International Journal for Quality Research 10(3) 495–510
ISSN 1800-6450

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Article info:
Received 23.11.2015
Accepted 08.02.2016

UDC – 54.061
DOI – 10.18421/IJQR10.03-04

IDENTIFICATION OF FACTORS AFFECTING LEAN MANUFACTURING IMPLEMENTATION IN PUMP MANUFACTURING COMPANIES IN INDIA- A CASE STUDY

Abstract: *Lean Manufacturing has now become a common word in the industrial corridors. It has now been applied to the industries of several domains. No wonder that the Pump manufacturing has also witnessed profound influence of Lean philosophy. Pump manufacturing in India has a history as old as 80 years with more than 500 pump manufacturing units presently working. The present research is an explorative study and was undertaken to identify various factors affecting lean manufacturing implementation in pump manufacturing industry. Analysis of results revealed that the companies registered increase in productivity and reduction in costs and wastes. Lack of understanding, Supply chain and Company culture are found to be the strongest barriers of lean manufacturing implementation. The multiple regression model revealed that Lack of workers support can be fairly reduced by educating them about Lean Manufacturing and establishing a healthy communication with workers. An analysis across different management levels revealed disparity in perceptions and views of personnel. There is a need for top management to align organization toward common goals so as to achieve better success in implementing lean manufacturing.*

Keywords: *Lean manufacturing, pump industry, lean manufacturing implementation*

1. Introduction

Lean manufacturing has become a very popular tool for production management. Industries from various domains are adopting lean manufacturing in hope for improving their performances. Many researchers have studied lean manufacturing implementation in different industries all over the world. Various aspects of lean manufacturing have been studied and analyzed by researchers. The Lean Manufacturing has become a talking point in industrial corridors. Indian industries also are adapting Lean Manufacturing as they also believe that it is beneficial for them.

This research is an Explorative kind of research which has been carried out by collection of data from employees of two major pump manufacturing industries. Plant 1 is more than 60 years old with employee

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strength of about 560 and is situated in central India. Plant 2 is established recently about, 3 years ago with employee strength of 140 and is situated in western India.

The purpose of this research is to identify various factors that affect lean manufacturing implementation in pump manufacturing industry. The research is done using a questionnaire based survey aided with non-structured interviews with employees of company at various levels.

2. Literature review

Researchers have defined Lean Manufacturing in different words. Shah and Ward (2003) defined Lean manufacturing as an integrated system composed of highly inter-related elements and a wide variety of management practices, including Just-in-Time (JIT), quality systems, work teams and cellular manufacturing.

Since the early 1980s, the new lean manufacturing methods have gained worldwide acceptance and international acclaim (Womack, 2007).

According to Hudli Mohd *et al.* (2010) "Lean production method is an effective way to improve management, enhance the international competitiveness of manufacturing enterprises." Following are some of the major lean manufacturing techniques (Mahapatra and Mohanty, 2007; Chaple *et al.*, 2014; Kumar Akhil, 2014):

1) 5S
2) Value Stream Mapping (VSM).
3) Group Problem Solving
4) Cross Functional Team
5) Kanban /Pull Production
6) Visual Control
7) Setup time reduction
8) Continuous flow
9) Leveled Production
10) One Piece flow
11) Kaizen
12) Poka-Yoke

Lean Manufacturing has also been applied in pump manufacturing industry and results were quite encouraging. Here are some examples of implementation of lean manufacturing in pump manufacturing industry:

- Ramamoorthy *et al.* (2008) reported that "...The efficiency of the centrifugal pump manufacturing industries is to be increased considerably by applying the Lean Manufacturing System and Kaizen Technique."
- Joshi *et al.* (2009) succeeded in reducing the throughput time of pump manufacturing by almost 35 % by implementing lean manufacturing techniques. They identified various wastes (Muda, Mura and Muri) to improve the productivity.
- Mopuru *et al.* (2013) applied lean manufacturing in oil pump unit in Chennai (India) and they report that "...The project was very useful for the organization and it has enhanced single piece flow, manpower reduction. Material movement and transport time is reduced".
- Prabhu C and Aravindha Balaji S (2014) applied Value Stream Mapping and successfully reduced production lead times with increased productivity.

3. Objectives of study

The objectives of this research are to identify factors which motivate pump manufacturing companies to adopt lean manufacturing, benefits achieved together with success achieved in elimination of seven wastes identified in lean manufacturing philosophy. The research also aims to identify major barriers faced by the concerned companies in implementing lean manufacturing.

4. Data Collection and Analysis

The research has five dimensions viz. trigger factors, expected benefits, benefits achieved, wastes eliminated and barriers interfaced. Here is a short description of included dimensions:

- *Trigger factors* are factors based on which organizations are compelled to adopt lean manufacturing.
- *Expected benefits* and *Benefits achieved* are benefits apart from trigger factors which are expected and achieved by implementing lean manufacturing.
- *Barriers experienced* are the major obstacles which companies face in the course of implementing lean manufacturing.
- *Wastes Eliminated* measures the extent of elimination of seven kinds of wastes as identified in lean manufacturing philosophy.

4.1. Sample Size determination

The sample size is statistically determined using the following equation:

$$n = \sigma^2 z^2 / L^2$$

where,

n = Sample Size
z = z value associated with the confidence level
L = Margin of Error
σ = Standard Deviation

Firstly, pilot survey was done on a sample of 30 respondents. Following data was obtained from this sample:

σ = 1.084, mean = 3.75, for all variables considered for study. The margin of error L is chosen as 5% of mean, thus L = .187 and z = 1.96, for 95% confidence level. This yields a value of sample size of 130.

$$n = (1.084)^2 * (1.96)^2 / (.187)^2 = 129.08 \approx 130$$

The data has been collected using convenient sampling. The employees of two pump manufacturing units located in central India (plant 1) and western India (plant 2) are considered for collecting data. The total number of valid and complete responses received is 135 which can be said to be satisfactory.

On analyzing the results of pilot study the results of all the variables included were found to be significant (having Cronbach's alpha higher than 0.60). Hence the pilot questionnaire was finalized and it was used for further study as well.

4.2. Respondent Profile

As stated above total 135 responses were collected from employees of the two pump manufacturing companies. A detailed analysis of respondent profile is presented here:

Table 1. Responses Rate

Plant	Total Staff	Responses available	Response rate	Cumulative %age
Plant 1	45	31	68.89 %	23
Plant 2	134	104	77.61 %	77
Total number of responses		**135**		**100**

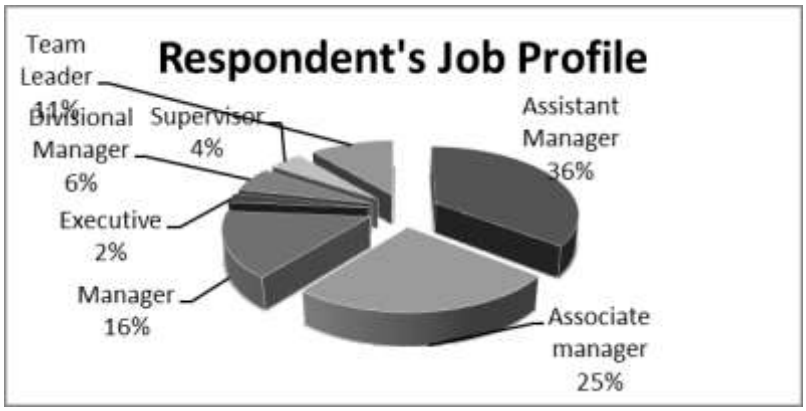

Figure 1. Respondents' Job Profile

Table 2. Management level wise available responses

S. No.	Management level	Job titles included	Respondent No.	Total	%age
1	Lower	Supervisors and Assistant Managers	6 + 48	54	40.00
2	Middle	Team leaders and Associate Managers	15 + 34	49	36.30
3	Top	Executives, Managers and Divisional Managers	3 + 8 + 21	32	23.70
			Total	**135**	**100**

4.3. Internal reliability

The data collected was tested for internal consistency using Cronbach's alpha. Cronbach's alpha (α) or Coefficient alpha is a measure of internal consistency reliability that is the average of all possible split-half coefficients resulting from different splitting of the scale terms, Malhotra and Dash, (2011). The value of Cronbach's alpha for various dimensions is found to be satisfactory as all the values are above the threshold value of 0.60.

Table 3. Cronbach's Alpha for various dimensions

S. No.	Item	Cronbach's Alpha	No. of Items
1	Trigger factors	0.694	8
2	Expected benefits	0.643	9
3	Success Achieved	0.838	9
4	Barriers	0.725	10
5	Waste elimination	0.633	7
7	**Overall**	**0.750**	**54**

5. Results and discussions

5.1. Identification of Trigger factors

The research was carried out to identify various factors affecting lean manufacturing adoption and implementation. Following trigger factors were observed on the basis of mean values and standard deviation of responses:

Table 4. Trigger Factors for adopting Lean Manufacturing

Rank	Trigger factor	Plant 1		Plant 2		Total	
		Mean values	**Std. Deviation**	**Mean values**	**Std. Deviation**	**Mean**	**Std. Deviation**
1	Increase in Profit margin	4.38	0.612	4.48	0.508	4.41	0.590
2	Reduction of Manufacturing costs	4.16	0.712	4.52	0.508	4.24	0.685
3	Reduction of inventories	4.17	0.730	4.06	0.814	4.15	0.748
4	Improving Plant utilization	4.11	0.775	3.90	0.790	4.06	0.780

1) **Increase in Profit Margin**: This has been rated as the highest trigger factor for adopting lean manufacturing in both the pump manufacturing units. It is observed that the factor is stronger at Plant 2 as compared to Plant 1.
2) **Reduction of Manufacturing costs:** This is the second major trigger factor for adopting lean manufacturing. It is observed that the factor is stronger at Plant 2 as compared to Plant 1.
3) **Reduction of Inventories:** The companies also wanted to reduce their inventory levels and hence switched to lean manufacturing. It is observed that the factor is stronger at Plant 1 as compared to Plant 2.
4) **Improving Plant Utilization:** Plant utilization is also found to be a major factor for adopting lean manufacturing. Considering means and standard deviation it is observed that the factor is stronger at Plant 1 as compared to Plant 2.

Employees of plant 1 are more inventories conscious while those of plant 2 are more concerned about profit, cost and quality.

Table 5. Management level wise view of Trigger factors

		Rank 1	Rank 2	Rank 3
Top level Management	Trigger factor	**Reduction of Manufacturing cost**	**Increasing Profit margins**	**Maintain Market share**
	Mean	4.25	4.25	4.19
	Std. Deviation	0.618	0.718	0.734
Middle level Management	Trigger factor	**Increase in profit margin**	**Reduction of Manufacturing cost**	**Reduction of Inventory**
	Mean	4.49	4.18	4.18
	Std. Deviation	0.545	0.659	0.755
Lower level Management	Trigger factor	**Increase in profit margin**	**Reduction of manufacturing cost**	**Reduction of inventory**
	Mean	4.43	4.30	4.22
	Std. Deviation	0.536	0.662	0.718

The most important trigger factor identified by top management is reduction of manufacturing costs followed by increase profit and maintaining market share.

However priorities of implementing lean manufacturing are seen to vary down the management levels. The middle and lower management has perception that lean is implemented to increase profits followed by reduction of costs and reduction of inventory. The disparity in views across management levels highlights misalignment of perception about goals of implementing lean manufacturing. To achieve profound success in lean manufacturing it becomes important that there is a uniformity of objectives throughout the organization, which is found to be missing in the concerned organizations.

5.2. Identification of benefits expected

The major benefits expected by the companies as revealed on the basis of frequency analysis are (Table 6 and 7):

Table 6. Benefits Expected by applying Lean Manufacturing

Rank	Expected Benefits	Plant 1		Plant 2		Total	
		Mean	**Std. Deviation**	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**
1	Improved Productivity	4.24	0.675	4.23	0.680	4.24	0.704
2	Reduced costs	4.14	0.781	4.16	0.735	4.15	0.768
3	Decreased Inventory levels	4.16	0.860	3.87	0.670	4.10	0.827
4	Improve Customer Satisfaction	4.01	1.029	4.03	0.795	4.01	0.977

Table 7. Management level view of Expected benefits

		Rank 1	Rank 2	Rank 3
Top level Management	Expected Benefits	**Reduction of wastes**	**Improve productivity**	**Improve Customer satisfaction**
	Mean	4.28	4.16	4.08
	Std. Deviation	0.851	0.808	0.749
Middle level Management	Expected Benefits	**Improving Productivity**	**Improve response time**	**Improve Customer satisfaction**
	Mean	4.31	4.02	3.92
	Std. Deviation	0.619	0.750	0.886
Lower level Management	Expected Benefits	**Improving Productivity**	**Improving quality**	**Improving Customer satisfaction**
	Mean	4.22	3.96	4.06
	Std. Deviation	0.708	0.795	0.843

- **Improved Productivity:** Improved productivity was the most highly expected benefit of lean manufacturing implementation. However, considering means and standard deviation it is observed that the factor is almost equally strong at Plant 1 as well as Plant 2.
- **Reduced Costs:** It was rated as second most sought after benefit. Considering means and standard deviation it is observed that the

factor is stronger at Plant 2 as compared to Plant 1.

- **Decreased Inventory Levels:** it was also an expected benefit. Considering means and standard deviation it is observed that the factor is stronger at Plant 1 as compared to Plant 2. However the strength of view is higher at Plant 2.
- **Improved Customer satisfaction:** Improving customer satisfaction was also a benefit sought by the companies.

The top management expected reduction of wastes, improvement and improving customer satisfaction as major expected benefits. However middle and lower management expected improving productivity as prime benefit. All the three management levels expect improved customer satisfaction as an benefit.

5.3. Benefits Achieved

The companies succeeded in achieving following benefits after implementing lean manufacturing.

Table 8. Benefits Achieved by applying Lean Manufacturing

Rank	Benefits Achieved	Plant 1		Plant 2		Total	
		Mean values	Std. Deviation	Mean values	Std. Deviation	Mean Values	Std. Deviation
1	Improved productivity	4.23	0.753	4.58	0.672	4.31	0.748
2	Improved quality	4.07	0.792	4.39	0.715	4.14	0.784
3	Reduced costs	4.09	0.739	3.81	0.833	4.02	0.767
4	Improved Profitability	3.97	0.908	3.94	0.727	3.96	0.867

- **Improved productivity:** The pump manufacturing companies experienced an increase in their productivity. However considering means and standard deviation it is observed that the increase is stronger at Plant 2 as compared to Plant 1.
- **Improved Quality:** The quality of production was improved. The improvement in quality was higher at plant 2 than plant 1.
- **Reduced Costs:** The cost of production of companies was also reduced. Considering means and standard deviation it is inferred that the reduction is higher at Plant 2 as compared to Plant 1.
- **Improved Profitability:** As a consequence of adopting lean manufacturing improvements in profitability was observed. Increase in profitability was almost same at both the pump manufacturing units.

Improvement in productivity was accepted across all management levels. as a benefit achieved by implementing lean manufacturing. Improvement in quality was also a benefit achieved by lower and top level management respondents but the middle management does not perceive it as achieved. The top management respondents observed increase in customer satisfaction levels however this has not been percolated to middle and lower management levels. This highlights the need for better communication across management levels.

Table 9. Management level view of Benefits achieved

		Rank 1	Rank 2	Rank 3
Top level Management	Benefits Achieved	**Improved productivity**	**Improved quality**	**Improved Customer satisfaction**
	Mean	4.31	4.38	4.06
	Std. Deviation	0.693	0.707	0.619
Middle level Management	Benefits Achieved	**Improved Productivity**	**Reduced costs**	**Improved Response time**
	Mean	4.33	4.20	4.08
	Std. Deviation	0.747	0.763	0.739
Lower level Management	Benefits Achieved	**Improved Productivity**	**Improved quality**	**Reduced inventory**
	Mean	4.30	4.07	4.07
	Std. Deviation	0.792	0.797	0.873

5.4. Identification of Barriers experienced

Following major barriers are observed to be obstructing progress of lean manufacturing implementation in the concerned pump manufacturing units:

Table 10. Barriers identified in implementing Lean Manufacturing

Rank	**Barriers Identified**	**Plant 1**		**Plant 2**		**Total**	
		Mean values	**Std. Deviation**	**Mean values**	**Std. Deviation**	**Mean values**	**Std. Deviation**
1	Lack of understanding	4.15	0.773	4.39	0.844	4.21	0.793
2	Supply Chain	3.84	1.025	4.23	0.762	3.93	0.982
3	Company culture	3.81	0.749	3.53	0.840	3.59	0.849

- **Lack of Understanding and its implications:** Lack of understanding is the most significant barrier identified. Hence it can be said that there is lack of clarity about lean manufacturing principles Due to lack of understanding the staff members cannot work smoothly and there may be a chaotic situation. The barrier is experienced strongly for Plant 2 than at Plant 1. However the view of Plant 1 respondents is more uniform as the value of standard deviation for plant 1 is less.
- **Supply Chain and its implications:** Another significant barrier experienced by companies is Supply Chain. Due to the presence of this barrier the reduction of inventory level was lesser than targeted. Lean manufacturing needs good support from all Supply chain stakeholders both upstream and downstream. The company adopting lean manufacturing must take measures to ensure cooperation from suppliers and distributors. Considering means and standard deviation it is inferred that the barrier is observed to be strong at Plant 2 as compared to Plant 1. This may be because Plant 1 is early established and it may have established good relationships with its suppliers due to which they cooperated to work as per lean manufacturing principles.

- **Company Culture and its implications:** Company Culture includes workers' behavior, worker-staff-management relationship, employee perceptions etc. There is a human tendency to resist change and the organizations under this research also faced this problem. Considering means and standard deviation it is inferred that the barrier is observed to be strong at Plant 1 as compared to Plant 2.

Table 11. Barriers viewed at different management levels

		Rank 1	Rank 2	Rank 3
Top level Management	**Barrier**	**Lack of understanding**	**Supply Chain**	**Company Culture**
	Mean	4.31	4.09	3.72
	Std. Deviation	0.738	0.963	0.888
Middle level Management	**Barrier**	**Lack of understanding**	**Supply Chain**	**Lack of suppliers support**
	Mean	4.14	3.71	3.63
	Std. Deviation	0.913	0.843	0.742
Lower level Management	**Barrier**	**Lack of understanding**	**Supply Chain**	**Company culture**
	Mean	4.20	4.02	3.59
	Std. Deviation	0.711	0.961	0.836

On analyzing the data considering different management levels, no significant difference in views of different management levels about barriers was observed. The respondents were equivocal in realization of barriers faced by the companies in implementing lean manufacturing.

5.5. Success achieved in Wastes Elimination/Reduction

As stated above there are seven different types of wastes identified in Lean manufacturing. Following wastes were eliminated /reduced by the pump manufacturing companies under consideration:

Table 12. Wastes eliminated successfully by implementing Lean Manufacturing

Rank	**Waste elimination**	**Plant 1**		**Plant 2**		**Total**	
		Mean values	**Std. Deviation**	**Mean values**	**Std. Deviation**	**Mean values**	**Std. Deviation**
1	Defect	4.31	0.698	4.35	0.551	4.32	0.665
2	Waiting	4.23	0.686	3.81	0.749	4.13	0.721
3	Overproduction	3.92	0.867	4.29	0.824	4.01	0.868
4	Over processing	4.08	0.746	3.65	0.709	3.98	0.758

Table 13. Management level view of Wastes eliminated

		Rank 1	Rank 2	Rank 3
Top level Management	**Waste eliminated**	**Defects**	**Waiting**	**Overproduction**
	Mean	4.31	4.16	4.03
	Std. Deviation	0.693	0.723	0.782
Middle level Management	**Waste eliminated**	**Defects**	**Waiting**	**Overproduction**
	Mean	4.43	4.18	4.06
	Std. Deviation	0.677	0.667	0.800
Lower level Management	**Waste eliminated**	**Defects**	**Waiting**	**Over processing**
	Mean	4.22	4.07	3.89
	Std. Deviation	0.634	0.773	0.744

- **Defects:** Both the pump manufacturing companies were able to reduce defects in their production output. Although the defect level is still high, it is reduced considerably as compared to times before lean manufacturing was implemented. The elimination of this waste was more successful at Plant 2 as compared to Plant 1.
- **Overproduction:** There was also a reduction in overproduction. As the lean manufacturing is a pull production technique the production levels are limited only to the requirement. The elimination of this waste was done more successfully at Plant 2 as compared to Plant 1.
- **Waiting Time:** There was also a reduction in waiting time. It symbolizes that the production schedules were streamlined, lines became more balanced and hence production planning was improved. The elimination of this waste was done more successfully at Plant 1 as compared to Plant 2.
- **Over processing:** The over processing was also reduced as a consequence of lean manufacturing adoption and implementation. The elimination of this waste was done more successfully at Plant 1 as compared to Plant 2.

Reduction in number of Defects and waiting time was noticed by all management levels personnel. Here also there is unanimity in the views across management levels which is desirable.

5.6. Correlations

Correlation analysis is carried out to identify any major correlations between variables. Pearson's correlation coefficient was used for this purpose.

Table 14. Correlation between Improved Flexibility and Improved Response Time

		SA_IF	SA_IRT
SA_IF	Pearson Correlation	**1**	
	Sig. (1-tailed)		
SA_IRT	Pearson Correlation	**.748****	**1**
	Sig. (1-tailed)	**.000**	
**. Correlation is significant at the 0.01 level (1-tailed).			

Where **SA_IF**= Success achieved in improving flexibility, **SA_IRT**= Success achieved in improving response time

On performing correlations analysis strongly positive correlation is observed between *Improved flexibility* and *Improved Response time*. The Pearson's coefficient value obtained is 0.748 which implies that flexibility of manufacturing system can be improved by improving response time i.e., reducing lead times.

Table 15. Correlation between Reduced cost and Improved Productivity

		SA_RC	SA_IPROD
SA_RC	Pearson Correlation	**1**	
	Sig. (1-tailed)		
SA_IPROD	Pearson Correlation	**.853**	**1**
	Sig. (1-tailed)	**.001**	
**. Correlation is significant at the 0.01 level (1-tailed).			

Where, **SA_RC**= Success achieved in Reducing costs, **SA_IPROD**= Success achieved in improving productivity

Another strong positive correlation was found between *Reduced costs* and *Improved productivity* with Pearson's coefficient value 0.853. It means that productivity can be improved by reduction of costs of production. This is a commonly accepted and understood fact and the same has been proved in this research also.

Table 16. Correlation between Lack of supplier support and Supply chain

		BI_SC	BI_LSS
BI_SC	Pearson Correlation	**1**	
	Sig. (1-tailed)		
BI_LSS	Pearson Correlation	**.632****	**1**
	Sig. (1-tailed)	**.003**	
**. Correlation is significant at the 0.01 level (1-tailed).			

Where, **BI_SC=** Barriers interfaced Supply chain, **BI_LSS**= Barriers interfaced Lack of suppliers' support.

A strong positive correlation was found between barriers *Lack of Suppliers' support* and *Supply Chain* with Pearson's coefficient value 0.632 .It implies that Supply chain performance can be improved if suppliers support is good.

5.7. Development of Regression Model

Multiple regression analysis is a stastical technique that simultaneously develops a mathematical relationship between two or more independent variables and an interval-scaled dependent variable (Malhotra and Dash, 2011).

A regression model was developed for *Lack of Workers Support* stepwise linear multiple regression. It was developed in order to identify contributors of workers resistance. The Regression Analysis revealed that workers support is significantly influenced positively by four input factors viz. *Lack of Leadership* (t= 4.009, p<0.01), *Past Failure* (t= 3.432, p< 0.01), *Lack of communication* (t= 3.035 p<0.01) and Company Culture (t= 2.379, p< 0.01). The predictor variable of *Lack of Workers support* has value of t= -1.528 and small value of p<0.00 suggests, it has negative impact on dependent variable than any other variable.

Where, **BI_LL** is Lack of Leadership, **BI_PF** past failures, **BI_LC** Lack of communication and **BI_CC** Company culture

Regression Equation:

Lack of Workers support (Y) = -.764 + 0.302 X_1+ 0.254X_2 + 0.226X_3 +0.173X_4

Where, Y = Lack of Workers' Support (BI_LWS)

X_1= Lack of Leadership
X_2 = Past failure experience
X_3 = Lack of communication
X_4= Company Culture

Table 17. Standardized and unstandardized coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	**-.764**	**.500**		**-1.528**	**.129**
	BI_LL	**.331**	**.083**	**.302**	**4.009**	**.000**
	BI_PF	**.250**	**.073**	**.254**	**3.432**	**.001**
	BI_LC	**.268**	**.088**	**.226**	**3.035**	**.003**
	BI_CC	**.245**	**.103**	**.173**	**2.379**	**.019**

Workers' support is a major concern in any changes adopted in organizations. This barrier is not just limited to Lean Manufacturing but affects any organization implementing changes. This research identifies *Lack of Leadership*, *Past failures*, *Lack of communication* and *Company Culture* as major reasons for Lack of workers' support. The workers' resistance can be reduced or eliminated by addressing identified factors.

Testing of hypotheses

Independent *t* test was applied to find out difference in opinions of employees of two companies about *Barriers Experienced* by the two pump manufacturing units under considerations Following hypotheses were tested using this test at a 95% confidence level:

Null Hypothesis H_0: $\mu_1 = \mu_2$

Alternate Hypothesis H_1: $\mu_1 \neq \mu_2$

where, μ_1 and μ_2 are means of plant1 and plant 2 respectively.

Table 18. Summary of Independent *t* test for Barriers Experienced

S.No	Barrier	Abbreviation	F Test	Null Hypothesis (H_0)	Remarks
1	Lack of Top Mgmt. Support	BI_LTMS	Variances Assumed Equal	Not rejected	$\mu_1 = \mu_2$
2	Lack of Understanding	BI_LU	Variances Assumed Equal	Not rejected	$\mu_1 = \mu_2$
3	Lack of workers' support	BI_LWS	Variances Assumed Equal	Rejected	$\mu_1 \neq \mu_2$
4	Lack of Suppliers' support	BI_LSS	Variances Assumed Equal	Not rejected	$\mu_1 = \mu_2$
5	Lack of Leadership	BI_LL	Variances Assumed Equal	Not rejected	$\mu_1 = \mu_2$
6	Company Culture	BI_CC	Variances Assumed Equal	Not rejected	$\mu_1 = \mu_2$
7	Lack of communication	BI_LC	Variances Assumed Equal	Not rejected	$\mu_1 = \mu_2$
8	Past failure	BI_PF	Not assumed equal	Not rejected	$\mu_1 = \mu_2$
9	Financial constraint	BI_FinCon	Variances Assumed Equal	Not rejected	$\mu_1 = \mu_2$
10	Supply Chain	BI_SC	Not assumed equal	Not rejected	$\mu_1 = \mu_2$

On analyzing the results of Independent *t test* (Table No. 10) it is observed that both the plants are equivocal in barriers perceived by them except in case of *Lack of Workers' support*. In case of Workers' support at plant 1 observed BI_LWS (Lack of Workers' support) as a stronger barrier than plant 2.

It implies that companies which were working with conventional systems are likely to face more resistance from workers than those units which adopt lean manufacturing system right from the establishment.

6. Conclusion

After analyzing responses it is concluded that Increase in Profit margin, Reduction of manufacturing costs, Reduction of inventories and Improving quality are the strongest trigger factors for adopting Lean Manufacturing in pump manufacturing industry. The companies succeeded in improving productivity and quality as well as reducing costs and wastes in the plant. In the course of implementing lean manufacturing the companies interfaced Lack of understanding, Supply Chain and Company culture as major barriers.

Strong positive correlations were observed between improved flexibility and improved response time, reduced cost and improved productivity as well as barriers Lack of suppliers' support and Supply Chain.

The Regression model for barrier 'Lack of worker's support' revealed that Lack of Leadership, Past failure experience, Lack of communication and Company contribute to increase workers' resistance. To counter this, company should have a deep understanding of lean manufacturing philosophy and principles. The workers should be educated and taken into confidence before implementation.

On analyzing the data management level wise it is observed there is lack of uniformity of goals across different management levels. There are differences observed in perceptions of personnel at different levels observed and this could be making lean manufacturing implementation difficult. For a smooth and successful lean manufacturing adoption it is important that whole organization is aligned to achieve common goals. This is not the case here. Due to misalignment of goals and objectives personnel at different level is trying to achieve different objective which in turn hinders the effective implementation of many lean manufacturing techniques such as Kaizen, cross functional team etc.

Lack of communication and leadership are primarily responsible for the differences observed. The onus of keeping the organization aligned is that of top management and hence more efforts should be made to improve communication in the organization and also to lead the lean implementation from front.

Managerial Implications

Improvement in productivity, quality and profitability are perceived to be consequences of an manufacturing implementation in both the pump manufacturing industries chosen for study. However lack of understanding and Supply chain posed as obstacles barring organizations from achieving maximum benefits. Lack of understanding has to be addressed by proper training of employees before and during lean manufacturing implementation. Higher emphasis must be given towards improving supply chain management and supply chain goals. These should be aligned with those of lean production system. A synergy between supply chain and production system has to be achieved for deriving maximum benefits of lean manufacturing implementation.

Both the companies have a similar view on barriers experienced except in case of Lack of workers' support where plant 1 (which is more than 50 years old) has a higher resistance than at plant 2 (recently established). In light of the above the workers of plant 1 should be further motivated towards the change.

Also it was Lack of Leadership, Lack of communication, company culture and past failure experience are contributors of Lack of workers' support. Out of these, lack of Leadership, lack of communication and

effects of company culture can be fairly minimized by a good understanding of lean manufacturing philosophy. So management must take employees of the company into confidence about lean manufacturing and its potential benefits.

7. Future scope for work

The results of research work presented in this paper can be further strengthened by applying other analytical methods such as structural equation modeling, factor analysis, comparative factor analysis etc. The research work can be extended to include other Indian pump manufacturing industries so that the outcomes can be said to be robust.

8. Limitations of the project

The project is mainly based on primary data collected from employees of two companies. It is assumed that respondents have responded with due concerns and sincerity. Also data could be collected from two pump manufacturing units only. The present study therefore cannot be generalized to reflect the entire Indian scenario.

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