

Identification of Major Lean Production Waste in Indian Automobile Industries

¹Kiran Ashok Rayate, ²Dr. H. P. Khairnar

¹P.G.Scholar, ²Assistant Professor,

^{1,2}Department Of Mechanical Engineering, Veermata Jijabai Technological Institute, Mumbai, India.

Abstract— Elimination of Industrial muda (waste) is major dispute faced by the Indian Automobile Industry's experts in daily production activities. Most of firms have eight types of industrial muda namely Waiting Time in processes, Transportation of raw material, Unnecessary Motion of products, Over Production, Over Processing, Improper inventory management, Defects in finished goods and Lack of knowledge. Every industry faces particular waste that occurs in their production activities. To find out the major contributing lean waste, a survey of 77 automobile industries in India is done and ranking is given based on average of the responses received from the industry. The respondent were asked to rank in order the major productivity loss by various lean waste to find highly impacted lean muda in Indian Automobile Industries. Based on the results transportation is major muda and over processing is minor muda. This study also discusses ways to eliminate these muda.

Index Terms— Inventory, Lean Waste, Muda, Over Processing.

I. INTRODUCTION:

The lean management makes it possible to obtain a product that adapts to actual demand of product using the minimum amount of resources and therefore minimizing the cost of product, with the appropriate quality and quick response. For this purpose, all activities that do not add value, called waste or muda, must be eliminated, including inappropriate processes, unnecessary inventory, unnecessary movement and stocks of all kind, which would result in increased costs [1]. Industries that have successfully reduced their internal muda through lean production also implement practices for better product management [2-3]. Lean production is a standard in the global automobile industry and is now find useful in other manufacturing sectors [4-5] and even in other service industries as well [6]. This attention on waste reduction is can be achieved in industry as process simplification, inventory reduction and the identification and elimination of non-value-adding processes or motions [7]. Most of the Indian automobile industry are using cellular manufacturing but to remove out various process waste and to compete in global market lean tools will definitely come handy for Indian automobile industry.

Landsbergis [8] have discussed the subject based on reviews of the literature, without the support of empirical data. Jackson [9] identified both positive and negative effects of Lean Production in terms of physical demands, social climate and autonomy. Lean manufacturing is also expected to enhance the industry's ability to improve customer value in terms of lower prices and quality products, which will enhance market performance of industry [10]. In order to test the proposed hypotheses, the authors used the International Manufacturing Strategy Survey (IMSS-IV) data collected in 2005. The ambiguity of the impacts of LP on working conditions was also detected by whom analyzed 52 scientific articles on the subject [11]. The use of surveys have been the most frequent research strategy to evaluate the human impacts of the Lean Production. It has been difficult to undertake deep investigations into this issue based on qualitative data. Surveys have been conducted by [12-13] states that field research was the most suitable method for learning about the company's general Lean history, the nature of its lean transformation and its inside/outside dynamics. We should highlight at this point that the case company's lean production efforts have been successful in terms of both financial measures such as savings, profit, etc. and non- financial such as operational measures. With the use of quasi-exploratory case study is to gain support and an explanation of our survey-based study. Most of the previous research focus on the impact of lean, but this study mainly focuses on the impact of major muda's that occurs in the industry. It also states that the level of muda that occurs and the parameters that are associated with the muda are explained.

II. METHODOLOGY:

A questionnaire was developed by us to collect the data to find out the major waste in Indian Automobile Industry. The questionnaire was developed as per the pre assessment made on the workplaces of the automobile industries. In questionnaire various 8 Lean waste are listed and respondent were asked to arrange them in order of major wastage of productivity in their firm. The Survey Invitation is send by mail to almost 188 Indian automotive manufacturing companies that manufactures two-wheel, three-wheel and four-wheel vehicles and automotive components. The company profile contains name of company, location, type of industry, main products, and E-mail address. After reminders and e-mails, 77 responses were received, a 41% response rate.

Table 1. Statistics of Respondent Companies

Sr. No.	Parameter Under Consideration	Indian Respondent N=77 (Out of 188)
---------	-------------------------------	--

1	No. of Employees in Company :	
	< 50	11
	50-100	8
	100-150	18
	150-200	13
	200-250	7
	250<	20
2	Company Domain :	
	Automobile Component Manufacturer	36
	Automobile Assembler	17
	Automobile part vendor	11
	Automobile service provider	13
3	Company Annual Sales (Approximately In INR)	
	<50 Lakh	8
	50 Lakh -1 Crore	12
	1 Crore - 5 Crore	26
	5 Crore – 10 Crore	10
	> 10 Crore	21
4	Annual Sales of Products (in Units/Year)	
	<500	0
	500-1,000	11
	1,000-5,000	6
	5,000-10,000	16
	10,000-20,000	12
	20,000-50,000	17
	50,000<	15
5	Average Domestic Sales of Company (in %)	81.221
6	Average Export of Company (in %)	18.779
7	Respondent Position in Company	
	CEO/President	7
	General Manager	15
	Factory/Plant Manager	11
	Production/Engineering Department Manager	23
	QC/QA Manager	9
	HR Manager	5
	Sales Manager	7

III. LEAN WASTE TAKEN INTO CONSIDERATION FOR ANALYSIS:

The details of various eight major waste taken into consideration are given below. The major wastes according to survey results are discuss along with the statistics obtained from the survey. Discussion on the each waste and remedies are discuss below.

1) Transportation:

The transportation is ranked first in wastage of time in Indian Automobile Industry according to survey results. Transportation is function of = f (plant process layout, travel distance, etc.). The majority of transportation costs is generated by moving raw materials to a manufacturing place and moving finished products to a customer. The finished product is form at far away from its application place and to transfer that finished product up to its application point lot of time and money is spend. The cause of this transportation is the centralized production of a product, and the design of the supply chain supporting production. In most industries, large scale centralized production is present and as a result product may be produced miles away from where it is needed. The supply chain management has a big effect on transportation. Sourcing raw materials locally in industry can reduce transportation costs and saves transportation time. When making sourcing decisions, the transportation costs are typically included in the total cost of the material being acquired [14]. Inside a facility, transportation is caused by wait time and inventory.

Every break in a process that causes wait time has the potential to allow WIP (Work in Process) to accumulate [14]. With large number of finished goods and raw material inventories, transportation costs also increases. The bigger the warehouse, the higher the transportation costs spend on the warehouse. In some cases, the transportation is typically of workers and not products. Many companies recognize and consider the transportation costs of employees travelling as well. To found match between sales and production figures of product, sale and product planner's need to meet regularly and if they are located far from each other then also transportation waste increases. To reduce transportation cost some industries have adopt the local manufacturing in which some big parts of product which are required in large numbers are manufactured near to customer place and by doing so the transportation cost and time is reduces. Every restaurant gives a make-to-order manufacturing facility close to customers. Companies should develop supply chains that minimize transportation muda. Survey results shows about 60% Indian automobile industries consider transportation as major wastage of productivity. The details of respondents who consider transportation as a major waste out of the eight waste are given below.

From Table 2 the percentage of respondents who consider transportation as major muda in automobile industry are 59.74%. The percentage of respondents rank transportation second are 12.99% and so on.

Table 2. The percentage of respondents for Transportation

Rank	No. of Response	Percentage
1	46	59.74
2	10	12.99
3	5	6.49
4	8	10.39
5	3	3.9
6	0	0
7	5	6.49
8	0	0

2) Inventory:

As Inventory is commonly thought of as the finished goods, a company accumulates before selling them to end users. But inventory can also describe the raw materials used to produce the finished goods, goods as they go through the production process (referred to as "work-in-progress" or WIP), or goods that are "in transit"[15]. Inventory is function of = f (cash flow, production, order, floor space, etc.). Causes of Inventory Overproduction, another of the 8 Wastes, are important cause of inventory. Processes and bonus or incentives that encourage producing too much product will lead to higher inventory levels. It protects against foreseen events such as a machine breakdown, material shortage, or natural disaster. Casually controlled processes lead to inaccurate forecasts, lot sizes, poor communication with customers and suppliers. All of these imperfections will result in higher inventory levels. The most prominent effect of inventory is the capital required to carry the inventory. The cost of inventory is major, and that cost generates no returns. By reducing the inventory required to operate, the business can spend the capital it requires in order to carry out that inventory in other productive activities and by doing this a growth in the business can be achieved. As inventory levels go up, the capital investment in storehouse space also increases. Large warehouse with improper management insures more time is spend in moving product into storage and out of storage locations. Damage to inventory also increases a waste of capital, as more inventories are stored for longer times will definitely produces some damage to raw materials and for finished goods also. The larger the inventory in the industry, more labors are required to maintain inventory.

Table 3. The percentage of respondents for inventory

Rank	No. of Response	Percentage
1	9	11.69
2	39	50.65
3	11	14.29
4	2	2.6
5	3	3.9
6	9	11.69
7	4	5.19
8	0	0

A plant that has one day's inventory on hand will have a fast and easy access to inventory compared to a plant with a year of product in storage as to get up to the stored parts is also consumes lot of time. Solution for inventory is essential to organize processes and reduce lead times. Every reduction in lead times allows a reduction in the inventory in hand. Eliminating WIP (work in process) can be achieved by creating a organize flow of material through the production process. Every interruption in a process requires WIP to be stored and relocate between manufacturing processes. Eliminating these interruptions allows the elimination of WIP. Better forecasting and a shift to a pull system will eliminate the large forecast variances that lead to overproduction and increases in inventory levels. Any effort seeking to reduce inventory must have rewards to motivate employees to minimize inventory. To popularize the proper usage of inventory management should make a decision as the reduction in inventory cost, a part of it will be given as bonus to the employees, so that employees also suggest some ways to minimize inventory waste. Survey

results stated that the inventory rank 2nd according to respondents and is second major waste out of the eight waste and results are given below.

From the table 3 the number of respondent percentage is 50.65% strongly agree inventory as second major waste in Indian automobile industry and 11.69% pick it as major waste. Some industry not consider inventory management as waste and placed it at 6th or 7th major waste of productivity in the industry and rightly so as many of companies implementing a lean techniques to counter this major waste.

3) Unnecessary Motion:

Unnecessary motion or movement in the manufacturing industry will result in processing delays. Other unutilized factor is employees lost time, unused skills, employee ideas, and guidance in simplifying the process. Unnecessary motion is a function of = f (operator experience, wastage of time, injury, difference in operators talent, underrated assignment to an experienced operator, etc.).

Survey results shows that the almost 30 people out of 77 placed Unnecessary motion in automobile industry as 3rd major waste from which the productivity is lost. From the table 4 the number of respondent percentage is 38.96% pick it as 3rd major waste and almost 40% respondent place it between four to sixth place. Therefore, survey results shows that automobile industry do consider the wasted or unnecessary motion as a major waste.

Table 4. The percentage of respondents for unnecessary motion

Rank	No. of Response	Percentage
1	4	5.19
2	5	6.49
3	30	38.96
4	9	11.69
5	10	12.99
6	13	16.88
7	3	3.9
8	3	3.9

4) Waiting Time:

Delay or waiting is usually caused by the loading and unloading the work piece in the machines and also waiting time is caused by processing delays, machine downtime, response time and signature required for approval of work is also contributes to wait time. The reason for the delay and waiting for materials is questionable especially in automobile industry as continuous and flexible production is generally present in them. The operator's time allocation is more than that of the actual processing time. This excess time allocation for the operators to do the job increases the overall wait time and delay in the process. Efforts need to make the flow smooth and even wait time = f (machine downtime, response time, signature approval, etc.)[16]. In Indian automobile industry even for single change in reference level of a product will required a involvement of a major authorities but they are not always present at their place and due to that often or not the delay in production or process to complete is takes place.

According to Survey results waiting time ranks 4th major wastage of productivity in Indian automobile industry. From the table 5 the percentage of respondents around 38% placed waiting time is 4th major waste in automobile industry. Even around 18.18 % respondent placed it at 3rd rank. So waiting time is also a major muda by whom the productivity of the automobile industry is gets affected.

Table 5. The percentage of respondents for waiting time.

Rank	No. of Response	Percentage
1	2	2.6
2	3	3.9
3	14	18.18
4	29	37.66
5	16	20.78
6	4	5.19
7	0	0
8	9	11.69

5) Defects in Product:

Defects in product leads to design changes, additional rework, process changes, inspection, and addition to that is machine downtime. The original cost as already spend and also unnecessary rework or replacement costs are added. Defect in product is function of = f (Inspection, rework, changes in design, changes in process parameters, scrap, some additional paperwork, etc.). Poor product quality and the resulting defects are a major source of waste for many automobile manufacturing companies. A defect is any non-acceptable error in a process that makes a product less valuable to a customer. To make it acceptable or useful to a customer it requires additional processing to correct the defect. By doing so lots of time and money is wasted. Therefore, defects in product is one of the major waste of productivity in Indian automobile industry. The lot of companies are focusing on adoption of lean tools to close look on quality of product to minimize the waste cause by it. Total Quality Management (TQM) was a majorly use in automobile manufacturing industry before lean was adopted extensively. It was easy for a firm to predict that defects in product is a major waste. Therefore, to counter that quality initiatives were designed to reduce and eliminate defects.

The processes that are prone to defects are made highly controlled. A well-controlled process should produce acceptable products every single time. Changes to machine setups, variations in raw materials, wear and tear of machines, improper maintenance and poor training of workers can all lead to variation in quality of product and may produce defects. Inadequate planning, poor communications and insufficient training can all lead to errors at workplace. Defects in product affects both direct and indirect costs. The direct cost consist of materials and labor work that get spend on the part which turn to be defective, and the rework cost consist of cost which is spend on correcting that product defect. If the product defects are overlooked and not corrected before dispatch, they can reach the customer. A dissatisfied customer can tell other people about product quality, which definitely affects the product sales, industry must make sure that no defected product could reach to customer. Workers are often responsible for product design, delivery, service, planning, and scheduling and if they treat properly by management, the defects can be eliminated from the root.

Survey results shows that around 25.97% respondent place product defect as 5th major muda in automobile industry and around 23.38% people placed it at 4th position. Therefore, defects in product is a major waste out of the eight waste. Table 6 shows the percentage of respondents for defects.

Table 6. The percentage of respondent for defects in product.

Rank	No. of Response	Percentage
1	4	5.19
2	6	7.79
3	8	10.39
4	18	23.38
5	20	25.97
6	7	9.09
7	6	7.79
8	8	10.39

6) Lack of Knowledge:

Operator skills and the knowledge decides the fortune of the finished product. Highly skillful machine operator will manufactures a product with very rare defects in it as compared to one who is less skillful. If operator and whole of firms employees are enough knowledgeable then there knowledge and skills can be shown in the product quality. Another profit of knowledgeable employees is, if any operator not come due to some reason then other operator who is replacing him or her is also of same skills and there will be no difference in product produced by both. Lack of knowledge about anything will not give us better results, it is applied in automobile industry also. Lack of knowledge is increase WIP as any difficulty is come during production is takes a lot of time to rectify and further more time to solve it. Lack of knowledge can be compensate by proper training of employees along with the proper guidance from higher people.

Survey results shows that around 35.06% puck it as 6th major waste out of eight major waste in Indian automobile industry. 19.48% respondent placed it at 5th place. Table 7 shows the details of the percentage of respondents for lack of knowledge.

Table 7. The percentage of respondent for lack of knowledge.

Rank	No. of Response	Percentage
1	3	3.9
2	2	2.6
3	4	5.19
4	3	3.9
5	15	19.48
6	27	35.06
7	12	15.58
8	11	14.29

7) Over Production:

Over production is also one of the major waste in Indian automobile industry. As parts or products are being manufacture without any prior order or demand from the customer side then the cash is get invested in those over produced component and the growth of the firm get affected. Those excess produce components may be sold with reduced price to clear out the stock to get investment back or to lower the inventory for the next year's production [17-18]. Producing more products than the actual demand or produce it before it actually needed is called as over production. Overproduction means making more than that is required by the next process, making earlier than that is required by the next process, or making faster than required by the next process[17-18]. The Lean principle is leads us to manufacture based upon a pull system, or producing them as order received from the customers [19].

Survey results shows that around 23.38% respondents from automobile industry placed overproduction at 7th major waste of productivity in Indian automobile industry and 35.06% placed it at 8th place. Table 8 shows the details of the percentage of respondents for over production.

Table 8. The percentage of respondent for over production.

Rank	No. of Response	Percentage
1	4	5.19

2	9	11.69
3	4	5.19
4	4	5.19
5	5	6.49
6	6	7.79
7	18	23.38
8	27	35.06

8) Over Processing:

To apply lean principle in Indian automobile industry it is important to observe each activity or each process as potential waste. Processing is function of = f (Work in Process (WIP), process steps needed, WIP location, etc.). The activity must add value to the product quality and so as to customer, and must be an activity that cannot perform of its on. To recognize over processing as waste it is important to examine every activity or process in correspondence to lean only. The primary cause of some processing steps to occur is a failure to recognize that processes as a waste. Every process in the manufacturing operation is often assumed value added process and that heads everyone to overlook processing as a one of the source of waste. In industry, many processes are unnecessary. Another usual cause of over processing is complicity. As the complicity of a process is increase, there will be rise in number of unnecessary steps. In an automobile industry, over processing is a very usual muda. Many steps of approval and reviews for making decision do not add any value in productivity. There may be many controls and sensors installed to ensure quality of product but many of these activities are wasteful. Eliminating processing steps that do not add any value to the process can effectively improve the speed of operation and significantly reduces the costs.

Survey results shows that about 24.68% respondent consider over processing as one of the major waste out of eight that cause loss in productivity. Table 9 shows the details of a percentage of the respondents for over processing. Over processing, is 8th major waste of productivity in Indian automobile industry according to survey results.

Table 9. The percentage of respondent for over processing.

Rank	No. of Response	Percentage
1	5	6.19
2	3	3.9
3	1	1.3
4	4	5.19
5	5	6.49
6	11	14.29
7	29	37.66
8	19	24.68

IV. RESULTS AND DISCUSSION:

Waste or Muda reduction is the major concern in the Indian automobile industry. The below table 10 states that transportation, inventory and unnecessary motion are major muda that affect the productivity of automobile industry according to survey results. The waiting time rank next to the first three waste in some industries, but in some of the industries transportation and inventory waste is completely eliminated by proper planning and scheduling. The Defects in product, lack of knowledge, over production and over processing are ranked as 5,6,7,8 respectively. This type of waste have major effect on cash flow and on productivity of the industry. The results indicate that transportation is a major waste in Indian automobile industries because 46 number of respondents out of 77 ranked it as major waste out of eight waste and approximately averaging 2.12 in ranking as well. The next in the list according to respondents is inventory muda with 39 out of 77 ranked in as second major waste and averaging 2.92 in ranking. The third major waste in Indian automobile industry is unnecessary motion with 30 respondents out of 77 ranked it as third major waste and averaging 4.06. The other major waste in Indian automobile industry are waiting time, defects in product, lack of knowledge, over production muda and over processing muda but are not consider major waste according to survey results as majority of respondent not consider them in top three waste. The waste or muda, which found themselves after rank 4, are not major muda or waste because many Indian companies have found a different solutions to tackle those waste. Lean manufacturing techniques also helps in that regards because these major waste are countered handsomely in lean manufacturing system. By adopting and implementing lean manufacturing system or lean tools the major three muda or waste also be tackled and minimize.

Table. 10 A ranking of the various waste based on respondent responses.

Sr No.	Major Waste Tool	1	2	3	4	5	6	7	8	Average Rank
1	Transportation	46	10	5	8	3	0	5	0	2.12~1
2	Inventory	9	39	11	2	3	9	4	0	2.92~2
3	Unnecessary Motion	4	5	30	9	10	13	3	3	4.06~3
4	Waiting Time	2	3	14	29	16	4	0	9	4.44~4
5	Defects in Product	4	6	8	18	20	7	6	8	4.68~5

6	Lack of Knowledge	3	2	4	3	15	27	12	11	5.71~6
7	Over Production	4	9	4	4	5	6	18	27	5.88~7
8	Over Processing	5	3	1	4	5	11	29	11	6.18~8

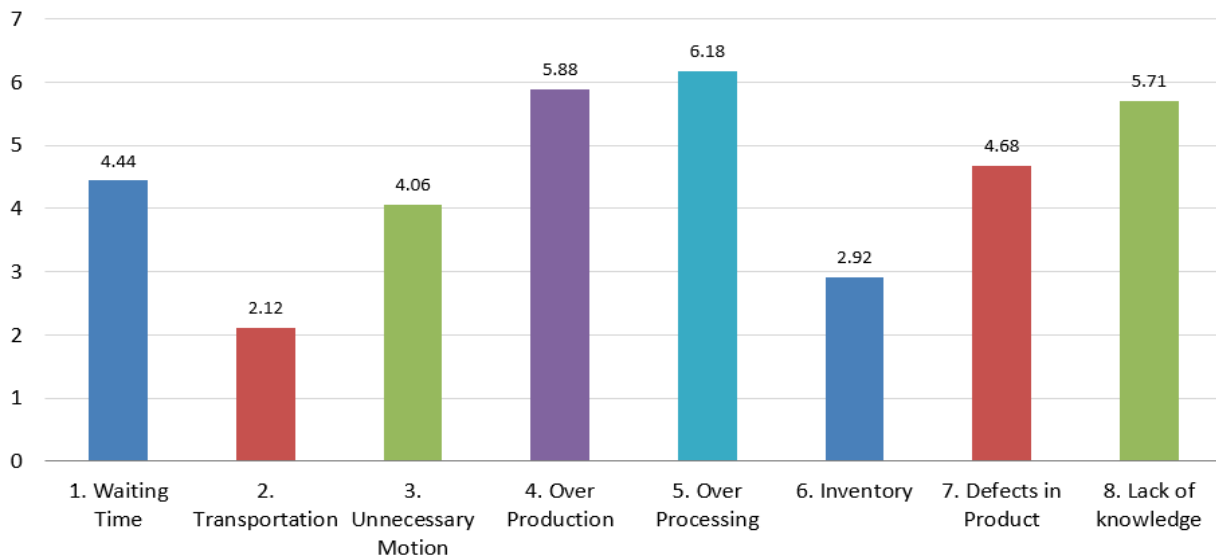


Fig. 1 Rank-wise major waste of productivity in Indian automobile industry.

V. CONCLUSIONS:

This work mainly focuses on exploration a major muda out of 8 types of muda occur in the Indian automobile industry. Every organization is facing some problems related to these wastes. To overcome the problem caused by these waste various lean tools are adopted in industry. Calculation carried out by using the average of ranks obtained from survey to find the major waste, which affects productivity in Indian automobile industry. From the results three major waste out of eight waste are identified. Mathematical results (Average of rank obtained from respondents) are in support to this major automobile waste and also theoretically explained about each waste in detail and how this type of muda affects the Indian automobile industry is also explained. The graph shown in above figure 1 states that how respondents responded to these different types of wastes. The majority of the response shows that three muda such as Transportation Muda, Inventory Muda and Unnecessary Motion Muda are the major muda, which affects the Indian automobile industry productivity. Hence, to demolish these major wastes from Indian automobile industry process planners, industrial experts and production managers need to have a close look at these three major muda. Taking necessary steps and adopting lean tools can counter these wastes. Removal of these major wastes form industry considerably increase the cash flow of company such that cash can be allotted to a places which produces maximum returns and also boost production rate and in turn have a pronounced impact towards the productivity of the Indian automobile industries.

REFERENCES

- [1] McCutcheon, D.M., Meredith, J.R., Conducting case study research in operations management. *Journal of Operations Management*, 11 (3), (1993) 239–256.
- [2] Womack J.P, Jones, DT, Lean Thinking. Banish Waste and Create Wealth in your Corporation. (2003) Simon & Schuster UK Ltd. London.
- [3] Abdulmalek F.A., Rajgopal, J. Analyzing the benefits of lean manufacturing and value stream mapping via simulation: a process sector case study, *International Journal of Production Economics*, 107 (1), (2007) 223–236.
- [4] John B, *The Lean Toolbox*, 2nd Ed, Picsie Books, Buckingham, England (2000) 21-24.
- [5] Ohno T, *Toyota Production System – Beyond Large Scale Production*, Productivity Press, Portland, OR.1988
- [6] Bicheno, J., Holweg, M. *The Lean Toolbox*, Fourth Ed. PICSIE Books, Buckingham, UK. 2009.
- [7] Conti R, Angelis, J, Cooper C, Faragher B, Gill C, The effects of lean production on worker job stress, *International Journal of Operations & Production Management*, 26 (9), (2006) 1013–1038.
- [8] Landsbergis, P.A., Cahill, J., Schnall, P The impact of lean production and related new systems of work organization on worker health. *Journal of Occupational Health Psychology* 4 (2), (1999) 108–130.
- [9] Jackson, P.R., Mullarkey, S., Lean production teams and health in garment manufacture. *Journal of Occupational Health Psychology* 5 (2), (2000) 231–245.
- [10] Lluís Cuatrecasas Arboles, Design of a rapid response and high efficiency service by lean production principles: Methodology and evaluation of variability of performance, *International Journal of Production Economics*, 80 (2002) 169– 183.
- [11] Lewchuk, W., Stewart, P., Yates, C., Quality of working life in the automobile industry: a Canada–UK comparative study. *New Technology, Work and Employment* 16 (2), (2001) 72–87.
- [12] Spear, S., Bowen, H.K. Decoding the DNA of the Toyota production system. *Harvard Business Review* 77 (5), (1999) 97–106.

- [13] Montabon, F, Sroufe, R., Narasimhan, R., An examination of corporate reporting, environmental management practices and firm performance. *Journal of Operations Management*, 25 (5), (2007) 998–1014
- [14] P. Arunagiri , A. Gnanavelbabu., Identification of Major Lean Production Waste in Automobile Industries using Weighted Average Method. *Procedia Engineering* 97 (2014) 2167 – 2175
- [15] <https://en.wikipedia.org/wiki/Inventory>
- [16] Arunagiri P., Gnanavelbabu, A., Investigation on Critical Factors Assessment of the Lean Production Systems in Industrial Environment, *Proceedings of ICRTES 13, Elsevier Science and Technology* (2013) 450-453
- [17] Ma Ga (Mark) Yang, Paul Hong n, Sachin B. Modi., Impact of lean manufacturing and environmental management on business performance : An empirical study of manufacturing firms. *Interntional Journal of Production Economics*, 129 (2011) 251–261.
- [18] Arunagiri P., Gnanavelbabu, A., Implementation of Lean Manufacturing System in Bogie Assembly in Railway Coach Factory, *Applied Mechanics and Materials*, Vol. 248, (2013) 511-515.
- [19] Arunagiri P., Gnanavelbabu, A., Review on Reduction of Delay in manufacturing process using Lean Six Sigma (LSS) systems, *International Journal of Scientific and Research Publications*, Vol. 3 (2), (2013) 1-5.

