EVALUATION OF OVERALL EQUIPMENT EFFECTIVENESS (OEE) THROUGH LEAN METRICS BY A FUZZY APPROACH IN AN INDUSTRY

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Abstract: Lean manufacturing is a philosophy as well as a technique tool that guides an organization in planning and controlling its operations, managing its business activities more efficiently and effectively to achieve a pioneer position in manufacturing industry. Lean concept implementation is to reduce or eliminate waste in the production process. The successful implementation of its techniques made the lean successful in manufacturing. In this paper, the author shows the systematic set of evaluating the lean score and OEE for driving productivity performances of industry. Here the performances are calculated through fuzzy approach, which will bring a unit less-score.
Keywords: lean manufacturing, lean performance, lean score, OEE, lean metrics

I. INTRODUCTION

Lean manufacturing is a performance-based process used in manufacturing organizations to increase Competitive advantage. The basic aim of lean manufacturing is to employ continuous improvement process to eliminate waste or non value added thing to organization. the main challenge to the organizations using lean manufacturing is to create a culture which will sustain long term commitment from top management through the entire work force. It is an commitment for more value for less work. It is well suited for new plants, products or processes. various methods are adopted as tools to reduce the unwanted or waste to get high quality, less production times and minimized cost. On implementation of lean manufacturing tools and techniques often requires a cultural change in all levels of organization and once a program is started, then it begins with a small success and later it grows and include the entire organization. The Toyota Production System (TPS) mainly focus on muda and mura. Muda focus on the waste steps and process that add cost and mostly used to improve the existing operations.

OEE is an excellent technique tool used for controlling, monitoring and improving the efficiency of any manufacturing processes (machines, cells, assemble lines etc.). It is a simple, practical and powerful tool which deals with the most common losses of the manufacturing processes. Likewise it categorizes those losses into three basic categories like availability, performance; quality. The global economic recession has caused a reduced volume of orders, market saturation and lower price competition pressure. The fast changing economic conditions such as global competition, declining profit margin, customer demand for high quality product, product variety and reduced lead–time etc. had a major impact on manufacturing industries. The application of this paper improves the process performance of the critical operational process, leading to better utilization of resources, decreases variations & maintains consistent quality of the process output

II. LITERATURE REVIEW

In this section, the author made a brief literature survey regarding the lean manufacturing and its performance measurement techniques of lean score and the Overall Equipment Efficiency. Lean manufacturing techniques and tools are well knowingly popularized over the last two decades and bringing a remarkable changes in all the wings of the manufacturing systems. In this contrast, particularly managers are going ahead in productivity by eliminating wastes through lean manufacturing tools and techniques. In this contrast, cost, quality and just in time (JIT) delivery and continuous improvement are playing a vital role [1, 9, 11]. After that benchmarking a comparative tool for the measurement of lean was proposed by many authors [2, 4]. By adopting this methodology, it is somehow hard to find the similar benchmarking company with our manufacturing specifications. Sometimes accessing to benchmarking data is also uneven and impossible so our paper proposes the self benchmarking process would become a solution. In this paper a method to measure degree of leanness which deals with multidimensional concept, unavailability benchmark and uncertaininty and vague human judgment. The multidimensional concept involves a number of measured lean practice components in order to arrive at a measure for the lean activity of a given organization [3]. This paper shows a systematic used set of combined OEE and Productivity measures can drive production improvements successfully. Here the author describes the two new productivity measures for driving production improvements [5]. The past few years have witnessed a tremendous growth in the number and variety of applications of fuzzy logic (FL).With the help of fuzzy logic, we can specify mapping rules in terms of words rather than numbers. Calculating with the words gives us imprecision and tolerance. The basic fundamental of fuzzy logic system was given by Bojadziev and Bojadziev [6]. Previously qualitative techniques such as surveys are used to measure lean performance level [7, 10, 12, and 13]. But the results obtained by the surveys vary from different individuals [10]. Nowadays, by basing on the globalization in the markets, optimization in manufacturing industries strongly recommend several issues in order to achieve the targeted sustainability index. Optimizing these indexes has become more important to practitioners and

academicians have been discussed in this paper [8].

III. THE PROPOSED WORK

In this section, we will propose

- The measurement of lean performance score by using the collected data of the lean metrics with the help of fuzzy logic technique.
- The measurement of Overall Equipment Efficiency of the firm with the same data.
- Comparing the results and will show that lean score is more sensible and accurate than the OEE.

Measurement of lean score

In this paper the author tries to discuss about various parameters which will support the lean Production systems. There are some lean parameters which will help to improve the lean performance of the system like elimination of wastes, continuous improvement, just in time, pull of materials, zero defects, decentralization etc. in this section the author has taken some parameters like elimination of wastes and just in time delivery as main lean performance evaluation attributes which results in maximum wastes in industry. Cost, quality and time are taken as surrogates for EW and delivery is considered for JIT. METRIC means improving quality. Various metrics are considered for different attributes to find out the lean score of the industry which are tabulated in below table no.1. Firstly he calculated the performance of each metric which are tabulated in below table 2. And next he continued for the whole industry by using fuzzy membership functions.

Table 1. Classification of lean metrics

LEAN ATTRIBUTE	PERFORMANCE CATEGORY	METRICS (M)	DESCRIPTION
WASTE ELIMINATION	QUALITY LOSS	1	PRODUCT LOSS
		2	NUMBER OF CUSTOMER COMPLAINTS PER YEAR
	AVAILABILITY LOSS	3	BREAK DOWNS
		4	SETUP AND ADJUSTMENT LOSS
		5	SHUTDOWNS
	TIME LOSS	6	SPEED LOSS
		7	STOPPAGE LOSS
		8	NON VALUE ADDED TIME
	COST LOSS	9	ANNUAL INVENTORY COSTS
		10	ANNUAL TRANSPORTATION COSTS
JIT	DELIVERY LOSS	11	ORDERS DELIVERED LATE
		12	AVERAGE TOTAL NUMBER OF DAYS FROM ORDERS RECEIVED TO DELIVERY

The above are the 12 metrics for the considered lean parameters and now we will find out the amount of loss is being occurred by every individual metric in this manufacturing company by taking the relevant data by using the table.2

Table 2. Formulation of lean metrics

Product Loss	$M_1 = \left(\frac{\text{Number of start up rejects + Number of production rejects}}{\text{Total number of products}}\right) X\ 100$
Number of customer complaints	$M_2 = \frac{\text{Number of customer complaints}}{\text{Total number of complaints}}\ X\ 100$
Breakdowns	$M_3 = \left(\frac{\text{Break down time}}{\text{Planned production time}}\right) X\ 100$
Set up and Adjustment Loss	$M_4 = \left(\frac{\text{Time taken for setup and adjustment loss}}{\text{Planned production time}}\right) X\ 100$
Shutdowns	$M_5 = \left(\frac{\text{Number of shutdowns}}{\text{Total planned shutdowns}}\right) X\ 100$
Speed Loss	$M_6 = \left(\frac{\text{Actual production}}{\text{Desired production}}\right) X\ 100$
Stoppage Loss	$M_7 = \left(\frac{\text{Minor stoppage time}}{\text{Operating time}}\right) X\ 100$
Non Value Added Time	$M_8 = \left(\frac{\text{Idle time + Interference time + Line balancing loss}}{\text{operating time}}\right) X\ 100$
Annual Inventory Costs	$M_9 = \left(\frac{\text{Annual inventory cost}}{\text{Total annual sales}}\right) X\ 100$
Annual Transportation Costs	$M_{10} = \left(\frac{\text{Annual transportation cost}}{\text{total annual sales}}\right) X\ 100$
Orders Delivered Late	$M_{11} = \left(\frac{\text{Orders delivered late}}{\text{Total deliveries}}\right) X\ 100$
Dispatch Time	M_{12} = Average total number of days from orders received to delivery

For this firstly we have to find out the method of measurement. In this paper we would like to use the quantititative approach of fuzzy systems. In this method we have to find out the best and worst performance conditions of each metric. Let the best performance be taken as point A and worst be as B. point A can be obtained from the industrial data and point B can be obtained from the manufacturer analyst of that industry. So by applying these values and finding out the fuzzy membership values for each metric with the below given formulae.

Fuzzy membership values can be calculated for each metric:

$$\mu_{F(M_i)} = \begin{cases} 1 & if\ M_i \le a \\ 1 - \left(\frac{M_i - a}{(b-a)}\right) & if\ M_i < b \\ 0 & if\ M_i \ge b \end{cases}$$

Eq.(1)

Lean score can be calculated as

$$\text{LEAN SCORE} = \left(\sum_{I=1}^{12} \frac{\mu_F(M_i)}{12}\right) X\ 100$$

Eq.(2)

Table 3 Lean score evaluation

METRIC	Hypothetical Performance Data	Point A	Point B	Membership value
M_1	2.41%	0	4%	0.39
M_2	5	0	4	0
M_3	4.1%	0	6%	0.31
M_4	6.09	0	8	0.23
M_5	1	0	2	0.5
M_6	0.87	0	2	0.56
M_7	4.13%	0	7%	0.41
M_8	9%	0	14%	0.35
M_9	7%	0	10%	0.3
M_{10}	3%	0	5%	0.4
M_{11}	6%	0	2%	0
M_{12}	12	0	14	0.14

LEAN SCORE	30

By summing up all the fuzzy membership values of the listed 12 metrics and taking up the average, we can get the final lean score of the manufacturing system which is the performance level or lean score of the plant as shown in the table.3. Lean score is nothing but the overall performance of the plant. So on observation of the individual membership function of the each metric we can easily find out that which is having the best performance and the worst of it. So by knowing this, we can do further improvements in the worst scenario and this will help the managers and upper level superiors to take immediate action on that metric ,that finally improve the plant efficiency.

OVERALL EQUIPMENT EFFECTIVENESS

Here, the author wants to find out the overall equipment effectiveness (OEE) of a manufacturing industry. The OEE score will gives us the plant equipment efficiency only. In this regard, the overall performance of the equipment is known. For calculating the OEE, three parameters like QUALITY, AVAILABILITY, and PERFORMANCE are sufficient.

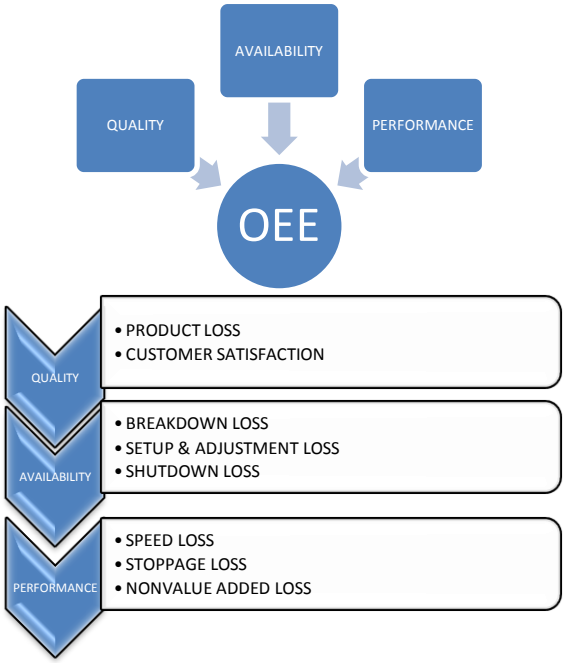

Fig 1. Classification of OEE and its Parameters

OEE = Availability X Quality X Performance Eq.(3)

From the above Fig.1, it is known that OEE depends on those three parameters. This OEE is concerned with the physical elements of the manufacturing industry only. OEE can be a part of the improvement in the plant production.

OEE can also take active participation in lean performance of any firm. Waste elimination can be calculated through OEE. The listed metrics from the above diagram are used to evaluate the performance of the OEE by considering their wastes. Performance of Each metric is calculated to unity as measuring through fuzzy membership functions.

OEE = Quality X Availability X Performance

$$\text{OEE} = \left((1-(M_1+M_2))\text{X}\left(1-(M_3+M_4+M_5)\right)\text{X}\left(1-(M_6+M_7+M_8)\right)\right)$$

$$= (1\text{-}0.0741)\ \text{X}\ (1\text{-}0.1119)\ \text{X}\ (1\text{-}0.14)$$

$$=0.7071 = \underset{\sim}{} 70.71\%$$

IV. RESULTS

In this paper, initially the author concentrated on the two most attributes of lean manufacturing process and next he had made the surrogates for each lean attribute with respect to cost, quality, time and delivery. Later on he relates each metric by using fuzzy membership functions and tried to find out the lean score of the plant. Next he calculated the overall equipment efficiency with the corresponding metrics. Now he wants to distinguish both of them and author suggests that lean score gives the better performance of the plant compared to the overall equipment efficiency. Evaluation of performances by using fuzzy membership values drives towards the productivity and helps the managers to get a better production.

V. CONCLUSION

This study has given the steps for the measurement of performance of the industry using fuzzy membership values. Waste elimination and JIT deliveries are considered to be the most important attributes of the industry. Cost, quality, time and deliveries are taken as important surrogates for these attributes in order to evaluate the lean score and the OEE of the plant. Continuous improvement plays a vital role in every industry in the present competitive global market to ensure a better product to the customers. By calculating the lean score in the industry, it is easier to identify the worst metric which is giving the worst performance and can be improved to get a better quality product. The author suggests that evaluation of plant efficiency has become very easy by using fuzzy membership values. The results partially support our theory and help the managers to drive better improvements towards productivity and enhance for the worldwide adaption. It gives a clear cut idea of the individual process performances and can be improved, if any process giving worst performance.

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