A PROPOSED STRATEGY FOR THE IMPLEMENTATION OF TOTAL PRODUCTIVE MAINTENANCE AT CONTINENTAL TYRE SOUTH AFRICA

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DECLARATION

"I, Christie Olivier, hereby declare that:

- **The work in this dissertation is my own original work;**
- **All sources used or referred to have been documented and recognized; and**
- **This dissertation has not been previously submitted in full or partial fulfilment of the requirements for an equivalent or higher qualification at any other recognized education institution."**

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CHRISTIE OLIVIER **DATE**

ABSTRACT

For a tyre manufacturing company to compete nationally and internationally, the maximum utilization of their equipment is extremely important. Thus, having a maintenance system in place that will ensure this will be essential.

In today's competitive environment, the need to go further than just scheduling maintenance in accordance with manufacturer's recommendations as a method of improving productivity and product quality was quickly recognized by those companies who were committed to total quality management programmes.

The objective of this study was to propose an appropriate strategy for the implementation of Total Productive Maintenance at Continental Tyre South Africa. To achieve this, the current Total Productive Maintenance (TPM) programme, in the steel stock preparation division in affiliated Continental plants in Otrokovice in the Czech Republic and Puchov in the Slovak Republic was evaluated. A comprehensive literature study was performed on Total Productive Maintenance programmes.

A questionnaire was designed based on the guidelines in the literature study in order to establish the effectiveness of implemented TPM programmes. The researcher used the random sampling method of selection and distributed the questionnaire to 62 potential respondents via hand-outs from each plant's respective heads of departments. 56 completed questionnaires were returned and these were processed and analyzed using Microsoft Office Excel 2003, running on the Windows XP suite of computer packages.

The opinions of the various respondents were compared with the guidelines provided in the literature survey, in order to identify how to answer two main questions the author wanted to use as part of selecting an appropriate implementation approach for TPM at Continental Tyre South Africa.

These were:

- How much are the employees involved and empowered to perform their TPM tasks?; and
- How effective is the implemented TPM programme?

The following were the main recommendations and conclusions:

- The experiences gained by plants like Otrokovice and Puchov must be used as a guideline for introduction and implementation;
- The employees that will be required to perform the TPM tasks must be properly trained and they should receive the necessary tools to perform their tasks;
- It is essential that everyone throughout the entire manufacturing organization is involved from the start in the development, improvement and maintenance of the TPM programme and that the driving force behind it should be a combination of maintenance, production and quality; and
- TPM will achieve it's objectives if:

  - The equipment effectiveness can be improved;
  - Autonomous maintenance is achieved;
  - Planned maintenance is in place;
  - Staff are trained in relevant maintenance skills; and
  - Early equipment management can be achieved.

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CHAPTER 1

PROBLEM DEFINITION AND DEFINITION OF KEY CONCEPTS

1.1. INTRODUCTION

Total productive maintenance (TPM) is destined to be the cornerstone for all future maintenance programmes. Therefore, before looking at the future of TPM let's take a look at the history of TPM as described by various researchers.

Venkatesh (2005) describes TPM as an innovative Japanese concept, the origin of which can be traced back to 1951 when preventive maintenance was introduced in Japan. Nippondenso, a major supplier to the Toyota Motor Company, was the first company to introduce plant wide preventive maintenance in 1960. Preventive maintenance is the concept wherein, operators produced goods using machines, and the maintenance group was dedicated to the work of maintaining those machines. However, because of the extra cost of maintenance staff, autonomous maintenance had to become part of a production operators' daily work. The maintenance crew was given the responsibility for equipment modification and improving reliability. The modifications were made or incorporated in new equipment. This led to maintenance prevention. Thus, preventive maintenance along with maintenance prevention and maintainability improvement gave birth to productive maintenance. The aim of productive maintenance was to maximize plant and equipment effectiveness to achieve an optimum life cycle cost of production equipment.

Slack, Chambers and Johnston, (2001:659) define total productive maintenance (TPM) as the productive maintenance carried out by all employees through small group activities, where productive maintenance is maintenance management that recognizes the importance of reliability, maintenance and economic efficiency in plant design.

There is a continuous search to improve maintenance activities. Emphasis is placed on the interaction between operators and maintenance staff to maximize up- time. The technical skills required for total productive maintenance are daily equipment checking, machine inspection, fine-tuning machinery, troubleshooting and repair.

Total productive maintenance is not costly to implement. However, it is not easy and should not be perceived as a short-term measure. It will not work unless it is given the wholehearted backing of management. The key to introducing total productive maintenance lies in the effectiveness of communications. It is usually necessary to choose one or more pilot areas in order to try out total productive maintenance, to demonstrate its benefits and establish the practical requirements of implementing total productive maintenance on a particular site.

1.2. MAIN PROBLEM

Roberts (1997) maintained that total productive maintenance evolved from total quality management, which evolved as a direct result of Dr. W. Edwards Deming's influence on the Japanese industry. According to Roberts (1997), the need to go further than just scheduling maintenance in accordance with a manufacturer's recommendations as a method of improving productivity and product quality, was quickly recognized by those companies who were committed to the total quality management programmes. To solve this problem and still adhere to the total quality management concepts, modifications were made to the original total quality management concepts. These modifications elevated maintenance to the status of being an integral part of the overall quality programme.

Although TPM was formulated during the 1970s, Nakajima (1989) postulates that it became popular among manufacturing professionals only after the late 1980s. Blanchard (1997) states that TPM emanated from the realization that

maintenance activities should not only be improved but also blended with managerial concepts. In particular, the importance of applying total quality for enhancing the quality of maintenance activities facilitated the evolution of TPM concepts. The fast rate of acceptance of TPM indicates the desire of today's practitioners for improving maintenance quality.

For a tyre manufacturing company to compete nationally and internationally, the maximum utilization of their equipment is extremely important. Thus, having a maintenance system in place that will ensure this will be advantageous. Currently, there is a reasonably high incidence of machinery and equipment breakdowns, causing frequent disruptions to the production schedules. Many product managers' working day consists of a series of problems that have to be resolved quickly, punctuated by a badly run meeting or two and some paperwork. They tend to be working in reaction mode without very much to show for their efforts. They would rather want to be able to plan and support improvement initiatives and to learn about new approaches and techniques. Many managers would be surprised by how factory floor personnel perceive them.

Davis (1994:5) argues that too many supervisors and managers are incompetent, badly informed and constantly making decisions that they don't completely understand, or pass the decision making to support department managers. It is because of this regime of crisis management, lack of management visibility, poor communications and lack of planning that this perception exists, and management credibility is all too often low. Factory personnel feel that they are never consulted or listened to, even in matters that they are properly qualified to give advice on. Thus they tend to let management get on with ill-informed decisions and mistakes and therefore become more and more frustrated. Implementing Total Productive Maintenance can make a large contribution to the meaningful involvement of factory workers in improvement initiatives whilst also ensuring higher machine availability.

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

What is the appropriate method for the implementation of Total Productive Maintenance at Continental Tyre South Africa?

1.3. SUB-PROBLEMS

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

(a) What does the literature reveal about total productive maintenance in manufacturing organizations?;
(b) What does a statistical analysis of the current status of maintenance, through evaluation of machine breakdown reports, at Continental Tyre South Africa reveal and what does a questionnaire about implemented TPM systems in affiliated Eastern European tyre manufacturing plants reveal?; and
(c) What implementation approach would be suitable to introduce TPM successfully at Continental Tyre South Africa?

1.4. DEMARCATION OF THE RESEARCH

In this study the empirical part of the research was focused on the steel material preparation departments at the tyre manufacturing plants of Continental Puchov, Slovakia and Otrokovice in the Czech Republic. A small part of the research also included Continental Tyre South Africa. However, the information gathered did not include any questionnaires, only actual machine breakdown data. The exclusion of other manufacturing departments within these plants and other manufacturing plants did not imply there was no need to research them.

1.4.1. Work level of the study group

The study was limited to operating level personnel within the steel stock preparation divisions of manufacturing. Management and supervisory level personnel were excluded.

1.4.2. Size of organization

The two organizations researched together employed approximately 4000 people, with Otrokovice having the largest share of 3000 personnel and Puchov the rest.

1.4.3. Geographical demarcation

The empirical component of the study was limited to the Continental plants in Puchov, Slovakia and Otrokovice in the Czech Republic, which are located in Eastern Europe.

1.5. DEFINITION OF KEY CONCEPTS

1.5.1. Total productive maintenance

Roberts (1997) claimed that total productive maintenance is a maintenance programme concept and philosophically it resembles total quality management in several aspects, such as:

- Total commitment to the programme by upper level management is required;
- Employees must be empowered to initiate corrective action; and

- A long-range outlook must be accepted as total productive maintenance may take a year or more to implement and is an on-going process.

Changes in employee mind-set toward their job responsibilities must take place as well. Total productive maintenance brings maintenance into focus as a necessary and vitally important part of the business.

1.5.2. Continuous improvement

Logathesis (1992:19) stated that there is a Japanese word describing the approach to gradual process improvement involving everybody. This word is *kaizen* and it is Japanese for continuous improvement. There are two distinct features inherent in the *kaizen* philosophy:

- There is urgency about the never-ending efforts for improvements and gradual change for the better. It is within this feature that total productive maintenance is very important; and
- There is an emphasis on the process rather than on the output.

1.5.3. Overall equipment efficiency

According to Ljungberg (1998:496), the definition for overall equipment efficiency includes downtime and other production losses which reduces throughput. Three dimensions of effectiveness are considered, namely availability, performance rate and quality rate.

The definition of overall equipment efficiency does not take into account all factors that reduce the capacity utilization, e.g. planned downtime, lack of material input, lack of labour, etc. (Nakajima, 1989).

1.5.4. Total quality management

Total quality management is an enhancement to the traditional way of doing business. It is a proven technique to guarantee survival in world-class competition. Only by changing the actions of management will cultures and actions of an entire organization be transformed. Total quality management is the art of managing the whole to achieve excellence. Besterfield (1998:458) defines total quality management as follows:

TQM is defined as both a philosophy and a set of guiding principles that represent the foundation of a continuously improving organization. It is the application of quantitative methods and human resources to improve all the processes within an organization and exceed customer needs now and in the future. TQM integrates fundamental management techniques, existing improvement efforts, and technical tools under a disciplined approach.

1.6. KEY ASSUMPTIONS

The following assumptions are made.

1.6.1. Assumption one

Assuming that Continental Tyre South Africa needs to compete nationally and internationally, it will have to reduce cost, improve quality and overall equipment efficiency and utilization.

1.6.2. Assumption two

It is assumed that the management of Continental Tyre South Africa wishes to adopt the total productive maintenance philosophy as part of their future strategic objectives.

1.7. SIGNIFICANCE OF PRIOR RESEARCH

1.7.1. Total productive maintenance

Ford, Eastman Kodak, Dana Corporation, Allen Bradley and Harley Davidson are but a few recognized companies that have implemented total productive maintenance successfully. All of them reported an increase in productivity using total productive maintenance. Today, with competition in industry at an all time high, total productive maintenance may be the only thing that stands between success and failure for some companies. It has been proven that it works. Employees must be educated and convinced that total productive maintenance (TPM) is not just another “buzz word” and that management is totally committed to the programme and the extended time frame necessary for implementation. If everyone involved in a total productive maintenance programme does his or her part, an unusually high rate of return compared to resources invested can be expected. (Roberts, 1997)

1.7.2. Continuous improvement

Schonberger & Knod (1988:197) wrote that production systems have been devised to make continuous improvement part of the employee’s job and productivity improvement rates have been spectacular in many Japanese companies. Indeed, it is popular for Japanese industrial people to speak in terms of a 67 percent learning curve, which is exceedingly high. 33 percent between doubled their quantities compared with typical Western rates of 5 to 20 percent.

1.7.3. Multi-skilled workers organized in teams

Teamwork implies the organization of up to 15 workers into self-managed flexible groups, each with a team leader. Team members rotate jobs and make collective decisions on how to manage the part of the production process for which they are responsible. The team takes over indirectly productive work, such as maintenance and repair, and quality control; the greater the variety of tasks, in place of monotonous work, stimulates greater motivation and provides more satisfaction; along with the introduction of teams, the number of wage grades tend to be reduced, and pay is more closely tied to effort and performance (Mission directed work teams 2004).

1.7.4. Empowerment of the work force

Empowerment means giving staff the authority to make changes to the job itself, as well as how it is performed. This can be designed into jobs to different degrees such as suggestion involvement, job involvement or high involvement. Mora (2000), suggests that empowerment is the deal, whilst trust, delegation and abundant appropriate training is the process and their ownership over the product, process and plant is the response.

1.8. OVERVIEW OF RELATED LITERATURE

1.8.1. Introduction

Todd (1994:4) stated that ever since the days of Henry Ford (and probably long before that), management of manufacturing companies have recognized the need to keep finding better ways to do things. Todd (1994:16) argues that continuous improvement in manufacturing has been the driving force behind many organizational strategies for many years. It is important to know that in order to be a successful company, improving manufacturing efficiency at least

as fast as competitors in order to survive as well as improving a lot faster than the competition to keep the job security and prospects that come from success, is required.

Nakajima (1988:4) reports on the success of the Nishio pump factory in Japan. Although this plant has cut metal processing for car pump parts, as well as oil and metal filling dust, there is neither oil nor dust on the floor. A successful worker participation campaign initially contributed to a cleaner workplace. At this plant the standards for a clean workplace are based on the 6 S's, these include the traditional 5 S's (*seiri* - organization, *seiton* - tidiness, *seiso* - purity, *seiketsu* - cleanliness and *shitsuke* – discipline), plus a sixth S, *shikkari-yarou*, or "let's try hard!" – which means every person should show initiative and make a special effort. According to Nakajima (1988:5) these workers efforts eventually bore fruit and since May 1982, there have been no equipment breakdowns. Prior to total productive maintenance implementation, they numbered more than 700 per month. Furthermore, it is reported that there are a mere 11 defects for every one million pumps produced.

Since South Africa's re-entry into the international arena, the tyre manufacturing industry has had to compete with fierce competition from world-class manufacturers. To become more competitive, it has to increase productivity to reduce costs while maintaining a high standard of quality. Since many of the products that are produced at Continental Tyre South Africa are destined for the European and Asian markets, it is important to make use of best practices to ensure that it is viable to export products to these markets. Therefore, to increase productivity, total productive maintenance will provide additional support.

1.8.2. Total Productive Maintenance

Venkatesh (2005) explained that TPM is an innovative approach to maintenance that maximizes equipment effectiveness, eliminates breakdowns, and promotes autonomous maintenance through day-to-day activities involving the total workforce. Thus TPM is not a specific maintenance policy, it is a philosophy, a culture and a new attitude towards maintenance. TPM is a three letter word, which could be best describes as follows:

- Total: Involvement of all functions and people at all level of the organization;
- Productive: Efficient and effective utilization of all the resources; and
- Maintenance: Keeping a man-machine-material system in an optimal condition.

The philosophy underlying TPM is that clean and better kept equipment is less likely to break down and any discrepancy that could have ended up as a major problem is easily detected and addressed in the earliest stages. It builds a culture of equipment and shop floor orientation through total employee involvement with a focus on customers. It builds an attitude of plant ownership whereby any stoppage of plant because of breakdown / failures or any wastage is considered as a shame.

1.9. RESEARCH DESIGN

The following procedure was adopted to solve the main and sub-problems.

1.9.1. Literature survey

A study of the literature was conducted which assisted in understanding the concepts of total productive maintenance associated with manufacturing industries. It was conducted with the use of secondary resources in the form of

textbooks, articles, research reports, the internet and unpublished internal documents.

1.9.2. Empirical study

A survey was conducted among the production operators and assistants within the steel stock preparation divisions of Barum Continental Otrokovice and Continental Matador Puchov in the Czech and Slovak Republic respectively. Using a questionnaire drawn up by the researcher, an analysis of implemented TPM systems in Eastern European Tyre manufacturing plants was done. The researcher obtained permission from the respective heads of the Commercial vehicle tyre divisions of the above mentioned plants to conduct the said research. In addition, actual breakdown analysis data was collected from the steel preparation area for the entire 2006 year to highlight the current status and effectiveness of the planned maintenance approach currently employed by Continental Tyre South Africa.

1.9.3. Analysis, conclusions and recommendations

The results of the literature survey and the empirical study were used to establish what total implementation model could be used to introduce TPM effectively at Continental Tyre South Africa and also what implementation process would be suitable to introduce TPM successfully at Continental Tyre South Africa?

1.10. OBJECTIVES OF THE STUDY

The purpose of this study was to assess how effective the current maintenance programme at Continental South Africa is, what the requirement is to run an effective TPM programme and how effective an implemented TPM programme is.

The objectives of the study were to:

- Assess the current effectiveness of the planned maintenance approach employed by Continental Tyre South Africa;
- Evaluate, using a questionnaire, how an implemented TPM system is perceived by a sample of employees in Continental Puchov, Slovakia and Otrokovice in the Czech Republic ; and
- Make recommendations on the approach Continental Tyre South Africa can use to implement an effective TPM system.

1.11. OUTLINE OF THE DISSERTATION

The study includes the following chapters.

Chapter 1: PROBLEM DEFINITION AND KEY CONCEPTS

Chapter 2: TOTAL PRODUCTIVE MAINTENANCE

Chapter 3: THE EMPIRICAL STUDY

Chapter 4: ANALYSIS AND INTERPRETATION OF THE RESEACH

Chapter 5: CONCLUSIONS AND RECOMMENDATIONS

1.12. CONCLUSION

This chapter introduced the research problem to be investigated as well as three sub-problems. Definitions of the terms used in the research were provided as well as the significance of the research. The demarcation of the research covered manager level, sample size and the geographical area. The research design was outlined for this study with the objectives of this paper.

Chapter 2 will provide an overview of total productive maintenance as well as the guidelines to be used when establishing an effective total productive maintenance system.

CHAPTER 2

TOTAL PRODUCTIVE MAINTENANCE

2.1. INTRODUCTION

Nakajima, as cited by Robinson & Ginder (1995:1), describes TPM as a "productive maintenance carried out by all employees through small group activities." He considers it an equal partner to total quality management in the attainment of world class manufacturing. According to TPM principles, the responsibility for optimizing equipment lies not just with the maintenance department, but with all plant personnel. Therefore, TPM is defined as a plant improvement methodology which enables continuous and rapid improvement of the manufacturing process through the use of employee involvement, employee empowerment and closed loop measurement of results.

Venkatesh (2005) argues that TPM can be considered as the medical science of machines. He continues by saying that TPM is a maintenance plan which involves a newly defined concept for maintaining plants and equipment. The goal is therefore to markedly increase production, while at the same time, increasing employee morale and job satisfaction.

Roberts (1997), states that the TPM programme closely resembles the popular Total Quality Management (TQM) programme and many of the same tools such as employee empowerment, benchmarking, documentation, etc. is used to implement and optimize TPM. Williamson (2000) suggest that TPM is the equipment and process improvement strategy that links many of the elements of a good maintenance programme to achieve higher levels of equipment effectiveness and includes:

- Improving equipment effectiveness by targeting the major losses;
- Involving operators in the daily, routine maintenance of the equipment;
- Improving maintenance efficiency and effectiveness;
- Training for everyone involved; and
- Life-cycle equipment management and maintenance prevention design.

Davis (1994:86) identifies the “six big losses” that encompasses the starting point for any plant that wants to implement TPM as part of their philosophy. The six big losses are really questions that are required to be asked of the people on the shop floor to understand whether there is a need to implement TPM activities. These questions are as follows:

1) Does the machine ever break down? If so, how often and why? Usually for how long?
2) Does the machine ever have to be changed over and / or set-up? If so how often? How long does it normally take?
3) Does the operator have to stop due to:
   - Minor breakdowns which are fixed quickly?
   - Things that stick?
   - The machinery having to be shut down or re-set?

   If so, how often? How long does each stoppage last, on average?
4) Are the machinery / processes working more slowly than it should? How often does it happen? How does it affect the production rate.
5) Do the machinery / process ever produce scrap or product that has to be re-processed. If so, how often? How much product or time is lost on average?

These six major losses will give a clear indication to a plant whether it is in need of TPM or not, or whether the TPM process that has been introduced is achieving the desired results that were expected when TPM activities were introduced.

The big six losses measure the cause of deterioration in separate components. Once the cause is known, it is possible to eliminate the cause and improve the overall equipment effectiveness. In the rest of the chapter, the researcher will explain the role of TPM, what the foundation is upon which TPM is based, how quality aspects like continuous improvement, employee involvement and teamwork fits into the TPM strategy. In addition the researcher will explain how TPM can be successfully implemented using strategies prescribed by a number of other researchers and finally highlight the benefits that can be achieved by implementing TPM.

2.2. THE ROLE OF TOTAL PRODUCTIVE MAINTENANCE

To understand what the role of TPM is one has to understand first of all what the definition of TPM entails. Shirose (1992:17) offers the following five point definition for TPM:

1) It aims at getting the most efficient use out of equipment;
2) It establishes a total (company-wide) PM system encompassing maintenance prevention, preventative maintenance and improvement related maintenance;
3) It requires the participation of equipment designers, equipment operators and maintenance department workers;
4) It involves every employee from top management down; and
5) It promotes and implements PM based on autonomous, small group activities.

To investigate the role TPM plays in an organization, one has to consider various aspects that play a part in the TPM process. These include aspects like current systems, procedures, processes, equipment and people. According to Davis (1994:4), when first introduced to TPM, its principles and approach, it can be difficult to understand the role TPM can play within a company and how it fits in

with other concepts and techniques. Questions such as the following will probably arise:

- How can it work in my business;
- How does TPM fit in with total quality;
- Is it part of just-in-time philosophy;
- Does it replace other maintenance techniques;
- Is it just another Japanese “buzz” word; and
- When is the right time to start TPM?

It is therefore important, that the role of TPM is understood and these questions be answered. The answers to these questions will be found by investigating further what the literature reveals about TPM and its place in an organization.

2.2.1. TPM and operational re-design

Davis (1994:6) explains in the following paragraphs clearly the ever-changing need in the business environment today to continually improve products supplied to customers. Customers needs have to be understood and it must be clear where TPM fits into these needs. Products delivered on time, without quality problems at the best price, is the cornerstone of customer requirements. Operating companies carry out two main processes, namely development and operation. In addition, operating companies are also influenced by external factors such as, market demand, customer taste and satisfaction, economy of particular nations and standards and legal codes. Companies do not have much control over these external factors. However, they do have control over the internal factors that determine how effectively it operates and can adapt to external demands and changes. The important internal factors, as described by Davis (1994:8), which a company can effectively influence and manage, includes the people, organization, systems, facilities, technology and culture. When an organization is faced with a gap in performance, quantity and quality, when

compared to their nearest competitors, action is needed. Small steps to improve can be achieved through improvement group activities. However, if a step change in performance is required, a more strategic approach is needed.

Management has to agree and promote a high level strategy for the future of the business and communicate it to all personnel. It will involve more effective material flow, effective facilities and effective use of people. It is by having effective facilities where TPM has to be promoted and fit in and making use of the people in the organization will help to achieve this.

2.2.2. TPM and total quality management

Roberts (1997) cited that TPM evolved from TQM, which evolved as a direct result of Dr. W. Edwards Deming's influence on Japanese industry. Dr. Deming began his work in Japan shortly after World War II. As a statistician, Dr. Deming initially began to show the Japanese how to use statistical analysis in manufacturing and how to use the resulting data to control quality during manufacturing. The initial statistical procedures and the resulting quality control concepts fueled by the Japanese work ethic, soon became a way of life for Japanese industry. This new manufacturing concept eventually became knows as Total Quality Management or TQM.

When the problems of plant maintenance were examined as a part of the TQM programme, some of the general concepts did not seem to fit or work well in the maintenance environment. Preventative maintenance (PM) procedures had been in place for some time and PM was practiced in most plants. Using PM techniques, maintenance schedules designed to keep machines operational were developed. However, this technique often resulted in machines being over-serviced in an attempt to improve production. The thought was often that if a little

oil is good, a lot should be better. Manufacturer's maintenance schedules had to be followed to the letter with little thought as to the realistic requirements of the machine. There was little or no involvement of the machine operator in the maintenance programme and maintenance personnel had little training beyond what was contained in often inadequate maintenance manuals.

The need to go further than just scheduling maintenance in accordance with manufacturer's recommendations as a method of improving productivity and product quality was quickly recognized by those companies who were committed to the TQM programmes. To solve this problem and still adhere to the TQM concepts, modifications were made to the original TQM concepts. These modifications elevated maintenance to the status of being an integral part of the overall quality programme.

Venkatesh (2005) claims that TPM closely resembles the popular Total Quality Management (TQM) programme. Many of the tools such as employee empowerment, benchmarking, documentation, etc. that are used in TQM are used to optimize TPM. The following are similarities between the two:

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

Vankatesh (2005) indicates in the following table what the differences between TQM and TPM are.

Table 2.1: The differences between Total Quality Management and Total Productive Maintenance

Category	**TQM**	**TPM**
Object	Quality (Output and effects)	Equipment (Input and cause)
Means of attaining goal	Systemize the management. It is software orientated	Employee participation and it is hardware orientated
Target	Quality for parts per million (PPM)	Elimination of losses and waste

Source: Venkatesh (2005)

2.2.3. TPM and traditional maintenance

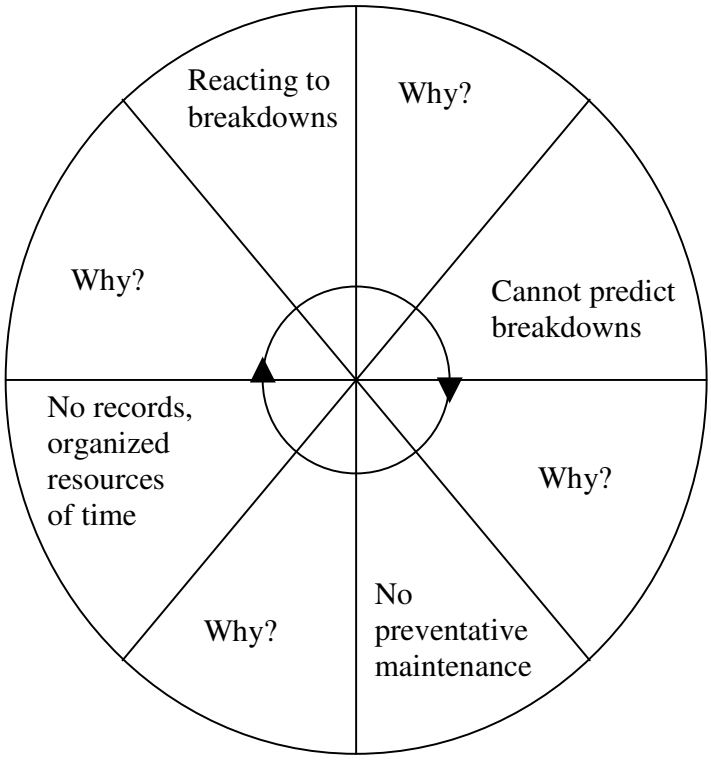
Traditional maintenance does not involve pro-active maintenance, but mainly reactive maintenance, resulting in loss of production and frustration with production personnel. The disadvantages of such a system, as identified by Davis (1994:14) are as follows. There is:

- No warning of failure;
- Possible safety risk;
- Unscheduled machine downtime;
- Production loss and delay; and
- Possible secondary equipment damage.

This results in breakdowns being accepted as part of daily life in the plant and therefore leads to having stand-by equipment and maintenance people as well as a large number of spare parts in stock. Davis (1994:14) argues that there is a perception that breakdown maintenance is the cheapest form of maintenance. It is the case however, that there is a move away from only having reactive maintenance to a more pro-active maintenance practices such as planned, preventative and predictive maintenance. This is only achievable if the maintenance people are allowed the time required to plan, schedule and carry out preventative and predictive maintenance tasks and also operate and update maintenance systems.

Below is a figure that illustrates the vicious cycle of reactive maintenance which has to be broken in order to make effective use of the available equipment.

Figure 2.1: The vicious cycle of reactive maintenance



Source: Davis (1994:15)

Davis (1994:15) states that if this vicious cycle is combined with the ineffective use of operators to assist with TPM based activities, then machinery condition and the general state of facilities will further deteriorate and lead to more and more problems. This includes for example, an increase in the number of breakdowns and time to fix them, deterioration in the operating performance of the machinery and an increase in the inconsistency of product output resulting in more scrapped or re-worked parts. The real cost of reactive maintenance includes the following.

- Lost production;
- Disrupted schedules;
- Repair costs;
- Stand-by machinery;
- Spare parts; and
- Additional work in progress.

2.2.4. The potential of TPM

Van der Waal and Lynn (2002:359) argue that TPM is a change management process that has been shown to have considerable impact on the internal efficiency of Western manufacturing organizations. Based on small group activities, TPM, which originated in Japan, takes the United States style productive maintenance to an organization wide level by gaining the support and co-operation of everyone from senior management down.

TPM is a programme for the fundamental improvement of the organization's maintenance functions. Its overall focus is on the elimination of waste in six potential areas:

- Breakdown losses, including time losses and quantity losses;
- Set-up and adjustment losses when production of one item ends;

- Idling and minor stoppage losses through temporary malfunction;
- Reduced speed losses, possibly through mechanical or quality problems
- Quality defects and rework caused by malfunctioning equipment; and
- Start-up losses during the early stages of production.

2.3. PILLARS OF TOTAL PRODUCTIVE MAINTENANCE

Kennedy (2005:3) states that TPM has developed significantly over the years since 1970. Originally there were five pillars or activities of TPM, also referred to as first generation TPM. It focused on improving equipment performance or effectiveness from an equipment focus perspective. Late in the 1980's it was first realized that even if the shop floor were committed fully to TPM and the elimination or minimizing of the "six big losses" , there were still opportunities being lost because of poor production scheduling practices resulting in line imbalances or schedule interruptions. Therefore, the development of second generation TPM, which focused on the whole production process and incorporated an extra pillar of TPM activity called support department improvement – product planning, evolved.

Kennedy (2005:4) found that in more recent times it has been recognized that the whole company can benefit from equipment operating perfectly resulting in significant improvements in output, quality and safety, hence the expansion of the support department pillar to include all support areas along with the addition of two further pillars focusing on quality and safety to create third generation TPM, which encompasses eight pillars of TPM activity.

Vankatesh (2005) also identified this third generation TPM structure and in the following paragraphs gives a description of the eight pillars of TPM and what the reason is for each pillar is and how it fits into the TPM process.

Pillar 1 - 5S: TPM starts with 5S. Problems cannot be clearly seen when the work place is unorganized. Cleaning and organizing the workplace helps the team to uncover problems. Making problems visible is the first step of improvement. Below is a table which describes what the 5S's are:

Table 2.2: The 5s's

Japanese Term	**English Translation**	**Equivalent 'S' term**
Seiri	Organization	Sort
Seiton	Tidiness	Systematize
Seiso	Cleaning	Sweep
Seiketsu	Standardization	Standardize
Shitsuke	Discipline	Self - Discipline

Source: Venkatesh (2005)

Pillar 2 - JISHU HOZEN (Autonomous maintenance): This pillar is geared towards developing operators to be able to take care of small maintenance tasks, thus freeing up the skilled maintenance people to spend time doing more value-added activity and technical repairs. The operators are responsible for the upkeep of their equipment to prevent it from deteriorating. Autonomous maintenance policy includes:

- Uninterrupted operation of equipments;
- Flexible operators to operate and maintain other equipments;

- Eliminating the defects at source through active employee participation; and
- Stepwise implementation of autonomous maintenance activities.

Steps in getting to a state of autonomous maintenance include:

- Preparation of employees;
- Initial cleanup of machines;
- Take counter measures;
- Fix tentative Jishu Hozen standards;
- General inspection;
- Autonomous inspection;
- Standardization; and
- Autonomous management.

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

- Practice concepts of zero losses in every sphere of activity;
- relentless pursuit to achieve cost reduction targets in all resources;
- Relentless pursuit to improve over all plant equipment effectiveness;

- Extensive use of PM analysis as a tool for eliminating losses; and
- Focus of easy handling of operators.

The Kaizen target is to achieve and sustain zero loses with respect to minor stops, measurement and adjustments, defects and unavoidable downtimes. It also aims to achieve approximately a 30% manufacturing cost reduction.

Pillar 4 - PLANNED MAINTENANCE: It is aimed to have trouble-free machines and equipment producing defect-free products for total customer satisfaction. This breaks maintenance down into 4 groups that were defined earlier.

- Preventive Maintenance;
- Breakdown Maintenance;
- Corrective Maintenance; and
- Maintenance Prevention.

With planned maintenance efforts evolve from a reactive to a proactive method and use trained maintenance staff to help train the operators to better maintain their equipment. The policy for planned maintenance is:

- Achieve and sustain availability of machines;
- Optimum maintenance cost;
- Reduces spares inventory; and
- Improve reliability and maintainability of machines.

Planned maintenance targets include zero equipment failure and break down, 50 % improvement in reliability and maintainability, reduction in maintenance costs by 20 % and the availability of spares all the time.

Pillar 5 – QUALITY MAINTENANCE: It is aimed towards customer delight through highest quality through defect-free manufacturing. The focus is on eliminating non-conformances in a systematic manner, much like Focused

Improvement. An understanding is gained of what parts of the equipment affect product quality, eliminating current quality concerns and then moving to potential quality concerns. Transition is from re-active to pro-active (Quality Control to Quality Assurance).

QM activities include setting equipment conditions that preclude quality defects, based on the basic concept of maintaining perfect equipment to maintain perfect quality of products. The conditions are checked and measured in time series to verify that measure values are within standard values to prevent defects. The transition of measured values is watched to predict possibilities of defects occurring and to take counter measures before hand. The quality maintenance policy includes:

- Defect free conditions and control of equipments;
- QM activities to support quality assurance;
- Focus of prevention of defects at source;
- Focus on poka-yoke. (fool proof system);
- In-line detection and segregation of defects; and
- Effective implementation of operator quality assurance.

Quality maintenance targets includes achieving and sustaining customer complaints at zero, reducing in-process defects by 50 % and reducing cost of quality by 50 %.

Pillar 6 – TRAINING: It is aimed to have multi-skilled revitalized employees whose morale is high and who are eager to come to work and perform all the required functions effectively and independently. Education is given to operators to upgrade their skill. It is not sufficient to know only "know-how" but they should also learn "know-why". By experience they gain, "know-how" on how to overcome a problem and what is to be done. This they do without

knowing the root cause of the problem and why they are doing so. Hence it becomes necessary to train them on knowing "know-why". The employees should be trained to achieve the four phases of skill. The goal is to create a factory full of experts. The different phases of skills are one, do not know, two know the theory but cannot do, three can do but cannot teach and four, can do and also teach.

The training policies are:

- Focus on improvement of knowledge, skills and techniques;
- Creating a training environment for self learning based on felt needs;
- Training curriculum / tools /assessment etc. conductive to employee revitalization; and
- Training to remove employee fatigue and make work enjoyable.

The target of training is to achieve and sustain downtime due to want men at zero on critical machines, to achieve and sustain zero losses due to lack of knowledge / skills / techniques and to aim for 100% participation in suggestion schemes.

Pillar 7 - OFFICE TPM: Office TPM should be started after activating four other pillars of TPM (JH, KK, QM, and PM). Office TPM must be followed to improve productivity, efficiency in the administrative functions and identify and eliminate losses. This includes analyzing processes and procedures towards increased office automation. Office TPM addresses twelve major losses. They are:

- Processing loss;
- Cost loss including in areas such as procurement, accounts, marketing, sales leading to high inventories;
- Communication loss;
- Idle loss;

- Set-up loss;
- Accuracy loss;
- Office equipment breakdown;
- Communication channel breakdown, telephone and fax lines;
- Time spent on retrieval of information;
- Non availability of correct on line stock status;
- Customer complaints due to logistics; and
- Expenses on emergency dispatches/purchases.

Pillar 8 - SAFETY, HEALTH AND ENVIRONMENT: In this area the focus is on creating a safe workplace and a surrounding area that is not damaged by our process or procedures. This pillar will play an active role in each of the other pillars on a regular basis. The targets are:

- Zero accident;
- Zero health damage; and
- Zero fires.

A committee is constituted for this pillar which comprises of representatives from offices as well as workers. Very high importance must be given to Safety in the plant. The safety manager looks after functions related to safety. To create awareness among employees various competitions like safety slogans, quizes, drama, posters, etc. related to safety can be organized at regular intervals.

2.4. EMPLOYEE INVOLVEMENT AND EMPOWERMENT

Robinson & Ginder (1995:3) claim that employee involvement is a necessary part of the TPM process. The goal is to tap into the expertise and creative capabilities of the entire plant or facility through the use of small group activities. The total involvement of plant personnel generates pride and job satisfaction as well as financial gains for the organization. To ensure successful employee involvement, a systematic approach must be designed in which all steps are clearly defined and communicated to all parties. TPM requires employees to take a more active role in decision making and to accept responsibility for the plant and its physical condition. They have a more active role to play in defining their job content, along with work systems and procedures. The intent is that each employee takes pride in plant equipment and is proud to be associated with the facility. Employee empowerment does not mean that all decisions are made by individual workers or small groups of employees. That is not the intention. Historically, upper management has played a key role in the decision making process. TPM increases workers' roles in providing input and in making tactical decisions. The most difficult aspect of empowering employees is deciding which decisions should be made by management, by workers, or a combination of the two. Utilizing the input from the employees within the organization helps to ensure that the company is maximizing the use of its resources. Many employees will think of a better way to do things, but will keep it to themselves if they think it is useless to bring up the idea. This calls for a change in the management styles of many companies. The dictatorial "boss-worker" managers of the past must give way to employee empowerment programmes. This employee involvement and empowerment step will require some traditional barriers to be broken down. When a company does not empower their employees, they provide their competitors with a big advantage in cost, quality and timely delivery. Allowing the employees to find solutions to problems, to find better methods and policies and then implement these changes will be the foundation for management teams.

The following table illustrates the differences between an empowered organization and a traditional command and control environment.

Table 2.3: Organizational differences in the approach to employee empowerment

Empowered environment	**Traditional command and control environment**
Goals of company are explicit priority	Goals of department are explicit priority
Structure is flat and flexible	Structure is hierarchical and inflexible
Team takes decision within agreed limits and in line with goals of the company / team	Management reserves the right to make all decisions
Teams have accountability	Manager is accountable
Information is constantly communicated	Information is restricted
Teams are customer-focused	Teams do not exist or remain departmental in focus
Team is pro-active	Team is reactive
TPM activities are conducted and improved by the team	Maintenance department conduct maintenance activities in the factory
Technical skills of operators are constantly improved and monitored. Skills are shared and transferred between classes of worker	No skills are given to operators. Skills are individualistic.
Teams are provided with the necessary problem-solving techniques required	Skills are protected and vested in the role of a specialist
Teams conduct problem solving work of a non-repetitive nature	Individuals in the factory should be treated as 'robots' and are capable of only repeating a set of predefined tasks
Factory management do not punish under-performance but look to assist and lead the teams where necessary	Managers should discipline all employees under their control.
Information is exchanged and shared freely and care is taken to ensure that the correct communication channels are created and frequently used	Information is restricted and not shared with those outside a department or job class. Operators are seen to be ignorant and incapable of understanding
Share power through empowerment of the teams. Decentralize as a means of increasing value-added	Technical and 'position' power dominate the organization. Centralized power management to avoid abuse by subordinates at all cost
Formal and informal rules are established by management and teams	Formal rules established by management only and imposed on individuals
Positive and healthy. Overcome by negotiation and understanding	Negative and destructive. Overcome by management intervention and punishment

Source: Rich (1999:203)

2.5. TEAMWORK

Rich (1995:205) believes that the development of team structures in world class manufacturing organizations represents the most visible element of the empowered approach and the recognition that the factory is not best served by the allocation of effort by a few managers, but must be conducted by the many factory employees supported by managers. These teams can be defined as a group of individuals, within the factory, who come together for a common purpose. This definition is all-encompassing and includes not only the performance improvement of the factory, but also the restoration, management, reporting and a host of other routines that are undertaken by the individuals concerned. The definition does not limit the team to the conduct of maintenance activities but can include wider efforts such as quality assurance, personnel matters, team briefings regarding company performance and a host of other routines.

Teamwork aspects that need to be tackled include aspects like the purpose of the team, the motivation and the individuals within teams, the understanding of the life cycle of a team by management and the barriers to teamwork and empowerment that needs to be addressed.

Kennedy (2005:9) sees the role of cross-functional teams and area-based teams as the most effective medium to address problems in the workplace where:

- Cross-functional teams consist of up to eight employees with representation from different departments to ensure that technical expertise is present to address the specific problem. They normally focus on all the value-added improvements along with all the technical non-value-adding issues that involve support groups from outside the area based team responsibility; and

- Area based teams consisting of 4-8 employees on the same shift with a defined area of responsibility supported by clear boundaries. They normally focus on non-value-adding losses and waste, areas of improvement that often impact on people issues but do not affect the technical integrity of the product.

Kennedy (2005:9) states that the impact of engaging all employees will positively change the culture at the work place. However, the critical issue is to find the time for the employees, especially operators, to get involved in formal continuous team activities.

The TPM change process, according to Rich (1999:210), is founded on a basic fundamental belief in teamwork and a rejection of the classical concepts that the process can be undertaken by the maintenance department alone or through a temporary alliance between production and maintenance departments. The development of teamwork within the factory is a change to the management system and includes many cross-functional managers involved in the TPM promotion office.

Some benefits highlighted by Rich (1999: 211) include aspects such as:

- The ability to achieve more (outputs) than the sum of the individuals who form the team;
- To distribute effort within the team and to allow individual skills to be learned and shared by the entire team;
- A greater commitment to decisions taken which involves risk by individuals not wishing to 'let the team down' or for implemented solutions to fail due to lack of involvement or effort;

- The development of problem-solving and decision-making routines based on the combined talent of the group whilst avoiding satisfactory responses to change;
- The creation of local information processing systems which generate information from data;
- The deployment of authority and responsibility serves to regulate any conflict in the workplace; and
- The use of total quality techniques allows the team to set and constantly improve workplace standards and enforce decisions directly.

Rich (1999:218) maintains that TPM teams allows the roles and responsibilities of the factory to be re-organized such that non-value-added routines of the maintenance department can be passed on to an aware and competent group of operators in the factory.

As an example of such implemented teamwork, a case study done by Van der Waal and Lynn (2002:359), claimed that a series of multi-disciplinary teams were implemented in the Enstra Paper Mill in South Africa, chaired by the production superintendent. These teams were there to solve day-to-day problems at operational level. Any problems that could not be resolved here was passed on to the next level, the focus team, which evaluated all equipment and processes and checked that the relevant practices were in place to prevent any losses. A third-level team, called the integration team, was set up to solve problems at systematic level, while a fourth tier, the strategic team, was responsible for all strategic and productivity issues.

Teamwork is therefore important at all levels, especially at shop floor level, where the product required by the customer is being produced. Making sure that teams are established and their roles and responsibilities are clarified is important in the

initial stages of implementation of a new initiative like TPM. Teamwork will be the future source of future continuous improvement activities to improve factory performance and ultimately customer satisfaction.

2.6. CONTINUOUS IMPROVEMENT

Kennedy (2005:10) claims that many people heard about continuous improvement, and most companies promote continues improvement. The problem Kennedy notes, however, is that it is in many cases done in a haphazard way. Often, many employees are trying to find a better and easier way to achieve their tasks, yet in some situations different shifts are doing things slightly differently, because they believe it is better that way.

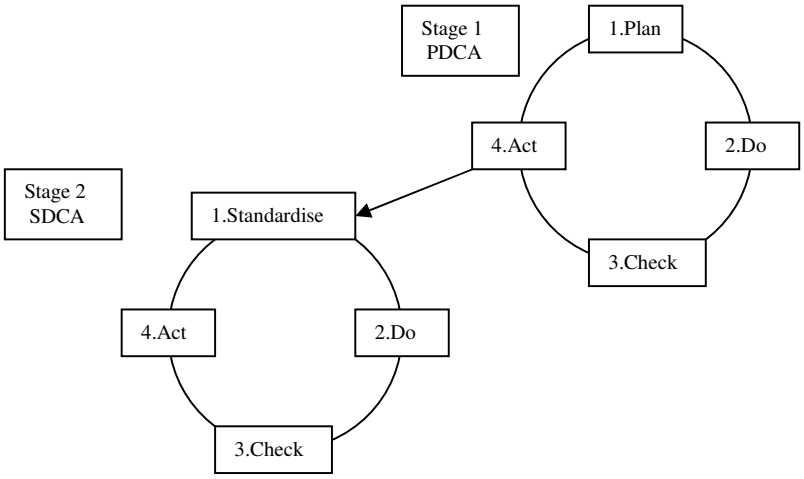
Kennedy (2005:10) argues that this can lead to what Deming refers to as 'variation in the processes'. When there is a problem, often this 'variation in the process' occurs, which creates many headaches in trying to identify the true reason or route cause of the problem. Therefore Kennedy suggests that formal continuous improvement is required. This is where the problem is clearly identified and measured, the root cause identified, a solution tested, the results measured and verified as an improvement and the documentation that results from this, is created and captured in the improvement.

Rich (1999:42) considers the same process advocated by Deming and refers to the Deming cycle termed 'Plan-Do-Check-Act' as the cycle for continuous improvement. The underlying process of improvement, identified by Deming, was that managers and employees should explicitly (PLAN) the improvement of the production process such that the major sources of variation are targeted for control, after which they should implement the selected solution (DO), then following a period of monitoring (CHECK) to ensure that the solution has created

improvements, the idea should be spread across the business (ACT). The action of spreading the learning from one business area to another allows a second cycle to be achieved which is a standardization of factory approaches and performance levels.

Once this process is complete, then the improvement initiatives are used to select the next largest source of variation and the process is repeated. The following model is a representation of the Deming cycle as explained in the above paragraph.

Figure 2.2: The Deming cycle



Source: Rich (1999: 42)

2.7. OVERALL EQUIPMENT EFFECTIVENESS (OEE)

Gupta, Tewari and Sharma (2006) conclude that overall equipment effectiveness (OEE) incorporates not only availability but also performance rate and quality rate. In other words, OEE addresses all losses caused by the equipment not being available when needed due to breakdowns or set-up and adjustment losses; not running at the optimum rate due to reduced speed or idling and minor stoppage losses; and not producing first pass quality output due to defects and rework or start-up losses. A key objective of TPM is to cost effectively maximize overall equipment effectiveness through the elimination or minimization of all these six losses. A simple model outlining these losses is shown in the following table.

Table 2.4: Overall equipment effectiveness model

OEE Measure	**Loss Category**	**Big six losses**
Availability	Downtime losses	1. Equipment failure (Breakdowns) 2. Changeover (Setup and adjustment)
Performance	Speed losses	1. Minor stoppages 2. Reduced speed and idling
Quality	Defect losses	1. Process defects 2. Reduced yield

Source: Mission directed work teams (2004)

In the following section the calculation for OEE is expressed, including definitions explaining each part of the calculation.

Overall Equipment Effectiveness (OEE) = A x PR x Q, where

A - Availability of the machine. Availability is proportion of time machine is actually available out of time it should be available.

PR - Performance Rate and PR=RE X SR

Rate efficiency (RE): Actual average cycle time is slower than design cycle time because of jams, etc. Output is reduced because of jams

Speed Rate (SR): Actual cycle time is slower than design cycle time machine output is reduced because it is running at reduced speed.

Q - Refers to quality rate. Which is percentage of good parts out of total produced sometimes called yield.

All these figures are usually expressed in percentage and higher OEE translates into higher equipment efficiency from the equipment. The OEE of most equipment ranges from 40%-60% when first time measured, whereas the benchmark is 85%. As such, OEE has become the accepted indicator to assess, that how plants actually manage their most expensive asset, the equipment, to produce saleable goods, with minimum losses and wastes.

2.8. THE IMPLEMENTATION OF TOTAL PRODUCTIVE MAINTENANCE IN AN ORGANIZATION

Willmott & McCarthy (2001) put TPM into perspective from total productive maintenance to total productive manufacturing. They believe that customers are the driving force behind any business. The need to satisfy and exceed their expectations can be achieved by adding value, quality and performance in all production operations.

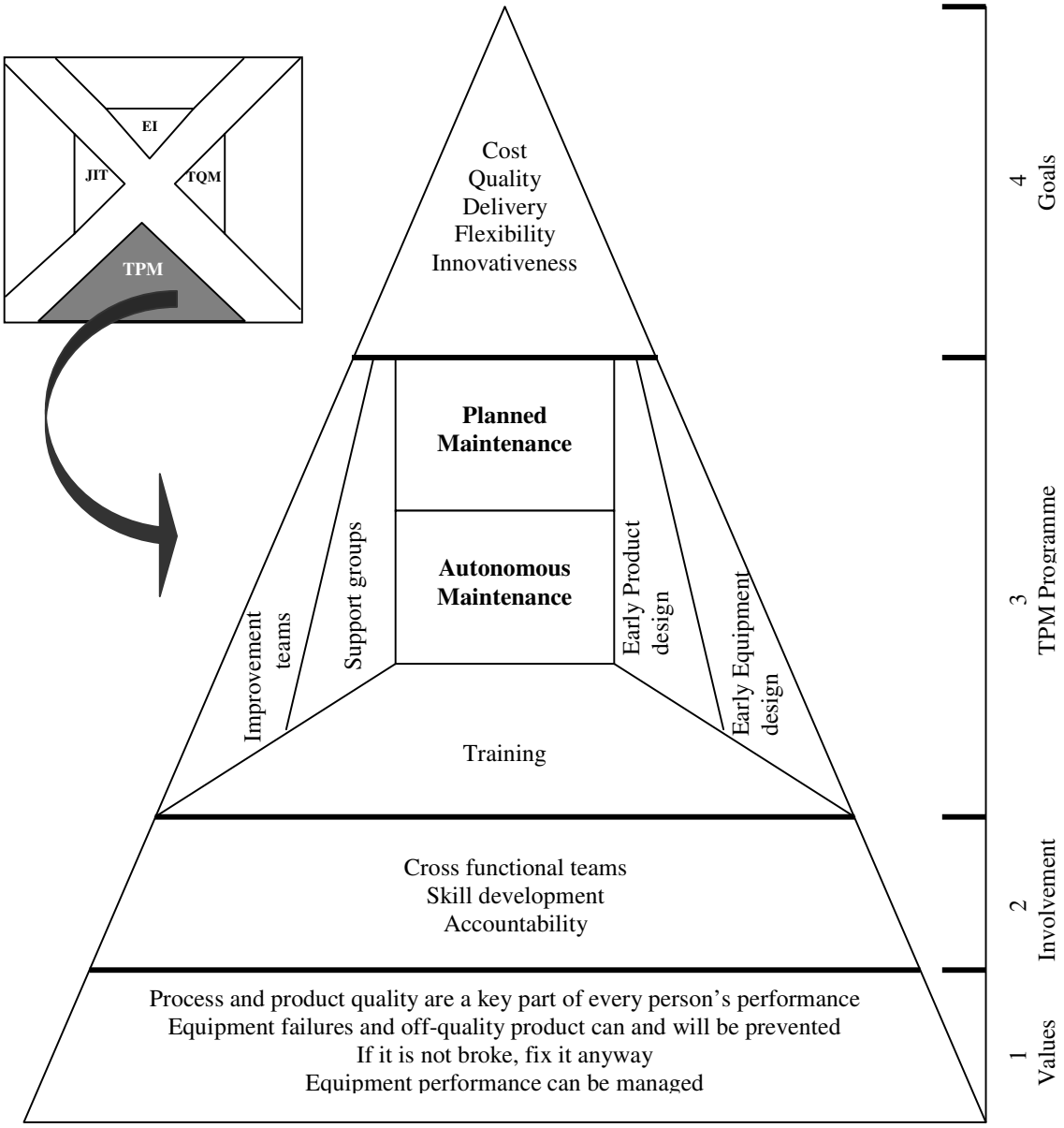
Willmott and McCarthy (2001) further argue that the answer is to view TPM not simply as total productive maintenance in the sense of overall equipment effectiveness (OEE), autonomous maintenance, 5 S's, and clean machines, but rather as the proven roots and origin for applying company-wide TPM. Company wide TPM recognizes that:

- If equipment OEE improves but the overall delivery time remains the same, the waste is not removed;

- If equipment capability improves but quality standards remain the same, a potential area of competitive advantage is lost;
- If knowledge gained about the process does not produce higher rates of return on investment, the organization is not making the best use of its capabilities; and
- If capabilities are increased but this is not met with new business, an opportunity to reduce unit costs is lost.

TPM implementation will not happen overnight and the entire organization has to be pulled into the implementation process as well as buy into it. Therefore, having a good implementation model is crucial. Figure 2.3 gives a typical model for the implementation of TPM, summarizing it into four steps, which include values, involvement, the TPM programme and its goals. In the next section of this chapter, the researcher will illustrate what other researchers perceive as the best way to address the implementation of TPM in an organization.

Figure 2.3: A model for Total Productive Maintenance



Source: Mckone & Weiss (1998:339)

2.9. STEPS FOR IMPLEMENTING TOTAL PRODUCTIVE MAINTENANCE

Various researchers give different approaches to the steps to implement TPM. However, these approaches are fairly similar. To illustrate this and to ensure that all these approaches are considered if an organization wants to introduce TPM in their organization, here follows three approaches as given by Gupta et al. (2006), Venkatesh (2005) and Kennedy (2005).

Gupta et al. (2006) list a 12-step process designed to implement TPM, accomplish TPM acceptance, create TPM support from management, unions and employees, create enthusiasm and positive expectations for TPM, develop a realistic custom installation plan and accomplish world-class results in a timely manner.

Step 1: Announcement of top management decision of implementing TPM. Top management needs to build an environment that will help with the introduction of TPM. Without this support of management, skepticism and resistance will prevent this initiative from getting off the ground. Detailed TPM articles including TPM objectives should be clearly stated in the company's newsletter or newspaper?

Step 2: TPM education programme and collection of information. This programme will inform and teach everyone in the organization about TPM activities, benefits and its objectives.

This step of implementing TPM also consists of the collection of information about TPM and to understand how it works. The TPM co-ordinator must understand what TPM is, how it works, it's proper implementation sequence,

the amount of effort that will be required, how it can be of benefit to the plant and how long it will take to implement.

Step 3: Establish an organizational structure: This group will promote and sustain TPM activities once they begin. Team-based activities are essential to a TPM effort. This group needs to include members from every level of the organization, from management to the shop floor. This structure will promote communication and will guarantee that everyone is working toward the same goals. (See Figure 2.3)

Step 4: Formulate basic TPM policies and goals. Analyze the existing conditions and set the goals that are result oriented, specific, measurable, achievable and realistic. Then predict the results. The established TPM policies and goals should be very clear to everyone involved in TPM implementation.

Step 5: Master plan for TPM deployment and its presentation. After establishing TPM policies and goals, a detailed proposed master plan for implementation of TPM is prepared and a proposal is presented to management. This activity can be carried out by a consultant, plant personnel, or both. Consultant involvement typically begins with a plant visit to observe production operations, learn about the equipment (type, function, condition, problems and losses etc.), study maintenance operations (structure, size and tasks etc.), gauge orderliness and cleanliness in the plant, and talk to employees to determine their motivation and attitude. The consultant then can develop and conduct the TPM presentation to management, including questions and answers, and covers the following: (Hartmann, 2000)

- TPM overview. What is TPM?
- What TPM can do for the plant, its expected costs and benefits?;
- Sequence of its implementation;
- Customized implementation strategy;

- How management and the union must support TPM; and
- How to get organized for implementing TPM.

The presentation also can be made by plant personnel covering the same points with examples and impressions from seminars, conferences, and plant visits. The presentation should end with a recommendation to install TPM.

Step 6: Feasibility study and its presentation. Hartmann (2000), according to Gupta et al. (2006), believes every successful TPM installation has been preceded by a good feasibility study. The results of the feasibility study, will establish a base line, against which TPM results and progress can be measured and also helps in setting the realistic goals, based on the data obtained. A feasibility study typically includes 2 to 6 teams (5 to 9 members each). It will include overall equipment effectiveness (OEE) observations and calculations for 40 to 100 percent of important equipment. The study will evaluate the condition of this equipment and the required current and future maintenance activities. Skills of plant personnel, cleanliness or orderliness of the plant, and plant culture (attitude, motivation, and management style) will also be studied. Then feasibility study results are presented. Both management and the union should be present in the presentation. The presentation should propose an installation strategy and identify a pilot installation. It should conclude with a recommendation that TPM is to be installed. At this point, management will make a second and final commitment to install TPM. Now, at this stage, almost everybody has had some exposure or heard about TPM during the execution of the feasibility study. The OEE results are typically much lower than management thought, creating a strong motivation to get going and improve the productivity of equipment and the quality of product. The feasibility study presentation meeting can be regarded as the TPM kickoff.

Step 7: Pilot installation. A TPM pilot installation should cover between 10 and 25 percent of plant equipment, not just a few selected machines. There should be a minimum of 6 TPM teams to insure survivability of the installation. Areas appropriate for pilot installations are where major improvement is needed (too many breakdowns, delays, or idle time, or low capacity or productivity) and where quick success is likely. A good feasibility study is required for all pilot areas. All employees in the pilot areas must receive TPM training. Clear goals and deadlines must be established and team meetings must be held on schedule.

Step 8: Plant-wide installation. TPM co-ordinators of most companies wait too long before expanding the TPM installation over the whole plant. There is no need to wait for final results of the pilot installation. A good and well thought out staggered expansion plan is important, as is a detailed installation plan for each additional area. Expansion initiatives should begin every 3 months (6 months maximum) using the same priorities and decision criteria as for pilots.

Step 9: Introduction audit. Hartmann (2000), according Gupta et al. (2006) feels that audits have proven to be very valuable to insure good progress and a proper and successful installation. There are two types of audits: the first audit is fairly simple and checks if the TPM fundamentals are done correctly (teamwork, organization, tasks, PM development, etc.) and whether the programme is on schedule. They are typically carried out 6-12 months after launch by internal or external specialists.

Step 10: Progress audit. It is usually the last step before the certification. This audit will point out existing deficiencies (and opportunities) to bring TPM to a successful conclusion. The theoretical part of the audit will be done in the office with the team going over a lot of data followed by a practical part out in the plant around the equipment. The progress audit comes 18-30 months after launch to determine if and how:

- Preventive maintenance is carried out by the TPM teams;
- Equipment improvement activities have been executed according to schedules;
- Increase in OEE has been reached;
- The improved equipment condition has been accomplished and documented; and
- The planned levels of skill have been accomplished.

Step 11: Certification. The certification process is gaining more and more importance, because a certificate is used to show to the customer that equipment and product quality have been improved and standard procedures are in practice to maintain the equipment to the highest levels. The International TPM Institute certification process is based on a strict set of certification requirements.

Step 12: TPM Award. The final and most rewarding step of a TPM installation is achieving the TPM Award. The award testifies that the plant is world-class, highly productive, produces only top quality product, maintains its equipment in top shape, and has a culture based on teamwork. McBride (2004), according to Gupta et al. (2006) stresses that maintenance and reliability as a core business strategy, is key to a successful TPM implementation. Without the support of top management, TPM implementation will fail. It is certain that implementing TPM using the above 12 steps will lead to “zero breakdowns” and “zero defects.” Ming-Hong (2004), according to Gupta et al. (2006) suggests that to be successful, not only support is required from top management, but also from the head of each department. The other key factor is that each employee must feel that they also have benefited from this activity. This will improve their performance. This improved performance will reflect in their monthly bonus. This will motivate the employee, which in turn will lead to better progress. The design of the activity should be kept as simple as possible.

The second approach the researcher wants to consider and make use of when giving direction into the decision regarding the implementation of TPM is an approach explained by Venkatesh (2005), who gives the following stages to introduction of TPM.

Stage one: Preparation:

Step 1 - TPM introduction in the organization through a management announcement;

Step 2 - Initial education and positive build up for TPM;

Step 3 - Setting up TPM and departmental teams;

Step 4 - Establishing the TPM working system and target; and

Step 5 - A master plan for institutionalizing.

Stage two: Introduction:

This is a ceremony and all should be invited. Suppliers, as they should know that the company wants quality supply from them. Related companies and affiliated companies who can be potential customers, sisters concerns etc. Some may learn from the company and some can help the company. Customers will get the communication from the company and that they care for quality output.

Stage three: Implementation:

In this stage, eight activities are carried which are called eight pillars in the development of TPM activity. Of these four activities are for establishing the system for production efficiency, one for the initial control system of new products and equipment, one for improving the efficiency of administration and

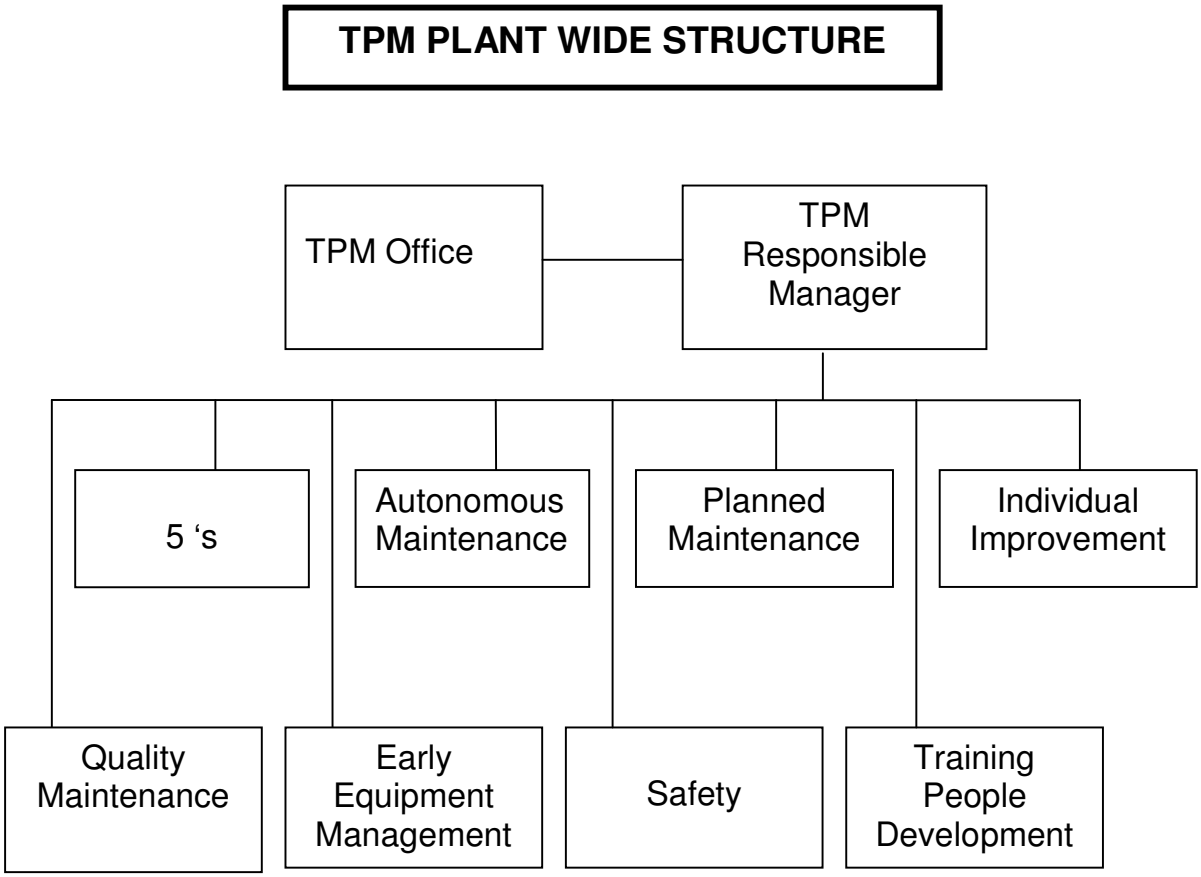
the other two are for the control of safety and the cleaning of the working environment.

Stage four: Institutionalization:

After all these activities the maturity stage is reached. Now is the time for applying for a TPM award. Also think of a challenging level to which the company can take this movement.

The figure below gives an overview of what the organizational structure of TPM implementation looks like.

Figure 2.4: Organization structure for Total Productive Maintenance implementation



Source: Venkatesh (2005)

Kennedy (2005:15) suggests a four phase approach to the introduction of TPM. Kennedy explains that the Centre for TPM in Australasia developed a flexible methodology, involving four key phases, based on practical research and experience with a variety of Australasian companies. He argues that it is proving to be a very successful guide in many diverse applications in both achieving and sustaining desired results. The four phase approach is as follows:

Phase 1: Awareness and preparation phase – initial education and development of a TPM introduction strategy supported by a site briefing;

Phase 2: Demonstration and learning phase – Introduction of the core pillars to several (typically 4) pilot areas to gain a greater understanding of the issues and have a positive impact on the site's performance;

Phase 3: Assessment and planning phase – Development of a site-wide implementation plan based on the learning's to date; and

Phase 4: Site wide implementation phase – Cascading of TPM throughout the site.

Kennedy (2005:16) suggests that any methodology used must be flexible enough to ensure that the following key issues are adequately addressed:

- How to get Senior management to actually understand TPM rather than think they understand TPM;
- How to get all employees to contribute and participate in TPM;
- How to ensure TPM is integrated into existing improvement initiatives; and
- how to ensure the company develops the in-house capability to sustain TPM?

2.10. WHY TOTAL PRODUCTIVE MAINTENANCE IS DIFFICULT TO IMPLEMENT?

According to Hartmann (2000), at least every second attempt of installation of Total Productive Maintenance (TPM), results in failure. The reasons are many: lack of proper understanding of the total effort required, lack of management support, lack of sufficient TPM staff, union resistance, not enough training carried out, change of priorities, lack of persistence, failure to develop a good installation strategy, and simply choosing the wrong approach. Choyds (2003) concluded that implementing TPM is a dramatic organizational change that can affect organization structure, work-floor management systems, employee responsibilities, performance measurement, incentive systems, skill development and the use of information technology. Not surprisingly the success rate of such large-scale change is less than 30% for most organizations.

Implementing TPM is not as easy a task as it seems to be. A great infrastructure and commitment of all personnel from top level management to bottom level is required. A lot of problems have to be faced, while implementing it. Some of them are:

- Sufficient resources like people, money, time, etc. and assistance are not provided;
- TPM is not a “quick fix” approach, it involve cultural change to the ways to do the things;
- Incomplete understanding of the methodology and philosophy by middle management;
- Many people treat it as just another “programme of the month” without paying any real focus and they also doubt it’s effectiveness;
- Workers show strong resistance to any change; and
- Many people consider TPM activities as additional work or a threat.

2.11. THE BENEFITS OF IMPLEMENTING TOTAL PRODUCTIVE MAINTENANCE

The best way to explain the expected benefits is to refer to a slide presented by Kennedy (2005:16), where it is explained in terms of maintenance expenditure, hidden cost of poor equipment effectiveness and the tangible and intangible benefits of TPM.

In his argument to explain the benefits of TPM, Kennedy postulates that the maintenance costs will halve, whilst the hidden costs will reduce by ten fold in a period of three years of sustained TPM. These costs include:

- Production inefficiencies;
- Capacity constraints;
- Poor output quality;
- No time for improvement activities;
- Yield and energy losses;
- Excess capital expenditure;
- Occupational health and safety issues; and
- Excess stock holdings.

However, the benefits that will be able to be measured and can be used to track the effectiveness include:

Capacity/OEE:	Up 25% to 100%;
Productivity:	Up 50% to 100%;
Scrap and rework:	Down 70% to 90%;
Customer complaints:	Down 50% to 75%;
Total operational costs:	Down 20% to 30%;
Maintenance costs:	Down 25% to 50%;
Accidents:	Down 90% to 100%; and
Inventories and stocks:	Down 40% to 60%.

Benefits that are not so easy to measure, but will improve the situation regarding the level of tangible targets achieve include:

- An engaged, self motivated workforce;
- Operators and maintainers become equipment-competent and care for their equipment;
- The elusive target of zero accidents and zero product defects is achieved;
- The workplace is neat clean and tidy and is a great place to work; and
- Customers are very impressed when they visit the site.

2.12. CONCLUSION

Mora (2002), states that implementing Total Productive Maintenance is not a difficult task. However, it requires some customized training in order to succeed. The results of implementing an effective programme in terms of increased plant efficiency and productivity are outstanding. According to Kennedy (2005:17), it should be acknowledged that a TPM implementation is not a short-term fix programme. It is a continuous journey based on changing the work-area, then the equipment so as to achieve a clean, neat, safe workplace through a "PULL" as opposed to a "PUSH" culture. Significant improvement can be evident within six months. However, full implementation can take many years to allow for the full benefits of the new culture created by TPM. At this crucial point of global competition, the implementation of TPM not a matter of liking it or following the fashion. While TPM in the 60's was just an innovative thing, today it has turned into a survival strategy. TPM is capable of bringing a machine back to original condition and even better. The cost of postponing a decision of implementing TPM, that has to make sooner or later, can be excessive. It is convincing that the losses for each day of delay are out of imagination. (Mora,2002). Successful TPM implementation can achieve better and

lasting results as compared to other isolated programmes because there is an ultimate change in people (knowledge, skills, and behavior) during the progress. Table 2.5 gives a summary of why companies should consider implementing TPM in their organization, including the motivating factors as well as the resulting benefits.

Table 2.5: Total Productive Maintenance motives, uniqueness, objectives and benefits

Motives of TPM	1. Adoption of life cycle approach for improving the overall performance of production equipment.
	2. Improving productivity by highly motivated workers which is achieved by job enlargement.
	3. The use of voluntary small group activities for identifying the cause of failure, possible plant and equipment modifications.
Uniqueness of TPM	1. The major difference between TPM and other concepts is that the operators are also involved in the maintenance process.
	2. The concept of "I (Production operators) Operate, You (Maintenance department) fix" is not followed.
TPM Objectives	1. Achieve zero defects, zero breakdown and zero accidents in all functional areas of the organization.
	2. Involve people in all levels of the organization.
	3. Form different teams to reduce defects and Self Maintenance.
Direct benefits of TPM	1. Increase productivity and OEE (Overall Equipment Efficiency) by 1.5 or 2 times.
	2. Rectify customer complaints.
	3. Reduce the manufacturing cost by 30%.
	4. Satisfy the customers needs by 100 % (Delivering the right quantity at the right time, in the required quality.)
	5. Reduce accidents.
	6. Follow pollution control measures.
Indirect benefits of TPM	1. Higher confidence level among the employees.
	2. Keep the work place clean, neat and attractive.
	3. Favorable change in the attitude of the operators.
	4. Achieve goals by working as a team.
	5. Horizontal deployment of a new concept in all areas of the organization.
	6. Share knowledge and experience.
	7. The workers get a feeling of owning the machine.

Source: Venkatesh (2005)

CHAPTER 3

THE EMPIRICAL STUDY

3.1. INTRODUCTION

In chapters 2 and 3, the researcher discussed TPM and the introduction of TPM in an organization. The literature study was used to establish the answer to the first sub-problem:

- What does the literature reveal about total productive maintenance in manufacturing organizations?

The purpose of this chapter is to describe the research methodology applied by the researcher to solve the remaining sub-problems. The development and structure of the questionnaire, the design of the questionnaire and the administration of the questionnaire will be discussed. The responses of the respondents will also be discussed, followed by an analysis thereof.

3.2. RESEARCH DESIGN

According to Jankowitz (1995:173), methodology is the analysis of data, the rationale for a particular method or methods used in a given study, Zikmund (1994:43) describes a research design as the master plan that specifies the methods and procedures used in collecting and analyzing information, whereas Leedy & Ormrod (2003:4) refer to research as the systematic process of collecting and analyzing information and data in order to increase the understanding of the phenomenon about which to be concerned or interested.

With this in mind, the research design for this study was broken down into the main problem, with three sub-problems. The main problem is as follows.

What is the appropriate method for the implementation of Total Productive Maintenance at Continental Tyre South Africa?

Following from the main problem, three sub-problems were identified to assist with the solution to the main problem, namely:

(a) What does the literature reveal about total productive maintenance in manufacturing organizations?;
(b) What does a statistical analysis of the current status of maintenance, through evaluation of machine breakdown reports, at Continental Tyre South Africa reveal and what does a questionnaire about implemented TPM systems in affiliated Eastern European tyre manufacturing plants reveal?; and
(c) What implementation approach would be suitable to introduce TPM successfully at Continental tyre South Africa?

The procedure used to solve the main problem and the sub-problems was as follows:

- In chapter 2 a literature survey was conducted providing information about total productive maintenance in manufacturing organizations; and
- In chapter 3 the researcher discussed the introduction of TPM in an organization, based on previous research conducted.
- In order to resolve sub-problems (b) and (c), a survey based on the key elements TPM identified in sub-problems (b) and (c), was developed and circulated to the steel stock preparation production personnel of the Continental plants in Puchov, Slovakia and Otrokovice in the Czech Republic respectively. In addition, the statistical data for the amount of breakdowns experienced, including reasons, in the steel stock preparation area at Continental Tyre South Africa for 2006 was collected and will be analyzed.

3.3. CONDUCTING THE EMPIRICAL STUDY

The empirical study was conducted by physically distributing a questionnaire to production personnel of the steel stock preparation departments of Otrokovice and Puchov. The results of the questionnaire were analyzed. Sampling procedures, the questionnaire and the research response are discussed in detail below.

3.4. SAMPLING METHODS AND SIZE

Before the study could be initiated, it was necessary for the researcher to decide if the entire production department of both companies should participate or if a sample of the workforce would be sufficient.

Wegner (2001:169) argues that it is not always practical to gather data on every possible observation in a population. If this is the case, a subset of all observations, called a sample, is usually gathered on the random variable. Leedy & Ormrod (2001:211) say that "the sample should be carefully chosen that, through it, the researcher is able to see all the characteristics of the total population in the same relationship that they would be seen were the researcher, in fact, to inspect the total population."

According to Wegner (2001:170) there are two basic methods of sampling:

- Non-probability sampling methods; and
- Probability sampling methods.

3.4.1 Non-probability sampling

Wegner (2001:170) defines the non-probability sampling method as any sampling method in which the observations are not selected randomly. There are three types of non-probability sampling procedures:

- Convenience sampling – a sample drawn to suit the convenience of the researcher;
- Judgmental sampling – judgment is used by the researcher to select the best sampling units to include in the sample; and
- Quota sampling – the population is divided into segments and a quota of observations is collected from each segment.

Wegner (2001:171) indicates that the disadvantage of non-probability sampling methods is the unrepresentative nature of the sample with respect to the population from which it is drawn.

3.4.2 Probability sampling

Wegner (2001:171) says that probability sampling includes all selection methods where the observations to be included in a sample have been selected on a purely random basis from the population. The following are probability sampling techniques:

- Simple random sampling – each observation in the entire population has an equal chance of being selected;
- Systematic random sampling – some randomness is sacrificed: sampling begins by randomly selecting the first observation and thereafter subsequent observations are selected at a uniform interval relative to the first observation;
- Stratified random sampling – if the population is regarded as being heterogeneous with respect to the random variable under study, the population can be divided into segments or strata where the sampling units

in each stratum are relative homogenous; and

- Cluster random sampling – the population is divided into clusters, where each cluster is similar in profile, to every other cluster.

It is clear that for the purpose of this research, the most useful sampling method is that of random sampling, which forms part of the probability group of sampling techniques.

3.5 Data types

According to Wegner (2001:7) data quality is influenced by three factors: the type, source and methods of data collection.

Date types are determined by the nature of the random variable which the data represent which can be:

- Qualitative random variables which yield categorical (non-numeric) responses; and
- Quantitative random variables which yield numeric responses.

3.5.1 Data types 1

- Nominal-scaled data is associated mainly with qualitative random variables where data is assigned to one number of categories of equal importance;
- Ordinal-scaled data is associated with qualitative random variables and is assigned to only one of a number of coded categories, but there is now ranking implied between the categories in terms of being better, older, longer, taller, stronger, etc.;
- Interval-scaled data is associated with quantitative random variables where the differences can be measured between values of quantitative random variables. This data possesses both order and distance

properties; and

- Ration-scaled data is associated with quantitative random variables where if the full range of the arithmetic operations can be meaningfully performed on the observation of a random variable, the data associated with that random variable is termed ratio-scaled.

3.5.2 Data types 2

- Discrete data is a random variable whose observations can take on only specific values, usually only integer values are referred to as a discrete random variable; and
- Continuous data is a random variable whose observations can take on any value in an interval and is said to generate continuous data.

For the purpose of this research, the most useful data type that will be used is that of nominal-scaled data.

3.6. THE QUESTIONNAIRE

The questionnaire is the data collection instrument used to gather data in all interview situations. Wegner (2001:17) says that the design of a questionnaire is critical to ensure that the correct research questions are addressed and that accurate and appropriate data for statistical analysis is collected.

3.6.1 The design

According to Wegner (2001:17) a questionnaire should consist of three sections:

- The administrative section is used to record the identity of the respondent

and the interviewer by name, date, and address, and where the interviews were conducted;

- The demographic or classification section describes the respondent by a number of demographic characteristics which generally include age, gender, residential location, martial status, language, qualification, etc.; and
- The information sought section makes up the major portion of the questionnaire and consists of all questions which will extract data from respondents to address the research objectives.

Leedy and Ormrod (2001:202) suggest that the following guidelines be used for developing a questionnaire that encourages people to be co-operative and yields responses one can use and interpret:

- Keep it short and as brief as possible;
- Use simple, clear, unambiguous language;
- Check for unwarranted assumptions implicit in the questions asked;
- Word the questions in ways that do not give clues about preferred or more desirable responses;
- Check for consistency;
- Determine in advance how the responses will be coded;
- Keep the respondent's task simple;
- Provide clear instructions;
- Give a rationale for any items whose purpose may be unclear;
- Make the questionnaire attractive and professional looking;
- Conduct a pilot test; and
- Scrutinize the almost-final product carefully to make sure it addresses the researchers' needs.

3.6.2 Validity and reliability

Leedy and Ormrod (2001:98) argue that validity of a measurement instrument is the extent to which the instrument measures what it is supposed to measure. It takes different forms, each of which is important in different situations:

- Face validity is the extent to which, on the surface, an instrument looks like it is measuring a particular characteristic;
- Content validity is the extent to which a measurement instrument is a representative sample of the content area being measured;
- Criterion validity is the extent to which the results of an assessment instrument correlate with another, presumably related measure; and
- Constructive validity is the extent to which an instrument measures a characteristic that cannot be directly observed but must instead be inferred from patterns in people's behavior.

Leedy and Ormrod (2001:99) state that the reliability of a measurement instrument is the extent to which it yields consistent results when the characteristic being measured has not changed. The following are forms of reliability that are frequently of interest in research studies:

- Inter rater reliability is the extent to which two or more individuals evaluating the same product or performance give identical judgments;
- Internal consistency reliability is the extent to which all the items within a single instrument yield similar results;
- Equivalent forms reliability is the extent to which two different versions of the same instrument (e.g. "Form A" and "Form B" of a scholastic aptitude test) yield similar results; and
- Test-retest reliability is the extent to which the same instrument yields the same result on two different occasions.

3.7. QUESTIONNAIRE COVER LETTER

In the covering letter and accompanying questionnaire (Appendix 1), the aim of the research was briefly explained, and the respondent was also assured that the content of the questionnaire would be regarded as strictly confidential. The covering letter was sent out attached to the questionnaire to the manufacturing heads of the steel material preparation departments of the Otrokovice and Puchov plants respectively, who handed it to all the personnel working on the machines in the area. The covering letter also identified the individual to whom the questionnaires must be returned and it was verbally agreed with the researcher that the questionnaires would be returned to him at the next plant visit.

3.8. RESPONSE RATE

Letters and questionnaires were e-mailed to the manufacturing heads of the steel material preparation area of the respective plants on 29 September 2006, who in turn handed it out to thirty eight employees in the Otrokovice plant and twenty four in the Puchov plants. By 30 October 2006, all thirty eight questionnaires were returned from the Otrokovice plant and eighteen from the Puchov plant were returned, resulting in an overall return rate of 89 percent.

3.9. ANALYSIS AND INTERPRETATION OF BIOGRAPHICAL INFORMATION

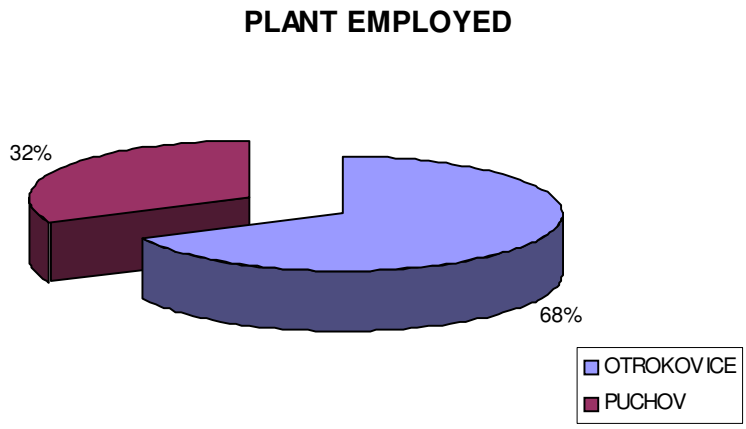
The final section of the questionnaire required the respondents to complete general biographical information within the steel preparation area of production. These included aspects that would give the researcher the ability to evaluate from which plant each respondent came from, what their job title was, which machine they worked on and what their vocational background was. The results of the questions posed in the final section of the questionnaire are presented in

Tables 3.1 to 3.4 and Charts 3.1 to 3.4.

Table 3.1: Responses according to plant employed

PLANT EMPLOYED	NUMBER	PERCENTAGE
OTROKOVICE	38	68%
PUCHOV	18	32%
TOTAL RESPONDENTS	**56**	**100%**

Chart 3.1: Responses according to plant employed



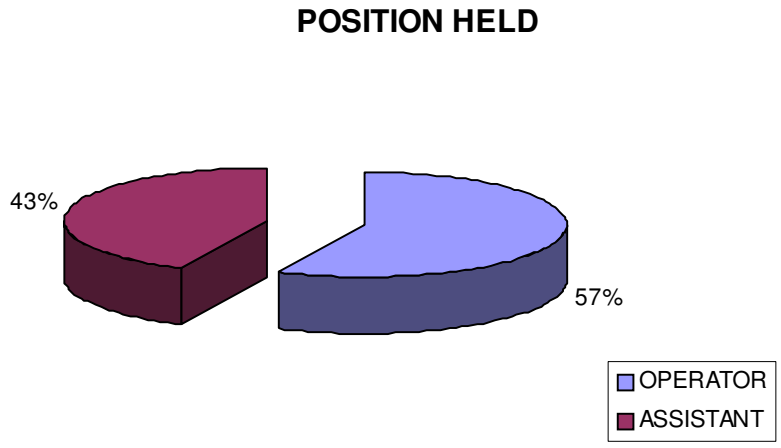
Source: Table 3.1

From Table 3.1 and Chart 3.1 it can be seen that Otrokovice has more than double the amount of responses. This is mainly due to the fact that they also produce passenger tyre material on the same lines and therefore, have more shifts producing material on the steelcord calender and additional cutting machines when compared with Puchov who only produce steel truck tyres. In addition, Otrokovice employs three times more employees than Puchov, as explained in the breakdown of the size of each organization.

Table 3.2: Responses by positions held

POSITION	NUMBER	PERCENTAGE
OPERATOR	32	57%
ASSISTANT	24	43%
TOTAL RESPONDENTS	**56**	**100%**

Chart 3.2: Responses by positions held



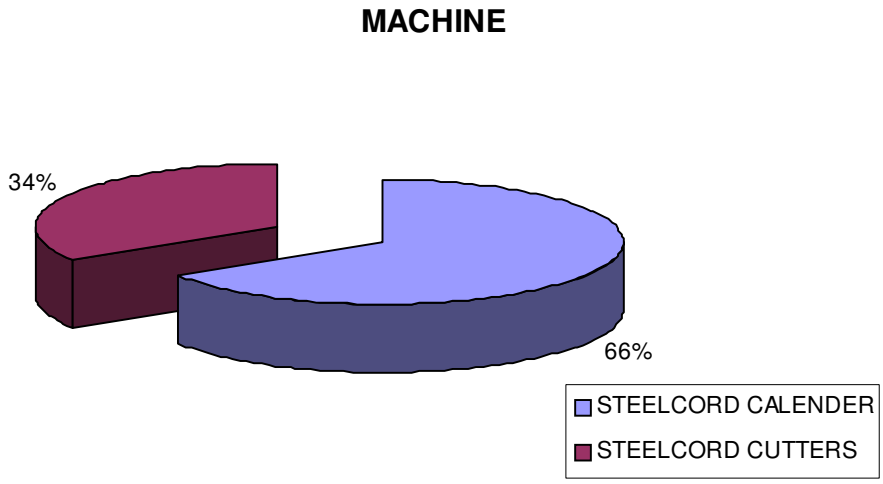
Source: Table 3.2

Table 3.2 and Chart 3.2 reflect the positions currently held by the respondents. The responses from operators is only slightly more than that of the assistants that work on the respective lines. This is a normal phenomena in the steel preparation area, as more operators are required than assistants to operate the various machines.

Table 3.3: Responses by machine

MACHINE	NUMBER	PERCENTAGE
STEELCORD CALENDER	37	66%
STEELCORD CUTTERS	19	34%
TOTAL RESPONDENTS	**56**	**100%**

Chart 3.3: Responses by machine



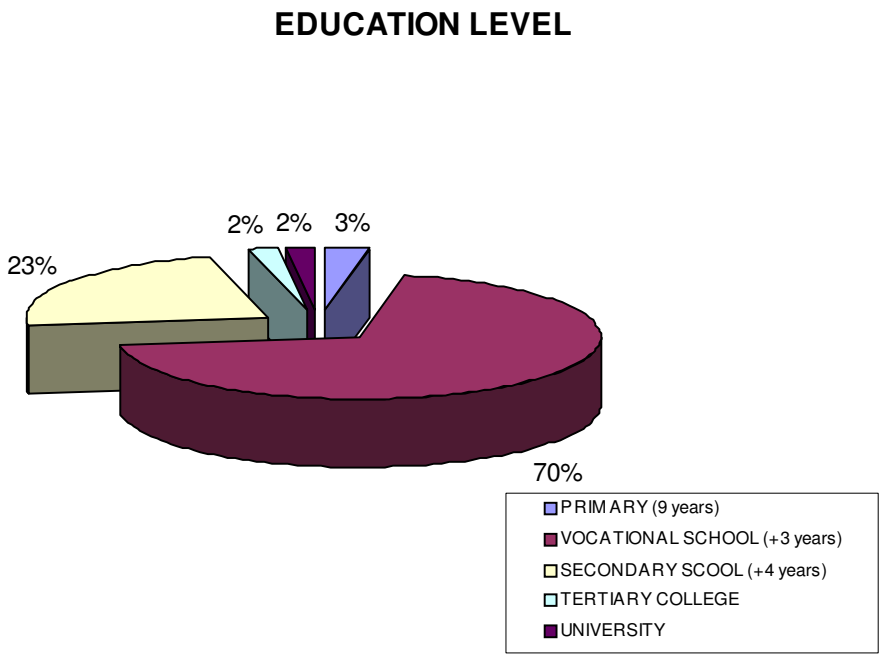
Source: Table 3.3

Table 3.3 and Chart 3.3 reflect the machine type each respondent works at. Two thirds of the respondents work on the Steelcord calender. This is a true reflection of the spread of employees by machine, as the Steelcord calender requires a larger number of employees per shift to operate it when compared with the Steelcord cutters.

Table 3.4: Responses according to education level

EDUCATION LEVEL	NUMBER	PERCENTAGE
PRIMARY	2	3%
VOCATIONAL SCHOOL	39	70%
SECONDARY SCHOOL (4 YEARS)	13	23%
TERTIARY COLLEGE	1	2%
UNIVERSITY	1	2%
TOTAL RESPONDENTS	**56**	**100%**

Chart 3.4: Responses according to education level



Source: Table 3.4

Table 3.4 and Chart 3.4 reflect the level of education the respondents have.

- The majority of the respondents are respectively 70 percent and 23 percent vocationally or secondary school educated employees;
- Only primary school educated account for 3 percent; and
- The other 4 percent are equally divided by having tertiary college and university education respectively.

To explain more clearly the educational system in the Eastern European countries of Czech and Slovak republic, the researcher has included a table showing the system of education. See appendix 2.

3.10 CONCLUDING REMARKS

The purpose of this chapter was to document the research methodology that was used during the study, as well as the quantitative analysis of the biographical details of the respondents.

In this chapter the researcher discussed sampling techniques as well as the development of the questionnaire, and presented an analysis about the biographical information of the respondents by the means of tables and charts.

The research findings will be analyzed in the following chapter to interpret how a sample of Eastern European manufacturing employees perceive the effect an implemented TPM system has had on their day to day working environment. In addition, the researcher will evaluate the results, as well as the literature study conducted, to guide him towards an approach that could be used for the implementation of TPM at Continental Tyre South Africa.

CHAPTER 4

ANALYSIS AND INTERPRETATION OF THE RESEARCH

4.1. INTRODUCTION

The purpose of chapter 3 was to describe the research methodology applied by the researcher to solve the sub-problems. The development and structure of the questionnaire, the design of the questionnaire and the administration of the questionnaire was discussed. The response of the respondents was also discussed, which was followed by an analysis of the biographical details of respondents.

The objective of chapter 4 is to assist the researcher to solve the second sub-problem:

- What does a statistical analysis of the current status of maintenance, through evaluation of machine breakdown reports, at Continental Tyre South Africa reveal and what does a questionnaire about implemented TPM systems in affiliated Eastern European tyre manufacturing plants reveal?

The responses of the questionnaire are presented in this chapter. The questions were designed to verify the information sourced during the literature study described in chapter 2. Finally, a conclusion regarding the responses and the integration of the literature will be presented.

4.2. MAINTENANCE AT CONTINENTAL TYRE SOUTH AFRICA

Continental Tyre South Africa follows the planned maintenance approach for all their equipment throughout the plant. A schedule is prepared at the beginning of each year and these schedules outline the only part of preventative maintenance that is being practiced at Continental Tyre South Africa. To explain the schedule in more detail, two tables of the planned maintenance schedules for 2006 for the equivalent areas researched in the Eastern European plants of Otrokovice and Puchov are presented.

Table 4.1: Planned maintenance schedule for Steelcord calender (CTSA)

Date	Hours	Reason	Remarks
03/03	8	PM Done	
16/03	8	PM Done	
04/05	8	PM Not Done	Due to breakdowns
17/05	8	PM Not Done	Rescheduled 02/06
29/05	8	PM Done	Shutdown work
22/06	8	PM Done	
10/08	8	PM Done	Done 09/08 Production demands
28/09	8	PM Done	Done 02/10 Production demands
16/11	8	PM Not Done	Production demands

For the Steelcord calender, out of a scheduled production period of 7200 hours, 72 hours are scheduled maintenance time. In the case of the Steelcord calender, two planned maintenance were operations cancelled, resulting in an effective 56 hours of planned and preventative maintenance.

Table 4.2: Planned maintenance schedule for Steelcord cutters (CTSA)

Date	Hours	Reason	Remarks
09/02	8	PM Done	
20/02	8	PM Not Done	Due to breakdowns
23/02	8	PM Done	Done 25/02 Broken extruder
27/03	8	PM Done	Done 02/04 Due to low floor levels
30/03	8	PM Done	Done 02/04 Due to low floor levels
13/04	8	PM Done	Done 16/04 Due to production demands
24/04	8	PM Done	
18/05	8	PM Halve Done	Only electrical part
22/05	8	PM Done	
29/05	8	PM Halve Done	Only mechanical part
05/06	8	PM Done	
26/06	8	PM Done	
06/07	8	PM Done	Done 09/07 Due to production demands
20/07	8	PM Done	Done 23/07 Due to production demands
24/07	8	PM Done	Done 30/07 Due to production demands
21/08	8	PM Done	
24/08	8	PM Done	Done 27/08 Due to production demands
07/09	8	PM Done	Done 10/09 Due to production demands
07/09	8	PM Done	
02/10	8	PM Done	
09/10	8	PM Done	Done 15/10 Due to breakdowns
12/10	8	PM Done	Done 15/10 Due to breakdowns
26/10	8	PM Done	Done 29/10 Due to production demands
13/11	8	PM Done	
20/11	8	PM Done	Done 26/11 Due to production demands
30/11	8	PM Done	Done 03/11 Due to production demands

The above table is similar to table 4.1 above, except that it includes two cutting machines. Therefore, out of a scheduled production period of 14400 hours, 72 hours are scheduled maintenance time, 208 hours are set aside for scheduled maintenance. In this case, a complete planned maintenance was not done and two were only done half-way, leaving and effective 192 hours of planned and preventative maintenance between these two machines. This is not a bad reward considering that these machines have to operate 24 hours a day, seven days a week to keep up with the production demands of customers.

The Eastern European plants follow exactly the same principle regarding planned maintenance. However, they have an additional advantage that includes the operators and assistants of the machines being made responsible for productive maintenance. Later in this chapter the researcher will explain in further detail what these productive maintenance tasks include. To illustrate the effectiveness of the planned maintenance approach followed by Continental Tyre South Africa, the researcher will provide two separate tables with the list of the reported breakdowns that were experienced on the above-mentioned equipment.

Table 4.3: Steelcord calender breakdown incidents (CTSA)

No. of incidents	Time (Minutes)	Reason for breakdown
22	897	Safety switches tripping
20	1076	Hydraulic and air pressure leaks
18	393	Blade and cutter problems
12	665	Poly splice and brake problems
8	535	Control panel problems
8	329	Wind-up tension problems
6	152	Faulty rolls
4	179	Settings
3	82	Rubber stuck in machine
3	30	Start-up
2	35	Lubrication
2	126	Faulty Hoist
2	46	Faulty proximity switch
1	39	Broken wind-up chuck
1	29	Faulty valve
1	27	Faulty bar
1	10	Faulty lights in creel room
1	5	Faulty gauge

Table 4.4: Steelcord cutters breakdown incidents (CTSA)

No. of incidents	Time (Minutes)	Reason for breakdown
100	4294	Splicer setting problems
86	1794	Gum edge blade, slitter blade and rollers
85	2171	Safeties tripping, sensors and proximity switches faulty
65	1492	Extruder problems
59	1546	Guillotine problems
47	2212	Conveyor problems
41	454	Wind-up problems
35	742	Faulty computer
24	534	Faulty let-of
20	2153	Magnet bar problems
9	571	Faulty hoist
9	275	Gearbox and drive problems
9	193	Hydraulic and air leaks
8	227	Stock jams
5	143	Angle set-up problems
3	67	Loading of cassette problems
3	31	Faulty hot box
2	148	Problematic bar
2	15	Metal detector faulty
1	151	Wire burnt off at wind-up
1	100	Breaker controller
1	80	Centralizer unit problems
1	41	Nozzle element faulty
1	25	Guillotine override
1	15	Sliding board problem
1	12	Leaking benzene container
1	9	Cycle problem

Table 4.3 and 4.4 above show the results of the number of incidents, time and reason for breakdowns for the Steelcord calender and cutters for the entire period from January to December 2006. It is clear that there was quite a substantial amount of production time lost on both machines during this period. Excluding the planned maintenance explained earlier, the Steelcord calender and cutters lost an amount of 77 hours and 324 hours respectively. This amounts to 3,2 days complete production lost at the Steelcord calender and 13,5 days lost at the two cutters combined. In addition, to compile the severity of the situation, the number of repeated incidents for similar breakdowns is very

high. The Steelcord calender had four cases where the incidences were higher than ten. In the case of the cutters there were ten incidences repeated more than ten times.

From the reasons for breakdown, the possibility to identify aspects that could be checked beforehand to prevent actual down time is there and must be evaluated. Therefore, the researcher decided that the best way to establish what the driving force behind the implementation of such a preventative approach to maintenance is, was to do a study in other plants. Thus a questionnaire was compiled, intending to answer two main questions the researcher wanted to use as part of selecting an appropriate implementation approach for TPM at Continental Tyre South Africa. These are:

1) How much are the employees involved and empowered to do their TPM tasks?; and
2) How effective is the implemented TPM programme?

In the questionnaire, question numbers one to nine will highlight if the employees are involved and empowered in the TPM process. Questions ten to eighteen aims to determine how effective this TPM process is running in the steel preparation areas of the Eastern European tyre manufacturing plants evaluated. The result from the survey conducted can be seen in Table 4.5 and Table 4.6.

4.3. EMPLOYEE INVOLVEMENT AND EMPOWERMENT

This is an important part of the strategy to consider when implementing any new system like TPM, because employees must be part of the processes from the start and it must feel as if they are included in the decision-making process. As cited before, Robinson and Ginder (1995:3) state emphatically that the more employees that are involved actively in the decision making process, the more chance of success a programme like TPM becomes. In addition, Rich (1999:210) agrees that the TPM change process involves teamwork between departments, involving everyone in each other's work to achieve a common goal.

In this section the emphasis is on determining whether employee involvement and empowerment exists in already in-place TPM programmes.

Table 4.5 shows the respondent's opinions to the extent to which Barum Continental Otrokovice's and Continental Matador Puchov's employee involvement and empowerment are in place with regard to the TPM process.

Table 4.5: Questionnaire results (Questions 1- 9)

1	Were you trained for TPM tasks?	**53(95%)**	YES	**3(5%)**	NO
2	Do you have the tools to perform your TPM tasks?	**54(96%)**	YES	**2(4%)**	NO
3	Are you involved in the improvement of the TPM system in your plant?	**45(80%)**	YES	**11(20%)**	NO
4	Are all people at all levels involved in the TPM process and ensuring that it is maintained in your plant?	**46(82%)**	YES	**10(18%)**	NO
5	Do you feel responsible for maintaining your machine in a good, clean functional state?	**56(100%)**	YES	**0(0%)**	NO
6	Did TPM improve your knowledge of the machine you operate?	**56(100%)**	YES	**0(0%)**	NO
7	Do you recieve any additional compensation for your TPM tasks?	**0(0%)**	YES	**56(100%)**	NO
8	What is your relationship with the maintenance department? **16(29%)** Excellent **32(57%)** Neutral/Normal **8(14%)** Bad				
9	Who is the driving force behind the TPM process in your plant? **3(5%)** Production **3(5%)** Quality **10(18%)** Maintenance **40(72%)** All three				

An analysis of table 4.5 indicates the following:

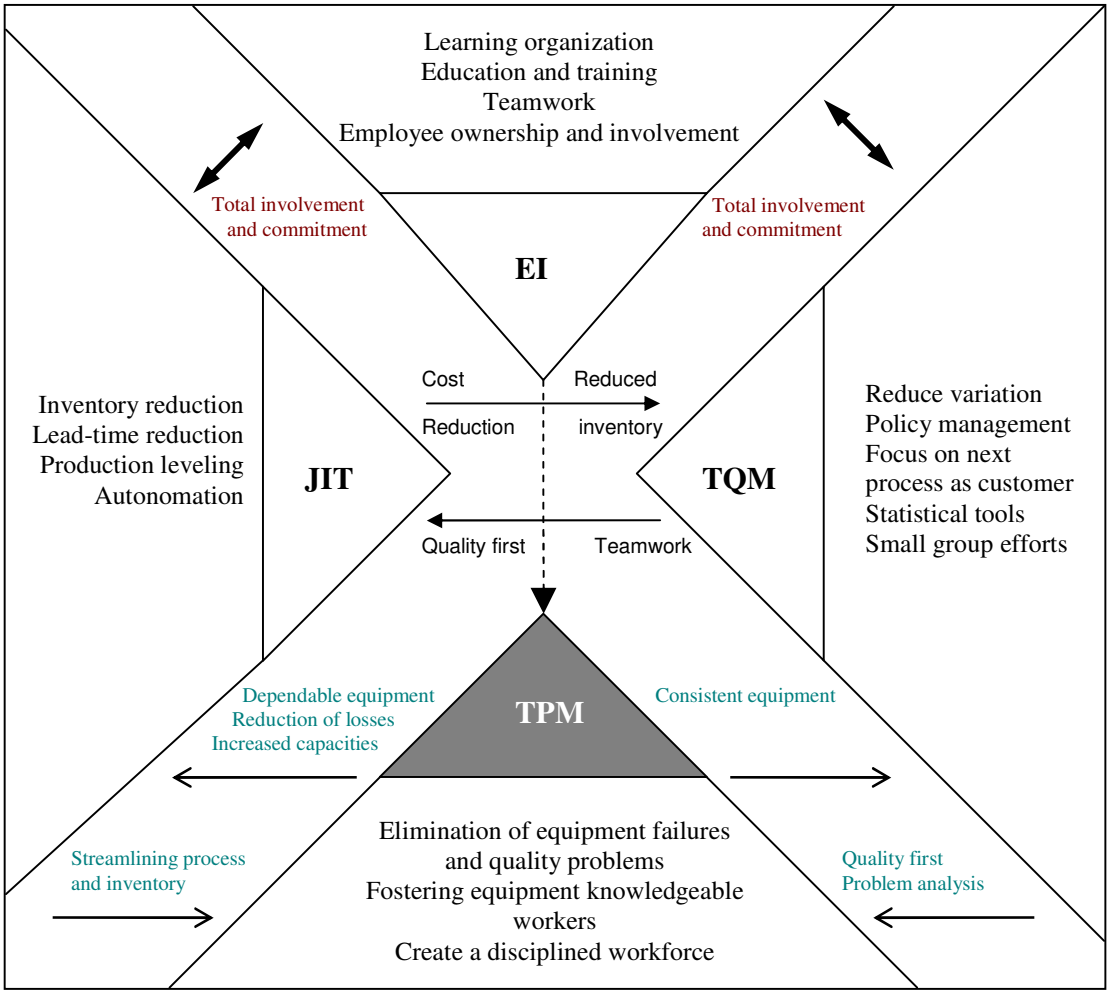
- 95% of the respondents have received training for the TPM tasks they have to perform; 5 % still require training;
- 96% of the respondents have the necessary tools to do the TPM tasks that were given to them to do; 4% still have to be provided with tools;
- 80% of the respondents are involved in the improvement of the TPM system in their plant; 20% need still need to become involved in the improvement programme;
- 82% of the respondents feel that all people at all levels in the organization are involved in the TPM process and ensure that it is maintained in their plant; 18% do not feel that everyone at all levels are involved in the TPM process and maintenance thereof;
- 100% of the respondents feel they are responsible to keep their machine in a good, clean functional state;
- 100% of the respondents stated that their TPM tasks have improved their knowledge of the machine they operate;
- Not one of the respondents receives any additional payment for the TPM tasks they perform;
- 86% of the respondents have a good relationship with the maintenance department; 14% do not have a good relationship with the maintenance department; and
- 72% of the respondents feel that production, quality and maintenance are the combined driving force behind TPM in their plant; 18% feel it is driven by the maintenance department only; 5% feel it is driven by quality; and 5% feel it is driven by production.

Relating the results of the analysis of Table 4.5 to the theory previously discussed, the findings are as follows.

The employees of the respective Eastern European plants are given the necessary tools, training, and responsibility to perform the TPM tasks they are given, with the additional benefits of gaining additional knowledge of the

machine they operate. This is indicative of the theory, where Robinson & Ginder (1995:3) argue that TPM requires employees to take a more active role in decision-making and to accept responsibility for the plant and its physical condition. They have a more active role to play in defining their job content, along with work systems and procedures. The intent is that each employee takes pride in plant equipment and is proud to be associated with the facility. Figure 4.1 below illustrates where employee involvement fits into world-class manufacturing and the interdependence of just-in-time, total quality management and TPM.

Figure 4.1: The interdependence of Just in Time, Total Quality Management, Total Productive Maintenance and Employee Involvement



Source: Mckone & Weiss (1998:338)

4.4. THE EFFECTIVENESS OF AN IMPLEMENTED TOTAL PRODUCTIVE MAINTENANCE SYSTEM

To establish if the TPM system has been successfully implemented in the Eastern European plants of Barum Continental Otrokovice and Matador Continental Puchov, the researcher made use of the questions prescribed in the text by Davis (1994:86), where he argues that the six big losses will give a clear indication to a plant whether it is in need of TPM or not, or whether the TPM process that has been introduced is achieving the desired results that were expected when TPM activities were introduced.

In this section the emphasis is on determining whether the implemented TPM systems have resulted in success for the Eastern European plants evaluated in this study. Table 4.6 shows the respondent's opinions to the extent to which Barum Continental Otrokovice's and Continental Matador Puchov's TPM process have been successfully implemented.

Table 4.5: Questionnaire results (Questions 10-18)

10	Using the TPM checklist you have, are you able to detect and prevent machine breakdowns before they happen?			**51(91%)** YES	**5(9%)** NO
11	What do your TPM tasks mainly involve (more than one answer possible)				
	56 (100%) cleaning around machine				
	33 (59%) small maintenance tasks				
	56 (100%) reporting of problems like leaks and damage to machine				
	0 big machine repair				
12	How long does your TPM tasks take every shift?				
	8(14%) less than 5 minutes **23(41%)** 5-10 minutes **25(45%)** 10-15 minutes				
13	Have your TPM tasks improve your equipment reliability? Does your machine have less breakdowns?			**45(80%)** YES	**11(20%)** NO
14	How often does your machine break down due to:	Every shift	Once a day	Less than that	
	minor things which are fixed quickly,	**29(52%)**	**11(20%)**	**16(29%)**	
	things that stick (bearing, conveyor etc.),	**0 (0%)**	**0 (0%)**	**56(100%)**	
	the machinery having to be shut down or re-set?	**8 (14%)**	**7 (13%)**	**41(73%)**	
15	Have your TPM tasks improve your productivity?			**46(82%)** YES	**10(18%)** NO
16	Have your TPM tasks improve your product quality?			**45(80%)** YES	**11(20%)** NO
17	Do you have less scrap/waste due to the machine problems?			**40(71%)** YES	**16(29%)** NO
18	Have your TPM tasks improve your morale? Are you motivated to work on the machine?			**46(82%)** YES	**10(18%)** NO

An analysis of table 4.5 indicates the following:

- 91% of the respondents are able to detect and prevent breakdowns before they happen, using the checklist provided to them for the equipment they work on; 11% of the respondents say that they are not able to do so;
- 100% of the respondents indicated that their TPM tasks mainly involve cleaning around the machine and reporting problems like leaks and damage to the machine; 59% of the respondents also indicated that they are responsible for small maintenance tasks; none of the respondents are involved in big machine repairs;
- 45% of the respondents take 10-15 minutes to complete their TPM tasks on a shift; 41% take between 5-10 minutes; 14% take less than 5 minutes;
- 80% of the people questioned feel that the TPM tasks they perform every shift have improved their equipment reliability and they have less breakdowns as a result thereof; 20% feel that it has not improved their equipment reliability;
- 52% of the respondents have on a shift some minor things go wrong with the machine that can be fixed quickly, compared to zero incidences of things like conveyors and bearings that stick and 14% shutdown and re-set aspects. For the same reasons 20%, 0% and 13% of the respondents say that these aspects occur once per day, whereas 29%, 100% and 73% say that it occurs even less than that;
- 82% of the respondents say that the TPM tasks they perform each day have improved their productivity; 18% disagree that TPM has improved their productivity;
- 80% of the respondents say that that TPM has improved their product quality; 20% did not feel that TPM has changed the quality of the product they produce;
- 71% of the respondents say that TPM has resulted in them producing less scrap or waste; 29% did not agree that TPM reduced the scrap or waste they produce; and
- 82% say TPM is a morale booster; 18% disagreed.

4.5. CONCLUDING REMARKS

The purpose of chapter 4 was to analyze and interpret the data obtained through the statistical analysis of machine breakdown reports at Continental Tyre South Africa and the research questionnaire about implemented TPM systems in affiliated Eastern European tyre manufacturing plants. The analysis and interpretation was undertaken in terms of the objectives stated in chapter 1. The evaluation done by the researcher indicates that the current planned maintenance system at Continental Tyre South Africa does not lean itself towards elimination of the big six losses and employee involvement and empowerment as discussed in chapter 2. On the other hand, the questionnaire revealed that TPM has been successfully implemented in affiliated Eastern European truck tyre plants and based on the positive feedback, general guidelines as well as strategic direction can be drawn to assist toward proper implementation of TPM at Continental Tyre South Africa.

Chapter 5 will focus on the recommendations to answer sub-problem 3, which is:

- What implementation approach would be suitable to introduce TPM successfully at Continental tyre South Africa?

The answer to the above mentioned question will be based on the findings from the questionnaire conducted as well as the literature study conducted. Problems and limitations encountered during the research, as well as opportunities for further research will be highlighted.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1. INTRODUCTION

In this final chapter, the researcher will provide a summary of what the current status of maintenance at Continental Tyre South Africa reveal and the implemented TPM systems in Continental plants in Puchov, Slovakia and Otrokovice in the Czech Republic.

The conclusions that have been reached with respect to the main problem and sub-problems will also be stated. Lastly, recommendations for future research and suggestions for the application of the findings will be presented.

5.2. PROBLEMS AND LIMITATIONS

During the course of the research project, no problems were encountered.

5.3. SUMMARY OF THE STUDY

5.3.1 Reasons for the research

Continental plants in Puchov, Slovakia and Otrokovice in the Czech Republic have made use of a total productive maintenance as part of their maintenance programme throughout their entire manufacturing divisions for a number of years and the effectiveness needed to be evaluated to assist in providing strategic guidelines for the implementation of TPM at Continental Tyre South Africa, which makes use of traditional preventative and reactive maintenance to cope with machine breakdowns.

5.3.2 The problem statements

The main problem identified in this study was:

What is the appropriate method for the implementation of Total Productive Maintenance at Continental Tyre South Africa?

The following three sub-problems were identified in order to make the main problem more researchable.

Sub-problem One

- What does the literature reveal about total productive maintenance in manufacturing organizations?

This sub-problem was addressed in chapter 2 by a literature review of total productive maintenance, discussing its role; the pillars on which it is based; how employee involvement and empowerment and teamwork fits in; how it can be measured; how to implement it; what the stumbling blocks are and the benefits of implementing total productive maintenance.

Sub-problem Two

- What does a statistical analysis of the current status of maintenance, through evaluation of machine breakdown reports, at Continental Tyre South Africa reveal and what does a questionnaire about implemented TPM systems in affiliated Eastern European tyre manufacturing plants reveal?

Using the internal maintenance call-out logging process, the researcher was able to collect the relevant data to analyze the major breakdown reasons at Continental Tyre South Africa. In addition, to complete the analysis about already existing TPM processes, the researcher deigned a questionnaire using nominal-scaled data which was distributed to 62 employees within the steel stock preparation departments in the manufacturing division of Barum Continental Otrokovice and Continental Matador Puchov. The respondents were assured of

their privacy and confidentiality so as to ensure honest and reliable information. The responses of the respondents were analyzed in chapter 4 in order to address the sub-problem above.

Sub-problem Three

- What implementation approach would be suitable to introduce TPM successfully at Continental tyre South Africa?

The results obtained from the questionnaire were presented in chapter 4 and the literature in chapter 2 will be used to make recommendations on what implementation approach would be suitable to introduce TPM successfully at Continental tyre South Africa.

The main findings of the research conducted can be summarized as follows:

- Continental South Africa's current planned maintenance programme is not as effective a maintenance system as management wishes it to be. Based on the number of days lost due to machine breakdowns, 3,2 and 13,5 days on the steelcord calender and cutter respectively, some intervention is required to improve equipment reliability and utilization;
- The first section of the questionnaire focuses on employee involvement and empowerment. 95% of the respondents said that they have been trained to perform the tasks required by them and that they have been given the necessary tools to perform these tasks;
- The respondents answered with a resounding 100% response rate that they feel responsible for the machines they work on and that the TPM tasks that they were given to do, increased their knowledge of the machine. In addition, 100% of the respondents said that they were not given additional money for performing their TPM tasks;
- The respondents also agreed by more that 80% that everyone throughout their plant is involved in the improvement, development and maintenance of the TPM programmes that is in place. In addition, more

than 70% believe that the driving force behind the TPM programme is a combination of the Engineering, Production and Quality departments.

- The second section of the questionnaire was aimed at getting an insight into the effectiveness of an implemented TPM system. The respondents agreed by more than 90% that they are able to detect and prevent breakdowns better after introduction of TPM;
- The respondents said that their main tasks in the TPM programme is to clean around the machine and report small leaks or damage on the equipment and more than 85% mentioned that these tasks only take between five and fifteen minutes a shift;
- This can explain why more than 80% of the respondents agreed that TPM has improved their equipment reliability, hence the response from approximately 50% of the respondents that the machine stops for minor things that can be fixed quickly on a shift. Also, it happens 100% less than once a day that things on the machine stick and 73% less than once a day that the machine has to be shutdown or restarted; and
- Lastly, more than 80% of the respondents see that TPM has improved their productivity, quality and morale and more than 70% see TPM resulting in less scrap or waste.

5.3.3 Review of the research project

- **Chapter One (PROBLEM DEFINITION AND DEFINITION OF KEY CONCEPTS)**

This chapter presented the main and sub-problems to be addressed. It also outlined the researcher's method for solving the stated problem and sub-problems.

- **Chapter Two (TOTAL PRODUCTIVE MAINTENANCE)**

In this chapter an overview of total productive maintenance suggested by literature was presented.

- **Chapter Three (THE EMPIRICAL STUDY)**

In this chapter the researcher covered the methods of how the research was conducted. An analysis of the biographical information was presented.

- **Chapter Four (ANALYSIS AND INTERPRETATION OF EMPIRICAL STUDY)**

In this chapter the data that was generated from the breakdown analysis of Continental Tyre South Africa's breakdown reports and the questionnaire were presented and analysed. The literature review was integrated with the data analysis.

- **Chapter Five (CONCLUSIONS AND RECOMMENDATIONS)**

The purpose of this chapter is to summarise the research project and to provide concluding remarks and recommendations.

5.4. RECOMMENDATIONS

- It is essential that the executive team at Continental Tyre South Africa realizes the need of a programme like TPM. Based on the results from the analysis of the breakdown reasons of critical processes in the steel stock preparation areas and the positive responses in the questionnaire, it should not be difficult for them to realize the need for such a programme;
- It is recommended that the knowledge gained by plants like Otokovice and Puchov be used as a guideline for introduction and implementation;
- It is recommended that the employees that will be required to perform the TPM tasks are properly trained and that they receive the necessary tools to perform their tasks;
- It is essential that everyone throughout the entire manufacturing organization are involved from the start in the development, improvement and maintenance of the TPM programme and that the driving force behind

them should be a combination of maintenance, production and quality;

- It is critical that the barriers to implementation be taken seriously at the start of the whole implementation process of TPM and plans be put in place to overcome them. Make sure that there is:

    - no lack of proper understanding of the total effort required;
    - no lack of management support;
    - no lack of sufficient TPM staff;
    - no union resistance;
    - enough training carried out;
    - change of priorities;
    - no lack of persistence;
    - no failure to develop a good installation strategy; and
    - no possibility of choosing the wrong approach.

- Choyds (2003), concluded that implementing TPM is a dramatic organizational change that can affect organization structure, work-floor management systems, employee responsibilities, performance measurement, incentive systems, skill development and the use of information technology. Therefore, all the above mentioned aspects must be given serious consideration before starting the TPM implementation process; and
- Lastly, building the TPM programme based on a solid foundation will guide Continental Tyre South Africa to achieve a sustainable TPM programme. The foundation on which the TPM should be build are the following:

    - Equipment cleaning;
    - Lubrication;
    - Correct operation; and
    - Regular inspection.

5.5. OPPORTUNITIES FOR FURTHER RESEARCH

This study can also provide the basis for further research. Total productive maintenance has been an approach available since 1951 and new directions in TPM could still be developed. The possibility exists to repeat the same study once TPM is in place at Continental Tyre South Africa.

5.6. CONCLUSION

Total productive maintenance can be seen as a means of getting better overall equipment efficiency and improved productivity, quality and morale, resulting in less scrap or waste.

Whether or not Continental Tyre South Africa uses any of the implementation approaches discussed earlier in this research paper, at the end of the day the effectiveness of the system depends on how well it is utilized and managed within an organization.

It can be concluded that whether TPM within an organization can achieve its objectives, depends on whether:

- The equipment effectiveness can be improved – This will require the identification and examining of all losses that occurs, i.e. downtime, speed and defect losses;
- Autonomous maintenance is achieved – This means allowing the people who operate the equipment to take responsibility for some of the maintenance tasks at repair, prevention or improvement level;
- Planned maintenance is in place – This requires maintenance staff to adopt a more facilitating and supporting role where they are responsible for the training of operators, problem diagnoses and devising and assessing maintenance practice;
- Staff is trained in relevant maintenance skills – This includes appropriate and continuous training; and

- Early equipment management can be achieved – This involves considering failure causes and the maintainability of equipment from the early stages of design, manufacturing installation and commissioning.

Total Productive Maintenance attempts to track all potential maintenance problems back to their root cause so that they can be eliminated at the earliest point in the overall design, manufacturing and deployment process.

The recommendations made in this research paper, if properly applied and implemented could form the basis of an effective Total Productive Maintenance at Continental Tyre South Africa.

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APPENDIX 1

QUESTIONNAIRE

Research Title: **Selecting an appropriate implementation strategy for Total Productive Maintenance at Continental Tyre South Africa**

Researcher: **C Olivier**

Quality Manager: Commercial Vehicle Tyres

Dear participant

I am currently busy with my Masters degree in business administration at the Nelson Mandela Metropolitan University in Port Elizabeth, South Africa. I am an employee of Continental Tyre in South Africa, currently working on contract in the Central Quality department, Commercial Vehicle Tyres in Hannover, Germany.

I have decided, after seeing how TPM has been introduced in your plant, to set up a questionnaire that I will use as part my research. It will be limited to all the production personnel from the Steel Calender and Steel cutting area only. Therefore, I humbly request that you please complete the questionnaire, which is absolutely anonymous and return it to me by 30 September 2006. I thank you in advance for your participation in this research

Christie Olivier

Total productive maintenance (TPM) in the plants Barum Continental Otrokovice and Continental Matador Púchov – QUESTIONNAIRE

1	Were you trained for TPM tasks?	Y	N
2	Do you have the tools to perform your TPM tasks?	Y	N
3	Are you involved in the improvement of the TPM system in your plant?	Y	N
4	Are all people at all levels involved in the TPM process and ensuring that it is maintained in your plant?	Y	N
5	Do you feel responsible for maintaining your machine in a good, clean functional state?	Y	N
6	Did TPM improve your knowledge of the machine you operate?	Y	N
7	Do you receive any additional compensation for your TPM tasks?	Y	N
8	What is your relationship with the maintenance department? Excellent / Normal/Neutral / Bad		
9	Who is the driving force behind the TPM process in your plant? Production Quality Maintenance All three		
10	Using the TPM checklist you have, are you able to detect and prevent machine breakdowns before they happen?	Y	N
11	What do your TPM tasks mainly involve (more than one answer possible) Cleaning around the machine Small maintenance tasks Reporting of problems like leaks and damage to machine Big machine repair		

12	How long do your TPM tasks take every shift? Less than 5 minutes Between 5 to 10 minutes More than 10 minutes			
13	Have your TPM tasks improve your equipment reliability? Does your machine have fewer breakdowns?		Y	N
14	How often does your machine break down due to:	Every shift	Once a day	Less than that
	- minor things which are fixed quickly,			
	- things that stick (bearing, conveyor etc.),			
	- the machinery having to be shut down or re-set?			
15	Have your TPM tasks improved your productivity?		Y	N
16	Have your TPM tasks improve your product quality?		Y	N
17	Do you have less scrap/waste due to the machine problems?		Y	N
18	Have your TPM tasks improved your morale? Are you motivated to work on the machine?		Y	N
19	Which plant you work in? Barum Continental Otrokovice Continental Matador Puchov			
20	What is your job title? _____ Which machine do you work on? _____			

21	Please provide an indication of your qualification/education? Primary school Vocational school Secondary school Tertiary college University

Thank you for your co-operation!

QUESTIONNAIRE (CONT.)

Vážený účastníku výzkumu,

Jmenuji se Christie Olivier, jsem zaměstnancem firmy Continental Tyre v Jižní Africe a nyní pracuji v oddělení Centrálního managementu kvality pro nákladní pláště v Hannoveru.

V současnosti dokončuji svou disertační práci na téma "Stratégi pro implementaci Totální Produktivní Údržby (TPM)". Dozvěděl jsem se, že tento systém byl zaveden ve Vašem podniku a proto bych Vám rád položil několik otázek. Zajímá mne především Váš názor na přínos TPM a jeho funkčnost. Mým cílem je zjistit, zda je vhodné doporučit zavedení tohoto systému v jiném podniku.

Následující stručný dotazník je zcela anonymní a obrací se na všechny zaměstnance z oblasti stříhání ocelových kordů a pogumování ocelových kordů. Po zodpovězení všech otázek předejte prosím dotazník panu 30 Septembre 2006. Předem Vám děkuji za spolupráci na mém výzkumu. S přáním pěkného dne.

Christie Olivier

TPM (Totální Produktivní Údržba) v závodech Barum Continental Otrokovice a Continental Matador Púchov - DOTAZNÍK

1	Prošel jste tréninkem TPM úkolů?	A	N
2	Máte k dispozici potřebné nástroje k provedení TPM úkolů?	A	N
3	Účastníte se zlepšování systému TPM ve Vašem závodě?	A	N
4	Jsou všichni pracovníci ze všech úrovní zahrnuti v procesu TPM a zajišťují jeho dodržování ve Vašem závodě?	A	N
5	Cítíte se být zodpovědný za udržování Vašeho zařízení v dobrém, čistém a funkčním stavu?	A	N
6	Zlepšila TPM Vaši znalost zařízení, se kterým pracujete?	A	N
7	Dostáváte nějaké dodatečné ohodnocení/odměnu za Vaše TPM úkoly?	A	N
8	Jaký je Váš vztah k oddělení údržby/jaké zkušenosti s tímto oddělením máte? dobré zkušenosti / neutrální vztah / špatné zkušenosti		
9	Kdo je řídící silou TPM procesu ve Vašem závodě? Výroba Oddělení kvality Údržba Všechna tři oddělení		
10	Jste schopen prováděním TPM úkolů odhalit poruchu zařízení a předejít jí dříve než k ní dojde?	A	N

11	Jaké činnosti z níže uvedených jsou Vašimi nejčastějšími TPM úkoly? (lze zaškrtnout i více možností): čištění zařízení a úklid kolem něj jednoduchá údržba podávání zpráv o problémech se zařízením - netěsnosti, poškození apod. velké opravy zařízení			
12	Kolik času Vám zaberou každou směnu TPM úkoly? méně než 5 minut 5-10 minut více než 10 minut			
13	Zlepšily TPM úkoly spolehlivost Vašeho zařízení? Snížil se počet poruch přístroje?		A	N
14	Jak často je potřeba řešit následující oruchy/zdržení?	Každou měnu	Jednou za den	Méně často
	- malé poruchy, které jste schopen rychle odstranit,			
	- zaseknutí stroje, mechanické poruchy (ložiska, dopravníku apod.			
	- nutnost vypnout či znovu nastavit zařízení?			
15	Zvýšila se díky TPM úkolům Vaše produktivita?		A	N
16	Zlepšila se díky TPM úkolům kvalita Vašich výsledků/výrobků?		A	N
17	Máte méně odpadu způsobeného problémy se zařízením?		A	N
18	Zlepšily TPM úkoly Vaši pracovní morálku? Cítíte se být motivován pracovat na zařízení?		A	N

19	V jakém závodě pracujete? Barum Continental Otrokovice Continental Matador Puchov
20	Jak se jmenuje pozice a zařízení, na kterém pracujete? (prosím vyplňte tiskacím písmem) Pozice: _____ Zařízení: _____
21	Jaké je Vaše nejvyšší dosažené vzdělání? Základní Vyučen Střední s maturitou Vyšší odborné Vysokoškolské

Děkuji za Vaši spolupráci!

APPENDIX 2

System of Education in the Czech/Slovak Republic

Description	As in questionnaire
Primary education: 9 years compulsory school attendance at the basic school (starts at the age of 6)	Primary school
Secondary education lasts usually 3-4 years. There are 3 types: 1) Vocational schools (apprentice schools) - prepare for practical professions (cook, mechanic, painter..) - 3 years, at the end you get an indenture which allows you to do these kinds of jobs	Vocational school
2) Grammar schools - 4 years, at the end school leaving exam in 4 subjects 3) Special secondary schools (technical, medical, schools of economics etc.) - 4 years, at the end school leaving exam in 4 subjects	Secondary school (4 years)
Tertiary education: a) Tertiary college - 2-3 years	Tertiary college
b) University - 4-6 years	University