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The Three-stage Method for Chinese Enterprises to Deploy TPM

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Abstract: The paper studies an effective way for Chinese enterprises to implement Total Productive Maintenance (TPM) to cut cost and increase efficiency under the impact of financial crisis. It first analyzes the problems of Chinese enterprises in equipment management, reviews the definition, benefits and five components of TPM. The paper suggests the three-stage method for Chinese enterprises to implement TPM systematically and successfully in order to deal with the difficulties and problems of Chinese enterprises in deploying TPM, which is proven effective and we hope our studies are useful for Chinese enterprises to change their extensive operation in equipment management.
Key words: TPM; Autonomous maintenance; Three-stage method; Equipment management

1. THE PROBLEMS OF CHINESE ENTERPRISES IN EQUIPMENT MANAGEMENT

Although Chinese enterprises have improved their ability in equipment management, for example, they have changed from break down maintenance to preventive maintenance, there are still many problems for them in equipment management as shown in figure 1 that make their productivity efficiency very low, in which the main reasons are as follow.

1.1 Pay More Importance to Equipment Usage and Ignore Maintenance

Many operators only pay importance to make use of equipment but ignore maintenance because first line managers concern production progress, which make the operator have no time to maintain equipments, if things continue this way, both managers and operators ignore the dairy maintenance and operate equipments even if there are some minor malfunction until they have to overhaul, which on one hand delay production and on the other hand increase repair cost.

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1.2 Equipment Operators are Short of Necessary Quality and Lack of Training

Most equipment operators come from technical training school and go on duty without formal training, so there are many safety hazards in equipment operation. According to our investigation, some operators go on duty without any training, some operate a machine for a time and then apply an operation license, and even some seasonal worker are farmers near the factory to work in it during slack farming season without license and training.

Frequent occurrence of accidents because of waiting for a stroke of luck

Waiting for a stroke of luck is the source of many machinery accidents, which give lessons to Chinese enterprises with blood. Only after an accident occurs, we recognize that we must inspect equipments, obey operation rules and dispose old equipments timely. However too many of us once on shore, pray no more，all hurts are forgotten, we still think that equipment inspection is an input without output, and eliminate old equipments is somewhat a waste. Therefore chances come over once again. According our investigation on coal, steel, electronic power, oil and chemistry industries in 2009, 70% grave accidents are relevant to poor equipment management and misusage of equipments.

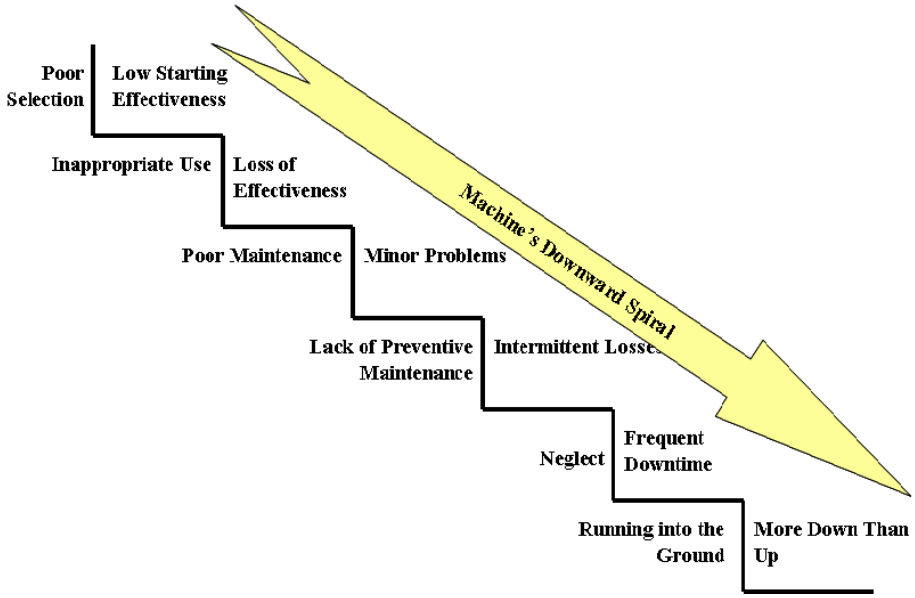

Figure 1: The Pathway to Equipment Destruction

2. WHAT IS TPM

TPM focuses primarily on manufacturing (although its benefits are applicable to virtually any "process") and is the first methodology Toyota used to improve its global position.

2.1 The Definition of TPM

We define TPM as a manufacturing initiative for optimizing the effectiveness of equipment by doing everything possible to make sure the machine keeps making good quality parts at the desired production rate every time you want it to, which involving all the contributors' active participation and teaming, making the operators the first line of defense against deterioration through autonomous maintenance.

2.2 The Benefits of Deploying TPM

At present TPM is spread all over the world, more and more enterprises have benefited from it, which brings not only tangible but also intangible effects as shown in table 1.

Table 1: The Tangible but Also Intangible Effects of TPM

Tangible effects	Intangible effects
● Improve OEE of equipments	● Improve the quality of enterprises
● Improve productivity	● Change the concepts of all staffs
● Decrease the maintenance cost of equipments	● Improve employees' innovation ability
● Improve product quality and reduce customers' complaint	● Establish the enterprise culture of autonomous working
● Decrease production cost	● Build an enterprise full of energy
● Shorten production cycle	● Make an enterprise reliable
● Improve the efficiency of indirect departments	

2.3 Five Components of TPM

(1) Maintenance prevention: select / design of the machine for optimum performance throughout its expected life in other words, one time decisions can affect effectiveness for life.

(2) Predictive maintenance: predict the life of critical machine components and replacing them, determine how long the machine or any of the systems will run before they go out of tolerance, how long they need lubrication, tuning, adjustments, overhauling or replacing, which results in cost avoidance.

(3) Corrective maintenance: uncover potential malfunctions and eliminate their causes to enhance machine's performance and reliability, the cornerstone of which is continuous improvement.

(4) Preventive maintenance: minimize machine deterioration by scheduling maintenance to minimize wear and breakdowns, which is a natural predecessor of TPM.

(5) Autonomous maintenance: make the machine operator the "first line of defense" through training and empowerment to ensure regular cleaning, lubrication, inspections and total ownership that achieves continuous improvement in equipment effectiveness.

3. THE DIFFICULTIES AND PROBLEMS OF CHINESE ENTERPRISES IN DEPLOYING TPM

Chinese enterprises have paid importance to external advanced experience and management methods, and many large-scaled enterprises began to introduce TPM in recent years in order to get success as that in Japan and Korea. However, they met so many difficulties and problems as follow in deploying TPM that they believe that TPM is not suitable for Chinese enterprises.

3.1 Lack of the Exact Support to TPM from top Management

TPM requires all staff including the top manager and operators to take part in TPM activities, but at present it is difficult for Chinese enterprises to require the plant manager to manage equipments directly. As we know the plant managers of Japanese enterprises that deploy TPM lead it directly and some of them take the post of the chief of TPM team, they attend the whole process of TPM such as plan auditing, achievement evaluation and motivation. We believe that it is favorable for successful TPM, after all equipment management has long-term influence on the existence and development of an enterprise. But most of Chinese enterprises have no such mechanism, the plant managers concern less on equipment management, if they are invited to take part in TPM, most of which is just a formality，which will leave hidden dangers for TPM because employees have sharp eyes.

3.2 Most Chinese Enterprises Haven'T Deployed 5S Successfully That is the Foundation of TPM

5S is five steps to shape up the workplace and the foundation for deploying TPM successfully that are sort (Seiri), straighten (seiton), shine (seiso), standardize (seiketsu) and sustain (Shitsuke). Although 5S was introduced in China since 1980s, in more than twenty years, some enterprises have benefited from it in economic efficiency, product quality and cost reduction, but too many enterprises haven't benefited from it due to their misunderstanding and errors in 5S management such as lack of leader's emphasis and employees' involvement. Without successful 5S as the foundation, it is difficult for TPM to come through.

3.3 Lack of Autonomous Activities of TPM Team Extremely Necessary for Successful TPM

TPM requires TPM team to work autonomously, which is very hard for Chinese enterprises to do so. It requires operators analyze, improve and solve various failure or hidden dangers during equipment operation in their spare time and the person in charge should reward them. But in China, the involvement of operators in equipment maintenance is very limited and they usually engage it in work hour. According to our investigation, most TPM teams haven't met the requirements.

4. THREE-STAGE METHOD IN DEPLOYING TPM FOR CHINESE ENTERPRISES

Considering the difficulties and problems Chinese enterprises met in deploying TPM, we propose the three-stage method for Chinese enterprises to deploy TPM as shown in figure 2.

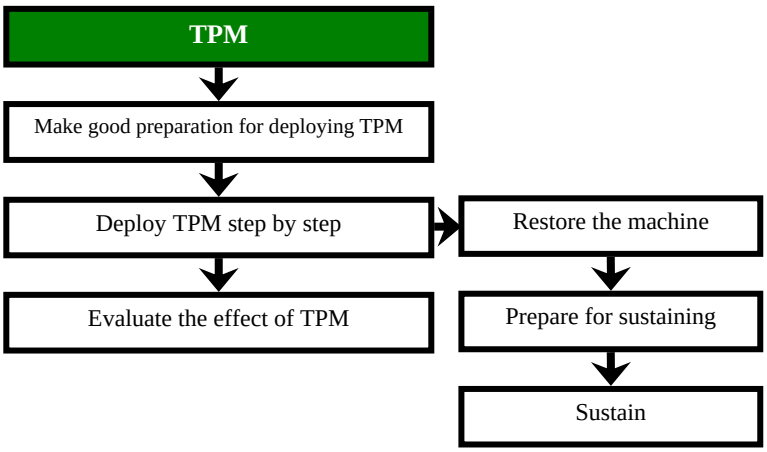

Figure 2: The Three-stage Method for Chinese Enterprises to Deploy TPM

4.1 The First Stage: Make Good Preparation for Deploying TPM

Sufficient preparation is half of a success, enterprises must prepare adequately in advance for implementing TPM smoothly and successfully, which at least includes following preparations.

4.1.1 Deploy 5S in Advance to Make Workplace Visual

The objective of deploying 5S is to maintain the area surrounding the machine clean and organized at all times to support the disciplined TPM activities, to establish an environment that is safe, a surrounding helps efficient working, "Visual workplace" helps avoid mistakes and helps train new employees easily, so that to promote a sense of ownership and pride in the workplace.

4.1.2 Establish a TPM Team

TPM team is essential for Chinese enterprises to deploy TPM. What is a team? Why we have so many teams, but we can't make the "whole greater than the sum of parts"? A team is a group of individuals working in pursuit of a common objective. Merely calling a group of employees a team does not make a functioning team, just as all star football team made up of the greatest players does not make the best team.

TPM requires more time, resources and efforts than most of Chinese enterprises believe they can afford. A typical TPM implementation requires company-wide participation and full results can only be seen after 3 years and sometimes 5 years. It is proven that an efficient TPM team can reduce this process greatly.

(1) The members of TPM team

Ideal number of team members is 5-9 and it should include all the operators of the machine (all shifts), the maintenance technicians specialized in mechanical, hydraulics, electronics, etc, manufacturing engineer, departmental supervisor, one or two "outside" operators and one member of the management (considering actual situation in China, we can choose the deputy general manager in charge of production as a team member but not the general manager).

(2) The leader of TPM team

Team leader should be closely associated with the machine, preferably the machine operator or maintenance technician, who must believe in discipline, accountability and open communication, and is able to "coach" the team into taking ownership of the machine, provide team training prior to TPM event and motivate the team to make TPM more smooth and successful.

(3) Essential elements for successful TPM team

The authors want to re-instate once again that the success in TPM will depend on how well you work as a team. This is by far the one of the most important aspects of TPM. If you are to be a successful TPM team you must achieve the objectives shown in table 2.

Table 2: The Essential Elements for Successful TPM Team

● Clear mission and goals	● Agreement on how to make decisions
● Everyone participates	● Understanding group process
● Clearly defined roles	● Using data or facts for problem solving and decision making
● Ground rules	
● Clear communication	● Continuous improvement mindset
● Supportive behavior	

4.1.3 Design TPM plan carefully

Planning must start two months before TPM event, in which:

• Select the candidate machine that is critical on the value stream mapping, make sure there is a backup machine with sufficient capacity, available to take up this machine's load and generate sufficient inventory of parts.

• Gather all the available information for this machine, for example, the user manuals, maintenance manuals, control circuit diagrams, drawings, the maintenance history for at least two years and the OEE data for this machine.

• Identify repeating and chronic problems by discuss with the operators and maintenance technician.

• Develop an action plan for the machine during TPM event and make sure all the necessary hand tools and power tools are available in sufficient quantity in order to quickly bring the machine in running condition.

4.1.4 Establish a Culture of Involvement and Autonomous Working

(1) Active participation of everyone including the management

A successful TPM can't realize without active participation of everyone, besides the operators and maintenance technicians, the participation of the management and other departments are very important for TPM activities. The management in different level should provide complete, real and visible support for TPM, which is necessary for sustaining TPM program. Chinese people like to follow their leaders, so top management should actively participate in TPM event, provide resources and empower the TPM team, middle managers should participate in audits and TPM kaizen events, plant manager should give the awards with fanfare to encourage the morale.

(2) A culture of autonomous working

Absolute faith & commitment of operators and maintenance technicians are the basis of a successful TPM. Because they spend the most time with the machines, can and will notice the abnormalities first, have the most unique knowledge of the machine, it's parts and it's functioning, have much closer emotional attachment with, and sense of ownership of the machines and are mostly technically inclined, so they are the "first line of defense" for the machine. We should provide them with adequate training and empowerment to ensure regular cleaning, lubrication, inspections and total ownership that achieves continuous improvement in equipment effectiveness, and more important, we should change their attitude from passive to autonomous maintenance since it is self-governing, self-ruling, non-centralized machine maintenance program.

4.2 Deploy TPM Step by Step

TPM is a long journey and systematic engineering, so we must deploy it step by step to make a solid foundation for the success. The steps and application of five components of TPM are shown in table 3 and figure 3.

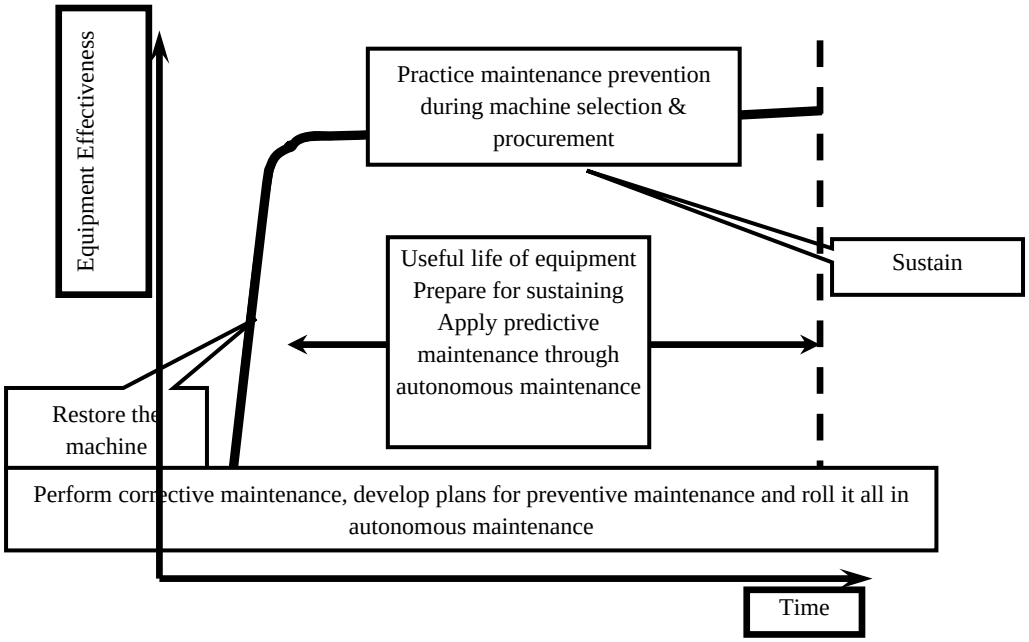

Figure 3: The Application of Five Components in Deploying TPM

Table 3: The Steps in Deploying TPM

Step	Objective	Activities
Step 1	Restore the machine	● Perform initial cleaning & inspection ● Eliminate causes of contamination & inaccessible areas ● Develop cleaning, lubricating, and inspection standards
Step 2	Prepare for sustaining	● Provide basic training in machine's function and controls to enable effective general inspection ● Enhance and implement autonomous inspection standards & schedules
Step 3	Sustain	● Follow up on all the above steps and advanced improvement activities

4.3 Evaluate the Effect of TPM

We select OEE as the indicator to evaluate the effect of TPM. OEE stands for Overall Equipment Effectiveness that is a measurement represents the percentage of time a machine was actually producing quality parts compared to the time it was planned to be. We use OEE to monitor & improve performance of the selected equipment, evaluate losses, identify causes and corrective actions, guide & monitor TPM implementation, compare before & after OEE values to monitor impact.

5. CASE STUDY: THE APPLICATION OF THE METHOD IN DONGGUANG GROUP COMPANY

Since 2006, we practice the three-stage method in several factories such as Dongguang Group Company (DG hereafter) that is a large-scale plant supplies various kinds of brakes for First Automobile Workshop. DG introduced TPM at the end of 2006 guided by a professional consulting company for six months and paid RMB 200 thousands, even it got some effect at the time, but after the consulters left, it almost restored to original situation. The CEO of DG is a graduate student of Changchun University of Science and Technology pursued his master degree in management in 2008. He talked about his puzzle when I organized the student to discuss TPM in the class. So our TPM research team went to the plant and spent three months investigating in it. We found that DG on one side has some advantages and on the other side some disadvantages for deploying TPM as shown in table 4.

Table 4: Advantages and Disadvantages of DG for TPM Program

Advantages	Disadvantages
● Good 5S foundation	● Lack of autonomous working environment
● Good working morale	● Pay attention to short-term effect
● Operators with formal certificate and training	● Top management doesn't care equipment maintenance almost.

So we guided them to deploy TPM from Sep. 2008 till Oct. 2009 according to the three-stage method we propose. Our main activities are shown in table 5.

Table 5: Main Activities in Deploying TPM

Stage	Activities	Time
Stage 1: Make preparation for TPM	Establish a TPM team: consist of seven members including the GM who promise that he will earnestly practice TPM by providing the resources needed, three operators of machine A, the workshop director, a maintenance technician and a manufacturing engineer, and the leader of the team is the workshop director.	Three days
	Provide training for the TPM team: let every member of the team become an expert in TPM	Ten days
	TPM team design TPM plan: design a detailed TPM plan and train plan in order to make good preparation for deploying TPM.	Five days
	Provide employees with TPM training: for the employees directly related to equipment maintenance we provide face-face training and we also provide other means for all staffs to learn about TPM such as network class, TPM board, etc.	Five days for face to face training
	Let all staff analyze the problem of DG in equipment management by brainstorming.	
	Select the equipment A as an example to deploy TPM, which is cutting machine with great improvement opportunity.	
Stage 2: Deploy TPM step by step	Restore the machine	Five days
	Prepare for sustaining	Three months
	Sustain	For ever
Stage 3: Evaluate the effect of TPM	The OEE of Machine A has changed from original 35% in Sep. 2008 to 75% in Sep. 2010.	Every three months

6. CONCLUSION

TPM has gotten great success in Japan, USA, Europe and South Korea, which is proven a very useful lean tool for enterprises to eliminate wastes and improve production efficiency. The three-stage method we propose takes the actual situation in Chinese enterprises into account and is proven applicable by practice. We herein thank a lot for DG that gave us an opportunity to practice our research and we hope our study will benefit more Chinese enterprises in the future.

REFERENCES

Nakajima, Seiichi (1989). *Introduction to TPM*. Cambridge, Mass: Productivity Press.

CHEN Lixia, MENG Bo. (2008). How to Make 5S as a Culture in Chinese Enterprises. *Proceeding of 2008 International Conference on Information Management, Innovation Management and Industrial Engineering*.

Leflar, James A. (2001). *Practical TPM: Successful Equipment Management at Agilent Technologies*.