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ROLE OF MANPOWER FLEXIBILITY IN LEAN MANUFACTURING

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ABSTRACT

The paper presents a study carried out in manufacturing industry for finding out the status of labour flexibility and extent of implementation of lean manufacturing. Labour flexibility was measured from the information collected on various parameters like ability of the workers to work on various machines, skill levels to perform on different jobs, cooperation in achieving production targets, attitude towards change, training, changes in the workforce strength over a period of time, ability of production workers to perform inspection jobs, extent of autonomous maintenance carried out, job designs. Status of lean manufacturing was found out from the levels of seven kinds of wastes, namely correction, that is, repairs or rework; motion- any wasted motion to pick up parts or stack parts; over production- producing more than needed, before it is needed; conveyance- wasted effort to transport materials, parts, or finished goods into or out of storage or between processes; inventory- maintaining excess inventory of raw materials, parts in process or finished goods; processing- doing more work than is necessary; waiting- any non-work time, waiting for tools, supplies, parts, etc. The study concludes that there is a very strong relationship between labour flexibility and lean manufacturing. The firms where the labour flexibility is higher are generating less amount of waste of resources and are closer to implementation of lean manufacturing. It is also brought out that a successful lean manufacturing implementation programme should address the human aspect first of all, particularly in Indian context.

Keywords: *Manpower, Flexibility, Lean manufacturing, multiple skills, waste.*

Introduction

In today's highly competitive market survival of a manufacturing organization depends upon its ability to introduce new and improved products while containing their prices within competitive range. Cost cutting through process improvement has assumed a great importance in all kinds of manufacturing organizations. Minimizing wastage of resources and moving towards implementation of lean manufacturing have become key strategies to achieve cost cutting. Lean manufacturing encompasses five interdependent principles; value definition; value stream analysis; flow; JIT/pull and perfection. 'Value definition' involves finding out the customer requirements, giving due weights to these requirements and bringing them into product designs. 'Value stream analysis' takes care of the design of the process to add value to the product in accordance with the customer requirements in the intended products. This value stream or production process is designed for transformation efficiency and effectiveness. The emphasis is on performance of value added activities and minimizing non value added activities. 'Flow' demands that the processes are so reliable that the transformation process goes on uninterrupted. 'JIT or Pull' requires that the production is carried out only when there is a confirmed customer

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order. The last principal of lean manufacturing, 'Perfection', ensures that all four aforementioned principles are perfectly implemented.

Successful implementation of lean manufacturing requires sophisticated flexible numerically controlled machines, use of latest technology, systems and procedures of work, standardization, multi skilled flexible work force and so on. In this paper, the importance of manpower flexibility for implementing lean manufacturing is highlighted.

In traditional mass manufacturing, there were specialized workers who were managed. The objective was to use their physical strength. They needed a great deal of supervision. Lean manufacturing on the other hand need flexible workforce who have multiple skills and are responsible. The aim is to use their intellect along with their physical strength. The workers need to be empowered, supervision reduced and officers need to devote time to high end jobs. In lean manufacturing the jobs are broader and the workers can derive pleasure and pride by performing these jobs.

Labour flexibility refers to the ability of the workforce to attain new skills and change jobs as and when required. Chen et al (1992) define labour flexibility as the ability of the workforce to perform a broad range of manufacturing tasks effectively. A flexible workforce is especially valuable in responding to the design changes and new product introduction. With labour flexibility, well trained multifunctional operators can be allocated to different work centres or redeployed to practice set-ups and other maintenance tasks. Higher labour flexibility provides enhanced capability to reassign tasks in the case of workforce absence.

While trying to find the reasons why Japanese flexible manufacturing systems outperform its counterpart in US, Jaikumar (1986) discovered that labour flexibility has proved the key to the success of flexible manufacturing systems in Japan. Brown et al (1988) also note that in search of flexibility, western countries are often technology driven while Japanese not only strive for technological improvements but also utilize flexible workforce. Labour flexibility can be enhanced through the management of workers' intellectual development such as multi discipline training and job rotation.

Gupta et al (2001), carried out a study to assess the role of labour flexibility in improving productivity in engineering industry. In this study, a questionnaire survey of engineering industry was carried out which was followed by detailed case studies in some selected organizations. The information collected from the industry was used to calculate the values of labour flexibility and productivity. Both partial productivities and total productivity were calculated. Correlation analysis was carried out which depicted strong correlation of labour flexibility with productivity. Another study by Khamba et al (2001), demonstrated a positive contribution of improving various kinds of flexibilities, including labour flexibility, towards technology management. Garg et al (2002) analysed the role of manpower in management of change and concluded that improvement in manpower flexibility facilitates management of change. Based on these and many other studies on manpower flexibility, it can be hypothesized that manpower flexibility has a strong correlation with lean manufacturing. The present study is undertaken to test the hypothesis and to ascertain the strength of relationship

The Study

The study was carried out in small scale auto parts industry of Punjab. The methodology adopted includes the following:

a) Preparation of a questionnaire covering various aspects of labour flexibility and lean manufacturing and its pre-testing

b) Collection of information through personal visits

c) Analysis of information and assessing the following:

i. Status of each aspect of labour flexibility

ii. Status of each aspect of lean manufacturing

iii. Status of each company in all aspects of labour flexibility taken together

iv. Status of each company in all aspects of lean manufacturing taken together

v. Correlation between various parameters of labour flexibility and lean manufacturing

A questionnaire was specially designed to collect information on various aspects of labour flexibility and lean manufacturing. These aspects are given in table 1and the table 2. The table also contain the codes given to the aspects. The codes have been used for carrying out statistical analysis of the collected data.

Considering the nature of various kinds of wastes to be measured to assess the status of lean manufacturing, it was decided to collect data from various industrial firms by personal visits and observations. The number of firms from where the data was collected was restricted to only ten. The questionnaire contained in all 30 questions on various aspects of labour flexibility. There were 18 questions on various types of wastes. In addition to the questions, information collected through personal observations and descriptions given in the questionnaire were made use of for determining the status of various major aspects of labour flexibility and lean manufacturing.

Table 1: Various Aspects of Labour Flexibility

S.No	Aspect	Code
i	Ability of the workers to work on various machines	LF1
ii	Skill levels of workers to perform on different jobs	LF2
iii	Cooperation of workers in achieving production targets	LF3
iv	Attitude of workers towards change	LF4
v	Training of workers	LF5
vi	Changes in the workforce strength over a period of time	LF6
vii	Ability of production workers to perform inspection jobs	LF7
viii	Extent of autonomous maintenance carried out by workers	LF8
ix	Job designs	LF9

Status of lean manufacturing was found out from the levels of seven kinds of wastes. Table 2 depicts these seven categories along with the codes given to each category.

Table 2: Various Aspects of Lean Manufacturing

S.No.	Aspect	Code
i	Correction, that is, repairs or rework.	LM1
ii	Motion- any wasted motion to pick up parts or stack parts.	LM2
iii	Over production- producing more than needed, before it is needed.	LM3
iv	Conveyance- wasted effort to transport materials, parts, or finished goods into or out of storage or between processes.	LM4
v	Inventory- maintaining excess inventory of raw materials, parts in process or finished goods.	LM5
vi	Processing- doing more work than is necessary.	LM6
vii	Waiting- any non-work time, waiting for tools, supplies, parts, etc.	LM7

Each question on labour flexibility and lean manufacturing had four options and thus a score between one to four. From these scores the percentage score achieved by each broader aspect of labour flexibility and lean manufacturing have been worked out.

Table 3 depicts the percentage scores of various aspects of labour flexibility as well as lean manufacturing. These scores have been worked out from the raw scores collected from

the response of the questionnaire using the following formula.

Percentage score $= \frac{\sum Sa_i}{nSm} \times 100$

Where Sa_i is the average score of a sub area which is further equal to $\frac{\sum S_i n_j}{N}$

Si is the score of a company in a sub area (i varies from 1 to 5),
Nj is the number of companies securing that score where Σj=N, total number of companies and Sm is the maximum score of a sub area, i.e., 5.

From the percentage score of each aspect of labour flexibility and lean manufacturing for each of the ten companies the following have been worked out:

Table 3: Percentage Scores of Companies in Various Aspects of Labour Flexibility

Firm/ Company	Percentage Score									
	LF 1	LF 2	LF 3	LF 4	LF 5	LF 6	LF 7	LF 8	LF 9	LF
1	45	49	68	64	68	65	52	28	67	56.22
2	47	52	65	60	65	64	53	28	63	55.22
3	65	67	81	67	77	74	60	44	69	67.11
4	39	44	70	60	69	62	50	29	64	54.11
5	55	56	77	67	74	72	57	42	70	63.33
6	57	59	80	68	78	75	56	43	72	65.33
7	57	58	83	59	76	70	50	41	61	61.66
8	64	66	80	58	80	74	61	47	71	66.44
9	53	56	78	60	72	63	52	27	62	58.33
10	38	41	68	57	61	61	49	24	61	51.11
Avg	52	55	75	62	72	68	54	35	65	59.7

Table 4: Percentage Scores of Companies in Various Aspects of Lean Manufacturing

Firm/ Company	Percentage Score							
	LM 1	LM 2	LM 3	LM 4	LM 5	LM 6	LM 7	LM
1	72	67	75	68	62	76	60	68.5
2	70	63	71	69	60	70	56	65.57
3	78	73	83	76	61	84	65	74.28
4	69	62	70	67	58	68	55	64.14
5	75	71	80	73	57	80	67	71.86
6	73	69	82	77	61	82	70	73.42
7	72	68	75	69	55	78	68	69.28
8	77	72	84	77	58	80	64	73.14
9	74	70	70	74	60	78	63	69.85
10	64	58	65	60	52	63	54	59.57
Avg.	72.4	67.3	75.5	71	58.4	75.9	62.2	

i. Average score of each aspect of labour flexibility in all the ten companies taken together
ii. Average score of each aspect of lean manufacturing in all the ten companies taken together.
iii. Average score of each company in all aspects of labour flexibility taken together
iv. Average score of each company in all aspects of lean manufacturing taken together

From these average scores, the status of each aspect of labour flexibility and lean manufacturing as well as the status of each company with regard to labour flexibility and lean manufacturing have been worked out. A brief explanation of these is given in the subsequent sections.

Labour Flexibility

In this section status of each aspect as well that of each company in labour flexibility have

been discussed.

Status of each Aspect

Figure 1 depicts the status of various aspects of labour flexibility pictorially. A close look at percentage score of various companies in labour flexibility depicts that workers try to cooperate in general in achieving production targets (75%) but this cooperation is limited to the activities to be carried out within the mutually agreed upon rules and regulations. Low scores of 'Ability of the worker to work on various machines' (52%) and on various jobs (55%) amply supports this view. Although a fair amount of training is being imparted (72%) yet multi-skilling of workers does not look to be of a good order.

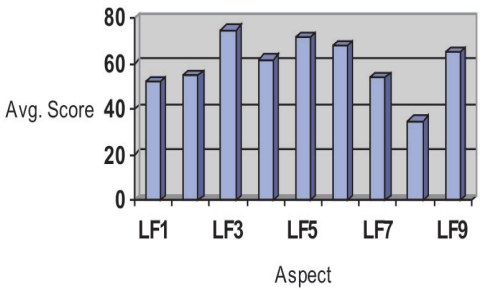

Figure 1: Status of Various Aspects of Labour Flexibility

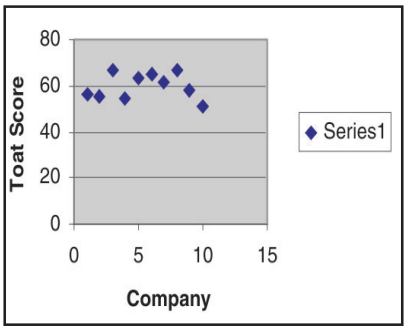

Figure 2: Status of Various Companies in Labour Flexibility

Two other important aspects which have become very crucial in today's industry i.e. 'Ability of production workers to perform inspection jobs' and 'Extent of autonomous maintenance carried out by workers' are found to be at a poor level with scores of 54% and 35% respectively. This dictates the need to reorient education and training and carefully implementing techniques like Total Productive Maintenance (TPM) and Total Quality Management (TQM). By giving equal weightage to all above major aspects, an average percentage score for manpower flexibility has been worked out to be 59.7%. Further, scores of all the 10 companies in various aspects of manpower flexibility and lean manufacturing have been worked out. Table 3 presents the details.

Status of Various Companies

Scatter diagram of figure 2 shows the status of various companies in labour flexibility. It is observed that the variation in the average score of the companies is not very large, the lowest score being 51.11% and the highest 67.11%. In case of the average score of various aspects in all the companies taken together the variation between the lowest score (35%) and the highest (75%) is very large. This phenomenon depicts that all the companies have made efforts to improve manpower flexibility. In all the companies some aspect of labour flexibility, particularly extent of autonomous maintenance and skill levels etc. have not been taken care of very well.

Further, it is seen that out of ten companies from where detailed information was collected, three have scores of above 65% which can be termed as good; two have a score between 60-65% which is fair and the remaining have a score of less than 60% which should be termed as poor in today's scenario. Overall, it can be said that labour flexibility in our industry is below satisfactory level (59.7%). Even the companies getting the highest scores are not at a very good or excellent level and there is a large scope for improvement which needs concerted and

sustained efforts.

Lean Manufacturing

Status of Various Aspects

Table 4 shows the average scores of each of the ten companies in various aspects (kinds of wastes) of lean manufacturing. Overall average score of each aspect as well as the average score obtained by each company in all aspects taken together are also shown in the table. Figure 3 gives a comparison of the average scores of various aspects. The figure represents a very interesting phenomenon.

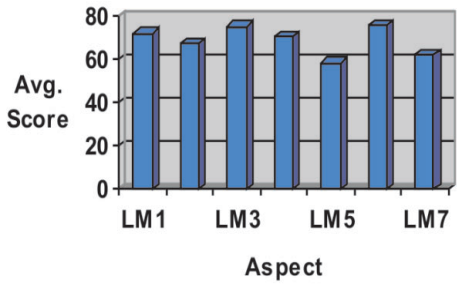

Figure 3: Average Score of Various Aspects of Lean Manufacturing

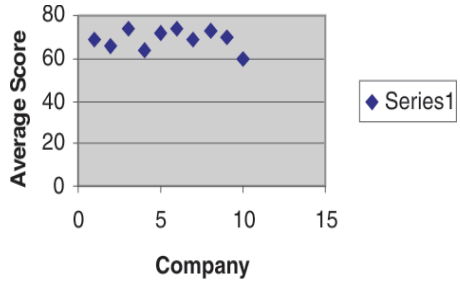

Figure 4: Status of Various Companies in Lean Manufacturing

Four aspects, i.e., Correction (72.4%), Over-production (75.5%), Conveyance (71%) and doing more work (75.0%) have scores of above 70% which can be termed as good. It shows that companies have paid attention to these areas and put in efforts to reduce wastes of these four types. They have been successful in reducing the amount of rework produced. In other words they try to produce the product of right quality in first attempt itself. A higher score of over-production depicts that the concept of Just in Time production is being implemented. Companies are producing only when there is a firm customer order. The old practices of producing in advance and keeping inventory in the finished goods stores is being replaced by producing only against confirmed orders. Further the companies have improved their material flow within the organization to optimize on material handling. This has reduced unnecessary transport of material within the work areas. The highest score has been achieved by 'doing more work than required' depicting thereby that now only those features of the product are taken care of which have their functional utility and are demanded by the customers. Unnecessary work done on the product which will not add value has considerably come down.

The remaining three aspects of lean manufacturing, namely, 'unnecessary motions' on work centres (67.3%), 'waiting due to various kinds of shortages' (62.2%) and 'higher inventories' (58.4%) have got comparatively low scores. Still there are unnecessary movements and efforts to pick up parts or place parts on the work centres. There is thus a need of a proper work place design through application of the principles of motion economy. Waiting due to various reasons have got a considerably low score. It shows that various kinds of shortages like material shortages, in availability of tooling, breakdowns etc. are still on quite a higher side. The lowest score has been received by 'inventory'. Inventories of raw materials, in-process goods and finished products are still on the higher side. This shows that processes are not so reliable and inventories have to be kept higher to take care of the flaws and shortcomings of the production processes.

Status of Various Companies in Lean manufacturing

Table 4 depicts the average score of each company in all aspects of lean manufacturing taken together. Figure 4 is a scatter diagram showing the total average score of the companies and their status with regard to Lean manufacturing. The scatter diagram depicts that four companies have scores between 70 and 75% which can be termed as good with regard to lean manufacturing status. Another four companies have scores between 65-70% and fall in the category of .fair'. the remaining two companies have scores less than 65% and fall in the 'unsatisfactory' category.

Relationship of Labour Flexibility and Lean Manufacturing

Table 5 shows the p values of coefficient of correlation between various parameters of labour flexibility. The table depicts that the relationships within all parameters of labour flexibility are significant. This shows that all factors are complementary to one another. If one becomes better it has a positive effect on other factors and vice-versa.

Table 5: Correlation Amongst Various Aspects of Labour Flexibility

Parameters	**LF 1**	**LF 2**	**LF 3**	**LF 4**	**LF 5**	**LF 6**	**LF 7**	**LF 8**	**LF 9**	**LF**
LF1	1	0.992	847	390	900	885	822	880	588	961
LF2	0.992	1	798	381	887	859	840	851	592	946
LF3	847	798	1	293	900	766	509	809	383	847
LF4	390	381	293	1	413	591	481	447	699	550
LF5	900	887	900	413	1	885	720	913	661	948
LF6	885	859	766	591	885	1	823	970	804	964
LF7	822	840	509	481	720	823	1	793	842	854
LF8	880	851	809	447	913	970	793	1	726	950
LF9	588	592	383	699	661	804	842	726	1	750
LF	961	946	847	550	948	964	854	950	750	1

Table 6: Correlation Amongst Various Aspects of Lean Manufacturing

Parameters	**LM 1**	**LM 2**	**LM 3**	**LM 4**	**LM 5**	**LM 6**	**LM 7**	**LM**
LM1	1	979	859	913	565	929	712	951
LM2	979	1	848	904	501	969	818	968
LM3	859	848	1	847	440	876	767	919
LM4	913	904	847	1	616	904	757	949
LM5	565	501	440	616	1	545	247	573
LM6	929	969	876	904	545	1	898	987
LM7	712	818	767	757	247	898	1	863
LM	951	968	919	949	573	987	863	1

Table 7: Correlation between Lean Manufacturing and Various Aspects of Labour Flexibility

Parameters	**LF 1**	**LF 2**	**LF 3**	**LF 4**	**LF 5**	**LF 6**	**LF 7**	**LF 8**	**LF 9**	**LF**
LM1	901	918	701	509	853	771	840	762	665	892
LM2	912	909	783	535	879	794	783	773	645	908
LM3	865	862	671	618	879	960	894	928	885	950
LM4	870	893	705	539	881	796	822	756	731	895
LM5	317	399	916	585	366	458	412	712	484	347
LM6	906	897	803	654	893	854	738	799	679	930
LM7	814	764	876	579	864	850	526	809	559	865
LM	915	917	771	639	914	879	812	832	752	951

Similarly the complementary nature of all parameters of lean manufacturing is evident from the significant relationships between them as shown in table 6.

Table 7 also shows the relationship of labour flexibility with all the parameters of lean manufacturing. It is seen that all relationships are positive and significant. This shows that

labour flexibility contributes towards achievement of lean manufacturing by reducing wastes of various resources.

The study concludes that there is a very strong relationship between labour flexibility and lean manufacturing. The firms where the labour flexibility is higher are generating less amount of waste of resources and are closer to implementation of lean manufacturing. It is also brought out that a successful lean manufacturing implementation programme should address the human aspect first of all, particularly in Indian context.

Conclusions

The study has shown that almost all the manufacturing units have put in efforts to reduce wastes of various kinds and move towards lean manufacturing. One of the strategies used for this purpose is to bring in labour flexibility. It has been shown that variations between the companies with regard to their overall standing in labour flexibility is not much but some aspects of labour flexibility are in a poor stage in almost all the organizations. It is also revealed that overall standing of the companies in labour flexibility needs improvement. Regarding wastages of various kinds considered under lean manufacturing, it is shown that some obvious areas have really improved but few areas like 'higher inventories' are at a poor level and need immediate attention. Further the study revealed that there is a strong correlation amongst all parameters of labour flexibility and lean manufacturing. It can be concluded that improving labour flexibility will certainly contribute towards achievement of lean manufacturing. The results go very well with the hypothesis as well as the studies appearing in the literature on the role of labour flexibility with productivity, technology management, management of change and other areas.

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