DIAGNOSIS AND STRATEGY DEVELOPMENT FOR INTRODUCING LEAN PRODUCTION SYSTEMS IN PRECAST FABRICATION

Chien-Ho Ko[1] and Chin-Yuan Ko[2]

ABSTRACT

The most challenge issue when enterprise implementing continuous improvement is how to select appropriate methods. The objective of this study is to develop a diagnosis model for analyzing appropriate methods. The model is developed using enterprise diagnosis methods that consist of three components, namely production system, fundamental management, and staff mentality. Those three perspectives stems from Toyota's 3 M's (muda, mura, muri). Applicability of the proposed model is validated using a real precast fabricator. Application results show that the developed model has potential to be used to analyze strategy required for introducing lean ideas.

KEY WORDS

Lean production, business diagnosis, precast, lean construction.

INTRODUCTION

The Just-In-Time (JIT) is the core of the Lean Production that is for production and a comprehensive concept for product development, manpower deployment, marketing, and supplier relationship management. The Lean Production techniques had been developed rapidly in recent years. However, most of them were lack of an integrated linkage. As a result, the introduction of Lead Production had been evolved into segmental technique application (Takahiro 1999).

Construction industry was deemed as a traditional industry. Construction technique is maturing after years of development. Therefore, architecture is safer than ever and it takes less time to construct a building. However, technique and speed are no longer the key elements for competition. Powerful management becomes the newly derived key element. Consequently, this study attempts to have the high cost and low efficiency issues of traditional construction improved with the Lean Production in order to improve the per se of businesses, upgrade the competition of businesses, and realize the ongoing concern of businesses. Lean Production diagnosis is constructed in this study in accordance with business diagnosis theory to assess precast fabrication before/when implementing Lean Production System. The

[1] Assistant Professor, Department of Civil Engineering, National Pingtung University of Science and Technology, 1, Shuefu Rd., Neipu, Pingtung 912, Taiwan, e-mail: fpecount@yahoo.com.tw, phone: +886-8-7703202, fax: +886-8-7740122; Research Director, Lean Construction Institute-Taiwan; Executive Director, Lean Construction Institute-Asia

[2] Assistant Researcher, Lean Construction Institute-Taiwan, http://www.TaiwanLCI.org/

developed model can also help precast fabrication comprehensively define business scope and understand implementation effect.

LITERATURE REVIEW

Just-In-Time (JIT) and autonomation are two pillars of Toyota Production System (Ohno 1988). The introduction of JIT and/or Lean Production into business operation has been proven beneficial to an enterprise. Natarajan (1991) said in their studies that the introduction of JIT helped prevent the waste of materials throughout production. Inman and Mehra (1991) believed that introducing JIT helped the communication between an organization and outsiders. According to the study of Ansari and Modarress (1990), the introduction of JIT could help reduce procurement cost, which was the concern of many organizations. The study of Green et al. (1992) had proven that the introduction of JIT helped reduce preparatory time, save time consumption, improve quality, increase productivity, and upgrade customer's confidence in products. Moreover, the introduction of JIT does help incubate the discipline of an organization and easy management (Yasin et al. 2003). It can integrate departments in an organization and ease up the gap between departments of an organization.

Autonomation describes a feature of machine design to effect the principle of jidoka 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 1988).

Ma (2000) had business diagnosis defined in the "Effective Business Diagnostics" as: Identify the flaws and faults of business management with diagnostics and techniques. Also the researcher proposed corrective actions with an objective method to help with its realization for improving enterprises, upgrading operating efficiency, and realizing enterprises' objectives. Feelder and Daniels (1992) thought that the meaning of diagnosis was to explain the abnormality of a research system in process the best possible.

DIAGNOSIS ARCHITECTURE

This study develops an enterprise diagnosis model for introducing lean production system to organization based on Drew's theory (2004). The model is constructed by three enterprise perspectives including operating system, management infrastructure, and staff's attitude. Those three perspectives stems from Toyota's 3 M's (muda, mura, muri). The Lean Thinking (Womack and Jones 1996) is emphasized in the diagnosis model. The operating system examines the non-productive activities in the operating system with the diagnostic items. In other words, it helps identify the loss of waste, variation, and gridlock. Regarding managing infrastructure and staff's attitude and behavior, corrective action standard proposed by Drew et al. (2004) and the Lean Management fourteen principles of Liker (2004) are adopted and integrated into the three perspectives of enterprises for diagnosis. The diagnosis method is illustrated as follows using three enterprise perspectives:

PRODUCTION SYSTEM

To introduce lean production in the enterprise, muda (the Japanese term for "waste") is first considered. Operating system includes three sources of loss including waste,

variation, and gridlock that causes precast fabrication's cost to go up and margin to go down. 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 of staff or material in the flow.
- Rework - repeated or modified procedure.
- 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 staff's attitude and behavior, there are five aspects concluded 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 are supporting business goal.
- Staffs find the root cause for problem solving once and for all.
- Staffs identify problems for improvement.
- Staffs consider the long-term system of an organization for decision performance.
- Management practice reflects the fact dealt with at the first line.
- The first line personnel are involved in the corrective action.
- Supervisors resolve the systematic issues.
- Employees in all level conduct open dialogue.

MANAGEMENT INFRASTRUCTURE

Mura (a Japanese term for unevenness, inconsistency in physical matter or human spiritual condition) is considered in this perspective. Management infrastructure in

this study include eight 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 Figure 1, is constructed in accordance with the aforementioned perspective diagnosis architecture. The procedure and method are illustrated as follows:

- Analyze business background: The first activity is to study the background of precast fabrication and the features of this industry; also, understand the business competition and industrial environment.
- 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 expectation and actual performance after introducing Lean Production.
- Identify diagnosis items: Diagnosis object and scope are identified from three perspectives, namely 1) operating system, 2) staff attitude and behavior, and 3) management infrastructure. Diagnosis items are identified and expanded from 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.

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

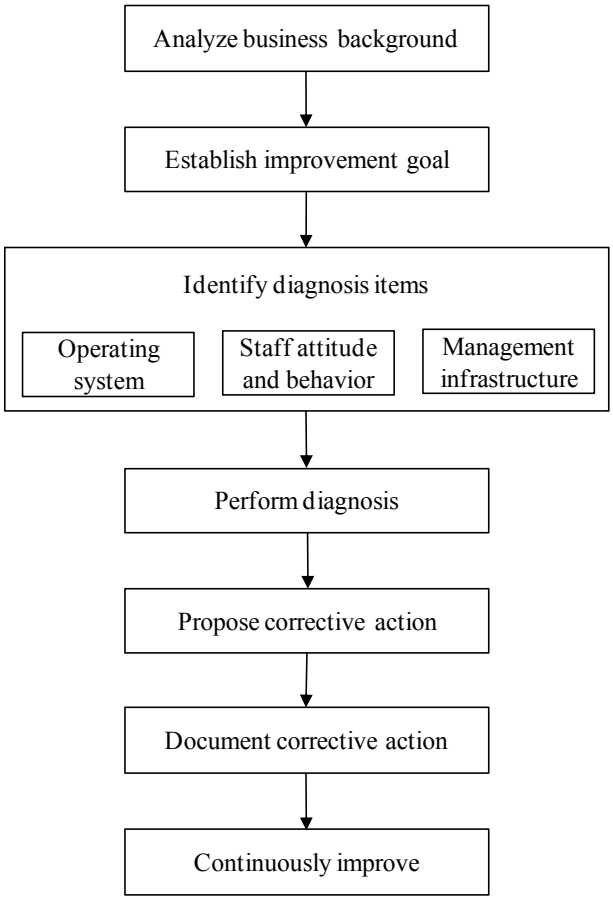

Figure 1: Diagnosis Procedure

VALIDATION

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

STUDIED CASE

A R Precast Fabrication Company is used as an example to explain the implementation of Lean Production diagnosis model. First of all, the background of this case study and competition are investigated. Then, the selected fabricator is analyzed using proposed diagnosis model. Finally, suggestions are made for the introduction of Lean Production. A qualitative case study is applied for diagnosis and analysis in this study.

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

Table 1: R Precast Fabrication Company Profile

Item	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

ANALYZE BUSINESS BACKGROUND

The 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 to identify business opportunities and threats. In other words, the five competitions of "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 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 of Taiwan. Therefore, there is no competitor in existence. However, the construction will not be hampered by replacing precast fabrication method with traditional construction. Some large-scale construction companies are the potential competitors. Other construction companies that are with better management technique will eventually become a threat to R Precast Company. In terms of supplier's price negotiation power, 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's price negotiation power, R Precast Fabrication Company's customers include self-sufficient customers and undertakers. The said self-sufficient customers meant for the construction companies within the group. The said undertakers include the customers for high-tech plant construction projects and business and resident building. In terms of customer's influence, it posts significant threat to R Precast Fabrication Company since the cost of precast fabrication method is 20%~30% higher than traditional construction method. As a result, price is quoted high too. Customers will base on the general construction method quotation to

negotiate with R Precast Fabrication Company. R Company does not take that threat lightly. In terms of the existing competitors, R Precast Fabrication Company conducts a monopoly operation. The precast fabrication method with the advantages of speed, quality, and anti-earthquake will bring business opportunities to 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 production system must be eliminated: waste, variation, and gridlock. The root causes of waste, variation, and gridlock are concluded in accordance with the diagnosis in this study as follows:
  (a) Waste: Things that will cause cost to go up but not value. In general, the waste of operating system includes production surplus, idling, delivery, over processing, inventory, unnecessary movement, and rework.
  (b) Variation: R Precast Fabrication Company uses 3D designing drawings to communicate with the contractor for confirmation. For preventing nonconforming products from occurring, R Precast Fabrication Company has established 6σ system to prevent product specification variation and to improve precision. R Precast Fabrication Company has created R&D patented techniques to prevent construction technique variation, material quality variation, and technique variation. In addition, those techniques can prevent the loss of productivity and the extended construction time.
  (c) Gridlock: R Precast Fabrication Company adopts custom-made production that is with the advantage of flexible modular specifications. However, it is unable to respond to customer's urgent orders under the consideration of time-consuming modular tooling change.

- Management infrastructure
  (a) Organizational structure: The top priority of the organization is to determine the scale of the first line team, which is determined in accordance with the considerations of process stability, importance, and work complication. Occupational support is assigned to the first line team and blended in the process. In practice, R Precast Fabrication Company has entrusted the foreman of subcontractor with the responsibility for planning. Worksite superintendent is the commanding authority of the foreman. Foreman has to make a decision for any nonconformity occurred at worksite. Worksite superintendent has to make a decision for any major nonconformity occurred at worksite with the quality control engineer invited for discussion if it is necessary.
  (b) Performance management system: According to Drew (2006), it is necessary to inspire employees and train employees for them to perform well at work. It is also important to offer good benefit package, adequate incentive plan, and performance evaluation system helping employees define clear career objective and plan. The performance evaluation system of the company in case study is with the personnel system

controlled by ERP SAP® including controlling performance by person/hour, shift, date, and month performance.

(c) Improving infrastructure continuously: The Lean Production of R Precast Fabrication Company was not planned by professional lean consultants. There was not a Lean Reformation Team organized at the time, instead, it was completed by each department in accordance with its objective. Under the circumstance, the vision of each department may be different from the vision of the company taking as a whole. The introduction of Lean Production could thus be introduced incomprehensively.

- Staff attitude and behaviour: Staff's attitude and behavior is critical to the success of organizational system. The introduction of Lean Production is affected by the support of management and staff. It takes one "responsible and determined" leader to have Lean Production promoted effectively (Womack 1996).
  (a) The spirit of continuing improvement: The interviewed R Precast Fabrication Company is positive in solving problems and staffs are with the spirit of reviewing problems and solving problems.
  (b) 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.
  (c) 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:
  (a) Component inventory from production surplus: It is resulted from the difference of speed of crane at worksite and modular production. Therefore, the JIT of crane modular at worksite is not realized. R Precast Fabrication Company may consider having the crane speed and production speed levelled up. It may also utilize rapid tool change technique to have modular supplied in time in order to prevent modular piling up at worksite.
  (b) Operation cannot be modified significantly: It is not easy to have worker's work habit changed. However, it can be done by education and training to help them understand the effect could be generated by changing 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 taking 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 work varies. Moreover, it is difficult to manage workers due to poor communication since workers are communicated indirectly through 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.

CONCLUSIONS

A strategy diagnosis model for introducing Lean Production to precast fabricator is discussed in this paper. Three perspectives of business operation system, i.e. production system, management infrastructure, and staff attitude and behaviour, are considered in the model. The lean diagnosis model proposed in this study could 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 development of lean diagnosis model relies on the knowledge and experience of analyzers. Moreover, if precast fabrication factory is without comprehensive database and if the diagnosis process is not supported by directors and/or staffs, the hidden problems of precast fabrication factories could not be revealed.

ACKNOWLEDGEMENTS

The authors would like to thank the studied precast fabricator for helping with the better understanding of current practice.

REFERENCES

Ansari, A. and Modarress, B. (1990). *Just-in-Time Purchasing*, Free Press, New York.

Daniels, H. A. M. and Feelder, A. J. (1992). Explanation and diagnosis in business assessment, *IEEE Transactions on Systems, Man and Cybernetics*, 22 (2) 397-402.

Drew, J., McCallum, B., and Roggenhofer, S. (2004). Journey to Lean: Making Operational Change Stick, Palgrave Macmillan, New Yprk.

Green, F.B., Amenkhienan, F., and Johnson, G., (1992). "Performance measures and JIT." *Management Accounting*, 10 32-36.

Inman, R. A. and Mehra, S. (1991). "JIT implications for service environments." *Production and Inventory Management Journal*, 32 (3) 16-21.

Liker J. (2004). The Toyota Way: 14 management principles from the world's greatest manufacture, McGraw-Hill, New York.

Ma, M.J. (2000). *Effective Business Diagnostics*, Chao-Yue Enterprise Management Publisher, Taipei, Taiwan (in Chinese).

Natarajan, R. (1991). "Inventory management – the big picture." *Production and Inventory Management Journal*, 32 (4) 29-31.

Ohno,T. (1988). *Toyota Production System: Beyond Large-Scale Production*, Productivity Press, New York.

Porter, M. (1980). *Competitive Strategy: Techniques for Analyzing Industries and Competitors*, Free Press, New York.

Takahiro, F., (1999). *The Evolution of a Manufacturing System at Toyota*, Oxford University Press, New York.

Womack, J.P. and Jones, D.T. (1996). *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*, Simon and Schuster, New York.

Yasin, M.M., Small, M.H., Wafa, M.A. (2003). "Organizational modifications to support JIT implementation in manufacturing and service operations." *Omega*, 31 (3) 213-226.