Journal of Engineering and Applied Sciences 8 (3): 75-80, 2013
ISSN: 1816-949X

Diagnosis for Introducing Lean Production Systems in Precast Fabrication

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Abstract: The most challenging issue when enterprises implement continuous improvement is how to select appropriate methods. The objective of this study is to develop a diagnosis model for analyzing appropriate improvement methods. The model is developed using enterprise diagnosis methodologies that consist of three components, the production system, fundamental management and staff mentality. These three perspectives stem from Toyota's 3 M's (muda, mura, muri). The applicability of the proposed model is validated using a real precast fabricator. The application results show that the developed model can be used to analyze the strategies required for introducing lean ideas in precast fabrication.

Key words: Business diagnosis, lean construction, precast, toyota production system, mura, muri, muda

INTRODUCTION

Just-in-Time (JIT) is the core of the lean production process and a comprehensive concept in product development, manpower deployment, marketing and supplier relationship management. Lean production techniques have spread rapidly in recent years. However, problems sometimes occur due to the lack of integrated linkage. The introduction of lean production has, therefore evolved into segmental technique application (Fujimoto, 1999; Wang *et al*., 2012).

The construction industry is deemed a traditional industry. Construction technique is now maturing after years of development. Architecture is now safer than ever, requiring much less time to construct a building. However, technique and speed are no longer the key competitive elements. Powerful management has become the newly derived key element. This study attempts to reduce the high cost and low efficiency issues in traditional construction using lean production. The goal is to increase business competitiveness. Lean production is constructed in this study in accordance with business diagnosis theory to assess precast fabrication before/while implementing a lean production system.

LITERATURE REVIEW

Just-in-Time (JIT) and autonomation are two pillars of Toyota Production System (Ohno and Bodek, 1988; Liker, 2003). The introduction of JIT and/or lean production into the business operation has been proven beneficial to an enterprise. In Ali *et al*. (2012), their study shows that the introduction of JIT helped prevent material waste throughout production. Inman and Mehra (1991) and Lacity *et al*. (2011) believed that introducing JIT helped communication between the organization and outsiders. Some research (Ansari and Modarress, 1990; Chen and Sarker, 2010; Mungan *et al*., 2010) also found that the introduction of JIT could help reduce procurement cost which is a concern of many organizations. The investigations by Green *et al*. (1992), White *et al*. (2010) and Al-Tahat *et al*. (2012) proved that JIT introduction helped reduce preparatory time, consumption, improved quality, increased productivity and the customer's confidence in the products. Moreover, JIT does help incubate the discipline of an organization and reduces management effort (Yasin *et al*., 2003). It can integrate departments in an organization and ease the gap between departments (Zelbst *et al*., 2010; Taylor *et al*., 2012).

Autonomation describes a feature of machine design to produce the jidoka principle used in the Toyota Production System (TPS). It may be described as intelligent automation or automation with a human touch. Autonomation prevents the production of defective products and focuses attention on understanding the problem and ensuring that it never recurs (Ohno and Bodek, 1988).

Ma (2000) defined the effective business diagnostics as: Identify the flaws and faults of business management with diagnostics and techniques. This researcher also proposed corrective actions using an objective method to help improve enterprises, upgrade operating efficiency and realize the enterprises' objectives. Daniels and Feelders (1992) thought that the meaning of diagnosis was to explain the abnormality in a research system in the best possible way.

DIAGNOSIS ARCHITECTURE

This study develops an enterprise diagnosis model for introducing the lean production system to organization based on Drew's theory (Drew *et al*., 2004). The model is constructed using three enterprise perspectives including operating system, management infrastructure and staff attitude. These three perspectives stem from Toyota's 3 M's (muda, mura, muri). Lean thinking (Womack and Jones, 2003) is emphasized in the diagnosis model. The operating system examines the non-productive activities in the operating system using diagnostic items. In other words, it helps identify loss from waste, variation and gridlock. The management infrastructure and staff attitude and behavior are examined using a corrective action standard proposed by Drew *et al*. (2004). The lean management 14 principles of Liker (2003) are adopted and integrated into the three perspectives for diagnosis. The diagnosis method is illustrated as follows using three enterprise perspectives.

Production system: To introduce lean production to the enterprise, muda (the Japanese term for waste) is considered first. The operating system includes three sources of loss including waste, variation and gridlock that causes precast fabrication costs to increase and the profit margin to decrease. The production system is evaluated using 10 items:

- Production surplus interrupted operating procedure
- Waiting (workers or machines) idle time that does not help increase value
- Work habits uneven workload level
- Delivery unnecessary raw materials delivery
- Over processing extra effort that does not help increase customer's value
- Inventory more components or materials than customers need
- Unnecessary movement unnecessary movement by staff or material in the flow
- Rework repeated or modified procedures
- Variation nonconformity
- Gridlock variation resulted from failure in responding to customer's demands

Staff attitude and behavior: Muri (a Japanese term for overburden, unreasonableness or absurdity) is considered in this diagnostic stage. In terms of the staff attitude and behavior, there are five aspects in this study including the spirit of continuous improvement, organizational concept, director's participation and support, lean attitude and behavior. The staff attitude and behavior is evaluated using 11 items:

- Flexibility is more important than scale of operation
- Value is increased at the first line
- Everyone should know what they are supposed to do
- Activities support the business goal
- Staff finds the root cause for problem solving once and for all
- Staff identifies problems for improvement
- Staff considers the long-term system of an organization for decision performance
- Management practice reflects that facts are dealt with at the first line
- The first line personnel are involved in the corrective action
- Supervisors resolve the systematic issues
- Employees at all levels participate in open dialogue

Management infrastructure: Mura (a Japanese term for unevenness, inconsistency in physical matters or human spiritual condition) is considered in this perspective. Management infrastructure in this study include 8 principles: Organizational structure, performance management system, continuing improving infrastructure, operating skill development procedure and important occupational support procedure management, reliable technique procedure and personnel, visual control, cultivating employees and talents incubation and establishing excellent partnership. Right side of each principle denotes evaluation criteria:

- Organizational structure group leader of operators
- Performance management system systematic evaluation procedure
- Infrastructure continuous improvement daily activity monitoring
- Operating skills development vision of an organization consistence with the vision of the team
- Important skill support flow organization with necessary skill
- Technique and supportive manpower industrial engineers
- Visual control employee training
- Training employees to become leaders company training courses

DIAGNOSIS PROCEDURE

The diagnosis procedure, shown in Fig. 1 is constructed in accordance with the aforementioned perspective diagnosis architecture. The procedures and methods are illustrated as follows:

Analyze business background: The first activity is to study the background of precast fabrication and the features of studied industry. The business competition and industrial environment must also be understood.

Establish improvement goal: Understand the expected production improvement scope and effect with the implementation of lean production by communicating to precast fabrication. It is referred for evaluating the difference between the expectation and actual performance after introducing lean production.

Identify diagnosis items: Diagnosis object and scope are identified from three perspectives, namely operating system, staff attitude and behavior and management infrastructure. Diagnosis items are identified and expanded from the diagnosis architecture.

Perform diagnosis: Diagnosis is carried upon verifying diagnosis items. Diagnosis data are collected by the way of interview and onsite observation.

Propose corrective action: Feasibility of the proposed corrective action concluded from the theoretical viewpoint and actual issues are discussed with the company's staff. Corrective action is suggested in this activity.

Document corrective action performance: Corrective action is documented. In addition, correction results and expected results are compared for the reference of future practice.

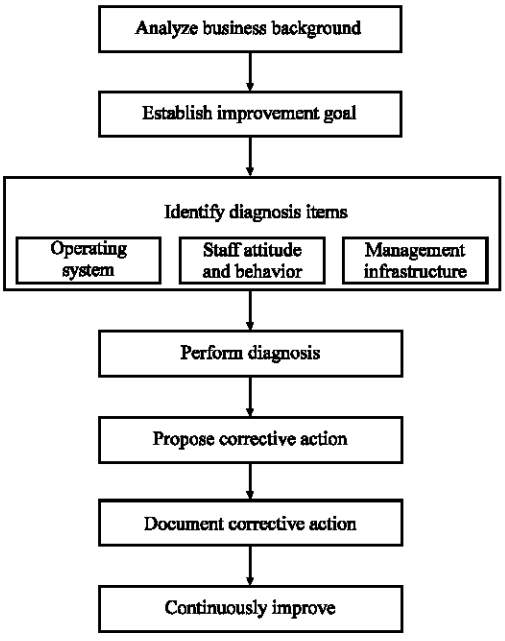

Fig. 1: Diagnosis procedure

Continuously improve for perfection: This activity reviews business continuously with corrective action performed accordingly by documenting the management cycle.

VALIDATION

This research investigates the applicability of the proposed diagnosis model using a real precast fabricator.

Studied case: The R. Precast Fabrication Company is used as an example to explain the lean production diagnosis model implementation. First the background of this case study and competition are investigated. The selected fabricator is then analyzed using the proposed diagnosis model. Finally, suggestions are made for lean production introduction. A qualitative case study is applied for diagnosis and analysis.

The R. Precast Fabrication Company was incorporated in 1975 to provide precast fabrication design, architecture and engineering technique service. The R. Precast Fabrication Company emphasizes technique, management and innovation. Therefore, it introduced the Enterprise Resources Planning (ERP) System in 2001 and underwrote plant construction engineering in 2003. The R. Precast Fabrication Company's profile is displayed in Table 1.

Analyze business background: R. Company's business competition and industrial environment is understood using Porter's five-force analysis. The mission of a business leader in a competitive environment is to analyze market competition and identify business opportunities and threats. In other words, the five competitions are the threat from new competitors, supplier's price negotiation power, customer's negotiation power, the threat of substituting products or services and the existing competitions. According to the five-force model of Porter (1980), powerful competition can be deemed as threat for it will force margin to go down. Insignificant competition can be deemed as opportunity for it allows enterprises to

Table 1: R. Precast Fabrication Company profile

Items	Content
Capital stock	US$ 3,000,000
Number of employees	500
Business operation	General construction engineering service including collective resident, hillside cottage, office building, high-tech factory, wholesale market, medical building, school architecture and church building
Products	Planning, designing, production and erection of precast column, beam, wall, prestressed board and hollow slab

make great margin. A responsive strategy could be formed internally to minimize threat by analyzing external threat with business diagnosis.

The studied case is a representative precast fabrication modular plant in Taiwan. Therefore, there is no existing competitor. Construction will also not be hampered by replacing precast fabrication method with traditional construction. Some large-scale construction companies are potential competitors. Other construction companies that have better management technique will eventually become a threat to the R. Precast Company. In terms of supplier price negotiation power, the R. Precast Fabrication Company is restricted by the raw material suppliers including Taiwan Cement Corporation, China Steel Corporation and crane equipment suppliers. In terms of customer price negotiation power, the R. Precast Fabrication Company's customers include self-sufficient customers and project underwriters. The said self-sufficient customers are construction companies within the group. The said underwriters include customers for high-tech plant construction projects, businesses and residential buildings. Customer influence poses a significant threat to R. Precast Fabrication Company since the precast fabrication method cost is 20-30% higher than traditional construction methods. As a result, the quoted price is also high. Customers will try to negotiate based on general construction method quotations with the R. Precast Fabrication Company. R. Company does not take this threat lightly. The R. Precast Fabrication Company conducts a monopoly operation. The precast fabrication method has the advantages of speed, quality and anti-earthquake technology that bring business opportunities to the R. Precast Fabrication Company.

Perform diagnosis: The three-perspective diagnosis analysis is conducted in this study with the proposed diagnosis structure.

Production system: The three sources of loss in the production system must be eliminated: Waste, variation and gridlock. The root causes of waste, variation and gridlock are diagnosed as follows:

Waste: Things that will cause cost to go up but not value. In general, the operating system waste includes production surplus, idling, delivery, over processing, inventory, unnecessary movement and rework.

Variation: R. Precast Fabrication Company uses 3D designing drawings to communicate with the contractor for confirmation. To prevent nonconforming products from occurring, R. Precast Fabrication Company has established a 6σ system to prevent product specification variation and improve precision. The R. Precast Fabrication Company has created R&D patented techniques to prevent construction technique variation, material quality variation and technique variation. These techniques can prevent productivity loss and extended construction time.

Gridlock: R. Precast Fabrication Company adopts custom-made production that has the advantage of flexible modular specifications. However, it is unable to respond to urgent customer orders due to time-consuming modular tooling changes.

Management infrastructure

Organizational structure: The top organization priority is to determine the scale of the first line team which is determined by considering the process stability, importance and difficulty in the research. Occupational support is assigned to the first line team and blended into the process. In practice, the R. Precast Fabrication Company has entrusted the subcontractor foreman with the responsibility for planning. The worksite superintendent is the command authority for the foreman. The foreman must make a decision for any nonconformity occurring at the worksite. The worksite superintendent must make a decision for any major nonconformity occurring at the worksite with the quality control engineer invited for discussion if necessary.

Performance management system: According to Drew *et al.* (2004), it is necessary to inspire employees and train employees to perform well at research. It is also important to offer a good benefit package, adequate incentive plan and performance evaluation system to help employees define a clear career objective and plan. The performance evaluation system of the company in case study is included in the personnel system controlled by ERP SAP®. This includes controlling performance by person/hour, shift, date and monthly performance.

Continuously improving the infrastructure: The lean production of R. Precast Fabrication Company was not planned by professional lean consultants. There was no lean reformation team organized at the time. Instead it was completed by each department in accordance with its objective. Under these circumstances, the vision of each department may be different from the company vision. The introduction of lean production could thus be introduced incomprehensively.

Staff attitude and behavior: Staff's attitude and behavior is critical to the success of any organizational system. The

introduction of lean production is affected by the management and staff support. It takes one responsible and determined leader to have lean production promoted effectively (Womack and Jones, 2003).

The spirit of continuing improvement: The interviewed R. Precast Fabrication Company is positive in solving problems and the staff has the spirit of reviewing problems and solving problems.

Organization concept: R. Precast Fabrication Company is progressive with lean production. The lean process of the team is enforced progressively under the promotion and supervision of the management.

Management's involvement and support: R. Precast Fabricator has tour inspection system step at the special project worksite for the visitation of administrative personnel so they can provide adequate support to the worksite, perform integrated evaluation and realize the objective in cost, progress, construction method and engineering technique.

DISCUSSION

Corrective action for introducing lean production is proposed in accordance with the three perspective diagnosis results in this study.

Production system perspective

Component inventory from production surplus: This results from the difference in crane speed at the worksite and modular production. Therefore, JIT for the crane module at the worksite was not realized. The R. Precast Fabrication Company may consider having the crane speed and production speed leveled up. It may also utilize rapid tool change technique to have modular supplied in time in order to prevent modules from piling up at worksite.

The operation cannot be modified significantly: It is not easy to change a worker's work habits. However, it can be done by education and training to help them understand the effect that could be generated by changing the operation.

Infrastructure management perspective

Improving infrastructure continuously: Having a lean reformation team formed at the preliminary stage is a right way to introduce lean production. Moreover, diagnosis items proposed in the study can be used to define the scope of corrective action. Corrective action should be taken once the nonconformity is identified. Unfortunately, R. Precast Fabrication Company does not follow this practice; instead departmental objective is defined independently. The vision of each department is different from the organization as a whole. Under this circumstance, lean production is introduced incomprehensively but fragmental and individual technique.

Staff's attitude and behavior: The first line workers are hired by contractors. Consequently, their qualification for the work varies. Moreover, it is difficult to manage workers due to poor communication since workers communicate indirectly through the contractor's supervisors. It is recommended to have an employment system in place in order to secure a good communication with and cooperation from workers.

CONCLUSION

A strategy diagnosis model for introducing lean production to a precast fabricator was discussed in this study. Three perspectives of business operation system, i.e., production system, management infrastructure and staff attitude and behavior are considered in the model. The lean diagnosis model proposed in this study can be used by enterprises to analyze the effectiveness of introducing lean production. In addition, it can be used to examine internal management and performance for reference of future improvement.

The diagnose model systematically surveys the current practice using lean thinking. Enterprise can add or eliminate diagnose items based on 3 M's (muda, mura, muri) of lean thinking. The lean diagnosis model development relies on the knowledge and experience of the analyzers. Moreover, if precast fabrication factory has no comprehensive database and if the diagnosis process is not supported by directors and/or staff, the hidden problems in precast fabrication factories will not be revealed.

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