

## Key Practice Areas of Lean Manufacturing

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**Abstract**— Today, many organizations are enthusiastic to adopt lean manufacturing strategy that would enable them to compete in this competitive globalization market. In this respect, it is necessary to assess the implementation of lean manufacturing in different organizations so that the important best practices can be identified. This paper describes the development of key areas which will be used to assess the adoption and implementation of lean manufacturing practices. Specifically, a set of 14 key areas is developed based on a thorough analysis and synthesis of previous studies. These areas are work processes, scheduling, inventory, equipment, layout, material handling, employees, quality, product design, suppliers, tools and techniques, customers, ergonomics and safety, and management and culture.

**Keywords:** Lean manufacturing, key practice areas

### I. INTRODUCTION

Lean manufacturing or lean production has attracted vast interest from both academicians and practitioners. Technical aspects of lean manufacturing have been widely discussed. It has become a universal production method and numerous plants around the world such as Toyota and other companies have successfully implemented it. Though Lean manufacturing started in the automotive industry, it has been applied successfully in other disciplines as well. Due to heightened challenges from global competitors, lean manufacturing has become a production method for many organizations to pursue. However, there is a lack of studies which are focused on consolidating the various key practices of lean manufacturing and investigating their level of adoption in real life. This paper reviews the practice areas of lean manufacturing suggested by previous authors. A set of 14 areas believed to be more comprehensive and encompassing is then proposed. This set of key areas will be used to explore the adoption of lean manufacturing practices in the future.

This paper is organized as follows. Firstly, lean manufacturing is reviewed. Secondly, comparison and analysis of previous research are done. Then, a set of key practice areas to assess the adoption of lean manufacturing is proposed and discussed. Finally, the paper ends with conclusions and future recommendations.

### II. LEAN MANUFACTURING

Toyota Production System (TPS) which was relabeled as Lean manufacturing by Womack, Jones, and Roos [1] in their book “The Machine That Changed the World” has influenced the manufacturing practices around the world. The fundamental of TPS is to eliminate wastes and produce only the items needed at the required time and in the required quantities. Principles of lean are universal as they are broadly accepted by many manufacturing operations and have been applied successfully across many disciplines [2]. It has become an integrated system composed of highly inter-related elements and a wide variety of management practices, including Just-in-time, quality system, work teams, cellular manufacturing, etc. [3] The main purpose of implementing lean manufacturing is to increase productivity, reduce lead time and cost, and improve quality, [4][5] thus providing the upmost value to customers.

There are many descriptions regarding lean manufacturing. It is most frequently associated with the elimination of the seven important wastes to ameliorate the effects of variability in supply, processing time or demand [6]. The seven wastes mentioned are: overproduction, waiting, unnecessary transport or conveyance, overprocessing or incorrect processing, excess inventory, unnecessary movement and defects. According to Womack Jones, and Roos, [1] lean manufacturing uses less of everything compared to mass production- half the human effort in the factory, half the manufacturing space, half the investment in tools, and half the engineering hours to develop a new product. In addition, it requires keeping far less than half of the needed inventory on site, results in many fewer defects, and produces a greater and ever-growing variety of products. In short, it is called lean because it uses less, or the minimum, of everything required to produce a product or perform a service [7].

### III. REVIEW AND ANALYSIS OF KEY AREAS FOR LEAN MANUFACTURING

Several authors have developed their own set of key areas to assess the adoption and extent of implementation of lean manufacturing in assorted manufacturing plants across the world. In this section, six previous relevant studies are reviewed and compared.

Sohal and Egglestone [8] assessed the adoption of lean manufacturing in Australian organizations by focusing on five areas: lean production methods, relationships with suppliers, new product development and launch, timeframe for holding inventory and organizational structural change. Merely 7 production methods were evaluated namely JIT, Kanban, Kaizen, Total Quality Management (TQM), Group Technology, Flexible Manufacturing System and Quality Circles. In addition, no specific practices on new product development were given.

Shah and Ward [3] examined the effects of three contextual factors: plant size, plant age, and unionization on the likelihood of implementing 22 lean manufacturing practices. The 22 practices were bundled into four core groups which were Just in time (JIT), Total Quality Management (TQM), Total Preventive Maintenance (TPM), and Human Resource Management (HRM). Data from Industry Week's Census of Manufacturing were used as study samples. Although Shah and Ward [3] successfully grouped the practices into four general areas, a few elements which were crucial for lean implementation such as suppliers, and improvement in inventory were not added. Moreover, the study did not include product design.

Shah and Ward [6] identified 48 items that represent lean manufacturing in 10 inter-related principal components. The 10 main components were: supplier feedback, JIT delivery by suppliers, supplier development, customer involvement, pull, continuous flow, setup time reduction, total productive maintenance, statistical process control, and employee involvement. They concluded that none of the 10 dimensions of lean production should be omitted because each of them was an important contributor to obtain synergistic performance goals. Almost half of the total items were on supplier and customer and there were no emphasis on layout and inventory practices. The 10 components also did not incorporate product design and inventory management which was vital to ensure the success of lean implementation in an organization.

A study has been done by Taj [9] in various manufacturing plants across China to investigate the adoption of lean production and assess its current state of practices. The assessment tool used in the study was developed by Strategos, Inc. and it included nine key areas

of lean manufacturing namely: inventory, team approach, processes, maintenance, layout/handling, suppliers, setups, quality, and scheduling and control. Despite this, the assessment areas did not contain customers and product design.

Doolen and Hacker [10] developed a survey instrument to assess the number and the level of implementation of a broad range of lean practices in electronic manufacturers in the Pacific Northwest. They identified six impact areas with each area specified with a set of supporting practices. The six areas were: manufacturing equipment and processes, shop floor management, new product development, supplier relationships, customer relationships and workforce management. Interestingly, areas such as safety and inventory were not included as important factors in their study.

Panizzolo [11] conducted a field survey in Italian manufacturers from a wide range of industrial sectors. The survey consisted of 48 lean practices in six different areas, which were process and equipment, manufacturing planning and control, human resources, product design, supplier relationships, and customer relationships. Among the six lean principles, quality was not taken in as a main area of intervention.

Most authors have mainly taken into account areas like employee involvement, maintenance and setup time, quality, planning and scheduling strategies, and suppliers in their assessment tool. These areas or components are seen as essential to be assessed within an organization towards becoming a lean manufacturer. However, a few areas such as product design and customers are less mentioned. The least mentioned by all the authors is safety. Table I summarizes the comparison between previous studies of lean manufacturing in various countries and industrial sectors.

### IV. PROPOSED KEY AREAS FOR ASSESSMENT

As evident from the review and analysis above, different sets of areas have been investigated by different authors. A consistent and cohesive model for assessing the key areas of lean manufacturing is still lacking in the literature. By integrating the common factors and introducing some new ones, a set of 14 areas which is more comprehensive and holistic is proposed. These areas are *work processes, scheduling, inventory, equipment, layout, material handling, employees, quality, product design, suppliers, tools and techniques, customers, ergonomics and safety, management and culture*.

Table I: Comparison of previous studies in investigating lean practices

Author(s)	Purpose	Areas of Practices	Study sector
Sohal & Egglestone [8]	To investigate the extent of lean implementation	5 areas	Wide range of Australian companies
Panizzolo [11]	To explore how lean production has been adopted by firms	6 areas with 48 practices	Italian own brand manufacturers
Shah & Ward [3]	To examine the effects of three contextual factors: plant size, plant age, and unionization on the likelihood of implementing lean manufacturing practices	22 practices in 4 bundles (JIT, TQM, HRM, TPM)	US manufacturing firms
Doolen & Hacker [10]	To assess both the number and the level of implementation of lean practices	6 areas with 29 practices	Electronic manufacturers in the Pacific Northwest
Shah & Ward [6]	To develop and validate a multi-dimensional measure of lean production	10 components with 48 items	Manufacturing firm implementing lean with more than 100 employees
Taj [9]	To investigate the adoption of lean production and assess its current state of practice in selected plants	9 areas	Wide range of manufacturers in China

Areas such as employees, equipment, scheduling, quality and suppliers are common in lean manufacturing and thus they are definitely applicable. *Employees* who are motivated and empowered are essential since people are the key element in lean manufacturing. Unexpected machine downtime would result in line stoppage and decrease productivity. Therefore, *equipment* is a vital area where preventive maintenance and reduction of setup time play an important role to ensure the success of lean manufacturing. Appropriate *scheduling* methods such as pull system could reduce inventories and avoid overproduction. In addition, *quality* is critical in lean manufacturing because poor quality management would result in many wastes such as scraps and rejects. *Suppliers* are also vital to lean manufacturing. It is important to encourage suppliers to develop capabilities of JIT production as well as JIT delivery in order to enhance long-term competitiveness. [12]

*Material handling* is identified as important in lean manufacturing because material movement and waiting time are wastes that need to be minimized. Another key area of lean manufacturing is *layout*. It determines the travelling

distance and processing sequence. An inappropriate layout would result in unnecessary transport or conveyance which is a major waste. It is also crucial to standardize *work processes* and eliminates non-value added activities in order to achieve lean. Other than that, there is a need to maintain the *inventory* at the minimum level because excess inventory would require more valuable space and result in higher carrying cost. *Product design* is also important as the choices of product structures and materials would affect the production methods and cost. Karlsson and Ahlstrom [13] found that concurrent engineering techniques play a vital role in a "lean" product development process. Another area included is *tools and techniques*. Using tools such as value stream mapping and poka-yoke, 5S etc. would assist organizations to ensure the success of lean manufacturing. Besides this, setting up good relationships with *customers* would enable an organization to meet customers' needs and predict their demands accurately.

Apart from the above areas, two new areas (i.e. *ergonomics and safety, management and culture*) are incorporated in the proposed model. Safety should be

Table II: Comparison of key areas between previous studies and authors' proposition

General Areas	Sohal & Egglestone [8]	Panizzolo [11]	Shah & Ward [3]	Doolen & hacker [10]	Shah & Ward [6]	Taj [9]	Authors' Proposition
Inventory	Timeframe for holding inventory					Inventory	Inventory
Human resources	Organizational structural change	Human resources	HRM	Workforce management	Employee involvement	Team approach	Employees
Processes		Process and equipment	JIT	Manufacturing equipment and processes	Continuous flow	Processes	Work processes
Facilities			TPM		TPM, setup time reduction	Maintenance, setups	Equipment
Layout						Layout / Handling	Layout
Handling							Material handling
Quality			TQM		SPC	Quality	Quality
Scheduling		Manufacturing planning and control		Shop floor management	Pull	Scheduling and control	Scheduling
Product design	New product development and launch	Product design		New product development			Product design
Suppliers	Relationships with suppliers	Supplier relationships		Supplier relationships	Supplier development, supplier feedback, JIT delivery by suppliers	Suppliers	Suppliers
Methods	Production methods						Tools and techniques
Customers		Customer relationships		Customer relationships	Customer involvement		Customers
Others							Ergonomics and safety Management and culture
	5 areas	6 areas	4 bundles	6 areas	10 components	9 areas	14 areas

highlighted as Ohno [14] once said that it is the foundation of all activities. Ergonomics is also important as it helps humans to improve productivity, reduce injuries and fatigues [15]. By using ergonomic features, unnecessary motions (one of the major wastes) are reduced. This helps to reduce mistakes caused by human errors thus enhancing the quality of products. Management and culture is also included as a new area in this study. It is critical for top management to understand and give ample support to sustain the lean concept. Communication between senior managers and employees is essential to ensure that the vision and mission of lean manufacturing is attainable. In essence, all the crucial factors discussed above are summarized and compared in Table II.

## V. CONCLUSION

This paper has reviewed the relevant studies on lean manufacturing and identified their limitations. The key areas proposed are more comprehensive to assess the current state of adoption and implementation of lean manufacturing. The proposed set of key areas will be

validated and improved using a pilot study that involves experts from the academia and industry. A survey for investigating the adoption and implementation of lean manufacturing using the proposed key areas will be carried out in the next stage of this research.

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