JIT System Implementation in Automobile Servicing

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Abstract—**The just-in-time (JIT) production system has been used in the United States for decades, often not to its full extent. Japan has also implemented JIT in many of their organizations both at home and in their manufacturing sites abroad. In this paper the data will be analyzed by automobile servicing company, data will be observed and analyzed. Several Indian firms have either initiated steps towards JIT implementation or claim to have already implemented many aspects of JIT. In this paper various practices and benefits are identified through literature review and appropriate weights are assigned to them using paired comparison method. Further particle swarm-based artificial neural network model with Fuzzy-TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) is applied to find the ranking of selected automobile servicing company and to optimize the servicing cost.**

Keywords— **Warehouse, Sale Forecasting, Supply Chain Management, Ensemble Support Vector Machine.**

I. INTRODUCTION

A wide range of customer are facing the problems in automobile servicing, like late delivery, longer duration maintenance, slower gradation process of accessories and device, unsatisfactory performance of vehicle even after servicing. This work will uncover the problem and issues which are coming as a barrier in smooth and successful implementation of JIT based system. Each vehicle contains approximately 15,000 parts. Because automakers decide to have suppliers take care of producing parts, managers of purchasing department have to figure out how to promote long-term relationships and mutual cooperation with suppliers. Their interactions extend from product development to manufacturing or the other option is to rely on shorter-term contracts and competitive bidding, as well as more in-house development and manufacturing, in an attempt to lower cost [1].

This study focuses on identifying the applied efforts by the automobile servicing companies and ranking is provided for these companies based on the degree of implementation of JIT production system using proposed TOPSIS method [2].

JIT promotes conditions necessary to manufacture high-quality products to meet customer demand with reduction of inventory and high level of productivity. It improves customer service changing the circumstances that cause a waste to exist. As a manufacturer produces and delivers items at the rate required by the customer at the precise time required, a customer is no longer dissatisfied by the defects of waste time, money and inventory. According to this aspect we could consider JIT a time-compression and customer-oriented strategy. It allows a multinational company to compete on waste elimination by taking time and inventory out of the entire system and deliver appropriate products with a fixed time frame as customers' need arises [3].

Thus, producing value-added services which implies continuous supply chain improvements with a goal to satisfy customer needs. If consider JIT distribution with customers, the relationship between JIT with customers and each of the organizational structure should be looked upon both internally and across boundaries. The coordination and integration of the company's structure as a single entity as well as recognizing the service level requirements of final customers are of vital importance for successful development and integration of JIT with customers [4].

Most of manufacturing and management systems are not aware about the methodology and benefits of JIT and even not confident about the successful implementation of these advance production methodology. The motive of this part is to draft out the challenges in automobiles service station and barriers in advancing the Indian automobile service station, barriers in implementation of JIT. There are still problems with the quality of the products, services and market environment [5].

Some of the problems identified are discussed as below:

- Lack of service management
- Failure of knowledge management system
- How to manage Workers
- Systems of total quality management

II. RELATED WORK

Singh et al. [1] discussed that the World class manufacturing is a management philosophy that emphasizes on meeting external and internal customer needs and specification and importance of doing things right for world market society. One of the world class production techniques is Just in Time (JIT). JIT production system has well defined elements that need to be implemented. Researches show that implementation of this system is not unique in all time, place and circumstances. Implementation of this system may differ from one company to another and the elements those are needed to a company may be very specific to its own need. Several Indian firms have either initiated steps towards JIT implementation or claim to have already implemented many aspects of JIT. In this paper various practices and benefits are identified through literature review and appropriate weights are assigned to them using paired comparison method. Further TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) is applied to find the ranking of selected organizations.

Sunil Kumar et. al. [2] stated that - In the era of cut throat competitive market, Indian industries are under tremendous pressure to continuously reduce the cost and improve product quality. The main objective of this research paper is to provide a road map for investigating the opportunities to reduce cost and improve productivity and quality in the existing production system through the application of Lean-Kaizen concept using value stream mapping (VSM) tool at shop for of an Indian Small-Scale Enterprise (SSE). On the basis of collected data from the selected industry, a current state map was made. After analysis, the current state map was modified to develop a future state map.

M.S. Abd-Elwahed et. al. [3] stated that - The main objective of this research is to measure the level of knowledge, understanding, and implementation of quality management tools in a sample of the industrial sector in Saudi Arabia, and to monitor the different policies to implement the quality strategies and the extent of their integration into the industrial management systems in general. A questionnaire to cover key elements, including knowledge and understanding of the various quality management (QM) approaches and the accompanying tools, is implemented. The impact of using each QM approach on the level of actual growth of the industrial organizations is verified, along with the impact of the executive method of management and its compatibility with the proper implementation of quality tools. The results of the study indicate that different visions of QM strategies and policies are still adopted by industrial companies participating in the survey. In addition, there is a difference in the levels of understanding and implementation of QM tools and techniques.

This study has focused on measuring the extent of the current use of quality tools and techniques (with Saudi industrial companies as a test case), based on a quantitative and qualitative analysis of survey data. It has also attempted to identify the significant barriers to QM implementation, as well as the key training needs in QM for the industrial sectors.

Aydin m. Torkabadi et. al. [4] stated that - This Paper focuses on the implementation of Just-In-Time (JIT) in Supply Chain Management (SCM) context. Three Pull Control Policies (PCPs), developed for controlling the inventory level, are discussed. Kanban, Con WIP, and a hybrid PCP, are recognized for implementation in multi-echelon, multi-stage, and multi-product supply chains. The performance of each policy is measured through three measurement criteria. Considering the uncertainty, the performances of policies are evaluated via a Fuzzy AHP method. For, identification, performance measurement, and evaluation of PCPs the study proposes an integrated approach. The approach explains the PCPs mechanisms, measurement criteria formulations, and multi criteria decision making methods. Finally, the solution approach is examined through a case study.

Najm A. Najmet. al. [5] stated that -We investigate two issues. The first is to determine the impact of TQM dimensions of a medical care system (quality system, quality leadership, medical and sanitary staff, relationship with patient, relationships with suppliers, and continuous improvement) on the hospital competitive advantage (innovation, competitive benchmarking) in sample Jordanian hospitals. The second is to explore the moderating effect of two basic organizational characteristics: the size and the age of a hospital, on the relationship between TQM dimensions and competitive advantage.

III.METHODOLOGY

The first step is to identify the benefits of implementing JIT production practices. Features of JIT based automobile servicing companies:

1. Less Space Needed: With a faster turnaround of stock, it will not need as much warehouse or storage space to store goods. This reduces the amount of storage an organization needs to rent or buy, freeing up funds for other parts of the business [6]
2. Waste Reduction: A faster turnaround of stock prevents goods becoming damaged or obsolete while sitting in storage, reducing waste. This again saves money by preventing investment in unnecessary stock, and reducing the need to replace old stock.
3. Smaller Investments: JIT inventory management is ideal for smaller companies that don’t have the funds available to purchase huge amounts of stock at once. Ordering stock as and when it’s needed helps to maintain a healthy cash flow [7].

Various JIT production practices adopted by automobile servicing companies are collected through literature review. Some of these practices are [8-10]:

- Preventive maintenance
- Repetitive nature of master schedule
- Set up time reduction
- Small lot size
- Equipment layout
- Synchronization of operations

Various benefits by applying JIT production practices are identified from literature review such as:

- Cost reduction
- Quality increased
- Guarantee
- Reduced Inventory
- Reduction in transportation time and cost

A. *Methods*

Artificial Neural Network

Artificial neural network is simple three-layer neural network having one input, hidden layers and output layer. The number of input layer neurons are equals the number of inputs as shown below in figure 1. Further PSO is use to optimize links passes through input layers to output layers.

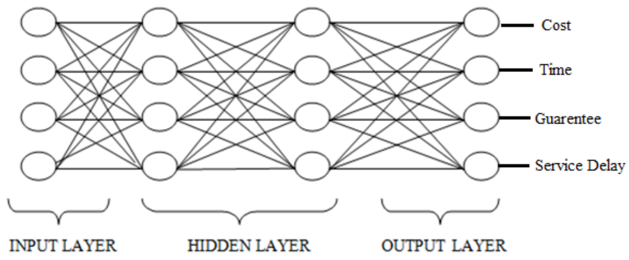

Figure 1: ANN Architecture Example

In artificial neural network currently predicts weights and biases. To predict weight and bias, data are inserted and forwarded though the entire network. The total net input to each hidden layer neuron is the total net input using an activation function, then repeat the process with the output layer neurons. So, the total net input for h_1 as in equation (1) and equation (2).

$$net_{h_1} = w_1 * i_1 + w_2 * i_2 + b_1 * 1 \quad (1)$$

Then sum of layer to get the output of h_1

$$out_{h_1} = \frac{1}{1 + e^{-neth_1}} \quad (2)$$

Further carrying out the same process for h_2 as above in figure 4.3. Then process is repeated for the output layer neurons, using the output from the hidden layer neurons as inputs. Here's the output for o_1 as in equation (3).

$$net_{o_1} = w_5 * out_{h_1} + w_6 * out_{h_2} + b_2 * 1 \quad (3)$$

And carrying out the same process for o_2. Then error is calculated for each output neuron using the squared error function and sum them to get the total error as in equation (4).

$$E_{total} = \sum \frac{1}{2}(target - output)^2 \quad (4)$$

The working of the neural network is focused towards adjusting the weights associated with entire network in order to reach the target data values, for minimizing the error between output and target values.

The developed ANN model architecture for predicting the cost optimization metrices is shown in Figure 2. The developed network architecture has four neurons in the input layer indicating number of spare part required, its price, its installation time and its delay time for shortage. 1 hidden layer with varying neurons, and 4 neurons in the output layer representing cost optimization metrices.

Approximately 70% of the experimental data was used for training, while the remaining 30% was reserved for testing. The observed experimental data are normalized for improving the performance of the network.

An MLP was used for nonlinear mapping between the input and output data. The BP algorithm was used for training the ANN model. This algorithm uses the supervised training technique, where the network weights and biases are initialized randomly at the beginning of the training phase. The error minimization process is achieved using the gradient descent rule. The sigmoid and linear functions were chosen as the activation functions for hidden and output layers.

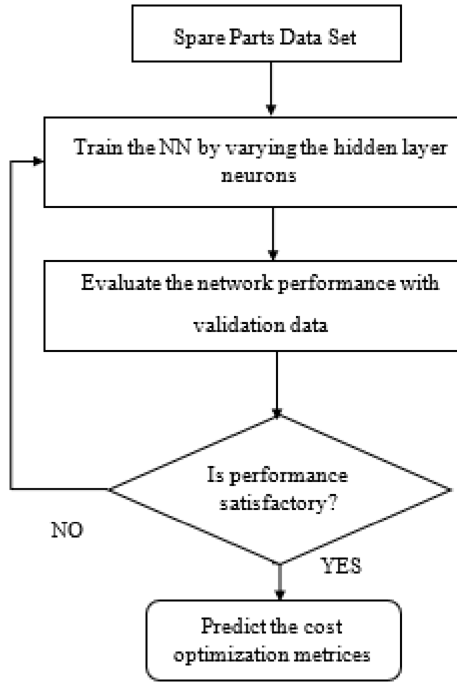

Figure 2: Proposed ANN Model for Predicting the Cost Optimization Metrices

Particle Swarm Optimization (PSO)

PSO is a computational technique recognized as one of the most efficient optimization strategies. The requirement of PSO over conventional search methods is their resistance to trapping in local optima due to the use of many points (population) in their search space simultaneously as possible solutions, instead of a point-to-point approach. PSO can obtain acceptable results (maximize or minimize) using fitness function and global best operator. The procedure for the design of a PSO is to find optimum cost metrices PSO Algorithm works as:

i. (Initialization) Randomly generate initial particles (links) in groups.
ii. (Fitness) Measure the fitness of each particle in the population.
iii. Find best fitness value link termed as Pbest.
iv. Among all Pbest find the best value called Gbest.
v. (Termination) Stop the algorithm if the termination criterion is satisfied; return to Step 2 otherwise.

Algorithm:

For every particle or jobs
Initialize jobs
end
Do
For each job
Calculate fitness value
If the fitness value is greater than the best fitness value (Pbest) in history
Then set current fitness value as the new Pbest
End
Choose the job with the best fitness value of all the particles as the Gbest

For each job
Calculate particle velocity
Update job position in queue
End
While maximum iterations or minimum error criteria is not attained.
Each Particle's fitness function is calculated using Pbest as well as Gbest which is best position among entire group of particles.
In each generation velocity and position of each particle is updated using following equation:
$v_{new} = v_{old} + c1 * r1 * (Pbest – present\_position) + c2 * r2 * (Gbest – present\_position)$
$present\_position = present\ position + v_{old}$
Where, v is the particle velocity.
Present_position is the current particle (solution).
Pbest and Gbest are defined as stated before.
r1 and r2 is a random number between (0,1).
c1, c2 are learning factors. usually c1 = c2 = 2.

Fuzzy-TOPSIS

TOPSIS method TOPSIS is relatively simple and fast, with a systematic procedure. It has been proved one of the best methods in addressing the rank reversal issue. The basic idea of TOPSIS is that the best decision should be made to be closest to the ideal and farthest from the non-ideal. Such ideal and negative-ideal solutions are computed by considering the other overall alternatives. The positive-ideal solution is a solution that maximizes the benefit criteria and minimizes the cost criteria, whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria.
The procedure of the Fuzzy-TOPSIS method is as follows:
Step 1: Assignment rating to the criteria and to the alternatives.
It is assumed that there is a decision group with N members. The fuzzy rating of the n^{th} decision maker about alternative V_i w.r.t. criterion X_j
Step 2: Compute the aggregated fuzzy ratings for alternatives and the aggregated fuzzy weights for criteria.

$$a_{ij} = \min\{a_{ij}^n\} \quad (5)$$

$$b_{ij} = \frac{1}{N}\sum_{n=1}^{N} b_{ij}^n \quad (6)$$

$$c_{ij} = \min\{c_{ij}^n\} \quad (7)$$

The aggregated fuzzy weight, $w_j=(w_{j1},w_{j2},w_{j3})$ for the criterion C_j are calculated as:

$$w_{j1} = \min\{w_{j1}^n\} \quad (8)$$

$$w_{j2} = \frac{1}{N}\sum_{n=1}^{N} w_{j2}^n \quad (9)$$

$$w_{j3} = \min\{w_{j3}^n\} \quad (10)$$

Step 3: Compute the normalized fuzzy decision matrix.

$$r_{ij} = \left(\frac{a_{ij}}{c_j}, \frac{b_{ij}}{c_j}, \frac{c_{ij}}{c_j}\right) \text{ and } c_j = \max\{c_{ij}^n\} \quad (11)$$

$$r_{ij} = \left(\frac{a_j}{c_{ij}}, \frac{b_j}{c_{ij}}, \frac{c_j}{c_{ij}}\right) \text{ and } c_j = \min\{a_{ij}^n\} \quad (12)$$

Step 4: Compute the weighted normalized fuzzy decision matrix, $v_{ij} = r_{ij} * w_j$
Step 5: Compute the Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS).The FPIS and FNIS are calculated as follows:

$$FPIS = \max(v_{ij}) \quad (13)$$

$$FNIS = \min(v_{ij}) \quad (14)$$

Step 6: Compute the distance from each alternative to the FPIS and to the FNIS.
Step 7: Compute the closeness coefficient CCi for each alternative.
Step 8: Rank the alternatives. The alternative with highest closeness coefficient represents the best alternative

B. Proposed Methodology

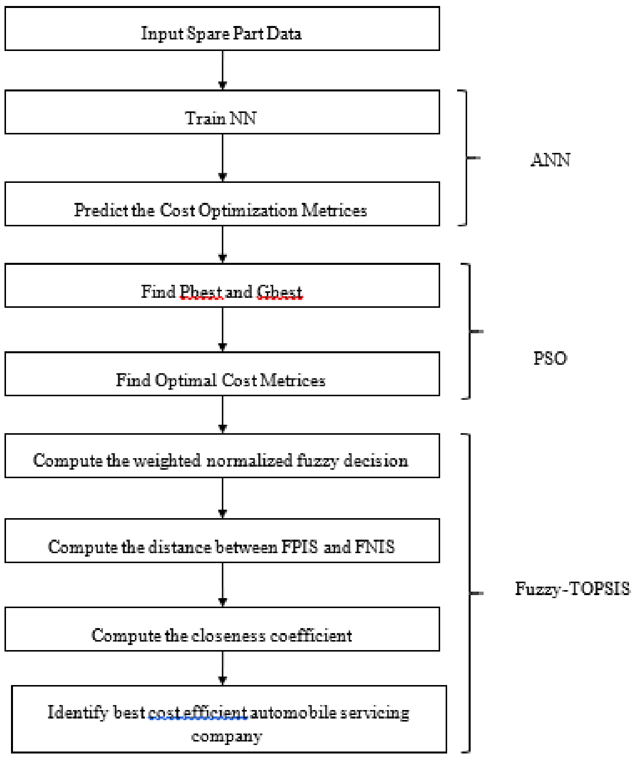

Figure 3: Flow Diagram of Proposed Methodology

The proposed methodology consists of four basic stages:

- Identification of the cost optimization metrices
- Development of an ANN to predict the servicing cost
- Use PSO to determine the optimum cost metrices
- Rank the alternatives using Fuzzy-TOPSIS to select the optimum cost

In the first stage, the NN is trained by using 70% reading and validated by using the remaining reading. In the second stage, PSO is used with ANN to identify the optimum cost metrices for each automobile servicing company (spare parts). In the last stage of the proposed methodology, Fuzzy-TOPSIS is used for ranking the alternatives from the identified parameters of each optimum cost metrices.

IV. CONCLUSION

The selection of optimum cost optimized servicing company with respect to various metrices is automobile servicing companies. Therefore, an effective multi-objective optimization technique is essential to resolve the problem. ANN is integrated with PSO to predict the optimum value of cost optimization metrices for each variable. A feed-forward back-propagation neural network approach was used to predict the performance of the cost metrices in estimating companies rank. The derived models were then used in an evolutionary PSO optimization process so that optimum metrices is identified for each parameter to achieve better cost effective company for servicing. Next, fuzzy-integrated TOPSIS was used to evaluate the best company for servicing.

The output of this research work will validate total quality model that was taken into use at the case company. Experimentation proved that the developed model would be used to add value to the case company's business in forms of cost saving, supply chain process streamlining and performance follow up. Moreover, JIT expert's managers will utilize the costing model as a strategic planning tool and as a supportive tool for decision making.

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