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ORIGINAL ARTICLE

A survey on lean practices in Indian machine tool industries

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Abstract Every manufacturing industry has put in continuous efforts for its survival in the current volatile economy. In order to face the situation, industries are trying to implement new and efficient techniques in their manufacturing operations. Some of the established tools in this context are lean practices, and its realization has been growing among the industries, particularly in automobile sector. To look beyond the auto-industry, a survey has been conducted to identify the status of lean practices in the machine tool manufacturing, which is one of the constituents of automobile value chain. A questionnaire tool applicable to machine tool environment has been designed and validated. The data recorded through the survey across the core machine tool manufacturers have been analyzed, and the results are presented. The results show that the status of lean implementation in the machine tool sector is still in infant stage. The reasons for low priority towards lean practices among the industries have been identified, and suitable measures have been suggested to address the problems. This will further assist the machine tool industries to gauge their level of leanness and will serve as a foundation for future research.

Keywords Lean tools · Waste · Mass production · Takt time · Lead time · Value chain · Value-added activity · Non-value-added activity

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1 Introduction

The business cycle in machine tool manufacturing closely follows the general economic cycle and has therefore always been subject to cyclical fluctuations. Businesses need to compete efficiently and quickly respond to market needs and niches. There is no doubt that the machine tool manufacturers are confronted with challenges and looking to implement improvements in their key activities or processes to cope with the market fluctuations and increasing customer requirements. Applying lean manufacturing philosophy is one of the most important concepts that help businesses to compete. Lean manufacturing or lean production, simply known as lean, is a production practice, which regards the use of resources for any work other than the creation of value for the end customer, is waste, and thus a target for elimination [1]. The automotive sector, which is extensively practicing lean concepts, can be considered as the major end user of machine tools [2]. The lean methods need to be systematically extended to the machine tool industry, so that the whole value chain will become lean, thereby, maximizing the benefit to customers and other stake holders. Even though the roots of lean concepts were evolved from mass production, its implementation in low discrete volume production of engineering products like machine tools has so far received less attention in the scholarly literature. With this back ground, an objective is set to evaluate the status of awareness and implementation of lean practices and to identify the lean needs for Indian machine tool manufacturing sector. A questionnaire-based survey was carried out, and the results are analyzed. The survey findings such as existing level of lean practices, reasons for less priority to lean concepts, type of lean tools employed, and perceived level of different wastes and the common difficulties encountered by the Indian machine tool manufacturers are discussed in this paper.

2 Literature review

Lean manufacturing (LM) is a multi-dimensional management practice including just in time, quality systems, work teams, cellular manufacturing, supplier management, etc., in an integrated system. The core motivation of lean manufacturing is that these practices can work synergistically to produce finished products at the pace of customer demand with little or no waste. The characteristics and impacts brought by lean practices have been presented in a number of works [1, 3–7]. It is demonstrated in the Japanese automotive industries as Toyota Production System (TPS) [8, 9]. TPS allows the continuous improvement of a business through the relentless elimination of waste, or non-value-added activities. Waste, in TPS, is defined as anything that does not add any value to the product or service from a customer's perspective [9]. There are seven types of fundamental wastes defined in TPS—correction, overproduction, motion, material movement, waiting, inventory, and processing [10]. To eliminate these wastes, TPS uses tools such as workplace organization, visual communication and control, quick changeovers, pull system, error proofing, etc. [1, 9–13]. Further, features of a typical LM model include: single piece flow production, non-value-added time elimination, production in the work content time only, relocation of required resources to the point of use, and leveled production by all the processes at the Takt time [14]. Pavnaskar has studied and organized a total of 101 lean manufacturing tools to serve as a link between manufacturing waste and lean tools to assist companies in lean transition [15].

The successful application of various lean practices had a profound impact in a variety of industries, such as aerospace, computer and electronics manufacturing, forging company, process industry (steel), and automotive manufacturing [16–20]; as a matter of fact, some industry may already be using some of the methodologies without actually realizing it. A study of the literature indicates that survey-based lean assessment work has been carried out in Australian manufacturing industry [21], electronics manufacturing [22], Spanish ceramic tile industry [23], and Malaysian electrical and electronics industry [24]. In light of the above findings, the present study is the first attempt that explores the degree of use of lean practices in machine tool industry and provides direction for future research.

3 Research objective and methodology

The primary aim of this study is to find out the needs and examine the degree to which the concepts of lean manufacturing are put into practice within Indian machine tool industries. In order to congregate the overall goal of the research, the survey methodology shown in Fig. 1 has been followed.

The questionnaire design proceeds in a systematic way with each item in the flow chart depend upon the successful completion of all the previous items. Therefore, it is important not to skip a single step. There are two feedback loops in the flow chart to allow revisions to the methodology and instrument. The survey instrument is developed into two modules by setting the following major topics as objectives. These different topics have then been converted and elaborated as explicit research questions in consultation with academicians, experts from machine tool industries, and most commonly cited lean manufacturing practices from the literature [7, 26].

Module I

- The status of lean manufacturing implementation.
- The motivation for lean implementation.
- The frequency of using different lean tools in machine tool industries.
- The general barriers/challenges in lean implementation concepts.
- Self-assessment of waste level.

Module II

Demographic data of industries—A separate section is included for demographic data.

This section contains questions related to work history and production details.

Five-point Likert scale has been used to state the respondents opinion with a minimum rating of 1 and maximum rating of 5 with an equal interval of 1 [27].

A full set of questionnaire is provided in the Appendix.

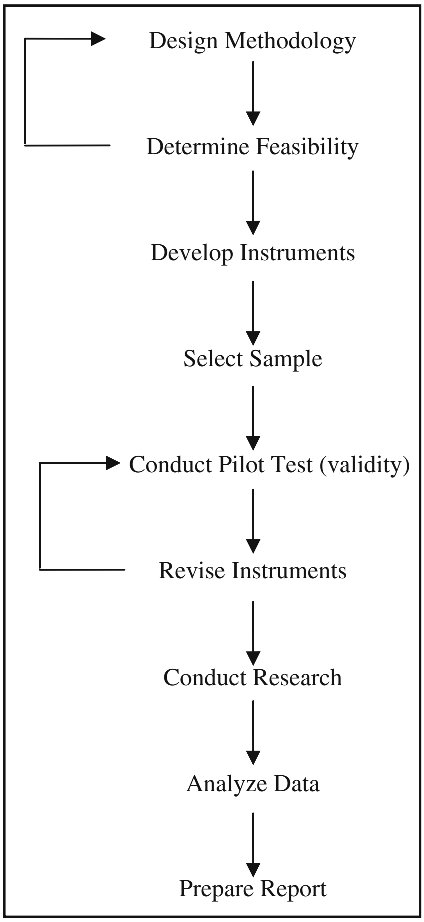

Fig. 1 Survey methodology [25]

3.1 Sampling plan

The machine tools industry can be divided into metal cutting and metal forming sectors. This survey mainly considers metal cutting machine tool manufacturers (conventional and computer numerically controlled machines) operating in India as population for study. The population of metal cutting machine tool industries in India under the organized category is about 150 [28]. The leading machine tool manufacturing industries located in various parts of India [29] are considered as sample for this study. The questionnaire was sent to the top executives of machine tool manufacturing industries, suppliers, and machine tool end users by mail. The respondents to the questionnaire were Managing Directors, General Managers, Deputy General Managers, Senior Managers, Assistant Managers, and shop floor engineers.

3.2 Construct validity

The face and content validity of questionnaire was determined by the industry and academic experts who are familiar with lean concepts. Based on their feedback, some changes were made before the questionnaires were distributed. In order to predict the reliability, Cronbach's alpha coefficient has been estimated using SPSS 15.0 (Statistical Package for Social Sciences) software.

3.3 Hypothesis formulation

Industry was the component of analysis in this study, and sources of information were responses from the industries. The following hypotheses have been developed to test the significance of the responses.

Null hypothesis H_0: The responses given by the industries to the survey items are not significant.

Alternative hypothesis H_1: The responses given by the industries to the survey items are significant.

4 Results and discussion

Reliability of the data is very important as the influences are derived from the collected data. Followed by the face and content validity, the questionnaire was checked for its reliability using Cronbach's alpha coefficient. Cronbach's alpha was calculated for two groups of questions, and the same is listed in Table 1.

Cronbach's alpha coefficient reflects the good internal consistency of the data gathered. It is in the range of 0.782 to 0.966 and a value greater than 0.7. Hence, it may be concluded that the data collected from the field survey are reliable and can be used for further analysis [30].

4.1 Company demographics

The frequency counts in this particular section of questionnaire bring out the information about the respondents and their distributions as shown in Fig. 2. Out of 150 questionnaires sent, 43 responses were received, at a 29%

Table 1 Cronbach's alpha values for the related questions

Question nos.	Cronbach's alpha, α
4 (ab), 4 (ac)	0.782
4 (a), 4 (ad)	0.966

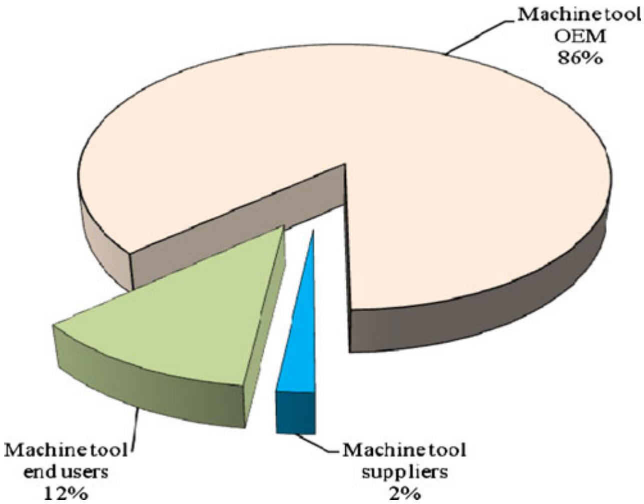

Fig. 2 Overall distribution of type of industries responded

response rate. The above response rate is considered reasonably good based on the recent survey-based research in operations management (7.47% [31], 13.5% [7]) and supply chain management (6.3% [32]).

The result shows that 86% of the responses are from machine tool original equipment manufacturers (OEM) followed by 12% from machine tool end users and 2% from machine tool suppliers. For further analysis, the input from machine tool manufacturers (OEM) and their suppliers were considered. As such, the extent of lean implementation is determined for the entire sample by calculating Likert scale mean and standard deviation. Higher scores are indicative of higher level of implementation and vice versa. The perceptions of respondents on lean practices were analyzed, and the observations are discussed in the following sections.

4.2 Hypothesis testing

The Statistical Package for Social Science 15.0 (SPSS) has been used for analyzing the data. In order to ascertain the statistical difference among participants' response, a non-parametric Friedman's test was conducted using a 0.05 level of significance. The results are tabulated in Table 2.

Table 2 shows the sub-titles of questionnaire and corresponding degrees of freedom. The critical value is obtained from the statistical table [33] and compared with the test statistics calculated using SPSS. The calculated test statistics value in all the three cases exceeds the critical value. So, the null hypothesis H_0 is rejected and alternative hypothesis H_1 is accepted. This result proves that there is a significant degree of difference among the participants response.

4.3 Reasons for low priority towards lean implementation

Based on the industry response, the status of lean implementation in the industries is grouped into five categories. The category wise response is portrayed in Fig. 3.

It can be seen that out of 38 responses received from machine tool manufacturers and its suppliers, only 31.6% of the industries have started implementing lean concepts in selected areas, with an average duration of 3 years. And about 15.8% are at planning stage and 7.9% companies would implement lean concepts after training within a year at the most. The remaining 17 companies (44.7%) have not yet taken up the lean initiatives, for a number of reasons. The responses for low priority towards lean implementation in machine tool industries are depicted in Table 3.

Table 3 shows the mean, standard deviation, and percentage of industries opted for specific reason whose response level is greater than mean value. These results predict that survey participants regard the "Effort required to change the mind-set of workers" as the important reason and "Low perceived benefits" as the least important based on the average mean value. The reasons for the above observations are presented as follows.

The major reason for the low priority to lean practices is related to the *human behavior* (mean=3.5). The difficulty

Table 2 Results of non-parametric Friedman's test

S. no.	Sub-titles of questionnaire	Degrees of freedom ($n-1$)	Critical value (χ^2_α)	Calculated test statistics	Result
1	Reasons for low priority towards lean implementation	37	52.19	70.59	H_0 is rejected
2	Status of lean tools employed in industries	37	52.19	75.04	H_0 is rejected
3	Important hurdles in lean implementation	37	52.19	69.25	H_0 is rejected.

n total no. of responses, χ^2 Chi-square distribution, α level of significance

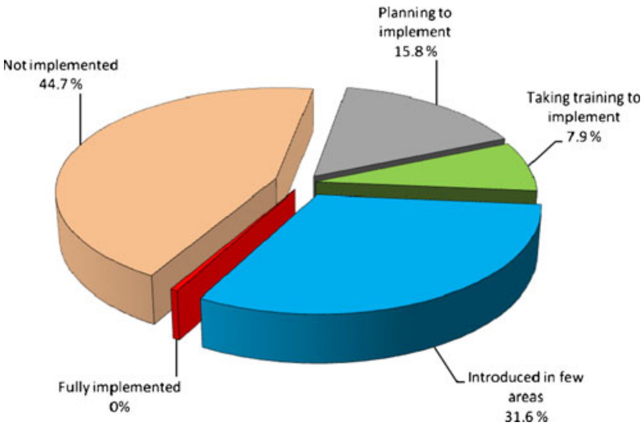

Fig. 3 Status of lean implementation in machine tool industries

of changing the mind—set of the people was strongly supported by the literature [24, 34–36]. The resistance to change may be because of fear of losing jobs, perception of additional workloads, and reduction of existing process time due to elimination of non-value-added activities. It might be possible to change the mind-set of employees if we could make them more aware of the lean benefits, consequences of waste, and survival of industry in the emerging economy. In the same way, *more time required to implement lean concepts*, *inadequate lean training opportunities*, *too general procedures and not industry—specific*, *less lean awareness programmes in India*, are few more significant factors leading to low priority in lean implementation. It has been observed from the literature that the biggest challenge in adopting the lean approach is to know which of the tools or principles to use and how to apply them effectively [26, 37]. So, the tools must be tailored to the realities of specific environments [38]. Another important point to be noted here is that lean is to be seen as a direction, rather than as a state to be reached after a certain time [39]. In addition to the above reasons, *high consultancy fee* and *initial investment* are perceived to be the obstacles to successful implementation of lean practices. These are related to "cost factor." Therefore, to get the ample support of management, it needs a detailed cost–benefit analysis. But, the benefits could be achieved only by transforming the employees as lean thinkers. To transform them as lean thinkers, suitable training and practices are the appropriate solutions. Further, the reasons like *lack of stiff competition and lower perceived benefits* are the choice of respondents for poor lean implementation. Also, becoming lean is not as easy as it seems, and misapplication of certain tool may result in additional wastage of resources and money [37].

4.4 Analysis of lean tools employed

There are different types of tools and techniques available for waste reduction or elimination [40]. These tools are labeled with multiple names; some of them have common characteristics with other tools. The participants are provided with a list of 36 lean tools and asked to indicate the frequency of application of these tools on a scale of 1 to 5, where 1 indicates never used; 2, rarely used; 3, partially used; 4, frequently used; and 5, continuously used. The responses are presented in Table 4.

The results of the survey highlight the status of different lean tools practiced with the mean value varying between 1.5 and 2.4 and covers up to 28 lean

Table 3 Reasons for low priority towards lean implementation

Reasons for low priority towards lean implementation	Mean	SD	% of industry response>mean
Effort required to change mind-set of workers	3.5	1.4	66
Too much time and more effort are required to implement lean	3.3	1.5	50
Inadequate training opportunity	3.2	1.3	45
The procedures are too general and not industry specific	3.2	1.2	45
Not an industry norm like ISO	3.1	1.2	50
Lean awareness program in our country is less	3.1	1.5	39
Lack of lean techniques awareness	3.0	1.3	47
The cost of consultant fee for training is high	3.0	1.2	34
Implementing lean projects need more investment	2.7	1.0	18
Lack of stiff competition	2.0	1.0	32
Low perceived benefits	1.9	0.9	24

SD standard deviation

Table 4 Status of lean tools employed in industries

Type of lean tool	Mean	SD	% of industries response>mean
Cross-functional team (CFT)	2.8	1.6	58
Work standardization	2.6	1.7	50
Process capability	2.5	1.4	47
Value engineering/value analysis	2.5	1.6	53
5S/foot prints	2.5	1.6	47
Root cause analysis/cause and effect diagram	2.5	1.4	53
Multiskill workers	2.5	1.6	45
Mixed model production	2.5	1.7	45
Kaizen	2.4	1.6	45
Target costing	2.4	1.5	47
Mistake proofing (Poka-yoke)	2.4	1.4	53
Failure mode and effect analysis (FMEA)	2.3	1.5	50
Supplier management (Keirestu)	2.3	1.4	39
Batch size/lot size reduction	2.2	1.6	37
Design for manufacture and assembly (DFMA)	2.2	1.6	39
Total productive maintenance (TPM)/OEE	2.2	1.5	39
Just in time (JIT)/pull system/Kanban	2.1	1.5	39
Visual management	2.1	1.4	32
New process equipment and technology	2.1	1.4	37
Single piece flow	2.1	1.5	32
Ergonomic work station [41]	1.9	1.2	42
Quality management system (QMS) (ISO9000, TS16949)	1.9	1.4	39
Indexed flow line	1.9	1.4	34
Line balancing (Heijunka)-leveling variety/volume	1.9	1.5	34
Quality function deployment (QFD)	1.9	1.2	42
Total quality management (TQM)	1.9	1.2	39
SQC	1.9	1.2	39
Cell layout	1.8	1.2	42
Value stream mapping (VSM)	1.8	1.3	37
Autonomation (Jidoka)	1.8	1.2	39
Calculation of Takt time	1.8	1.3	32
Part-set concept	1.8	1.1	37
Single minute exchange of dies (SMED)	1.8	1.3	32
Andon	1.7	1.2	37
Video time study	1.6	1.0	34
Milk runner system	1.5	1.1	21

SD standard deviation

tools (out of 36) and delivers an important message that most of the lean tools are rarely used in machine tool industries. The results further indicate that the fundamental building blocks of lean manufacturing, like milk runner system, andon, single minute exchange of dies, part-set concepts, value stream mapping, and cellular layout, are less frequently practiced in machine tool industries. Understanding the reasons behind low level of lean practices is important to make lean implementation possible in machine tool industries. The main reasons are lack of awareness, uneven adoption of lean tools, and tools not tailored to the user's needs. Herron and Braident [42] and Bhasin and Burcher [43] also suggested to embrace more lean tools rather than practicing one or two isolated ones to support the overall strategy of the industry and to realize the potential benefits of lean.

Table 5 Important hurdles in lean implementation

Barriers in lean implementation	Mean	SD	% of industries response>mean
Lower volume of demand	3.6	1.4	76
The customer orders are highly fluctuating/varying	3.6	1.6	71
Customer-specific tooling	3.3	1.3	74
Long lead time to produce a machine tools	3.3	1.5	63
Frequent design changes	3.2	1.5	45
It does not address the needs of machine tool industries	2.9	1.3	66
Most of the machine tool components are bought-out items	2.9	1.5	66
Resource constraints with reference to volume	2.9	1.3	71
Handling of big size machine tool components in shop floor are difficult unlike in mass production	2.8	1.6	55

SD standard deviation

4.5 Barriers in lean implementation

The analysis of the results summarized in Table 5 indicates the difficulties experienced by the machine tool industries in lean implementation.

Table 5 indicates that the lower volume of demand and highly fluctuating/varying customer orders are the serious hurdles faced by the industries (mean value=3.6). In the same way, the following reasons are indicated as other obstacles in lean implementation.

- Customer-specific tooling
- Long lead time to produce a machine tool
- Frequent changes in design
- Does not address the needs of machine tool industries
- Rely on bought-out items
- Resource constraints with reference to volume
- Perception of difficulties in handling of big size machine tool components unlike in mass production

The above factors may have a significant influence on day to day operational strategy variation. An industrial study conducted as a part of the present research work has revealed that most of the machine tool manufacturing activities are highly influenced by the customers. So, the level of adoption of lean production differed between mass production and low-volume high-variety environments (machine tool manufacturing).

4.6 Prevailing status of lean wastes

Another important area worth exploring was awareness about waste prevailing in organizations. The consolidated responses are presented in Fig. 4.

Figure 4 highlights the waste level in three categories such as low, medium, and high. It was found that the major wastes indicated as medium level are inventory, waiting, motion, re-work, process resetting, and underutilized people. The options for higher level of wastes are re-work, inventory, and underutilized skills of employees. These results indicate that the factors discussed in Section 4.5, like lower volume of demand, fluctuations in customer orders, and customer-specific tooling (accessories), might have influence on waste generation. Since the varieties are high, possibility of committing mistakes will also be high (working with different products every time). The shop floor employees learn lessons from previous defects and failures and use them for defect prevention in case of repeated orders. So, it is concluded that the variety change, frequent design changes, and customer influence on manufacturing process play a significant role in waste generation.

The other wastes like inventory and waiting are the consequences of re-work and process resetting. It is

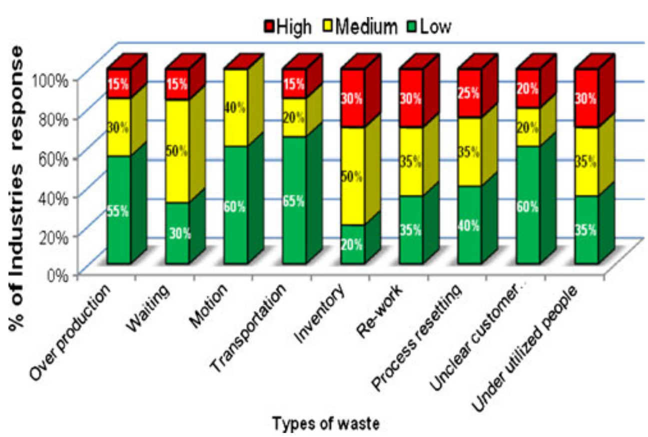

Fig. 4 Prevailing status of lean wastes

observed by the authors during the interaction with some of the respondents that lead time for purchase (more than 3 months) and minimum purchase quantity of major machine tool components like servo drives/motors, precision spindles, ball screws, linear guide ways, and precision bearings (since the components are imported) may be the other significant waste drivers for high inventory. Jha's [44] report on "Competitiveness of Indian manufacturing industry" revealing the realities of inventories which are being used to meet demand rather than developing a quick response manufacturing to meet changes in market needs also supports the results of this survey. Lean manufacturing begins with a focus on customer's desire and subsequent production based on customer pull. But, the emerging environment with volatile demand, high product variety with lower volume challenges pull production. It indirectly forces to keep more resources to satisfy the customer needs and confronts the lean implementation. The selection of appropriate production control methodologies such as push, pull, and hybrid push–pull systems to avoid inventory generation and have a smooth production as discussed by Karmarkar [45], De Toni et al. [46], Razmi et al. [47], and Razmi and Ahmed [48], which also support the issues prevailing in machine tool industries.

Further, the low volume of demand may be the reason for using skilled people to other work, which leads to predominantly stated waste in the form of untapped human skills. Also, most of the industries are using problem-solving tools like cross-functional team, root cause analysis, 5S, and so forth as lean tools. The study results reveal that the lean concepts are not attempted in a coherent way. A true understanding of lean manufacturing and its benefits begin with a clear understanding of the value-added versus non-value-added activities from the perspective of the customers. Therefore, implementation could be constrained by the need for more in-depth training in lean concepts, tools and techniques.

5 Conclusions

This paper presented a significant insight into the current status of lean manufacturing implementation in Indian machine tool industries, as well as tinted some allied issues. Firstly, the work has attempted to formulate a simple questionnaire-based tool to identify the existing level of lean practices, reasons for inadequate priority to lean concepts, type of lean tools employed, perceived level of different wastes, and the common difficulties encountered by the Indian machine tool manufacturers. The tool was validated through face, content, and reliability tests, and then the involvement in lean manufacturing activities is studied and discussed. The survey result revealed that 31.6% of the companies have implemented different lean tools and techniques in selected areas. The remaining 68.4% of the companies have not yet taken up the lean initiatives. The progress in lean implementation is also snail-paced, and it has a further scope to develop focused lean concepts, which could be implemented in other kind of manufacturing environment like low volume and high variety. It is concluded that the major reasons for low level of lean implementation are *anxiety in changing the mind-set of workers*, *lack of awareness and training about the lean concepts*, and *cost and time involved in lean implementation*. Therefore, the machine tool manufacturing companies need to give attention to implement lean in all the key areas from a holistic perspective. Appropriate lean education and research set up in association with industries has to be fostered and encouraged to stimulate the lean awareness and higher technological standards in manufacturing. The role of lean thinking is immense towards achieving this objective.

6 Limitations and future research

The response to the questionnaire may be limited by respondent's knowledge about lean practices. The person who has extensive knowledge about lean manufacturing could only provide correct response to the questionnaire; else, the outcome will be unreliable input data/poor response rate. Despite these limitations, this study will provide a foundation to trigger furthering lean practices research in machine tool manufacturing sector.

Further research in this area is needed to develop a suitable training demonstrator to teach lean concepts, train the employees, and transform them as lean thinkers. This would help to foresee the firms operations, learn to recognize the value-added and non-value-added activities, and inculcate the habit of wearing "muda spectacles" at all times by everyone. Further, a detailed description of how the lean concepts could be systematically combined, to facilitate the organizations to meet the Takt time in confronting surge and volatile environment, needs to be addressed. This new proposal has to be effectively implemented, not only to manufacturing industries, but also to reach the minds of young engineers.

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Appendix

PSG COLLEGE OF TECHNOLOGY, COIMBATORE – 641 004
DEPARTMENT OF MECHANICAL ENGINEERING

Lean Questionnaire

Objectives of the Research

a. To identify the level of implementation of Lean Manufacturing concepts in Machine Tool industries.

b. To identify the different areas of resource optimization in Machine Tool industries.

c. To identify the Lean tools with high leverage suitable for Machine Tool industries.

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Note :
All information given will be kept with utmost confidentiality and is for research purpose only. Kindly return this questionnaire by using the provided envelope before January 2009.

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PSG COLLEGE OF TECHNOLOGY, COIMBATORE – 641 004
DEPARTMENT OF MECHANICAL ENGINEERING

SECTION – A

Instructions

- Please indicate your response by tick mark ☑ in the appropriate box.

I. **Implementation of Lean Manufacturing concepts**

1. What is the status of Lean Manufacturing Implementation in your Organization?

Not implemented	Planning to implement	Taking training to implement	Introduced in few areas	Fully implemented
1	2	3	4	5

If answer is (1) : Go to Q 7, Others (2, 3, 4 & 5): Go to Q 2

2. When did you initiate Lean techniques in your company?

Year

3. In your opinion, what is the main motivation for lean implementation in your organization?

Strongly Disagree	Disagree	Average	Agree	Strongly Agree
1	2	3	4	5

Description	Level of agreement				
	1	2	3	4	5
a) To face the dynamic customer demand					
b) To enhance the customer delight					
c) To improve the company's brand					
d) To Provide competitive power to company					
e) To increase the market share					
f) To match the industry standards.					
g) Top management/corporate decision					
h) To enhance the management efficiency					
i) To enhance Quality Management System (QMS)					
j) To set a vehicle for performance improvement					
k) To improve the product quality.					
l) To reduce the product cost					
m) To provide tool for employees kaizen programme					
n) To improve the involvement & commitment of shop floor employees					
o) To improve the quality of work life					
p) To reap the benefits of lean manufacturing.					
q) To optimize the utilization of resources.					
r) To enhance the reliability of resources					
s) To reduce the product lead time.					
t) To reduce various types of wastes					
u) To increase the flexibility					

If you have other reasons, please specify

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DEPARTMENT OF MECHANICAL ENGINEERING

4. Which of the following lean tools are being used in your company?

Never used	Partially used	Rarely used	Frequently used	Continuously used
1	2	3	4	5

Description		Level of agreement				
		1	2	3	4	5
a) Value stream mapping(VSM)						
b) Just in time (JIT)/ Pull system/Kanban						
c) Batch size/lot size reduction						
d) 5S/Foot prints						
e) Ergonomic work station						
f) Visual management						
g) Video time study						
h) Milk runner system						
i) Total Quality Management (TQM)						
j) Total Productive Maintenance (TPM)/OEE						
k) Autonomation (Jidoka)						
l) Failure Mode And Effect Analysis (FMEA)						
m) Mistake proofing (Poka-yoke)						
n) Statistical Quality Control (SQC)/ 7 QC Tools	(i) At your door step					
	(ii) At your process					
o) Root cause analysis/ Cause and effect diagram						
p) Quality Management System (QMS) (ISO9000,TS16949)						
q) Process capability						
r) Supplier management (keiretsu)						
s) Cross functional team (CFT)						
t) New process equipment & technology						
u) Quality Function Deployment (QFD)						
v) Andon						
w) Part-set concept						
x) Multiskill workers						
y) Indexed flow line						
z) Design for Manufacture and Assembly (DFMA)						
aa) Single Minute Exchange of Dies (SMED)						
ab) Single piece flow						
ac) Cell layout						
ad) Calculation of takt time						
ae) Line balancing (Heijunka)/levelling variety/volume						
af) Kaizen						
ag) Work standardization						
ah) Mixed model production						
ai) Target costing						
aj) Value Engineering/Value analysis						

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Is there any other tool that has not been covered above that you wish to add? ____________________

5. To what extent do you think that the IT tools can help in lean implementation?

	Very poor	Poor	Average	Good	Excellent
Description	1	2	3	4	5
1. In your company					
2. For the industry					

6. What is your company's methodology in Lean Implementation?

a) Through external consultant	
b) By internal improvement teams	

If the Q 2, 3, 4, 5 & 6 is answered Go to Q 8,

7. Reasons for giving low priority to lean implementation in your organization:

Strongly Disagree	Disagree	Average	Agree	Strongly Agree
1	2	3	4	5

Description	Level of agreement				
	1	2	3	4	5
a) Lack of Lean Techniques awareness					
b) Lean awareness programme in our country is less					
c) Non availability of training opportunity					
d) Lack of stiff competition					
e) The procedures are too general and not industry - specific					
f) Too much time and more effort are required to implement lean					
g) Effort required to change mind - set of workers					
h) Implementing lean projects need more investment					
i) The cost of Consultant fee for training is high					
j) Not an industry norm like ISO					
k) Low perceived benefits					

Do you have other reasons? Please specify

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8. Do you think the lean manufacturing implementation in machine tool industries is difficult?

Yes	
No	

If yes, Could you please highlight the reasons?

Strongly Disagree	Disagree	Neither agree or nor disagree	Agree	Strongly Agree
1	2	3	4	5

Description	Level of agreement				
	1	2	3	4	5
a) It does not address the needs of machine tool industries					
b) Lower volume of demand					
c) The customer orders are highly fluctuating/varying					
d) Customer specific tooling					
e) Frequent design changes.					
f) Most of the machine tool components are bought-out items					
g) Handling of big size machine tool components in shop floor are difficult unlike in mass production					
h) Long lead time to produce a Machine Tools **					
i) Resource constraints in reference to volume					

**(Lead time is the average length of time between the capture of a customer order & the shipment of the product to customer.)

Do you have other reasons? Please specify

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II Different types of waste

1. Assess the level of waste in you organization

Nil	Low	Medium	High	Very High
1	2	3	4	5

Description	1	2	3	4	5
a) Producing more or faster than that required by the next process customer is a waste. Your assessment level of such waste in your organization					
b) Queuing, waiting periods are waste. Your assessment level of such waste in your organization.					
c) Employees' frequent walking inside the shop floor is waste. Your assessment level of such waste in your organization.					
d) Unnecessary movement of goods or materials inside the shop floor is waste. Your assessment level of such waste in your organization.					
e) Excess inventory ties up a great deal of cash, which is wasteful. Stockpiling, queuing between processes are waste. Your assessment level of such waste in your organization.					
f) Having to re-work parts because of manufacturing errors is a large source of waste. Your assessment level of such waste in your organization.					
g) Rework/Rejection leads to process resetting. Assessment level of process adjustment in your organization.					
h) Unclear customer requirements cause the manufacturer to add unnecessary processes and it is a waste. Your assessment level of such waste in your organization.					
i) Under-utilized people – not tapping into people's education, skills, experience, knowledge, creativity. Your assessment level of such waste in your organization.					

2. Is there any other waste that has not been covered in the above list that you wish to add?

a) In your company____________________

b) For the machine tool industry in particular ____________________

3. List down few major wastes eliminated by implementing lean manufacturing in your shop floor.

4. List down few major wastes that you plan to eliminate in future (please specify the percentage of elimination targeted).

a. Processing	
b. Lack of information	
c. Underutilization of resources	
d. Over production	
e. Waiting time	

f. Motion	
g. Transport	
h. Inventory	
i. Defects	

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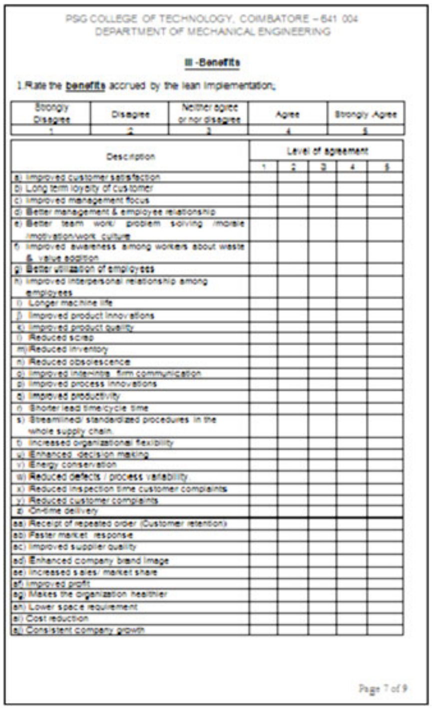

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III -Benefits

1.Rate the **benefits** accrued by the lean implementation.

Strongly Disagree	Disagree	Neither agree or nor disagree	Agree	Strongly Agree
1	2	3	4	5

Description	Level of agreement				
	1	2	3	4	5
a) Improved customer satisfaction					
b) Long term loyalty of customer					
c) Improved management focus					
d) Better management & employee relationship					
e) Better team work/ problem solving /morale /motivation/work culture					
f) Improved awareness among workers about waste & value addition					
g) Better utilization of employees					
h) Improved interpersonal relationship among employees					
i) Longer machine life					
j) Improved product innovations					
k) Improved product quality					
l) Reduced scrap					
m) Reduced inventory					
n) Reduced obsolescence					
o) Improved inter-intra firm communication					
p) Improved process innovations					
q) Improved productivity					
r) Shorter lead time/cycle time					
s) Streamlined/ standardized procedures in the whole supply chain.					
t) Increased organizational flexibility					
u) Enhanced decision making					
v) Energy conservation					
w) Reduced defects / process variability					
x) Reduced inspection time customer complaints					
y) Reduced customer complaints					
z) On-time delivery					
aa) Receipt of repeated order (Customer retention)					
ab) Faster market response					
ac) Improved supplier quality					
ad) Enhanced company brand image					
ae) Increased sales/ market share					
af) Improved profit					
ag) Makes the organization healthier					
ah) Lower space requirement					
ai) Cost reduction					
aj) Consistent company growth					

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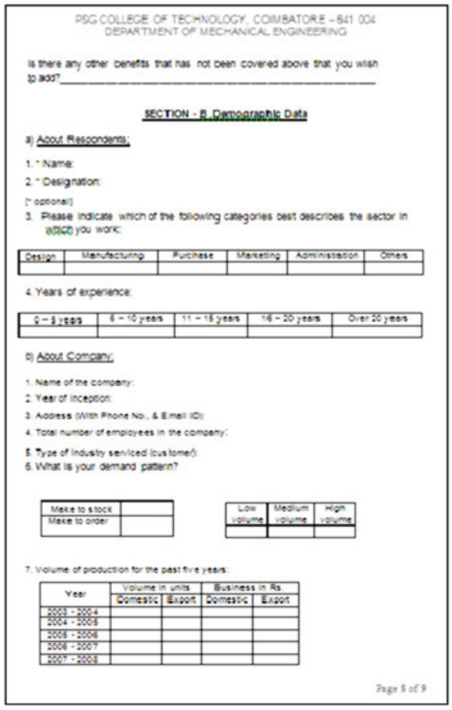

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Is there any other benefits that has not been covered above that you wish to add?________________________

SECTION - B Demographic Data

a) About Respondents:

1. * Name:
2. * Designation:

(* optional)

3. Please indicate which of the following categories best describes the sector in which you work:

Design	Manufacturing	Purchase	Marketing	Administration	Others

4. Years of experience:

0 – 5 years	6 – 10 years	11 – 15 years	16 – 20 years	Over 20 years

b) About Company:

1. Name of the company:
2. Year of inception:
3. Address (With Phone No., & E.mail ID):
4. Total number of employees in the company:
5. Type of industry serviced (customer):
6. What is your demand pattern?

Make to stock	
Make to order	

Low volume	Medium volume	High volume

7. Volume of production for the past five years:

Year	Volume in units		Business in Rs.	
	Domestic	Export	Domestic	Export
2003 - 2004				
2004 - 2005				
2005 - 2006				
2006 - 2007				
2007 - 2008				

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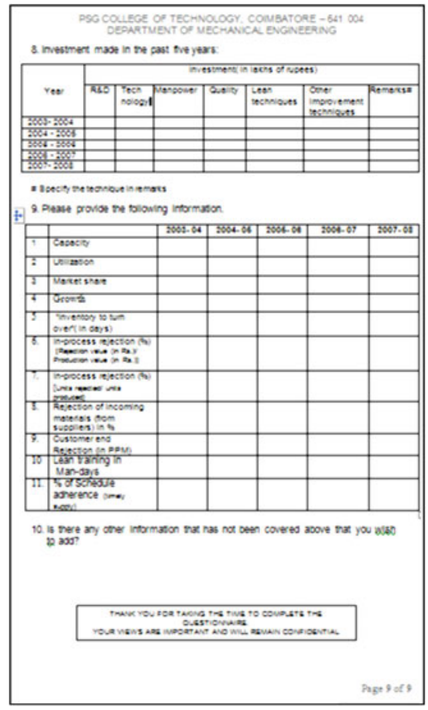

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8. Investment made in the past five years:

Year	Investment(in lakhs of rupees)						
	R&D	Tech nology	Manpower	Quality	Lean techniques	Other improvement techniques	Remarks#
2003- 2004							
2004 - 2005							
2005 - 2006							
2006 - 2007							
2007- 2008							

\# Specify the technique in remarks

9. Please provide the following information.

		2003-04	2004-05	2005-06	2006-07	2007-08
1	Capacity					
2	Utilization					
3	Market share					
4	Growth					
5	"Inventory to turn over"(in days)					
6.	In-process rejection (%) (Rejection value (in Rs.)/ Production value (in Rs.))					
7.	In-process rejection (%) (Units rejected/ units produced)					
8.	Rejection of incoming materials (from suppliers) in %					
9.	Customer end Rejection (in PPM)					
10	Lean training in Man-days					
11.	% of Schedule adherence (timely supply)					

10. Is there any other information that has not been covered above that you wish to add?

THANK YOU FOR TAKING THE TIME TO COMPLETE THE QUESTIONNAIRE
YOUR VIEWS ARE IMPORTANT AND WILL REMAIN CONFIDENTIAL

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