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Reduction of Lead Time by Implementing Lean. Manufacturing System in a Tyre Retreading Industry

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Abstract:
Lean Manufacturing system has emerged as an important area of research in Indian context. Reduction in lead time helps to improve the productivity. Here the factors affecting the lead time are identified. This study has helped to establish an attempt to develop structural model of variables, important to implement by Ism approach to determine the key factors which affect the lead time. As by this tool, scrap, information delay and long supplier lead time are the key factors. As the scrap and long supplier long lead time can be solved by using proper supplier selection using AHP and TOPSIUS Method. The aim of this paper is to reduce lead time and improve productivity by determining the appropriate supplier providing the most customer satisfaction by delivery product on time.

Keywords: *Ism tool, Supplier Selection, multi criteria decision making, AHP, TOPSIS method.*

1. Introduction

In order to maintain a competitive position in the global market, organizations have to follow strategies to achieve shorter lead times, reduced costs and higher quality. In this paper we have identified key factors, which affect the lead time, through Ism Approach and Scrap, information delay and supplier long lead time are identified as key factors. Scrap and supplier lead time problem is solved by proper supplier selection based on AHP, we have calculated the weights for each criterion and inputted those weights to Topsis method to rank suppliers.

2. Literature Review

Reduction in lead time leads to improve productivity- Rakesh Attri, Nikhil Dev and Vivek Sharma states about well established methodology for identifying relationship among specific items which define a problem or an issue. . This approach has been increasingly used by various researchers to represent the interrelationships among various elements related to the issue. ISM approach starts with an identification of variables, which are relevant to the problem or issue. Then a contextually relevant subordinate relation is chosen. Having decided the contextual relation, a structural self-interaction matrix (SSIM) is developed based on pair wise comparison of variables **[1**]. Rajesh Kumar, Mehta. D. Mehta, Naveen. K. Mehta states about lean is about generating more values for buyers by removing activities that are regarded waste. The core objective of lean production is elimination of waste. The paper is an attempt to study issues and challenger pertaining to lean manufacturing practices **[2].** Akhil Kumar slates about various issues and barriers of LM. Naveen Kumar Sanjay Kumar deals about structural model of variables to implement lean concepts in Indian automobile industry **[3].** Stuart- H. Mann deals with Industrial engineering applications the final decision is based on evaluation of criterias by using AHP an effective approach in dealing with this kind of decision problems**. [4**]Palic L &Lalic B states about methods to evaluate and select the projects. The tool help us with simulating the project based on changes in perception of criteria**[5].** PemaWaugehen. Ruben Phipon develop a methodology to evaluate suppliers in supply chain based on technique for order preference by similarity to ideal solution method (TOPSIS) **[6]**

3. Problem Identification

The major problems which increases the lead time are Improper mixing of the compound. The improper mixing of the compound is occurred due to improper quality of the raw material. The next identified problems are the waiting time due to information delay from QC department and long Supplier delivery lead time that leads to delay in delivery of the product. “Reduction in the lead time to improve the productivity by lean manufacturing”.

4. Methodology

Using Interruptive Structure Modelling(ISM) approach the factors affecting the lead time are identified. To define an issue or a problem ISM can be used. It will identify and summarize relationships among variables. The various factors affecting lead time are Information delay, Waiting time, Supplier delivery lead time, Order preparation, Transit, Scrap and Change over time. The key factors that affect lead time are Information delay, Scrap, supplier long delivery lead time. The supplier delivery lead time and scrap can be solved by having good supplier rating. The standard supplier rating can be done by using AHP (Analytical Heirachy Process) and best supplier can be selected by using TOPSIS

A) ISM APPROACH

In order to develop he contextual relationship among the variables ISMmethodology uses expert opinions based on various management techniques. The experts from the industry and various academia should be well concerned with the problem under consideration. For analyzing the factors, a contextual relationship of ‘leads to’ or ‘influences’ type must be chosen. This means that one factor influences another factor. On the basis of this, contextual relationship between the identified factors is developed. After identifying seven key enablers through brainstorming technique, the key enablers are achieved that will affect the lead time. The four symbols (V, A, X, O) have been used to denote the direction of relationship between enablers (i and j) during the analysis of the enablers in developing SSIM which are shown in Table 1. The ranking of variables is provided in Table2

A – Enabler i will help to achieve enabler j;
V – Enabler j will help to achieve enabler i;
X – Enabler i and j will help to achieve each other; and
O – Enabler i and j are unrelated

		7	6	5	4	3	2
1	Information Delay	0	0	A	A	0	A
2	Process waiting time	0	V	A	A	V	
3	Supplied delivery lead	0	0	A	A		
4	Order Preparation	0	V	A			
5	Transit	0	V				
6	Scrap	0					

Table 1: Structural Self-Interaction Matrix

		1	2	3	4	5	6	7	R
1	Information Dealy	1	1	0	1	1	0	0	4
2	Process waiting time	V	1	V	1	1	V	0	3
3	Supplied long delivery time	0	1	1	1	1	0	0	4
4	Order Preparation	V	V	V	1	1	V	0	2
5	Transit	V	V	V	V	1	0	0	1
6	Scrap	0	1	0	1	1	1	0	4
7	Change over time	0	0	0	0	0	0	1	1
		1	4	1	6	5	1	1	

Table 2: Ranking of variables

In the level partition, the reachability set consists of the enabler which shows the value 1 in the row. antecedent sets are indicated by the value 1 in the columns. Intersection shows the common enablers from reachability and antecedent. which is shown in Table 3. by providing these values as the input to theism and if the reachability and antecendent values that enabler is removed from the table. Finally the key values are correctly identified, though various iterations these are shown in table 4 and

Enabler	Reachability	Antecedent	Intersection
1	1, 2, 4, 5	1	1
2	2, 4, 5	1, 2, 3, 6	2
3	2, 3, 4, 5	3	3
4	4, 5	1, 2, 3, 4, 6	4
5	5	1, 2, 3, 4, 5, 6	5
6	2, 4, 5, 6	6	6
7	7	7	7

Table 3: Iteration 1

Iteration V			
Enabler	Reachability	Antecedent	Intersection
1	1	1	1
3	3	3	3
6	6	6	6

Table 4: Final Iterated Result

- Enabler 3-Supplier long lead time and Enabler 6- scrap can be solved by proper supplier selection by using AHP and TOPSIS

B) Criteria Comparison using AHP

AHP is used to evaluvate the weights of the criteria. The various criterias chose n in AHP are Cost-CR1, Quality-CR2, Delivery-CR3, Warranty-CR4, Reputation-CR5, Capacity-CR6. The normalized Matrix can be obtained from these values by dividing individual values by the sum of each columns. 4suppliers A, B, C, D are considered.

Criteria Comparison

	CR_1	CR_2	CR_3	CR_4	CR_5	CR_6
CR1	1	0. 33	3	5	4	6
CR2	3	1	5	6	7	6
CR3	0. 33	0. 2	1	3	4	5
CR4	0. 2	0. 167	0. 33	1	2	3
CR5	0. 25	0. 143	0. 25	0. 5	1	3
CR6	0. 167	0. 167	0. 2	0. 33	0. 33	1

Normalised Matrix

	CR_1	CR_2	CR_3	CR_4	CR_5	CR_6	W
CR1	0. 194	0. 15	0. 299	0. 311	0. 214	0. 245	0. 24
CR2	0. 583	0. 46	0. 498	0. 373	0. 315	0. 245	0. 44
CR3	0. 065	0. 09	0. 100	0. 187	0. 214	0. 204	0. 15
CR4	0. 639	0. 07	0. 033	0. 062	0. 107	0. 122	0. 08
CR5	0. 049	0. 06	0. 025	0. 031	0. 054	0. 122	0. 06
CR6	0. 032	0. 07	0. 020	0. 021	0. 018	0. 041	0. 04

Cost

	A	B	C	D
A	1	5	7	9
B	0. 2	1	3	7
C	0. 143	0. 33	1	5
D	0. 11	0. 143	0. 2	1
Sum	1. 454	6. 473	11. 2	22

Delivery

	A	B	C	D
A	1	0. 143	0. 2	5
B	7	1	3	7
C	5	0. 33	1	7
D	0. 2	0. 143	0. 143	1
Sum	13. 2	1. 62	4. 34	20

Warranty

	A	B	C	D
A	1	8	8	6
B	0. 125	1	3	7
C	0. 125	2	1	7
D	0. 167	0. 143	0. 143	1
Sum	1. 14	11. 143	12. 143	21

Reputation

	A	B	C	D
A	1	2	5	4
B	3	1	5	3
C	0. 2	0. 2	1	0. 2
D	4	2	5	1
Sum	8. 2	5. 2	16	8. 2

capacity

	A	B	C	D
A	1	0. 167	0. 143	0. 167
B	6	1	0. 2	1
C	7	5	1	5
D	6	4	0. 2	1
Sum	20	10. 167	1. 543	9. 167

	CR_1	CR_2	CR_3	CR_4	CR_5	CR_6
A	0. 624	0. 632	0. 115	0. 592	0. 044	0. 327
B	0. 220	0. 122	0. 547	0. 190	0. 214	0. 309
C	0. 116	0. 044	0. 291	0. 171	0. 509	0. 037
D	0. 040	0. 040	0. 047	0. 048	0. 233	0. 327

Table 5: Performance of each alternative with respect to each criteria

C) TOPSIS method

It is used to select the best alternative from the selected attributes. Topsis procedure starts with using the weights calculated with AHP. From that calculate negative and positive ideal solutions & separation measures. Then rank the preferences candidate in descending order. the various steps of Topsis are as follows.

Establish a decision matrix for the ranking and normalize the decision matrix using the following equation

$$r_{i,j} = \frac{w_{i,j}}{\sqrt{\sum_{k=1}^{n} w_{i,j}^2}} \quad i = 1,2,\ldots n \; j = 1.2 \ldots . m$$

Weighted normalized decision matrix is calculated by multiplying the normalized decision matrix by its associated weights as

$$v_{i,j} = w_i r_{ij} \; i = 1,2,\ldots . n \; j = 1,2,\ldots . m$$

Identify the positive ideal solution (PIS) and negative ideal solution (NIS), respectively, as follows:

$$\text{PIS} = A^* = \{v_1^*, v_2^* \ldots . v_m^*\} = \{(\max v \mid j \in \Omega_b), (\max v_{i,j} \mid j \in \Omega_c)\}$$
$$\text{NIS} = A^* = \{v_1^-, v_2^- \ldots . v_m^-\} = \{(\max v \mid j \in \Omega_b), (\max v_{i,j} \mid j \in \Omega_c)\}$$

Ωb is associated with benefit criteriaΩc is associated with cost criteria.

Determine the separation measures of each alternative from the ideal and negative-ideal solution as below respectively:

$$d_i^* = \sqrt{\sum_{j=1}^{m} (v_{i,j} - v_j^*)^2} \quad i=1,2,3\ldots n$$
$$d_i^{-} = \sqrt{\sum_{j=1}^{m} (v_{i,j} - v_j^-)^2} \quad i=1,2,3\ldots n$$

Calculate the relative closeness of the ith alternative to ideal solution using the following equation:

$$\mathbf{RC_i} = \frac{d_i^-}{d_i^* + d_i^-} \quad i= 1,2,.n$$

$\mathbf{RC_{i \in [0,1]}}$

By comparing RCi values, the ranking of alternatives are determined. The higher the closeness means the better the rank. Ranked the alternatives starting from the value that closest to1 and in decreasing order. The tables below show the performance results of the Topsis method.

Decision Matrix

	CR_1	CR_2	CR_3	CR_4	CR_5	CR_6
A	0.361	0.364	0.016	0.342	0.002	0.094
B	0.054	0.015	0296	0.036	0.044	0.104
C	0.014	0.002	0.079	0.025	0.253	0.002
D	0.002	0.050	0.002	0.002	0.058	0.109
Xi^2	0.431	0.431	0.394	0.405	0.357	0.309
$Erij^2$	0.657	0.657	0.627	0.636	0.598	0.555

Separation from positive ideal solution

	CR_1	CR_2	CR_3	CR_4	CR_5	CR_6	Si
A	0	0	0.01	0	0.02	0	.110
B	0.018	0.071	0	0.002	.00090	0	.303
C	0.031	0.117	0.003	0.002	0	0.0004	.392
D	0.041	0.130	0.014	0.004	0.007	0	0.443

Seperation from negative ideal solution

	CR_1	CR_2	CR_3	CR_4	CR_5	CR_6	Si
A	0.0412	0.1332	0.0004	.004	0	0.0036	.423
B	.0046	0.0096	0.0139	.0003	0.0002	0.0004	.170
C	.007	0.005	0.0030	.0012	0.002	0	.420
D	0	0	0	0	0.0036	0.0004	0.028

Supplier	Si	Rank
A	0.79	1
B	0.36	3
C	0.517	2
D	0.058	4

Table 6: Ranking suppliers using Topsis Method

5. Conclusion

Main purpose of this paper is to combine ISM, AHP and TOPSIS methods to identify the key factors which affect the lead time and to solve these factors to improve he productivityby reducing the lead time. By proper supplier selection using AHP and TOPSIS best supplier is selected, so that quality and supplier lead time problem can be improved, so that rejection rate of raw materials can be decreased. .

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