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Gap Analysis of Value stream mapping tool implementation in manufacturing operation using Fuzzy Topsis

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Abstract
In today's world, technology plays a vital role demanding productivity improvements, downtime reduction in manufacturing operations industry. Depending upon the strategy and lean methodology organizations follow and apply VSM and JIT in their respective fields. The present research work discusses the methodology to determine the gap analysis of VSM tool implementation in manufacturing operation in a different set of companies using fuzzy topsis. The algorithm and methodology determines the prioritization of various factors that can and will play an important role in implementation of VSM Tool across different organizations. The methodology will determine the ranking of organization based on the closeness coefficient.

1. Introduction

A value stream includes all activities required to transform a product from raw material into the finished goods. Value Stream Mapping scrutinizes business processes from beginning to end and a visual representation map is drawn of every process involved in the material and information flows. Then a future state map is drawn to show how things should work for best competitive advantage. Value Stream Mapping helps to identify the current flow of material and information in processes for a family of products, highlighting the opportunities for improvement that will most significantly impact the overall production system.

The purpose of this study is to develop a value stream map for a manufacturing company in Minnesota. The goal is to identify and eliminate waste which is any activity that does not add value to the final product, in the production process. In order to collect the information needed to complete the project, the researcher will take a tour of the production facility. This will enable the researcher to be familiar with the activities being performed at the shop floor. It would also help in getting a vivid idea of the production flow. In addition, a classroom environment would-be set with leads from the various departments of the company so that the researcher can observe and collect information related to product families for the practical mapping and product/process flow from start to finish. This information would highly assist the researcher to visualize the current state of the process activities by mapping the material and information flow and looking for opportunities to eliminate wastes and to improve the process flow.

Based on all the information gathered, the company would utilize these results as a plan to map the future state and implement lean manufacturing techniques so that wastes can be eliminated, flow maximized and throughput increased.

Every organization is striving hard on getting more work done in less time and with greater ease. The fundamental aim of any organization has been to continuously minimize waste and maximize flow which would ultimately lead to customer satisfaction by providing right product at the right time in the right quantity and the right quality at a reasonable price. This can be achieved greatly by adopting lean manufacturing system which is more than a cost reduction program. It aims at eliminating wastes which could be in the form of excess production and inventory, redundant movement of material, waiting and delays, over processing, excess worker motion, rework and corrections.

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Part of lean manufacturing is assessing operations and processes or products that add cost rather than value. Each step of the manufacturing process is examined to determine if it adds value to the product. If it does not add value, the process could be assigned to a subcontractor or outsourcing company in order to focus the workforce on value added operations of its core business. This is known as value stream which is a set of processes required to transform raw materials into finished goods that customer's value.

Lean manufacturing is also popular by the name Just-In-Time Manufacturing developed by Toyota, the Japanese car manufacturer. This concept is now applied by diverse industries and businesses including engineering, administration, project management, manufacturing and administration. Lean manufacturing aims at transforming an organization into an efficient, smoothly running, competitive and profitable organization that continues to learn and improvise.

The application oflean paves its way to reduce lead time and increase throughput by eliminating wastes which comes in various forms.

2. Literature Review

In this literature review, Different Research papers have been written on VSM and Fuzzy Topsis tools.

R. Mohanraj [1] has used integrated value stream mapping using Fuzzy QFD. He has used Fuzzy QFD technique for effective leanness improvement in VSM. Sanjay Kumar et al. [2] prepared framework to check lean performance of different type of firms using fuzzy Topsis. He has focus on different issues of firms and ranks them according to lean performance.

Hossein safari [3] has used Fuzzy Topsis for ranking of different supplier. In this research paper, he has taken different factors which effect supplier performance and ranked them using fuzzy Topsis. Mbuzo [4] has used Fuzzy topsis in retail banking system and focus on fuzzy effectiveness of self-service innovation system.

Markus P. Roessler et al. [5] has done quantification and multidimensional assessment of value stream mapping after considering variability. John Tingstorm et al [6] used VSM technique in R & D. he has defined value in literature review and conclude that it is difficult to identify value in R & D between different processes. In his research, he showed that small evolutionary steps can give improvement in different process.

Silva [7] has presented case study of appeal industry in Sri Lanka. She has prepared current and future state of VSM. She identifies waste at different process and suggested to reduce waste by implementing lean manufacturing tools.

Above research papers has been focuses on VSM application in different industry and used Fuzzy Topsis approach for ranking of supplier and lean assessment so, we can use fuzzy Topsis approach to check Effective implementation of VSM in manufacturing sector.

Lean utilizes proper tools to make work flow as smooth as possible so that it reaches its end customer [8] Value stream management is a process of planning and linking lean initiatives through systematic data capture and analysis which consists of eight steps.

1.Commit to lean
2.Choose the Value Stream
3.Learn about Lean
4.Map the current State
5.Identify Lean Metrics
6.Map the Future State (using the demand, flow, and leveling concepts)
7.Create Kaizen Plans
8.Implement Kaizen Plans

Value stream Management is a systematic approach that tells how and when to implement improvements that aids in meeting customer demand. The tools of lean manufacturing such as value stream mapping, supermarket, heijunka, u-shaped cells and point kaizen workshops must be applied in a proven, structured process to attain success. The lean management principles are of great essence to transform an organization into lean. The following are the lean management principles:

- Define value from the customer's view perspective.
- Identify the value Stream
- Eliminate the seven deadly wastes
- Make the work flow
- Pull work, don't push it
- Pursue to perfection
- Continue to improve

It is a tool of lean manufacturing that helps to understand the flow of material and information as products make their way through the value stream. The value stream includes the value adding and non-value adding activities that are required to bring a product from raw material through delivery to the customer. In other words, value stream mapping is an outline of a product's manufacturing life cycle that identifies each step throughout the production process. It is a visual representation of the material and information flow of a particular product family [9].

Value stream mapping is a powerful yet simple tool which allows the user to see the waste throughout the stream [10]. It consists of sketching the current and future state map.

The current state map charts the present flow of material and information as a product goes through the manufacturing process. It is a simplified visual blue print that identifies value and waste throughout the system and encourages systematic approach to eliminating waste. The future state map is a chart that shows how to create a lean flow. It adopts lean manufacturing techniques to eliminate waste and reduce non-value added activities to the minimum.

The goal of value Stream Mapping is to move from batch and push to one piece flow and pull through the entire value stream. Introducing a lean value stream that optimizes the flow of the entire system from information, to material, to finished goods arriving at the customer's door is the ultimate goal. It helps in reducing lead time, inventory, and overproduction and improves throughput, efficiency and quality. It aims at continuously improving in a capable, sustainable manner.

4. Methodology

Topsis means Technique for order of preference by similarity to ideal solution (TOPSIS). Fuzzy Topsis was developed by Hwang and Yoon in 1981. There was further development in 90's and TOPSIS can choose shortest distance between Positive ideal solution (PIS) and Negative ideal solution was developed (NIS).

For Effective VSM implementation assessment using Fuzzy Topsis, there is need to develop Fuzzy Topsis algorithm step by step which can be used to check effective implementation of value stream mapping tool.

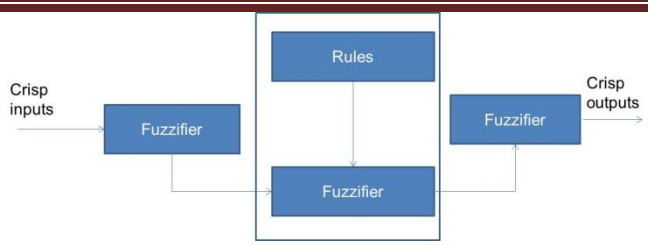

Fig. 1 Fuzzy Topsis

If we select three companies X, Y and Z and take different factors to evaluate VSM implementation effectiveness.

Step-1: There is need to select the linguistic scale for importance weight criteria.

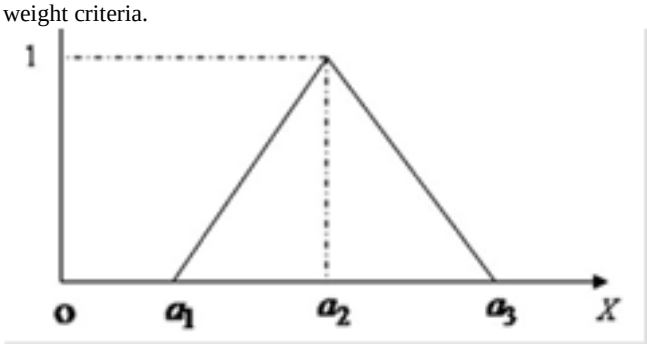

Fig. 2 Weight Criteria (TFN)

TFN (Triangular fuzzy number) membership function divide on 5 scale rating (Very good, good, fair, Poor, Very poor).

Step-2: Obtain the linguistic rating of criteria and effective VSM implementation against these criteria of three companies (X, Y and Z)

Below five criteria to be consider for three X,Y and Z companies. :

1. Training of employees for VSM
2. Leadership involvement
3. Effective JIT implementation
4. Optimal flow design
5. VSM tool implementation

Step-3: Compute aggregate weight of various criteria and aggregate weights of different criteria and fuzzy ratings of X,Y and Z firms.

Below formula to be used:

$$\tilde{x}_{ij}^{k} = (a_{ij}^{k}, b_{ij}^{k}, c_{ij}^{k})$$
$$\tilde{w}_{j}^{k} = (w_{j1}^{k}, w_{j2}^{k}, w_{j3}^{k})$$

$$a_{ij} = \min_{k}\{a_{ij}^{k}\}, \quad b_{ij} = \frac{1}{K}\sum_{k=1} b_{ij}^{k}, \quad c_{ij} = \max_{k}\{c_{ij}^{k}\}$$

$$w_{j1} = \min_{k}\{w_{jk1}\}, \quad w_{j2} = \frac{1}{K}\sum_{k=1}^{K} w_{jk2}, \quad w_{j3} = \max_{k}\{w_{jk3}\}$$

Step-4: Normalize the aggregate fuzzy ratings using below formula :

$$\tilde{R} = [\tilde{r}_{ij}]_{m\times n}, i = 1, 2, \ldots, m; j = 1, 2, \ldots, n$$

$$\left.\begin{array}{l} \tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \quad \text{and} \\ c_j^* = \max_i c_{ij} \quad \text{(benefit criteria)} \end{array}\right\}$$

$$\left.\begin{array}{l} \tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) \quad \text{and} \\ a_j^- = \min_i a_{ij} \quad \text{(cost criteria)} \end{array}\right\}$$

Step-5: Calculate weighted normalized fuzzy ratings of X,Y and Z company against each criteria.

$$\tilde{P} = [\tilde{p}_{ij}]$$

where

$$\tilde{p}_{ij} = \tilde{r}_{ij} \times \tilde{w}_j$$

Step-6: Calculate the fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS)

$$A^+ = (\tilde{p}_1^+, \tilde{p}_2^+, \ldots, \tilde{p}_m^+)$$
$$A^- = (\tilde{p}_1^-, \tilde{p}_2^-, \ldots, \tilde{p}_m^-)$$

J1 and J2 represent the criteria benefit and cost

$$\tilde{p}_j^+ = \left(\max_i \tilde{p}_{ij}, j \in J_1; \min_i \tilde{p}_{ij}, j \in J_2\right)$$
$$\tilde{p}_j^- = \left(\min_i \tilde{p}_{ij}, j \in J_1; \max_i \tilde{p}_{ij}, j \in J_2\right)$$

Step-7: Calculate the distance between each weighted FPIS and FNIS.

$$d_i^+ = \sum_{j=1}^n d(\tilde{p}_{ij}, p_j^+)$$
$$d_i^- = \sum_{j=1}^n d(\tilde{p}_{ij}, p_j^-)$$

Step-8: Calculate the closeness coefficient of each alternative by using below formula:

$$CC_i = \frac{d_i^-}{d_i^- + d_i^*},$$

Rank down X, Y and Z companies to based on closness coefficient. The company is having higher closness coefficient to be rank 1 and sequence them.

6. Conclusions

Different researchers have done work on Fuzzy Topsis for multi decision criteria. As Value stream mapping tool is an identified waste from supplier to customer. In this context, this research paper focused on Fuzzy Topsis methodology algorithm for Value stream mapping tool. This methodology can be used to find Gap of Value stream mapping tool in manufacturing industry and talk about different factors which can play role for implementation of VSM effectiveness of X, Y and Z companies. Higher ranking to be given to company which is having higher closeness coefficient. Thus Value stream mapping tool implementation can be checked with Fuzzy Topsis methodology and rank them in sequence of order.

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Nomenclature

TCN	Triangular Fuzzy Number
VSM	Vlue stream mapping