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Fuzzy QFD Integrated Value Stream Mapping: An Enabler of Lean Manufacturing Practices

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Abstract: *Lean manufacturing is one of the initiatives that many major businesses were trying to adopt in order to remain competitive in increasingly global market. There are many tools in lean manufacturing, among which value stream mapping (VSM) is an important tool which aims to identify various value added and non value added activities in that stream. This article describes the methodology where current state map (CSM) was prepared and using fuzzy quality function deployment (QFD) tool lean proposals were prioritized. After applying the identified lean proposals, future state map (FSM) was generated. The proposed FSM was implemented in the case organization and improvements in leanness performance measures were quantified.*
Keywords: *Lean manufacturing; Value stream mapping; automotive component; Fuzzy QFD.*

I. INTRODUCTION

VSM is considered as the initial step to implement lean manufacturing. VSM tool is used to map various value added activities (VA) and non value added activities (NVA), which the product comes through during the transformation of raw material to the final product (Hines & Rich, 1997). In this context, the case study was conducted in an Indian automotive component manufacturing organization, where VSM tool was used to identify the current state and by prioritizing the various tools/techniques using Fuzzy QFD, FSM was prepared and implemented. QFD was selected over basic approach like Pugh matrix because it is more scientific approach and fuzzy logic can be integrated with QFD to eliminate vagueness and inconsistency associated with crisp values (Vinodh et al., 2011a). The novelty of the proposed approach is that it integrates QFD with VSM framework for enabling the prioritization of improvement techniques to be deployed in industrial scenario.

II. Case Study

This section deals with the details about the case organization, CSM and FSM development.

2.1 About the case company

The case company is an automotive component manufacturing company supplying components to a leading automotive organization. The company is involved in manufacturing piston components of various sizes. For this case study, one model of piston component (Part number: 7040538) is considered.

2.2 Current State Mapping

Current state map shows the present scenario of the manufacturing system and is shown in Fig. 1.

"Insert Figure 1"

2.2.1 Physical system of the company

Every week material has been procured from supplier at an average of 2.5 Lakhs. The process sequence starts with machining process. The company has six semi automatic lathe centers which perform machining like turning, grooving and chamfering on the work pieces. Face grinding is done at one face of the work piece using rotary grinding machine. Inspection is carried out at various levels of processes of work pieces to maintain quality. Finally, work pieces are dipped in oil bath and dried. During oil dipping process, about 6000 work pieces are stocked in a perforated tray. The dried parts are inspected visually for any flaw lines and dents at face side. The accepted parts were packed in a plastic tray containing cups to accommodate parts. The packed parts were subjected to shipment to the customers.

Up Time calculation: $Uptime = \frac{\text{Available opertaing time}}{\text{Available production time}}$

Company is functioning only one shift in a day.

Cycle time calculation: Cycle time = $\frac{\text{Available time}}{\text{components produced}}$

Using the above formula cycle time and uptime has been calculated and used in CSM and FSM.

III. Fuzzy Qfd

The proposed architecture of Fuzzy QFD integrated with VSM. As shown in Figure 1, after the construction of current state map, Wastes are categorized as over production, over processing, waiting, transportation, defects, inventory, and storage. Then the proposals/improvements identified during brainstorming sessions are designated as design attributes. The proposals identified are Kaizen, Kanban, 5S, Poka-Yoke, Quick Change Over(QCO), Super Market Concept(SM), Autonomous Maintenance(AM), Visual Maintenance, Virtual Work(VW) and Work Cell(WC). Then, Fuzzy QFD model used to prioritize the improvement proposals.

Fuzzy Function Matrix

The waste prioritization and methodology selection was done by constructing and deriving an House of Quality (HOQ) adopted from Quality Function Deployment (QFD).

In order to overcome vagueness, linguistics variables are used to build the HOQ, we propose to express importance weights, as well as relationships and correlations, with fuzzy triangular numbers. The relationship matrix R_{ij} (i = 1,...,n, j = 1,......,m) of the HOQ is a matrix whose generic entry *(i, j)* assesses how the j-th Proposed Methodology (PM) performs in minimizing the *i*-th Identified Waste (IW). The rating were adapted from Vinodh & Chintha (2011b). Once relationships between PMs and IWs were assessed using Linguistic variables and then transferred into fuzzy numbers as shown in Table 1 and the relative importance RIj of the j-th Proposed Methodology can be computed as a fuzzy cumulative value using Equation (1) (Vinodh & Chintha, 2011b). $RI_j = \sum_{i=1}^{n} W_i \otimes R_{ij}\ j = 1,\dots,m$ (1)

where W_i is the weighted importance of the i[th] Identified Waste and R_{ij} the fuzzy number expressing the relationship between the j[th] Proposed Methodology and the i[th] Identified Waste. $Score_j = RI_j \oplus \sum_{j' \neq j} T_{j'j} \otimes RI_{j'}, \quad j = 1,\dots,m$ (2). T_{jj}*'* of the correlation matrix is assessed using the linguistic variables as shown in Table 1 has an incremental change of the degree of attainment of the *j*-th attribute when the attainment of the *j'*-th one is unitary increased. So, the final $score_j$ of the *j*-th proposed methodology can be computed using Equation (2) (Vinodh & Chintha, 2011b).

The resulting $score_j$ is also a fuzzy number. In order to rank the proposed methodologies, the crisp values are used. The crisp value of a fuzzy triangular number *a(l, m, u)*, is computed using Equation (3)(Vinodh & Chintha, 2011b). $Crisp\ Value = \frac{l+2m+u}{4}$ (3). Based on the crisp values, the proposed methodology with the highest crisp value is given more importance. After ranking the proposals, the identified best improvement proposals are 5S, QCO, SM, AM, VM, VW and WC. The weights for the identified wastes were obtained from the experts. Then relational ship matrix and correlation matrix was constructed after discussing with the cross functional team.

IV. Future State Mapping

The identified proposals are implemented in future state map and are shown in Fig. 2.

"Insert Figure 2"

With reference to Figure 2, the improvements in each cell are discussed as follows. At cell number 1**,** lathe and Face Grinding are placed together. To achieve Quick change over, Automatic loading system has been introduced. Cutting tools can be sharpened earlier during idle time and also stocked well in advance in tool magazine. Total number of operators required to work in this cell is = 4+3=7.

At cell number 2: Inspection and Oil Dipping will be carried out. Number of operators required to work in this cell =2+2=4.

At cell number 3: Visual Inspection and Packing will be done.

These will be done manually to keep the packed goods ready for shipment. Number of operators required to work in this cell =3. Sorting out and random inspection are eliminated in FSM. Total number of operators = 7+4+3=14.

V. Results

After implementing the proposals, to quantify the benefits, the following measures were determined. In order to quantify the improvements from the perspective of leanness, the values of the parameters before and after implementation of VSM are presented as follows. Non value added time has been reduced from 14 to 8.5 days; Total cycle time has been reduced from14 to8.5 days; Work in process inventory between machines has been reduced from 20000 to 18000 units; The above result shows that, there is a significant improvement in leanness after implementing FSM.

VI. Conclusions

In the present study, VSM was the main tool used to identify the opportunities for leanness improvement. In this context, this paper reports a case study that is focused on the development of VSM integrated Fuzzy QFD approach for an automotive component manufacturing organization. Various proposals from the perspective of leanness improvement were prioritized using Fuzzy QFD and implemented in FSM. After implementing the proposals, leanness performance measures have been improved significantly. Thus the effectiveness of the VSM tool has been practically validated in a real time manufacturing environment.

References

[1] P Hines, and N. Rich, The seven value stream mapping tools, *Int. J. Operations and Production Management*, 17(1), 1997, 46–64.

[2] S. Vinodh, M. Sakthivel and R. Mohanraj, QFD integrated value stream mapping: an enabler of lean manufacturing, *Int. J. Productivity and Quality Management*, 7(4), 2001, 501–522.

[3] S. Vinodh, and S.K. Chintha, Application of fuzzy QFD for enabling agility in a manufacturing organization, *The TQM Journal*, 23(3), 2011, 343-357.

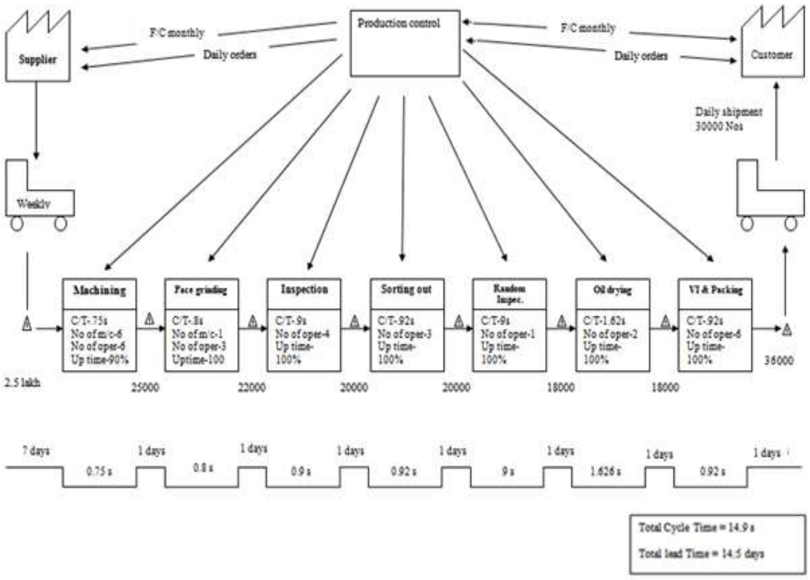

Figure 1. Current State Map

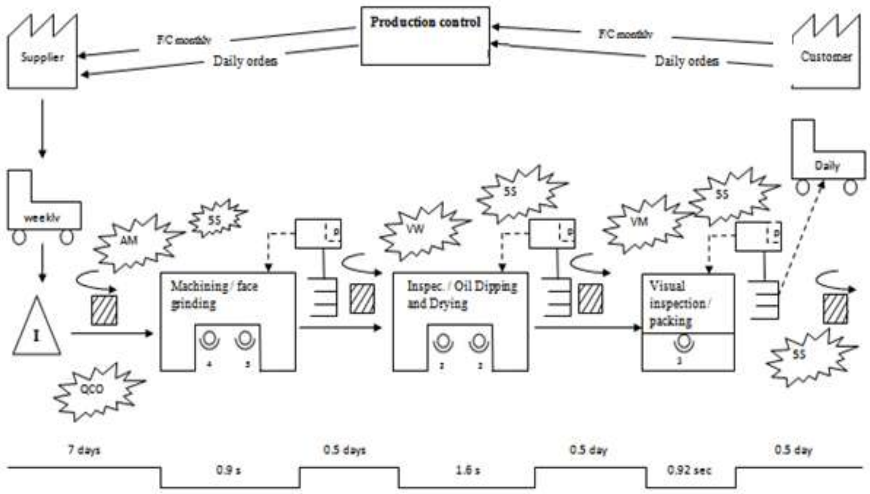

Figure 2. Future State Map

Total cycle time-3.42 s
Total lead time- 8.5 days