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Original Article

Relationship model and supporting activities of JIT, TQM and TPM

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Abstract

This paper gives a relationship model and supporting activities of Just-in-time (JIT), Total Quality Management (TQM), and Total Productive Maintenance (TPM). By reviewing the concepts, 5S, Kaizen, preventive maintenance, Kanban, visual control, Poka-Yoke, and Quality Control tools are the main supporting activities. Based on the analysis, 5S, preventive maintenance, and Kaizen are the foundation of the three concepts. QC tools are required activities for implementing TQM, whereas Poka-Yoke and visual control are necessary activities for implementing TPM. After successfully implementing TQM and TPM, Kanban is needed for JIT.

Keywords: JIT, TQM, TPM

1. Introduction

Since the 1980s there has been an increasing awareness and implementation of practices associated with Just-in-time (JIT), Total Quality Management (TQM), and Total Productive Maintenance (TPM). Research on JIT, TQM, and TPM has generally investigated their implementation and their impacts to a production system separately. Nevertheless, there has not been a careful examination of the common and unique practices associated with these concepts.

The goals of JIT, TQM and TPM are similar, which are continuous improvement and waste reduction (Schonberger, 1986; Nakajima, 1988; Ohno, 1988; Powell, 1995). Therefore, in practice, manufacturing plants are likely to combine the implementation of JIT, TQM, and TPM. A few studies have tried to explore the relationship between JIT and TQM empirically (e.g. Flynn *et al.*, 1995; Sriparavastu and Gupta, 1997). Also, McKone et al. (2001) indirectly consider all three concepts while focusing on only one of them. Moreover, Roth and Miller (1992) state that maintenance management may well be the biggest challenge facing companies that implement JIT, TQM, and computer-aid manufacturing. Huang (1991) discusses the importance of considering the integration of JIT, TPM, quality control, and factory automation with worker participation. Further, Cua *et al.* (2001) provide the relationship model between implementation of JIT, TQM and TPM associating to manufacturing performance.

Even though there is some research involving the relationships between the three concepts, no research considers the supporting activities of the three concepts and how to apply the three concepts simultaneously. Hence, we develop a relationship between the three concepts and describe supporting activities of the three concepts. Further, an implementation procedure of the three concepts is provided.

2. Conceptual Review

The earliest JIT articles were written in English in 1977 (Sugimori *et al.*, 1977) and several years later, the impact of JIT practices on manufacturing performance was recognized. JIT is a manufacturing system with the primary goal of continuously reducing and ultimately eliminating all forms of waste (Sugimori *et al.*, 1977; Ohno, 1988; Brown and Mitchell, 1991; Schonberger, 1986; 1996). The focus is on minimizing raw material, work-in-process, and finished goods inventory with a view to cutting inventory costs and also helping to

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expose other more serious inefficiencies in the manufacturing cycle (Wakchaure *et al.*, 2006). The success of JIT was proven through its application at Toyota Motor Corporation (Amasaka, 2001; 2003). Today, JIT practices are common in manufacturing and JIT was proposed as a new management technology principle for 21st century manufacturing (Amasaka, 2000).

TQM began to be introduced in the US around 1980, primarily in response to severe competitive challenges from Japanese companies. TQM is a manufacturing concept aimed at continuously improving and sustaining quality products and processes by capitalizing on the involvement of management, workforce, suppliers and customers, in order to meet or exceed customer expectations (Dean and Bowen, 1994; Hackman and Wageman, 1995; Powell, 1995). Based on the review, quality management frameworks typically emphasize the importance of cross-functional product design and systematic process management. The stresses include the involvement of customers, suppliers and employees to insure quality products and processes. Today, the recognition of TQM as a competitive advantage is widespread around the world, and very few companies ignore the term TQM (Dean and Bowen, 1994).

TPM began in Japan through Nippon Denso Company, part of the Toyota's group, in 1971. TPM is considered as evolution in preventive maintenance, originally conceived in the United States in the 1950s. The conception of TPM was an answer to the demands of a more and more competitive market that obliged the companies to draw some attitudes, such as: eliminating waste, always obtaining the best performance of the equipment and reducing interruptions or stops of production. Hence, TPM is a manufacturing concept designed primarily to maximize equipment effectiveness throughout its entire life through the participation and motivation of the entire work force (Nakajima, 1988).

3. Comparisons of JIT, TQM, and TPM

General characteristics of JIT, TQM, and TPM are shown in Table 1. JIT and TPM were originally found in

Table 1. General characteristic comparison of JIT, TQM, and TPM

Characteristics	JIT	TQM	TPM
Originality	Japan	US	Japan
Emphases	- Waste reduction including inventory - Continuous improvement - Customer responsiveness including flexibility	- Customer satisfaction - Employee involvement - Continuous improvement	- Machine and equipment downtime - Machine and equipment efficiency
Supporting factors	- Administrator deployment - Team employment - Employee involvement - JIT flow - Pull system	- Administrator deployment - Team employment - Education	- Administrator deployment - Maintenance activity - Employee involvement
Inclusion	- Line balancing - Setup time reduction - Batchsize reduction - Skill development - Consistency of quality control - Continuous work improvement - Pull system - Long-term supplier relationship - Preventive maintenance	- 7 traditional QC tools - 7 new QC tools - Statistical methods - Cross functional administration - Quality control circle activity	- Individual improvement - Autonomous maintenance - Planned maintenance - Operation and maintenance development - Initial phase management - Quality maintenance - TPM in office - Safety, hygiene and
Usefulness	- Increase product quality - Decrease manufacturing defective - Increase customer responsiveness - Reduce inventory - Increase accuracy of demand forecast - Reduce manufacturing costs	- Increase customer satisfaction in quality - Decrease operations wastes	- Increase efficiency of machines and equipment - Increase product quality - Reduce loss of setup - Reduce maintenance time and cost

Table 2. Similarities and Differences of JIT, TQM, and TPM

Characteristics	JIT	TQM	TPM
Objectives	- Inventory control - Lead time reduction - Defective rate reduction	- Cost down and quality improvement - Customer satisfaction increase	- Increase machine efficiency - Maintenance system establishment
Accent	- Machine and operator management	- Operator management	- Machine management
Wastes	- 7 wastes	- Defects - Inventory	- Machine breakdown - Set up time - Defects
Employees	- Multi skilled workers - Employee involvement	- Educated workers - Employee involvement	- Self maintenance workers - Employee involvement

Japan whereas TQM was established in US. JIT emphasizes waste reduction, continuous improvement and customer responsiveness. There are 7 wastes in JIT, which are waste from overproduction, waste of waiting time, transportation waste, inventory waste, waste of motion, and waste from product defects. TQM stresses customer satisfaction underlying quality by using employee involvement. TPM highlights machine and equipment maintenance in order to increase machine efficiency and decrease machine downtime. The factors supporting JIT, TQM, and TPM are quite similar. They are administrator deployment, team employment, and employee involvement. JIT extends the supporting factors to JIT flow and pull system whereas TQM does education and TPM does maintenance activities. There are many tools used in making JIT, TQM, and TPM active. They are shown in Table 1.

The main objectives of JIT, TQM, and TPM, which are quite similar, are cost reduction and quality enhancement. To achieve the main objectives, JIT goes to inventory control, lead time reduction and defective rate reduction, whereas TQM aims at cutting costs by improving quality and TPM targets increasing machine efficiency and establishing maintenance system. The wastes considering in JIT are the well-known 7 wastes whereas the wastes in TQM are defects and inventory; and the wastes in TPM are machine breakdown, set up time and defects. About employees, all three concepts have a similar idea in educating employees and having employee involvement. Table 2 shows the similarities and differences of JIT, TQM, and TPM.

4. Relationship among JIT, TQM, and TPM

The relationship among JIT, TQM, and TPM was constructed based on the review and survey. First, Krajewski and Ritzman (1999) state that Kaizen would help in developing JIT TQM, and TPM activities effectively. JMAC America (2010) propose that 5S would be a foundation of JIT, TQM, and TPM implementation. Further, based on the pillars of TQM and TPM, 5S shows as a column of the houses of TQM whereas it shows as a foundation in the pillars of TPM. Moreover, JIT would be a supporting activity of TQM implementation.

Gross and McInnis (2003) state that a kanban system is an important part of JIT and Poka-Yoke is an element in quality control. Quality control is a pillar of TQM house. Higgins and Mobley (2001) state that visual control is an important technique in machine maintenance. Further, George and Weimerskirch (1994) state that Quality Control (QC) tools are basic tools of TQM. For the TPM, Nakajima (1988) states that preventive maintenance is an action in planned maintenance and planned maintenance is one of the pillars in TPM house. Based on the above review, 5S, Kaizen, preventive maintenance, Kanban, visual control, Poka-Yoke, and QC tools were main issues of the survey. Thirty people who work in the companies employing JIT, TQM, and TPM in Thailand were interviewed. By analyzing the data collected, a relationship model and supporting activities were constructed as shown in Figure 1. 5S and Kaizen were the foundations of JIT, TQM, and TPM, whereas Poka-yoke and preventive maintenance were the basic of JIT and TPM. Kanban seemed to be the key of JIT whereas visual control was essential for TPM. Lastly, QC tools were the vital tools for TQM.

5. Adjusted Relationship Model and Supporting Activities

Even though the model in Figure 1 seemed to be reasonable, the model was reexamined by using Analytic Hierarchy Process (AHP) technique to ensure the correctness of the model. The goal of AHP process was the success of JIT, TQM, and TPM application. The criteria are 1) Lead time of JIT, TQM, and TPM application, 2) Performance efficiency, 3) Defects and product quality and 4) Machine breakdown. The alternatives were 5S, Kaizen, preventive maintenance, Kanban, visual control, Poka-Yoke, and QC tools. A survey based on AHP was carried out. The result shows that defects and product quality is the most important criterion whereas

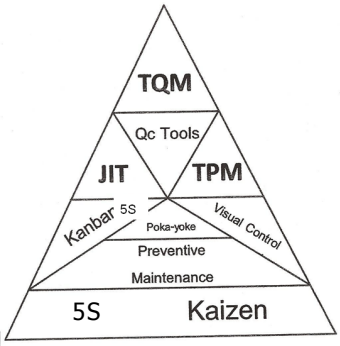

Figure 1. Relationship model of JIT, TQM, and TPM

machine breakdown is the second most important. Lead time of JIT, TQM, and TPM application and performance efficiency seem to be the last and the second last in importance. Figure 2 shows the priorities of the criteria.

Moreover, with the overall inconsistency ratio of 0.03, important weights of 5S, Kaizen, preventive maintenance, Kanban, visual control, Poka-Yoke, and QC tools are 0.118, 0.164, 0.214, 0.073, 0.132, 0.136, and 0.162, respectively. Figure 3 shows the importance weights. It can be seen that preventive maintenance is the most significant activity for implementing JIT, TQM, and TPM. Kaizen is the second. QC Tools, Poka-Yoke, visual control and 5S are in third, fourth, fifth, and sixth place in order of decreasing importance weight and the least important activity is Kanban.

In case that only the most critical criterion, which is defects and product quality, is considered, Figure 4 shows the important weights of all supporting activities. It can be seen that preventive maintenance and Kaizen remain the first and second most important. 5S is the third most important one. Visual control and Poka-Yoke are the fourth and fifth, whereas QC tools is the seventh and the last one is Kanban. Therefore, by adjusting the results to the relationship model shown in Figure 1, preventive maintenance, Kaizen, and 5S seem to be the foundation of overall JIT, TQM, and TPM. Based on the previous study, QC tools are for TQM; and Poka-Yoke and visual control are the main activities of TPM. Kanban is the key activity of JIT. Therefore, the relationship model is adjusted as shown in Figure 5.

6. JIT, TQM, and TPM Implementation

As shown in Figure 5, there are three stages of JIT, TQM and TPM implementation. The first stage is employing 5S and preventive maintenance. The second stage is implementing Kaizen. In case of emphasizing in TQM, QC tools is

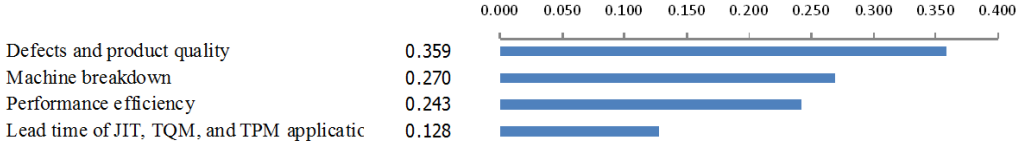

Figure 2. Priorities of the criteria

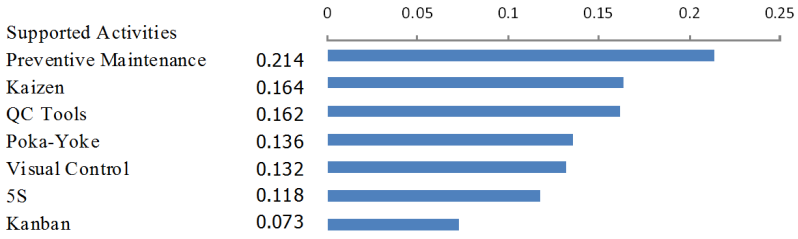

Figure 3. Overall important weights of supporting activities

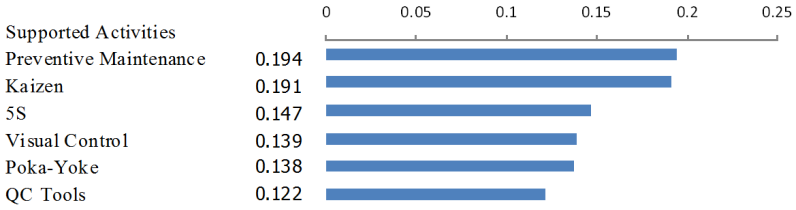

Figure 4. Important weights of supporting activities relating to defects and product quality

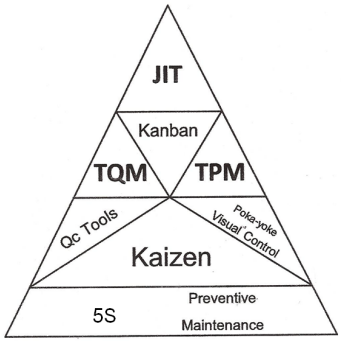

Figure 5. Adjusted relationship model

needed in the second stage whereas emphasizing TPM needs visual control. When both TQM and TPM are achieved, Kanban is required in the third stage to accomplish JIT.

7. Conclusion and Discussion

This paper presents a relationship model and supporting activities of JIT, TQM, and TPM. Based on reviewing the concept of JIT, TQM, and TPM, the supporting activities relating to JIT, TQM, and TPM include 5S, Kaizen, preventive maintenance, Kanban, visual control, Poka-Yoke, and QC tools. In order to obtain the concept of JIT, TQM, and TPM relationship, 30 people who work in the companies employing JIT, TQM, and TPM in Thailand were interviewed. Based on the interview and conceptual review, the initial model was constructed. 5S and Kaizen were the foundation of the three concepts whereas preventive maintenance and Poka-Yoke seemed to be required. Kanban was needed for implementing JIT and visual control was necessary for TPM. Lastly, Implementing TQM, which was the last one, required QC tools. Even though the model was constructed based on the interview and conceptual review, it was then tested by using the Analytic Hierarchy Process (AHP) technique to ensure the correctness of the model. It was found that the relationship model needed to be adjusted. JIT becomes the last to obtain while Kanban remains the activity associated with JIT. QC tools are the activities of TQM, and Poke-Yoke and visual control are the activities of TPM. The foundations become 5S, preventive maintenance, and Kaizen.

Even though the relationship model and supporting activities of JIT, TQM, and TPM provided in this paper are given based on the conceptual review, interview, and AHP technique, the activities considering in this paper seem to be limited. Future researches may be given to the supporting activities. Moreover, more data may need to be collected to get more accurate result.

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