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Improving the performance of job shop manufacturing with demand-pull production control by reducing set-up/processing time variability

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Abstract

This study was aimed at investigating the effects of reducing set-up/processing time variability on the production performance of a job shop environment with demand-pull production control. Simulation was employed as the modelling tool. It was found that reducing processing time variability is more effective for a cellular layout than for a functional layout where parts are transported and processed piece by piece within cells. On the other hand, reducing set-up time variability should be given a higher priority for a functional layout or a cellular layout where parts are moved by batches within cells. In addition, set-up or processing time variability hardly affected the selection of appropriate configuration of a job shop with demand-pull production control.

Keywords: Just-in-Time; Kanban; Job shop; Simulation modelling

1. Introduction

Since the development of the Just-in-Time (JIT) manufacturing techniques at Toyota production plants in the early 1970s, these techniques have been adopted by manufacturing firms globally for improving productivity. One important aspect of JIT manufacturing is the demand-pull production control using Kanbans ('the Kanban system', hereafter). The Kanban system provides a highly visible mechanism for controlling the production and movement of parts and thus, avoids excessive stock build-up. A detailed description of the operation of the Kanban system was provided by Monden (1983).

Although the Kanban system has been mostly implemented in repetitive manufacturing environments (i.e., flow shops), Gravel and Price (1988) and Lee et al. (1994) have reported the potential of the Kanban system to increase the productivity of job shop environments. In addition, considering the usually lower efficiency of job shop manufacturing in comparison with repetitive manufacturing, Stockton and Lindley (1995) and Sandras (1985) stressed the importance of the Kanban system in driving continuous improvement activities in job shop environments.

It is important to note that a crucial prerequisite for realising the benefits of the Kanban system is

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to reduce production fluctuations to a minimum (i.e., to achieve smooth production flows) (Monden, 1983; Kimura and Terada, 1981). However, in job shop environments, workers are confronted with diversified product types with few repetitions (as opposed to the repetitive product mix of repetitive manufacturing) and thus, the learning curve for production operations is more difficult to evolve. Eventually, the lack of proficiency very often leads to more variable machine set-up and part processing times and in turn, production fluctuations. Therefore, devising strategies for reducing set-up/processing time variability is essential for the Kanban system to operate smoothly in job shop environments.

The purpose of this study is to investigate the effects of reducing set-up/processing time variability on the production performance of job shop manufacturing with the Kanban system, and to derive proper implementation strategies under different shop conditions. A simulation model of a job shop environment was developed, and an experiment was carried out using the shop model to collect shop performance data for further analysis.

This paper is organised in seven sections. A review of studies related to investigating the effects of set-up/processing time variability on Kanban-based systems is given in the next section. Design of the simulation experiment and shop model is presented in Sections 3 and 4, respectively. In Section 5, development and execution of the simulation model is described. Simulation results are presented and discussed in Section 6, and finally, conclusions are given in Section 7.

2. Literature review

Several researchers had investigated the influences of processing time variability on the performance of Kanban-based production systems using simulation. Huang et al. (1983) investigated the effects of variable processing times on the performance of a 3-line, 4-stage repetitive production system with Kanbans. They found that overtime required increased dramatically as the variation in processing times increased. Although adding Kanban capacity reduced overtime, it was effective only up to approximately four Kanbans. They concluded that a Kanban system would not be effective with highly variable processing or set-up times.

Philipoom et al. (1987) studied the effect of processing time variability on the number of Kanbans required for a job shop comprising six workstations and producing two products. As Huang et al. (1983) reported, they found that increase in processing time variability significantly increased the number of Kanbans required to meet the demand.

Villeda et al. (1988) performed a simulation study of a 3-line, 4-stage repetitive production system with Kanbans. It was observed that both the output rate of the system and work centre utilisation declined as variability of work centres increased. They concluded that the more variable the processing times, the larger the extent of improvement in the production rate through unbalancing work centres. In addition, they stressed that the variability in final assembly of a Kanban-based system is amplified and transmitted to the entire system.

A study by Chaturvedi and Golhar (1992) simulated a Kanban-based continuous production line where one final product is produced through nine sequentially arranged workstations. Their analysis showed that increase in the variability of a normal processing time distribution resulted in deteriorations in the order completion time and WIP inventory. System performance was worst with an exponential processing time distribution, which further affected station utilisation and throughput.

Yavuz and Șatir (1995) simulated a Kanban-based mixed-model production line producing four products through five stations along the line. They found that as processing time variability increased, a larger lot size or number of Kanbans was needed to alleviate the resulting decline in system performance. In addition, larger processing time variability resulted in longer production lead times when product variety was high.

All these reports highlight the importance of reducing processing time variability in achieving the benefits of the Kanban system. However, the