A SWOT analysis of total productive maintenance frameworks

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Abstract: In the literature of Total Productive Maintenance (TPM), a large number of frameworks have been proposed by different authors and consultants. If an organisation or a maintenance manager has to make a strategic decision of implementing TPM, it may not be easy for them to identify a suitable framework from a plethora of frameworks that are available in literature. Hence, in this paper, an attempt has been made to perform a comparative study of these frameworks using a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis. In addition to this, the SWOT analysis helped us consolidate a list of critical success factors for TPM apart from identifying the potential weaknesses and threats. Further, it can be concluded that implementation of TPM is by no means an easy task, as it is heavily burdened by weaknesses and threats. However, if an organisation implementing TPM gives due considerations to these weaknesses and threats, it can utilise the significant strengths and opportunities offered by TPM to achieve a competitive advantage.

Keywords: Total Productive Maintenance; TPM; frameworks; Strengths, Weaknesses, Opportunities and Threats analysis; SWOT analysis.

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1 Introduction

Ben-Daya and Duffuaa (1995, p.21) described maintenance as "a function in an organization, which operates in parallel with production. The primary output of production is the desired product and its secondary output is demand for maintenance. Maintenance acts as a secondary input to production in the form of production capacity". Equipment maintenance has matured from its early approach of 'breakdown/corrective maintenance'. In the earlier days, when 'mass production' was at its peak, the primary function of operation was to get the equipment running. Once it has broken down, it will be repaired and rectified by the maintenance people. Generally the operations department would not want the equipment to stop as it was more focused on meeting the daily targets. Since breakdown maintenance tends to keep the shop floor idle for a longer time, the concepts of scheduled maintenance and routine maintenance were introduced. Routine maintenance can be considered as a cyclic operation recurring periodically, where routines are established by defining the frequency of the tasks and the time taken to complete the task. Scheduled maintenance on the other hand is defined as the 'periodic replacement of parts based on their age' (Nagarrur, 1999).

As the competition in market started increasing, organisations found out a different way to carry out maintenance leading to the next phase: i.e. 'Preventive Maintenance

(PM)'. This approach to maintenance was based on the belief that if the equipment was occasionally stopped and maintenance was performed regularly as per schedule, the catastrophic breakdowns could be avoided. Mostafa (2004) defined PM as the practice that encompasses all planned, scheduled and corrective actions before the equipment fails. In other words, PM can be defined as follows: "actions performed on a time or machine-run based schedule that detect, preclude, or mitigate degradation of a component or system with the aim of sustaining or extending its useful life through controlling degradation to an acceptable level".

In tandem with the competition built-up, globalisation is also happening at a rapid pace. Manufacturers were expected to deliver high quality product/service at competitive costs. Hence to survive, organisations were forced to cut down the cost. In dealing with the aspect of cost, experience has indicated that a large percentage of the total cost is due to maintenance-related activities (i.e. the costs associated with maintenance, labour and materials and the cost due to production losses). According to a study reported by Mobley (1990), 15–40% (average 28%) of the total production cost is attributed to maintenance activities in the factory. Further, these costs are likely to increase even more in the future with the added complexities of factory equipment through the introduction of new technologies, automation, the use of robots and so on (Wang and Lee, 2001). Since performance of facilities and equipment is critical to a manufacturer's ability to produce low-cost, high-quality products; an effective maintenance became increasingly important. Managers too slowly recognised the criticality of the maintenance function to organisational success. This recognition of equipment's role in manufacturing led to the development and growing implementation of a comprehensive concept of equipment repair, service and maintenance. In response to it, the Japanese in 1971 introduced the concept of Total Productive Maintenance (TPM). Waeyenbergh and Pintelon (2002) have traced these developments of maintenance in a time perspective.

1.1 Total productive maintenance

TPM is not a radically new idea; it is simply the next step in the evolution of good maintenance practices. Based on the planned approach to PM, the Japanese evolved the concept of TPM (Ireland and Dale, 2001). Chan et al. (2005) have discussed the differences between PM (preventive, predictive and proactive maintenance) and TPM. TPM provides a comprehensive life-cycle approach to equipment management that minimises equipment failures, production defects and accidents. It is an aggressive strategy that focuses on actually improving the function and design of the production equipment (Swanson, 2001). It involves everyone in the organisation, from top level management to production mechanics, and production support groups to outside suppliers. TPM aims to increase the availability/effectiveness of existing equipment in a given situation, through the effort of minimising input (improving and maintaining equipment at optimal level to reduce its life-cycle cost) and the investment in human resources which results in better hardware utilisation (Chan et al., 2005). Another goal of TPM as stated by Schippers (2001) is to reduce and to control the variation in a process. These objectives require strong management support as well as continuous use of work teams and small group activities to achieve incremental improvements. Seth and Tripathi (2005) have studied the strategic implications of Total Quality Management (TQM) and TPM in an Indian manufacturing set-up. They have examined the relationship between factors influencing the implementation of TQM and TPM and business

performance for the following three approaches in an Indian context: TQM alone, TPM alone and both TQM and TPM together, by carrying out an empirical survey-based research on a sample size of 108 manufacturing companies and identified two sets of factors which are critical for the effectiveness of TQM and TPM: universally significant factors for all the three approaches like leadership, process management and strategic planning; and approach-specific factors like equipment management and focus on customer satisfaction.

Our aim is not to discuss about TPM in detail as there is already a significant amount of literature available. The most commonly cited references come from Seiichi Nakajima – who is recognised as the 'Father of TPM'. He has written the following books: *Introduction to TPM* (Productivity Press, 1988) and *TPM Development Program* (Productivity Press, 1989), which describe the building blocks of a TPM programme, explain the overall equipment effectiveness measurements, provide sample implementation plans and document the potential benefits. Similarly, Terry Wireman, who has written *TPM, An American Approach* (Industrial Press, 1991) looks at TPM from the perspective of the maintenance organisation and describes the concept of TPM as a part of the overall manufacturing system. Another prominent TPM authority, Shirose (1992), described TPM from the viewpoint of the equipment operators in his book *TPM for Operators* (Productivity Press, 1992). One common conclusion found from these books is that – in TPM, maintenance has to be recognised as a valuable resource in an organisation i.e. the maintenance organisation now has a role in making the business more profitable and the manufacturing system more competitive by continuously improving the capability of the equipment, as well as making the practice of maintenance more efficient.

TPM methods and techniques have been successfully implemented in Japan, and later were adopted in other advanced and advancing countries in the world. For example, Cigolini and Turco (1997) have conducted a study regarding the TPM implementation process by studying the case study of Italian companies which are implementing TPM and found that none of the surveyed companies developing TPM adopted a methodological pattern different from the preparation, kick-off and implementation phases, as widely suggested in the literature. Bamber et al. (1999) had discussed about the factors affecting the successful implementation of TPM and described the same using a case study of a medium-scale manufacturing industry in the UK. Tsang and Chan (2000) had studied the implementation of TPM in China through a case study approach. Ireland and Dale (2001) discussed about TPM implementation in three industries – a rubber product industry, a packaging company and a motorised vehicle manufacturer. Chan et al. (2005) had discussed about TPM implementation in a semiconductor industry in Hong Kong. Hence for implementing TPM successfully, organisations or consultants or researchers follow a structured approach resulting in development of a framework. Since, these organisations, consultants or researchers are from different countries and background, each framework is different, thus inundating the literature with a plethora of frameworks. For example, recently, Ahmed et al. (2005) presented a generic model using the total TPM concept in conjunction with Ecology-Oriented Manufacturing (EOM) and 5S focusing on their joint strengths in attaining organisational goals in furtherance to the equipment maintenance objectives. This poses a major problem for an organisation, when it decides to implement TPM. Since implementing TPM is a strategic decision and assuming that managers tend to utilise a framework for implementation, they cannot afford to make a mistake in selecting a

suitable framework. They are left with a problem of how to choose one particular framework from the list of frameworks. Hence in this paper, an attempt has been made to overcome the above problem. The paper is arranged as follows: Section 2 discusses briefly about the frameworks of TPM that were identified after conducting a detailed study of TPM literature, Section 3 describes the comparison of frameworks of TPM, while Section 4 enumerates the Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis for the frameworks of TPM to identify each framework's strengths, weaknesses, opportunities and threats and thereby help the management or decision maker choose the right framework for his/her organisation. Section 5 lists out the conclusions.

2 Frameworks of TPM

One of the important requirements for the success of TPM is that it requires a consistent and repeatable methodology for implementation. According to Wireman (1991, p.15), "there is no single correct method for implementation of a TPM program". This is supported by Bamber et al. (1999), who have concluded that there is "a complexity and divergence of TPM programs adopted throughout industry". From these statements, it is evident that there is a lack of standard, structured implementation process or procedure for TPM implementation, and a structured implementation process can be one of the success factors for TPM programme in an organisation. Most of the TPM prize winning plants in Japan followed a strict TPM implementation process by Japan Institute of Plant Maintenance (JIPM). The implementation process is usually represented in the form of a framework. A framework can act as a guide and it provides a structured way to achieve certain objectives. A review of literature revealed that different frameworks of TPM are available. Among them, very few frameworks were proposed by academicians, while most of them were proposed by consultants who have developed these frameworks based on their consultancy experience with various organisations. These frameworks are assumed to be generic in nature because the consultants will be providing maintenance consultancy to different types of industries in different parts of the world. Unless it is generic in nature, it cannot be applied uniformly to different types of industries. In all these frameworks, the principal activities of TPM are organised as 'pillars/elements'. The elements of different frameworks are shown in Table 1.

Table 1 Different frameworks of TPM

1	Seiichi Nakajima	2	TPM Club India
	1 Focused improvement (Kobetsu kaizen)		1 Individual improvement
	2 Autonomous maintenance (Jishu hozen)		2 Autonomous maintenance
	3 Preventive maintenance		3 Planned maintenance
	4 Training and education		4 Education and training
	5 Maintenance prevention (Initial flow control)		5 Development management
	6 Quality maintenance		6 Quality maintenance
	7 Administrative TPM		7 Office TPM
	8 Safety and environmental management		8 Safety, health and environment
3	Aramis Management System	4	Strategic Work Systems Inc.
	1 Safety and environmental management		1 Improving equipment effectiveness by targeting the major losses
	2 Focused equipment and process improvement		2 Involving operators in daily runtime maintenance of their equipment
	3 Work area management		3 Improving maintenance efficiency and effectiveness
	4 Operator equipment maintenance		4 Training for everyone involved
	5 Maintenance excellence for TPM		5 Life-cycle equipment management and maintenance prevention design
	6 Education and training		6 Winning with teamwork focused on common goals
	7 Human resource management		
	8 Administration and support systems improvement		
	9 New equipment management		
	10 Process quality management		
5	Volvo Cars Gent	6	Yeomans and Millington
	1 Customer-ordered production		1 Increase equipment effectiveness
	2 Individual improvement		2 Training
	3 Autonomous management		3 Autonomous maintenance
	4 Planned maintenance		4 Early equipment management
	5 Quality management		5 Planned preventive maintenance system
	6 Early product management		
	7 Early equipment management		
	8 Logistics		
	9 People management		
	10 Office management		
	11 Safety and environment		
	12 Supplier support		
	13 Integration in society		

Table 1 Different frameworks of TPM (continued)

7	Terry Wireman	8	The Centre for TPM (Australasia)
	1 Maximise equipment effectiveness		1 Safety and environmental/risk management
	2 Improve maintenance efficiency and effectiveness		2 Focused equipment and process improvement (Macro and Micro)
	3 Train to improve the skills of all people involved in TPM		3 Work area management
	4 Involve operations personnel in daily maintenance of equipment		4 Operator equipment management
	5 Manage equipment in order to prevent maintenance		5 Maintenance excellence management
			6 Logistics and support improvement
			7 New equipment/product management
			8 Education and training
			9 People support systems improvement
			10 Process quality and innovation management
9	Imants BVBA Consulting and Services	10	Australian Die Casting Association
	1 Autonomous maintenance		1 Operator equipment management (autonomous maintenance)
	2 Equipment and process improvement and overall equipment effectiveness		2 Equipment and process improvement (equipment improvement)
	3 Planned maintenance		3 Planned maintenance
	4 Early management of new equipment		4 Education and training
	5 Process quality management		5 Process quality management (quality maintenance)
	6 TPM in administrative and support departments		6 New equipment management (maintenance prevention)
	7 Education and training		7 Administration system improvement (TPM in the office)
	8 Safety and environmental management		8 Environmental and safety management
11	Cayman System	12	Phillips 66 (Borger and Sweeny Complexes)
	1 Autonomous maintenance		1 Team running maintenance
	2 Quality maintenance		2 Focused improvement
	3 Planned maintenance		3 Planned maintenance
	4 Individual improvement		4 Support, service and training
	5 Training, people development		5 Total quality conditions
	6 Environment Health and Safety (EHS)		6 Teamwork
	7 Early equipment management		
	8 5S’s		

Table 1 Different frameworks of TPM (continued)

13	Society for Maintenance and Reliability Professionals	14	Advanced Productive Solutions (S.L. Barcelona)
	1 Restoring equipment to a new-like condition		1 Focused improvement
	2 Operator involvement in maintaining equipment		2 Autonomous maintenance
	3 Improving maintenance efficiency and effectiveness		3 Effective maintenance
	4 Training people to improve their job skills		4 Quality maintenance
	5 Equipment management and maintenance prevention		5 TPM in administration
	6 Effective use of preventive and predictive maintenance technology		6 Safety, health and environment
			7 Training and education
			8 Early maintenance
15	Promaint Inc.	16	MAX International Engineering Group
	1 Focused improvement		1 Small group activities to eliminate the major equipment losses
	2 Autonomous maintenance		2 Integrated maintenance system
	3 Planned maintenance		3 Planned maintenance system
	4 Training and education		4 Improving education and skills
	5 Initial phase management		5 Feedback process for product, process and equipment improvement
	6 Quality maintenance		6 Quality maintenance system
	7 Efficient administration		7 Administrative system
	8 Safety and environment		8 Safety, hygiene and environmental system
17	Steinbacher and Steinbacker	18	Society of Manufacturing Engineer
	1 Maintenance prevention		1 Improve equipment effectiveness
	2 Predictive maintenance		2 Involve operators in daily maintenance
	3 Autonomous maintenance		3 Improve maintenance efficiency and effectiveness
	4 Corrective maintenance		4 Education and training
	5 Preventive maintenance		5 Designing and managing equipment for maintenance prevention
19	Shekhar Jitkar	20	Venkatesh
	1 Individual improvement		1 5S
	2 Planned maintenance		2 Autonomous maintenance (Jishu hozen)
	3 Initial control		3 Kobetsu kaizen
	4 Education and training		4 Planned maintenance
	5 Autonomous maintenance		5 Quality maintenance
	6 Quality maintenance		6 Training
	7 Administration		7 Office TPM
	8 Safety, health and environment		8 Safety, health and environment

A brief description of each framework is given below:

1 *Seiichi Nakajima:* Nakajima's framework consists of eight pillars. It is the most generally accepted model and it is the commonly used model for TPM implementation in Japan (Nakajima, 1988).

2 *TPM Club India:* This framework is more or less similar to that of Nakajima's framework as it also consists of eight pillars. But the naming of elements tends to be different from the Nakajima's framework (TPM Club India, 2003).

3 *Aramis Management System:* Aramis Management System (AMS) is an organisation providing consultancy services for organisations implementing TPM. According to AMS, TPM is basically a re-focusing of Total Quality Control (TQC) principles towards increased equipment utilisation that provides a structured, holistic approach to maintenance of the entire production operation. In this framework, the TPM goals are partially achieved by demystifying appropriate aspects of equipment maintenance and empowerment of personnel, which creates self-perpetuating ownership and positive attitudes towards process and equipment management. The framework consists of ten pillars (Aramis Management System, 1998).

4 *Strategic Work Systems Inc.:* Strategic Work Systems, Inc. is a consultancy firm which emphasises that TPM is an equipment and process improvement strategy that links many of the elements of a good maintenance programme to achieve higher levels of equipment effectiveness. In addition to the five key elements or pillars of TPM it also includes a sixth element – teamwork, focused on common goals including equipment reliability (Williamson, 2000).

5 *Volvo Cars Gent:* The implementation of TPM at Volvo Cars Gent (VCG) is based upon 13 committees or development pillars. Some of the unique pillars in this framework are: customer-ordered production, early product management, logistics, supplier support and integration in society (Volvo Cars Gent, 1998).

6 *Yeomans and Millington:* Yeomans and Millington have developed their framework based on the theory of the classic Japanese TPM approach, which is built on five strategic pillars (Yeomans and Millington, 1997).

7 *Terry Wireman:* The framework consists of the following five pillars and three of the pillars are similar to the framework proposed by Yeomans and Millington. According to Wireman, many companies do not include maintenance prevention among the goals (or pillars) of their TPM programmes because they lack the data to pursue that goal and many (to varying degrees) do strive to put the other four pillars in place. Hence his framework gives importance to maintenance prevention. He also emphasises on training to improve the skills of the people involved in TPM and has classified it into two major components. One is soft skill training, such as how to work as teams, diversity training and communication skills. The second is technical training, which ensures that the employees have the technical knowledge to make improvements to the equipment (Wireman, 1991).

8 *The Centre for TPM (Australasia):* The Centre for TPM (CTPM) Australasia (1998) has traced the history of TPM development since its first introduction in 1970. According to CTPM, originally there were five activities of TPM that is now referred to as 'First Generation TPM'. It focused on improving equipment performance or

effectiveness only. Further they claim that, late in the 1980s, it was realised that even if the shop floor was committed fully to TPM through the elimination or minimisation of the six big losses, there were still opportunities being lost because of poor production scheduling practices resulting in line imbalances or schedule interruptions. To overcome this, the development of 'Second Generation TPM (Total Process Management)' happened, which focused on the whole production process. Finally, in more recent times, it has been recognised that the whole company must be involved if the full potential of the capacity gains and cost reductions is to be realised. Hence 'Third Generation TPM (Total Productive Manufacturing/Mining)' has evolved which now encompasses the eight pillars of TPM with the focus on the 16 major losses incorporating the 4Ms – man, machine, methods and materials. At the CTPM, the Japanese eight pillars have been expanded to ten pillars of Australasian third generation TPM to better suit the needs in Australia and New Zealand.

9 *Imants BVBA Consulting and Services:* This framework consists of eight pillars. The nature of framework is that it involves the cooperation of the equipment and process support personnel, equipment operators and the equipment supplier. They must work together to eliminate equipment breakdowns, reduce scheduled downtime, and maximise utilisation, throughput and quality (Imants BVBA Consulting and Services, 2004).

10 *Australian Die Casting Association:* A company named Nissan Casting in Australia has adopted the framework developed by Australian Die Casting Association (ADCA). The framework consists of eight pillars. This framework is similar to that of JIPM framework, but the names of many of the major pillars of JIPM are changed to avoid confusion caused by the literal Japanese translation (Luxford, 1998).

11 *Cayman System:* The framework consists of eight pillars. In this framework, the emphasis is on following the established pillars and to create an integrated structure to promote TPM as company culture (Cayman Business Systems, 1998).

12 *Phillips 66 (Borger and Sweeny Complexes):* The framework consists of six pillars. According to this framework, the implementation plan was built around the five pillars of TPM. The first phase focused on operator autonomous maintenance, clean-to-inspect and some basic focused improvement projects with the idea of stabilising the failures and eliminating repetitive work. In this phase, they attempted to get the equipment back to a new-like condition. They have also included some of the preliminary steps to planned maintenance in this first phase. The second phase concentrated on focused improvement projects to design out failures due to poor or inadequate design. The third phase put together a planned maintenance approach and included some replacement of inadequate or inappropriate equipment. The final phase was to implement condition monitoring through advanced autonomous maintenance (Jim and Douglas, 1998).

13 *Society for Maintenance and Reliability Professionals:* According to Society for Maintenance and Reliability Professionals (SMRP), the cultural environment in which the TPM strategy was developed may be different from the culture in a typical non-US manufacturing plant, and hence requires additional consideration. They have analysed that organisations were doing PM to little effect – either over-doing it on

some equipment and achieving little uptime improvement, or under-doing it on other equipment and experiencing unplanned equipment downtime and hence they focused on optimising the PM practices using a TPM/RCM approach. They also found that the critical success factors are to develop better equipment histories, to plan and schedule maintenance, to be far more proactive in eliminating defects from the operation, regardless of whether they were rooted in process, equipment or people issues. Using this framework, it was much easier to develop a sense of teamwork for problem resolution. This framework consists of six pillars (Moore and Rath, 1998).

14 *Advanced Productive Solutions (S.L. Barcelona):* Advanced Productive Solutions (1998) argues that TPM should not be observed as the indiscriminate application of maintenance methods. It also emphasises that the data, information and knowledge are to be used as instruments to carry out the operative activities but what really leads to results is the management capacity that guides the efforts towards the achievement of the established goals. The framework consists of eight pillars (Advanced Productive Solutions, 1998).

15 *Promaint Inc.:* According to Promaint Inc. (2004), TPM is a company-wide commitment involving all employees in a relentless pursuit of zero downtime, zero defects, zero accidents and zero waste through implementation of the eight pillars.

16 *MAX International Engineering Group:* Max International Engineering Group has commented that TPM is not a short-term fix, but a long, never-ending journey to best in class factory performance through: on-going management commitment, increased employee responsibilities, cross-functional teams, root cause fixes, discipline, standardisation and simplification and continuous improvement to achieve the goals of zero unplanned downtime, zero speed losses, zero defects, zero accidents and minimum life-cycle cost. It consists of eight pillars (Max International Engineering Group, 2004).

17 *Steinbacher and Steinbacker:* The framework consists of five pillars. This is the framework followed by the Western countries and the authors have emphasised on training and education as an integral element of their pillars rather than a stand-alone pillar as in the Nakajima model (Steinbacher and Steinbacker, 1993).

18 *Society of Manufacturing Engineers:* The Society of Manufacturing Engineers has emphasised that the core of TPM is a new partnership among the manufacturing or production people, maintenance, engineering and technical services to improve Overall Equipment Effectiveness (OEE). The framework consists of five pillars (Williamson, 1995).

19 *Shekhar Jitkar:* Jitkar (2004) observed that TPM is to maintenance as total quality is to production and commented that many of the same tools such as employee empowerment, benchmarking, documentation, etc. are used to implement and optimise TPM. He has also observed that philosophically, TPM resembles TQM 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 TPM may take a year or more to implement and is an on-going process.

According to Jitkar (2004), TPM must evolve in five directions concurrently – as a business strategy, and in the following areas of operation – from equipment to product on system and further to encompass company-wide activities, number of measures/performance indicators, skills to be built in each phase, and finally behavioural improvement for a cultural transformation. The framework consists of eight pillars (Jitkar, 2004).

20 *Venkatesh J.***:** The framework consists of eight pillars (Venkatesh, 2003). This framework is similar to that of Jitkar's framework.

3 Comparison of frameworks of TPM

The various frameworks of TPM are compared and it is shown in Table 2.

The comparison table shows a matrix of numbers, which represents the order of each pillar/elements (given row-wise), as mentioned in the corresponding frameworks (given column-wise). Based on this comparison, it was found that there are few elements that are occurring in most of the frameworks. These elements are considered as the common elements. If minimum 10 or more authors have considered an element in their framework, then it is considered as a 'common element'. The basis of choosing minimum 10 or more authors is based on the following premises: about 20 frameworks of TPM have been studied. If 10 authors or more have explained or used an element then it means that the occurrence of such an element within a sample of 20 is quite high, i.e. it implies 50% of the surveyed authors feel that it is an important aspect of TPM. Hence it is considered as a valid assumption that if a majority of authors (50% or more) accepts as a pillar, then it should be considered as common elements of TPM. The common elements identified from this analysis are as follows:

- Focused improvement/Kobetsu Kaizen
- Autonomous maintenance/Jishu Hozen
- Training and education
- Maintenance prevention/Early equipment management
- Quality maintenance/Process quality management
- Administrative TPM/Office TPM
- Safety, health and environment
- Planned maintenance

It was also found that, among the frameworks surveyed, only very few frameworks are unique, while most of them are more or less similar. Only the naming and the number of pillars/elements differ slightly. Such frameworks having similar pillars/elements (based on names and number of pillars/elements) are grouped together into three clusters, namely Group A, Group B and Group C. Group D consists of frameworks having 'unique' pillars/elements. Grouping of various frameworks of TPM is shown in Table 3.

Table 2 Comparison of frameworks of TPM

S no. ↓	*Authors/consultants* →	*Seiichi Nakajima (1988)*	*TPM Club India (1998)*	*Aramis Management Systems (1998)*	*Strategic Work Systems, Inc. (Williamson, 2000)*	*Volvo Cars Gent (1998)*	*Yeomans & Millington (1997)*	*Terry Wireman (2000)*	*The Centre for TPM, (Australasia) (2002)*	*Imants BVBA Consulting and Services (2004)*	*Australian Die Casting Association (Luxford, 1998)*	*Cayman Systems (1998)*	*Phillips 66 (Borger and Sweeny Complexes) (Jim & Douglas, 1998)*	*Society for Maintenance & Reliability Professionals (Moore & Rath, 1998)*	*Advanced Productive Solutions (S.L. Barcelona) (1998)*	*Promaint Inc. (2004)*	*MAX International Engineering Group (2004)*	*Steinbacher and Steinbacker (1993)*	*Society of Manufacturing Engineers (Williamson, 1995)*	*Shekhar Jitkar (2004)*	*Venkatesh (2003)*
	No. of pillars/elements	8	8	10	6	13	5	5	10	8	8	8	6	6	8	8	8	5	5	8	8
	↑ Name of the pillar/element ↓																				
1	Focused improvement/individual improvement/focused equipment and process improvement/increase or maximise equipment effectiveness (Kobetsu kaizen)	1	1	2	1	2	1	1	2	2	2	4	2	2	1	1	1		1	1	3
2	Autonomous maintenance/operator equipment maintenance (Jishu hozen)	2	2	4	2	3	3	4	4	1	1	1			2	2		3	2	5	2
3	Preventive maintenance	3																5			
4	Training and education/training, people development/support, service and training	4	4	6	4		2	3	8	7	4	5	4	4	7	4	4		4	4	6

Table 2 Comparison of frameworks of TPM (continued)

S no. ↓	*Authors/consultants* →	*Seiichi Nakajima (1988)*	*TPM Club India (1998)*	*Aramis Management Systems (1998)*	*Strategic Work Systems, Inc. (Williamson, 2000)*	*Volvo Cars Gent (1998)*	*Yeomans & Millington (1997)*	*Terry Wireman (2000)*	*The Centre for TPM, (Australasia) (2002)*	*Imants BVBA Consulting and Services (2004)*	*Australian Die Casting Association (Luxford, 1998)*	*Cayman Systems (1998)*	*Phillips 66 (Borger and Sweeny Complexes) (Jim & Douglas, 1998)*	*Society for Maintenance & Reliability Professionals (Moore & Rath, 1998)*	*Advanced Productive Solutions (S.L. Barcelona) (1998)*	*Promaint Inc. (2004)*	*MAX International Engineering Group (2004)*	*Steinbacher and Steinbacker (1993)*	*Society of Manufacturing Engineers (Williamson, 1995)*	*Shekhar Jitkar (2004)*	*Venkatesh (2003)*
	No. of pillars/elements	8	8	10	6	13	5	5	10	8	8	8	6	6	8	8	8	5	5	8	8
5	Maintenance prevention/new equipment management/early equipment management/new equipment or product management/initial phase management/designing and managing equipment/development management/life-cycle equipment management and maintenance prevention design/initial flow control	5	5	9	5	7	4	5	7	4	6	7		5	8	5		1	5	3	
6	Quality maintenance/process quality management/process quality and innovation management/total quality conditions	6	6	10		5			10	5	5	2	5		4	6	6			6	5
7	Administrative TPM/office TPM/administration and support systems improvement/office management/efficient administration	7	7	8		10				6	7				5	7	7			7	7

Table 2 Comparison of frameworks of TPM (continued)

S no.	*Authors/consultants* →	*Seiichi Nakajima (1988)*	*TPM Club India (1998)*	*Aramis Management Systems (1998)*	*Strategic Work Systems, Inc. (Williamson, 2000)*	*Volvo Cars Gent (1998)*	*Yeomans & Millington (1997)*	*Terry Wireman (2000)*	*The Centre for TPM, (Australasia) (2002)*	*Imants BVBA Consulting and Services (2004)*	*Australian Die Casting Association (Luxford, 1998)*	*Cayman Systems (1998)*	*Phillips 66 (Borger and Sweeny Complexes) (Jim & Douglas, 1998)*	*Society for Maintenance & Reliability Professionals (Moore & Rath, 1998)*	*Advanced Productive Solutions (S.L. Barcelona) (1998)*	*Promaint Inc. (2004)*	*MAX International Engineering Group (2004)*	*Steinbacher and Steinbacker (1993)*	*Society of Manufacturing Engineers (Williamson, 1995)*	*Shekhar Jitkar (2004)*	*Venkatesh (2003)*
	No. of pillars/elements	8	8	10	6	13	5	5	10	8	8	8	6	6	8	8	8	5	5	8	8
8	Safety, health and environment/risk management	8	8	1		11			1	8	8	6			6	8	8			8	8
9	Planned maintenance/planned preventive maintenance system		3			4	5			3	3	3	3	6		3	3			2	4
10	Work area management			3					3												
11	Maintenance excellence for TPM			5					5												
12	Human resource management/people management			7		9															
13	Improving maintenance efficiency and effectiveness				3			2						3					3		
14	Winning with teamwork focused on common goals				6								6								
15	Customer-ordered production					1															
16	Early product management					6															
17	Logistics/logistics and support improvement					8			6												

Table 2 Comparison of frameworks of TPM (continued)

S no. ↓	*Authors/consultants* →	*Seiichi Nakajima (1988)*	*TPM Club India (1998)*	*Aramis Management Systems (1998)*	*Strategic Work Systems, Inc. (Williamson, 2000)*	*Volvo Cars Gent (1998)*	*Yeomans & Millington (1997)*	*Terry Wireman (2000)*	*The Centre for TPM, (Australasia) (2002)*	*Imants BVBA Consulting and Services (2004)*	*Australian Die Casting Association (Luxford, 1998)*	*Cayman Systems (1998)*	*Phillips 66 (Borger and Sweeny Complexes) (Jim & Douglas, 1998)*	*Society for Maintenance & Reliability Professionals (Moore & Rath, 1998)*	*Advanced Productive Solutions (S.L. Barcelona) (1998)*	*Promaint Inc. (2004)*	*MAX International Engineering Group (2004)*	*Steinbacher and Steinbacker (1993)*	*Society of Manufacturing Engineers (Williamson, 1995)*	*Shekhar Jitkar (2004)*	*Venkatesh (2003)*
	No. of pillars/elements	8	8	10	6	13	5	5	10	8	8	8	6	6	8	8	8	5	5	8	8
18	Supplier support					12															
19	Integration in society					13															
20	People support systems improvement								9												
21	5S's											8									1
22	Team running maintenance												1								
23	Restoring equipment to a like-new condition													1							
24	Effective maintenance														3						
25	Integrated maintenance system																2				
26	Feedback process for product, process and equipment improvement																5				
27	Predictive maintenance																	2			
28	Corrective maintenance																	4			

Table 3 Grouping of various frameworks of TPM

Group	*Authors/Consultants*	*No. of pillars*	*Remarks*
A	Seiichi Nakajima, TPM Club India, Imants BVBA Consulting and Services, Australian Die Casting Association, Advanced Productive Solutions, Promaint Inc. and Shekhar Jitkar	8	Closely follows the JIPM framework
B	Cayman System, Max International Engineering Group, Venkatesh	8	Few pillars are different than the JIPM framework
C	Strategic Work Systems, Yeomans and Millington, Terry Wireman, Society for Maintenance and Reliability Professionals, Society of Manufacturing Engineers	5–6	Pillars covers only the basic definition of TPM
D	Aramis Management System, Volvo Cars Gent, The Centre for TPM Australasia, Phillips 66, Steinbacher and Steinbacker	5–13	Completely different from JIPM and different from each other

Since implementation of TPM programme is a strategic decision, it is necessary that managers should identify a suitable framework and they cannot afford to make a mistake in the selection process. But a greatest hurdle in this selection process is the availability of large numbers of frameworks in the literature. Hence a strategic tool – the SWOT analysis was chosen for analysing these frameworks. Since this methodology can be used to assess the strengths, weaknesses, opportunities and threats of each TPM framework, it can provide adequate support for the manager in making a better decision of selecting a suitable TPM framework.

4 SWOT analysis of frameworks of TPM

This methodology originally seems to be from the business management literature and the researchers at Stanford Research Institute developed it. The background to SWOT stemmed from the need to find out why corporate planning failed. SWOT is the acronym for a company's strengths, weaknesses, opportunities and threats (Kotler and Armstrong, 1996). A SWOT analysis evaluates an organisation's internal strengths and weaknesses and its external opportunities and threats. It is a valuable strategic planning tool, because it focuses on the key elements of an organisation's position within a market. It is also referred to as the 'design school model' (Mintzberg, 1994), which seeks to address the question of strategic formulation from a twofold prospective: from an external appraisal (of threats and opportunities in an environment) and from an internal appraisal (of strength and weakness in an organisation). The two perspectives can be differentiated by the different degree of control attainable within each. The dynamic and unrestricted nature of the external environment can seriously hamper the process of detailed strategic planning, while internal factors are to be more easily manageable for the organisational entity. The aim of SWOT analysis is to identify the extent to which the current strategy of an organisation and its more specific strengths and weaknesses are relevant to, and capable of dealing with the changes taking place with business environment (Johnson and Scholes, 1994). Several authors have used SWOT analysis (e.g. Weihrich, 1982; Piercy

and Giles, 1989; Dealtry, 1992; Dalu and Deshmukh, 2001). According to them it also aims to prepare an organisation for problems, which may arise, allowing for the development of contingency plans.

According to the advocates of SWOT, strengths refer to inherent abilities to compete and grow strong. Weaknesses are the inherent deficiencies that cripple growth and survival. Strengths and weakness are mostly internal. Opportunities are the good chances and openings available for growth. Threats are externally wielded challenges, which might suppress inherent strengths, accelerate weakness and stifle opportunities from being exploded. To succeed in any field, weaknesses must be overcome through strengths and threats must be transferred into opportunities. The four elements of a SWOT analysis undertaken as part of a wider strategic planning are shown below:

Strength: A resource or capacity the organisation can use effectively to achieve its objectives.	*Weakness:* A limitation, fault or defect in the organisation that will keep it from achieving objectives.
Opportunity: Any favourable situation in the organisation's environment.	*Threat:* An unfavourable situation in the organisation's environment that is potentially damaging to its strategy.

In this paper, the SWOT analysis has been adapted as follows to analyse the TPM frameworks.

Strength: If any TPM framework has a unique element/feature when compared to others, then it is considered as the strength for that framework.	*Weakness:* If the common elements of TPM that were identified in comparative analysis are missing in a framework, then it is considered as the weakness for that framework.
Opportunity: In a TPM framework, if an element, which may not be an important element for TPM implementation or if it is not directly related to TPM, but if incorporated can provide significant competitive advantage to the organisation, then it is considered to be opportunity for other frameworks.	*Threat:* If an element in the framework, which may not be an important element for TPM implementation, but if it is not present/implemented can spoil the entire implementation, then it is considered as a threat.

Based on these concepts of SWOT analysis, the strengths, weaknesses, opportunities and threats for different frameworks of TPM were identified. Since those frameworks having common pillars, may have same strengths, weaknesses, opportunities and threats, it was considered logical to perform a SWOT analysis on a group. SWOT analysis has been performed for each of the groups mentioned in Table 3. Some frameworks are unique for which it was proposed to perform SWOT analysis individually, especially for those frameworks that are unique and classified under Group D. The SWOT analyses for Group A, Group B, Group C and Group D are discussed in the following sections.

4.1 SWOT analysis for Group A frameworks

Group A consists of the following seven frameworks, namely, Nakajima (1988), Advanced Productive Solutions (1998), Luxford (1998), TPM Club India (2003), Imants BVBA Consulting and Services (2004), Jitkar (2004), Promaint Inc. (2004).

4.1.1 Strengths

- widely accepted model
- promotes economic efficiency
- maintenance expenses are planned and controlled (Adair-Heely, 1989)
- promotes zero accident, zero defect and zero failure
- prevention philosophy
- all workers participation by organising overlapping small groups in an hierarchical system
- operation and maintenance of equipment by operators
- reduction in indirect labour, the overhead of scheduling the PM work around production and other logistical problems get reduced (Van-Lane, 1991)
- helps keeping a clean working environment
- automisation and unmanned plant operations
- to get the most efficient use of all production equipment/facilities (i.e. overall equipment effectiveness)
- equipment becomes more reliable, and the process more repeatable, scheduling the flow of work through the process becomes easier (Steinbacher and Steinbacker, 1993)
- eliminates 16 major losses
- supports the lean and six sigma initiatives
- provides way to refine the current maintenance practices
- establish documented improvement methods
- helps to correct design weaknesses in the machines
- team-based improvement activity
- reduction of the maintenance force
- as employee involvement increases, it also improves employee relations
- operators are recognised as thinking contributors to the company
- operators become more familiar with the tools and techniques used in the problem solving process, hence the rate at which problems are resolved will increase
- reduced variation
- increased flexibility
- increased labour productivity
- reduced replacement parts cost
- reduced energy costs

4.1.2 Weaknesses

Culture

- a culture where PMs are only widely carried out (Williamson, 2002)
- changing the corporate culture is more easily said than achieved (Wireman, 1998; Labib, 1999; Cooke, 2000)

Knowledge about TPM

- lack of understanding of TPM concepts by top management (Wireman, 1998; Bamber et al., 1999; Melani, 2004)
- lack of maintenance basics (Wireman, 1998; Elliott, 2001)
- underestimating the importance of knowledge (Elliott, 2001)

Training

- lack of in-house training facilities and lack of time/interest to send employees elsewhere for their training and development (Ahmed et al., 2004)
- no associates training on TPM know-how (Adam et al., 1997; Co et al., 1998; Wireman, 1998; Melani, 2004)

Management

- lack of long-term vision/commitment – quick return expected by management (Al-Najjar, 1996; Adam et al., 1997; Co et al., 1998; Yamashina, 2000; Ahmed et al., 2004)
- contradiction of management initiatives (Cooke, 2000)
- initiated as part of downsizing effort (Wireman, 1998)
- lack of management support (Jostes and Helms, 1994; Adam et al., 1997; Co et al., 1998; Cooke, 2000; Yamashina, 2000; Melani, 2004; Pomorski, 2004)
- lack of sustained momentum (Adam et al., 1997; Co et al., 1998)
- not dedicating full time for TPM implementation (Melani, 2004)

Participation

- lack of participation/commitment from non-manufacturing units such as administration, marketing, purchasing and maintenance (Cooke, 2000; Ahmed et al., 2004; Melani, 2004)
- no formal teamwork between maintenance and operations (Cooke, 2000)
- resistance to daily discipline (Pomorski, 2004)
- lack of collaboration between operator and maintenance staff (Cooke, 2000)

- lack of involvement of production associates (Adam et al., 1997; Co et al., 1998; Cooke, 2000; Melani, 2004)
- resistance or indifference of managers and engineering personnel (Bamber et al., 1999; Yamashina, 2000)

Resources

- lack of human resources both in terms of number and skill/expertise (Adam et al., 1997; Ahmed et al., 2004; Pomorski, 2004)
- lack of time to think, and a belief that re-engineering is expensive (Ahmed et al., 2004)
- no delegate person (Adam et al., 1997; Co et al., 1998)
- shortage of funding for investment/tight budget/long-term investment (Cooke, 2000; Ahmed et al., 2004)
- introduction of TPM to machines that were not really important to the product process (Bamber et al., 1999)
- trying to develop TPM on a broad plant-wide scale will almost always strain limited resources and interrupt production and maintenance in today's lean enterprises (Williamson, 2002)
- there is so much emphasis on the production or operations side of TPM that the maintenance staff gets covered up with requests to fix problems and make improvements at the expense of other pressing work throughout the plant (Williamson, 2002)

Role of data

- data are collected but not analysed (Labib, 1999)
- equipment data, especially overall equipment effectiveness data, are not routinely tracked or reviewed (Williamson, 2002)
- lack of a critical OEE focus (Wireman, 1998)
- oversimplification of the TPM development process often leads to a half-baked effort with less than desirable results. This often comes from starting TPM activities before fully realising what TPM truly is and what it takes to achieve sustainable results (Williamson, 2002)

Others

- a flurry of cleaning, fixing up, labelling, tagging and colour-coding activities overshadow the fundamental purpose of TPM (Williamson, 2002)
- how to relate TPM activities to cost reduction (Yamashina, 2000)
- inconsistent and unclear expectations (Pomorski, 2004)

- no change in the rewards and recognition systems (Wireman, 1998)
- pressure of workload (Cooke, 2000)
- simultaneous introduction of TPM on too many machines (Chan et al., 2005)
- the challenge of passion (Elliott, 2001)
- time for the evolution of TPM (Melani, 2004)
- TPM is promoted and sponsored by the maintenance or plant engineering department and manufacturing has not bought into the concept (Williamson, 2002)
- underestimating the task (Elliott, 2001)
- there is an attempt to accelerate the rate of TPM development throughout the plant without first establishing a pocket of excellence (Williamson, 2002)
- the programme does not implement change on the shop floor and is not managed (Bamber et al., 1999)
- poor structure to support the TPM teams and their activities (Bamber et al., 1999)

4.1.3 Opportunities

- link TPM activity directly to corporate business goals and objectives
- integrate TPM with other continuous improvement programmes
- quick responsive to market changes
- minimise inventory
- helps to achieve zero defects
- helps to achieve zero break-downs
- reduces maintenance calls for machines
- development of innovative designs for maintenance prevention
- ensure quick availability of products to customers
- provides better services in the global/world market
- improves productivity
- increases the morale of employee
- improves safety and reduces accidents
- less investment on new equipments, as present equipments will be in good condition
- reduces warranty costs due to better quality products obtained from better processes
- changes the attitude of the employees towards continuous improvement
- helps operators to become multi-skilled

- builds teamwork and cooperation among employees
- though 5S is part of TPM implementation process, importance to 5S has to be provided as in Group B frameworks

4.1.4 Threats

- complexity strangles performance (Elliott, 2001)
- copying another plant or facility's approach to TPM almost always results in failures (Wireman, 1998; Williamson, 2002)
- convincing workers, especially when they are unionised, because TPM eventually creates excess people (Yamashina, 2000)
- getting competent maintenance and quality managers, good and competent consultant because they are the key people to the success of the TPM journey (Yamashina, 2000)
- inconsistent and unclear expectations
- its implementation lacks focus (Labib, 1999; Yamashina, 2000)
- lack of state-of-the-art (modern) technology and lack of understanding about the role of technology (Ahmed et al., 2004)
- lack of structural format in TPM implementation (Adam et al., 1997; Bamber et al., 1999)
- limited involvement/experience and skills in TPM (Bamber et al., 1999)
- missing the point of TPM and focused primarily on autonomous maintenance or operator involvement (Williamson, 2002)
- no specific measurement method on result (Jostes and Helms, 1994; Blanchard, 1997; Lungberg, 1998; Johnson and Lesshammar, 1999; Lawrence, 1999; Dal et al., 2000)
- resistance to daily discipline
- risk of losing core people after extensive education and training (Yamashina, 2000)
- risk of the leakage of confidential information via the consultant (Yamashina, 2000)
- shortage of process improvement engineers (Yamashina, 2000)
- there is not a business case for changing the way the company pays attention to their equipment performance and reliability (Williamson, 2002)
- too much focus on output measures rather than the quality of the process inputs
- TPM is seen as another quick improvement fad that will likely be replaced with yet another one next year (Williamson, 2002)
- TPM is faced as a programme, but must be faced as a process (Melani, 2004)

- the programme is not serious about change (Bamber et al., 1999)
- the programme is too high level, run by managers for managers (Bamber et al., 1999)
- attempts to apply TPM in the same way it is implemented in Japan, using the standard approach found in Japanese publications (Bamber et al., 1999)

4.2 SWOT analysis for Group B frameworks

The frameworks developed by Cayman Systems (1998), Max International Engineering Group (2004) and Venkatesh (2003) are more or less similar to Group A frameworks. But in these frameworks, at least one pillar/element is different from the frameworks in Group A and hence they are grouped separately. Table 4 shows the SWOT analysis for Group B frameworks.

Table 4 SWOT analysis for Group B frameworks

Strengths	*Weaknesses*	*Opportunities*	*Threats*
• It focuses on 5S as it emphasises on a separate pillar • A new pillar called integrated maintenance system has been added (Max International Group, 2004) • Other strengths are more or less similar to Group A	• Implementation needs expertise • Some of the pillars as shown in Group A are missing. For example, autonomous maintenance is missing (Max International Group, 2004), early equipment management (Venkatesh), office TPM is missing (Cayman Business Systems) • Other weaknesses are more or less similar to Group A	• Feedback systems can produce better results • Can provide quick change over to products and processes • Other opportunities are more or less similar to Group A	• Threats are more or less similar to Group A

4.3 SWOT analysis for Group C frameworks

The frameworks developed by Strategic Work Systems (Williamson, 2000), Yeomans and Millington (1997), Wireman (1991), Society for Maintenance and Reliability Professionals (Moore and Rath, 1998) and Society of Manufacturing Engineers (Williamson, 1995) are completely different from both Groups A and B. These frameworks have about six pillars/elements each and hence they are grouped separately. Table 5 shows the SWOT analysis for Group C frameworks.

Table 5 SWOT analysis for Group C frameworks

Strengths	*Weaknesses*	*Opportunities*	*Threats*
• A simple and basic framework because it addresses only the basic elements of maintenance • Focuses on life-cycle equipment management (Williamson, 2000) • Highlights about maintenance efficiency and effectiveness (Williamson, 2000; Yeoman and Millington, 1997)	• Consists of only six pillars and some essential pillars like quality maintenance, health, safety and environment are missing • Most of the pillars are same as that of Nakajima's framework • These frameworks are like a guidelines and not focused • Other weaknesses are more or less similar to Group A	• Focus should be on quality maintenance, safety, health and environment • Other opportunities are more or less similar to Groups A and B	• Threats are more or less similar to Group A

4.4 SWOT analysis for Group D frameworks

The remaining frameworks developed by Steinbacher and Steinbacker (1993), Aramis Management System (1998), Phillips 66 (Jim and Douglas, 1998), Volvo Cars Gent (1998) and The centre for TPM, Australasia (2002) are completely different from other groups and also wide differences exist between them. Further the number of pillars/elements of each framework in this group varies from 5 to 13. Considering all these facts, the SWOT analysis was carried out for individual frameworks. Tables 6–10 show the SWOT analysis for these frameworks.

Table 6 SWOT analysis for Group D frameworks

Strengths	*Weaknesses*	*Opportunities*	*Threats*
• Special focus on work area management, maintenance excellence and human resource management • It also focuses on reward and recognition • It improves the relationship between trade union • Other strengths are more or less similar to Group A	• No supplier support for machine and spare parts • Weaknesses are more or less similar to Group A	• It may help to achieve excellence through continuous improvement activities • Others are opportunities more or less similar to Group A	• Threats are more or less similar to Group A

Table 7 SWOT analysis for Group D frameworks

Strengths	*Weaknesses*	*Opportunities*	*Threats*
• Special focus on unique pillars like customer-oriented production, logistics, supplier support and integration in society • Environmental compliance is not compromised as it has a pillar of integration in society • Service levels are maintained or improved • It is a realistic model as it has been implemented in an organisation • Special focus on individual improvement • Other strengths are more or less similar to Group A	• Loss of focus, as too many elements across the organisation are emphasised • Other weaknesses are more or less similar to Group A	• Quick responsiveness to market changes • Helps to become more customer responsive • Other opportunities are more or less similar to Group A	• Threats are more or less similar to Group A

Table 8 SWOT analysis for Group D frameworks

Strengths	*Weaknesses*	*Opportunities*	*Threats*
• Improvised model of the TPM (JIPM) • It emphasises on maintenance excellence • Special focus is on logistics and support improvement • Helps to mitigate risk, as it focuses on risk management and work area management • Other strengths are more or less similar to Group A	• Focuses on many pillars/elements at the same time • Office TPM is missing • Other weaknesses are more or less similar to Group A	• It aims to provide good support to customers through efficient logistics and support improvement • Other opportunities are more or less similar to Group A	• Threats are more or less similar to Group A

Table 9 SWOT analysis for Group D frameworks

Strengths	*Weaknesses*	*Opportunities*	*Threats*
• A more realistic model as it has been implemented in an organisation • Highlights the role of total quality conditions • Gives more importance to teamwork • Other strengths are more or less similar to Group A	• Basic theory of TPM is not covered fully in this framework, as it consists of only six pillars • No focus on supplier support, Office TPM, early equipment management, autonomous maintenance, health, safety and environment • Other weaknesses are more or less similar to Group A	• Opportunities are more or less similar to Group A	• Threats are more or less similar to Group A

Table 10 SWOT analysis for Group D frameworks

Strengths	*Weaknesses*	*Opportunities*	*Threats*
• It is a basic model of TPM • Gives more importance to predictive maintenance • Other strengths are more or less similar to Group A	• Consists of only five pillars • No attention has been paid towards education and training, quality maintenance, health safety and environment, and early equipment management • Pillars like corrective, preventive maintenance are part of planned maintenance pillar in other frameworks • Some pillars are similar to that of Nakajima's framework • Other weaknesses are more or less similar to Group A	• Opportunities are more or less similar to Groups A, B and C	• Threats are more or less similar to Group A

5 Conclusion

In this paper, a brief overview about the history of maintenance was provided to identify how the maintenance systems/practices have evolved over the time. Presently, TPM has been widely acknowledged and used by many industries for various reasons. Hence a literature review on TPM was carried out, which revealed that there are many frameworks for implementing TPM, which helps us to conclude that the implementation of TPM will differ from organisation to organisation even though the objectives are mostly similar. About 20 frameworks of TPM were identified, which are primarily developed by organisations, consultants and researchers from different countries and are adopted by different industries. These frameworks were compared and it was found that only few frameworks are unique while in others, the naming and the number of pillars/elements differ slightly. This poses a problem for the managers or practitioners when they would like to choose a particular TPM framework suitable for implementation. Since the decision of implementing TPM in an organisation is a strategic decision, they cannot afford to make a mistake. Hence in this paper, the SWOT analysis – a critical and quick decision-making tool was used for the analysis of different aspects of the TPM frameworks, namely, the strengths, weaknesses, opportunities and threats. Based on the analysis, it was found that each framework has its own strengths and weaknesses. The SWOT analysis also suggests that implementation of TPM is by no means an easy task, as it is heavily burdened by weaknesses and threats; however, if organisations could implement TPM properly, it offers significant strengths and opportunities to achieve a competitive advantage.

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