An Application of Value Network Mapping in Workload Control Concept

Mem. Muroran Inst. Tech., 62(2012) 21~26

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An Application of Value Network Mapping in Workload Control Concept

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(Received 28 January 2012, Accepted 17 January 2013)

Workload control (WLC) concept has been recognized for job shop practices. One of major parts of order release and review (ORR) is the order entry phase. Value network mapping (VNM) is an alternative approach of the value stream mapping (VSM). All parts on shop floor are mapped in the complete network flows with detailed data. An objective of this research is to use a case-based approach to apply VNM for supporting data in ORR strategy. A variety of material flow analysis and product grouping tools are employed to use in the empirical study. It is fruitful to handle multiple products in complex bill of material and becomes easier to visualize for anticipation a bottleneck. All necessary data are clearly shown for production planner in order to prepare for performing an optimization analysis in order release phase.

Keywords : Workload control, Order entry phase, Value network mapping, Job shop environment

1 INTRODUCTION

Presently, many companies around the world have to face more competition to response customers need in term of cost, quality and time. Based on production environments, production and control system in make-to-order (MTO) is more complicated from several uncertainty factors involved(1) . The characteristic of MTO environment is to produce high variety of products in low volume(2) . Moreover, many MTO companies operate by using job shop production.

Job shop is production system that typically deals jobs differ with respect to the set of operations to be performed, with respect to the sequence in which the operations must be executed, and with respect to processing times during fabrication(3) . Researchers have developed many tools and techniques to find better solutions for this attractive problem. However, workload control (WLC) is a promising mechanism amid others as suggested by Hendry and Kingsman(4) .

The development of WLC has highlighted the benefit of control policies that has been recognized for job shop practices. An order release and review (ORR) technique plays a majority role to manage the transition of production orders from production planning to the shop floor control(5) . One of major parts of ORR is the order entry phase, which deals with production order preparation, processing requirement, and job routing(6) .

Value network mapping (VNM) is an alternative approach of the value stream mapping (VSM)(7) . All parts on shop floor are mapped in the complete network flows with detailed data. VNM can apply with job shop companies where produce products such as equipment cabinets, jigs and fixtures, small turned parts etc.

An objective of this research is to use a case-based approach to apply VNM for supporting data in ORR strategy. An empirical study is an actual manufacturer of precision tool engineering that operates in job shop environment. The remainder of the paper is organized as follows. Section 2 presents a literature review. A proposed method is described in section 3. Section 4,

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an overview about the case organization is provided. Results and discussion of the proposed method are mentioned and analyzed in section 5. Finally, section 6 presents the conclusions of the paper and suggestions for future research.

2 LITERATURE REVIEW

2.1 The order entry phase in workload control concept

A significance approach for job shop production is based on WLC concept. This concept buffers the shop floor against the dynamics of arriving orders by using input/output control. A typical WLC concept consists of three major decision moments; order entry phase, order release phase and dispatching phase, respectively.

At each phase is operated as a class of hierarchical capacity-oriented with input control and output control(8) . On the one hand, input control regulates the allowable jobs to the next level, acceptance jobs for entering into the pool, releasing jobs to shop floor and dispatching jobs for processing. On the other hand, the control of workload through regulation of the outward flow is leaded by medium term, short term and daily capacity management. Additionally, due date assignment or due date acceptance is also considered at order entry level(9) . Figure 1 presents the hierarchical WLC concept.

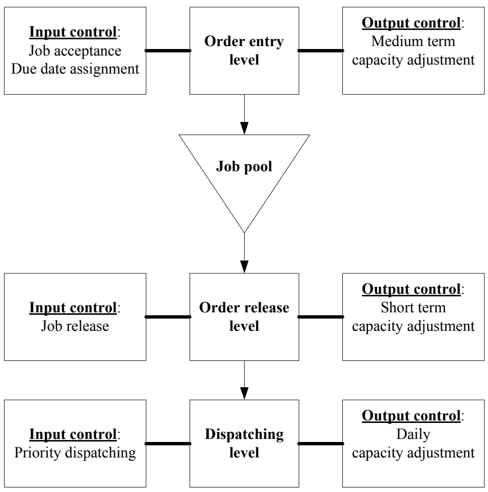

Fig. 1 Input and output control in WLC concept

Ossterman et al.(10) asserted that an job release is an important decision within WLC concept because it determines when each job should enter to the shop floor and remains on the floor until its operations have been finished. However, job entry control has influenced to prepared information before releasing selected orders. The job routing is defined and the availability of the required materials, tooling and fixture is provided. More detailed planning for the workload of the job is generated.

2.2 Overview of value network mapping

One of the effective tools for implementing lean production is value stream mapping (VSM). VSM is a powerful tool which not only expresses material flows, but also provides information flows(11) . However, many researchers observed that job shop environment companies have multiple streams coming together. Therefore, it fails to map VSM. VNM is generated to eliminate this weakness.

Unlike traditional flow mapping tools, VNM is developed to map the complete flow network in a value stream for complex product, complex bill of material (BOM) and several levels of assembly(12) . This approach was proved to support facility improvements i.e. the creation of manufacturing cells and the addition of material handling information(13) .

VNM integrates and enhances basic industrial engineering (IE) tools such as multi-product process chart (MPPC) and flow process chart (FPC) to elaborate algorithms for clustering of identical manufacturing routing and outline the improvement facility layout. Moreover, these algorithms utilize data structures that capture the complete assembly structure of the product instead of focusing only the key components.

3 METHOD

A proposed method is depicted in Figure 2. The various steps are described below

(1) Use products BOM and the manufacturing routings of the components in the BOM. MPPC, the basic IE tool, is generated in this step for showing the flow in the facility.
(2) Collect detailed data for enhanced flow process chart (FPC). The enhanced FPC is a data collection tool to record all operation, transport, delay, inspection, material handling and essential information in the production’s flow.

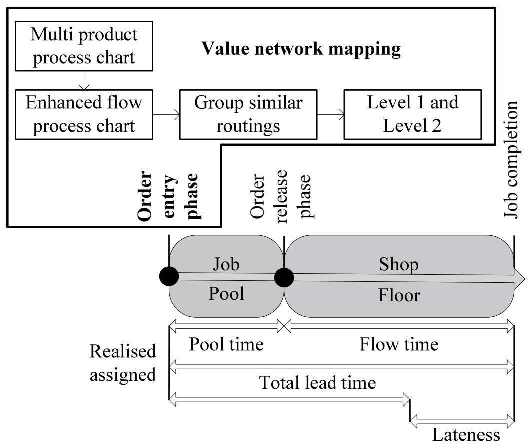

Fig. 2 A schematic diagram of proposed method

(3) Group products into families. Data are collected and observed for grouping product families on

the basis of the pair-wise similarity coefficients (PWSC) which is obtained by the "Jaccard" similarity function as below

$$S_{ij} = \frac{X_{ij}+\sqrt{X_{ij}\cdot Y_{ij}}}{X_{ij}+X_i+X_j+\sqrt{X_{ij}\cdot Y_{ij}}} \quad (1)$$

where $0 \leq S_{ij} \leq 1$; X_{ij}= number of machines used by both part 'i' and part 'j' (number of matches); X_i= number of machines used by part 'i' only; X_j= number of machines used by part 'j' only; Y_{ij}= number of machines that are used neither by part 'i' nor by part 'j' (number of misses).

(4) Draw the level 1 (product family) and level 2 (component family). These maps of VNM state the material handling information associated with every flow of parts on any machines.

4 CASE STUDY

The research is applied in a job shop MTO company, precision tools engineering. Due the higher work in process (WIP) levels and the increasing of jobs, the instinctive style for scheduling can not successfully used by the planner. Hence, this company finds a new approach to support the planner for reducing WIP, reducing lead times, improving delivery date devotion.

This paper illustrates some products which processing data and sequence data were obtained from the company. This company has 11 stations including drilling machine, CNC machining center, wire cut machine, grinding etc.

Five illustrative products are displayed in the form of MPPC as shown in Fig 3. The use of MPPC is preferable to deal with a number of products. This tool can be used not only as input for a cluster analysis procedure, but also exploration the identification process. A friendly-user form as enhanced FPC is employed to determine all necessary data. Figure 4 displays the enhanced FPC for one component in the case study.

5 RESULTS AND DISCUSSION

From previous section, results are structured according to provide essential information at order entry phase in WLC.

A cluster analysis is operated to group components with similar manufacturing path into same families. The PWSC, which is exhibited in Table 1, is calculated by applying equation 1 ("Jaccard" similarity function) with the MPPC. It is benefit to visualize the arrangement of the cluster in dendrogram that is shown in Fig. 5. The clustering dendrogram state that components can be partitioned into 3 clusters; {7,8,6,11,1, 3}, {2,5,12} and {4,9} with 1 exceptional component 10 .

Finally, to map a large number of different flows can be divided at two levels. MPPC and enhanced FPC are integrated to map the flows of a complete family of products at level 1. At level 2, each family flow is mapped by using MPPC, enhanced FPC and the cluster dendrogram. Level 1 diagram and level 2 diagram for component family 1 are presented in Fig. 6 and Fig. 7, respectively.

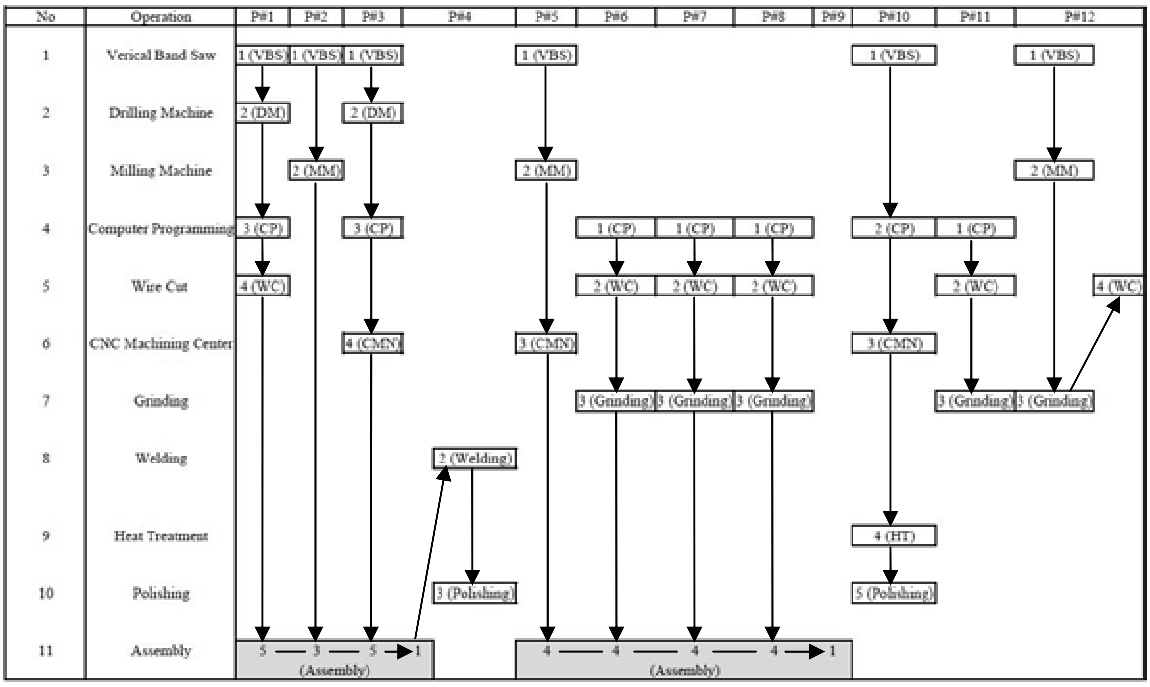

Fig.3 A multi product process chart

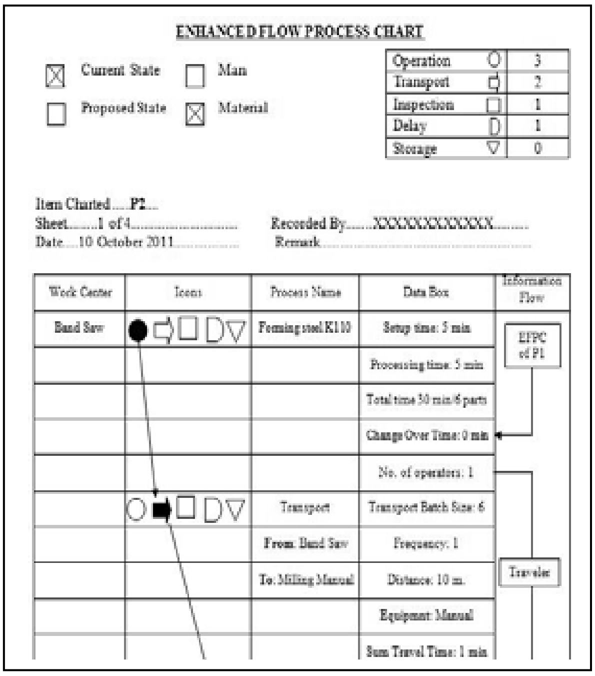

Fig.4 A sample of enhanced flow process chart

The case study produces a wide range of products that use different combination of parts, whose routing will characterize different work centers located in the same facility. The application of VNM with level 1 and 2, both levels of flow mapping effort to combine and /or merge several flows in order to generate more compact flow diagram without eliminating any components.

6 CONCLUSION

This research applies VNM to support data in order entry phase of WLC concept. A variety of material flow analysis and product grouping tools are employed to use in the empirical study which operates in job shop environment. It is fruitful to handle multiple products in complex bill of material and becomes easier to visualize for anticipation a bottleneck. All necessary data are clearly shown for production planner in order to prepare for performing an optimization analysis in order release phase. Future studies should perform an optimization method at order release phase by useful data from the proposed research.

Table 1 Jaccard similarity matrix

	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**
P1	1	0.563	0.775	0.333	0.475	0.696	0.696	0.696	0.463	0.426	0.563	0.491
P2		1	0.563	0.463	0.883	0.393	0.393	0.393	0.657	0.333	0.000	0.646
P3			1	0.333	0.696	0.491	0.491	0.491	0.463	0.618	0.333	0.281
P4				1	0.393	0.393	0.393	0.393	0.657	0.333	0.000	0.000
P5					1	0.333	0.333	0.333	0.549	0.491	0.000	0.563
P6						1	1.000	1.000	0.549	0.281	0.883	0.563
P7							1	1.000	0.549	0.281	0.883	0.563
P8								1	0.549	0.281	0.883	0.563
P9									1	0.000	0.000	0.000
P10										1	0.333	0.281
P11											1	0.646
P12												1

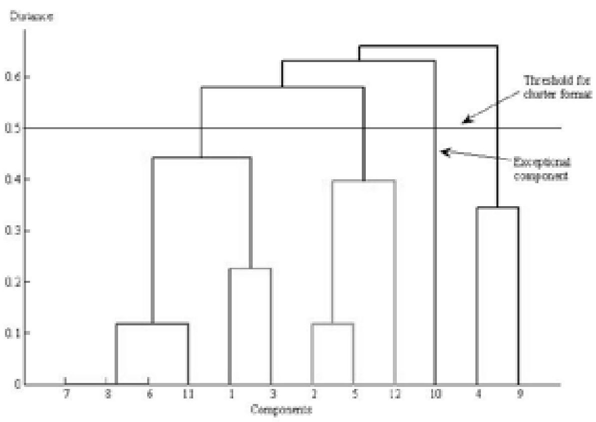

Fig.5 Part family dendrogram

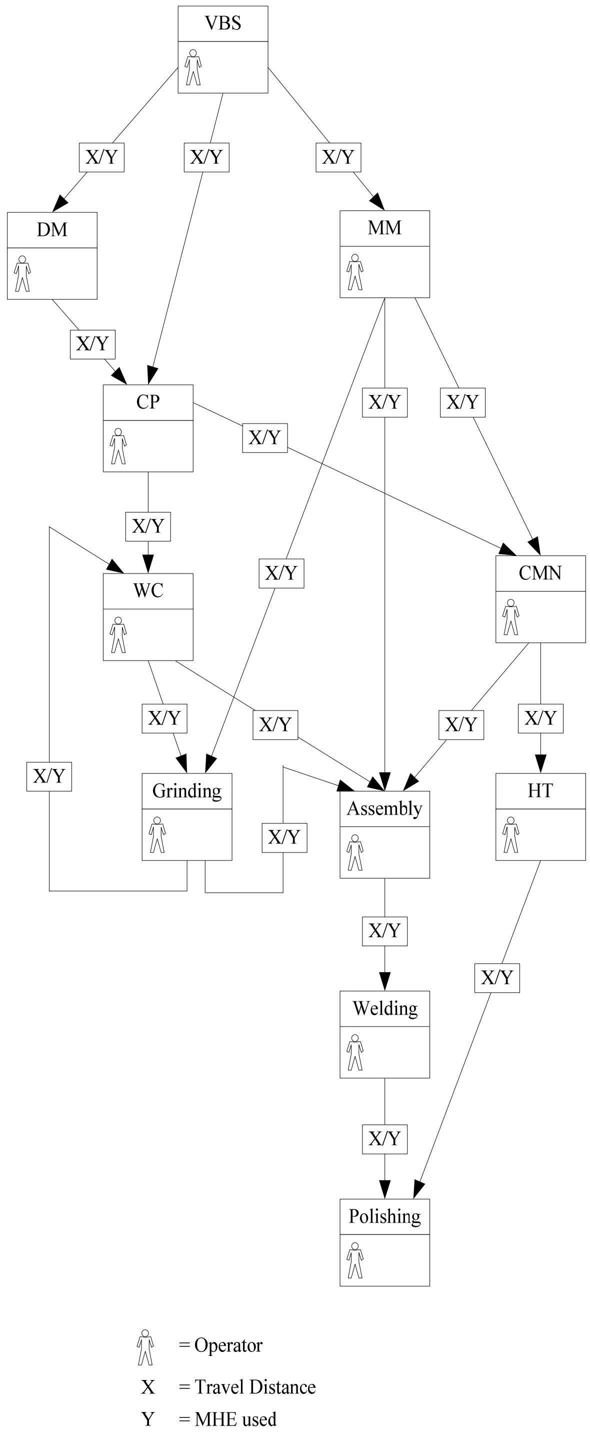

Fig. 6 VNM at level 1

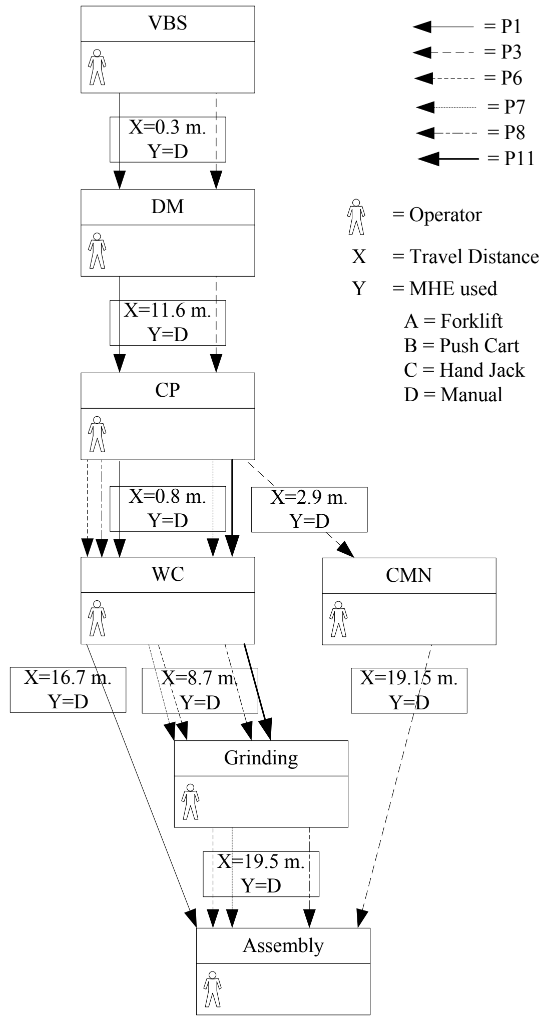

Fig. 7 VNM at level 2 for component family 1

ACKNOWLEDGMENT

The authors would like to take this opportunity to thank the Supply Chain and Engineering Management (SCEM) Research Unit, Industrial Engineering Department, Chiang Mai University.

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