TPM implementation to invigorate manufacturing performance: *an Indian industrial rubric*

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Abstract— The intent of the study is to appraise the challenges faced by Indian manufacturing industries to implement Total Productive Maintenance (TPM). The scheme of this research is to critically analyse the factors influencing TPM implementation in Indian manufacturing organisations, and to formulate comprehensive strategy for overcoming impediments to successful TPM implementation. The analysis focuses on systematic identification of barriers encountered by Indian manufacturing industries in their attempt to implement TPM practices and devises success factors towards amplifying manufacturing performance in Indian industries through optimal strategic TPM initiatives to confront exponential global challenges. The paper divulges that TPM implementation is by no means an easy task, which is heavily hampered by behavioural, organisational, cultural, technological, departmental, operational and financial obstacles.

Index Terms— Critical success factors, Indian manufacturing organizations, Total productive maintenance, TPM implementation, Manufacturing performance.

1 INTRODUCTION

GLOBALISATION and economic turbulence is the hallmark of contemporary business environment. The manufacturing sector over the past three decades has experienced an unprecedented degree of change embracing radical changes in management approaches, product and process technologies, customer expectancies, supplier attitudes as well as competitive behaviour [1]. The dynamic business environment turns out to be highly exigent and manufacturing industries are finding it acutely difficult to endure the competition and customer expectations. The global marketplace has witnessed an exponential upsurge in pressure from consumers and competitors for increased value from their purchase in terms of quality, faster delivery, and lower cost not only in manufacturing but also in the service sector [2], [3]. At present, manufacturing organisations compete on various factors such as technology, time, cost, quality, reliability, innovation, and knowledge management. There is a colossal emphasis upon manufacturing organisations to adapt Total Quality Management (TQM), lean and six sigma principles, and business process improvement strategies for achieving remarkable results in quality, cost, and delivery by focusing on process performance [4]. Rapidly changing requisites of novel manufacturing and aggrandising global competition has stressed upon the review of the aspect of a maintenance management system towards enhancing organisational competitiveness [5].

Manufacturing organisations perceived and approbated that the equipment maintenance and its reliability are important strategies that can significantly influence the organisation's dexterity to compete efficiently [6]. The maintenance processes can be streamlined to eliminate wastes thereby resulting an upswing of performance in areas valued by customers [7]. This has stimulated the manufacturing organisations to adapt Total Productive Maintenance (TPM) as a substantial process improvement and problem solving methodology for enhancing the organisation's responsiveness to satiate customer needs and influencing cost optimisation as part of management strategy to increase the market share and maximize profit. TPM has been acknowledged as the most propitious strategy for improving maintenance performance in order to succeed in an exceedingly demanding market arena [8]. The TPM implementation that has emerged as an operational strategy renders organisations with a guide to fundamentally transform their shop floor by integrating processes, culture, and technology [9].

2 TOTAL PRODUCTIVE MAINTENANCE

Operations management is perhaps the prime producer of three letter acronyms and over the past few decades, several philosophies have emerged. In these times of irrepressible competition and the trend towards an unstipulated commerce on a global scale, academics and practitioners are in perpetual search for concepts and means that could offer organisations a persistent enhancement of performance in terms of productivity, quality, cost and delivery [10]. One such proactive strategy is Total Productive Maintenance (TPM). It is a production-driven improvement methodology that is contrived to optimise equipment reliability and ensure effectual management of plant assets using employee involvement and empowerment, by linking manufacturing, maintenance and engineering functions [11]. TPM initiatives are aimed at addressing major losses and wastes associated with the production systems by virtue of continuous and systematic evaluations, thereby resulting in substantial improvements in the production facilities [12], [13], [14]. Ahuja and Khamba [1] states that TPM implementation can considerably contribute towards improvement in organisational behaviour in the manufacturing business-transcending world class competitiveness. The key objective of an effective TPM initiative is to bring critical maintenance skilled trades and production workers together [15], together with its three ultimate goals: zero breakdowns, zero

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defects and zero accidents [16], [17].

The manufacturing organisations in their quest of beating the global competition in demand-driven environments are progressively adapting strategies like Total Quality Management (TQM) and TPM to achieve accelerated, focused, and sustainable results. The key focus of TQM is on employee empowerment for improving product quality, which aptly complements TPM that equivalently focuses on employee empowerment for enhancing production system availability, reliability, and capacity. TPM is an innovative approach to plant maintenance that is concomitant and works synergistically with TQM, just-in-time manufacturing (JIT), continuous performance improvement (CPI), Total Employee Involvement (TEI) and other world-class manufacturing strategies [18], [19], [20]. Willmott [16] reports that TPM aims to actively encourage a culture in which operators develop "ownership" of their machines, learn more about them, and collaterally develop problem solving and diagnostic skills.

With equipment availability, utilisation and reliability becoming critical issues in capital-intensive operations, TPM evolves to be strategically imperative in such businesses. The inception of TPM is destined to actualise collaboration between production and maintenance functions by an amalgamation of teamworking, continuous improvement, and good working practices [21].

The philosophy of TPM shifts the paradigm of an organisation's conventional maintenance system from being reactive to being more proactive by maintaining the equipment in optimum condition at all times. TPM methodology embraces an array of techniques that assures each piece of equipment in a production process is always able to perform its required task. It also articulates all other maintenance and reliability processes and methodologies together for a new business strategy that focuses on results and changes the work culture along the line. TPM promotes the participation of all employees to improve production equipment's availability, performance, quality, safety, and reliability. TPM is a long-term programme that strives to tap the "hidden capacity" of unreliable and inefficient equipment. It capitalises on proactive and progressive maintenance strategies and calls for the knowledge and collaboration of operators, maintenance technicians, equipment suppliers, engineering, and support personnel to optimize equipment performance, thereby resulting in elimination of breakdowns, reduction of unscheduled and scheduled downtime, improved utilization hence productivity and enhanced product quality. The bottom-line accomplishment of a successful TPM implementation in an organisation embodies lower operational costs, prolonged equipment life span and lower overall maintenance expenditure [22].

2.1 Hurdles to TPM implementation: *A review*

Literature states that TPM implementation is not an effortless task by any means. The failure of TPM implementation is primarily due to the lack of a support system to facilitate learning and transform the same into effective TPM practices followed by its diffusion. Many organisations that attempted to implement TPM initiatives experienced difficulties and are unable to gain the anticipated benefits. The failure of an organisation to successfully implement TPM philosophy has been attributed to various barriers including lack of management commitment and understanding, lack of adequate training, failure to allow adequate time for its evolution [23]. Some of the conspicuous hurdles in TPM implementation includes partial implementation of TPM, inordinate expectations, lack of a systematic approach for achieving the objectives of implementation, cultural resistance to change, inadequate training and education, lack of organisational communication, and implementation to conform to societal norms rather than for its instrumentality to achieve world class manufacturing [24].

A further cogent influencing factor for failure of TPM implementation program is the organisation's ineffectualness to obviate resistance to change. There are different dimensions of resistance to change such as, individual's reluctance to change roles [5], [21], inability to change organisational roles and culture [25], [26] and inability to create dissatisfaction with the current situation [27], [28]. Bamber et al. [29] has carried out a study intended to reveal the factors affecting the successful implementation of TPM in UK small-to-medium size enterprises (SME). Davis [30] has epitomised a range of reasons for the failure of TPM within UK manufacturing organisations including lack of top management support and commitment, use of inexperienced consultants, failure to implement change on the shop floor, inadequate training and education for employees, lack of structured approach to support TPM initiatives and lack of employee involvement. According to Cooke [21], the failure of TPM implementation program is prominently due to the inability of management to holistically implement the TPM practices at the workplace. He also emphasise that considerable deviations have been observed between the official TPM policies and the actual practices deployed at workplace. McAdam and Duffner [31] have outlined that copious issues arise while trying to implement TPM in a union environment. Workers perceive that the TPM mainly strives to improve production efficiency, reduce labour, and increase employee workload. Some operators are not keen for additional responsibilities and are satisfied with the current situation. Furthermore, the skilled trades like maintenance technicians enjoy feeling indispensable and believe that the autonomous maintenance approach is posing a threat to their jobs.

2.2 Success factors for TPM implementation: *A review*

Several generic success criteria for TPM implementation is presented in the TPM literature. For an organisation to realise the true potential of TPM philosophy and ensure successful TPM implementation, the goals and objectives of TPM need to be integrated into its overall business strategy because TPM influences the whole organisation, not just production. Lycke and Akersten [32] have recommended that cautious, thorough planning and preparation are indispensable for a successful company-wide TPM implementation and so is top management's belief and understanding in the philosophy. For TPM to be successful, the improvement processes need to be re-

marked as availing not only to the organisation but also to the employees [33]. Groote [34] suggests an approach to evaluate maintenance performance based on quality audit and quantifiable maintenance performance indicators. He proposes that the effectiveness of maintenance functions ought to be defined through relative economic and technical ratios, to allow the management to track the evolution of its performance and to make crucial decisions for improved maintenance management. Bohoris et al. [35] enunciates, significance of inducing a change in the management structure, managing synergy between production and maintenance functions, concentrating on continuous production system improvements, use of efficient computerised maintenance management system (CMMS) and gradual TPM implementation as a pilot project on a few machines at a prescribed time acts as catalysts for successful TPM implementation. A typical TPM development program should emphasise the need for top management's initiative in launching and implementing TPM, formulation of TPM policies, goals and concepts and its effective communication within the organisation and frame a system for training and employee involvement [36]. Building of teams, inducing synergy, recognising them and enabling them to display their efforts supports TPM's success [37]. Top management's support and commitment in fortifying a suitable environment for the introduction of TPM in conjunction with its planning and co-ordination is regarded as a key success factor. Hansson et al. [38] have emphasised upon effective management of organisational change in pursuance of an improved organisation's performance for strategic survival in the competitive environment.

Blanchard [39] proposes a provision of suitable training to the employees at an early phase of TPM implementation in order to obtain shop floor's buy in. Hence, the whole of shop floor should receive a comprehensive suite of new skills, new knowledge and new abilities apropos to TPM even before the pilot implementation program embarks. Davis [30] strongly suggested to approach TPM realistically and to establish a practical and comprehensive training programme for all employees. Furthermore, he proposes to accept that the TPM programme will take a long time to be diffused across the organisation. Davis [30] stated that the success factors for TPM implementation include refinement of maintenance systems and culture, and developing a network of TPM coordinators thereby promoting and supporting TPM activities. Developing impeccable performance measures, continuous monitoring of its progress and frequent publishing of the benefits in terms of financial gains caused by TPM fosters the success and sustainability of TPM implementation. The TPM methodology also accentuates the importance of conducting audits and benchmarking activities that cater cardinal measures for invigorating maintenance productivity to achieve world-class competitiveness [40]. Nevertheless, there has not been any reference to the challenges faced, lessons learnt and strategies for overcoming impediments to successful implementation of TPM from an Indian industrial frame of reference. Along these lines, the present study assumes significance as it emphasises upon formulation of critical success factors to overcome the barriers to implement TPM in Indian manufacturing organisations.

3 Challenges in implementating TPM in Indian manufacturing organisations

Organisations across the world have faced stern cut-throat competition in the past three decades and the Indian manufacturing sector too could not elude the clench of globalisation. Indian manufacturing is slowly but surely breezing back in the national economic space. In recent times, the Indian manufacturing industry witnessed irrepressible competition, primarily due to the ingression of multi-national companies in the wake of liberalisation.

The Indian manufacturing sector is in need of competitive manufacturing and maintenance strategies to bridge the productivity gap in order to accomplish the vision of contributing 25% to the Nation's GDP by 2022 against the contribution of 16% in 2011 [41]. Indian manufacturing sector has interconnections with the all other sectors of the Nation's economy. The progress of manufacturing still sets the timbre for the overall business cycle and the health of this sector is very much at the core of India's socio-economic fabric. The economic benefits of playing the manufacturing card are quite apparent - if India is to sustain overall GDP growth of 8% per annum, it is essential that both manufacturing and services grow at more than 11% per annum [42].

Due to the opening up of the Indian economy from barely a regulated economy, the Nation's manufacturing sector encountered an arduous task of competing in the global marketplace. The vehement competition witnessed emulation in terms of low costs, improved quality and high product performance [43]. Furthermore, shorter lead times, condensed product development times and reduction of inventory resulted in growing demands on organisations' readiness and versatility. Conventionally, Indian industries experienced innate paucities such as poor responses to changing market scenarios, impoverished quality, low productivity, low knowledge and skill base of employees, poor cost effectiveness of production and maintenance systems, tenacious organisational character and structure, dubious policy regimes, elevated customer complaints, high internal taxes, high utility rates, less automation in production and uplifted wastages associated with production systems [22]. The Indian manufacturing sector is faced with the challenge of embracing cost effective manufacturing strategies to survive in the competitive environment. Consequently, the implementation of TPM philosophy is recognised as one of the key factors to improve organisational efficiency and in turn, productivity thereby enabling the Nation's manufacturing sector to become more attractive for foreign direct investment (FDI). In the course of implementing TPM initiatives, the Indian manufacturing industries have frequently been plagued with teething problems and challenges like reluctance to change, adversity in understanding business economics, failure to achieve equivalent benefits as developed countries by emulating the TPM implementation methodology adopted overseas.

Over the past decade, it has been exigent that the Indian manufacturing industries have to shed the lethargic ethos and progress uncompromisingly to unfold and adapt proactive strategies to overcome the innate paucities in manufacturing and maintenance systems for harnessing distinctive competencies when compared to their global competitors. The sector's journey in implementing and sustaining TPM is evident from the increasing number of TPM awards won by Indian manufacturing industries, which is depicted in Fig. 1.

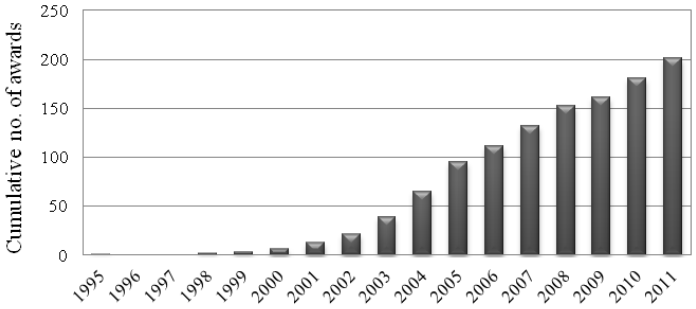

Fig. 1. Cumulative number of TPM awards (JIPM) won by Indian manufacturing industries

Hitherto, 144 companies in India have won cumulatively 201 TPM awards from Japan Institute of Plant Maintenance (JIPM). Hence, India ranks next to Japan in the world on the number of TPM awards won by one country [44]. The present study critically analyses the factors influencing TPM implementation in Indian manufacturing organisations thereby formulating a comprehensive strategy for overcoming obstacles to successful TPM implementation. Despite the existence of various paradigms of TPM implementation, most of them are undergoing failures and hence this study is pertinent to these circumstances.

4 Research Methodology

An empirical research has been carried out in the medium and large-scale manufacturing industries in India, which aggregates the information from organisations that have successfully implemented TPM and that are in the process of implementing the TPM methodology, to analyse the challenges faced during implementation including lessons learnt and benefits accomplished as a result of TPM implementation. The study is conducted mainly at plant level and an extensive survey has been carried out in a reasonably large number of manufacturing organisations (62 organisations) in India to determine the challenges faced by Indian manufacturing organisations during TPM implementation. A mixture of qualitative and quantitative analysis has been used for the study, which comprises of questionnaire survey, detailed interviews, observation from past experiences and informal conversation. These multiple methods or "methodological triangulation" [45], are used in order to strengthen the internal validity of the data collected. It is germane to remark that the organisations surveyed have two years of experience in the implementation of TPM methodology. Accordingly, 62 responses to the TPM questionnaire can be perceived as a representative sample of the Indian manufacturing sector. A detailed TPM questionnaire has been designed in pursuance of appraising the crucial barriers that hampers successful TPM implementation in Indian manufacturing organisations and unfolding critical success factors contributing to successful TPM implementation. For efficiently conducting the survey, the questionnaire has been designed using comprehensive literature review [46], [47], [48], [49], [50], [12] and validated by TPM practitioners (TPM co-ordinators and managers) from Indian manufacturing industries. The questionnaires were sent by Email to the chosen organisations and were subsequently contacted via telephone to explain the context of the research work and to clarify any doubts to expedite responsiveness to the questionnaire. In addition to the questionnaire, detailed telephonic interviews were also conducted in the selected organisations. The respondents of the questionnaire and to the interviews encompass a widespread of employees representing various levels of hierarchy within the organisation. It includes vice presidents, head of operations management, general managers, TPM co-ordinators, TPM managers, maintenance managers, maintenance technicians, production supervisors, production engineers and production operators. The questionnaire harnessed information that was not captured in the interviews; however, in general, the findings from the survey are consistent with the qualitative data obtained from the interviews. The responses both from the questionnaire and from the interviews were consolidated and analysed critically to determine the obstacles to TPM implementation and revealing the critical success factors for successful TPM implementation.

5 Barriers to Implement TPM in Indian Manufacturing Organisations

Many literatures highlight that industries by adapting the TPM philosophy are reaping its rewards and experiencing remarkable productivity increase, reduction in operational and maintenance costs and a major decrease in losses due to defects and equipment breakdowns. In contrast, several organisations that initiated a TPM journey had miserably failed thereby inflicting to relinquish the process completely. The review of literature has exposed that the human and maintenance related factors have commonly been treated as evaded areas in conventional Indian manufacturing organisations. Traditionally, the maintenance function has been considered as a low profile job with its scope limited to reactive and preventative maintenance [51] and has been perceived as an irrepressible black box in the operation and evolution of manufacturing systems. Antecedently, as a result of a regulated economy, the top management of Indian manufacturing organisations overlooked not only the equipment related losses, deterioration and failures but also the significance of maintenance performance enrichment in gaining the competitive edge. Formerly, a lethargic approach was prevailing in Indian industries towards organisational performance enhancement through strategic maintenance initiatives. Consequently, a sluggish industrial growth was attributed and Indian entre-

preneurs have found it acutely arduous to compete in the vibrant global environment. Nevertheless, in recent times, Indian industrialists started to appreciate and comprehend the true contribution of maintenance function towards the enhancement of organisational performance. As a result, since early 1990s, considerable number of maintenance initiatives has been implemented in Indian manufacturing organisations owing to the burgeoning competition primarily due to cost competitiveness, lean manufacturing, rapid product development, ingression of multi-national corporations and increased quality apprehension. For more than a decade, India has predicated its relentless perseverance to achieve the competence thereby enabling them to be an integral player in the competitive global marketplace [52]. TPM philosophy has gained extensive recognition within the Indian manufacturing sector as a prime mover for enhancing organisational competitiveness [53]. Having understood the benefits of TPM philosophy, investment on TPM initiatives to enhance competitiveness of manufacturing industries became imperative to Indian entrepreneurs. In the past one and half decades, top Indian industrialists have taken a proactive stride to incorporate state-of-art maintenance enrichment initiatives in their organisations in order to improve organisational performance [54].

In the pursuit of accomplishing manufacturing excellence by virtue of maintenance improvement initiatives, most of the leading manufacturing organisations in India have made sincere efforts to embrace proactive TPM implementation initiatives since late 1990s. Nevertheless, as a result of submissive organisational attitudes and colonial roots of the manufacturing environment, these organisations have encountered a substantial number of obstacles in implementing TPM methodology. A methodical identification of these obstacles can serve as a platform to foster organisations to develop and establish an extensive TPM implementation program that successfully overcome the barriers for TPM implementation in Indian manufacturing organisations. This study reveals the obstacles faced by Indian manufacturing industries whilst their attempt to implement TPM initiatives. The responses of the questionnaire survey, detailed interviews and informal conversation have been analysed to determine the barriers hampering effective TPM implementation. These obstacles have been broadly categorised as behavioural, organisational, cultural, technological, departmental, operational and financial barriers [22].

5.1 Behavioural barriers:

- Lack of motivation to enhance organisational performance.
- Reluctance to change owing to job insecurity and a premonition of loss of specialisation due to technological advancements.
- Resistance from employees to accept and adapt to novel concepts and changes.
- Intermittent problems towards the success of Cross Functional Teams (CFT).
- Lack of multi-skill development and periodic evaluation and upgrade of employees' skills.

5.2 Organisational barriers:

- Lack of top management commitment and inadequate communication.
- Lack of a systematic approach to record, monitor and evaluate key performance indicators such as overall equipment effectiveness (OEE), return on capital employed (ROCE) and return on net assets (RONA).
- Inability to drive and manage cultural transformation and attain total employee involvement.
- Lack of reward and incentive system in the organisation.
- Inability of management to persuade tenacious unions about the benefits of TPM.
- Lack of awareness and understanding of TPM concepts and principles.
- Failure to develop the competencies of employees to foster TPM maturity.
- Feebleness of top management to implement a change management program.

5.3 Cultural barriers:

- Lack of top management's ability to motivate employees towards developing new skills.
- Powerful unions, stern mindsets, inflexible modus operandi and resistive attitudes on existing set-up within the organisation.
- Inefficacy in aligning employees to organisational goals and objectives.
- Ambiguity in roles and responsibilities of the employees and its benefits to the individuals.
- Minimal employee involvement in decision making processes.
- Attitude of accepting cost of poor quality (COPQ), for instance, considering rework as an element of a typical production process.
- Lack of consistency, poor quality consciousness and resistance to change conjointly resulting in lack of professionalism in enabling cultural transformation.

5.4 Technological barriers:

- Lack of computerised maintenance management system (CMMS).
- Fewer accents towards improvement of production capabilities beyond the design competence.
- Lack of infrastructure for preventative maintenance.
- Lack of impetus to evaluate and develop the reliability of the production system.
- Inadequate cognizance of the effect of organisational inefficiencies.
- Insufficient workforce training against the pace of technological advancements
- Inadequate training on quality improvement methodologies, and problem solving and diagnostic techniques
- Longer changeover and set-up times leading to a poor flexibility of production systems.

5.5 Departmental barriers:

- Presence of a strong demarcation between the responsibilities of production and maintenance departments.

- Less synergy and coordination between production and maintenance departments.
- Lack of trust by maintenance personnel in the production operators' competence to perform autonomous maintenance activities.
- Unwillingness of production operators to buy-in to the concept of autonomous maintenance.

5.6 Operational barriers:

- Resistance from shop floor workforce to perform autonomous maintenance activities.
- High emphasis on restoration of the equipment rather than failure prevention.
- Lack of standardisation, for example the use of standard operating procedures etc.
- General attitude of accepting high level of defects associated with the production systems.
- Lack of structured procedures and documentation for planned maintenance activities.
- Lack of employee empowerment; poor employee involvement in equipment and improvement related decision-making processes.
- Limited 5S implementation resulting in a discouraging work environment.
- Increasing workload in production thereby resulting in less or no focus in TPM activities.
- Restraining or transferring operator's responsibilities of performing autonomous maintenance tasks in comparison to the initial phases of TPM implementation, creates a negative impact on operator's professional development thereby resulting in dissatisfaction.
- Greater focus on accomplishing daily production targets, consequently lacking time and resources for process improvements.
- Non structured and unplanned TPM implementation approach.
- KPIs are formulated solely to satisfy the internal and external audit processes.

5.7 Financial barriers:

- No investment allocation for TPM activities.
- Inability of management to support TPM initiatives due to financial crisis as the implementation process requires considerable number of dedicated resources.
- Lack of suitable incentive and reward system.
- Initial phase of TPM implementation requires considerable proportion of additional resources.

6 Critical success factors for successful TPM implementation

Over the past decade, Indian entrepreneurs recognised the strategic implications of maintenance management to improve organisational competitiveness [51]. In the current context, Indian manufacturing industries embarked to contemplate the efficacy of maintenance initiatives in enhancing the reliability and cost effectiveness of production systems, thereby facilitating manufacturing organisations to acquire competencies for mitigating the challenges in the global marketplace. In recent times, the contribution of effective maintenance towards efficient manufacturing has received a greater attention.

Davis and Willmott [55] have suggested that a systematic approach with effective tools and techniques, and a philosophy that empowers and motivates the workforce are the two key factors enabling successful TPM implementation in industries. A basic framework has been outlined representing the factors affecting a successful TPM implementation in small-to-medium size enterprises (SME) within the UK manufacturing sector which embodies employee involvement, a systematic plan for TPM implementation, alignment of goals and objectives, management commitment, performance measurement and its review and motivation of management and employees [29]. From observation, the primary factors for successful implementation of TPM in UK manufacturing includes developing a systematic and realistic implementation plan, acknowledging the fact that TPM implementation and its diffusion across the organisation is a prolonged process, workforce motivation, establishing a network of TPM coordinators, top management support and commitment, cater with time and resources for implementation process, establishing performance indicators and constantly monitoring and reviewing the results [30].

Indian manufacturing industries have experienced a tenacious resistance from within and have suffered as a result of inappropriate maintenance improvement strategies, lack of workforce competency, poor work atmosphere and scarce resources to support TPM implementation. Conspicuously, it can be witnessed that Indian manufacturing organisations are yearning to adapt a germane approach to overcome the barriers detailed in the previous section to reap the true benefits of TPM philosophy. Therefore, it is indispensible for the Indian manufacturing organisations to foster proactive strategies for indigenous implementation of TPM methodology pertaining to the Indian cultural framework. Establishing and holistically adapting critical success factors are exigent for Indian manufacturing organisations to enable successful implementation of TPM. The critical success factors for a successful TPM implementation in Indian manufacturing organisations can be classified into two major categories:

Human-oriented factors:

- Top management commitment
- Total employee involvement
- Cultural transformation

Process-oriented factors:

- Conventional and proactive maintenance strategies
- Training and education
- Failure prevention and focused production system enhancement

Human-oriented factors play a vital role in formulating the foundation prior to TPM implementation, whereas the process-oriented factors are imperative for the subsequent phase of

achieving a successful implementation within the organisation.

6.1 Top management committment

The successful implementation of TPM necessitates top management support, commitment and its involvement. Organisation's top management is required to demonstrate a strong commitment towards TPM implementation and should endeavour to develop systems for multi-level communication to all employees expounding the significance and benefits of the entire program by linking TPM to the overall business objectives and strategy. The initial step is to establish a strategic direction for TPM implementation by formulating an apposite TPM policy and a master plan for effective TPM implementation within the organisation, followed by evolving a TPM team engaging employees from various functions and hierarchical levels of the organisation. Enabling cultural transformation, revising the business plan so as to integrate TPM goals, communicating TPM goals and objectives throughout the organisation, building substantial success stories to enhance motivation for implementing TPM, providing sufficient resources for influencing process improvements, providing appropriate training and education for the workforce to develop TPM related competencies, encouraging cross functional working within the organisation by obviating barriers linked to middle level management and enhancing inter-departmental synergy, and developing reward and incentive systems to promote proactive maintenance initiatives are the main contributions by the top management towards successful TPM implementation. Hence, management commitment and involvement is vital to ensure that the TPM programme does not loose its implementation momentum by re-assuring their support to the employees.

6.2 Total employee involvement

With a view to align employees towards the goals and objectives of the organisation towards a sustainable TPM implementation process, employees at all levels in the organisation should comprehend the elemental principles and strategies of TPM. Total employee involvement is undoubtedly a prerequisite to a successful TPM implementation and can be effected by a system of employee empowerment, establishing a sense of ownership in the use of their routine operating equipment, enhancing the competencies of operators towards their function, providing an encouraging and safe working environment, sufficient workforce counselling, union buy-in, effective suggestion schemes, establishing a reward and incentive scheme to all employees, and recognition of employees' efforts that contributes to organisational performance. The most effective approach to ensure workforce buy-in is by involving the employees and obtaining their views and ideas at an early phase of the implementation programme. This will subsequently reduce the risks for the employees to renounce the programme at the later stage of its implementation. An understanding of work behaviour for augmenting group efficiency will engender better organisational designs that foster people's minds and create internal commitment. The holistic implementation of these initiatives augments total employee involvement resulting in a successful TPM implementation in an organisation.

6.3 Cultural transformation

The colossal challenge for an organisation is to accomplish a radical transformation in its culture for ascertaining total employee involvement towards manufacturing and maintenance performance enhancement through TPM implementation. The TPM implementation process requires an implementation team impelled by a change agent who is responsible for managing change within the organisation throughout the process. Traditionally, Indian manufacturing industries have been resisting any change initiative at workplace. Hence, the top management has to make concerted efforts to enhance motivation within the organisation by creating awareness about the true potential of the total productive maintenance philosophy and effectively communicating to the employees regarding the direct benefits of TPM to the workforce. Incidentally, organisations should effectuate union buy-in by involving the union representatives during the planning and execution phases of TPM implementation which as a resultant addresses most of the employees' behavioural barriers towards successful TPM implementation. It is imperative to develop consciousness through the unions that TPM implementation will generate additional skill sets and competencies thereby not only making the employees more valuable to the organisation but also develops a highly multi-skilled workplace, which in turn enhances employee job security. This approach can assist top management to effectively stimulate a successful TPM implementation program by obviating the misconceptions regarding the implementation of TPM methodology. Furthermore, various other strategic initiatives like encouraging cross-functional working, fostering the development of skill and knowledge base of all employees and establishing incentives and rewards mechanisms suitable to all employees, can also be successfully effectuated in the organisations for motivating and aligning the employees to the organisational goals and objectives to meet the global corporate challenges. Due consideration of these factors will also enhance the success rate of change programs like TPM implementation.

6.4 Conventional and proactive maintenance strategies

To facilitate a successful TPM implementation, the organisation must develop competencies for improving its conventional maintenance performance. Consequently, standard work practices and safe operating procedures need to be established and holistically implemented by a competent and motivated workforce, as majority of the failures of TPM journey can be attributed to the lack of standard operating procedures for business functions including production systems. The organisations need to devise processes and procedures for collecting and analysing data associated with manufacturing performance and focus upon influencing continuous improvements in the production systems thereby enhancing manufacturing and in turn organisational performance. The manufacturing industries should emphasise to address the issues associated with the manufacturing system by focusing upon the root cause of the issues, instead of impressing upon mere rejuvena-

tion. Furthermore, the manufacturing organisations have to make strenuous efforts to implement state-of-art maintenance enhancement programmes such as predictive maintenance and computerised maintenance management systems to boost up the manufacturing performance through modern proactive maintenance improvement strategies. The organisations finally need to manifest the true potential of TPM by promulgating and communicating the TPM policies and the master plan, developing a dedicated organisational structure for implementing TPM, and focusing on a pilot TPM implementation on critical model machines thereby creating an environment of acceptability towards the philosophy of TPM followed by its horizontal deployment throughout the organisation. In order to reap the impeccable benefits of TPM, organisations need to holistically implement autonomous maintenance and planned maintenance activities, quality maintenance initiatives, methodologies to improve efficiency of support and administrative functions, an early equipment management program, and technical training in equipment operation and maintenance.

6.5 Training and education

The organisation's success in fully achieving the benefits of TPM through effective implementation of conventional and proactive maintenance strategies is decisively reliant upon the competencies of the workforce. Hence, pertinent training and education for employees at all levels within the organisation should be conceded as a key success factor for successful implementation of TPM. The objectives of the training must encompass systematic development of competencies, knowledge and mindset essential for an employee to execute provided tasks. This resultantly enables improved productivity and accomplishes highest standards of quality, reduction in idle working hours, equipment failures and accidents, upsurge in the number of improvements (kaizens), to establish multi-skilled work force, and to generate a sense of pride and belonging amongst all employees within the organisation. Besides providing training to foster technical competencies, the organisations need to endow the workforce with quality improvement and behavioural training to transform the mindset of employees from "I operate, you inspect, you maintain" to "I operate, I inspect, I maintain". In this regard, it is management's responsibility to identify training needs, set targets for training, develop training packages, and ensure effective execution of the training program followed by an evaluation process to cognise its effectiveness.

6.6 Failure prevention and focused production system enhancement

Manufacturing organisations should make intensive efforts to improve the performance of production systems by accentuating on failure prevention initiatives and enhancing the focus on manufacturing system improvements. This can be effectuated by fostering production associated competencies, by actualising feedback from customer and other departments, focusing upon transforming lessons learnt from existing equipments to the future systems, improving safety at workplace, integrating design-oriented improvements, linking TPM with other performance improvement initiatives, and improving workplace organisation by implementing 5S principles.

Seamless information flow is another factor that enables exemplary performance of any change program. Information can influence people's behaviour when a programme like TPM disseminating the espoused strategy and emphasising balanced assessment is in place.

Additionally, the consistency of the critical success factors in accomplishing successful TPM implementation can be assessed by the use of key performance indicators (KPIs) which helps to evaluate manufacturing performance. KPIs are used extensively within organisations to measure distinct parameters across various categories of metrics. They are cardinal to establish objectives, evaluate performance and fortify positive behaviours. The manufacturing organisations should develop and accordingly deploy elemental KPIs in order to evaluate the success of TPM implementation process. By comparing the maintenance performance levels of pre-implementation (TPM) and post-implementation (TPM) phases, the business can evaluate the strategic impact of implementing TPM within the organisation. The results and benefits of the TPM implementation programme needs to be astutely analysed and shared with the employees in order to elevate employee satisfaction and motivation, and to ensure employee participation and organisation contributions in the future as well.

Holistic adaptation of the postulated critical success factors is strongly believed to obviate adverse effects of the barriers to TPM implementation. This can strategically impel organisations to develop competencies to achieve sustainable world-class competitiveness. A meticulous review of the critical success factors for successful TPM implementation offer managerial insights into the path for achieving business excellence through eminence in TPM and maintenance management.

7 Conclusion

TPM is not a quick solution. It necessitates a change in both the company's and employee's attitude, and their values, which takes time to bring about. Hence, it entails long-term planning. Rapid and organisation wide benefits should not be stressed during the initial phases of implementation. A full-scale TPM implementation across the organisation will be short-lived if it is not done ensuing culture change. In order to restrain ambivalence and elevate the chances of success during the initial phase, small-scale pilot TPM projects need to be administered where rapid and visible gains are likely. The organisations can then use the experience gained from these pilot projects to fine tune the subsequent full-scale implementation. The study has revealed the fact that formerly Indian manufacturing organisations have to a certain extent, struggled while endeavouring to implement TPM initiatives, in view of the fact that it requires to effectuate considerable cultural transformations within the organisation to enable a mindset refinement amongst employees. The research has critically evaluated various barriers and challenges that influence the successful implementation of TPM in Indian manu-

facturing industries. The obstacles experienced by the organisations have been broadly categorised as behavioural, organisational, cultural, technological, departmental, operational and financial barriers. The problems associated with these barriers have been critically analysed to excogitate human-oriented and process-oriented critical success factors for successful TPM implementation in Indian manufacturing organisations.

Furthermore, it has been unfolded by the analysis that successful implementation of TPM initiatives can be rationally actualised in Indian manufacturing industries through a radical culture change and a zealous commitment by the top management. To successfully implement and sustain TPM practices, Indian manufacturing organisations must be predisposed to nurture an atmosphere that is willing to fortify the TPM philosophy and its resultant workplace changes. The contribution of top management is found to be one of the highly decisive factors for successful TPM implementation. Hence successful managers must know how to utilise TPM initiatives in varying circumstances to promote employee involvement in every stage of the production and maintenance processes, thereby to optimise process flow, improve product quality and minimise operating and maintenance costs. It is a futile attempt to try to re-invent the TPM implementation methodology. The key is to learn from organisations that succeeded in implementing TPM philosophy and consequently follow (and adapt when essential) the established and proven TPM implementation approach to ensure successful transformation. It can be perceived from the research that it is indispensable for flourishing manufacturing organisations to incorporate proactive maintenance strategies into their manufacturing scheme to effectively enhance manufacturing and maintenance performance, improve plant profitability, ensure better utilisation of resources, and reduce unnecessary downtime thus enhancing organisational competitiveness. Implementation of a successful TPM programme is a vast challenge, but the huge potential pay-off will justify the effort.

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