International Journal of Advance Research in Science and Engineering
Volume No.10, Issue No. 05, May 2021
www.ijarse.com
IJARSE
ISSN: 2319-8354

Comprehensive analysis of barriers in implementation of Lean Manufacturing in Indian industries

Manojkumar J [#1], ManivelMuralidaran V [*2], Balaji M[*3]

[#]*PG Scholar, Department of Mechanical Engineering,*
Kumaraguru College of Technology, Coimbatore, India

[*]*Asst. Professor, Department of Mechanical Engineering,*
Kumaraguru College of Technology, Coimbatore, India

[*] *Associate Professor, Department of Mechanical Engineering,*
Kumaraguru College of Technology, Coimbatore, India

ABSTRACT

Lean manufacturing is a manufacturing strategy that improves the productivity by minimizing the waste. It has been proved from certain studies that implementation of lean thinking in manufacturing sector is beneficial in many fold. It is very important to identify the lean manufacturing barriers to adopt successful implementation of lean manufacturing strategies in Indian industries. The objective of this research article is to evaluate and review the literature on lean barriers for effective implementation of lean strategy in Indian industry. The strategies of implementation have been compared with the foreign industries to identify the feasibility to apply in India. Literature review has been presented to look into various lean manufacturing implementation barriers prevails in India. Based on the literature review the performance measures were identified. Those performance measures are logically and technically related with the lean barriers to evaluate and quantify the barriers. The major barriers identified are supply chain issues, leadership management, organization culture, technological challenges and financial capabilities of the organization. The performance measures identified are the cost, quality, delivery reliability, volume flexibility and safety and employee innovativeness. Interpretive Ranking Process is adopted for the evaluation of lean barriers. Pairwise comparison was carried out to evaluate the lean barriers. By evaluation and quantifying the barriers this can be suggested to the industry for implementation. The successful implementation of lean manufacturing strategy mainly focusses on elimination of waste and proper utilization of work space, proper organization of work place to reduce inventory, to increase productivity and to increase customer satisfaction.

Keywords—*Lean manufacturing, Supply chain issues, Leadership management, Interpretive Ranking Process*

I. INTRODUCTION:

Lean manufacturing philosophy that is now being adopted by many big industrial giantsacross world to improve the current process. This study applies lean manufacturing tools were applied to these process to eliminate them

or reduce their impact on total production time. Lean tools are used to reduce costs and improve quality of products.

Lean implementation strategies identified the best tools to improve continuous improvement of total process like 5s,kaizen,tpm etc.,[2].M. Mohan Prasad.,2020).increase quality of products and we maintain the standard base line of process. In lean manufacturing strategies will gives the less investment with high yield of product by means of quality of product. In today's word, customer statisfication is very important for marketing a good products. In industries eliminate all kind of waste by means of improve profit of company[3].(Virender Chahal.,2017).use lean manufacturing system use minimum materials and reduce human interference(DharmikMistry.,2020).identify the barriers of manufacturing system and resolve by using techniques to implement [4]. In this mainly lacking is order from top management to worker in production line through communication gap[5]. Lack of top management system, lack of understanding ,lack of rectify the solution in best way. Increase customer statisfication cost and quality of product and quick delivery is important [6].TISM-total interactive structural modeling.In this approach use to increase business processes[7].(AnupPrabhakarrao Chaple.,2018). In this research paper study what are all process will be lacking to improve productivity. It is used to identified defects of lean implementation(Rakesh Kumar.,2014).DEMEATEL-decision making trial and evaluation labatory. In this study, unproper team utilization and adopt new technology by using technological person(Balkrishna E. Narkhede.,2020).in this approach, analyze the manufacturing companies to facing problems to implementation of lean manufacturing process(Amir H. AbolhassaniKyLayfieldBhaskaran Gopalakrishnan.,2016).Reduction of inventory, rejection will be controlled and unnecessary motion will be eliminated(Jaiprakash Bhamu.,2020).

II LITERATURE REVIEW

The objective of literature review based on evaluation of performance measures and a lean barriers which affects lean implementation in indian industries. In company the organizational culture is important for the good performance of the company. Information is passing one by one communication gap is identify. Its is to rectify by means of effective lean implementation[9]. In organization (DEMATEL) approach will apply to develop a current process of the company to successful implementation of lean system. Now a days, manufacturing industries will be growing rapidly by means of new technology to adopt company are spending money to new machines and technology to improve the current process[11].organization system will be flexible amount of work reduced by means of lean systems[13]. Lean concepts will be implementation will be moderately increased day by day. A study of lean principles and adopt by means of critical factor in top management[14]. Lean manufacturing system has improved rapidly, customer satisfication is important for growing a good industry. Quality of product with exact delivery time is considered[16].Lean process will be minimized labor work time and increase growth of company. Lean tools will be yearly adopt by Toyota production system to implement in organization[18]. In this method, we collect the data from the industrial experts and give solution by means of GRA method. With help of this method we will give results based on the performance. In this method use tools like 5s,JIT,TPM,TQM, lean training etc. Based on this method we follow the mathematical model[23].Collect the lean barriers and implement based on lean six sigma concepts in small and medium –

sized enterprises to fine-tune barriers. In this method based on literature survey and experts option we standardize the 16 into 12 based on LSS implementation. It will improve the organization performance[24]. In global market, good products with minimum cost will satisfy customer. In lean manufacturing strategies is used to find out the problem and eliminate waste by means of good resources. Understanding the lean concepts and give solution to future problems. In this method ISM is used to validate the results[25].Lean concepts will used to develop the nature of work system to give best performance of the improving organizational performance. Lean tools are used to identify the organization culture development[26].Lean tools are used to eliminate waste and improves production process of system. This tools are used to improve process like 5s,Kanban, poke yoke,7QC,JIT etc.,[27]. The manufacturing company will consider warehouse and transportation are implement lean concepts to obtains certain results. In this study recent literature review and improve process by means of lean principles[28].Lean means elimination of waste. Lean kaizen concepts will be improves continuous improvement of process. It is used to find cycle time, bottle necks are identified.This method used to reduce cycle time, improve productivity of process and rework elimination. Kaizen is an very effective techniques to find ineffectiveness of organization systems[29].SME is used to develop the competitiveness of people to improve level of performance. Tools is main important of achieve high outcome of process. The economy of country will increase based on the entrepreneurs in the world to improve economy. New techniqueswill improve the quality of brick[30]. Barriers are identify based on IRP model and evaluate based on pairwise comparison. Group discussion techniques will be determines the list of barriers. Dominance matrix also developed by means of validating the current process. It will be improve the level of performance[31]. In this literature review will find the barriers, based on that we evaluation of IRP model. Then given to experts option to get results. Finally limited barriers will apply to valuate production process. In this techniques find lean barriers and performance measures will be validate[32].In this study we classified as lean barriers and performance measures as follows

A.LEAN BARRIERS

According to lean barriers we classified in six lean barriers that affecting the lean implementation. we classified as leadership management, knowledge, organization culture, technological challenges, financial capabilities and supply chain issues. In this barriers which affects the lean implementation in indian industries as follows

Leadership management barriers: there are number of barriers related to leadership management lack of top management ,lack of leader ship quality, lack of top management for approval, lack of adequate support from top management, lack of top management support.

Knowledge: lack of education and training, lack of communication, lack of lean understanding, insufficient supervisor skills to implement lean.

Organization culture: lack of supplier relationship, awareness of lean techniques, lack of co-operation with supplier and distribution, poor facility layout and planning culture, lack of cultural barriers.

Technological challenges: lack of learning new things, lack of adopt new technology, low skilled people, lack of adopt training lack of innovations.

Financial capabilities: lack of insufficient investment cost, lack of insufficient resources, lack of financial issues, poor sales, lack of financial resources.

Supply chain issues: lack of inflexible process, lack of trust among supply chain employee, lack of education in supply chain equipment.

B.PERFORMANCE MEASURES:

Lean manufacturing focuses on the needs of the customer by improving on-time deliveries, decreasing costs and eliminating quality defects. Lean businesses measure the success of their efforts by monitoring the total cost, quality, cycle time and on-time delivery.

In lean manufacturing system the performance measures is main role to play in the areas of targets to establish business process and individuals(eg: customer statisfication). Based on objectives performance measures categorized into five types: cost, quality, delivery reliability, volume flexibility, safety, employee innovativeness.

Performance measures related to cost and quality: Lean manufacturing is a production system that eliminates waste through all steps in the process to build a product. Companies using lean systems work to reduce costs, inventory and cycle time -- the period from when an order is taken until the product ships to the customer. Lean manufacturing focuses on the needs of the customer by improving on-time deliveries, decreasing costs and eliminating quality defects. Lean businesses measure the success of their efforts by monitoring the total cost, quality, cycle time and on-time delivery.

Performance measures related to delivery reliability and volume flexibility:

It analyses how well a supplier delivers what the customer wants and when they want it. The goal is to achieve 100% on-time delivery without any special deliveries or overtime payments, which only increase the delivery cost. Volume flexibility is the ability of an organization to change volume levels in response to changing socio-economic conditions profitably and with minimal disruptions.

Performance measures related to safety and employee innovativeness:

It measures productivity by the speed of product or service delivery, customer feedback, or by individual and department self-evaluations. Safety performance can be measured in a number of ways, usually through a combination of output and input indicators. It is used to measure activities to prevent (e.g. safety training, safety audits).

Interpretive ranking process(IRP)

Interpretive ranking process is adopted for the evaluation of lean barriers. IRP used to determine the most important methods of lean barriers and performance measures are used to calculate based on ranking of lean barriers and successful implementation of lean manufacturing in indian industries.

Evaluate lean barriers with IRP:

IRP is used to evaluate the barriers based on literature survey to standardize the lean barriers and their importance of lean implementation.

IRP is the ranking process to create knowledge and compare one variable to another by ranking process.

Lean barriers and performance measures are identified based on literature review(Linda L. Zhang2017).

In this study lean barriers are more but we select repeating barriers 6 lean barriers and performance measures to meet cross-intersection matrix.

The most important lean barriers and performance measures are identified based on literature survey.

In this method we list the barriers and performance measures to analyze the numbering of dominance matrix.

Lean barriers and performance measures validating:

The most repeating lean barriers are discussed in the articles. We finalize the most important barriers. There are many barriers are identified and discussed based on literature survey we finalize the top 6 lean barriers i) leadership management (B1), ii) knowledge (B2),iii) organizational culture (B4), iv) Technological challenges (B5), v) Financial capabilities (B6) vi) Supply chain issues (B7).(Note: In the rest of the text, the code in small brackets is used to represent the corresponding lean barriers).

In same way, we finalize 6 performance measures based on literature survey. The data collection related to activities is achieving its objectives and if progress is being made towards attaining organization goals. In 6 performance measures includes i) Cost (P1), ii) Quality (P2), iii) Delivery reliability (P3), iv) Volume flexibility (P4), v) Safety (P5), vi) Employee innovativeness (P6). (Similarly, in the rest of the text, the code in small brackets is used to represe0nt the corresponding performance measures).

Interpretive evaluation process

Developing cross intersection matrix: In relationship between lean barriers and performance measures are identified based on study.In table 1, The cross-intersection matrix is a binary matrix by nature. The cell value 1 indicates that a relationship exists between the corresponding lean barriers and performance measure; the cell value 0 indicates that no relationship exists. Thus, the cell value 0/1 indicate that the lean barriers doesn't affect/affects the corresponding performance measures. For example, the value 1 between leadership management and quality indicates that leadership management affects quality.

Table 1: the cross- intersection matrix

	Performance measures	Cost	Quality	Delivery reliability	Volume flexibility	Safety	Employee Innovativeness
Lean barriers		**P1**	**P2**	**P3**	**P4**	**P5**	**P6**
Leadership management	**B1**	0	1	1	1	1	1
Knowledge	**B2**	0	0	0	0	0	1
Organizational culture	**B3**	0	0	0	0	0	1
Technological challenges	**B4**	0	1	1	1	1	1
Financial capabilities	**B5**	0	0	0	0	1	0
Supply chain issues	**B6**	0	1	1	1	0	1

International Journal of Advance Research in Science and Engineering
Volume No.10, Issue No. 05, May 2021
www.ijarse.com
IJARSE
ISSN: 2319-8354

Interpreting the relationships: As table 1 is used to represent a relationship in the above cross- intersection matrix, it has to be interpreted. In interpreting the relationship, based on literature survey, we obtain the interpretations and further develop the interpretive matrix,

Where we replace each 1 in table1 with the corresponding relationship interpreted.The interpretive matrix provides new knowledge: In cross intersection matrix , the relationship between lean barriers and performance measures and it can help practitioners better understand how lean barriers affects the performance measures. In this method, the matrix can support practitioners with managerial decision making in lean implementation.

Developing the dominating relationship matrix: In this step, the lean barriers are compared in pairwise comparison to determine their levels of performance. The most important lean barriers and the less dominating lean barriers are coincide with each performance measures. As that we consulate and give the ranking process.

In conducting the study of pairwise comparison, there are two way, In the first one, a relationship exist between only one barriers (e.g., barrier 1), relationship not exist (e.g., named; barrier 2) and performance measures in consideration. In such situation, barrier 1 dominates barrier 2 with respect to the performance measures. Thus, the barrier 1 is the dominating lean barriers and barrier 2 is the one being dominated. In second situation, relationship exist between both lean barriers and performance measures. In this method barrier 1 represent the more important lean barrier and barrier 2 represent the less important lean barriers, with the comparison results. The dominating relationship matrix is developed.

Developing the dominance matrix: To identify the number of dominating relationship between any two lean barriers, the dominance matrix is developed, as shown in table 2. The matrix is developed by replacing the performance measures in each cell in the dominating relationship matrix with their numbers, As the empty cells represents that there are all 0 in the dominating matrix. By default; 0 is omitted.

Table 2. The dominance matrix

		Elements being dominated						No. dominating (D)	Net dominance (D-B)	Rank dominating
		B1	B2	B3	B4	B5	B6			
Dominating elements	B1	1	3	4	4	3	3	18	4	III
	B2			2	1			3	-12	VI
	B3	1	1		1	2	4	9	-6	V
	B4	3	5	3	4	4	4	23	9	I
	B5	5	2	1		5	1	14	-1	IV
	B6	4	4	5	4	1	3	21	6	II
No. being Dominated(B)		14	15	15	14	15	15	88		

For lean barriers, it dominates other and is dominated by others, In this regards, for a lean barriers, the total number being dominated denoted as B, is defined as total number of relationships where the lean barriers is dominated by others, its total number of dominating, denoted as D, the total number of relationships where the lean barriers dominates by others. For any lean barriers, the different between D and B, i.e., D-B, is defined as its net dominance, In developing the dominance matrix, for each lean barriers, We calculate its number being dominated (i.e., B). its number dominating (i.e., D) and its net dominance (D-B), For example, for B4, D is 23 and B is 14. Its net dominance is, thus 23 (i.e.,23-14).

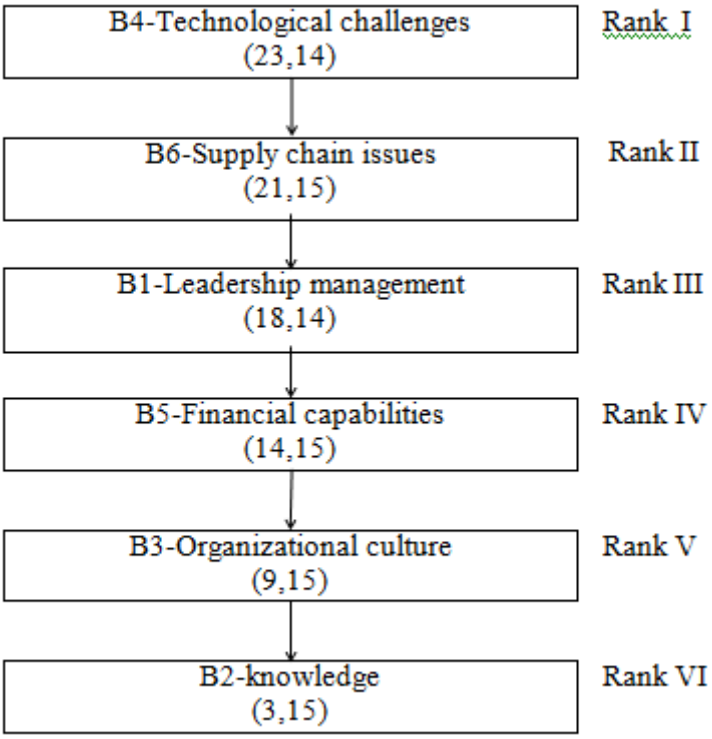

Fig.1.The IRP based lean barriers evaluation model.

With the net dominance values, we rank the 6 lean barriers. The ranking is based on the decreasing order of the net dominance values. Thus, the lean barrier with a higher net dominance is ranked higher. The ranks are provided in Table 2. The lean barriers with higher ranks influence more on the performance measures, where as these with lower ranks influence less [32].

International Journal of Advance Research in Science and Engineering
Volume No.10, Issue No. 05, May 2021
www.ijarse.com
IJARSE
ISSN: 2319-8354

Table-3:The updated dominance matrix

		Elements being dominated						No. dominating (D)	Net dominance (D-B)	Rank dominating
		B1	B2	B3	B4	B5	B6			
Dominating elements	B1	1	3	4	4	3	3	18	4	III
	B2			2	1			3	-12	VI
	B3	1	1		1	2	4	9	-6	V
	B4	3	5	3	4	4	4	23	9	I
	B5	5	2	1		5	1	14	-1	IV
	B6	4	4	5	4	1	3	21	6	II
No. being Dominated(B)		14	15	15	14	15	15	88		

The dominance matrix is updated is shown in table 3.the modified dominance matrix and updated ranks of lean barriers are provided.

With the modified ranks in table 3. The IRP based lean barriers evaluation model is developed shown in fig.1. In developing this model, all the lean barriers are arranged in ascending order and given in ranks. In thus,B4 having the highest rank:I is placed at the top, whereas others are placed one by one below it. For each lean barriers, its number dominating and number being dominated are provided in small brackets in the model, Each arrow represents a dominance relationship between lean barriers and performance measures.

The dominance matrix model, indicates that the important levels of lean barriers and performance measures. In this method is provided for developing a good decision based on the performance measures. In this regarding, we eliminate the lean barriers to achieve good level of performance.

CONCLUSION:

In this study, we identified lean barriers and then we take the lean barriers and performance measures based on the literature survey and classified into it. We adopt interpretive ranking process to rank and their importance of lean implementation and the lean barriers are compared in pairwise comparison to determine their level of performance. finally we rank, based on dominance matrix. By evaluation and quantifying the barriers this can be suggested to the industry for implementation.

REFERENCES:

[1] Rasli Muslimen, Sha'ri Mohd. Yusof, and Ana Sakura Zainal Abidin,"A Case Study of Lean Manufacturing Implementation Approach in Malaysian Automotive Components Manufacturer".Electrical Engineering and Intelligent Systems, Vol. 130, No. 327-335, LLC 2013, DOI 10.1007/978-1-4614-2317-1_27.

[2] M. Mohan Prasad, J. M. Dhiyaneswari, J. Ridzwanul Jamaan et al, "A framework for lean manufacturing implementation in Indian textile industry". Materials Today: Proceedings, Elsevier, 2020.

[3] Virender Chahala* and M.S. Narwalb, "An empirical review of lean manufacturing and their strategies".Management Science Letters, Vol. 7, No.321-336, 2017.

[4] Dharmik Mistry, Viraj Shah, "Application of Lean Manufacturing Tools andTechniques: A Case Study in a Manufacturing Industry". Applied Science & Engineering Technology, Vol.8, No.1260-1267, 2020, 2321-9653.

[5] Jamwal, A., Aggarwal, A.,Gupta, S. and Sharma, P. (2019) "A study on the barriers to lean manufacturing implementation for small-scale industries in Himachal region (India)".Intelligent Enterprise, Vol. 6, No. 393-407, 2019.

[6] Piyush Jaiswal ,"Barriers in implementing lean manufacturing in Indian SMEs: a multi-criteria decision-making approach". Modelling in Management, 2020, 1746-5664,DOI 10.1108/JM2-12-2019-0276.

[7] Pratik Badgujar ,Bachchan Kanungo ,G.D. Thakar, "IDENTIFICATION OF FACTORS AFFECTING LEAN MANUFACTURING IMPLEMENTATION IN PUMP MANUFACTURING COMPANIES IN INDIA-ACASE STUDY". International Journal for Quality Research, Vol.10, No. 495–510, 2016, 1800-6450.

[8] Anup Prabhakarrao Chaple, Balkrishna Eknath Narkhede, Milind M. Akarte, Rakesh Raut, (2018)"Modeling the lean barriers for successful lean implementation: TISM approach". International Journal of Lean Six Sigma, 2018, 2040-4166,https://doi.org/10.1108/IJLSS-10-2016-0063.

[9] Rakesh Kumar, Dr. Vikas Kumar, "Barriers in Implementation of Lean Manufacturing System in Indian industry: A survey".Latest Trends in Engineering and Technology, Vol. 4, NO. 243-251, 2014, 2278-621X.

[10] Arvind Kumar Shrimali and V. K. Son,"Barriers to Lean Implementation in Small and Medium-Sized Indian Enterprises". International Journal of Mechanical Engineering and Technology, Vo. 8, No. 1-9, 2017, 0976-6359 .

[11]. RaBalkrishna E. Narkhede& Rakesh Dut& Matthew Roy & Vinay Surendra Yadav &BhaskarGardas, "Implementation barriers to lean-agile manufacturing systems for original equipment manufacturers: an integrated decision-making approach".Advanced Manufacturing Technology, 2020,https://doi.org/10.1007/s00170-020-05486-5.

[12] Amir H. Abolhassani KyLayfield Bhaskaran Gopalakrishnan , (2016),"Lean and US manufacturing industry: popularity of practices and implementation barriers". International Journal of Productivity and Performance Management , Vol. 65, No. 1-16, 2016, http://dx.doi.org/10.1108/IJPPM-10-2014-0157.

[13] Jaiprakash Bhamu, Jagdish Bhadu, and Kuldip Singh Sangwan, "Lean Manufacturing Implementation in Ceramic Industry: A Case Study".Enhancing Future Skills and Entrepreneurship, Sustainable Production, Life Cycle Engineering and Management,2020, https://doi.org/10.1007/978-3-030-44248-4_3.

[14] Priti B. Khadse & Avinash D.Sarode & RenuWasu, "Lean Manufacturing in Indian Industries :A Review". Latest Trends in Engineering and Technology, Vol. 3, No. 175-181, 2013, 2278-621X.

[15] C. Cruz-Villazon, J. R. Otegi-Olaso, M. E. Aguilar-Fernandez and L. Fuentes-Ardeo, "Lean Thinking: A Useful Tool to Integrate Sustainability into project Management". Project Management and Engineering Research, No. 35-48, 2019, https://doi.org/10.1007/978-3-319-92273-7_3.

[16] RewersP., Trojanowska J., Chabowski P, "Tools and methods of Lean Manufacturing - a literature review".proceedings of 7th International Technical Conference TECHNOLOGICAL FORUM 2016, Czech Republic, 28-30.06.2016, pp.135-139.

[17] Leksic, I.a,*, Stefanic, N.a, Veza, I.b, "The impact of using different lean manufacturing tools on waste reduction". Advances in Production Engineering &Management,Vol. 15, No. 81-92, 2020, 1854- 6250.

[18] Vasudev Krishnan, C. MallikaParveen,"comparative study of lean manufacturing tool used in manufacturing firm and service sector". Proceedings of the World Congress on Engineering, Vol I, WCE 2013, 2013, 2078-0966.

[19] Akhilkumar, "A Qualitative Study on the Barriers of Lean Manufacturing Implementation: An Indian Context (Delhi Ncr Region)". Engineering And Science, Vol. 3, No. 21-28, 2014, 2319 – 1805.

[20] Dr. Ashish Thakur, "A Review on Lean Manufacturing Implementation Techniques: A Conceptual Model of Lean Manufacturing Dimensions".12th GLOBAL CONGRESS ON MANUFACTURING AND MANAGEMENT, GCMM 2014, 2455-4537.

[21] Antony Pearce and Dirk Pons, "Implementing Lean Practices: Managing the Transformation Risks". Journal of Industrial Engineering, Vol. 2013, No. 1-19, Article ID 790291, 2013,http://dx.doi.org/10.1155/2013/790291.

[22] ProtikBasu, Pranab K. Dan, "A comprehensive study of manifests in lean manufacturing implementation and framing and administering model". International Journal of Lean Six Sigma,Vol. 11, No. 797-820, 2020, 2040-4166.

[23] VirenderChahal and M. S. Narwal, "A Theoretical Analysis for Prioritizationof Lean Strategies: A Survey of Indian Manufacturing Industries".Advances in Industrial and Production Engineering, No. 365-373, 2019,https://doi.org/10.1007/978-981-13-6412-9_35.

[24] Sandesh Kanhu Gaikwad and Ananna Paul, "Analyzing barriers and strategiesfor implementing Lean Six Sigma in the context of Indian SMEs". Benchmarking: An International Journal,2020, 1463-5771,DOI 10.1108/BIJ-11-2019-0484.

[25] Rakesh Kumar* and Vikas Kumar, "Application of interpretive structural modellingapproach for the analysis of barriers affecting lean manufacturing implementation in Indian manufacturing industry". Int. J. Business Performance and Supply Chain Modelling, Vol. 9, No. 1-17, 2017.

[26] Balaji M, Dr. M. Muniraju, "CHALLENGES IN IMPLEMENTATION OF LEAN MANAGEMENT IN INDIAN MSMES – A STUDY". International Journal of Management Studies, Vol. IV, No. 1-10, 2017, 2231-2528.

[27] Shyam Sunder Sharma, Pankaj Pandey, Bhupendra Prakash Sharma, "Identification and Categorization of Lean Manufacturing Barriers in Indian SMEs".AIP Conference Proceedings 2273, 060001 (2020); https://doi.org/10.1063/5.0024294 2273, 060001.

[28] MORADLOU, Hamid and PERERA, Terrence, "Identification of the Barriers in Implementation of Lean Principles in Iranian SMEs: Case Study Approach".Management and Business Research, Vol. 17, No. 33-41, 2017, 0975-5853.

[29] Sunil Kumar &Ashwani Kumar Dhingra&Bhim Singh, "Process improvement through Lean-Kaizen using value stream map: a case study in India". The International Journal of Advanced Manufacturing Technology, Advanced Manufacturing Technology, 2018, https://doi.org/10.1007/s00170-018-1684-8.

[30] B.C. Arevalo-Barrera, F. E. Parreño-Marcos, J. C. Quiroz-Flores, J. C. Alvarez-Merino, "Waste Reduction Using Lean Manufacturing Tools: A Case in the Manufacturing of Bricks". Proceedings of the 2019 IEEE IEEM, 2019, IEEE1287.

[31] Linda L. Zhang, Balkrishna E. Narkhede, Anup P. Chaple, "Interpretive Ranking Process-based Lean Manufacturing Barrier Evaluation". Proceedings of the 2017 IEEE IEEM, No. 1591-1597, 2017, 978-1-5386-0948-4/17/$31.00 ©2017 IEEE.

[32] Linda Zhang, BalkrishnaEknathNarkhede, Anup P. Chaple, "Evaluating lean manufacturing barriers: an interpretive process". Manufacturing Technology Management, No. 1-25, 2017, https://doi.org/10.1108/JMTM-04-2017-0071.