A case study of total productive maintenance implementation at precision tube mills

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Abstract

Purpose – The purpose of this paper is to investigate the contributions of successful total productive maintenance (TPM) initiatives to competitive manufacturing. It also seeks to critically examine the implications of strategic TPM implementation initiatives in an Indian manufacturing organisation.

Design/methodology/approach – The study is carried out at a precision tube mill that has successfully implemented TPM and has reaped significant benefits as a result of TPM implementation, to study the TPM implementation issues and achievements realised as a result of strategic TPM implementation. The approach is directed towards the justification of TPM implementation for its support to competitive manufacturing in Indian industries.

Findings – The study reveals the exploits of Indian entrepreneurs with TPM practices and highlights the contributions of TPM in realising the overall organisational goals and objectives. The study reveals that strategic TPM initiatives can significantly contribute towards the improvement of manufacturing performance in the organisation, leading to the realisation of core competencies for meeting global challenges.

Research limitations/implications – The study is conducted to develop an understanding of contributions of TPM initiatives towards building manufacturing competencies in Indian manufacturing industry. The present study endeavours to investigate the effect of an aggressive TPM implementation plan for strategically meeting global challenges and competition.

Practical implications – The study highlights the contributions of strategic TPM initiatives to organisational performance and highlights the need for the successful management of TPM programmes for establishing sustained maintenance improvement initiatives.

Originality/value – The study highlights the contributions made by holistic TPM implementation at a precision tube mills in an Indian manufacturing enterprise.

Keywords Productive maintenance, Manufacturing systems, Industrial performance, Competitive advantage, India

Paper type Case study

Introduction

Recent competitive trends have prompted top management of manufacturing enterprises to look at the performance of each and every business function, including manufacturing or maintenance, for achieving competitive advantage (Ben-Daya and Duffuaa, 1995; Pintelon et al., 2006). With increased global competition, attention has been shifted from increasing efficiency by means of economies of scale and internal specialisation to meeting market conditions in terms of flexibility, delivery performance and quality
(Yamashina, 1995; Karuppuswamy et al., 2007). In today’s dynamic environment, a reliable production system must be seen as a critical factor for competitiveness (Brah and Chong, 2004). Poor organisational competencies in managing the maintenance function effectively can severely affect competitiveness by reducing throughput, increasing inventory, and leading to poor due-date performance (Patterson et al., 1996, Ashayeri, 2007). The traditional misconception about maintenance being viewed as an operational expense to be minimised and not as an investment in increased process reliability has to be done away with in realising manufacturing performance excellence. Equipment technology and development capabilities have become major factors that demonstrate the strength of an organisation and set it apart from others (Schuman and Brent, 2005; Braglia et al., 2006). Maintenance has now become a strategic tool to increase competitiveness rather than simply an overhead expense that must be controlled (Waeyenbergh and Pintelon, 2007). Investment in maintenance, one of the basic functions of a firm, returns improved quality, safety, dependability, flexibility and lead times (Teresko, 1992). Over the past decade there has been increased recognition that in world-class manufacturing (WCM), maintenance is not a separate, isolated function that makes repairs and performs assorted activities as needed. Rather, maintenance is a full partner, striving together with the other functions to achieve the firm’s strategic goals (Etienne-Hamilton, 1994). Thus, maintenance has become a strategic issue for manufacturers across the world. Ever-increasing business pressures have been putting the maintenance function under the spotlight as never before (Garg and Deshmukh, 2006).

Modern manufacturing requires that organisations that wish to be successful and to achieve world-class manufacturing must possess both effective and efficient maintenance. One approach to improve the performance of maintenance activities is to implement a total productive maintenance (TPM) system. TPM is considered to be an effective strategic improvement initiative for improving quality in maintenance engineering activities (Ollila and Malmipuro, 1999; Pramod et al., 2007). TPM is all of the strategies needed to sustain a healthy maintenance log (Steinbacher and Steinbacher, 1993). TPM is the general movement on the part of businesses to try to do more with less (Lawrence, 1999). TPM has been widely recognised as a strategic weapon for improving manufacturing performance by enhancing the effectiveness of production facilities (Dwyer, 1999; Dossenbach, 2006). TPM represents a shift in the way progressive world-class companies think about maintenance. It is a radical departure from the traditional view of breakdown maintenance. TPM is a methodology and philosophy of strategic equipment management focused on the goal of building product quality by maximising equipment effectiveness. Originally introduced as a set of practices and methodologies focused on manufacturing equipment performance improvement, TPM has matured into a comprehensive equipment-centric effort to optimise manufacturing productivity. It embraces the concept of continuous improvement and total participation by all employees and by all departments (Society of Manufacturing Engineers, 1995). The ultimate goal of TPM is to implement “perfect manufacturing” (Shirose, 1992).

**Total productive maintenance**

TPM is a maintenance program that involves a newly defined concept for maintaining plants and equipment. TPM had its genesis in the Japanese car industry in the 1970s. It evolved at Nippondenso, a major supplier of the Toyota Car Company, as a necessary
element of the newly developed Toyota Production System. The origin of TPM can be traced back to 1951, when preventive maintenance was introduced in Japan. TPM brings maintenance into focus as a necessary and vitally important part of the business. TPM is a innovative Japanese concept. TPM initiatives help in streamlining the manufacturing and other business functions and in garnering sustained profits (Ahuja and Khamba, 2007). TPM is an operations improvement process (machine efficiency and reliability) involving all affected employees with a view to getting as close to zero breakdowns and zero defects as possible. TPM is a production-driven improvement methodology that is designed to optimise equipment reliability and ensure the efficient management of plant assets (Robinson and Ginder, 1995). TPM provides a comprehensive, life-cycle approach to equipment management that minimises equipment failures, production defects, and accidents. It involves everyone in the organisation, from top-level management to production mechanics, and production support groups to outside suppliers (Ahuja and Khamba, 2008a). It encompasses all departments including maintenance, operations, facilities, design engineering, project engineering, construction engineering, inventory and stores, purchasing, accounting and finance, and plant and site management (Wireman, 1990). Total productive maintenance is based on teamwork and provides a method for the achievement of world-class levels of overall equipment effectiveness through people and not through technology or systems alone (Willmott, 1994). TPM is intended to bring both functions (production and maintenance) together by a combination of good working practices, team working, and continuous improvement (Cooke, 2000).

TPM is a structured equipment-centric continuous improvement process that strives to optimise production effectiveness by identifying and eliminating equipment and production efficiency losses throughout the production system life-cycle through active team-based participation of employees across all levels of the operational hierarchy. The goal of the TPM program is to markedly increase production while at the same time increasing employee morale and job satisfaction. TPM has emerged as a potent means to improve overall company performance. Strategic TPM programs have demonstrated a major impact on bottom-line results, along with substantially improving capacity while significantly reducing not only maintenance costs but also overall operational costs. Successful implementation of TPM programs has resulted in the creation of much safer and more environmentally sound workplaces. Another strategic outcome of TPM implementations is the reduced occurrence of unexpected machine breakdowns that disrupt production and lead to losses, which can exceed millions of dollars annually (Gosavi, 2006). TPM employs OEE as the core quantitative metric for measuring the performance of a productive system (Shirose, 1989; Jeong and Phillips, 2001; Huang, 1991). OEE has been used as an impartial daily snapshot of the equipment and promotes openness in information sharing and a no-blame approach in handling equipment-related issues. The basic practices of TPM are often called the “pillars” or “elements” of TPM. The entire edifice of TPM is built and stands on eight pillars (Sangameshwan and Jagannathan, 2002). TPM paves the way for excellent planning, organising, monitoring and controlling practices through its unique eight-pillar methodology involving:

1. autonomous maintenance;
2. focused improvement;
3. planned maintenance;
The eight-pillar model of TPM implementation is depicted in Figure 1.

Companies practising TPM invariably achieve startling results, particularly in reducing equipment breakdowns, minimising idling and minor stops (indispensable in unmanned plants), lessening quality defects and claims, boosting productivity, trimming labour and costs, shrinking inventory, cutting accidents, and promoting employee involvement (as shown by the submission of improvement suggestions) (Suzuki, 1994). Strategic TPM implementation programs have revealed a significant realisation of manufacturing performance achievements leading to improved core competitiveness of organisations (Ahuja and Khamba, 2008a, b). TPM has tangible and measurable effects on production, quality, and profits: improving quality, reducing cost, increasing equipment uptime, cutting inventory, cutting delivery time, practising employee participation and experiencing a cleaner working environment. The actual targets of TPM are fixed more concretely in terms of productivity, quality, cost, delivery, safety and morale (PQCDSM) (Tajiri and Gotoh, 1992). Total workforce engagement using TPM methods is a very valuable way to reduce loss and improve

Figure 1.
Eight-pillar approach for TPM implementation

Note: Approach suggested by the Japan Institute of Plant Maintenance
profits (Gardner, 2000). Moreover, successful TPM implementation leads to significant intangible benefits such as continuous improvement of workforce skills and knowledge, fostering employee motivation through adequate empowerment, clarification of roles and responsibilities for employees, a system for continuously maintaining and controlling equipment, enhanced quality of work life, reduced absenteeism and enhanced communication in the workplace (Carannante, 1995). Greater job satisfaction translates into higher productivity and quality and ultimately contributes to lower manufacturing costs, since TPM envisions organisations to consider the human aspect of TPM in combination with technical and financial impacts (Hamrick, 1994).

TPM in the Indian context
As organisations across the globe have faced stiff, cut-throat competition in the last three decades, Indian industry too has not escaped the brunt of globalisation. Indian manufacturing industry has also witnessed irressible competition in recent times, predominantly in the wake of liberalisation, since the early 1990s. Intense competition has been witnessed in terms of low costs, improved quality and diverse products with superior performance (Chandra and Sastry, 1998). Moreover, shorter lead times, innovation times and reduced inventories have led to increasing demands on organisations’ preparedness, adaptability and versatility. An insight into the contemporary manufacturing scenario has revealed that maintenance and human factors have remained neglected areas for a long time in Indian manufacturing organisations (Ahuja and Khamba, 2008c). Traditionally, maintenance has been treated as a necessary evil and seen as an uncontrollable black box in operations. Maintenance efforts have usually been directed towards maintaining the basic equipment conditions of manufacturing systems, with reasonable success, and maintenance has often been a disregarded issue in manufacturing organisations. In the Indian context, maintenance has been viewed as a reactive, problem-fixing strategy and an operating expense to be minimised (Seth and Tripathi, 2005). Due to the callous attitude of Indian entrepreneurs towards maintenance in the past, they have found it extremely hard to compete effectively with their Western counterparts in the wake of the liberalisation of economy in the early 1990s.

Manufacturing organisations in India have been forced to look for proactive strategic maintenance improvement initiatives to harness their manufacturing competencies to meet global competition. Indian entrepreneurs have understood the significance of improving maintenance performance in the organisations and have realised the need to adopt effective maintenance improvement programs and initiatives that are capable of delivering improved manufacturing performance, boosting productivity, reducing costs, improving plant profitability, minimising unnecessary downtime and assuring better utilisation of resources.

With regard to TPM implementation, leading Indian manufacturing organisations have in the recent past taken a lead in breaking the shackles and have demonstrated their sincere intent to imbibe proactive maintenance improvement initiatives through TPM adaptations, with reasonable success. While implementing effective TPM programs, Indian manufacturing organisations have often been plagued with teething problems and challenges like difficulties in understanding business economics, the reluctance to imbibe changing practices, vague worker apprehensions, and the
inability to realise the same level of benefits as reaped by developed countries by imitating the TPM implementation procedures and practices adopted abroad.

Indian manufacturing organisations need to shed their sluggish character and move forward aggressively to develop and adapt proactive processes and practices to overcome the inherent deficiencies in manufacturing systems to harness their distinct competencies in comparison with their global competitors. According to the Confederation of Indian Industries (CII) – TPM Club India, nearly 350 organisations across the country have shown interest in adapting TPM programs and have initiated strategic proactive initiatives towards implementing TPM practices. It has been observed through a detailed survey that to date only approximately 120-125 organisations have shown highly satisfactory results by reaping excellent results through holistic TPM implementation. In their pursuit of TPM implementation, many Indian organisations have been honoured to receive the Award for Excellence in Consistent TPM Commitment – Second Category, the Award for Excellence in Consistent TPM Commitment – First Category, and the Award for TPM Excellence from the Japan Institute of Plant Maintenance (JIPM). Although a reasonable number of Indian entrepreneurs have experienced organisational success and transformation through TPM implementations, very few studies have been reported highlighting the achievements of Indian entrepreneurs through TPM initiatives. Thus, there is an earnest need to evaluate the contributions of TPM in the Indian manufacturing environment. The present study endeavours to investigate the effect of an aggressive TPM implementation plan for strategically meeting global challenges and competition.

Research methodology
The study was carried out in a large-scale manufacturing organisation in India that has successfully implemented TPM and has reaped significant benefits as a result of TPM implementation, to study TPM implementation issues and the achievements realised as a result of strategic TPM implementation. In this study, a precision tube mill situated in Eastern India was critically scrutinised to ascertain the contributions made by TPM initiatives in an Indian manufacturing organisation towards the realisation of manufacturing competencies. The approach was directed towards the justification of TPM implementation for its support to competitive manufacturing in Indian industries. The methodology employed in the present study is depicted in Figure 2.

To conduct the survey effectively, the exploits of the manufacturing organisation regarding strategic TPM initiatives were explored through extensive plant visits, interviews/discussions with TPM practitioners, investigation of the TPM initiatives deployed over a period of time, and close analysis of the achievements made through TPM initiatives. The study reveals the exploits of Indian entrepreneurs with TPM practices and highlights the contributions of TPM in realising overall organisational goals and objectives.

Case study
The study highlights the contributions of TPM initiatives in a manufacturing enterprise, in a developing country like India, to realising enhanced manufacturing performance. The study reveals that strategic TPM initiatives can contribute
significantly towards improvement in manufacturing performance in the organisation leading to the realisation of core competencies for meeting global challenges.

The Tata Steel Tubes Strategic Business Unit (SBU), the largest domestic manufacturer of steel tubes, was formed after the merger of the erstwhile Indian Tube Company with Tata Steel in October 1985. It has been an independent strategic business unit of Tata Steel since August 1993, headed by the Executive in Charge (Tubes). TTD has a gross turnover of Rs 557 crores (as of financial year 2003), which forms 7 per cent of Tata Steel’s turnover, and a net profit of Rs 16 crores. The Tubes SBU employs 1,676 personnel (as of 30 September 2003), and this is 5 per cent of Tata Steel’s total workforce. The SBU produces welded tubes. There are two distinct businesses:

1. the “Commercial Tubes Business”, served by the “Standard Tube Plant”; and
2. the “Precision Tube Business” served the “CR-ERW Plant”, particularly for the boiler and auto segments.

The Tubes SBU is the first tube company in the country to obtain ISO-14001 certification in environmental management systems. It has been ISO-9001 certified, which addresses in-process inspection/tests/performance audits and corrective and preventive actions to ensure product and service quality.

Precision welded tubes are manufactured by the high frequency induction welding process, which is commonly known as the ERW process for historical reasons. At present, the precision plant has two mills i.e. a three-inch mill and two-inch mill. The three-inch mill was commissioned in 1957 and produces tubes with an outside diameter (OD) ranging from 31.75 to 76.20 mm. In August 1993, a new two-inch precision tube mill facility was created; with the commissioning of this mill, precision-welded tubes of
OD as low as 15.88 mm and with thickness of 0.9 mm could be produced. Both two-inch and three-inch mills together produce tubes having outside diameters ranging from 15.88 to 76.20 mm. The precision tube mills manufacture the auto and boiler categories of tube. The mills have an annual capacity of 33,000 MT. Auto tubes are further segmented as:

- welded;
- normalised; and
- cold drawn.

Slit coils of both boiler and auto tubes are rolled in the two-inch and three-inch mills. This production capacity is sensitive to product mix as the auto and boiler category tubes pass through different product routings. Tata Tubes is ranked second in the boiler tube business, fourth in auto tubes and third in the overall precision tubes business in the domestic market. The total annual market demand for precision tubes in India is around 280,000 MT, of which the boiler and auto segments constitute 150,000 MT and 130,000 MT respectively. Tata Tubes has maintained its position of ranking third (11 per cent market share) in the precision tubes business over the years.

In order to become a world-class manufacturer and supplier of precision tubes, TPM was introduced in October 2000 to improve the overall effectiveness of equipment and all-round business excellence. The reasons behind TPM implementation in the organisation included several external factors (tough competition from competitors, the need to expedite new product development, increased raw material costs and high customer expectations regarding quality and delivery) and internal factors (unsafe workplaces, low productivity, high defects, poor equipment conditions, frequent equipment breakdowns, dirty and oily floors, long search times for tools and materials, low worker skills and motivation). The formal TPM kick-off took place in September 2001.

The Tubes Division has business objectives in place to achieve growth and cost leadership that includes:

- being a dominant player in the tubes business with a turnover of Rs. 1,500 crore and a net profit of Rs. 100 crore in the financial year 2008 by incorporating world-class technology;
- delivering superior products and services to our customers and upholding Tata values of good governance and ethical business practices in our SBU; and
- continuing to improve the quality of life of our employees and the communities we serve.

In line with the division’s objectives, TPM policy has been framed as follows: striving relentlessly to become a world-class manufacturer and supplier of precision tubes by integrating and adapting all business excellence initiatives with total productive maintenance as the working philosophy. The goals framed by the organisation to achieve the objectives include:

- maximising overall equipment effectiveness;
- achieving 100 per cent delivery compliance;
- reducing cycle time in all processes; and
- attaining industry leadership on cost and quality.
The inter-relationship between company objectives and TPM policy is shown in Table I. The organisational structure for TPM implementation at PT Mills is shown in Figure 3.

Employees were provided with extensive training to improve their competencies related to their jobs and visits were also arranged to different TPM industries to acquaint employees and managers with best TPM practices available in the country and globally. Managers and supervisors were also encouraged to attend TPM-related training courses and TPM conferences. A skill gap matrix was prepared for all employees and supervisors on the basis of the desired and present skill levels of the workforce. Appropriate training programs were then developed and deployed for employees throughout the organisation. The training and education strategy adopted by the organisation is shown in Figure 4. The manager model machines at PT Mills were picked up in October 2000. The contribution of

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<th>Element of company’s objectives</th>
<th>Element of TPM policy</th>
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<td>Financial</td>
<td>Improve shareholder value</td>
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<td>Customer</td>
<td>Enhance customer relationships by implementing retail value management</td>
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<td>People</td>
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Table I. Inter-relationship between company’s objectives and TPM policy

Figure 3. Organisational structure for TPM implementation
TPM initiatives on the model machines was demonstrated with the help of JIPM consultants. The TPM kick-off was organised by the MD of Tata Steel in September 2001. In the beginning, six TPM circles were formed at the PT Mills as a horizontal deployment in September 2001. Four pillar heads were appointed (Jishu Hozen, Kobetsu Kaizen, Planned Maintenance, and Education and Training) in September 2001, while the Safety, Health and Environment pillar head was appointed in April 2002, the Quality Maintenance pillar head was appointed in September 2002, and the Office TPM pillar head was appointed in September 2003. The performance of TPM circles and pillar heads was reviewed by Engineer-in-Charge (Tubes) once in a month, while pillar head review was done by the Head of the PT Mill once a week. Central group review was done for both the TPM circles and the pillar heads once a week.

JIPM consultants reviewed the progress on TPM once every two months. TPM quiz competitions were also organised from time to time, and a best circle kaizen competition was organised every month.

The analysis of the results of TPM implementation reveal that the organisation has reaped significant benefits as a result of strategic TPM implementation program. The results reveal that the organisational manufacturing performance improvements realised as a result of strategic TPM implementation included:

- a 78 per cent improvement in productivity (tonnes/month);
- a 92 per cent improvement in Productivity (tonnes/man/year);
- a 59 per cent improvement in overall equipment effectiveness;
- a 63 per cent reduction in equipment breakdowns and failures;
- an 85 per cent reduction in customer complaints;
- a 22 per cent improvement in delivery compliance;
- 140 times enhancement in operating profits;
- an 80-90 per cent reduction in rejections;
Figure 5. Results of TPM implementation

(a) Productivity (Tonnes/Month)

(b) Productivity (Tonnes/Man/Year)

(c) Overall Equipment Effectiveness

(Continued)
Figure 5.
Total productive maintenance implementation (Continued)
Figure 5.
The realisation of zero major accidents;
an 80 per cent reduction in minor accidents;
a 10 per cent improvement in plant yield;
a 43 per cent reduction in variable costs;
a 34 per cent reduction in work-in-process inventory; and
significant improvements in employee suggestions and contributions.

The results of TPM implementation at PT Mills are shown in Figure 5. Further, TPM implementation has also resulted in the realisation of several intangible benefits, such as:

- a clean and safe workplace;
- a change in management thinking (before TPM management was thinking of closing the plant, but after introducing TPM management is in the process of modernising the plant); and
- high workforce morale.

Conclusions
A manufacturing facility has been studied and analysed to study TPM implementation issues, the roadmap followed and the key benefits achieved as a result of TPM implementation. The research highlights the contributions of various TPM implementation initiatives in Indian industry to accruing strategic benefits to meet the challenges posed by global competition. The study reveals that the TPM initiatives are far more influential in affecting manufacturing performance improvements as compared to traditional maintenance practices. This validates the extremely high potential of TPM initiatives in realising overall organisational competencies. The study reveals that TPM initiatives have significantly marshalled the organisation towards building the capability for sustained competitiveness. The study shows that systematic TPM interventions in the organisation have significantly contributed to improving the manufacturing system’s productivity, quality and safety and the morale of the workforce, and have also ensured the cost effectiveness of the manufacturing functions within the organisation. The findings suggest that effective TPM initiatives can significantly contribute towards the realisation of strategic manufacturing performance improvements for competing in the highly dynamic global marketplace.

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