Analysis of The Issues In Implementation of Lean Manufacturing For Sustainable Development Using ISM

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Abstract

In the past decade, competition in the global market is increasing. So industries are adopting lean manufacturing for the sustainable development. In the implementation of the lean manufacturing for sustainable development, they are facing many issues. This paper 12 these issues have been identified by export opinion in academic and industrial level. Interpretive structural modeling (ISM) approach used to set inter-relation between them. The result of MICMAC analysis will be useful for the successful implementation of the lean manufacturing for the sustainable development.

Keyword: Lean Manufacturing, Interpretive Structural Modelling, Issues in Implementation LM.

Introduction

In recent time business is conducted in a global economy and with this competition is also increasing day by day. Customer wants the product or services at lower prices without compromising the quality. This putting tremendous pressure on the manufacturers to implement lean manufacturing to achieve sustainable development. Schonberg coined the term World Class Manufacturing (WCM), which means a manufacturing technology having the right production capability to make money by satisfying the customer, with high quality of products and services

at the right price, at the right time. Just in time(JIT), manufacturing and total quality management (TQM) are all techniques to achieve World Class Manufacturing (Cammell, 1991). Lean manufacturing can be used to improve the operational performances of the organization. Lean manufacturing basically refers to manufacturing processes with minimum waste. Lean manufacturing approaches were developed by Eiji Toyoda and Taiichi Ohno of Toyota in the 1950s and 1960s Womack et al. (1990).As different authors describes lean manufacturing in different ways. Lean manufacturing identify and eliminate the waste from the system. Waste in Japan as defined by Toyota's Fujio Cho define waste as anything other than the minimum amount of materials, parts, equipment and workers (working time) which are absolutely essential to production (Suzuki, 1978). Krafric (1988) define lean as a production system that uses everything in order to improve production and quality. Shah and Ward (2003) describe lean production is a multi-dimensional approach that encompass a wide variety of lean practices, some of them are continuous improvement, just-in-time, production smoothing, cellular manufacturing, lot size reduction, pull system, focused factory production, cycle time reduction, safety improvement programs, quick change over technique, total quality management, self-directed work teams, re-engineered production system etc. in an integrated system. The intention of Lean manufacturing is to identify and eliminate that processes, resources which do not add value to a product or services.

While implementing lean manufacturing system in industries to bring some significant business development, it has to face many issues such as lead time reduction, inventory reduction, workers participation to the management's decisions, change over time reduction, culture change, throughput time reduction, breakdown maintenance reduction, customers satisfaction, vendor development etc.

The objective of this paper to identify some the issues in implementation of lean manufacturing for sustainable development though the expert opinion and literature review. ISM technique is used to analyze these issues. Main objectives of this paper are:

• To identifies and analysis the issues in implementation LM for sustainable developments.

• To develop ISM model using issues in implementation LM for sustainable developments.

• To suggest research insights using MICMAC analysis.

Literature Review

Lean manufacturing is based on the Toyota Production System. The concept of the TPS was in the book name as The Machine that Changed the World, Womack et al. (1991). Hines et al. (2004) converse about this evolution of lean. Researcher found many issues facing while implementing lean manufacturing for the business developments for the sustainable development Rishi et al. (2018) employ the lean technique in the axle housing manufacturing process to improve its productivity. To increase the productivity, Kaizen technique is used by reducing the lead time. Kumar and Kumar (2015) present benefits gained by implementing lean manufacturing in the Indian industry. Bhamu and Sangwan (2014) published a lean manufacturing literature review paper. As per his research a total of 209 research papers during the period from 1980 to 2012 have been reviewed. Robinson et al. (2012) improved service and process delivery by using lean approach and discrete event simulation. Upadhye et al. (2010) focus on the importance of lean manufacturing to achieve sustainable development for the significant improvements in the business development. The way to achieve sustainable development lies in the customer satisfaction through reduces cost, reduces delivery lead time, improved quality, and proper communication. Lean Manufacturing philosophies assist to managers to identify and eliminate or minimize waste at every stage of operations in a systematic approach. His research presents a model to implement Lean manufacturing principles in an organization. This paper identified some issues as lead time reduction, inventory reduction, quality improvements, breakdown maintenance reduction, customer satisfaction, vendor development, fast development of new product Abdulmalek and Rajgopal (2007) describe a case where lean manufacturing principles were adapted for the manufacturing process sector for application at a large integrated steel mill. Value stream mapping was the main tool used to identify the opportunities for various lean techniques. They also describe a simulation model contrast the ‘‘before’’ and ‘‘after’’ scenario, in order to demonstrate to managers potential benefits such as decrease production lead-time and work-in-process inventory.

Thought the extreme literature survey some issues are identified in implantation of lean manufacturing in sustainable development. They are as follow;

1. Workers Involvements: Workers participation plays an important role in lean manufacturing for sustainable development. So worker training for the lean manufacturing should be done and

standard of procedure are to be used on the work stations, skill development classed, 5S training to be given to the worker. The worker to become a participant in decision making and thus necessary putting trust and responsibility in the hands of the workers, to become the same interest group by way of having long term relationship

2. Customer satisfaction: In India the customer awareness is increasing due to increasing number of middle class customers who are differ value demanding value for their money while not ready to negotiation on quality of the products. The key to achieve sustainable development of lean manufacturing lies in the customer satisfaction by improved quality, reduced cost, reduced delivery lead times and proper communication.

3. Inventory reduction: Inventory is defined as the stock maintain by the origination to meet the fluctuation in the demand. Higher the inventory leads higher to cost of the organization. Lower the inventory lead to failure the fluctuation demand of the customer. This also leads to customer dissatisfaction. The inventory level should be optimum to meet the fluctuation demand of the customer.

4. Lead time reduction: lead time is the time between the order placement and the shipment of the completed order to the customer. A shorter lead time is a competitive advantage as many customers want the delivery of their products as soon as possible following the placement of the order. Automated transports, JIT are some solution to reduce the lead time reduction.

5. Throughput time reduction: Throughput time is the time required for a material, part or sub-assembly to pass through a manufacturing process that convert the raw material to the finish good. Kaizen, JIT are some technique to reduce the throughput time.

6. Communication: It is necessary for the development of the organization that there will be involvement of the worker to the decision making. There should be proper communication between the top management and the workers. There should also communication between the different departments of the organization. These issues can be solved by using the cross work force technique.

7. Vendor development: Vendor development is one of the popular techniques of planned sourcing, which improves the value we receive from suppliers. It can be defined as any activity that a buying firm undertakes to improve a supplier's performance and capabilities to meet the buying firms' supply needs.

8. Breakdown maintenance reduction: Breakdown maintenance time is the taken to maintain the machine failure. It can be planed and unplanned. This is the one of the reason of existence inventory in the system. Preventive maintenance is a solution to reduce the breakdown maintenance time.

9. Change over time reduction: The setup time necessary to prepare a given part of a production system to a different product is a typical example of waste, as no added value is provided during that process, and thus it should be reduced to the lowest possible value.

10. Cultural change: Every business has a culture. Sometimes it develops on its own as a company grows. Other times it is enlightened by a specific plan. As new employees come into the company, they adapt to the company's culture and persuade it as well. To keep your company's culture in the right direction requires a strategy and tactical plan. Some it create issues to organization changing.

11. New product development time reduction: It is the required to the development of the new product in the market. It is necessary to the implementation of the lean manufacturing for the sustainable development that the new product development time should be minimum.

12. Improved material handling and housekeeping: Effective housekeeping is essential to eliminate and minimize workplace problems and accidents, that product can produces safely and properly. It is about cleanliness, keeping work areas clean and orderly and maintaining work space. The proper layout of the workplace focuses on arrangements of tools and equipment and the adequacy of storage facilities.

Methodology

Interpretive structural modelling (ISM) approach has been used to analyze the issues in implementation of lean manufacturing for sustainable development. This is a wildly and powerful used methodology in decision making in literature for such type of analysis.

Overview of ISM

Interpretive structural modelling is an interactive learning process. This approach is used to identifying and set the relation among the specific variables and which define issues and problems. In ISM technique, a set of different directly and indirectly related variable/variable are

structured into a comprehensive well define systematic model. Warfield developed this powerful methodology for complex issues.

Various steps of ISM methodology are as follows:

- Identify the issues/factor related to the problems by research paper and survey.
- Establish a contextual relationship between issues/factor with respect to which pairs of elements would be examined.
- Develop a structural self-interaction matrix (SSIM) of issues/factor.
- This matrix indicates the pair-wise relationship among issues/factor of the system.
- Checked for transitivity of matrix.
- Develop a reachability matrix (RM) from the SSIM.
- Partition the reachability matrix into different levels.
- Convert the reachability matrix into conical form.
- Finally the hierarchy of the variables is formed.

Table 1 Application of ISM approach in different Areas.

S.No	Name of Authors (year)	Area of Application
1	Sandeepa and Chand (2018)	Analysis of flexibility factors in Sustainable Supply Chain
2	Gothwal et al. (2017)	Analysing the factors affecting the flexibility in FMS
3	Cagno et al. (2014)	Occupational safety performance for Small and Medium-sized Enterprises
4	Attri et al. (2013)	Modelling the enablers in the implementation of Total

		Productive Maintenance
5	Ansari et al. (2013)	Analysis of barriers to implement solar power installations in India
6	Sunil et al. (2011)	Barriers to implement green supply chain management in automobile industry
7	Singh and Kant (2008)	Knowledge management barriers
8	Ravi et al. (2005)	Productivity improvement in supply chain
9	Sharma et al. (1995)	Waste management in India

4.1.1 ISM Modelling for Analysing the Lean Practices

The various steps which lead to the development of ISM model are illustrated below:

Step 1: Structural Self-Interaction Matrix (SSIM)

The expert of both, industry and academic identify contextual relations among the factors. Following symbols are used to denote the direction of relation:

• V: factor i will lead to j

• A: factor j will lead to i

• X: factor i and j will lead to each other

• O: no relation between factors.

On the basis of the contextual relation, Structural Self-Interaction Matrix (SSIM) has been developed among the factors

Table 2: Structural self-interaction matrix (SSIM)

Factors	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
1	V	V	V	O	V	O	X	V	V	V	V
2	O	A	A	O	O	A	A	A	A	O	

3	A	V	O	A	A	O	A	X	X		
4	A	V	O	A	A	A	A	A			
5	A	V	O	A	A	A	A				
6	V	V	V	V	O	V					
7	O	V	O	O	O						
8	A	O	O	O							
9	A	V	O								
10	O	O									
11	O										

Step 2: Reachability Matrix

Now convert the SSIM into Initial Reachability Matrix in form of binary elements (0 or 1). This Matrix is obtain by assigning 0 and 1 in place of V, A, X and O. Following are the rule of converting the SSIM into Initial Reachability Matrix:

- If the (i, j) entry in the SSIM is V then substitute in the (i, j) entry in the reachability matrix as 1 and (j, i) entry as 0.
- If the (i, j) entry in the SSIM is A then substitute in the (i, j) entry in the reachability matrix as 0 and (j, i) entry as 1.
- If the (i, j) entry in the SSIM is X then substitute in the (i, j) entry in the reachability matrix as 1 and (j, i) entry as 1.
- If the (i, j) entry in the SSIM is O then substitute in the (i, j) entry in the reachability matrix as 0 and (j, i) entry as 0.

Table 3: Initial Reachability Matrix

Factors	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	1	1	1	1	1	1	0	1	0	1	1	1
2	0	1	0	0	0	0	0	0	0	0	0	0
3	0	0	1	1	1	0	0	0	0	0	1	0

4	0	1	1	1	0	0	0	0	0	0	1	0
5	0	1	1	1	1	0	0	0	0	0	1	0
6	1	1	1	1	1	1	1	0	1	1	1	1
7	0	1	0	1	1	0	1	0	0	0	1	0
8	0	0	1	1	1	0	0	1	0	0	0	0
9	0	0	1	1	1	0	0	0	1	0	1	0
10	0	1	0	0	0	0	0	0	0	1	0	0
11	0	1	0	0	0	0	0	0	0	0	1	0
12	0	0	1	1	1	0	0	1	1	0	0	1

Table 3 is known as initial reachability matrix which is obtained by the SSIM, Now this initial reachability matrix is to check for transitivity. Transitivity is a relation between three elements such that if relationship holds between the first and second element – second and third element, then relationship must necessarily holds between the first and third elements and transitivity is denoted by 1* in table no 4.

Table 4: Final Reachability Matrix

Factors	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	1	1	1	1	1	1	1*	1	1*	1	1	1
2	0	1	0	0	0	0	0	0	0	0	0	0
3	0	1*	1	1	1	0	0	0	0	0	1	0
4	0	1	1	1	1*	0	0	0	0	0	1	0
5	0	1	1	1	1	0	0	0	0	0	1	0
6	1	1	1	1	1	1	1	1*	1	1	1	1
7	0	1	1*	1	1	0	1	0	0	0	1	0
8	0	1*	1	1	1	0	0	1	0	0	0	0
9	0	1*	1	1	1	0	0	0	1	0	1	0
10	0	1	0	0	0	0	0	0	0	1	0	0
11	0	1	0	0	0	0	0	0	0	0	1	0
12	0	0	1	1	1	0	0	1	1	0	1*	1

Step 3: Partitioning the RM

Now from this final RM, Reachability Set (RS) and Antecedent Set (AS) are achieved and from this RS and AS, intersection set (IS) is derived of all these sets is derived for the measures. Elements for which AS and IS have same value is placed at the top level of ISM hierarchy. Once the top level measure is identified, it is extracted from consideration and other top level measures of the remaining sub-graph are found. This procedure is continued till all levels of the structure are identified. These identified levels help in the development of digraph and the final model. Top level measure is positioned at the top of digraph and so on. From Table 5 requirement uncertainties and validation of product is found at the top level I, these are positioned at the top of hierarchy.

Table 5: Iteration 1

Factor	RS	AS	IS	LEVEL
1	1,2,3,4,5,6,7,8,9,10,11,12	1,6	1,6	
2	2	1,2,3,4,5,6,7,8,9,10,11	2	I
3	2,3,4,5,11	1,3,4,5,6,7,8,9,12	3,4,5	
4	2,3,4,5,11	1,3,4,5,6,7,8,9,12	3,4,5	
5	2,3,4,5,11	1,3,4,5,6,7,8,9,12	3,4,5,	
6	1,2,3,4,5,6,7,8,9,10,11,12	1,6	1,6	
7	2,3,4,5,7	1,6,7	7	
8	2,3,4,5,8	1,6,8,12	8	
9	2,3,4,5,9,11	1,6,9,12	9	
10	2,10	1,6,10	10	
11	2,11	1,3,4,5,6,7,9,11,12	11	
12	3,4,5,8,9,11,12	1,6,12	12	

Table 6: Iteration 2

Factor	RS	AS	IS	LEVEL
1	1,3,4,5,6,7,8,9,10,11,12	1,6	1,6	
3	3,4,5,11	1,3,4,5,6,7,8,9,12	3,4,5	
4	3,4,5,11	1,3,4,5,6,7,8,9,12	3,4,5	

5	3,4,5,11	1,3,4,5,6,7,8,9,12	3,4,5,	
6	1,3,4,5,6,7,8,9,10,11,12	1,6	1,6	
7	3,4,5,7	1,6,7	7	
8	3,4,5,8	1,6,8,12	8	
9	3,4,5,9,11	1,6,9,12	9	
10	10	1,6,10	10	II
11	11	1,3,4,5,6,7,9,11,12	11	II
12	3,4,5,8,9,11,12	1,6,12	12	

Table 7: Iteration 3

Factor	RS	AS	IS	LEVEL
1	1,3,4,5,6,7,8,9 ,12	1,6	1,6	
3	3,4,5	1,3,4,5,6,7,8,9,12	3,4,5	III
4	3,4,5	1,3,4,5,6,7,8,9,12	3,4,5	III
5	3,4,5	1,3,4,5,6,7,8,9,12	3,4,5,	III
6	1,3,4,5,6,7,8,9,12	1,6	1,6	
7	3,4,5,7	1,6,7	7	
8	3,4,5,8	1,6,8,12	8	
9	3,4,5,9	1,6,9,12	9	
12	3,4,5,8,9,12	1,6,12	12	

Table 8: Iteration 4

Factor	RS	AS	IS	LEVEL
1	1,6,7,8,9,12	1,6	1,6	
6	1,6,7,8,9,12	1,6	1,6	
7	7	1,6,7	7	IV
8	8	1,6,8,12	8	IV
9	9	1,6,9,12	9	IV
12	8,9,12	1,6,12	12	

Table 9: Iteration 5

Factor	RS	AS	IS	LEVEL

1	1,6,12	1,6	1,6	
6	1,6,12	1,6	1,6	
12	12	1,6,12	12	V

Table 10: Iteration 6

Factor	RS	AS	IS	LEVEL
1	1,6	1,6	1,6	VI
6	1,6	1,6	1,6	VI

Step 4: Development of Conical Matrix

Table no. 11 show a conical matrix obtain by final reachability matrix of same level across same level of column and row that show driving power and dependent power.

Factor	2	11	10	3	4	5	8	9	7	12	1	6	Driving Power
2	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
11	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**
10	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**
3	**1**	**1**	**0**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**5**
4	**1**	**1**	**0**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**5**
5	**1**	**1**	**0**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**5**
8	**1**	**0**	**0**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**5**
9	**1**	**0**	**0**	**1**	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**6**
7	**1**	**1**	**0**	**1**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**6**
12	**0**	**1**	**0**	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**0**	**0**	**7**
1	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**12**
6	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**12**
Dependent Power	**11**	**9**	**3**	**9**	**9**	**9**	**4**	**4**	**3**	**3**	**2**	**2**	**78**

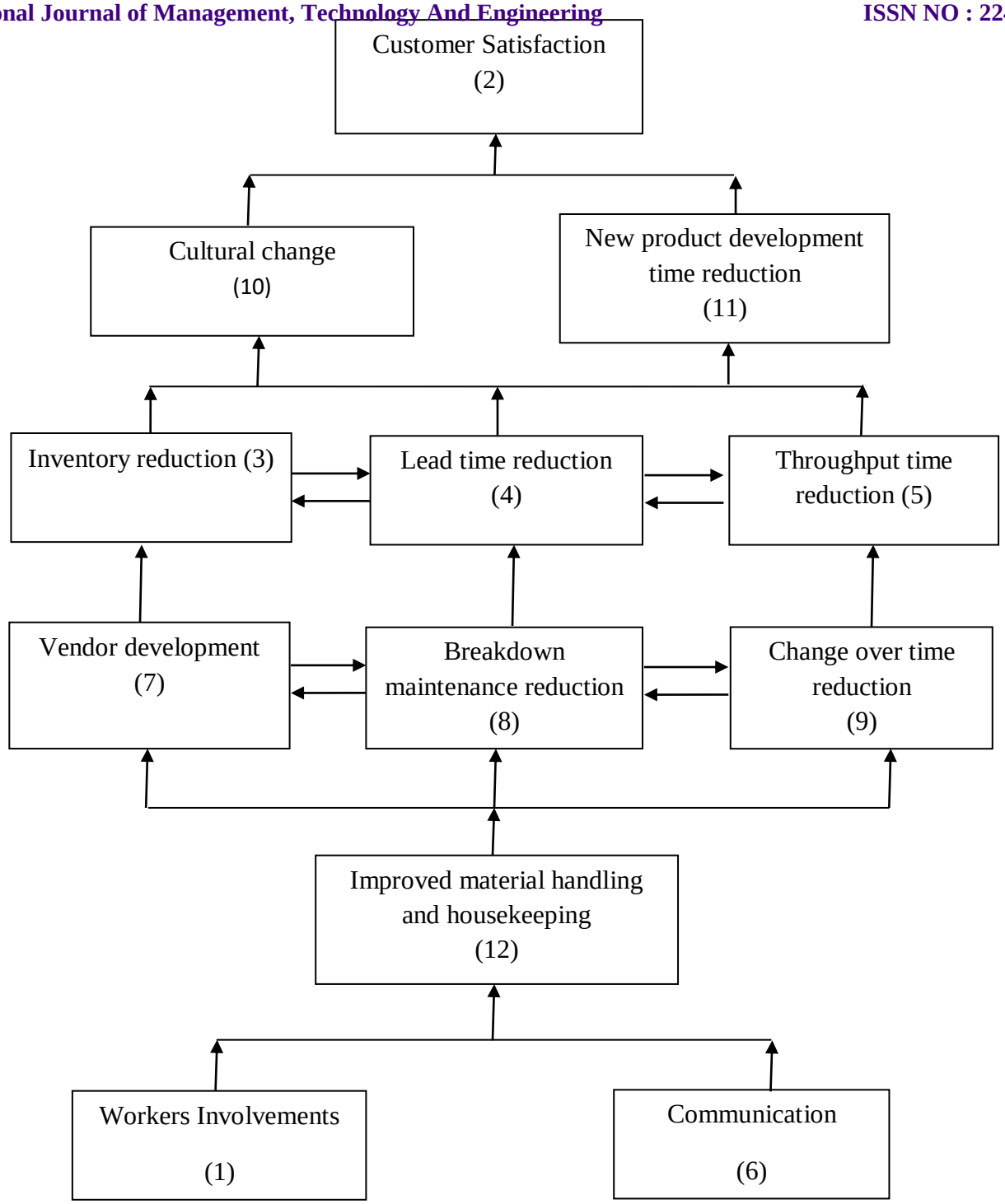

Figure : ISM model of LM practices

MICMAC Analysis

SMICMAC known as 'Cross-Impact Matrix Multiplication Applied to Classification'. Duperrin and Godet develop this technique in 1970. In this technique all the elements are plotted on x-y axis by there driving power and dependant power. And divide them in four clusters.

Cluster I: Autonomous variables —These factors have weak drive power and weak dependence power. In this cluster we have four factors i.e. vendor development, breakdown maintenance reduction, change over time reduction and cultural change.

Cluster II: Dependence variables — These factors have weak drive power but strong dependence power. In this cluster we have five factors i.e. customer Satisfaction, inventory reduction, lead time reduction, throughput time reduction and new product development time reduction.

Cluster III: Linkage variables – These factors have strong drive power as well as strong dependence power. In this cluster we have no factor.

Cluster IV: Driving variables – These factors have strong drive power but weak dependence power. In this cluster we have three factors i.e. Workers Involvements, Communication and Improved material handling and housekeeping.

Table 12: cluster of measures

Driving Power

12		1,6										
11												
10		IV								III		
9												
8												
7			12									
6			7	9								
5		I		8					3,4,5	II		
4												
3		10										
2									11			
1											2	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**

Dependent Power ⟶

Result and Discussion

The main objective of this paper is to identify the issues in the implementation of the lean manufacturing for the sustainable development. In this paper, 12 issues have been identified through the export opinion of the academic and the industries. An ISM model has been developing to set inter-relation between them. MICMAC analysis find there are four factors in the autonomous cluster factors which have weak dependent power and weak driving power i.e. vendor development, breakdown maintenance reduction, changeover time reduction and cultural change. There are five factors in the dependent variable cluster which have weak driving power and strong dependent power i.e. customer Satisfaction, inventory reduction, lead time reduction, throughput time reduction and new product development time reduction. There found no factor in the third cluster i.e. linkage cluster. In this there is strong dependent power and strong driving power. The last cluster is driving variable cluster which have strong driving power and weak dependant power i.e. workers involvements, communication and improved material handling and housekeeping. They are treated as the key issues in the implementation of the lean manufacturing for sustainable development.

Conclusion

In the recent time many industries are implementing lean manufacturing to reduce/eliminating wastes. But, while implementing LM in the industries the faces many issues. In this research workers involvements, communication and improved material handling and housekeeping are the three factors which have high driving power and low dependent power. So work on the these issues can lean to successful implementation of the lean manufacturing for the sustainable development.

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