Identification and Ranking the Key Dimensions of Lean Manufacturing using NEW Approach in Gas Industry

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***Abstract*- Identifying and ranking the key dimensions of Lean manufacturing/services (LM can be considered the first step in implementing these systems in industry, because as long as the managers and staff have not action is to overcome these obstacles, failure of this project seems inevitable. In this study, after identifying the key dimensions to successful implementation of LM in the gas industry through literature review and interviews with experts, 7 main dimensions detected. Then, using SWARA (Stepwise weight assessment ratio analysis) technique, the final weight of dimensions was calculated and ranked in order of importance. The final result of research in assessing and implementing LM systems in the gas industry showed that Services improvement as the most important and Equipment and services process was detected in the lowest rank. Therefore gas industry by addressing and fostering these dimensions as an effective step in the successful implementation of the LM system and will be improving the quality of customer service.**

Keywords: Lean manufacturing/services, Key dimensions, SWARA, Gas industry.

I. INTRODUCTION

One of the most claimed issues is that the era of mass production has reached the end of its life cycle and replaced by new methods including flexible allocation [1]. Lean manufacturing is a new step in production that combines the advantages of mass production and manual production. Lean refers to lean production or lean manufacturing, so that it uses less materials and manpower compared with mass production. This system only uses half of manpower efforts in the factory, half production space, half equipment investment and also half engineering hours for production of new products in half period [1, 2].

Generally, the lean manufacturing paradigm is removing any non-value added activities. Lean manufacturing principles include: eliminating wastes, zero defects, multi-dimensional teams, and reduction of organizational layers, team leadership, and vertical information systems, continuous improvement and pull systems. This method is based on systems including workers with several skills, automatic and flexible machines. In this method, the organization management tries to remove production space, equipment investment, engineering work hours and stagnant inventory and pays attention to zero defect and zero inventory. In lean manufacturing, the producers try to achieve advantages and avoid disadvantages in manual and mass production. They have measures that reduce products cost and produce the products that the customers need them using skilled staff in all organizational levels and multi-dimensional machineries with capability of producing various products [3].

Lean production aims to have better functions for customers, staff, stockholders and society [4]. However, in England, less than ten percent of the firms succeeded in using lean manufacturing methods [5]. Although, the advantages of lean manufacturing are not always obvious but now, the methods and tools of lean manufacturing have been considered by producers compared with traditional methods [6]. Indeed, lean manufacturing is an exponential jump from Ford mass production to new paradigm of production. Although, leanness is the same in all companies, but the process of converting to lean firm provides specific and different outputs in organizations [7].

In this research, with literature review and identification of lean manufacturing dimensions and key criteria's, presenting a model in this field and finally ranking of this dimensions using SWARA, can help the gas industry in implementation of lean systems and achieving to the competitive advantages and satisfying of her customer needs.

II. THE THEORICAL BASED OF THE RESEARCH

A. Lean manufacturing dimensions

Association of Standards and Technology in the American Ministry of Commerce has defined lean manufacturing/ service as follows: “A systematic approach to recognize and eliminate waste through continuous improvement and launch production just when the customer needs it”. Generally, from this perspective, the production system of production factors, materials, human force, parts, machineries, time and etc. that is used more than minimum amount and does not create value added in the product is called waste. However, the idea of eliminating waste was introduced by Taylor and in academic management for the first time and it was completed in on time production [8]. Lean manufacturing (LM) eliminates waste via inventory control and reduction of process lag time. LM was developed by Toyota initially via focusing on eliminating all forms of waste, including defects needed to duplication, removing unnecessary process steps; unnecessary materials or individuals, waiting time, inventory and overproduction [1, 9].

The lean manufacturing philosophy helps the managers to reduce operations costs through elimination of waste. Waste is everything that does not provide the product or service value added [9, 10]. Through eliminating waste, ultimately, the value of production systems is increased for producing products with good quality in order to increase customer satisfaction [11]. Lean manufacturing is related to zero inventory and on time production approach [10, 11]. Several researchers have focused on the key principles of lean production, such as paying attention to individuals [12], quality management, pull production [13] and mistake proofing [14]. At the operational level, these principles lead to techniques such 5S. In addition, measures such as on time production, total production maintenance (TPM), and management are used. Total quality is used to remove different types of waste. In literature, different definitions of lean philosophy can be found which have a common principle of eliminating waste and reducing costs. Basically, the term "lean" refers to a set of activities or strategies to eliminate waste, reduce non-value added (NVA) operations costs and improve value-added process.

Toyota suggested statistical quality control procedures in 1949 according to statistical quality control program to overcome crises. At the same time, Eij Toyoda with the engineer of the company, Taiichi Ohno traveled to America for research on cars manufactured in the world's largest and most efficient production plant (Ford's Rough in Detroit) to use their style. At that time, Ford manufactured 7000 cars per day that seemed a fairy tale compared with its results of 1950 Toyota cars in 13 years. Hence, Toyoda decided to investigate on the production of this plant for three months. During his stay in Ford, Eiji wrote a letter to his boss in Japan and mentioned that he can make some improvements in production systems. Then he and Ohno (after few visits to Detroit) returned to Japan and finally concluded that Ford's production volumes cannot be used in Japan, so they concluded that the lean manufacturing principles cannot be implemented in Japan because it produces significant amount of waste [1, p. 49]. Therefore, they made a new style that was called "lean" later. Now, Toyota is the "leader" among competitors [15].

They found that a lot of wasting is occurred in manpower, efforts, materials, time and space, inventory, and processing defects, excessive waiting time, transportation, and accommodations. They were able to see that the professionals who were away from assembly workers do not have value-added activities. They are only responsible for product and process design and they give orders to workers. The only activity of a foreman is to ensure that the workers follow orders and the assembly line workers have one or two simple duties [1]. From these observations, they understood that this type of losses (human resources and material resources) is less in Japan and Toyota Company and they could not copy and implement what they have seen in America. When Ohno returned to Japan, in the first step, he constituted a team by workers and encouraged them to work together and implement the best method of operation and in the next step, he expanded their duties including repairing of tools, checking the quality, and other activities such as 5S. Then he expanded their duties further.

What is important in the move towards lean manufacturing is building and deployment of key subsystems and beginning from what subsystem depending on the administrator of the organization. To achieve all the goals of lean manufacturing, after the implementation of a subsystem, other subsystems required for lean should be implemented in the organization [16]. Companies need to know the importance of lean manufacturing and what is not working well [17, 18]. Ranko (2012) simulated the lean tools in an efficient production system. This research suggests following items for companies that want to employ lean manufacturing [18]:

1. How much leanness is critical for them?
2. What factors are critical for success of lean?
3. What is not working well?
4. What should be done to promote leanness efforts?

New tools were identified for lean manufacturing in addition to tools had been identified before including modeling, analysis of bottlenecks, cellular manufacturing, lean supermarket, visual control, and zero quality control [18]. In order to be truly effective, lean manufacturing should not just focus on manufacturing, but also it should consider the entire supply chain. Six characteristics of lean supply chain include demand management; reduce costs and waste, process standardization, industrial standardization, organizational and cooperation cultural change [19].

B. The proposed conceptual model of research

The terms such as "lean production", "lean product", "lean assessment", "lean measurement ", and "lean indices" have been used in the literature on various databases such as Scopus, Google, Scholar, ISI Web of Knowledge and etc. The most common indices can be extracted in the manufacturing industry with reference to the literature. In another study, Amelia et al (2013) designed a conceptual model by the aim of extracting the most commonly used lean indices and dimensions by survey on 25 articles which focuses primarily on the key areas for measuring the leanness in production [20]. Table I summarizes the key dimensions mentioned since 1996 to 2013, along with the importance of factors and dimensions in 25 important studies:

TABLE I

The importance of factors and dimensions [20]

Dimension	Factor	Frequently
Work force	Developing of work force Contribution of work force	14 (H) 4 (VL)
Manufa-cturing process & equipment	SPC TQM Process focus Pull system JiT Eliminate of waste (TPM) Decrease of set up time Process control Work standardization Continues improvement Manufacturing smoothing 5s New process/Equipment technologies Safely improvement Decreasing of time cycle Value identification	12(L) 14(H) 13(L) 13(L) 11(L) 12(L) 11(L) 8(VL) 6(VL) 5(VL) 6(VL) 5(VL) 4(VL) 4(VL) 4(VL) 4(VL)
Supplier	Supplier development JiT delivery with supplier	8 (L) 7 (VL)
Planning & manufacturing scheduling	Management/Shop organization	7 (VL)
Costumer	Costumer Relationship Costumer contribution	6 (VL) 5 (VL)
Visual information system	Visual management system Visual information system	5(VL) 4 (VL)
Technology & service development	DFMA/DFM	4 (VL)

According to Table I and analyses of the literature and following questions, seven dimensions were identified as the main dimensions of a lean assessment:

1. What are the indicators of lean measurement in the production system?
2. What similarities exist in factors discussed among researchers?
3. What are the differences in findings?

The Table II shows the description of each dimension:

TABLE II

The description of lean dimensions

Dimensions of lean manufacturing	Description
Equipment and services process	Ensure that quality standards are observed. Many efforts have been done to reduce the time set for continuous flow production, and services process redesign according to cellular manufacturing and preventive maintenance [21].
Planning and services scheduling	Synchronous services and market demand. This goal can be achieved through leveled product. Use small batches, pull control and ... [21].
Visual information systems	A simple information system depended on the direct information flow that allows related decision makers to have a quick feedback and corrective action including performance information appeared in the press boards [22].
Services improvement	Substantial choice of services structures and technical solutions. Innovative operation agreements in the services operations / advanced methodologies in the design of services such as QFD, design review, FMEA or VRP and etc [22].
Workforce management	Employee participation in plans of continuous quality improvement, development of authority and responsibility taking, including recruitment and selection, training, evaluation and reward for promoting employees' participation, empowerment, and accountability [21].
Contact with supplier	Increase the level of "operational integration" between buyer and supplier considering viewpoints on the transfer of materials from supplier to supplier (logistical relation) that impact on some viewpoints in R&D and logistics [21].
Customer relationship	Develop a logistics relation. Making efforts to ensure advanced and reliable deliveries, development of marketing and business techniques to create a predictable and stable demand, as well as improving the competitiveness and professional of the personnel to deal directly with customer [20].

According to literature review and interview with experts and managers of gas industry, the conceptual model of dimension is proposed as figure 1:

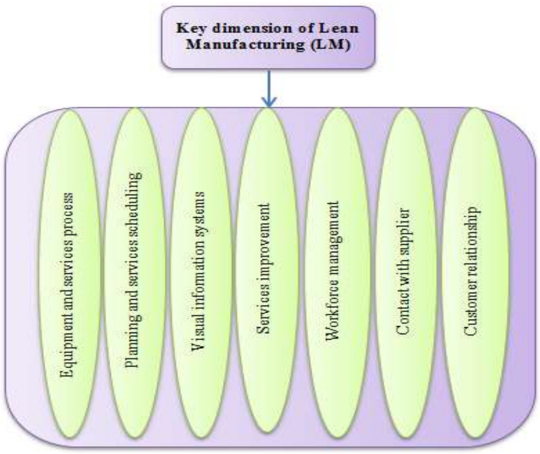

Figure 1. Research proposed conceptual model of Lean dimensions

III. RESEARCH METHOD

The present study is applied firstly because investigates the efficacy of the theories on “lean manufacturing” and expands applied knowledge in this area, and secondly because the suggested tool (model) is used for implementation in an organization and it is descriptive in terms of collecting and analysis of data obtained via questionnaire.

IV. PRIORITIZING THE LEAN KEY DIMENSIONS VIA SWARA

In order to prioritize the identified key dimensions, SWARA technique is used. SWARA is one of the new methods of MCDM which was used in 2010 to develop analysis of the differences between the criteria. In SWARA, each expert ranks the criteria at first. The most important criterion is scored one and the least important one receives low score. Finally, the criteria are prioritized according to average values of the relative importance. In this method, the expert assesses the calculated weights. In addition, each expert specifies the importance of each criterion according to tacit knowledge, information and experience. Then according to the average value of the group's ranks obtained by experts, the weight of each criterion is determined [23]. Therefore, in this study, the views of 15 gas industry experts were used. The weight of each criterion indicates its importance. Measuring of weight is an important topic in many issues of decision-making. SWARA is one of the weighting methods in which professionals play an important role in the calculation of their weight and final assessment. Figure 2 shows the technique executive steps [24, 25].

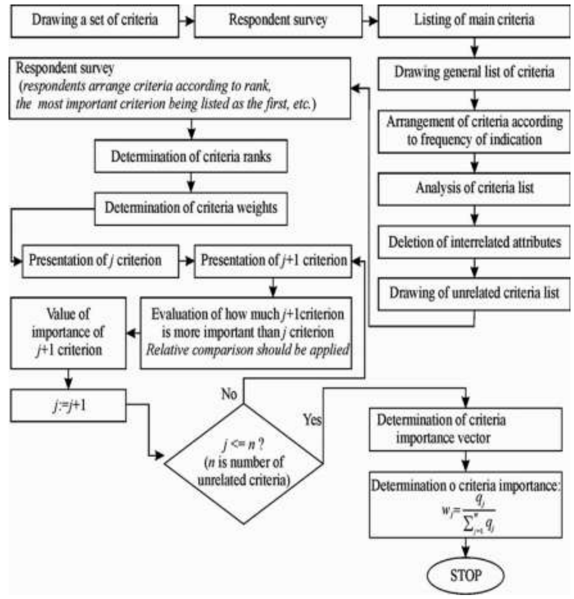

Figure 2. The technique executive steps

After the literature review of research and interview with experts, 7 dimensions of lean manufacturing in gas industry were identified as Table III:

TABLE III
Key dimensions of lean manufacturing

Key dimensions	Symptom
Workforce management	D1
Customer relationship	D2
Visual information systems	D3
Services improvement	D4
Equipment and services process	D5
Contact with supplier	D6
Planning and services scheduling	D7

Then, these dimensions were studied using SWARA technique. SWARA technique is based on expert’s opinions, and it is a judgment method. In this research, we have used from 15 experts as Table V:

TABLE IV
Information of experts

Group	Classification	Number
Record of service	Manager	1
	Exploitation engineering	8
	Programming and control	6
Education level	Licentiate	4
	Master	9
	Doctoral	2
Sexuality	Male	13
	Female	2

For doing so, the opinions of 15 experts on key dimensions were identified and the dimensions initial weight was extracted. In fact, the experts were asked to prioritize each dimension individually, and finally to calculate the relative importance of these dimensions, count the number of priorities of each dimension according to experts' viewpoints. For example, the fourth dimension was placed six times in rank one, four times in rank two, three times in rank three, and two times in ranks 4 and 5. After prioritizing key dimensions by the experts, to calculate the weight of each dimension, the number of priorities for each dimension was multiplied by the difference score of the highest score and relevant score.

Table V summarizes final calculation of the weight and importance of each of the dimensions using SWARA that dimensions can be ranked according to the last column weights.

TABLE V
The weight and importance of each of the dimensions

Dimension	Sj	Kj = Sj+1	Wj	Qj	Rank
Services improvement (D4)	-	1	1	0.207	1
Contact with supplier (D6)	0.15	1.15	0.869	0.180	2
Customer relationship (D2)	0.16	1.16	0.749	0.155	3
Workforce management (D1)	0.13	1.13	0.662	0.137	4
Visual information system (D3)	0.14	1.14	0.580	0.121	5
Planning and services scheduling (D7)	0.13	1.13	0.513	0.106	6
Equipment and services process (D5)	0.15	1.15	0.446	0.092	7

V. CONCLUSION AND RECOMMENDATION

Identification and ranking (Determination of importance) the key dimension of lean manufacturing/service system is one of managers basic tasks and engineers of industry. In this research, seven key dimensions (Workforce management, Customer relationship, Visual information system, Services improvement, Equipment and services process, Contact with supplier, Planning and services scheduling) were identified after the literature review of key dimensions of LM and interview with experts of gas industry, that these dimensions construct the conceptual model. Then the identified dimensions were ranked using SWARA new technique and expert's opinions of gas industry. The results of this technique explant that Services improvement is as the most important of dimension, and Equipment and services process is the lowest important in implementation of LM system in gas industry. So, the gas industry can success in implantation of this system, reduce wasting costs and to find an opportunity to superior performance.

We can use FAHP, FANP … for ranking of dimensions, and also is recommended to path analysis for confirmation the relationship between dimensions in research conceptual model using SPLS software.

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