

Experiences of Implementing TPM in Swedish Industries

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Abstract. The global marketplace is highly competitive and organisations, who want to survive long-term, have to continuously improve, change and adapt in response to market demands. These improvements should focus on cost cutting, increasing productivity levels and quality and guaranteeing deliveries in order to satisfy customers. Total Productive Maintenance (TPM) is one method, which can be used to achieve these goals.

TPM is a change management approach that involves employees from both production and maintenance departments. The purpose is to eliminate major production losses by introducing a program of continuous and systematic improvements to production equipment. TPM should be developed and expanded to embrace the whole organisation and all employees should be involved in the process as members of improvement teams.

This paper gives a short description of the development of TPM and the TPM implementation process. Findings are reported from a case study in which one of the authors had the possibility of following and guiding a company through their TPM implementation. The implementation process takes several years and the research has focused on the initial three years. The study demonstrates that driving forces, obstacles and difficulties often are dependent on the organisation, its managers and the individual employees.

Key Words : *Total Productive Maintenance, TPM, quality, maintenance, implementation, teamwork, change.*

BACKGROUND

The aim of maintenance is to support and maintain efficient production (Jonsson, 1997). Traditionally maintenance philosophies have focused on the availability of production plants (Ollila & Malmipuro, 1999). Modern maintenance methods can have a significant impact on better quality in production plants. To go even further, maintenance must be an integral part of business strategy (Maggard & Rhyne, 1992; Kelly, 1998).

According to Riis et al. (1997), one major trend in the development of maintenance management is the linkage of maintenance to quality improvement strategies and the use of maintenance as a competitive strategy.

The human aspects and the importance of a learning organisation have attracted more attention since the TQM concept has been spread into organisations. The human aspects of a maintenance management system go hand in hand with those of TQM (Jonsson, 1997). Links between job fulfilment and continuous improvements, customer satisfaction and performance are very strong and job satisfaction, job commitment, and pride of workmanship are the most important factors in achieving employee fulfilment and empowerment (Deming, 1986). Similar findings have been found in the area of maintenance (Jonsson, 1999). Total Productive Maintenance (TPM) is one method, which link maintenance to quality improvement strategies.

TOTAL PRODUCTIVE MAINTENANCE, TPM AND TQM

In manufacturing industry quality, productivity and delivery are dependent upon the condition of the equipment. TPM takes a holistic view of the production and maintenance departments, which makes it a suitable method for increasing the productivity by reducing losses in production (Lycke, 2000). TPM can be regarded as continuous improvements, focusing on the equipment and the production. The goal is to increase the overall equipment effectiveness by autonomous maintenance. This requires, among other things, a focus on preventive activities, quality, maintenance and the equipment's reliability and availability.

TPM as defined by Nakajima (1988) is "productive maintenance carried out by all employees through small group activities" and it is based on the principle that equipment improvements must involve everyone in the organisation. Japanese manufacturing industry has developed the technique in order to provide both effective and efficient maintenance. This has arisen in response to the need of Just In Time (JIT) and Total Quality Management (TQM) (Kelly, 1992). TPM is, like JIT and TQM, a fundamental factor in world-class manufacturing quality and productivity (Nakajima, 1989).

The word "total" in "Total Productive Maintenance" has three meanings related to three important features of TPM (Nakajima, 1989):

Total: - *Total effectiveness*, i.e. predictive and productive maintenance.

- *Total PM* (Preventive Maintenance), i.e. maintenance prevention and activities to improve maintainability as well as preventive maintenance.
- *Total participation*, i.e. autonomous maintenance by operators and small group activities in every department and at every level.

Somehow, the words "productive" and "maintenance" also need to be explained:

Productive: Continuous improvement activities in every department and at every level.

Maintenance: All improvements should be standardised and maintained.

In this respect it could be of interest to compare the connection of "productive" and "maintenance" with for instance Juran's (1995) thoughts about "breakthrough" and "control" or Kaizen (Imai, 1986) about improving and maintaining standards. The Deming cycle (Deming, 1993) is also interesting in this context. All of those concepts are based upon employee involvement in continuous improvements and that the improvements should be implemented, applied, and adopted. Thus the underlying ideas are similar.

TPM is, in fact, nothing other than systematic work with quality (Lycke, 2000), and can be used to tackle the challenge of zero losses i.e. the goal is zero defects and zero breakdowns. When there are no failures, defects or breakdowns, equipment effectiveness improves and enables costs and stock to be reduced, hence improving productivity.

TPM is a natural way for companies, which are already working with quality, to make further progress. TPM promotes co-operation between maintenance and production and it is a concept that focuses on improvements on the equipment. This results in improvement and greater efficiency in both the production process and the maintenance process.

Many manufacturers around the world can reap the benefits of implementing TPM through reduced maintenance costs and the significant improvements in production equipment availability and utilisation rates. Results show that this working methods gives higher productivity, better quality, fewer breakdowns, lower costs, higher reliability of delivery, better work environment, higher safety and higher morale among the workers (Nakajima, 1988; Maggard & Rhyne, 1992; Lycke, 2000).

TPM

TPM was developed in Japan and the Japan Institute of Plant Maintenance (JIPM) has developed a TPM implementation model consisting of twelve steps (Nakajima, 1988), see figure 1. Most companies, which implement TPM, follow these steps to a greater or lesser degree. For details about the 12-step model, see e.g. Nakajima (1988, 1989).

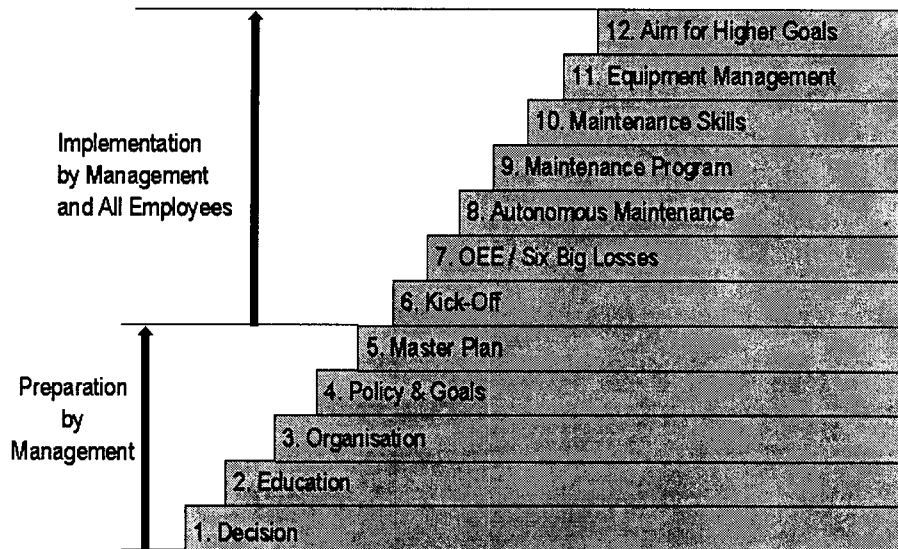


Figure 1: The JIPM 12-step model for implementing TPM

Careful, thorough planning and preparation are the keys to successful company-wide implementation. TPM is a long-range strategy for changes and it is about changing people's attitudes, increasing their motivation and competence and in setting their enormous potential free. Furthermore, the environment must be adapted to support these changes. The senior management's commitment is necessary but it is also important that the organisation adjusts to the changes in a way that does not confront unnecessary resistance.

It is vital to point out that working with TPM is not a project. It is a way of working. This means also that there is no end to the process of TPM implementation. The last step in the implementation model is the need to "aim for higher goals". The vision of this way of working is to create trouble-free operations. The method of working and the vision should be committed everywhere in all departments of the company. Every employee should be involved in the creating of trouble-free processes.

EXPERIENCES FROM IMPLEMENTING TPM

To get more experiences of the implementation process of TPM, a longitudinal case study has been conducted in a typical, medium-sized Swedish manufacturing company. One of the authors has had the opportunity of both monitoring and guiding a company through part of its TPM implementation program, i.e. action research. The implementation process takes several years and the research focuses

on the initial three years of the process and identifies driving forces, obstacles and difficulties that can be encountered when implementing TPM.

During these years, several organisational changes took place. The most important event was the change of ownership from a well-reputed Swedish company to a large American corporation.

Organisational changes have a considerable influence on the operations in a company. The introduction of new concepts during organisational changes will always have a marked effect on the company's results. It is not always the case that these effects will be negative – it can be that results are positively affected. Nevertheless, it is important that there is a sense of understanding in the company that change will always result in effects of one way or another.

The idea to implement TPM at the company came from one of the more influential managers, who in fact later became the new factory manager. This means that the implementation process has had the continual support of the senior management. Furthermore, management was very eager to learn about TPM. This was a very advantageous factor in the implementation process.

The JIPM 12-step model (Figure 1) was the basis for the implementation, but the model was adapted to conform to the company culture. Information to all employees and education of all affected people was necessary in the beginning. A special TPM-organisation was built within the organisation and a TPM co-ordinator and three pilot teams were selected. It was important not to start too many TPM teams from the beginning.

Several other authors have reported on various experiences from implementation of TPM, based on surveys as well as in-depth studies. Hipkin and De Cock (2000) have performed a study of the implementation of RCM and TPM at four different companies. Their studies had a duration of only 4 months; however, their results regarding driving forces and obstacles were similar to those of the present study. Bamber, et al. (1999) present a number of factors, affecting the successful implementation of TPM. They have developed a generic model indicating such factors and have studied the validity of this model in a UK manufacturing company. Their findings are also very similar to the ones reported in this paper.

McAdam & McGeough (2000) have concentrated on TPM implementation success factors related to job demarcation and multi-union situations. Tsang & Chan (2000) have studied the implementation of TPM in a work environment that is very traditional and with workforce who are passive and not willing to take new challenges. A five-year implementation study, using a three-phase programme, is described.

Cigolini & Turco (1997) have studied TPM practices within the framework of continuous improvement work. Their study is limited to experiences of manufacturing companies having performed just the kick-off phase in their TPM programmes.

PILOT TEAMS

The Swedish company, involved in the study, wanted to create pilot groups with different personnel configurations. This was proposed because it was felt to be important to be able to distinguish between results from different pilot teams and to do comparisons. If the pilot groups chosen were too similar to each other the comparisons between them would probably not be useful for drawing conclusions from the experiment.

The first pilot group was established in the production sector A, and their production equipment was working satisfactory. The employees were not over-stressed and they enjoyed a pleasant working environment. The group consisted of eight persons who worked three shifts. They were responsible for four numerically controlled sliding and screw cutting lathes and milling cutters. This machinery was rather new and was functioning satisfactorily.

The second pilot group was taken from the production section B, and their equipment consisted of a turning lathe, one robot and one measuring machine. These machines were quite old and supplied three different numerically controlled milling cutters with material. This meant that this section was a bottleneck and it was very hard to reach daily production targets. This meant that the working environment was somewhat stressful.

The third pilot group was selected from the assembly department. The reason for this was to examine if TPM could be successfully implemented in assembly where they did not have a lot of equipment. The third group had a rather good working environment. However, they were at the same time affected by other changes that were being undertaken in the assembly department, which meant that they had too much work to do and therefore they found it hard to reach the required daily volumes.

Table1. Prerequisites for the different groups

Group	Section	Equipment	Climate	Other
1	Production	Quite new	Pleasant	
2	Production	Old	Stressful	Bottle neck
3	Assembly	None	OK	Many changes

In the beginning, efforts concentrated on establishing, building, and training the different groups. The workers were simply not used to working together in teams.

The problems experienced during the first weeks and months were, among other things, to make the operators understand that team meetings are also to be considered as work. It was hard for them to stop producing, attending a meeting instead. Another problem was getting the operators to talk. They were not used to discussing problems and improvements in their work place. It took some time before they started to co-operate. During this period ongoing training in TPM took place.

When they realised that the meetings would be a permanent feature, they started to co-operate by complaining about many different problems in their working area.

There was obviously a great potential for improvements to be made. The TPM co-ordinator made a "things-to-do list" and started to help the teams improving their work place. When the operators discovered that something new was really happening, many became enthusiastic and started to work hard in co-operation with the TPM co-ordinator.

As time went on, the pilot teams began to work with small improvements in their working areas. Together with maintenance personnel and production engineers, they were, step by step, able to improve their working environment and their equipment.

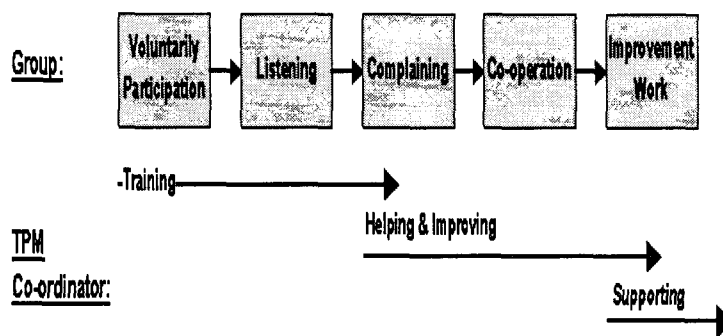


Figure 2: Different phases in establishing and building teams.

Each of the three pilot teams had one meeting every week. To make the teams understand the importance of these meetings it was necessary to make them part of the weekly routine. The meetings were therefore always on the same weekday, and at the same time.

As explained earlier, it took some time for the teams to start working with improvements. One of the first things the pilot teams were requested to accomplish was to follow-up the equipment disturbances and losses in the production. No guidance was given on how this should be done.

In the beginning the teams simply made notes of the disturbances on a piece of paper. After some time though, they suggested a standard form for the recording of all disturbances. They assumed that this would facilitate their work.

Gradually they refined and improved the form so it would fit the working place. They divided the disturbances and losses into different categories, which made the follow-up easier. The different categories used included adjustments, meetings, time lost during waiting for material, computer failures, set-ups, and breakdowns. They also made use of different colours for different types of losses.

At the weekly meetings they followed-up and summarised the losses of previous week. They explained and discussed the nature of the losses and suggested

improvements to reduce them. The most common losses at this time were various adjustments and set-up time.

Unconsciously the teams started doing TPM work. They began to search for the causes of the losses and as awareness and knowledge about these causes grew, they were able to start to reduce them.

Following-up of the losses in production and trying to reduce the losses was an overarching task. This led to increased co-operation between the different departments involved.

THE FIRST EVALUATION

About one year after the pilot teams were established it was time to produce a summary and conduct an evaluation of the development to date. Of course there had been various types of continuous evaluation or follow-ups during the year, but this evaluation was more objective and planned.

Pilot team 1 cohered as a team very quickly and they were open-minded. The team consisted of people of different ages and there was also a woman in the team. They listened to each other and they requested help from the maintenance and production engineering departments. They also realised that they had a chance to show how good they were and to be a good example and, moreover, they really believed in TPM.

The members of pilot team 2 were very strong individuals and they were aware that they were not forming a team. They did not want to be looked upon as a collaborative team. The team consisted of men of about the same age. There existed some type of rivalry within the team. They had a difficult working situation with the heavy workload and a problematic bottleneck to deal with.

There was also weak leadership in this production sector, and they had no confidence in their production supervisor. The team had failed with other things before and they seemed to have decided from the beginning that TPM would not be successful in their team. They did not want to change and much later it transpired that they did not get along with the TPM co-ordinator.

It took a long time before pilot team 3 started its improvement work. It was hard to translate the TPM concept from production to assembly and it took long time before they realised that TPM was something for them. It was also hard to convince the team that they could in fact affect their own working situation.

The development of the TPM implementation process was significantly affected by the attitudes of the individual team members in the different teams. It was obvious that organisational and psychological issues affected the behaviour in the teams.

It was decided that pilot teams 1 and 3 should go on with the implementation of TPM, but that the implementation should be stopped in pilot team 2. The cause

for this drastic decision was simply that this team had made it clear that they did not want to co-operate. It was not in any way dependent on their working situation.

Another conclusion reached was that it seemed that human beings subjectively decide whether something will succeed or fail. Therefore, it is most likely that the individuals within a team and the leadership are of vital importance for how a team will develop and grow.

ESTABLISHING NEW TEAMS

During the time when the first three pilot teams were established the production manager started to implement new ideas in the production department. Among other things, groups were formed in every production sector. These groups would work with improvements in their own working area. This meant that every operator would become part of an improvement group. The groups had weekly meetings that were led by the production supervisor.

When it was decided to stop TPM implementation work with the second pilot team it was also decided to start three new pilot teams instead (called pilot team 4, 5 and 6 below). This time, the TPM co-ordinator did not have to devote a lot of time to establishing teams from a group of people. There were already teams in the production department who were already at the "complaining" or the "improvement" phase.

Pilot team 4 consisted of seven operators, six men and one woman, one production engineer and the production supervisor. In the beginning they were a bit suspicious of the TPM concept, despite their own initiative to work with TPM. They did not think that the company would concentrate on TPM in the long term and they had seen other unsuccessful initiatives before.

Pilot team 5 consisted of twelve operators, eleven men and one woman, two production engineers and one production supervisor. This team managed themselves with only a little information and help from the pilot programme, and they created their own TPM programme. They were very independent and they did not allow anyone to come in and take over the TPM training. It has therefore been very hard to follow their results.

Pilot team 6 consisted of six operators, all of whom were men, and one production engineer. This team was returning good results regarding availability and quality. Probably they did not understand why they should work with TPM, because there was much suspiciousness and scepticism in the team. It was hard to change their attitude and it took a long time before they accepted the TPM work.

THE SECOND EVALUATION

Two years after the first pilot teams were established it was time to evaluate the work again. This time the evaluation would form the basis for the decision as

to whether or not the implementation of TPM should be extended to the whole organisation.

The first team had developed further and they were managing all by themselves. They were on the third and fourth steps of the seven step autonomous maintenance program (i.e. making standards for cleaning and lubrication and training in general maintenance), see Nakajima (1988) for details about the seven step autonomous maintenance program.

The second team had continued to develop, even though they did not get any support from the TPM co-ordinator. They did improve their work environment, although they were never prepared to call it TPM work.

The third team was managing almost on their own, although the TPM co-ordinator participated in their meetings now and then. They had conducted the initial cleaning and were working on standards for cleaning and lubrication.

The fourth team was developing fast and they had conducted their first initial cleaning. There were plans for initial cleaning on all of the other equipment within the production section. This meant that they were on the first and second steps of the autonomous maintenance program.

The fifth team had developed their own TPM work. They did not want external help from the TPM co-ordinator. This meant that it was hard to evaluate how they had managed. They needed more training and guidance in TPM work.

The sixth team was very independent. They worked with TPM in their own way. They had done the initial cleaning and were working on improvements.

EXPERIENCES

The results from the second evaluation were mainly positive and it was not difficult to make the decision that the company should continue with the implementation of TPM. Based on facts from the results achieved so far, plans for the future implementation process were put together.

TPM implementation is a long-range process and sometimes it can be hard to see results since small improvements are achieved on an ongoing basis. Another problem with longitudinal studies is that these studies are not isolated and changes within or outside the case study company affect the results. It can be hard to prove which changes brought about individual results.

Three pilot teams were selected in the first stage. The development of the three TPM teams was markedly varied. They all had different primary prerequisites but they also all received the same information and support. Therefore, the development within each team seems to be dependent on the primary prerequisites. Some factors for the fluctuations experienced in team development have been identified during the process, and they are all related to either organisational or personal issues.

These factors can be divided into two categories, namely driving forces and obstacles. The most obvious driving forces are the commitment and management

visions of the senior management. Their commitment and contact with the teams were important for the team members. This also facilitated communication. Those teams who showed interest in the TPM concept developed faster. They showed an understanding of the benefits and were eager to increase their own competence. This in turn resulted in faster and more visible results, which affected working environments, wellbeing and productivity in a positive manner. These teams developed a positive and self-perpetuating cycle and consequently developed at much quicker rate.

Obstacles standing in the way of the implementation of TPM were also identified. One important thing was that one of the teams experienced that there was no time for TPM. They also made it very clear that TPM was nothing for them. They showed no openness or willingness to learn. Earlier failures were brought up, and there was no sense of understanding for this new concept. They could not see the benefits of TPM and could not see why they had to change. This team had a very strong de facto leader and they had no confidence in either the TPM co-ordinator or the production supervisor.

RESULTS

In spite of a number of major changes (for example new ownership) within the company during the past three years, TPM is now deeply rooted in the working practices of all employees and new TPM teams have been established.

One of the biggest benefits is that TPM has provided a communication channel between production, maintenance and engineering departments. The co-operation between these departments has increased considerably. Better understanding for and knowledge about each other's work has also led to increased respect and a better working environment. Suspiciousness is rare today.

The commitment of management, together with clear, common goals and visible results has, among other things, resulted in shared responsibility for the equipment, fewer breakdowns and higher reliability levels.

Another visible result is better-organised work places. It is also cleaner and tidier in the production department. This, together with increased interest for the equipment and for teamwork, has led to a positive work environment, which is continually developing and is manned by satisfied employees.

The flow in production is steadier and there are few delays. This is a result of better co-operation when, for example, problems related to quality have been solved. Fewer breakdowns and stoppages have led to higher reliability, which in turn provides a steadier flow. It is therefore also easier now to plan the production.

It was important to support the changes the teams wanted to accomplish. The teams were allowed to do things that were important for them, even if that had very little to do with TPM. This resulted in mutual trust. It is important that the TPM

co-ordinator works with a sensitive ear and really listens to the individuals and the teams.

During the preparation and implementation processes a number of driving forces and obstacles for implementing TPM were identified. These are:

- Driving forces:** Visible and committed management
 Information and education
 Competence and understanding
 Continuity, persistent and long-term thinking
 Long-term thinking
 Communication
 Visible results
 Participation
 Engagement and motivation
- Obstacles:** Organisational changes
 Lack of knowledge
 Lack of support
 Indistinct leadership
 Earlier failures with other improvement concepts
 Lack of time
 Lack of confidence in management
 Strong informal leaders
 Individuals instead of teams
 Satisfied with the situation

CONCLUSION

There are many obstacles and difficulties that can be encountered when trying to implement a new methodology. But if there is an awareness of some of these problems from the beginning, it is possible to prepare for them and hence there will be better chances to succeed.

It can be hard to get the senior management commitment. Since TPM implementation is a long-term process, it can be difficult to visualise the long-term profitability of an investment of time and effort.

Implementing TPM means changing the company culture a little. This is a long-range process and most people are afraid of changes. TPM should not be implemented "by the book". The implementation process should be adapted to fit the company.

The implementation of TPM must not be looked upon as an isolated phenomenon. The implementation must be adapted to other circumstances, such as the quality system, other quality methods, and so on.

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