (1990:177) gives the following definition for breakdown maintenance: “is maintenance where a repair carried out after failure occurs.”

2.3.2 Planned preventative maintenance

Planned preventative maintenance (PPM) is based on standard inspection, servicing, exchange and statutory tasks that are scheduled at fixed time intervals, or other defined parameters that relate to ageing of equipment or machinery.

Chambers (1975:16) gives the following definition for scheduled preventative maintenance: “the planned and regular scheduled inspection and repair of equipment and facilities to minimise breakdown and depreciation.” Takahashi & Osada (1990:177) gives the following definition for scheduled preventative maintenance: “After determining an optimum period of maintenance cycles, repairs or replacements are undertaken”. Nakajima et al (1996:5) gives the following definition for PPM daily maintenance and cleaning, periodic inspection or equipment diagnoses to measure deterioration, restoring to correct and recover from deterioration.

2.3.3 Preventative maintenance or condition based maintenance

Preventative maintenance is planned work to prevent the failure of and relates to the physical condition of the equipment. This maintenance work will be performed only if determined to be necessary by some condition monitoring technique such as inspection, condition monitoring technique and performance measuring.

Takahashi and Osada (1990:177) give the following definition for preventative maintenance: “an inspection to investigate deteriorating condition, and repairs based on such inspections.”

2.3.4 Reliable cantered maintenance

Reliable cantered maintenance (RCM) is a maintenance technique that developed in the aircraft industry to ensure cost effective maintenance, coupled with increased reliability and safety of equipment.

Thus RCM analysis is to design a preventative maintenance program that will ensure economical operation and contain only the tasks having a positive effect on equipment safety and reliability.

The decision logic of RCM is divided into the following four areas safety, operations, environmental and hidden failure detection.

1. **Safety:** could the failure cause injury, death or any other damages.
2. **Operation:** would the failure have any adverse effect on operational capability (output, quality or cost).
3. **Environmental:** would the failure breach environmental standard or regulations.
4. **Hidden failure detection:** will the operator under normal conditions detect the failure.

Each critical item is evaluated to determine the applicable preventative maintenance task and if that task is warranted, this analysis forms part of the preventative maintenance program.

2.3.5 Total Productive Maintenance

2.3.5.1 What is Total Productive Maintenance

Total productive maintenance can be considered as the medical science of machines. TPM is a maintenance program, which involves a new defined

concept for maintaining plants and equipment. The goal of the TPM program is to increase production while, at the same time, increasing employee morale and job satisfaction. TPM brings maintenance into focus as a necessary and vitally important part of the business. It is no longer regarded as a non-profit activity. Down time for maintenance is scheduled as a part of the manufacturing day and, in some cases, as an integral part of the manufacturing process. The goal is to keep emergency and unscheduled maintenance to a minimum. (Venkatesh, 2006).

TPM combines preventative maintenance with the total involvement of the whole work force by using small group activities. This empowers the operator to undertake maintenance activities such as lubrication of their own equipment and frees the maintenance personal to concentrate on preventative maintenance activities. (Venkatesh, 2006).

Nakajima (1988:10) lists the definition of TPM using the following five elements:

1. TPM aims to maximise equipment effectiveness.
2. TPM establishes a thorough system of preventative maintenance (PM) for the equipments entire life span.
3. TPM is implemented by various departments (engineering, operations, maintenance).
4. TPM involves every employee, from top management to workers on the floor.
5. TPM is based on the promotion of PM through motivational management autonomous small group activities.

2.3.5.2 Why the introduction of Total productive maintenance

Shirose (1992:16) states that the introduction of TPM brings the whole company behind actually achieving a goal such as zero breakdowns and zero defects and these goals pay off as higher productivity and enhanced profitability.

As stated by Shirose (1992:23) total productive maintenance (TPM) has the characteristic of aggressively pursuing an absolute goal such as zero

breakdowns. In order to have “zero” anything it must be prevented from happening even once.

The three reasons that caused the implementation of TPM to spread so swiftly through out the Japanenes industry were stated by Suzuki (1992:7) as:

1. Giving outstanding results.
2. Transforming the whole company
3. Giving something to strive towards.

2.3.5.3 Important tangible benefits of Total productive maintenance (TPM)

Shirose (1992:12) cites the following tangible benefits of Total productive maintenance:

- The skills and knowledge of the entire workforce, starting with operators, are enhanced. This improves the problem solving abilities and accelerates the pace of improvement within the company.
- Marshalling all employees’ strengths inspires confidence that result in even the highest targets being surpassed.
- Communication within the workplace is stimulated; workplace and human relations become more open.
- Employees become more alert, observant and aware of problems.
- Trust in the company increases as a result of factory visits by outside groups and observers and this helps to increase sales.
- Labour management relations is improved and smoother communication with suppliers is achieved.

2.4 THE MAINTENANCE PRODUCTION LINK

TPM is a concept that improves the quality of the employees through a team approach to maintenance and this in turn improves the culture of an organisation. TPM can also be used in conjunction with RCM as both these concepts complement each other and are central to the improved reliability of

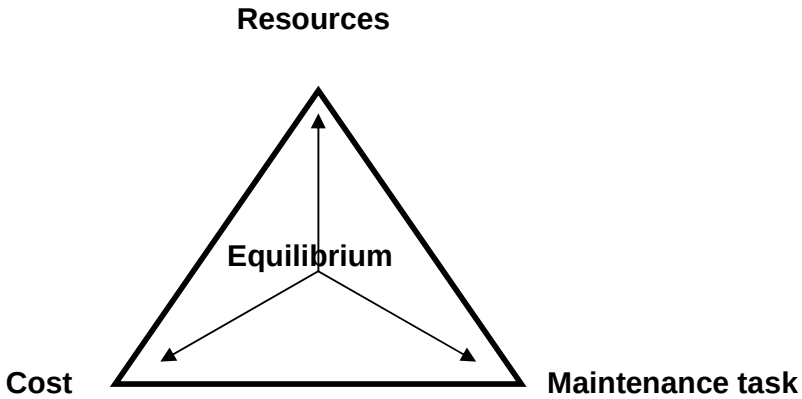
machinery and equipment and the reduction of maintenance costs. Ben-Daya (2000:82) Management should continuously seek ways to improve cost effectiveness and contribute to the profitability of the company. The efficient functioning of equipment and machinery is often overlooked and results in loss of production or slowed production and lost revenue. This is unacceptable in a world-class organisation that is well managed. The maintenance management systems have a vital role to play in the reduction or elimination of these losses.

The role of the maintenance engineer is the management and organization of resources to control the availability and performance of equipment and machinery at some specified level of operation. The challenges to the maintenance engineer are:

- Management of supporting resources to accomplish defined tasks at the required level and determining the extent of the maintenance tasks.
- Maintenance engineering is a management challenge and not solely technical in nature.
- The control of maintenance costs and ever increasing pressure to reduce these costs.
-

The three bullet points above must be in equilibrium to achieve optimal output of the maintenance department.

Figure 2.1 The three-dimensional goal



Source: Adapted from Steyn, Basson, Carruthers, Du Plessis, Kuschke, Kruger, Van Eck, Visser, (2005:8)

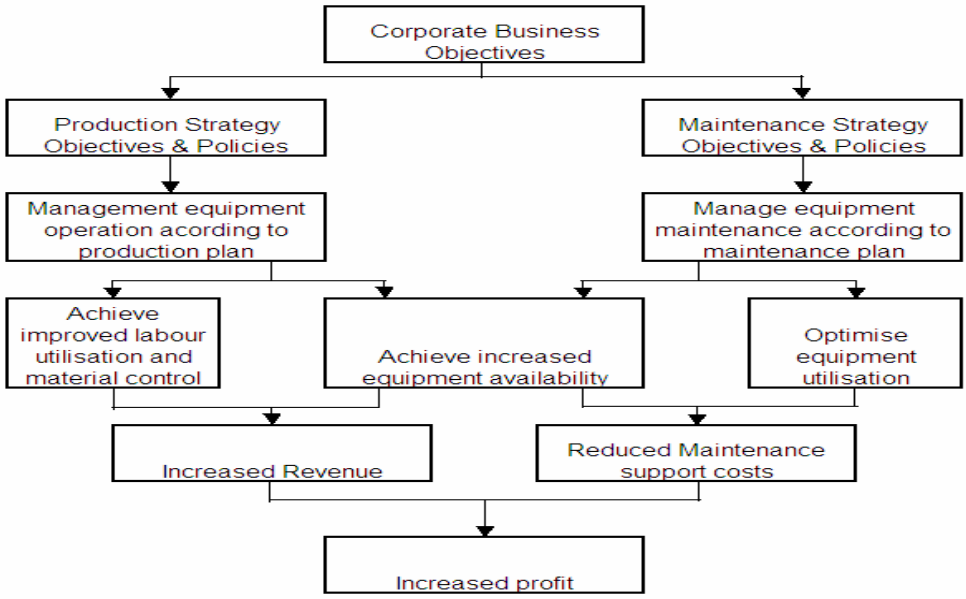
- **Cost:** The maintenance costs must stay within budget as this affects the bottom line of the company.
- **Resources:** The maintenance tasks must be carried out with minimum resources to achieve the desired targets set by management.
- **Maintenance Tasks:** the planned tasks should be completed on time and within budget.

The existence of all three these dimensions implies that the maintenance manager must make decisions regarding trade-offs among the three dimensions.

The maintenance manager has to choose one of the following trade-offs:

- The task could meet requirements of budget but exceed the resource requirements.
- The tasks could remain within budget and resource requirements but fail as the task doesn't meet specifications set.
- The task could be done to specification but would exceed the budget allocated.

Figure 2.2: The management challenge



Source: Lindhorst (2000:27)

2.4.1 Maintenance department challenges

The maintenance department's contribution to increasing the company's profit is achieved by minimizing the operating production equipment costs and improve the availability of the equipment and machines for productive use.

To improve the availability of equipment and machinery requires engineers and production managers to understand the reliability characteristics such as the mean time between failures (MTBF) and improve the maintenance mean time to repair (MTTR) Venkatesh (2006). TPM uses a measure of effectiveness called overall equipment effectiveness (OEE) that is the product of three efficiencies (Labib,1996:792). Nakajima et al (1996:30) describes these efficiencies as follows.

1. **Availability** is a percentage derived from breakdown, setup and adjustments and other (tool changes).
2. **Performance rate** is a percentage derived from minor stoppages, idling and reduced speed.
3. **Quality Rate** is a percentage derived from defects and reworks and start-up and yield losses.

OEE provides the means to evaluate the production process by measuring the effective utilization of the capital assets. The goal of OEE is to eliminate the six big losses. The relationship between the six process losses and OEE are shown in table 2.1.

The calculation formula for OEE=Availability x Efficiency x Quality

Table 2.1: Six process losses and Overall Equipment Effectiveness (OEE).

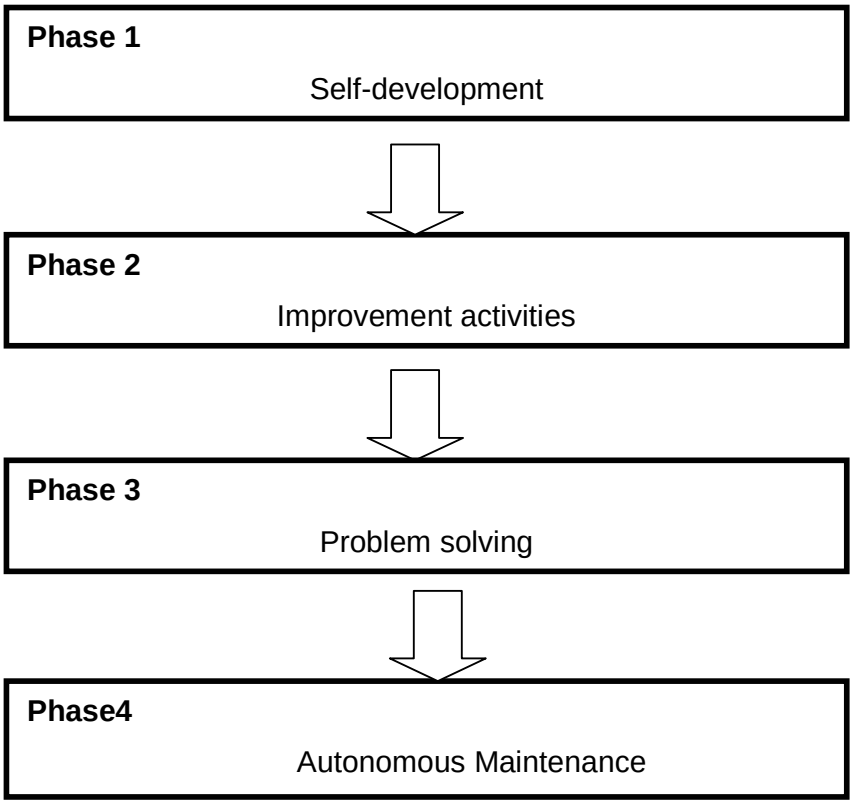
Six process losses	Type of loss	OEE calculation
Breakdowns	Equipment Availability	Availability
Setup and Adjustment		X (multiplied by)
Idling and minor stops	Performance Efficiency	Efficiency
Reduced speed		X (multiplied by)
Process defects	Quality rate	Quality
Setup loss		= OEE

Source: Hamacher (1996:142)

Labib (1996:793) gives the following shortcomings of TPM, Managers tend to focus on early results rather than activities aimed at reducing losses in the long run. Continuous improvement means data analysis. Often data are collected and not analysed. The TPM philosophy is sound. Its implementation lacks focus and a systems approach that is compatible with different environments. TPM succeeds not because of its systems or engineering techniques but because of its attention to the management of the human factor. There is no one prescription for achieving best maintenance practices. Reliability can be improved by better workmanship, correct and applicable maintenance tasks by improving equipment design.

Any TPM program goes through four phases the four phases of TPM are shown in figure 2.3. Labib (1996:793).

Figure 2.3: The four phases that any TPM program goes through.



Source: Labib (1996:793).

2.4.2 The conditions that promote breakdowns and defects?

Without a TPM philosophy properly implemented in a typical workshop environment, the following conditions promote breakdowns and defects, as stated by Shirose (1992:6).

The condition of equipment:

- The equipment is generally very dirty.
- Cutting debris is scattered on and around the equipment.
- The equipment leaks hydraulic fluid and lubricants.
- Cutting oil is scattered around.
- Oil pans are overflowing.
- Employees don't mind seeing dirt and grime piling everywhere. It normal becomes a norm.
- Grime from cutters and grinders are caked onto the equipment.

- Motors are coated with layer of oil mist.
- Motors are allowed to get very hot and make strange noises.
- Limit switches on machinery are covered with oil.
- Large covers are used to protect machines, but their internal parts are not cleaned.
- A broken V-belt is not replaced on the machine that uses multiple belts; the machine is allowed to operate with a belt missing.
- Some parts rattle and vibrate.
- The equipment is positioned to make access for routine checks difficult.
- Oil cans are left empty and dirty.
- Drains are clogged
- Wires and pipes are left in chaotic configuration, marking is hard to see.

(Shirose, 1992:6 ; Nakajima et al, 1996:49-53).

The condition of the area around equipment:

- It takes a lot of time to recover cutting debris.
- The cutting debris is scattered around so it takes a long time to sweep up.
- There is no stand for the oil cans and oil equipment.
- The floors are left dirty, slippery with oil.
- The jigs are not kept tidy and organized.
- There are a lot of useless items lying around.
- Things are not kept in a specific place.

(Shirose, 1992:6 ; Nakajima et al, 1996:51).

Equipment operators:

- Operators occasionally make errors.
- Operators do not perform regular checks, they don't even know how.
- When equipment must be oiled, only some operators know when and were to oil and how much to use. Even those operators who know the oiling schedule and procedures do not always perform it correctly.
- Operators do not know how to replace equipment parts or perform precision checks.

- When operators find equipment abnormality, they call a maintenance worker without trying to figure out what is wrong themselves.
- Operators do not regard breakdowns and defects as their problems.
- Operators use measuring instruments that have exceeded their used period.

(Shirose, 1992:6 ; Nakajima et al, 1996:55).

General conditions:

- Equipment breakdowns occur frequently, at a rate of three (3) per cent or higher.
- It takes a long time to fix minor problems and often the repair is temporary.
- Repairs generally take a long time.
- Problems following changeover occur more often depending on changeover.
- Changeover and adjustment take a long time and people accept adjustments as natural.
- Idling and minor stoppages happen often, extra workers handle them but they still prevent automated processes from operating for long periods of time without human assistance.
- The process capability index (Cp) fluctuates, but its value is less than 1 (not good).
- Rework occurs at a rate of three per cent and has become chronic.
- It is very hard to understand the causes of problems that make rework necessary.
- The processing speed has been decreased because too many defects occurred when it was maintained at the rated speed.
- Model specific standard cycle times have not been established.
- Workers know what the models specific standard cycle times are but do not keep to them.
- No one has qualitatively analysed speed loss.

(Shirose 1992:6 ; Nakajima et al, 1996:56)

Fick (1992:33) stated that maintenance characteristics can be improved by the execution of planned maintenance tasks, which also reduces the administration

tasks and delays in the provision of maintenance support such as materials, spares and other resources.

Maintenance costs can be improved by increasing labour productivity, reducing inventory of material and spares. The productivity of maintenance labour will be improved through implementation of a well-designed maintenance system, with proper controls of maintenance employees and task executed. The consideration of the maintenance tasks and the support requirements, with accurate forecasting and planning will result in minimal delays, usage of material and spares.

The close monitoring of maintenance costs, equipment availability and the analysis of these results, allows timely actions to be taken to improve design of equipment, quality of maintenance, labour utilisation and allocation of resources.

2.5 THE BENEFITS OF TOTAL PRODUCTIVE MAINTENANCE

The implementation of TPM in an organisation will have significant benefits. These are summarised briefly.

The value of a TPM program cannot be realised if the following three points dose not occur. Leblanc (1995: 49):

1 Cost savings from TPM can be predicted or measured.
2 Cross-functional teams are integrated to enhance the value of TPM.
3 Root causes of equipment problems are effectively identified

2.5.1 Enhancing production personnel

The factory floor employees are recognised as key business assets and they must not be wasted. The concept of Total productive maintenance (TPM) is based on the involvement, motivation and enhancement of shop floor employees. This allows them to have some control over their working environment. The employees are trained and developed to their full potential

and rewarded for their contribution to making the business more competitive and profitable.

TPM provides considerable benefits to factory floor employees, in terms of improved working environment, enhancing their skills and their personal attributes.

According to Davis (1995:55), the main benefits of TPM for operators are:

- Clean tidy and safe workplace. This is one of the most tangible benefits of TPM as it improves the workplace and general working conditions.
- Problems and faults are repaired. Through the TPM team, problems that hinder employee's work are rectified.
- Employees have more control over their own work environment, by participation and implementation of improvements in their areas.
- Opportunities for employees and machine operators to increase their skills and knowledge by working closely with the maintenance technicians and engineers. TPM programs also incorporate increased training and development opportunities for shop floor employees.
- The work environment is more controlled due to faults and operator problems being repaired properly.
- Dangers and difficult tasks are investigated and eliminated, increasing machinery effectiveness.

2.5.2 The benefits to maintenance personnel

(Davis,1995:56; Nakajima et al, 1996:14)points out the following benefits for the maintenance team:

- Machinery and equipment that is kept clean and in good condition are better and safer to work on.
- TPM reduces the number of breakdowns.

- Skilled maintenance technicians and engineers are relieved of many unskilled tasks that were traditionally carried out by them.
- Maintenance personnel can spend more time on what they are best equipped to do as the unskilled tasks have been removed. Their time can be used in preventing and predicting breakdowns and machinery deterioration.
- Maintenance personnel have more time to properly analyse the cause of breakdowns and reduced performance and come up with engineering solutions.
- Maintenance personnel will have more time to increase their skills and knowledge. The role of maintenance personnel changes as they learn more about other engineering and maintenance tools and techniques that apply to them.

Maintenance personnel also gain from working closely with production and become involved in the advising and training of production personnel.

Nakajima et al (1996:14) points out the following benefits to implementing a TPM program:

- TPM builds healthier companies by strengthening people as well as equipment.
- The skills of every employee need to be strengthened.
- Stronger employees build a stronger more resilient company

2.5.3 The quality dividend

Takahashi and Osada, (1990:126) state that maintenance is traditionally associated with machinery reliability this is measured by the availability of equipment and machinery. They also believe that the connection between machinery condition and product quality has not really been recognised. TPM emphasises improving all aspects of machinery operation and eliminating all losses. Thus linking machinery condition to product quality. Where TPM has been implemented in manufacturing businesses it has led to improvements in product quality reducing the number of defects and quantity of reworks.

TPM identifies quality problems such as defects, reworks, start up losses, yield losses and ensures that they are addressed. The pursuit of total quality is inherent in the TPM approach.

2.5.4 Business improvements

Davis (1995:57) states that TPM provided benefits to the whole business in the form of:

- Improving effectiveness of machinery and equipment with a direct affect on business ratios and competitiveness.
- Improving the quality of products, less scrap and rework, which reduces manufacturing costs and increases customer satisfaction.
- Enhances factory floor employees, by improving motivation and moral due to an improved working environment and training for factory floor employees.
- More controlled and organised manufacturing operations with less “fire fighting” allowing more time for continuous improvement and development.
- Better working conditions for all personnel.

The benefits in this chapter can be achieved by the implementation of the Total productive maintenance (TPM) approach. These benefits are achieved through the commitment from all employees and the effective application of the maintenance tools and techniques.

2.6 THE REQUIRED PLANT WIDE ROLE CHANGE FOR TPM IMPLEMENTATION

Top management must support and encourage the organisational changes discussed in Table 2.2. The table also compares the change in roles before and after TPM implementation, of the operator, journeyman maintenance, industrial engineer and management. A key to effective preventative maintenance component within TPM is the operator. Up to 75 per cent of breakdowns can be detected and prevented by a well-trained operator (Rubrich and Watson 2000:217).

Table 2.2: The required plant wide role change for TPM implementation.

Traditional role	Traditional Responsibilities	TPM Role	TPM Responsibilities
Operator	• Told what to do. • Ideas or opinions are never asked. • Feels no connection to job, customer or company.	**Owner Operator**	• Empowered to run their part of the business. • Visits and talks to customers. • Trained to conduct daily routine preventative maintenance tasks. Undertakes minor repairs. • Leads and contributes to problem solving.
Journeyman maintenance	• Fixes equipment as it breaks down, never given time to do the repair right. • Is physically and emotional separated from production and customers. • Has developed a fire fighting mentality.	**Maintenance Technician**	• Trains all operators in daily routine preventative maintenance tasks. • Thinks preventative maintenance. • Conducts scheduled downtime prevention maintenances inspections and tasks. • Helps to diagnose, develop and implement predictive maintenance strategies.
Industrial manufacturing Engineer	• Responsible for equipment design and supplier selection. • Works through floor supervision when equipment problems exist.	**Industrial manufacturing Engineer**	• Educates equipment suppliers on requirements for documentation and maintainability. • Works on the floor with owner- operator and supervisors to solve problems. • Trains technicians. • Corrects and improves current equipment.
Management	• Limited trust of employees. • Not close to production process (except supervision). • Limited communication with operators. • Comfortable with breakdown maintenance.	**Management**	• Spends up to 20 per cent of their time on the floor as a TPM cheerleader and roadblock buster. • Encourages planned shutdowns for improvements. • Open, rapid communication via daily walk through and at least monthly plant wide meetings.

Source: Rubrich and Watson, (2000:218)

2.7 SUMMARY

In this chapter the different maintenance philosophies and their benefits have been discussed as well as and their advantages and disadvantages were highlighted. The concept of Total productive maintenance (TPM) techniques was described. The different maintenance and engineering analysis techniques such as breakdown maintenance, planned preventative maintenance, preventative maintenance or condition based maintenance, reliable cantered maintenance and total productive maintenance were discussed and a brief description of each technique is given. What TPM is, why the introduction of TPM and the benefits of TPM are discussed in detail in the text above? The highlights and challenges that management faces and the benefits of TPM, such as the improvement of morale, enthusiasm and participation of all employees within the whole company.

The author believes that good morale in the company, will lead to success of the company and result in the overcoming of most difficulties that may arise from changing external environments.

The implementation of TPM philosophy takes time, effort, human resources and financial costs but the benefits that are achieved from implementation of TPM far outweigh the difficulties.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION.

Research design is planning. It is the visualization of the data and the problems associated with the employment of those data in the entire research project. Research design is common sense and the clear thinking necessary of the management of the entire research endeavour – "the complete strategy of attack on the central research problem" (Leedy, 1997: 93). Specific research design methods also imply different skills, assumptions and research practises (Myers, 1975:5)

Vogt (1993:196) as quoted by Collis and Hussey (2003:113) define research design as a "science and art of planning procedures for conducting studies as to get a more valid finding". Research design provides a detailed plan used to guide and focus research.

Leedy and Omrod, (2001: 143) state that some authors follow a more philosophical approach to research design, while others follow a pragmatic approach. The importance of including both schools of thought in a study of social science research is increasingly emphasised by contemporary social scientists.

The object of this chapter is to establish an appropriate research strategy for the research problem. The research strategy must be applicable to the nature of the problem. It is assumed that the nature of the research problem, the objective of the research and the methodology of the research focuses the research towards qualitative research.

3.2 WHAT IS RESEARCH DESIGN?

3.2.1 Definition of research

Various definitions can be given for the concept research. Some of the descriptions give a broad and generic view of research while others refer specifically to social science research.

Vogt (1993:196) as quoted by Collis and Hussey (2003:113) define research design as a “science and art of planning procedures for conducting studies as to get a more valid finding”. Research design provides a detailed plan used to guide and focus research.

Leedy and Omrod (2001: 4) define research as studious inquiry or examination, having for its aim the discovery of new facts and their correct interpretation.

The term research design is made up of two distinct elements, namely research and design. A brief definition of each will be discussed.

3.2.2 Definition of design

It is easier to define or describe the concept of design than the concept research. Soanes (2003: 236) states “design is a plan produced to show the working of something before it is made”. Leedy and Ormond, (2001: 91) state, “research design includes the planning, visualisation of data and the problems associated with the employment of the data in the entire research project”.

From the above definitions, research design can be interpreted as the preparation of an action plan aimed at organising and integrating data, in overall framework in order to solve the research problem. The basic to design are four fundamental questions.

- What is the data needed?
- Where is the data located?
- How will the data be secured?

- How will the data be interpreted?

3.2.3 Validity and reliability

The research must satisfy certain tests of validity and reliability. Leedy (1997: 32) states that validity and reliability are two words that you will encounter repeatedly in research methodology. They are used primarily in connection with measurement instruments. The integrity of your research may well stand or fall on the basis of how well you understand their meaning and how carefully you obey their demands. They govern the acquisition of data and the skilfulness with which you design the research structure and create the instruments of measurements as an integral part of it.

Leedy (1997: 32) states "validity is concerned with the soundness, the effectiveness, of the measuring instrument. In a standard test, for instance, validity would raise such questions as:

- What does the test measure?
- Does it, in fact, measure what it is supposed to measure?
- How well, how comprehensively, how accurately does it measure it"?

There are several types of validity. According to Leedy and Ormond, (2001: 103) they are:

- Face validity – is concerned with the subjective judgement of the researcher.
- Content validity – is the accuracy with which an instrument measures the representative sample, factors or situations under study.
- Criterion–related validity – employs two measures of validity, the second assessment instrument as a criterion check against the accurate correlation of first related measure.
- Construct validity – is any concept such as honesty that cannot be directly observed or isolated.
- Internal validity – is the freedom from bias in forming accurate conclusions about cause –and effect and other relationships within the data.

- External validity – is concerned with the generality of the conclusions reached from a sample to other cases.

Credibility is an important aspect to consider in this research project, as the objective was to identify absents of Total productive maintenance (TPM) philosophy at Venture SA. To confirm the findings in the quantitative study, the questions in the qualitative study were directly related as a validity process.

The Oxford Dictionary (1998: 1301) defines "reliability as able to be trusted; predictable or dependable". According to Leedy and Ormond (2001: 31), it is the extent to which, on repeated measures, the indicators yield similar results. Reliability in qualitative projects can be assured by using, amongst others, multiple researchers as well as peer examination and mechanical recording devices.

3.2.4 The critical approach

The critical approach is based on the argument that the researchers cannot distance themselves from people in their research. They have to empower people through their research in order to bring about social justice Jackson (1995:11). The relative success of research in South Africa may in the future be measured against its ability to conform to the requirements of the critical approach. It is important to state that there is no specific method or technique associated with this research approach and this method or technique does not seem to be that important. According to Jackson (1995:11,13), researchers using this approach show a preference for the historical method of research.

3.2.5 Models and modelling

This research proposes to attempt to formulate a generic model of excellence in Total productive maintenance (TPM) implementation. Mouton and Marais (1992:138) describe the term "model" as one of the most ambiguous in the vocabulary of social scientists. The terms "model" and "theory" are frequently used as synonyms. Mouton and Marais (1992:138) continue that a model

performs a heuristic function as opposed to a theory that performs an explanatory function.

The focus of research design is to maximise the validity and reliability of the research findings. According to Leedy (1993:128), the use of human subjects in research raises the question of ethical standards and should not go without careful scrutiny.

3.3 QUANTITATIVE VERSUS QUALITATIVE RESEARCH

It is best to visualise the distinction between quantitative and qualitative research as a continuum. All research methods could be placed somewhere between the extremes of pure quantitative and pure qualitative research (Jackson, 1995:13). It is however, plausible to indicate whether research projects have a more qualitative or more quantitative nature. This in turn would play an important role in decisions on processes to follow and measuring instruments to select (van Biljon, 1999:37).

A summary of the main differences between qualitative and quantitative research are stated in Table 3.1. This Table shows how quantitative and qualitative research differs in terms of hypotheses, concepts, measures, data, theory, research procedures and analyses.

Table 3.1: Differences between qualitative and quantitative research

Quantitative	Qualitative
• Test hypothesis that the researcher begins with. Hypotheses are stated explicitly and are formulated beforehand • Concepts are in the form of distinct variables. Concepts have an unambiguous meaning • Measures are systematically created before data collection and are standardized. The researcher remains largely aloof • Data are in the form of numbers from precise measurements • Theory is largely causal and is deductive • Procedures are standard, and replication is assumed • Analysis proceeds by using statistics, tables or charts and discussing how what they show relates to hypotheses	• Capture and discover meaning once the researcher becomes immersed in data. Hypotheses are frequently undeclared or merely stated in the form of a research goal • Concepts are in the form of themes, motifs, generalizations, taxonomies. Concepts can be interpreted in a number of ways • Measures are created in an ad hoc manner and are often specific to the individual setting or researcher. The researcher is involved with the phenomena/ events • Data are in the form of words from documents, observations, transcripts • Theory can be causal or non-causal and is often inductive • Research procedures are particular, and replication is very rare • Analysis proceeds by extracting themes or generalizations from evidence and organizing data to present a coherent, consistent picture

Source: Van Biljon (1999:38)

3.3.1 Quantitative research

Mouton and Marais (1992: 159) define quantitative research as more highly formalized as well as more explicitly controlled, with a range that is more exactly defined, and which, in terms of the methods used, is relatively close to the physical sciences.

Leedy and Ormond (2001: 101) reinforce this definition by defining quantitative research as more highly formalised as well as more explicitly controlled, with a range that is more exactly defined, and which, in terms of methods used, is relatively close to the physical sciences.

Quantitative research seeks to quantify human behaviour, through numbers and observations. The emphasis is on precise measurement, the testing of hypotheses based on a sample of observations, and statistical analysis of the data. Relationships among variables are described mathematically, and the subject matter is, as in the physical sciences, treated as an object (Jackson, 1995: 13).

3.3.2 Qualitative research

Mouton and Marais, (1992: 155) define qualitative research projects as “those projects in which the procedures are not as strictly formalized, while the scope is more likely to be under defined, and a more philosophical mode of operation is adopted”.

3.3.3 Characteristics of qualitative research

- It is not always easy to describe the meaning of qualitative research.
- It is not always possible to classify methods in terms of the level of qualitative.

3.4 CHOOSING THE MOST APPROPRIATE RESEARCH METHOD

In many research studies it would be beneficial and appropriate to use a combination of both qualitative and quantitative methods. Time, resources or expertise may be the constraint in most cases, to combine both research approaches.

Therefore Leedy (1197: 109) advises that one should choose one approach for the overall design of your first few studies. Furthermore, he advises against making this choice on the basis of what you want to avoid, rather than on what fits your research interests and skills. Thus, avoiding statistics or disliking mathematics is not a good reason for choosing qualitative study. Before choosing to design and conduct either type of study, consider the particular demands of the specific research approach, reflect on your individual strengths and weaknesses as a researcher and determine whether you have the characteristics/ attributes that will allow you to be successful with that approach.

Leedy (1997: 109) continues by designing a table to guide you in the selection of an appropriate research approach. By listing many critical components that should be considered, Table 3.2 can help you to make a well-informed decision. Keep in mind, however, that the items in Table 4.2 are not ordered from most to least important. Time will weigh heavily into the research decision. Even if every item but one seems to “fit” the qualitative approach, you still may not be able to choose that approach; (for example, if your audience would not accept such an approach). Consider each component carefully before making your final decision.

Table 3.2: Which approach should be use?

Use this approach if:	Quantitative	Qualitative
1. You believe that:	There is an objective reality that can be measured	There are multiple constructed realities
2. Your audience is:	Familiar with/supportive of quantitative studies	Familiar with/supportive of qualitative studies
3. Your research question is:	Confirmatory, predictive	Exploratory, interpretive
4. The available literature is:	Relatively large	Limited or missing
5. Your research focus:	Covers a lot of breadth	Involves in-depth study
6. Your time available is:	Relatively short	Relatively long
7. Your ability/desire to work with people	Medium to low	High
8. Your desire for structure is:	High	Low
9. You have skills in the area(s) of:	Statistics and deductive reasoning	Attention to reasoning and inductive reasoning
10. Your writing skills is strong in the area of:	Technical, scientific writing.	Literary, narrative writing

Source: Leedy (1997: 109)

The model shown in table 3.3 can solve problems using a qualitative method.

Table 3.3: Research method selection model

	Form of research question	Requires control over behavioural events?	Focuses on contemporary events?
Experiment	How, why	Yes	Yes
Survey	Who, What, where, how many, how much.	No	Yes
Archival analysis	Who, What, where, how many, how much.	No	Yes / No
History	How, why	No	No
Case study	How, why	No	Yes

Source: Adapted from Yin (1994: 6).

3.5 RESEARCH GOAL

Mouton and Marais, (1992: 42) state that a research goal provides a broad indication of what researchers wish to attain in their research. Is the aim of the project to describe, to explain, or to predict, is the aim exploratory? Is it to evaluate some practice or programme?

In order to achieve the primary objective of the research project, data has to be gathered and analysed on the inefficiencies in the material distribution process. For this purpose, a data collection instrument will be developed that will meet the requirements of validity and reliability and a methodological approach in analysing the data will be conducted.

3.5.1 Exploratory projects

As clearly indicated in the term, the goal which is pursued in exploratory studies is the exploration of a relatively unknown research area. The aims of such studies may vary quite considerably. Van Biljon (1999: 53) states the objectives of such a project.

- Gain new insights into the phenomenon by becoming familiar with the facts, people, and concerns involved;
- Undertake a preliminary investigation and determine feasibility before a more structured study of the phenomenon;
- Generate many ideas and develop tentative theories and conjectures;
- Determine priorities and develop techniques for future research; and
- Develop new hypotheses about an existing phenomenon

Mouton and Marais (1992: 43) state that exploratory projects usually lead to insight and comprehension rather than the collection of accurate and replicable data. The methods frequently used in exploratory projects include in-dept interviews, the analysis of case studies and the use of informants.

3.5.2 Descriptive projects

The primary aim of descriptive projects is to portray accurately the characteristics of a particular individual, group, situation, organisation, tribe, sub-culture, interaction, or social object (Mouton and Marais, 1992: 155).

Van Biljon (1999: 54) states the aim of descriptive projects:

- Provide an accurate profile of a group;
- Describe a process, mechanism, or relationship;
- Give a verbal or numerical picture;
- Find information to stimulate new explanations;
- Present basic background information or a context;
- Create a set of categories or classify types;
- Clarify a sequence, set of stages, or steps; and
- Document information that contradicts prior beliefs about a subject.

Mouton and Marais (1992: 44) state that the single common element in all of these types of research is the researcher's goal, which is to describe that which exists as accurately as possible. The description of some phenomena may

range from a narrative type of description (as historical analysis) to a highly structured statistical analysis.

3.5.3 Explanatory projects

Explanatory projects are built on exploratory and descriptive projects and go on to identify the reason something occurs. The primary aim of explanatory projects is to test a hypothesis of a cause and effect relationship between the variables.

Van Biljon (1999: 55) identifies the following aims of explanatory projects:

- Determine the accuracy of a principle or theory
- Find out which competing explanation is better
- Advance knowledge about an underlying process
- Link different issues or topics under a common general statement
- Build and elaborate a theory so it becomes more complete
- Extend a theory or principle into new areas or issues
- Provide evidence to support or refute an explanation.

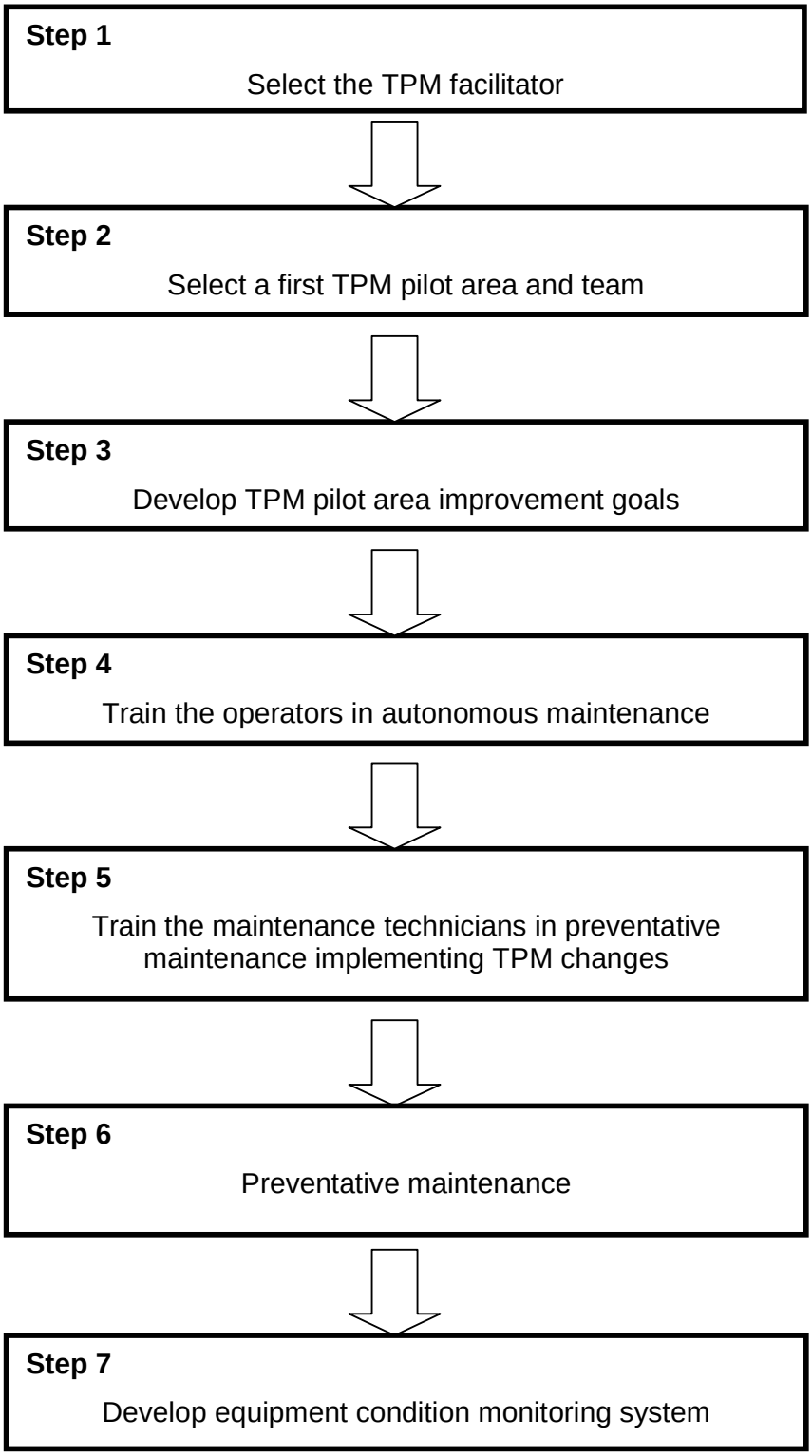
3.6 CATEGORIES TO BE USED IN THE QUANTITATIVE STUDY

With the key components discussed in chapter two, the researcher has developed seven categories to evaluate the absence of Total productive maintenance (TPM) at Venture SA.

The seven categories are shown in figure 3.1:

- The first category
- The second category
- The third category
- The four category
- The fifth category
- The sixth category
- The seventh category

Figure 3.1: The seven categories in the distribution process



Source: Pieterse (2005:78)

According to Leedy and Ormond (2001: 103), criterion–related validity employs two measures of validity, the second assessment instrument as a criterion check against the accurate correlation of first related measure. To test the validity of the findings a second assessment validity measure will be used.

3.7 RESEARCH STRATEGY

According to Mouton and Marais (1992:49) the two research strategies are contextual research strategies that deal with projects such as historical sciences, language, arts, jurisprudence and theology and general research strategy that deals with experimental studies, comparative research and various types of surveys.

For the purpose of this project the focus is on a general research strategy where key people from Ventrue SA East London plant, who are directly involved with total productive maintenance (TPM), were analysed and reported on. The project sample was compared on common aspects, but it was impossible to make general inferences about non participating Venture SA plants.

3.8 QUESTIONNAIRE CONSTRUCTION

Leedy and Ormrod (2001:205) prescribe a guide for the construction of a questionnaire. This guide was used to substantiate the relationship between the research problem and the question being asked. The guide for the construction of a questionnaire is depicted in Table 3.4 and Annexure B.

Table 3.4: Guide to the construction of a questionnaire

Table 3.4: Guide to the construction of a questionnaire.					
Question	**Why is the question being ask? How does it relate to the research problem?**	**Type of Questions**			
		Multiple choice	Yes / No Answer	Open ended Question	Counter check

Source: Leedy and Ormond (2001: 205).

The aim of this chapter was to highlight the research methodology that was used during the study. This involved discussing the research design,

questionnaire design and carrying out a pilot study. This was followed by analysing the response rate as well as a quantitative analysis of the biographic details of respondents in both tabular and chart form.

In the following chapter, an analysis and interpretation of the survey results will be provided. The chapter will conclude with the development of a theoretical model for Total productive maintenance (TPM).

3.9 QUESTIONNAIRE DESIGN

A problem associated with a questionnaire design is the determination of the number of statements necessary. Having too many statement questions may result in boredom on the part of the respondent. However too few questions in the questionnaire will lead to inaccuracy in the outcome of the findings of the research. The type of questions that should be ask, the wording of the questions and ensure that they are intelligible and unambiguous (Collis and Hussey, 2003:174).

The questionnaire that was used to conduct the survey of all level employees at Venture SA is shown in Annexure B. The actual questionnaire used in the study is broken down into two sections A and B and contains seven statements in section A and seven statements in section B (see Annexure B). The question was intended to describe the benefits of Total productive maintenance (TPM) to measure existing activities and conditions at Venture SA.

A factor that influenced the respondent's frames of reference is the number of points that are used on the rating scale when answering the questions. The author chose the five point Likert scale to measure a series of statements related to the benefits of Total productive maintenance (TPM). The respondents were required to indicate a degree of agreement or disagreement with each of the five scale points below.

The five scale points were labelled as follows.

5	-	Strongly agree.
4	-	Agree.
3	-	uncertain.
2	-	disagree.
1	-	Strongly disagree.

In compiling the statements for the questionnaire the author kept the following criteria in mind.

- The use of short simple statements.
- To be as objective as possible in the evaluation of the results.
- The use of a variety of statements under each heading or each section in order to improve consistency and accuracy of evaluation.

3.10 RESEARCH POPULATION

Levels of the organisation were surveyed using a questionnaire to obtain the primary data required for the research. A random sampling method was used. The research population was employed by Venture SA which was divided into hierarchical levels. The sampling units in each segment are relatively homogeneous. Thereafter random samples were selected from each segment.

The sample size in each segment is as follows.

Senior management	-	Four managers.
Supervisors	-	Seven personnel.
Operator level	-	37 personnel.
Maintenance technicians	-	Nine personnel.
Quality Inspectors	-	Five personnel.
Planners production	-	Four personnel.
Graduate trainees	-	Four personnel.

3.11 RESPONSE RATE

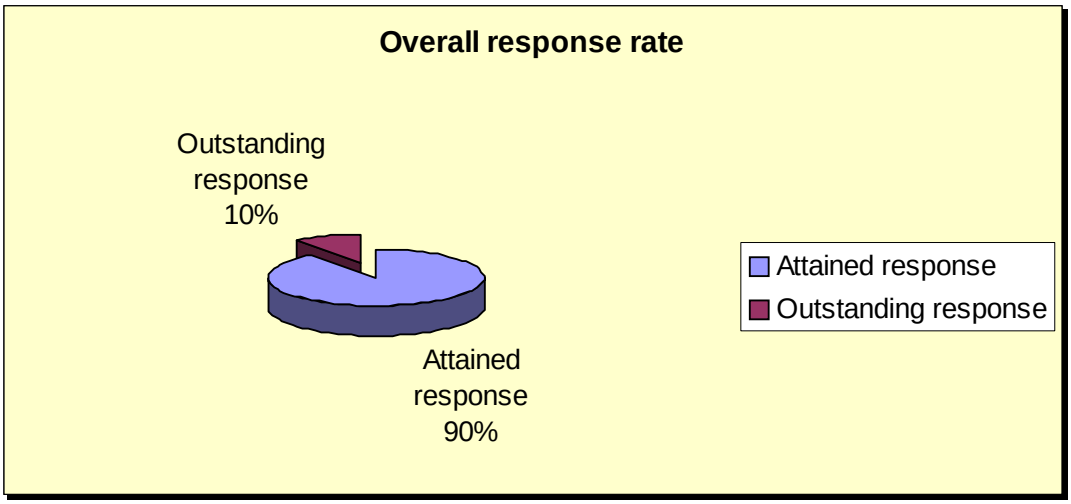
From the representative sample of 70 respondents, 63 responses were received, making a response rate of 90 per cent. The responses that were not received constituted only 10 per cent of the sample. The overall response rate is depicted in Table 3.5

Table 3.5: Overall response rate

RESPONSES	RESPONSE FREQUENCY	PERCENTAGE
Attained responses	63	90%
Outstanding responses	7	10%
TOTAL	**70**	**100%**

Source : Results obtained from overall analysis of survey responses

Chart 3.1: Overall response rate.



Source : Table 3.1 converted to a Pie Chart

The questionnaire was compiled, tested and sent out on 6 August 2006. Respondents were requested to return the questionnaires by the 15 August 2006.

A total of 70 questionnaires were distributed at Venture SA East London. The highest response rate came from 31 Operators and nine technicians.

3.12 SUMMARY

In this Chapter the components from the Total productive maintenance (TPM) implementation model were grouped together to form the following seven categories Select the TPM facilitator, Select a first TPM pilot area and team, Develop TPM pilot area improvement goals, Train the operators in autonomous maintenance, Training the maintenance technicians in preventative maintenance implementing TPM changes, Preventative maintenance, Develop equipment condition monitoring system.

This will be used to determine the absence of TPM at the Venture SA East London plant. The intention of the dissertation was to optimise the TPM philosophy and is done by identifying a lack of Total productive maintenance (TPM) knowledge and awareness (which is the first sub-problem).

The planning of the questionnaire was discussed. The objective of the questionnaire was to evaluate the patterns and relationships that exist between management and employees at Venture SA that have an impact on Total productive maintenance (TPM) philosophy of the benefits of TPM. Literature reviews suggest that an important component of TPM is a clean tidy and safe workplace, problems and faults are repaired, employees have more control over their own work environment, by participation and implementation of improvements in their areas, opportunities for employees and machine operators to increase their skills and knowledge by working closely with the maintenance technicians and engineers, the work environment is more controlled due to faults and operator problems being repairs properly and dangers and difficult tasks are investigated and eliminated, increasing machinery effectiveness. Chapter 5 is the results and analysis of the empirical study. The absence of TPM at Venture SA East London plant will be highlighted.

CHAPTER 4

EMPIRICAL FINDINGS

4.1 INTRODUCTION

A questionnaire was administered to 70 employees of Venture SA. The chosen population consisted of the following.

- The plant manager and departmental managers formed part of senior management.
- All engineering and production foreman formed part of middle management.
- Line supervisors, artisans, clerical workers and machine operators formed part of the operator level.

Of the 70 questionnaires sent out, 63 were returned. However one was discarded as unusable as it was completed incorrect and six were not returned.

The main aim in this chapter is to provide the empirical findings and interpretation of them in the above mentioned three sections of Venture SA East London, namely senior management, middle management and operator level. In the previous chapter the research methodology was described and the biographical information of the respondents were analysed and interpreted. An empirical study was conducted to assess the Implementation of TPM in organisations. This chapter will present the results of the empirical study. The results are presented in a tabular format. These follow the same sequence as the questions in the survey questionnaire.

A summary of the results achieved is presented below.

The responses on the Total productive maintenance (TPM) strategies used at Venture SA East London are analysed and interpreted. Finally, a seven-step theoretical TPM implementation model for Venture SA East London will be presented based on the implementation model presented in Chapter two figure 2.3.

4.2 ANALYSIS OF BIOGRAPHICAL INFORMATION

The respondents that participated in this project were employees from Venture South Africa at the East London plant.

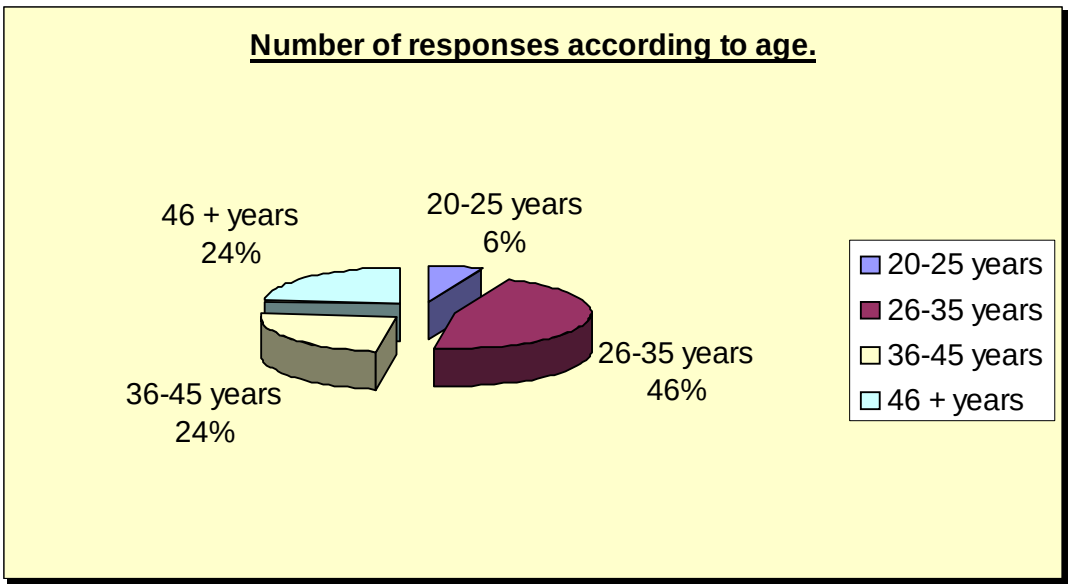
The biographical information was analysed according to age, gender, qualification and position or designation. It also determined whether they had been involved in a TPM implementation in the past three years and if they had seen improved equipment reliability at Venture SA.

Table 4.1: Number of Reponses according to age

AGE	NUMBER OF RESPONSES	PERCENTAGE OF RESPONSES
20-25 years	4	6 %
26-35 years	29	47 %
34-45 years	15	24 %
46 + years	15	23 %
TOTAL	**63**	**100 %**

Source : Results obtained from respondents' analysis by age

Chart 4.1: Number of responses according to age.



The majority of respondents, as indicated by Table 4.1 were older than 25 years of age. This translates to 94 per cent of the respondents. This indicates that the majority of respondents had been employed for several years and thus have more experience than those entering the workplace.

Table 4.2: Number of responses according to gender

GENDER	NUMBER OF RESPONSES	PERCENTAGE OF RESPONSES
Male	51	81%
Female	12	19 %
TOTAL	**63**	**100 %**

Source : Results obtained from respondents' analysis by gender

Table 4.2 indicates that the majority of respondents are males representing a total of 81 per cent , compared with the females who account for 19 per cent of the respondents. This can be attributed to their being more males found in the work environment compared to females.

Chart 4.2: Number of responses according to gender

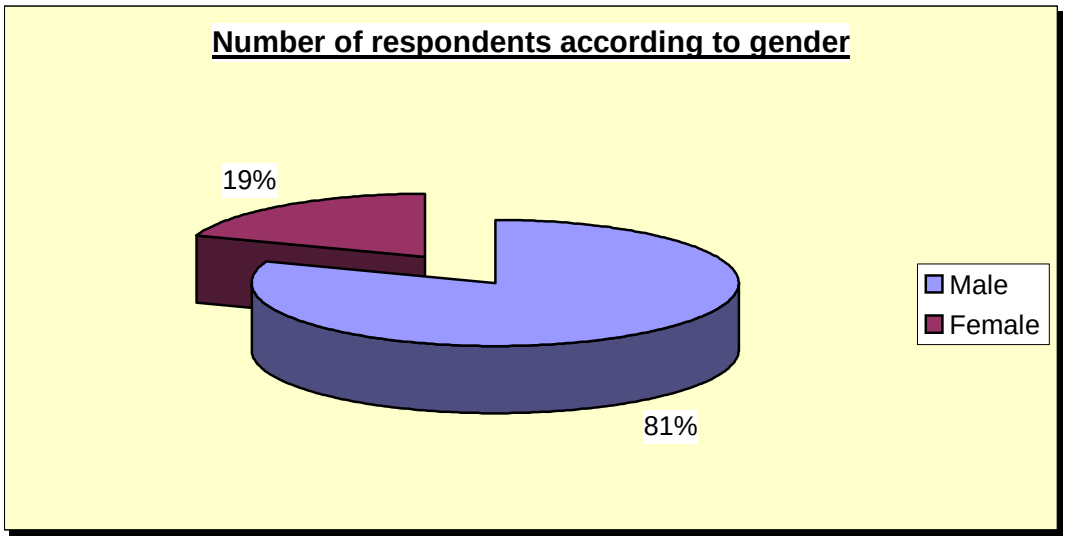


Table 4.3: Responses by qualification

QUALIFICATION	NUMBER OF RESPONSES	PERCENTAGE OF RESPONDENTS
High School	42	66%
Bachelor's degree or diploma	20	32%
Honour degree or equivalent		0%
Master's degree	1	2 %
Doctorate	0	0 %
TOTAL	**63**	**100 %**

Source : Results obtained from respondents' analysis by qualification

Table 4.3 indicates the majority of respondents had completed high school or have completed a bachelor's degree / diploma. This translates to 66 per cent response rate. This indicates that the majority of the respondents have some form of education. The majority of respondents have a high school education level.

Chart 4.3: Responses by qualification.

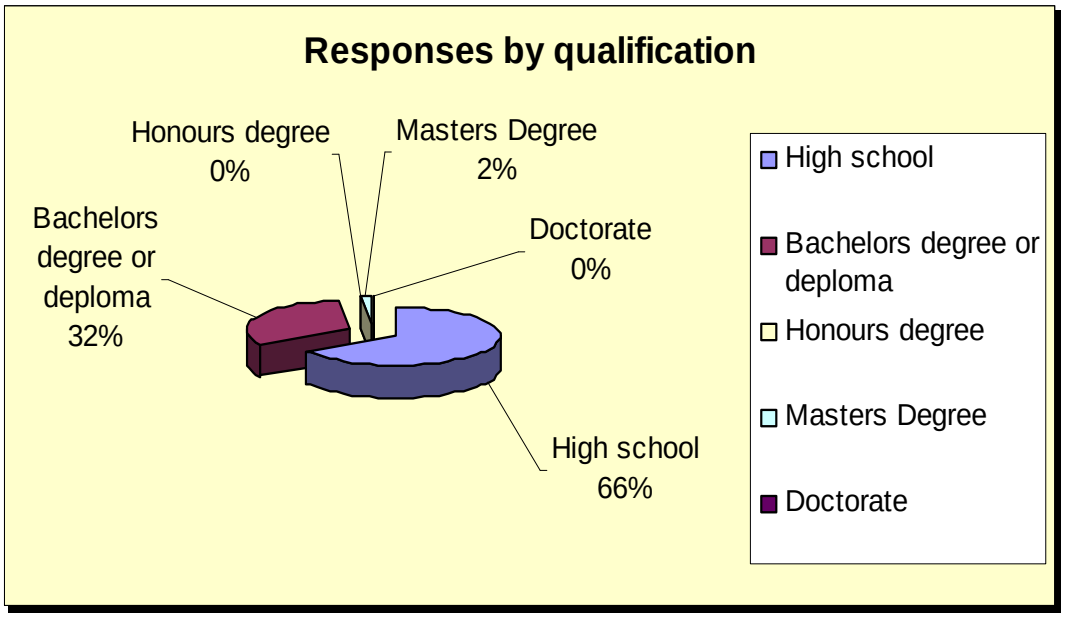
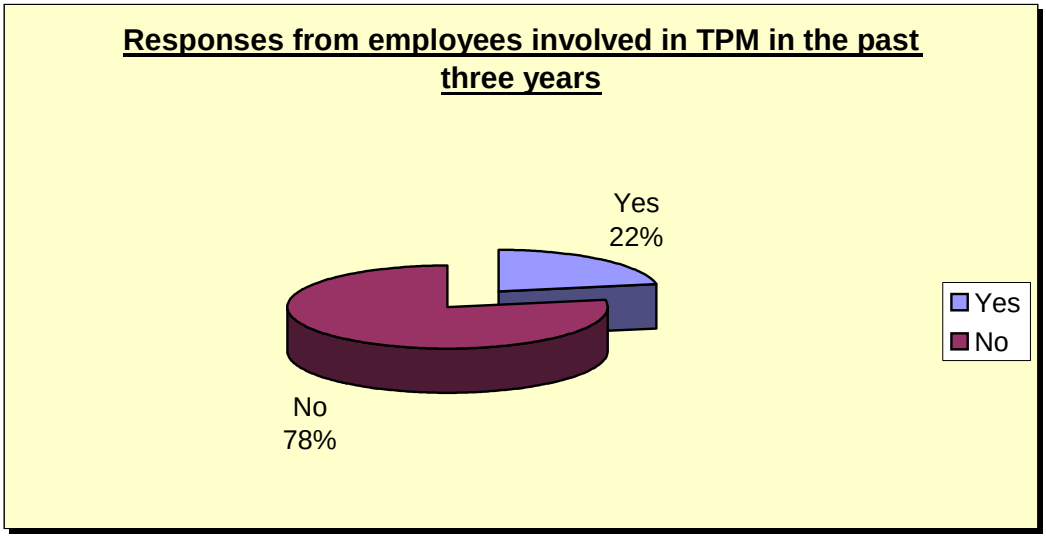


Table 4.4: Response from employees involved in Total productive maintenance (TPM) in the past three years.

EMPLOYEES INVOLVED IN TPM	NUMBER OF RESPONSES	PERCENTAGE OF RESPONDENTS
Yes	14	22 %
No	49	78 %
TOTAL	**63**	**100 %**

Source : Results obtained response from employees involved in Total productive maintenance (TPM) in the past three years.

Chart 4.4: Responses from employees involved in TPM in the past three years.



The results in table 4.4 indicate that more than half 78 per cent of the employees had not been involved in Total productive maintenance (TPM) in the past three years. This indicates that TPM is not being widely practiced at Venture SA East London.

In section A question seven this question concerns the reliability of the machinery in your organisation 30 respondents out of 63 said yes. In other words the respondents rate the machinery as being reliable. Also 20 of the respondents stated that the improvement has taken place over the past year.

4.3 SELECTING A TOTAL PRODUCTIVE MAINTENANCE (TPM) FACILITATOR.

Table 4.5 shows the responses to step one of the Total productive maintenance (TPM) model, which refers to selecting a TPM facilitator. Pieterse (2005: 30) states that TPM is proactive as it focuses on all aspects of shop floor arrangement by following a team approach.

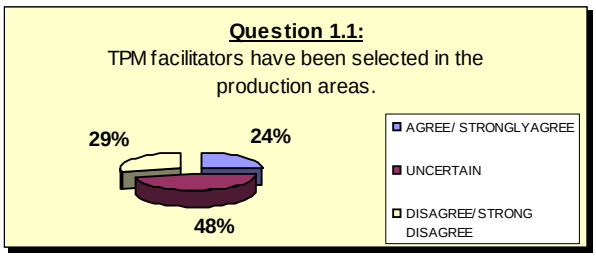
Table 4.5: STEP 1 - SELECT A TPM FACILITATOR.

STEP 1: SELECT A TPM FACILITATOR. N = 70		**Strongly agree/ Agree**	**Uncertain**	**Strongly disagree/ Disagree**
TPM facilitators have been selected in the production areas.	No %	15 24%	30 48%	18 29%
You have been trained on what TPM is about.	No %	9 15%	9 15%	45 71%
You had been involved in the launch of the TPM program.	No %	6 10%	10 16%	47 75%
A TPM island of excellence has been developed in production areas.	No %	7 11%	30 48%	26 41%
The rest of the plant employees has been given an overview of what TPM is.	No %	4 6%	35 56%	24 38%

Source : Survey Questionnaire, Section B : Step 1

Table 4.1 reveals 48 Per cent of respondents were uncertain that a facilitator has been selected in their production areas and 24 per cent of respondents strongly disagree that a facilitator was selected in their production area.

Chart 4.5 Response of employees that TPM facilitators have been selected in the production areas.



Thus Total productive maintenance (TPM) facilitators have not been selected or introduced to the respondents. Thus there is a low level of implementation at Venture SA and a lack of understanding of what TPM is and the benefits thereof as stated by Davis (1995:55).

Chart 4.6 shows that the level of training of the employees and management on what TPM is about is low with 72 per cent of respondents strongly disagreeing and 14 per cent being uncertain. This substantiates this fact.

Chart 4.6: Response of employees that they have been trained on what TPM is about.

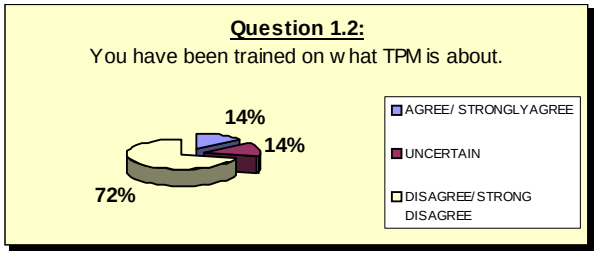


Chart 4.7 shows that 74 per cent of respondents strongly disagree that they were involved in the launch of the TPM program. This is an indication that the employees are not included in the launch of the TPM program.

Chart 4.7: Response of employees that they had been involved in the launch of the TPM program.

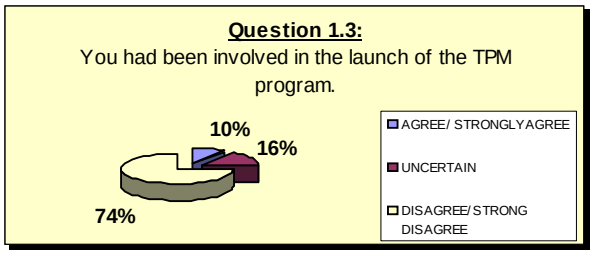


Chart 4.8 shows that the development of Islands of TPM excellence has not been developed in the production area, with 48 per cent of respondents being

uncertain and 41 per cent of respondents strongly disagreeing that islands of excellence had been developed.

Chart 4.8: Response of employees that a TPM island of excellence has been developed in production areas.

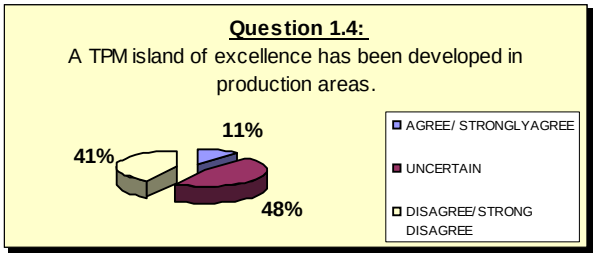
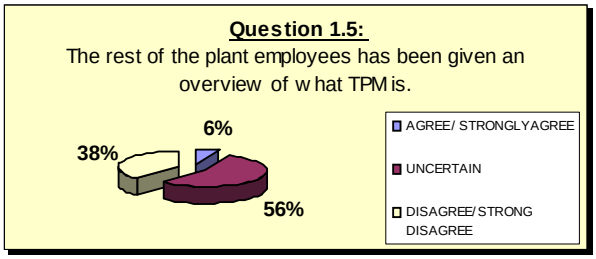


Chart 4.9 shows that no adequate overview of what TPM is has been given to employees with 56 per cent of respondents being uncertain and 38 per cent of respondent's disagreeing. This indicates a lack of understanding and training on what TPM is.

Chart 4.9: Response of employees that the rest of the plant employees has been given an overview of what TPM is.



4.4 SELECT THE FIRST TPM PILOT AREA AND TEAM

Table 4.6 reflects the responses to step two of the Total productive maintenance (TPM) model which is selecting the first TPM pilot area and team. Suzuki (1992:17) stated that TPM is an idea that improves people.

Table 4.6: Step 2 - Select the first TPM pilot area and team.

STEP 2: SELECT THE FIRST TPM PILOT AREA AND TEAM. N = 70		Strongly agree/ Agree	Uncertain	Strongly disagree/ Disagree
You have been trained in 5S and TPM.	No %	20 32%	5 8%	38 60%
Lost production costs are a major problem in your production area.	No %	47 75%	8 13%	8 13%
Downtime costs are a major problem in your production area.	No %	37 59%	12 19%	14 23%
Quality problems are a major problem in your production area.	No %	48 76%	8 13%	7 11%
Maintenance downtime is high in your production area.	No %	19 31%	12 19%	32 5%
Machinery stops often for maintenance problems.	No %	24 38%	6 10%	33 52%

Source : Survey Questionnaire, Section B : Step 2

Table 4.6 reveals that the majority of respondents disagree that they have been trained in 5S or TPM with 60per cent of respondents strongly disagreeing. Respondents did indicate on the questionnaire that they had received 5S training.

Chart 4.10: Response of employees that they have been trained in 5S and TPM.

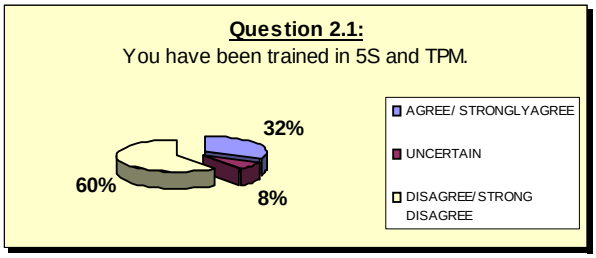


Chart 4.11 shows that 75 per cent of respondents agree that lost production costs are a major problem. This indicates that employees are aware that lost production costs are a problem for the organisation.

Chart 4.11: Response of employees that lost production costs are a major problem in your production area.

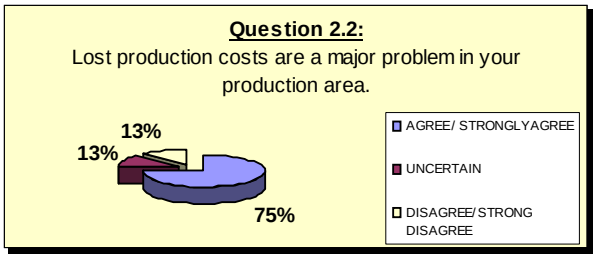


Chart 4.12 shows that 59 per cent of respondents strongly agree that downtime costs are a problem in production areas.

Chart 4.12: Response of employees that downtime costs are a major problem in your production area.

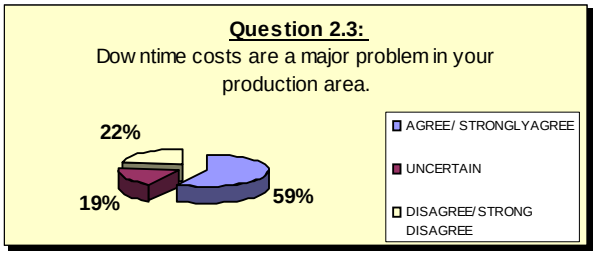


Chart 4.13 shows that 76 per cent of respondents strongly agree that quality problems are a major problem.

Chart 4.13: Response of employees that quality problems are a major problem in your production area.

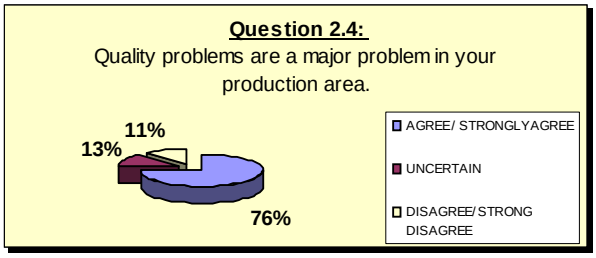


Chart 4.14 shows that 51 per cent of respondents strongly disagree that quality problems are high in production areas.

Chart 4.14: Response of employees that Maintenance downtime is high in your production area.

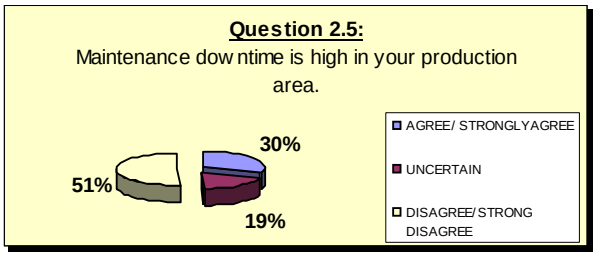
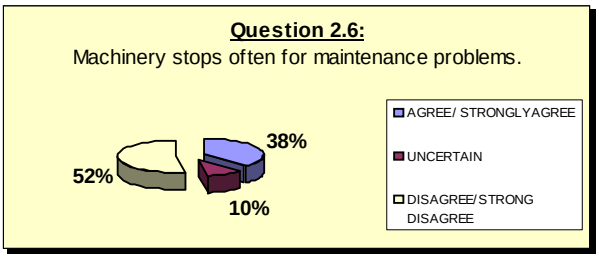


Chart 4.15 shows that 52 per cent of respondents disagree strongly that machines stop often for maintenance problems. This indicates a high level of machinery and equipment availability.

Chart 4.15: Response of employees that Machinery stops often for maintenance problems.



4.5 DEVELOPMENT OF TPM PILOT AREA IMPROVEMENT GOALS

Table 4.7 shows the responses to step three of the Total productive maintenance (TPM) model and development of TPM pilot area improvement goals.

Shirose (1992:16) states that the introduction of total productive maintenance (TPM) brings the whole company behind the goal of actually achieving zero breakdowns and zero defects and these goals pay off as higher productivity and enhanced profitability.

Table 4.7: Step 3 - Development of TPM pilot area improvement goals

STEP 3: DEVELOPMENT OF TPM PILOT AREA IMPROVEMENT GOALS. N = 70		Strongly agree/ Agree	Uncertain	Strongly disagree/ Disagree
TPM pilot area improvement goals have been set for your production area.	No %	9 14%	40 63%	14 22%
You are aware of the TPM improvement goals targets set for production areas.	No %	11 17%	32 51%	20 32%
Your production area is a model for other TPM areas.	No %	8 13%	40 63%	15 24%

Source : Survey Questionnaire, Section B : Step 3

Table 4.7 provides evidence of uncertainty that TPM pilot area improvement goals have been set and respondents are uncertain of TPM improvement goals and targets set. 63 per cent of respondents are uncertain if improvement goals have been set for production areas.

Chart 4.16: Response of employees that TPM pilot area improvement goals have been set for your production area

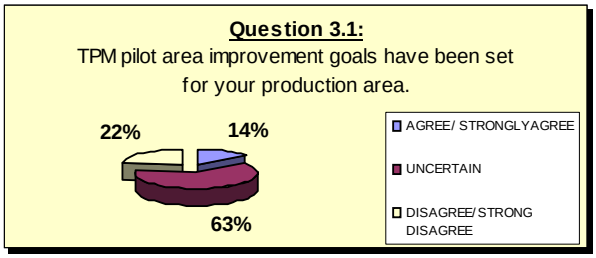


Chart 4.17 shows that 51 per cent of respondents are uncertain if there is TPM improvement gaols set for their production areas.

Chart 4.17: Response of employees that they are aware of the TPM improvement goals and targets areset for their production areas

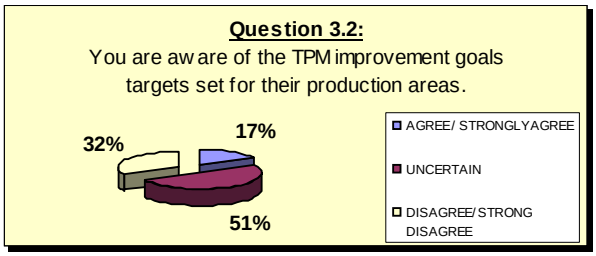
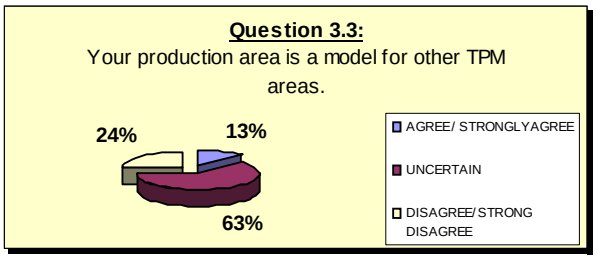


Chart 4.18 shows that 63 per cent of respondents are uncertain if their area is a model area for other TPM areas in the organisation.

Chart 4.18: Response of employees that their production area is a model for other TPM areas



This substantiates an absence of implementation of TPM at the Venture SA East London plant.

4.6 TRAIN THE OPERATOR IN AUTONOMOUS MAINTENANCE

Table 4.8 shows the responses to step four of the total productive maintenance (TPM) model which is train the operator in autonomous maintenance.

The journal *Strategic direction* (2003:17) stated that Total productive maintenance (TPM) has the potential to organize manufacturing productivity with a modest investment in equipment and machinery maintenance. The concept of autonomous maintenance sounds simple and is relatively easy to

implement in an organisation with an ethic of learning, provided people at all levels support the concept.

Table 4.8: Step 4 - Train the operator in autonomous maintenance

STEP 4: TRAIN THE OPERATOR IN AUTONOMOUS MAINTENANCE. N = 70		**Strongly agree/ Agree**	**Uncertain**	**Strongly disagree/ Disagree**
The machinery in your department is clean.	No %	40 63%	13 21%	10 16%
Daily checks are carried out on machinery and equipment.	No %	40 63%	11 17%	12 19%
Yellow TPM action tags are used to identify problems on equipment.	No %	10 16%	26 41%	27 43%
All the lubrication points on machines are marked for easy identification.	No %	17 27%	23 37%	23 37%
Operating pressure is marked on air or oil or stream pressure gauges.	No %	29 46%	23 37%	11 17%
The equipment in the production areas needs to be painted.	No %	25 40%	18 29%	20 32%
The equipment in the production areas needs to be cleaned.	No %	46 73%	11 17%	6 10%
The ability to clean, inspect and prevent failures on machinery has improved over the past year.	No %	37 59%	13% 21%	13 21%
Lubrication and cleaning standards are set for machinery.	No %	30 48%	24 38%	9 14%
Operators know how the machinery they operate works.	No %	43 68%	9 14%	11 17%
Operators are trained how the machinery they operate works.	No %	41 65%	10 16%	12 19%
There are checklists for operators.	No %	45 71%	4 6%	14 22%
There are checklists for technicians.	No %	34 54%	16 25%	13 21%
Operators conduct daily checks on machinery and equipment they operate.	No %	33 52%	9 14%	21 33%

Source : Survey Questionnaire, Section B : Step 4

Table 4.8 reveals that 63 per cent of respondents strongly agreed machinery in department is clean.

Chart 4.19: Response of employees that the machinery in their department is clean.

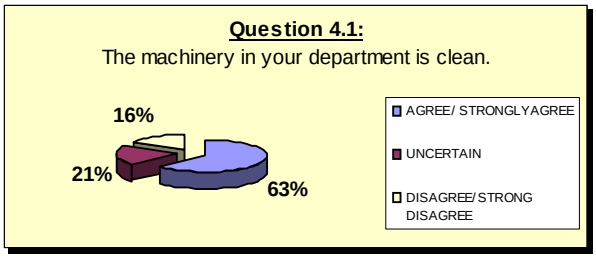


Chart 4.20 shows that 63 per cent of respondents strongly agreed that daily checks are carried out on machinery and equipment.

Chart 4.20 Response of employees that daily checks are carried out on machinery and equipment

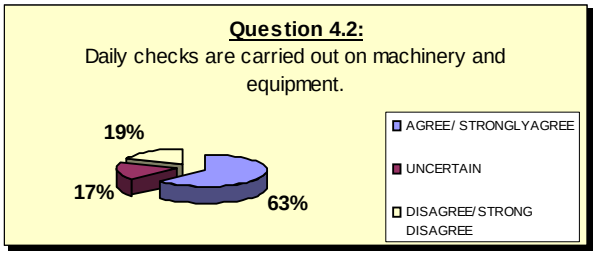


Chart 4.21 shows that 43 per cent of respondents strongly disagreed and 41 per cent are uncertain that yellow TPM action tags are used to identify problems on equipment.

Chart 4.21: Response of employees that yellow TPM action tags are used to identify problems on equipment

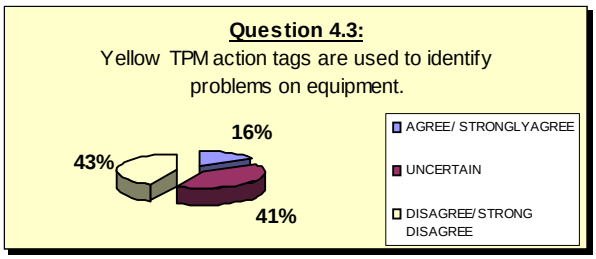


Chart 4.22 shows that 37 per cent of respondents are uncertain and 37 per cent strongly disagree that all the lubrication points on machines are marked for easy identification.

Chart 4.22: Response of employees that all the lubrication points on machines are marked for easy identification

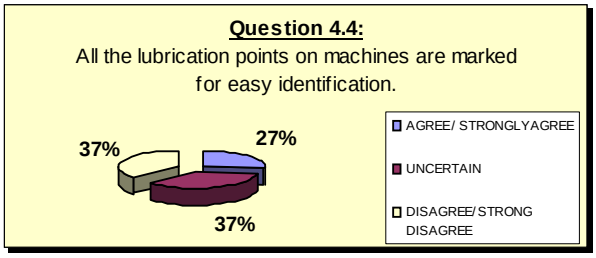


Chart 4.23 shows that 46 per cent of respondents strongly agree and 37 per cent are uncertain that operating pressure are marked on air or oil or stream pressure gauges.

Chart 4.23 Response of employees that Operating pressure is marked on air or oil or stream pressure gauges

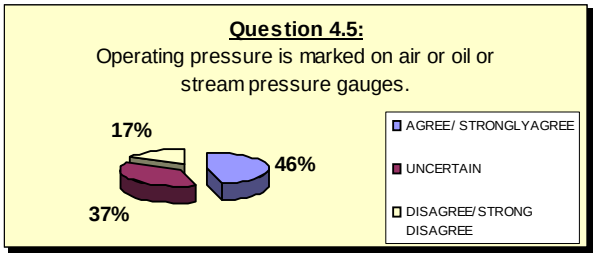


Chart 4.24 shows that 40 per cent of respondents strongly agree and 32 per cent disagree that the equipment in the production areas needs to be painted.

Chart 4.24: Response of employees that the equipment in the production areas needs to be painted

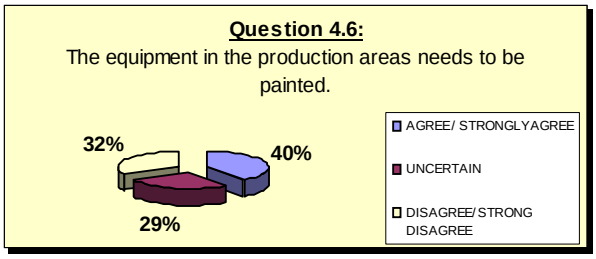


Chart 4.25 shows that 73 per cent of respondents strongly agree that equipment in the production areas needs to be cleaned and 17 per cent of respondents were uncertain.

Chart 4.25: Response of employees that the equipment in the production areas needs to be cleaned

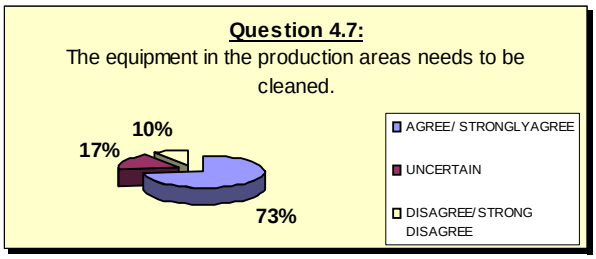


Chart 4.26 shows that 59 per cent of respondents strongly agree that the ability to clean, inspect and prevent failures on machinery has improved over the past year.

Chart 4.26: Response of employees that the ability to clean, inspect and prevent failures on machinery has improved over the past year.

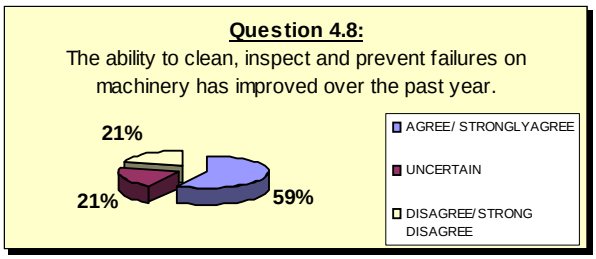


Chart 4.27 shows that 48 per cent of respondents strongly agreed that lubrication and cleaning standards are set for machinery.

Chart 4.27: Response of employees that lubrication and cleaning standards are set for machinery.

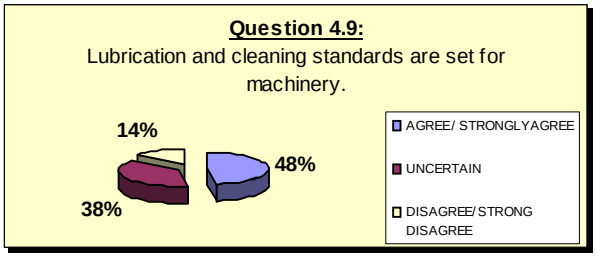


Chart 4.28 shows that 68 per cent of respondents strongly agree that operators know how the machinery they operate works.

Chart 4.28: Response of employees that operators know how the machinery they operate works

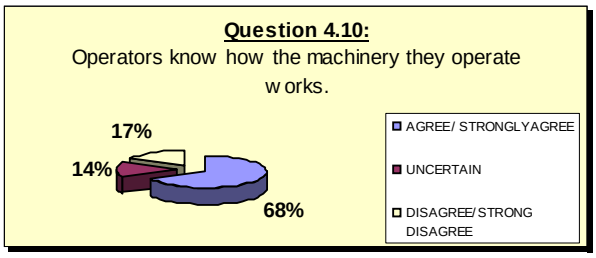


Chart 4.29 shows that 65 per cent of respondents strongly agreed that operators are trained how the machinery they operate works.

Chart 4.29: Response of employees that Operators are trained how the machinery they operate works

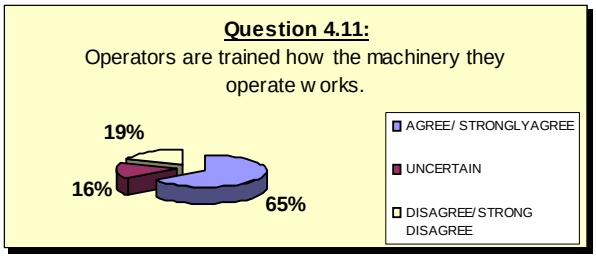


Chart 4.30 shows that 71 per cent of respondents strongly agree that there are checklists for operators.

Chart 4.30: Response of employees that there are checklists for operators.

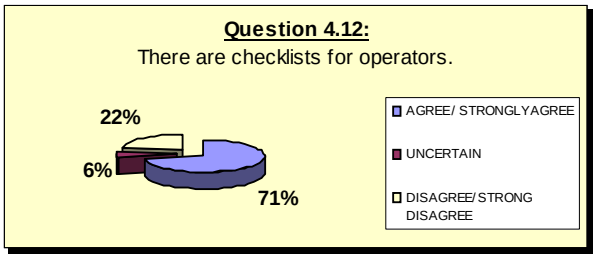


Chart 4.31 shows that 54 per cent of respondents strongly agreed that there are checklists for technicians.

Chart 4.31: Response of employees that there are checklists for technicians

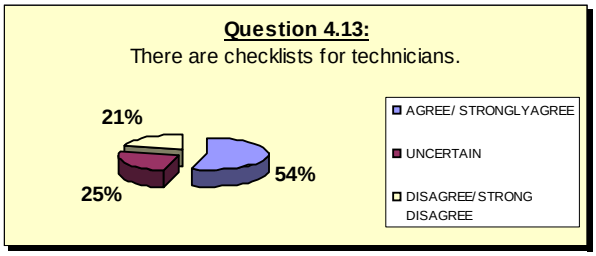
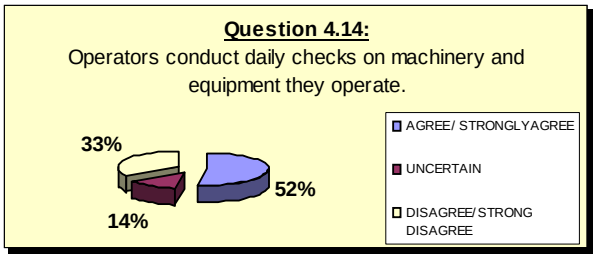


Chart 4.32 shows that 52 per cent of respondents strongly agreed that operators conduct daily checks on machinery and equipment they operate.

Chart 4.32: Response of employees that operators conduct daily checks on machinery and equipment they operate.



There is a 53 per cent response from respondents indicating that autonomous maintenance is partially implemented. However work is still required to improve the level of implementation of this step of the model in figure 2.3.

4.7 TRAIN THE MAINTENANCE TECHNICIANS IN PREVENTATIVE MAINTENANCE

Table 4.9 shows the responses to step five of the TPM model, which refers to the activities involved in training the maintenance technicians in preventative maintenance.

Takahashi and Osada (1990:177) defines preventative maintenance as an inspection to investigate deteriorating condition, and repairs based on such inspections. Venture SA is capturing downtime and analysis is done by the engineering department. Labib (1996:793) gives the following shortcomings of TPM: Managers tend to focus on early results rather than activities aimed at reducing losses in the long run. Continuous improvement means data analysis. Often data is collected and not analysed.

Table 4.9: Step 5 - Train the maintenance technicians in preventative maintenance.

STEP 5: TRAIN THE MAINTENANCE TECHNICIANS IN PREVENTATIVE MAINTENANCE. N = 70		Strongly agree/ Agree	Uncertain	Strongly disagree/ Disagree
The role of the maintenance technician has changed from a fire fighting mentality to a preventative maintenance approach with support to operators over the past year.	No %	28 44%	14 22%	21 33%
Maintenance technicians provide support to operators by having direct contact with the operator.	No %	41 65%	5 8%	17 27%
Maintenance technicians do preventive maintenance checks.	No %	34 54%	21 33%	8 13%
There is a critical spares program in place.	No %	24 38%	28 44%	11 17%
Chronic problems with equipment are identified.	No %	36 57%	14 22%	13 21%
Chronic problems with equipment are eliminated.	No %	29 46%	21 33%	13 21%
The downtime is captured and analysed by the engineering department	No %	38 60%	18 29%	7 11%
The 5 whys is used to analyse data and eliminate equipment problems.	No %	16 25%	27 43%	20 32%

Source : Survey Questionnaire, Section B : Step 5

Table 4.9 indicates that 44 per cent of respondents strongly agreed that the role of the maintenance technician has changed from a fire fighting mentality to a preventative maintenance approach with support to operators over the past year.

Chart 4.33: Response of employees that the role of the maintenance technician has changed from a fire fighting mentality to a preventative maintenance approach with support to operators over the past year

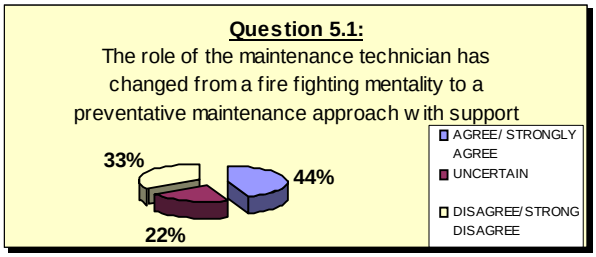


Chart 4.34 shows that 65 per cent of respondents strongly agreed that maintenance technicians provide support to operators by having direct contact with the operator.

Chart 4.34: Response of employees that maintenance technicians provide support to operators by having direct contact with the operator

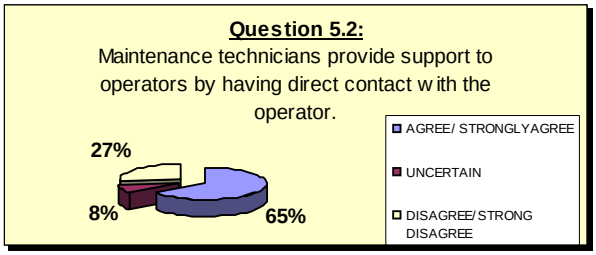


Chart 4.35 shows that 54 per cent of respondents strongly agreed that maintenance technician's do preventive maintenance checks.

Chart 4.35: Response of employees that maintenance technicians do preventive maintenance checks

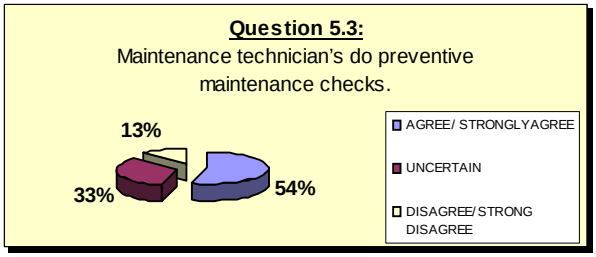


Chart 4.36 shows that 44 per cent of respondents were uncertain if there is a critical spares program in place.

Chart 4.36: Response of employees that there is a critical spares program in place

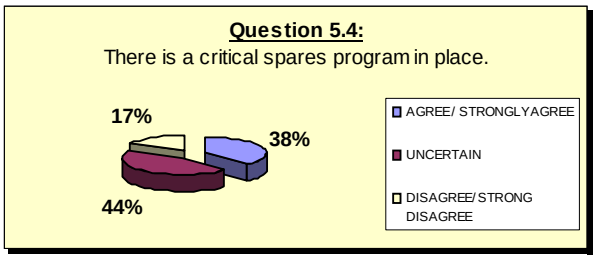


Chart 4.37 shows that 57 per cent of all respondents strongly agreed that chronic problems with equipment are identified.

Chart 4.37: Response of employees that chronic problems with equipment are identified

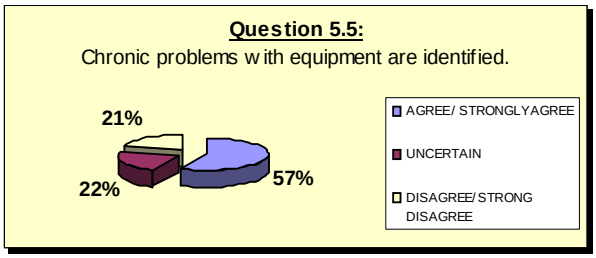


Chart 4.38 shows that 46 per cent of respondents strongly agreed that chronic problems with equipment are eliminated.

Chart 4.38: Response of employees that chronic problems with equipment are eliminated

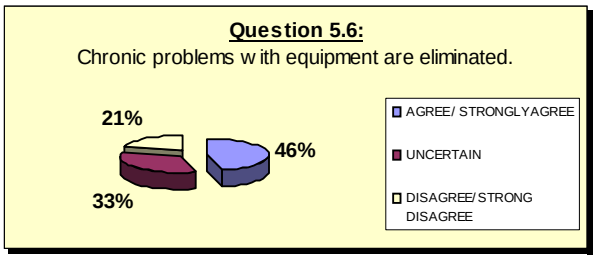


Chart 4.39 shows that 60per cent of all respondents strongly agree that downtime is captured and analysed by the engineering department.

Chart 4.39: Response of employees that the downtime is captured and analysed by the engineering department

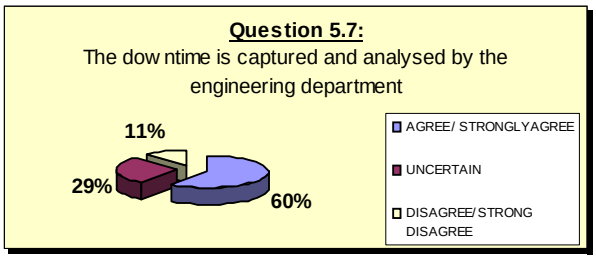
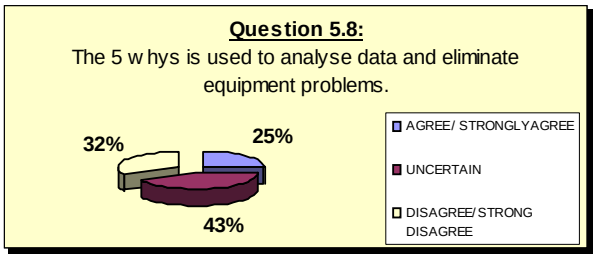


Chart 4.40 show that 43 per cent of respondents are uncertain and 32 per cent disagree that the 5 whys are used to analyse data and eliminate equipment problems.

Chart 4.40: Response of employees that the 5 whys are used to analyse data and eliminate equipment problems



49 per cent average strongly agreed response from respondents indicating that technicians are trained in preventative maintenance. This is an acceptable result considering that the majority of respondents were operators and not maintenance technicians.

4.8 PREDICTIVE MAINTENANCE

Table 4.10 shows the responses to step six of the TPM model, which refers to predictive maintenance.

Takahashi and Osada.(1990:177) define for preventative maintenance as an inspection to investigate deteriorating condition, and repairs based on such inspections.

Table 4.10: Step 6 - Predictive maintenance

STEP 6: PREDICTIVE MAINTENANCE. N = 70		**Strongly agree/ Agree**	**Uncertain**	**Strongly disagree/ Disagree**
The equipment that can be monitored is checked using condition-monitoring techniques. (e.g. fans vibration monitoring)	No %	28 44%	29 46%	6 10%
Temperature measurement is used to detect impending failure of equipment. (e.g. thermal imaging of DB's)	No %	26 41%	29 46%	6 13%
Oil analysis measurement is used to detect impending failure of equipment (e.g. oil analysis of transformers and moulding machines)	No %	24 38%	31 49%	8 13%

Source : Survey questionnaire, Section B : Step 6

In table 4.10 46 per cent of respondents are uncertain that the equipment that can be monitored is checked using condition-monitoring techniques.

Chart 4.41: Response of employees that the equipment that can be monitored is checked using condition-monitoring techniques. (e.g. fans vibration monitoring)

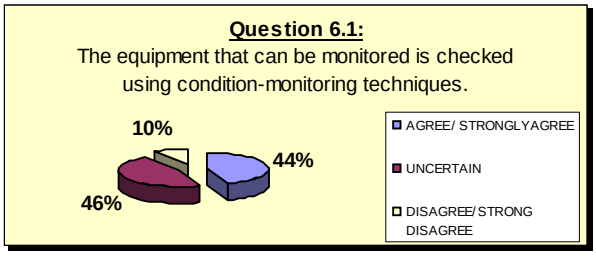


Chart 4.42 shows that 46 per cent of respondents were uncertain whether temperature measurement is used to detect impending failure of equipment such as fans.

Chart 4.42: Response of employees that temperature measurement is used to detect impending failure of equipment. (e.g. thermal imaging of distribution boards)

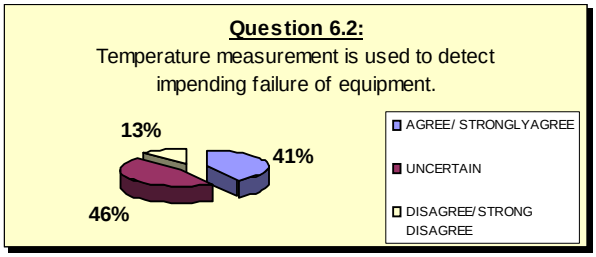
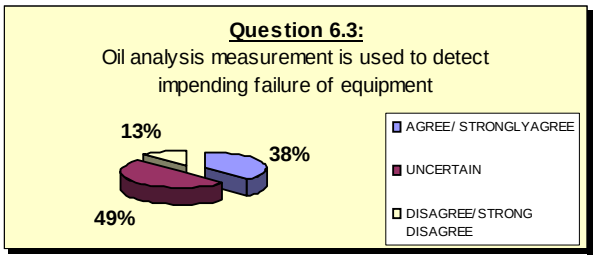


Chart 4.43 shows that 49 per cent of respondents were uncertain that oil analysis measurement is used to detect impending failure of equipment.

Chart 4.43: Response of employees that oil analysis measurement is used to detect impending failure of equipment (e.g. oil analysis of transformers and moulding machines)



47 per cent of respondents are uncertain that predictive maintenance techniques are used.

4.9 DEVELOP CONDITION MONITORING SYSTEM

Table 4.11 shows the responses to step seven of the TPM model, which refers to developing a condition-monitoring system. Nakajima (1988:36) states that preventative maintenance alone cannot eliminate breakdowns. According to the principal of reliability engineering, the cause of equipment failure changes with the passing of time.

Nakajima (1988:40) states that to eliminate failure or hidden defects they must be identified and treated before machine breakdown. These are counter measures that assist in eliminating failures:

- Maintain well regulated basic conditions (cleaning, lubricating and bolting)
- Adhere to proper operating procedures.
- Restore deterioration.
- Improve design weaknesses.
- Improve operation and maintenance skills.

Breakdowns often occur because people fail to implement simple measures. The main reasons for the success of TPM are its pursuit of zero breakdowns and zero defects.

Table 4.11: Step 7- Develop condition-monitoring system.

STEP 7: DEVELOP CONDITION MONITORING SYSTEM. N = 70		**Strongly agree/ Agree**	**Uncertain**	**Strongly disagree/ Disagree**
The maintenance department has all the equipment needed for condition monitoring of machinery in the plant.	No %	20 32%	27 43%	16 25%
Condition monitoring is done on machinery that allows for this method of monitoring an impending failure.	No %	18 29%	36 57%	9 14%
Condition monitoring has improved the reliability of the machinery in production areas.	No %	22 35%	27 43%	14 22%

Source : Survey Questionnaire, Section B : Step 7

Table 4.11 shows that 43 per cent of respondents are uncertain that the maintenance department has all the equipment needed for condition monitoring of machinery in the plant. Only 44 per cent of the maintenance staff strongly disagrees.

Chart 4.44: Response of employees that the maintenance department has all the equipment needed for condition monitoring of machinery in the plant

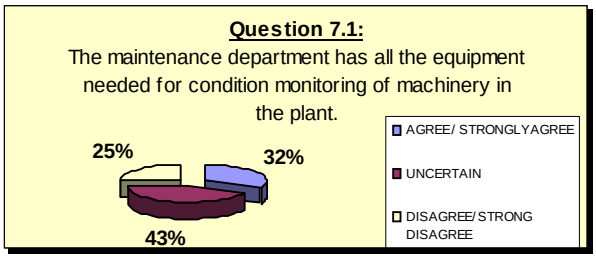


Chart 4.44 shows that 57 per cent of respondents are uncertain that condition monitoring is done on machinery which allows this method of monitoring an impending failure. Only 56 per cent of maintenance staff strongly agreed that condition monitoring is done.

Chart 4.45: Response of employees that condition monitoring is done on machinery that allows for this method of monitoring an impending failure

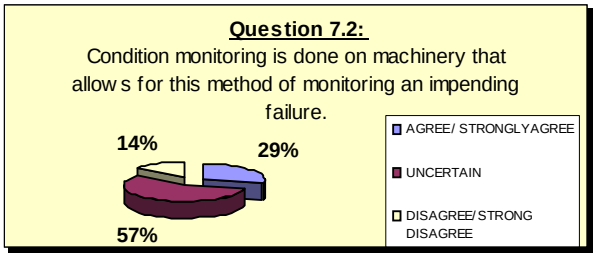


Chart 4.45 shows that 43 per cent of respondents are uncertain that condition monitoring has improved the reliability of the machinery in production areas. Only 44 per cent of the maintenance staff strongly agreed.

Chart 4.46: Response of employees that condition monitoring has improved the reliability of the machinery in production areas

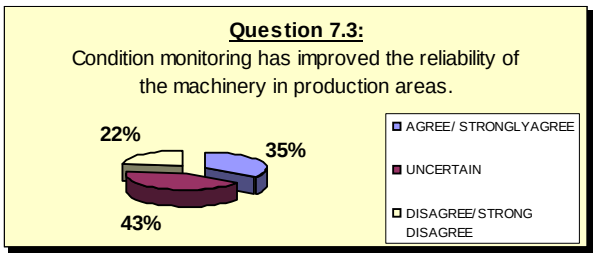


Chart 4.46 shows that 48 per cent of respondents were uncertain that condition-monitoring techniques are used or the equipment is available to the maintenance department to conduct this type of testing. This is the case if you consider all the respondents surveyed. However, if only technical maintenance employees are considered the results would have been different as these employees would understand the questions and be in a position to comment accurately.

Considering the response from the maintenance technician's only, maintenance employees indicated that they disagreed that the maintenance department had all the equipment needed for condition monitoring, they agreed that condition monitoring is being done and they also agreed that reliability of machinery was improved by condition monitoring.

4.10 OVERVIEW OF TOTAL PRODUCTIVITY MAINTENANCE (TPM) AT A PLASTIC PAINTING PLANT

The repairing of individual components after their failure (Corrective maintenance) is costly. To keep the losses such as loss in production due to breakdowns under control TPM combines with maintenance techniques such as planned and preventative maintenance to reduce these costs and improve the availability of the machinery and equipment to production.

The vision of Venture SA is to constantly produce plastic painted bumpers for customers at zero defects at lowest possible cost. In order to achieve this vision the company has implemented a planned preventative maintenance philosophy and partly introduced TPM and embarked on a process of optimisation of operating and maintenance costs.

The adoption of the TPM approach was undertaken to encourage the people on the floor to assist in the maintenance of their equipment and machinery. They are also encouraged to improve the production methods, which will lead to positive influences on equipment and machinery efficiencies reducing operating and maintenance costs.

4.11 THEORETICAL IMPLEMENTATION MODEL FOR TOTAL PRODUCTIVE MAINTENANCE

A theoretical seven-step implementation model for Total productive maintenance (TPM) (refer to Figure 2.3), which was developed and presented in chapter two, was used as a basis for the formulation of the questionnaire. It was established from the findings of the questionnaire presented earlier in this chapter that there was a trend of agreement / strong agreement from the respondents. In this section the proposed additions / alterations to the strategies and activities related to each phase of the model will be presented.

4.11.1 Proposed additions / alterations to steps of implementation model for total productive maintenance (TPM).

The seven steps of the implementation model for total productive maintenance (TPM) will be reviewed in terms of possible additions / alterations.

- **Step 1 – Select the TPM facilitator**

  No alterations / additions were proposed by the respondents. The author however has established by the survey that the selection of TPM facilitators at Venture SA East London plant has not taken place and 51

per cent of respondents strongly disagreeing that facilitators have been selected.

- **Step 2 – Select a first TPM pilot area and team**

  Several respondents 32 per cent strongly agreed and 52 per cent strongly disagreed that the selection of a TPM pilot area and team had taken place. Thus no fault can be found with the TPM implementation model. However this substantiates that no implementation has taken place at the Venture SA East London plant.

- **Step 3 – Develop TPM pilot area improvement goals**

  No alterations / additions were proposed by the respondents. 51 per cent of the respondents were uncertain, however the theoretical TPM implementation model cannot be faulted or dose not directly affects the level of uncertainty.

- **Step 4 – Train the operators in autonomous maintenance**

  No alterations / additions were proposed by the respondents. There is 49 per cent strongly agreed response from respondents indicating that technicians are trained in preventative maintenance. This is a good result considering that the majority of respondents were operators and not maintenance technicians.

  The theoretical TPM implementation model cannot be faulted or directly affect the response.

- **Step 5 – Training the maintenance technicians in preventative maintenance**

  No alterations / additions were proposed by the respondents.

There is 49 per cent average strongly agreed response from respondents indicating that technicians are trained in preventative maintenance. This is a good result considering that the majority of respondents were operators and not maintenance technicians.

- **Step 6 – Preventative maintenance**

  No alterations / additions were proposed by the respondents.
  47 per cent of respondents were uncertain whether predictive maintenance techniques were used.

- **Step 7 – Develop condition-monitoring systems**

  No alterations / additions were proposed by the respondents.

  48 per cent of respondents were uncertain whether condition-monitoring techniques were used or whether equipment is available to the maintenance department to conduct this type of testing.

  This is the case if you consider all the respondents surveyed. However if only technical maintenance employees are considered then the results would have been different as maintenance employees would understand the questions and be in a position to comment accurately.

Figure 4.1 Details of each phase of the seven-phase theoretical model for Total productive maintenance

Step 1 **Select the TPM facilitator**
The following steps are required to carry out a TPM implementation program: • Select the TPM facilitators in production areas. • Train all the employees in the production areas what TPM is about. • Involve all employees in the launch of the TPM program. • Develop islands of TPM excellence in production areas. • The rest of the plant employees are to be given an overview of what TPM

is.
Step 2 **Select a first TPM pilot area and team**
The selection of a TPM pilot area and team takes place as follows: • Select a multi functional team consisting of operators, maintenance technicians, supervisors and managers. • Train all team members in 5S and TPM. • Make all employees aware of lost production costs by displaying this information in the green areas. • Make all employees aware of quality problems by displaying this information in the green areas. • Make all employees aware of maintenance downtime by displaying this information in the green areas.
Step 3 **Develop TPM pilot area improvement goals**
The development of TPM pilot area improvement goals takes places as follows: • Set the TPM pilot area goals by consultation and consensus of the team. • Make all employees at all levels aware of the TPM goals that have been set. • The outcome should be a production area that is a model for other TPM areas.
Step 4 **Train the operators in autonomous maintenance**
The following issues need to addressed the training of operators in autonomous maintenance: • The operators are to be trained by the maintenance technician to carry out basic maintenance tasks. • Daily check sheets for all machinery need to be made up if they don't exist. • Machines need to be cleaned to identify any hidden defects.

• Identify all lubrication points on the machinery and equipment in the area. • Mark all operating pressures on pressure gauges, levels on all level indicators etc. • Paint all equipment and machinery that requires painting in the TPM area. • Set cleaning and lubrication standards for all equipment and machinery. • Train/ retrain all operators to know how the machines they operate works. • Make up checklists for operators. • Make up checklists for technicians. • Operators do daily checks on equipment and machinery.
Step 5 **Training the maintenance technicians in preventative maintenance**
The following aspects form part of training the technician in preventative maintenance: • The technician's role must be changed to a preventative maintenance mentality. • Maintenance technicians provide support to operators through training and communication. • Preventative maintenance checks are done by technicians. • A critical spares program is put in place. • Chronic problems on equipment and machinery are identified and eliminated. • Downtime is captured and analysed. • The 5 whys are used in problem solving and technicians are trained in this method.
Step 6 **Preventative maintenance**
The following issues are important in a preventative maintenance system: • All equipment that's condition can be monitored are checked using condition monitoring techniques.

• Oil analysis is used. • Infra red imaging photography is used.
Step 7 **Develop condition-monitoring systems**
The following aspects are to be discussed with regard to the development of a condition monitoring system: • The maintenance department should have the equipment to conduct most of the simple condition monitoring. • The condition monitoring can also be contracted out to companies that specialise in condition monitoring. This is the normal rout followed by plant engineers.

Source: Researchers own structure adapted from Pieterse (2005:78)

4.12 CONCLUDING REMARKS

The purpose of this chapter was to present and analyse the research findings of the Total Productive Maintenance (TPM) questionnaire. The results of the questionnaire were substantiated by information gathered and reported in chapter two.

The respondents' comments were summarised with a view to including them in the seven-step total productive maintenance (TPM) implementation model for organisations. The seven-step Total productive maintenance (TPM) implementation model was presented in chapter three figure 3.1 The details of each phase of the model were presented in Figure 4.1.

This resolved the sub-problems of the study, namely absences of Total productive maintenance (TPM) knowledge and awareness, unsatisfactory plant availability without Total productive maintenance (TPM), low level of implementation of Total Productive maintenance (TPM). How can the results obtained from the resolutions of sub-problems 1 and 2 be combined into a set of

strategies, which can be used by organisations to effectively implement a TPM program?

The final chapter presents a summary of the main findings and conclusions will be drawn based on the results of the empirical survey. This will be followed by recommendations on an effective seven-step Total productive maintenance (TPM) implementation model for organisations.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY OF THE MOST IMPORTANT FINDINGS FROM THE EMPIRICAL STUDY

The results of the salient research findings are based on facts established from the theoretical and empirical analysis. The findings were integrated with the findings of the literature survey, which examined strategies for seven-step Total productive maintenance (TPM) implementation model for the workplace. In this final chapter, the main findings will be summarised and conclusions will be drawn based on the results of the empirical survey. The problems that were experienced as well as limitations of the study will be highlighted. The research has identified several factors that are driving the need for a change at the Venture SA East London plant to a TPM philosophy. One of the factors is that firstly the globalisation of the manufacturing industries and customers are demanding more value. Recommendations regarding the implementation of a Total productive maintenance (TPM) programme, as well as strategies for further research will be discussed.

5.2 MAIN FINDINGS

After assessing the survey questionnaires the following main findings were established.

5.2.1 Bibliographical information

From the bibliographical information the researcher will address the following in his recommendations.

5.2.2 Age of the respondents

The majority of the respondents 94 per cent were older than 26 years of age. 46 per cent of the respondents were 26 –35 year age group; only six per cent of respondents were in the 20-25 years age group. Thus the majority of the work force has been employed for several years at Venture SA.

5.2.3 Gender of respondents

More than three quarters 81 per cent of the respondents were male and 19 per cent were female.

5.2.4 The involvement of respondents in TPM over the past three years

Three quarters 78 per cent of the respondents had not been involved in Total productive maintenance (TPM) in the past three years. This shows an absence of a TPM philosophy in the organisation and a need for proper implementation of TPM.

5.2.5 The job categories of respondents

The employee's response per job category is that 51 per cent were operators, 15 per cent were maintenance technicians and six per cent were in management positions.

5.2.6 The response that reliability of machinery had improved by respondents

20 out of the 63 that is 32 per cent of respondents answered yes that they had seen an improvement in the reliability of the machinery and equipment over the past year. This shows that although there is an absence of TPM this does not indicate a total absence of maintenance. This just indicates that another maintenance philosophy is being followed such as PM or RCM.

5.2.7 Survey Questionnaire

The majority of respondents agreed to the steps in the seven-step Total productive maintenance (TPM) implementation model presented in chapter four see figures 4.1. The model was developed from the theoretical and empirical research findings.

5.2.8 Suggested alterations to seven-step TPM implementation model

Several of the respondents suggested that some of the strategies or activities in the seven-step Total productive maintenance (TPM) implementation model do not need to the altered or eliminated, and these will be discussed below. The researcher will address these in his recommendations.

5.2.9 Selecting a TPM facilitator.

The respondent's felt that TPM facilitators had not been selected and the respondents had not been trained on what TPM is about. The rest of the plant employees have not been given an overview of what TPM is with the majority of respondents being uncertain. The developments of TPM islands of excellence have not been undertaken in production areas. The methodology suggested in the model is not flawed and should remain as it is. In this case this step has not been followed during implementation.

5.2.10 Selecting the first TPM pilot area and team.

A number of respondents indicated that they had not been trained in 5S or TPM, the majority of respondents were aware of lost production costs due to production loss and downtime. Respondents also agreed that quality was a problem and that downtime in their production area was high. However respondents disagreed that the machinery stopped often for maintenance downtime. There is a lack of training and poor implantation of TPM, the pilot

areas have not been selected. The methodology suggested in the seven step model in not flawed and must remain unchanged.

5.2.11 Development of TPM pilot area improvement goals

The respondents disagreed with the development of the TPM pilot area improvement goals, the majority being uncertain if these goals have been set, stating that this had not happened in their production areas. Respondents also disagreed that their areas are a model area for other TPM areas. The methodology suggested in the model is not flawed and must remain unchanged.

5.2.12 Training the operators in autonomous maintenance

The respondents agreed that operators were trained in autonomous maintenance and checklists were in place and being used. Respondents also agreed that operators were trained in the operation of their machinery, but not trained on 5S and TPM. The implementation of TPM goes hand in hand with 5S thus it is important that all the employees are trained in 5S as well as TPM. The methodology suggested in the model in not flawed and must remain unchanged.

5.2.13 Training the technician in preventative maintenance

The respondents were uncertain whether predictive maintenance was in place. This question would be better understood if it had been analysed using the response from maintenance employees in the organisation, as they would have been aware of the extent of implementation. The result of responses from maintenance employees only are that the majority strongly agree that the role of maintenance technicians has changed to a preventative maintenance approach, 65 per cent agreed that maintenance technicians provide support to operators, 54 per cent of operators agreed that preventative maintenance checks are done on their machinery. The methodology suggested in the model is not flawed and must remain unchanged.

5.2.14 Preventative maintenance

The respondents were uncertain that a condition monitoring system was in place. This question would be better understood if it had been analysed using the response from maintenance employees in the organisation, as they would have been aware of the extent of implementation. The results from the maintenance employees only are that 56 per cent agree that equipment that can be checked by condition mentoring are being checked, 89 per cent agree that temperature measurement is used to detect impending failure of machinery. 78 per cent agree that oil analysis is used to detect impending failure of machinery. The methodology suggested in the model in not flawed and must remain unchanged.

5.2.15 Develop a condition monitoring system

The results from the maintenance employees only are that only 44 per cent disagree that the maintenance department has the equipment needed for condition monitoring. This was a response to the question however the condition monitoring is contracted out to specialist firms. 56 per cent agreed that condition monitoring is done on machinery. 44 per cent agree that condition monitoring has improved the reliability of machinery. The methodology suggested in the model is not flawed and must remain unchanged.

5.3 PROBLEMS AND LIMITATIONS

No major problems were experienced during the study. However, several of the respondents approached were unaware of the meaning of TPM. Once this was explained by means of an example, all respondents were able to complete the survey questionnaire and no other further difficulties were encountered.

A limitation of the research endeavour was that only a limited number of employees were able to participate in the study. The study focused only on the Venture SA East London plant where 20 per cent of employees took part in the survey.

5.4 RECOMMENDATIONS

The objective of this study was to investigate the seven-step TPM implementation model that can be utilised by organisations. In order to achieve this objective it was necessary to adopt the following approach:

5.4.1 The approach followed to determine a TPM implementation model that can be utilised by organisations

- Firstly, a seven-step TPM implementation model was developed from the theoretical findings in chapter two. The model serves as a basis for organisations wanting to introduce a TPM programme to allow employees to unlock their potential and maximise their performance through autonomous maintenance.

- Secondly, TPM strategies employed by organisations were assessed in terms of the seven-step Total productive maintenance (TPM) implementation theoretical model. A questionnaire was used to establish whether respondents agreed / disagreed with the theoretical model. The use of the questionnaire was to determine the extent of TPM implementation at Venture SA East London plant.

- Thirdly, an integrated TPM implementation model presented in Figure 5.1 was developed. The seven-step Total productive maintenance (TPM) implementation model presents strategies that can be used by organisations to effectively implement a TPM program.

The researcher believes that for Total productive maintenance (TPM) to work in an organisation it needs to make use of the following recommendations:

5.4.2 Top down direction

Recommendation 1:

Firstly, it is imperative that top management get involved in the TPM implementation process this can be achieved by top management attending a workshop on TPM implementation. Thus top management will be made aware of the benefits of TPM and the disadvantages of not implementing TPM in the organisation.

The successful implementation of TPM requires clear direction to be given by top management. The goal being to avoid a haphazard approach were each organisation can decide if they will implement TPM and then develop their own unique approach. This approach prevents the sharing of knowledge or tools.

Secondly, this ensures that top management buys into the TPM program and provides the necessary support to the implementation team.

5.4.3 Integrating approaches

Recommendation 2:

TPM approach must be integrated with the existing PM systems. The establishment of stand-alone processes creates “process silos” were each process has to compete with others.

5.4.4 Data driven decisions

Recommendation 3:

There is a lack of useful data available to the shop floor employees at Venture SA East London plant also this data is not being effectively utilised. This makes the driving of decisions difficult, simple data collection processes need to be developed and implemented. This allows the data to be used immediately by shop floor employees to access the success of any changes implemented to the production process equipment.

5.4.5 The workshop objectives

Recommendation 4:

The aim of the workshop is to transform the organisation from the top down by developing new ways of performing maintenance work. With the help of the seven-step TPM implementation model implement a TPM program at Venture SA East London plant. The aim should be for this plant to become a model TPM plant for all other Venture SA plastic painting plants. resulting in an inevitable improvement in machinery performance and the motivation of the workforce by involvement of all employees in the maintenance program.

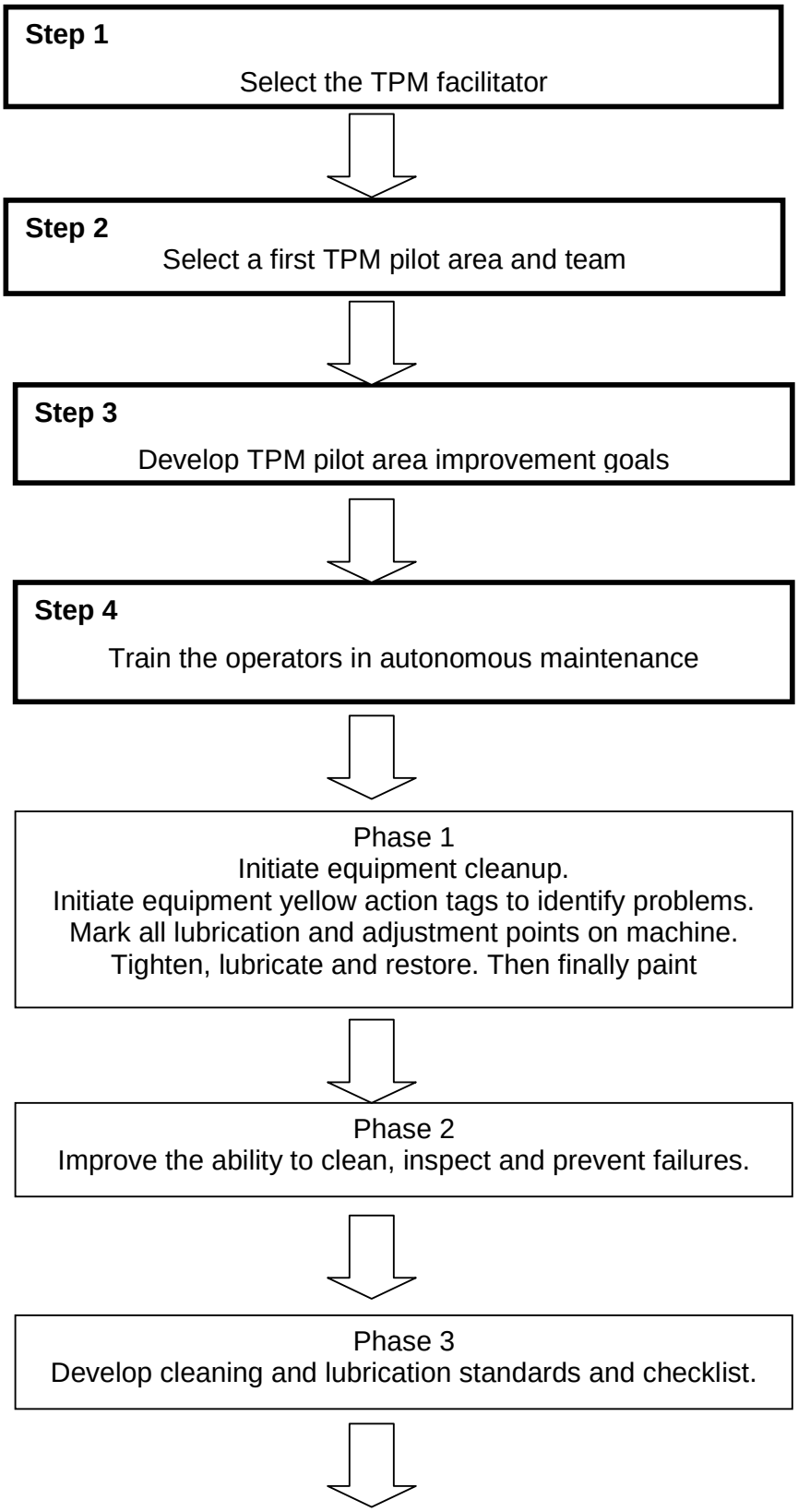
5.5 A TPM IMPLEMENTATION MODEL FOR VENTURE SA

There are many models for the implementation of Total productive maintenance (TPM). The following model was proposed for the implementation of a TPM philosophy at Venture SA's East London plant.

Pieterse (2005:78) states that Total productive maintenance (TPM) is a drastic step, but necessary changes in the way companies do business. Past research by Pieterse on the most commonly used lean manufacturing tools has shown that TPM is not widely adopted among automotive suppliers. The implementation must be planned and executed carefully and commitment by top management must be guaranteed. The implementation of TPM is not a quick process and the process must be sustained and supported by top management throughout the implementation phases.

The theoretical model shown in figure 5.1 is a typical implementation model and the steps and phases should be followed exactly for successful implementation (Pieterse, 2005:78).

Figure 5.1: Implementation model for Total productive maintenance (TPM)



Phase 4
Develop equipment operating skills and general inspection standards and checklists

Phase 5

Implement daily operator activities

Step 5

Training the maintenance technicians in preventative maintenance

Phase 1

Provide technical support to operators

Phase 2

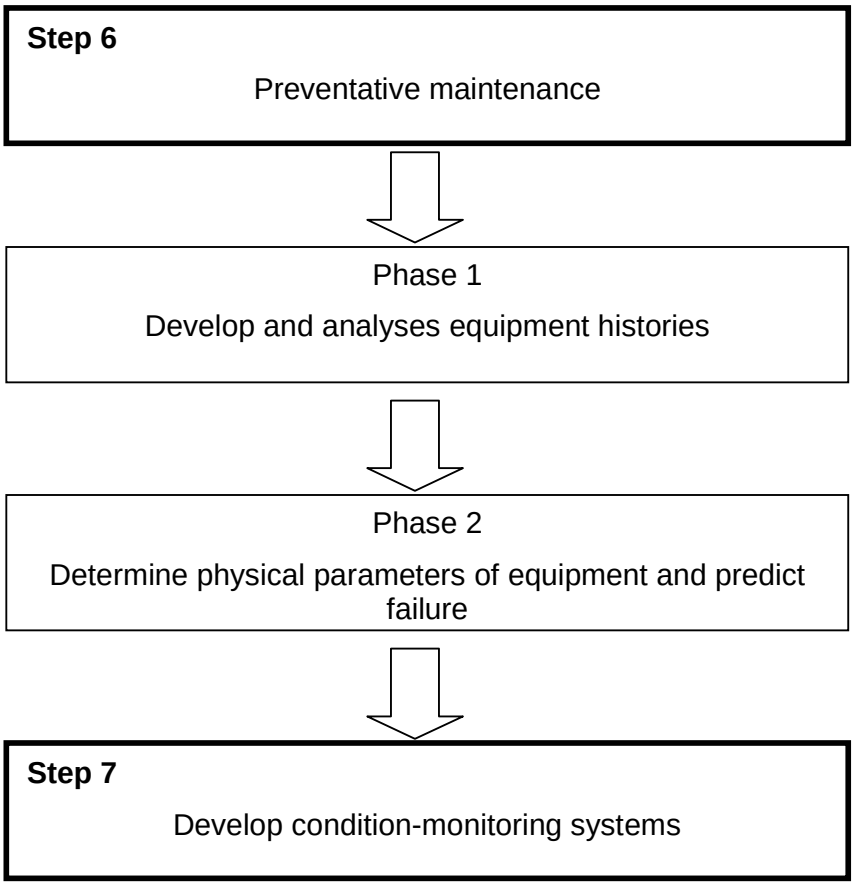
Develop a critical spares management program

Phase 3

Eliminate equipment deterioration through scheduled general inspection and equipment overalls

Phase 4

Identify chronic equipment problems and eliminate them



Source: Pieterse (2005:78)

5.6 OPPORTUNITIES FOR FURTHER RESEARCH

A number of related issues could be addressed by further research. Some of these research issues are outlined below.

- The development of an improved TPM model that can be used by Heads of Department and maintenance managers for the integration of autonomous maintenance in organisations.

- The development of an assessment tool for measuring the TPM culture in organisations.

- Further research should be conducted at other organisations as it can be seen from the results of the questionnaire that the understanding and implementation of TPM at Venture SA East London plant is inadequate.

- Quantifying the benefits of TPM, this is a major hurdle facing most implementers of TPM. There has been little success in isolating a piece of production equipment, applying the TPM process and measuring the benefits. This is due to the long time frame required to implement TPM and the difficulty in isolating the benefits.

5.7 CONCLUDING REMARKS

In this chapter the main findings were outlined from the survey undertaken. It was established that more male employees compared to female employees are involved in Total productive maintenance (TPM) in organisations.

A model for the implementation of TPM is presented. This is a generic model that can be used in any organisation.

The majority of respondents agreed to the seven-step total productive maintenance (TPM) implementation model, with only a few minor changes taking place. Other findings were summarised. Problems encountered as well as limitations of the study were explained. Opportunities for further research were outlined. Finally, recommendations based on the research findings were made.

It was clear from the research findings that not all employees have been exposed to TPM at the Venture SA East London plant. This can be attributed to the fact that managers believe that maintenance should only take place when there is a problem and have a “we run it you fix it mentality”. Yet these managers fail to realise that by incorporating a TPM philosophy into an organisation helps to retain and develop

employees through involvement in autonomous maintenance. It also helps to minimise the unnecessary loss of production due to unscheduled machinery stoppages. TPM also eliminates the six big losses such as breakdowns, set up and adjustment losses, idling and minor stoppages, reduced speed, defect and rework and setup and yield losses.

Today, the reality of the global economy places enormous pressures on organisations to be increasingly competitive. Organisations need to be flexible, able to grow and learn on a continuous basis. The success of organisations relies on the implementation of an effective maintenance strategy thus the implementation of TPM can no longer be avoided and the benefits outweigh the disadvantages.

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ANNEXURE A

QUESTIONNAIRE COVERING LETTER

Dear Respondent

ASSESSMENT OF THE ABSENCE OF A TOTAL PRODUCTIVE MAINTENANCE (TPM) PROGRAM AT A PLASTIC PAINTING PLANT.

Your assistance in filling and returning this questionnaire will be highly appreciated. It should only take a few minutes of your time.

In order to meet the requirements for the Masters Degree in Business Administration (MBA) at the Nelson Mandela Metropolitan University, I am currently conducting a survey on the absence of Total productive maintenance (TPM) implementation by organisations.

It will be highly appreciated if you can complete this questionnaire and return it to me by the 31 August 2006.

Please indicate if you wish to receive a copy of the summary of the findings.

Yours sincerely

……	……..
Calvern Anthony Hempel	**Doctor S. Krause**
Researcher	**Promoter**

Nelson Mandela Metropolitan University

for tomorrow

ANNEXURE B QUESTIONNAIRE

Nelson Mandela Metropolitan University – Masters Business Administration

Management / employee survey on the absence of Total productive maintenance (TPM) program at a plastic painting plant.

All information provided in the questionnaire will be treated as confidential.

Venture SA

20/7/2006

Job title: _____

Type of work activity: _____

INSTRUCTIONS:

1. All statements can be answered by simply placing a cross (x) in the appropriate block. Please do not mark more than one block per statement.

Strongly agree.	Agree.	Uncertain.	Disagree.	Strongly Disagree.

5 - Strongly agree.

4 - Agree.

3 - Uncertain.

2 - Disagree.

1 - Strongly disagree.

2. Please answer all the questions. If you do not find a answer that exactly fits your perception, please mark the answer closest to it.

6 July 2006

RESEARCH QUESTIONNAIRE

SECTION A : DEMOGRAPHIC INFORMATION

Please mark the appropriate box with an X

1. What is your age?

	20 – 25 years	(1)
	26 – 35 years	(2)
	36 – 45 years	(3)
	46 + years	(4)

2. What is your gender?

	Male	(1)
	Female	(2)

3. What is your highest qualification?

	High School	(1)
	Bachelor's degree or diploma	(2)
	Honour degree or equivalent	(3)
	Master's degree	(4)
	Doctorate	(5)

4. How long have you been working for the organisation?

	0 – 1 years	(1)
	2 – 5 years	(2)
	6 – 10 years	(3)
	11 – 15 years	(4)
	16 + years	(5)

5. What position do you hold?

……

6. Have you been involved in the TPM program in the past three years?

	Yes	(1)
	No	(2)

7. Has the reliability of the machinery in your organisation improved?

	Yes	(1)
	No	(2)

If yes;

Over the past year		(1)
Over the past three years		(2)

SECTION B : SEVEN-PHASE Total productive maintenance (TPM) IMPLEMENTATION MODEL

This section of the questionnaire is designed to assess the absence of Total productive maintenance (TPM) found in organisations. Please indicate the degree to which you agree / disagree with the following statements by marking with an X on the appropriate box.

STEP 1 : SELECT A TPM FACILITATOR.

Please indicate the degree to which you agree / disagree with the following statement to define the selection of a TPM facilitator.

		(5)	(4)	(3)	(2)	(1)
SELECT A TPM FACILITATOR		Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
1.1	TPM facilitators have been selected in the production areas.					
1.2	You have been trained on what TPM is about.					
1.3	You had been involved in the launch of the TPM program.					
1.4	A TPM island of excellence has been developed in production areas.					
1.5	The rest of the plant employees has been given an overview of what TPM is.					

STEP 2 : SELECT THE FIRST TPM PILOT AREA AND TEAM.

Please indicate the extent to which you agree / disagree that the following activities can be used to select the first TPM pilot area and team.

		(5)	(4)	(3)	(2)	(1)
SELECT THE FIRST TPM PILOT AREA AND TEAM.		Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
2.1	You have been trained in 5S and TPM.					
2.2	Lost production costs are a major problem in your production area.					
2.3	Downtime costs are a major problem in your production area.					
2.4	Quality problems are a major problem in your production area.					
2.5	Maintenance downtime is high in your production area.					
2.6	Machinery stops often for maintenance problems.					

STEP 3 : DEVELOPMENT OF TPM PILOT AREA IMPROVEMENT GOALS.

Please indicate the extent to which you agree / disagree with the following statements regarding the development of TPM pilot area improvement goals.

		(5)	(4)	(3)	(2)	(1)
DEVELOPMENT OF TPM PILOT AREA IMPROVEMENT GOALS.		Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
3.1	TPM pilot area improvement goals have been set for your production area.					
3.2	You are aware of the TPM improvement goals targets set for their production areas.					
3.3	Your production area is a model for other TPM areas.					

STEP 4 : TRAIN THE OPERATOR IN AUTONOMOUS MAINTENANCE.

Please indicate the extent to which you agree / disagree that the following statements regarding training the operator in autonomous maintenance.

		(5)	(4)	(3)	(2)	(1)
TRAIN THE OPERATOR IN AUTONOMOUS MAINTENANCE.		Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
4.1	The machinery in your department is clean.					
4.2	Daily checks are carried our on machinery and equipment.					
4.3	Yellow TPM action tags are used to identify problems on equipment.					
4.4	All the lubrication points on machines are marked for easy identification.					
4.5	Operating pressure is marked on air or oil or stream pressure gauges.					
4.6	The equipment in the production areas needs to be painted.					
4.7	The equipment in the production areas needs to be cleaned.					
4.8	The ability to clean, inspect and prevent failures on machinery has improved over the past year.					
4.9	Lubrication and cleaning standards are set for machinery.					
4.10	Operators know how the machinery they operate works.					

4.12	There are checklists for operators.					
4.13	There are checklists for technicians.					
4.14	Operators conduct daily checks on machinery and equipment they operate.					

STEP 5 : TRAIN THE MAINTENANCE TECHNICIANS IN PREVENTATIVE MAINTENANCE.

Please indicate the extent to which you agree / disagree with the following statements regarding the training of the maintenance technicians in preventative maintenance.

		(5)	(4)	(3)	(2)	(1)
TRAIN THE MAINTENANCE TECHNICIANS IN PREVENTATIVE MAINTENANCE.		Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
5.1	The role of the maintenance technician has changed from a fire fighting mentality to a preventative maintenance approach with support to operators over the past year.					
5.2	Maintenance technicians provide support to operators by having direct contact with the operator.					
5.3	Maintenance technician's do preventive maintenance checks.					
5.4	There is a critical spares program in place.					
5.5	Chronic problems with equipment are identified.					
5.6	Chronic problems with equipment are eliminated.					
5.7	The downtime is captured and analysed by the engineering department					
5.8	The 5 whys is used to analyse data and eliminate equipment problems.					

STEP 6 : PREDICTIVE MAINTENANCE.

Please indicate the extent to which you agree / disagree that the following issues should be discussed on the implemented of predictive maintenance system.

		(5)	(4)	(3)	(2)	(1)
PREDICTIVE MAINTENANCE.		Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
6.1	The equipment that can be monitored is checked using condition monitoring techniques. (e.g. fans vibration monitoring)					
6.2	Temperature measurement is used to detect impending failure of equipment. (e.g. thermal imaging of DB's)					
6.3	Oil analysis measurement is used to detect impending failure of equipment (e.g. oil analysis of transformers and moulding machines)					

STEP 7 : DEVELOP CONDITION MONITORING SYSTEM.

Please indicate the extent to which you agree / disagree with the following issues to be discussed on development of a condition monitoring system.

		(5)	(4)	(3)	(2)	(1)
DEVELOP CONDITION MONITORING SYSTEM.		Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
7.1	The maintenance department has all the equipment needed for condition monitoring of machinery in the plant.					
7.2	Condition monitoring is done on machinery that allows for this method of monitoring an impending failure.					
7.3	Condition monitoring has improved the reliability of the machinery in production areas.					

ANNEXURE C: Why – Why problem analysis.