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A Strategic Application of the Lean Management Techniques Through Lean Indexes Based on Point Rating System

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Abstract: In today's industrial scenario huge losses/wastage occur in the manufacturing shop floor. This waste is due to operators, maintenance personal, process, tooling problems and non-availability of components in time etc. Other forms of waste includes idle machines, idle manpower, break down machine, rejected parts, etc. are all examples of waste. The present study gives a detailed project report on the maximum wastage in a real organization and suggested the best suitable lean maintenance techniques to optimize these wastes and thus results for the better improvement of the OEE. The study presents in a strategic way of study regarding the application of these concepts in a real organization which builds its business success on the phenomenon called knowledge.

Key words: Critical factor, FMECA, lean manufacturing, lean techniques, lean indexes, total productive maintenance

INTRODUCTION

Lean manufacturing: Lean manufacturing is the implementation of the concept that anything that does not create value in the product is to be eliminated. Subsequent survey reveals the application of lean leadership and points out future possibilities for improvement (Dombrowskia and Mielke, 2013). The significance role of TPM as an important complementary to lean production is observed has not been well addressed in the available literature. Most of the researches available investigate these initiatives separately, rather than addressing on the significant role of TPM as one of the main thrust. The beneficial outcome from TPM methodology is quite hindered and unexposed in some literatures related to lean production. The outcomes from this review is hope justify the needs of further research in the area of TPM integration with lean production, aimed at strengthening its philosophy towards more realistic applications (Bakri *et al*., 2012).

Overall equipment effectiveness is the best way practices for the calculation of the performance of the industry. It is very simple and practical. In this, it considers the most important sources of the manufacturing product losses and categorizes into lean indexes and become an excellent tool for measuring where you are and how can you improve? It is mainly used as a key metric for TPM and lean manufacturing (VI, 2005). Before one can stop waste, he should able to see it, recognize it as waste, identify who is responsible and finally appreciate its size and magnitude. Finally, when the waste is not measured, people may think it is small or trivial and therefore will not be motivated to stop it. The Toyota Production System (TPS) focuses on muri and muda. Muri focuses on the preparation and planning of the process or what work can be eliminated in the design process. Muda are those waste steps and processes that add cost. Muri is used in new product design and muda is used to improve existing operations. A lean system declares war on wastes or "muda". These wastes are classified as.

Over-production waste: Over-production waste occurs when more goods are produced than can be sold, resulting in idle finished goods inventory.

Processing waste: Processing waste comes from unnecessary processing that does not add value to the item being produced or worked on.

Transport waste: When anything people, equipment, supplies, tools, documents or materials is moved or transported unnecessarily from one location to another, transport waste is generated.

Waiting time waste: When resources like people and equipment are forced to wait unnecessarily because of delays in the arrival or availability of other resources including information, there is waiting time waste.

Inventory waste: Inventory wastes come from the purchasing, issuance, storage of excess or excessive supplies, materials and other resources.

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Motion waste: Motion waste happens when unnecessary body movements are made when performing a task.

Defects: Quality is doing the right thing right the first time. It is about prevention and planning, not Correction and inspection.

Reputation: The reputation of a business is essential to its survival. The trust and confidence of the consumer can have a direct and profound effect on a company's bottom line.

Non-value-added-processing: The processes add no value to the product. Some of the more common examples of this are reworking, deburring and inspecting.

Underutilized people: This includes underutilization of mental, creative and physical skills and abilities where non-lean environments only recognize underutilization of physical attributes. Some of the causes for this waste include-poor workflow, organizational culture, inadequate hiring practices, poor or non-existent training and high employee turnover.

Lean manufacturing techniques: In order to reduce or eliminate the above wastes, lean practitioners utilize many tools. Successful practitioners recognize that, although most of these may be implemented as stand-alone programs, few have significant impact when used alone. Kaizen: Kaizen means improvement, continuous improvement involving everyone in the organization from top management, to managers then to supervisors and to workers.

Zero defect: The technique for producing parts with zero defects in the manufacturing line. By producing like this defective product waste will be reduced.

Pull system: The technique for producing parts at customer demand. Service organizations operate this way by their very nature. Work cells: The technique of arranging operations and people in a cell (U-shaped, etc.) rather than in a traditional straight assembly line. Among other things, the cellular concept allows for better utilization of people and improves communication. Maintenance management: Maintenance capitalizes on proactive and progressive maintenance Methodologies and calls upon the knowledge and cooperation of operators, equipment vendors, engineering and support personnel to optimize machine performance.

Quality management: Quality management is a management system used to continuously improve all areas of a company's operation. QM is applicable to every operation in the company and recognizes the strength of employee involvement.

Kanban: A method for maintaining an orderly flow of material. Kanban cards are used to indicate materialorder points how much material is needed, from where the material is ordered and to where it should be delivered.

HR management: The HR unit is heavily involved in increasing needs and requirements by Participation in programme coordination group-support recruitment and training of lean facilitators, Involvement in other training and information activities related to lean.

Six sigma: A process must produce no >3.4 defects per mln opportunities. It is very closely associated with zero defects.

Problem overview: In order to resist the competition of the global market conditions, every manufacturing company is trying to adopt the best techniques and methods to get the best output. So in this scenario, everyone are concentrating more on the elimination of waste, rather than implementing new techniques. As the implementation of new techniques, machinery, training to employee's results in more expensive. This study emphasizes mainly on the elimination of major losses of an industry with the help of selective best lean manufacturing techniques.

MATERIALS AND METHODS

Determining the lean indexes for the elimination of waste by team of experts: Firstly, a detailed study about the industry and their contributing wastes in the industry has to be done. Considering, different lean indexes with respect to the cost, quality, time, deliveries and reputation aspects (Srinivasa Rao and Niraj, 2016) has been made. Those lean indexes are listed in Table 1. In this research >30 lean tools are used for the analysis based on the production environment. Each type of organisation uses a particular type of lean tools for the particular problem The first layer is the goal layer (the top layer) which presents the overall goal of evaluation that is industrial performance evaluation is based on value creation.

The second layer is the rule layer which presents the overall goal in all aspects that is sub goal including value creation ability, sustainable development ability. The third level is the scheme layer which are various specific techniques of performance evaluation (Table 1).

Now it is the time to compare every individual metric with the other and wanted to give the priorities of these

Table 1: Classification of Lean parameters for better OEE

First layer	Second layer	Third layer	Calculating lean indexes
OEE	Overproduction wastes (L_1)	Kaizen (X_1)	Breakdowns (A)
	Transportation wastes (L_2)	Zero defects (X_2)	Speed loss (B)
	Inventory wastes (L_3)	Pull of materials (X_3)	Scrap loss (C)
	Motion wastes (L_4)	Total productive maintenance (X_4)	Shutdowns (D)
	Over processing wastes (L_5)	Total quality maintenance (X_5)	Number of customer complaints (E)
	Waiting time waste (L_6)	Human resource management (X_6)	Non value added time (F)
	Product defect waste (L_7)	Kanban (X_7)	Orders delivered late (G)
	Bad reputation (L_8)	Work cells (X_8)	-
	Under utilized people (L_9)	Six sigma (X_9)	-

Table 2: Comparison judgement matrix

Variables	A	B	C	D	E	F	G	Total (N)	N+1
A	-	2	1	2	2	1	1	9	10
-	B	-	2	2	1	0	0	5	6
-	-	C	-	2	3	1	0	6	7
-	-	-	D	-	3	0	1	4	5
-	-	-	-	E	-	1	1	2	3
-	-	-	-	-	F	-	3	3	4
-	-	-	-	-	-	G	-	0	1

0→no impact;1→minor impact; 2→medium impact; 3→major impact

lean indexes. For this expert's judgment system is used to extract 7 lean performance measures from an initial list and to score them using data gathered from the survey. In this context, a survey with a questionnaire consists of 20 questions with answers which are explained to each worker by rigorous training method for filling it is made. The questionnaire consists of questions in 4 point rickets scales. These forms were given at random about 30 employees in various expertises.

Most of the forms given to manufacturing side as the most of the work relays on lean manufacturing, working conditions and ergonomics human factors only. The distribution was 10 manufacturing, 5 engineering, 5 maintenance, 5 quality, 2 suppliers, 1 ergonomics, 1 occupational safety, 1 communication. By substituting the collected data in the value engineering technique method (Xine *et al*., 2012) the lean indexes are arranged in a high to low weighted prioritized way which is shown in Table 2 and 3. All questions are based on variable point scales and to identify the major waste through the oral interview which is made among the workers and team leaders.

The above Table 1 shows that maximum wastage is seen in scrap loss and the rest are following it. So it can be considered as the most critical measure and measures have to be taken to decrease these losses. Below are the few techniques to be considered for minimising the scrap loss.

Table 3: Relation of lean indexes with lean techniques

Lean techniques	Sum of lean indexes	Weightage
Kaizen (X_1)	Scrap loss, breakdown loss, speed loss, non value added time loss	27
Zero defect (X_2)	Scrap loss, speed loss, breakdown loss	23
Pull of materials (X_3)	Customer complaints, Scrap Loss	10
Maintenance management (X_4)	Scrap loss, speed loss, breakdown loss, shutdown loss	28
Quality management (X_5)	Customer complaints, speed loss, break down loss	20
HRM (X_6)	Customer complaints, late deliveries	05
Kanban (X_7)	Late deliveries	01
Workcells (X_8)	Speed loss, non value added time loss	10
Six sigma (X_9)	Scrap loss, speed loss, non value added time loss	16

Relating lean indexes and lean techniques: By using brain storming technique by a group of experts in various fields gave the relations with the second and third layer of lean indexes for the overall equipment efficiency of the plant. In present study, the Kaizen is assumed to be dependent on following lean indexes like Scrap loss, breakdown loss, shutdowns, speed loss, non value added time loss and its weightage is calculated by summing the weightage of these indexes.

Similar weightages are calculated for zero defects, pull of materials, maintenance management, quality management, hrm, kanban, workcells and six sigma. From the Table 2, it is clear that maintenance management has achieved the highest weight age among all the techniques of lean manufacturing. In this context, major losses of the industry can be diminished by adopting maintenance techniques (Srinivasa Rao and Niraj, 2016).

Using the weighted method, analysis carried out and the results suggests that top 9 lean tools out of 30 tools are highly effective. Mathematical calculations also support these major tools. The theoretical explanations are narrated for each major tool and how it is used in the industrial environment.

RESULTS AND DISCUSSION

Evaluating the types of wastes of the firm with respect to the second and third layer lean performance measures to reduce them, in order to improve OEE: By using the FMECA and value engineering techniques, integration of lean techniques and wastes for bringing the priorities among them has been considered (Niraj *et al*., 2012).

Table 4 has been evaluated by the experts from various departments basing on various literatures of the value engineering concepts (Niraj *et al*., 2012). This study shows the dependency relationships of various parameters. The Table 4 draws the concentration on various industrial wastes and this study gives the list of maximum wastages of our industry and also the list of maximum scores of the lean techniques suggested for minimization of wastes. Figure 1 and 2 are drawn from Table 4.

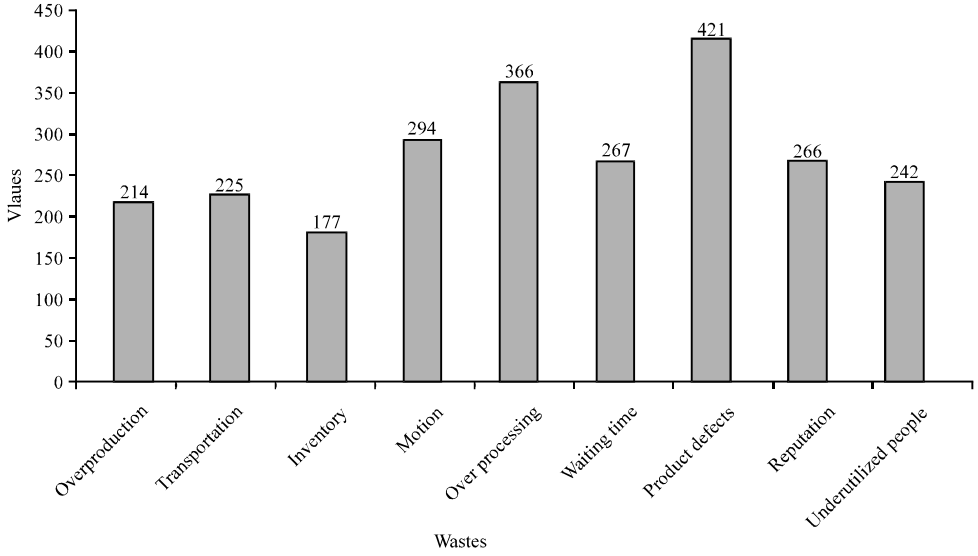

Fig. 1: Total points achieved by individual wastes

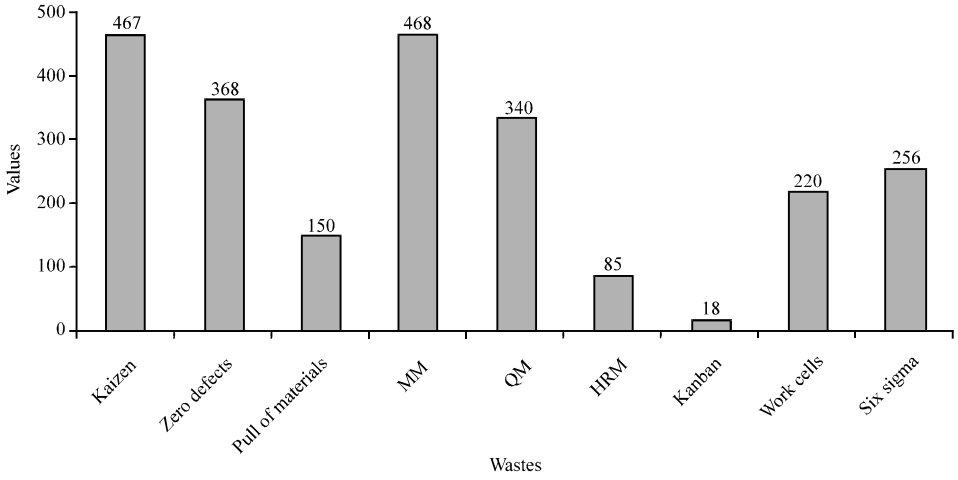

Fig. 2: Total score achieved by individual Lean Technique

Table 4: Calculation of weights for lean techniques and wastes

Lean technique / Lean wastes	Kaizen (27)	Zero defects (23)	Pull of materials (10)	MM (28)	QM (20)	HRM (5)	Kanban (1)	Workcells (10)	Six sigma (16)	Total
Overproduction	3 (81)	1 (23)	2 (20)	1 (28)	1 (20)	1 (5)	1 (1)	2 (20)	1 (16)	214
Transportation	2 (54)	1 (23)	2 (20)	1 (28)	1 (20)	2 (10)	4 (4)	5 (50)	1 (16)	225
Inventory	1 (27)	1 (23)	4 (40)	1 (28)	1 (20)	2 (10)	3 (3)	1 (10)	1 (16)	177
Motion	2 (54)	2 (46)	1 (10)	3 (76)	2 (40)	1 (5)	1 (1)	3 (30)	2 (32)	294
Over processing	2 (54)	4 (92)	1 (10)	4 (112)	2 (40)	1 (5)	1 (1)	2 (20)	2 (32)	366
Waiting time	3 (81)	1 (23)	2 (20)	2 (56)	1 (20)	2 (10)	1 (1)	4 (40)	1 (16)	267
Product defects	5 (135)	3 (69)	1 (10)	2 (56)	3 (60)	1 (5)	2 (2)	2 (20)	4 (64)	421
Reputation	2 (54)	1 (23)	1 (10)	1 (28)	4 (80)	5 (25)	4 (4)	1 (10)	2 (32)	266
Underutilized people	1 (27)	2 (46)	1 (10)	2 (56)	2 (40)	2 (10)	1 (1)	2 (20)	2 (32)	242
Maximum score	467	368	150	468	340	85	18	220	256	-

Table 4 has been studied in different cases. Firstly, the maximum lean waste of the industry and the maximum lean score technique has been noticed. So from the Table 4 product defect is the first maximum wastage producing parameter followed over processing waste. Likewise, maintenance management is the first best suggested technique to control this waste. The reseracher has concentrated only on two parameters every time to minimize the waste.

Table 5: Calculation of weights for lean techniques and wastes

Leantechnique lean wastes	Kaizen (27)	Zero defects (23)	Pull of materials (10)	MM (28)	QM (20)	HRM (5)	Kanban (1)	Workcells (10)	Six sigma (16)	Total
Overproduction	3 (81)	1 (23)	2 (20)	1 (28)	1 (20)	1 (5)	1 (1)	2 (20)	1 (16)	214
Transportation	2 (54)	1 (23)	2 (20)	1 (28)	1 (20)	2 (10)	4 (4)	5 (50)	1 (16)	225
Inventory	1 (27)	1 (23)	4 (40)	1 (28)	1 (20)	2 (10)	3 (3)	1 (10)	1 (16)	177
Motion	2 (54)	2 (46)	1 (10)	3 (76)	2 (40)	1 (5)	1 (1)	3 (30)	2 (32)	294
Over processing	2 (54)	4 (92)	1 (10)	4 (X)	2 (40)	1 (5)	1 (1)	2 (20)	2 (32)	366
Waiting time	3 (81)	1 (23)	2 (20)	2 (56)	1 (20)	2 (10)	1 (1)	4 (40)	1 (16)	267
Product defects	5 (135)	3 (69)	1 (10)	2 (X)	3 (60)	1 (5)	2 (2)	2 (20)	4 (64)	421
Reputation	2 (54)	1 (23)	1 (10)	1 (28)	4 (80)	5 (25)	4 (4)	1 (10)	2 (32)	266
Underutilized people	1 (27)	2 (46)	1 (10)	2 (56)	2 (40)	2 (10)	1 (1)	2 (20)	2 (32)	242
Total	467	368	150	300	340	85	18	220	256	-

Table 6: Calculation of weights for lean techniques and wastes

Leantechnique lean wastes	Kaizen (27)	Zero defects (23)	Pull of materials (10)	MM (28)	QM (20)	HRM (5)	Kanban (1)	Workcells (10)	Six sigma (16)	Total
Overproduction	3 (81)	1 (23)	2 (20)	1 (28)	1 (20)	1 (5)	1 (1)	2 (20)	1 (16)	214
Transportation	2 (54)	1 (23)	2 (20)	1 (28)	1 (20)	2 (10)	4 (4)	5 (50)	1 (16)	225
Inventory	1 (27)	1 (23)	4 (40)	1 (28)	1 (20)	2 (10)	3 (3)	1 (10)	1 (16)	177
Motion	2 (X)	2 (46)	1 (10)	3 (76)	2 (40)	1 (5)	1 (1)	3 (30)	2 (32)	294
Over processing	2 (54)	4 (92)	1 (10)	4 (112)	2 (40)	1 (5)	1 (1)	2 (20)	2 (32)	366
Waiting time	3 (81)	1 (23)	2 (20)	2 (56)	1 (20)	2 (10)	1 (1)	4 (40)	1 (16)	267
Product defects	5 (X)	3 (69)	1 (10)	2 (56)	3 (60)	1 (5)	2 (2)	2 (20)	4 (64)	421
Reputation	2 (54)	1 (23)	1 (10)	1 (28)	4 (80)	5 (25)	4 (4)	1 (10)	2 (32)	266
Underutilized people	1 (27)	2 (46)	1 (10)	2 (56)	2 (40)	2 (10)	1 (1)	2 (20)	2 (32)	242
Total	278	368	150	300	340	85	18	220	256	-

Table 7: Calculation of weights for lean techniques and wastes

Leantechnique lean wastes	Kaizen (27)	Zero defects (23)	Pull of materials (10)	MM (28)	QM (20)	HRM (5)	Kanban (1)	Workcells (10)	Six sigma (16)	Total
Overproduction	3 (81)	1 (23)	2 (20)	1 (28)	1 (20)	1 (5)	1 (1)	2 (20)	1 (16)	214
Transportation	2 (54)	1 (23)	2 (20)	1 (28)	1 (20)	2 (10)	4 (4)	5 (50)	1 (16)	225
Inventory	1 (27)	1 (23)	4 (40)	1 (28)	1 (20)	2 (10)	3 (3)	1 (10)	1 (16)	177
Motion	2 (X)	2 (46)	1 (10)	3 (76)	2 (40)	1 (5)	1 (1)	3 (30)	2 (32)	294
Over processing	2 (54)	4 (92)	1 (10)	4 (112)	2 (40)	1 (5)	1 (1)	2 (20)	2 (32)	366
Waiting time	3 (81)	1 (X)	2 (20)	2 (56)	1 (20)	2 (10)	1 (1)	4 (40)	1 (16)	267
Product defects	5 (X)	3 (69)	1 (10)	2 (56)	3 (60)	1 (5)	2 (2)	2 (20)	4 (64)	421
Reputation	2 (54)	1 (X)	1 (10)	1 (28)	4 (80)	5 (25)	4 (4)	1 (10)	2 (32)	266
Underutilized people	1 (27)	2 (46)	1 (10)	2 (56)	2 (40)	2 (10)	1 (1)	2 (20)	2 (32)	242
Total	278	322	150	300	340	85	18	220	256	-

Case 1: In this case the author has suggested implementing the MM technique for reducing the wastes in product defects and over processing as they are the key element parameters. After implementation of the technique reduce the respective lean wastes from the total lean waste and from the maximum score of the lean technique. Now again check the maximum lean waste parameter and the maximum score of the lean technique as a next case. The results for this case is tabulated in Table 5.

Case 2: From the Table 5, this case has been derived. In this case product defect is the first parameter giving maximum wastage and followed motion waste (unnecessary movements of men, machine, tool, material and so on..). Here, the best lean principle suggested is Kaizen technique. Here also the author concentrated on the two maximum waste causing parameters. After the implementation of this technique again the process is repeated like at the end of the above case and the results are tabulated in Table 6.

Case 3: In this case, the first maximum wastage is from waiting time and next is the reputation waste. The best technique to be implemented in this case is zero defects. After the implementation of this technique the process is followed as Table 7. So likewise the cases move forward to minimize the wastes in the industry. In every case the two top waste producing parameters and the best lean principle to be implemented are to be considered. This process goes on till we achieve the best production in the industry.

From the Fig. 1 it is clear that it is drawn between different types of wastes in the industry and the amount of waste producing in the industry. In this industry according to our study product defect is playing a vital role in producing maximum amount of waste and next is over processing waste followed other. In order to get the best production, we have to minimise these wastes by using lean techniques. Basing on our study our industry experts has suggested a few lean techniques to be implemented so that the waste can be minimized.

Here, Fig. 2 is derived from the results of Table 4. This graph 2 is drawn between the various lean techniques and the maximum score suggested by the industry experts. Our study reveals that maintenance management has been suggested as the first best principle for elimination of wastes and next is kaizen and rest followed on.

In this study, a rigorous study for finding the different wastes produced in the industry has been done and considered different lean indexes with respect to cost, quality and time. From the above results, it can be seen that major wastage is seen in product defect and next in over processing, underutilized people, motion waste. Similarly, the survey results gave the best suitable techniques to counter it. In this context, mapping lean indexes and techniques with the lean manufacturing wastes has been done. This study results suggests the industry that by adopting maintenance management technique can eliminate the product defect waste and over processing waste. Likewise by adopting kaizen technique reduces the wastage from product defect and motion waste. Similarly, by adoption of the lean techniques reduces the various wastes till the performance of the industry is satisfied. The strategic approach studied in this study is a very simple process and gives best performance with simple techniques (Sundar *et al*., 2014).

CONCLUSION

In this study, a wide range of management techniques are compared with the various lean indexes to determine the most critical waste management parameter and the best suited management technique to counter it. The best suited management technique is suggested to counter the top two waste management parameters as a first approach of strategic application of management techniques. Similarly, in the successive step, the one management technique and two waste parameters are selected till the required performance is optimum. The systematic application of management technique requires less cost, less man power, less time, less resistance from the systems. In this study it has been seen that the maximum amount of wastage is due to product defect and followed by over processing and so on. This study suggests the best suited lean technique to reduce the waste in this industry is by maintenance management and next is kaizen.

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