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Computers & Industrial Engineering 46 (2004) 101–120

computers & industrial engineering

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Comparing variance reduction to managing system variance in a job shop[☆]

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Accepted 10 November 2003

Abstract

Variance within the manufacturing system leads to uneven shop loads, long manufacturing lead times, and unreliable customer service. This study compares techniques that reduce system variance to techniques that manage system variance. The study is placed in a dual resource constrained job shop. Results indicate that reducing system variance improves flow time and customer service performance measures, such as mean tardiness and percent tardy jobs more than techniques that react to system variance.

Keywords: Worker flexibility; System variance; Variance reduction; Customer service

1. Introduction

Schmenner and Swink (1998) argue that the key to improving productivity is to improve the continuity of work flow and decrease its variability. They suggest that this can be done by cross-training the work force, conducting faster equipment changeovers and instituting other policies that will reduce variance. This theory is partially supported by Schmenner (2001) using historical evidence. But, there has been no review of the existing literature to determine whether prior research findings support their theory.

As an initial step in testing their theory, this paper first examines and classifies types of management decisions in terms of their influence on variance. This classification suggests that while there are several

[☆] This manuscript was processed by Area Editor Gary L. Hogg.
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doi:10.1016/j.cie.2003.11.002

'causes' of variability, the primary (important) sources of variability are the manner in which orders (demand) arrive into the shop, and the amount of work that is associated these orders. Management may treat this natural variance as a given and simply react to it, or it may choose to modify or influence the manner in which this variance is realized by the shop. The commonly used methods of coping with system variance, such as scheduling and flexibility (e.g. labor flexibility) are also studied to understand how they influence shop flow.

The simulation experiment is placed in a dual resource constrained (DRC) job shop to examine whether it is better to eliminate variance or to react to variance. In a DRC shop both the machines and the workers can become the constraint. A DRC environment is chosen for this study, since it is representative of the job shops commonly found in actual practice (Wisner & Siferd, 1995).

2. Literature review

Hopp and Spearman (1996) extensively examined variance in small flow shops and single machine shops and used Eq. (1) to demonstrate how variance increases the time a job spends in a queue in front of a single machine

$$\text{Queue Time} = \left(\frac{c_a^2 + c_p^2}{2}\right)\left(\frac{u}{1-u}\right)t_p \tag{1}$$

The first term demonstrates that variance within the manufacturing system influences times in the queue. If either the square of the coefficient of variation of job arrivals at the machine, c_a^2, or the square of the coefficient of variation of job processing times at the machine, c_p^2, increases, then the time in the queue increases. The second term ($u/[1-u]$) in Eq. (1) shows how increasing the utilization, u, influences queue times. The third term means that the effective processing time, t_p, has a direct linear relationship to the time in the queue.

While Eq. (1) is concerned only with a single machine system, it suggests that there are two basic approaches to coping with variance. First, managers can create systems to react to variance as it emerges. Most of the research about scheduling procedures, dispatching rules and strategic investments in process flexibility is concerned with techniques to react to variance. These approaches primarily influence the utilization levels of the machines. Management's second choice is to proactively attack the sources of variance and seek to eliminate them. The new manufacturing paradigms such as just-in-time management and total quality management are examples of proactive strategies. These proactive strategies seek to reduce system variance by creating simple, visible control systems, which signal immediately when variance emerges, so that employees can eliminate the variance. These approaches reduce the coefficients of variation in the first term of Eq. (1).

Hayes and Wheelwright (1984) identified eight categories of management decisions as shown in column 1 of Table 1. The types of decisions made in each decision category are shown in column 2. The third column lists the shop characteristics that are influenced by each type of decision. The fourth column of Table 1 labeled 'shop control mechanism' gives examples of common techniques used to control or react to sources of variance in the shop. In the last column, the type of variance that is created and/or controlled is classified as either c_a^2 or c_p^2. The arrival and processing variances are linked, because variance in processing times create variances in departure times which in turn leads to variance in