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The effect of reliability consideration on the application of quality index

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Abstract

Quality index (QI) has been proposed as a screening mechanism for machine-part matrices in the development of cellular manufacturing systems. In this paper the effect of reliability consideration on the application of QI and the relative sensitivity of job shop and cellular manufacturing systems to reliability changes are evaluated by simulation modeling. Performance measures such as mean flow time and work-in-process inventories are used in the comparative study of job shop and cellular manufacturing.

Keywords: Reliability consideration; Quality index; Cellular manufacturing

1. Introduction

Cellular manufacturing is now widely accepted as an effective configuration for batch-type manufacturing systems. It improves the manufacturing efficiency by organizing production into independent manufacturing units called "machine cells". A machine cell in cellular manufacturing has the capability of fully processing a family of similar parts (part-family). The reduction in set up times, simplification of material flow, and shortening of throughput times are some of the improvement offered by cellular manufacturing (Burbidge 1992; Hyer 1984).

A cellular manufacturing system is, usually, developed based on the machining requirements of parts which are organized in a binary matrix with zero/one entries (machine-part matrix). A block diagonal form of a machine-part matrix in which "one" entries are concentrated along the diagonal of the matrix is used to identify machine-component groups for cellular manufacturing (King & Nakornchai, 1982; McAuley, 1972). The structure of a machine-part matrix has a significant impact on the performance of a cellular manufacturing system.

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Despite significant changes brought about by the introduction of cellular manufacturing, the controversy about the performance of cellular manufacturing systems remains unresolved to date. A frequently cited problem in this respect is the excessive inventories due to the dedication of machines to machine cells (Christy & Udayan, 1986; Flynn & Jacobs, 1986). In response to this criticism of cellular manufacturing systems, several studies have been conducted that consider the initial structure of the machine-part matrix and its impact on the performance of such systems (Djassemi, 1994; Seifoddini & Djassemi, 1995). These studies show that the failure of a cellular manufacturing system in most cases can be traced back to the characteristics of the original manufacturing system. Some of the most influential factors in the performance of cellular manufacturing systems include the structure of the machine-part matrix, the stability of the product mix of the manufacturing system, and the reliability of machines in manufacturing cells.

Quantitative measures such as bond energy (McCormick, Schweitzer & White, 1972), grouping efficiency (Chandrasekharan & Rajagopalan, 1989), grouping efficacy (Kumar & Chandrasekharan, 1990), grouping capability index (Hsu, 1990), and quality index (QI) (Seifoddini & Djassemi, 1997) have been developed to evaluate the structure of the machine-part matrix. QI has been specifically developed to determine the suitability of a manufacturing system based on the structure of the machine-part matrix, the production volume of parts in the product mix, and the processing times of manufacturing operations. A simulation study by Seifoddini and Djassemi (1995) established the relationship between the values of QI and the performance of the corresponding cellular manufacturing system. This study indicates that low value of QI for the block diagonal form of the machine-part matrix is a warning signal for possible failure of the associated cellular manufacturing system, in terms of, its performance as compared to the corresponding job shop manufacturing system. On the other hand, a high value of QI is, generally, an indication of superior performance by the cellular manufacturing system. Therefore, QI, can be used as a preliminary screening mechanism for the selection of a manufacturing system for conversion to cellular manufacturing.

As mentioned earlier, the reliability of machines is an influential factor in the performance of a cellular manufacturing system. It is expected that both the QI value for the selection of a manufacturing system for cellular manufacturing and the performance of such a system is affected by the reliability level of manufacturing facilities. Previous studies of QI and its relation to the performance of cellular manufacturing systems have not considered the reliability factor.

In this paper, the performance of a manufacturing system under job shop and cellular manufacturing is evaluated at different QI levels subject to changes in the reliability of machines in manufacturing cells.

2. Definition of the problem

Reliability is one of the major factors affecting the performance of a manufacturing system. Not only delays due to the machine breakdowns impact the production rate, but the disturbances caused by these breakdowns lead to scheduling problems which decrease the productivity of the entire manufacturing operations. Due to the varying nature of production systems, the adverse effects of machine break downs are felt differently in different manufacturing situations. While, highly automated mass production systems are most sensitive to the reliability changes, job shop manufacturing systems are more flexible in dealing with machine failures (Flynn, 1989; Madu & Kuei, 1992; Miriyala & Viswandham, 1989).

Dedication of machines and part-families to manufacturing cells in cellular manufacturing while