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TOOLING MANAGEMENT: A STRONG TPM PILLAR

Ashutosh Kolhatkar[1] & Anand Pandey[2]

[1]Research Scholar, Symbiosis International (Deemed University), Lavale, Pune, Maharashtra, India

[2]HOD, SIT, Symbiosis International (Deemed University), Lavale, Pune, Maharashtra, India

ABSTRACT

In order to achieve manufacturing excellence through the Total Productive Maintenance (TPM) initiative, various aspects must be considered in order to improve the effectiveness of the tooling division and make it a major strength of the organization. The paper reviews the literature of various authors on the subject of TPM implementation approaches, pillar structures, and success enablers and barriers. It evaluates a captive tool room in India to classify the scenario observed within the organisation in view of TPM implementation. Based on the specific role of the tool room in developing new tooling or the tool maintenance function, it follows an approach of either Early Management, Planned Maintenance, or the Focused Improvement Pillars of TPM. Whereas, organisations having both these roles do not give enough justice to tooling functions when attached to any one of these pillars. The paper illustrates and specifies the various aspects to be considered under the purview of the tool room. The study provides guidance to organisations that are unsure whether to follow standard TPM practise or develop a separate pillar for tooling management in light of organisational structure, technological advantage, and long-term growth. The approach of the TPM strategy will help enhance organisational sustained performance and will give the Indian industry a competitive edge in the challenging market.

KEYWORDS: *Total productive maintenance, tooling management, Indian Industry, TPM pillars*

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INTRODUCTION

TPM is one of the Japanese philosophies used in the industry to achieve manufacturing excellence. TPM was developed in Japan by Seiichi Nakajima, and the TPM process was introduced in 1971 (Shirose, 1999). The aim of the process was to enhance machine maintenance and its performance. The organization, Nippon Denso, was first awarded the PM prize in recognition of exhibiting this process. Later, the Japanese Institute of Plant Maintenance (JIPM) enlarged the role of TPM to include eight pillars. The introduction of these pillars was in view of clarifying the roles and responsibilities of various functions in order to enhance the machine performance, thereby achieving total employee involvement and a teamwork atmosphere. It has a major role in taking an organisation towards zero breakdowns, zero defects, and zero accidents.

With 8 pillars of TPM: Focused improvement, Autonomous Maintenance, planned maintenance, education & training, Early management, Quality management, Safety Health Environment, and office TPM, it allocates major roles and responsibilities to production, maintenance, engineering, Quality and reliability. It also focuses on Human resources, new products, and equipment development. It covers the support functions of safety, health, and the environment, as well as office functions. The industries that apply the TPM philosophy establish an organogram of various functions. Broadly, industries follow the conventional approach recommended by JIPM while implementing TPM. The basic approach of eight pillars broadly takes care of the concept of enhancing the productivity of machines by total employee involvement. Despite that, various studies elaborate on changes in approach, number of pillars, steps of implementation, and adaptability to the industry's objectives for successfully implementing TPM. The whole purpose of changing the approach is in view of fully utilizing the strengths of the organization, suitability with the organisational structure, and the drive towards meeting the objectives.

Industries like the automotive industry, the electrical industry, and the medical industry have a vital tooling function in the production system. The tooling function has two major roles viz. new tooling development, for new products and life cycle management, and for tool maintenance services to support production. While new tooling development follows the early management pillar approach, tool maintenance service follows either planned maintenance or a focused improvement approach. With the tooling function having both of these output parameters, organizations' decision to attach it to any one of these pillars does not give enough justice to such an important entity. It is essential to bring in a specific focus on tooling contributions throughout the entire system and create major support in achieving the organisational goal. The paper herewith illustrates the importance of various aspects regarding the operations involved in tooling and the need-based addition of the 9th pillar for tooling management in the TPM structure.

TPM PILLARS DEVELOPMENT

The concept of preventive maintenance (PM) was transferred from the United States to Japan in the 1950s. While Japan learned the concepts of productive maintenance, corrective maintenance, maintenance prevention, and reliability engineering from the United States, they were suitably modified in the Japanese way to bring total productive maintenance (TPM) methodology. The modification was made in view of bringing in an overall perspective of improving production efficiency, the operator’s participation in routine maintenance, and the effective use of small group activities. Nippondenso Co., Ltd. was the first organisation to implement these concepts and was awarded a productive maintenance (PM) award in the year 1971. The Japanese Institute of Plant Maintenance (JIPM), earlier the Japanese Institute of Plant Engineers (JIPE), supported the development and put in a lot of effort to spread the TPM concept. With the initial development in the fabrication and assembly industries, it was further extended to process industries as well (Japan Institute of Plant Maintenance, E. 1996).

While TPM initially focused on production activities, it expanded its horizons to practically all functions of the organization. The TPM concept has gained worldwide acceptance and has spread to Asia, Europe, North America and Latin America. The well-established TPM by now aimed to create a robust corporate and production system that focused on zero defects, zero accidents, zero failures, and zero losses. TPM has a lot of common points with the Just-in-Time (JIT) concept and Total Quality Control (TQC). And the principles of TPM were driving all-round improvement in productivity, Quality, Delivery, Cost, Safety & Morale parameters.

Over the period, TPM was a philosophy rather than a mere machine maintenance implementation. While Nakajima (1988) described it as an innovative approach, Chaneski (2002) explained it as a programme implementation. Lawrence (1999) found it to be a way to extract more from less. Besterfield (2011) mentioned it as a collaborative approach of various functions for the purpose of improving productivity. Rhyne (1990) mentioned it as coordination between maintenance and production; Blanchard (1997) mentioned it as a life cycle strategy.

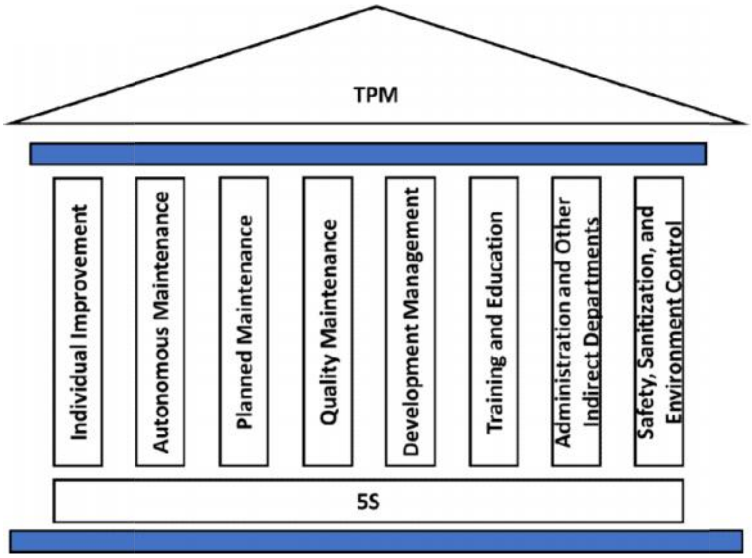

Figure 1: TPM* Pillar Structure *as* Suggested *by JIPM, (2022).

To encompass the involvement of all employees and ensure overall organisational gain, the TPM philosophy is built on eight pillars. These 8 pillars include Focused improvement or Kobetsu Kaizen, Autonomous Maintenance or Jishu Hozen, Planned Maintenance or Kaikaku Hozen, Training and Education, Early or Development Management, Quality Maintenance, Office TPM and Safety Health, and Environment (Japan Institute of Plant Maintenance, E. 1996). There is a strong linkage between these pillars. The 5S system of Seiri (Sort), Seiton (Set in order), Seiso (Shine), Seiketsu (Standardize), and Shitsuke (Sustain) forms the foundation of the structure. Figure (1) illustrates the TPM pillar structure with the latest pillar nomenclature (Japan Institute of Plant Maintenance, 2022). Each pillar has a definite role to play in the system. Individual improvement works on eliminating the losses, thereby achieving organisational effectiveness. Autonomous maintenance works on the principle of empowering the operators to carry out routine maintenance and bring in machine ownership. The role of planned maintenance is to support the autonomous maintenance pillar and further improve machine performance. Training and education pillar practically support each and every pillar for necessary knowledge, skill, and competency development. The early or development management pillar is involved in new products as well as equipment development with the underlying thought of maintenance reduction or elimination. Quality maintenance has a prime role in achieving zero defects. Office TPM, or the administration, is a service and support function, and TPM's objective is to bring agility to the entire process. And finally, the safety, sanitization, and environmental control pillar focuses on safety, health, and sustainability aspects and works towards zero accidents or incidents.

TPM IMPLEMENTATION APPROACHES

While implementing TPM, the focus is on reducing losses, i.e., weaknesses. The other aspect that becomes a key enabler for successful implementation is making use of strengths. As per Patterson, Kennedy and Fredendall (1995), the TPM system should take advantage of organisational capabilities. The use of strengths and capabilities needs to be brought into the structure. This could be in the form of new product development, research and development, tooling, supply chain etc. This will help to align the organisational goals with the roles and responsibilities of various functions. Jain, Singh and Bhatti (2018) evaluated enablers for successful implementation of TPM in terms of human, work, maintenance, knowledge, organization and customer categories. Gupta and Khanna (2019) discussed managerial, organizational, cultural, employee, financial, strategic, operational, technical, equipment, customer, informational, governmental, infrastructural, educational, and physiological perspectives. While these aspects are important for the success of TPM, there are a few barriers that cause hindrance to its implementation. Rathi et al. (2021) elaborated on various barriers in implementing TPM in the Indian industry. These are towards lack of motivation, commitment, communication, co-ordination, adoptability, training, planning, finance, time, teamwork etc. Two critical barriers identified are the lack of organisational structure and total employee involvement. Studies indicate the need to take along all the agencies of the organisation while driving TPM. Diaz-Reza et al. (2018) elaborated on managerial commitment as one of the most important aspects of strategy deployment in TPM. Innovation, research, and development are the key aspects for sustained performance and growth over a long period of time other than these factors. Visionary top management would consider these aspects in the TPM structure and provide the system in line with them.

Jain, Singh, and Bhatti (2020) evaluated various strategies for improving the performance of TPM implementation. These strategies were preventive maintenance initiatives, top management leadership, implementation of TPM pillars, and the role of TPM enablers. It is important to identify critical success factors in the implementation. The pillars are nothing, but the basic practices adopted by the organisation to fully explore and utilise human intellectual potential. While describing TPM pillars, Singh and Singh (2019) discussed various approaches as suggested by researchers for implementing TPM based on changing conditions and applications other than the conventional 8-pillar approach by JIPM. Ahuja and Khamba (2009) mentioned the Western 5 pillar approach, the 6-pillar model by Bamber, and the five-phased roadmap by Naguib. The western 5-pillar approach was based on maintenance prevention, preventive maintenance, autonomous maintenance, corrective maintenance, and predictive maintenance. Naguib (1993) explained the five-phased approach of management commitment and support, restructuring of maintenance into production modules, planning roadmap, skill competency and team building, and an assessment process with a feedback system. As part of the TPM improvement plan, Willmott (1994) used a three-stage approach that considered conditions, measurement, and improvement cycle. McKone, Schroeder, and Cua (1999) illustrated a framework consisting of autonomous maintenance and planned maintenance in relation to environmental, organizational, and managerial contexts. Carannante, Haigh, and Morris (1996) suggested an eight-step approach as follows: system, measurement, autonomous maintenance, housekeeping, continual improvement, culture, training, and plant design for implementing TPM. While Bamber, Sharp and Hides (1999) suggested a 6-step approach that included creating a steering committee, understanding the situation, restraining and driving forces, development of a plan, executing the plan, and reviewing the mechanism. This research indicates that there is no fixed formula for achieving improvement, but the approach mainly depends on organisational structure, culture, demand, and the objectives driving towards the vision.

In this context, the situation in India is no different. According to CII, nearly 300 organisations in India are keen on implementing TPM practise as of now. While Vikram Cement was the first Indian company to get a TPM excellence award in 1995, Sundram Fasteners Ltd. was the first Indian engineering company to get an award in 1998 (Gupta and Khanna, 2019). During the period from 2009 to 2019, more than 40% of TPM awards have been won by Indian companies (Janangiraman, 2021). While elaborating on the needs of Indian industry, Ahuja &Khamba (2009) demonstrated a structure for indigenous TPM methodology. An indigenous strategy in view of the condition of Indian industry was suggested to apply for the successful implementation of TPM. There are inherent characteristics of the Indian industry like poor responsiveness, low productivity standards, lack of quality approach, rigid organogram, lack of common driving standards and policies, and lack of skill, competency, and expertise. These characteristics pose enormous challenges while being competitive worldwide. Majumdar and Manohar (2012) emphasized a framework to focus on the foundation, implementation, and operational stages of TPM for improving productivity and business competitiveness. It's a general perspective in the Indian industry that maintenance is an operating cost and focus is given to reduce the cost rather than getting a competitive advantage by leveraging it. While the situation is improving with the implementation of the TPM philosophy, the approach is also shifting from reactive to proactive. With TPM, machine maintenance is proving to be a strategy for organisational benefits. There is also a thought process in understanding the TPM methodology and implementing it suitably while adapting to the organisational needs and conditions.

TOOLING MANAGEMENT

In industries such as automobiles, electrical, electronics, and the medical industry, tooling plays a major role in the entire production system. The study of a captive tool room of one of the major electrical products industries in India is considered here to understand various aspects from a TPM perspective. Tools designed and manufactured to meet the tooling requirement include Press tooling, moulds, jigs, fixtures, special-purpose set-ups, gauges, and other such built equipment. These tools are important for new product development as well as life cycle management. While these tools are built to meet the component's quality and performance standards, they also play an important role in increasing productivity and capacity. These tools are crucial in demonstrating the breadth and depth of manufacturing capability. Typically, any such large industry has a diverse range of products in its portfolio to meet market demand and specific segmentation. More variety, more and more tooling will be required. The variety and the new tooling demand cause a dynamic situation in the tooling workshop. The tooling workshop has one more important role to play. This is the cost of keeping this tooling in good working order for the rest of its life. This is referred to in the industry as a tool maintenance function. Because of the wear and tear on the tooling element, it requires periodic upkeep. This is referred to as preventive maintenance. The tooling during its production run may undergo breakdown. This may occur due to uncertain conditions caused by reliability issues. It may be due to built-in reliability during design, manufacturing, or in the installation process. Or it could be due to operational reliability issues during production or the maintenance process (Kolhatkar and Pandey, 2022). The activity of restoring the basic condition of tooling after such a mishap is referred to as "breakdown maintenance." Though these two activities form a major part of the tool maintenance function, the industry has now started moving towards predictive maintenance in tooling. Predictive maintenance is built on the principle of monitoring the condition of a tool and setting up a trigger for carrying out the maintenance. So, the maintenance is carried out only when warranted. This has a significant impact on tool maintenance costs. The tool maintenance function also performs tool modifications for product change, tool life enhancement, tool repair time reduction, etc. as a part of corrective maintenance. Figure (2) shows the classification of the tool maintenance functions as reactive or proactive.

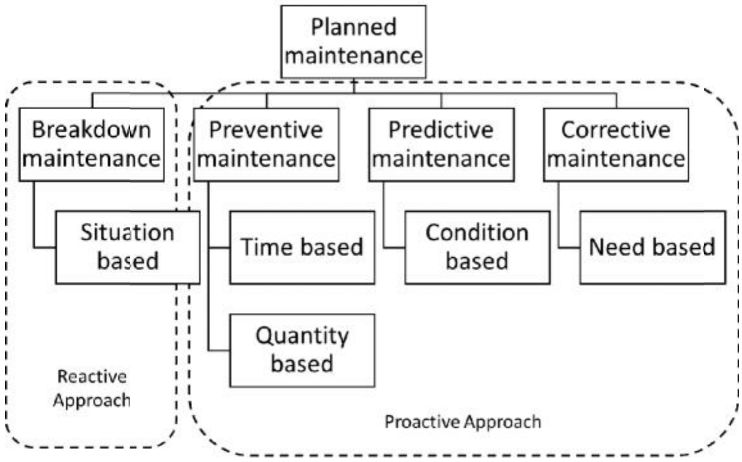

Figure 2: Planned Maintenance Pillar Activities.

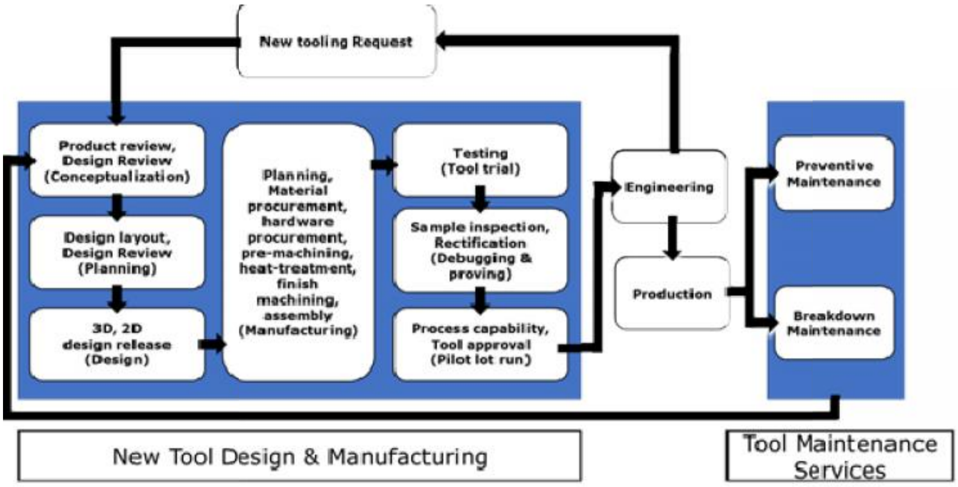

Figure 3: Toolroom Activity Interrelation.

Figure (3) illustrates various activities performed by the tool room and their interrelations. It clearly indicates the stages followed right from the initiation of a new tooling request till the tool is approved as a part of new tool manufacturing. Thereafter, the tool maintenance activities are performed on the tooling until its life is over. Engineering and production teams are the customers for this tool room. As a part of industrialization, the engineering function serves as a liaison between the tool room and production.

As the tooling section or the tool room performs both the functions of new tool manufacturing and tool maintenance services, the philosophy requirements for these functions are different. New tool design and development is comparatively a long-term activity, and it looks at breakthrough changes. The tool maintenance function focuses on providing short-duration, quick support for the production system. There is a distinct difference in the working philosophy and approaches of both these tooling functions, as illustrated in table (1).

Table 1: Approach Difference in Two Major Functions of Tool Room

Aspect	*New Tool Manufacturing*	*Tool Maintenance Function*
Concept	New concept	No change
Improvement	Breakthrough	Incremental
Activity duration	Long period of time (1 to 12 months)	Short period of time (2 hrs to 15 days)
Machinery Requirement	High	Low
Analysis tools	DFMEA/ PFMEA	Root cause/ KT analysis
Reliability	Inherent/ built	Operational/ service
Delivery parameter	Lead time	MTTR/ MTTM
Quality parameter	First time right	MQBF/ MQBM
Cost parameter	Cost per part over the life of tool	Cost of maintenance

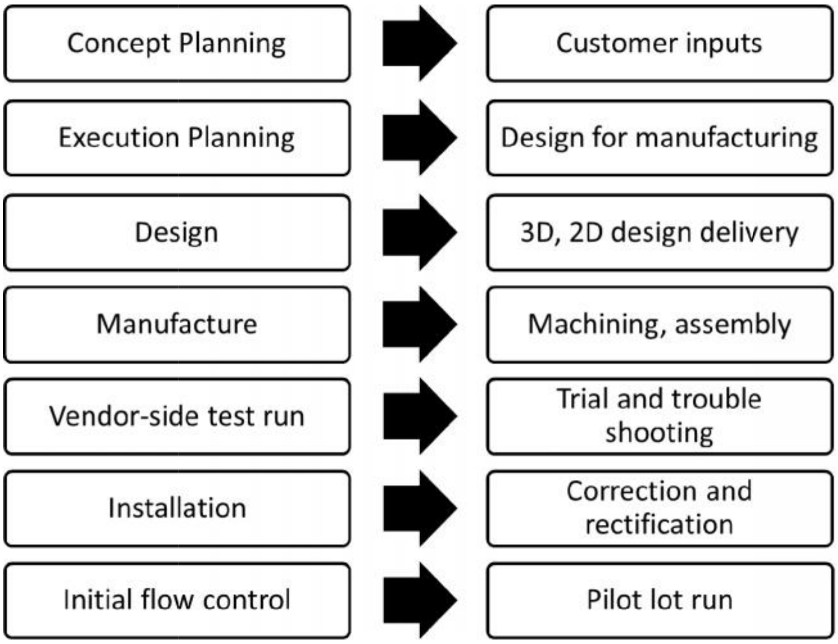

Figure 4: Corresponding Toolroom Activities For Early Management Pillar.

From the TPM perspective, it follows the Early Management (EM) pillar approach for new tool development that covers new products as well as new equipment management. This pillar is also termed "development management" in some industries. The tooling development process is similar to early equipment management, where it covers the topics of conceptual planning through the readiness for production. This is illustrated in the TPM philosophy as the 7 steps of the EM pillar. During these steps, various activities are carried out in the tool development process. The tool development activities corresponding to early management steps are shown in Figure (4). The concept planning stage can be referred to as the customer input phase, where there is an understanding of the need for new tooling. It is to assess the present method of manufacturing the component, find the gaps or problems in the existing system, and grasp the need to prevent these gaps. The following step is execution planning, in which product engineering is done with manufacturability in mind. While doing this, it is important to consider the inputs and look for alternatives to resolve the issues. At this stage, inputs from manufacturing and tool maintenance are taken to address their viewpoints. Thereafter, the stage of design uses various software to convert the requirement into the form of a design release. The design deliverables are in 3D or 2D form based on the manufacturing capability. Reliability, maintainability, operability, safety, and flexibility are the main considerations in the design. Planning, procurement, machining, and assembly form the major activities in the manufacturing stage. Once the tool is built, it follows the action of trial and troubleshooting. The inputs from the trial and component inspection reports give rise to the stage of correction and rectification. This is followed by taking a pilot lot run in the production scenario to validate short-term process capability and hand over the tool to production function.

Table 2: TPM Master Plan for Tool Room Activities

Steps of Implementation		
Function	**Stages**	**Significant Activities**
New Tool Manufacturing	1	Conceptualization
	2	Planning
	3	Design
	4	Manufacturing
	5	Trial run
	6	Debugging & proving
	7	Pilot lot run
Tool Maintenance service	1	Tools evaluation
	2	Restoration of deteriorated tools
	3	Information management system
	4	Develop Time Based Maintenance system
	5	Develop Condition Based Maintenance system
	6	Evaluation of planned maintenance system

The tool that runs in production undergoes wear and tear. This calls for upkeep of tooling over its entire life. The tool maintenance function of the tool room comes into the picture at this point. It follows the planned maintenance (PM) pillar approach. The traditional PM pillar focuses on supporting autonomous maintenance activities and enhancing the performance of machines or equipment by plugging loopholes. It also carries out periodic maintenance, corrective maintenance, condition-based or predictive maintenance, and maintenance prevention activities for the machine. The corresponding steps to be followed for implementing TM pillar activities for tool maintenance function are given in table (2). It starts with evaluating the basic condition of all tooling. This helps in categorizing the entire set of tools based on criticality and is useful for prioritizing the activities. Based on the data, the initial activity is to resolve chronic issues and restore the basic condition of the tooling. While this is being done, an information system helps with history generation and effective data upkeep for analysis. The next step is to establish a preventive maintenance system. This is either a time-based or production quantity-based system. This step is followed by predictive or condition-based maintenance. During the step of evaluating the planned maintenance system, various parameters can be monitored for performance enhancement. The major parameters under consideration are Mean time to maintain (MTTM), mean time to repair (MTTR), mean quantity between maintenance (MQBM), mean quantity between failure (MQBF), and extended life expectancy. It follows the TPM concept of achieving zero breakage, zero failures, zero defects, and zero accidents. The entire system is to support production by enhancing the availability of tooling at an optimum cost.

TM also has a strong linkage with the pillar of focused improvement, or the Kobetsu Kaizen (KK) pillar. The KK pillar works on the principle of eliminating 16 types of losses. These losses are captured based on equipment, people, or other factors. It focuses on the cost evolution due to these losses and prioritizes improvements. While these losses are captured for machine breakdown and set-up losses, they also capture tooling equipment failure losses, material yield losses, and speed losses, which are directly linked with tooling management. The early management aspect of tooling has a major role to play in reducing material yield loss, energy loss, and speed loss. The planned maintenance aspect of tooling has a major role to play in improving the availability of tooling and reducing minor losses.

DISCUSSION

There are eight basic pillars under TPM as per JIPM guidelines. These pillars are Jishu Hozen, Kobetsu Kaizen, Planned maintenance, Training and Education, Development Management, Quality Management, Safety Sanitization and Environment control & Administration. These constitute an overall structure for ensuring the operational efficiency of a manufacturing organization. This is true for most industries, whereas in industries where tooling technology has a key role to play, like the automobile industry, electrical industry, medical industry, or home appliance industry, it is difficult to assign a suitable weightage for the tooling content considering the linkage with practically every pillar. Tooling management has a very strong linkage with early management, planned maintenance, and the focused improvement pillar. If the industry is only involved in new tooling development, it can create a sub-section of tooling management under the early management pillar. If it has only tool maintenance as its activity, it can consider tooling management as a sub-section of planned maintenance. In the same scenario, if the organization is more focused on loss reduction, it can create a sub-section under the focused improvement pillar. So, as a TPM structure, there is no fixed place for tooling management.

There are several industries in India that have tooling management as a separate pillar. At one of the TPM award-winning groups of companies, Tooling Management (TM) is the 9th pillar in all its plants in India today. The scope of this pillar varies from plant to plant. Few plants consider cutting tool management under the TM pillar. At some plants, press tooling maintenance is considered under the TM pillar, and so on. For a single function to be handled under the TM pillar is somewhat simpler in view of the basic 8 pillars.

In the situation where tooling management handles both the functions, i.e., of new tooling and tool maintenance, either of these linkages is not suitable. By virtue of its operations, TM brings in technology. The new tooling helps to bring in innovation through which the cost per component over its entire life is reduced. The kaizens done in the tool maintenance function enhance the overall productivity, reliability, quality, and safety aspects. There it shows a strong need for a separate pillar. With the inclusion of this pillar, the entire TPM system gets strength. It becomes the backbone of the structure. The need for a separate pillar for tooling management is justified based on the following 3 major perspectives:

Organizational structure/Roles and Responsibility: With the new pillar of tooling management, there would be a clear-cut focus with a dedicated team to work with. This would give enough weightage to the tooling entity in the entire organization. Role clarity within the members would avoid clashes of objectives and priorities. While having a distinct significance for two activities in the tool room, roles and responsibilities can be established without any ambiguity. Moreover, the capacity of the tool room in the form of machinery and highly skilled trained manpower can be effectively utilized with synergy between the two activities.

Innovation and new technology: There are great opportunities to make breakthrough improvements in the phase of new tool development. Whether a tool is to be developed for a new product or for life cycle management, the entire process can be thought of in a different manner. Over time, technological advancements in tool construction, tool materials, processing, and manufacturing will result in significant improvements in quality, productivity, cost, and delivery.

Long term perspective/sustained results: The whole purpose of TPM is to increase the efficiency and effectiveness of the system to get a competitive advantage in terms of profitability and market support. This advantage is not for one time but for a relatively long period of time. Any organisation, in its vision, looks for a longer sustenance perspective. To achieve sustained growth, it needs upgradation of its technology, in terms of new products, new techniques, strategies, and so on. For the quick development of new products, bringing in new technology in manufacturing, getting an innovative approach, and tooling management focus give a noticeable advantage to the organization.

CONCLUSION

The TPM philosophy is gaining wide importance in the Indian industry to enhance its performance. The number of industries applying for TPM awards is increasing year on year. Though there are the basic 8 pillars of TPM, a need is felt by several industries to add or reduce the number of pillars based on the organogram or role of a specific function.

Tooling management is one of the vital functions in many Indian industries, especially in the automobile, electrical, or medical industries. From the perspective of new tooling development, the function is attached to the early management pillar. From the tool maintenance perspective, it is either attached to planned maintenance or the focused improvement pillar.

When the tooling management function has both the roles of new tooling development and that of tool maintenance services, it is necessary to have a separate pillar for "Tooling Management." Organizations need to understand the situation and create a separate pillar to bring a specific focus to the activities.

- A separate pillar will help establish a clear strategy in the tool room for new tooling as well as for tool maintenance services in terms of structure and role clarity. It will bring attention to the important function of the organisation under the TPM umbrella.
- The technological and innovation aspects of tooling management will bring breakthrough advantages to the organisation and prove to be the strongest support pillar.
- The focus on technology in new tooling development will ensure sustained growth for the organization and align itself well towards the long-term vision.

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