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Implementation of an overall design of a flexible manufacturing system

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Abstract

In this study, an implementation of the design of an FMS is performed to calculate necessary number, utilization and sequence of workstations and plant layout for given production quantities of different parts, processing sequence and times. Analytical bottleneck model and rank order clustering techniques are used in the calculation and analysis of the system. Manufacturing cells are constituted for similar parts to simplify the analysis of the system and to efficient use of workstations. Results are compared with the conventional manufacturing conditions to determine the effectiveness of the implementation.

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Keywords: Flexible manufacturing; bottleneck model; workstation sequence; utilization; rank order clustering.

1. Introduction

Flexible Manufacturing Systems (FMS) are preferred in more and more establishments with each passing day because of their numerous advantages such as low amount of stock, high competitiveness, high product quality, low manufacturing lead time (MLT), quick response to customer demands, low labor cost, etc. since they have first conceptualized during the mid 1960s. FMSs are able to manufacture a wide variety of products with much higher productivity when compared with conventional atelier type manufacturing [1]. Flexible manufacturing (FM) can be defined as a computer controlled workstation and material handling system which enables processing and/or

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assembly of a wide variety of parts quickly with minimum workstation configuration periods and maximum workstation utilization. FMSs include the material transport system, the buffer, the workpiece warehouse, human resources and others besides the processing equipment [2, 3]. A typical FMS can process one or more part families continuously and simultaneously without human intervention and is flexible enough to suit changing market conditions and product types [4]. FMSs can easily and quickly be configured to manufacture new parts or products. On the other hand, there are some important parameters that have to be considered such as financial and technological factors, educational adequateness, maintenance and spare part potentials, industrial relations, rival companies, unemployment and government policies, etc. in passing to FM. The complex structure of FMSs and quick changes in customer demands require detailed analyses of manufacturing processes. In the literature there are plenty of studies about mathematical [1, 3, 5-11, 16-19] and simulation based [1, 2, 12-15, 20-24] analysis of FMSs.

Nomenclature

BS_i	number of busy servers at station i
f_{ijk}	frequency for operation k of part j at station i
m	number of different parts
n	number of different stations
n_{tr}	average number of transports
p_j	fraction of part j in total number of parts
r	number of different operations
R_{pi}	production rate of station i
R_p^*	maximum production rate
s_i	number of servers at station i
s^*	number of servers at bottleneck station
t_{ijk}	processing time for operation k of part j at station i
t_{tr}	average transport time between servers
U_i	average utilization of station i
U_s	overall utilization
WL_i	average workload of station i
WL_{tr}	average workload of transport system
WL^*	average workload of bottleneck station

2. Theoretical Background

Manufacturing processes have to be planned carefully to obtain high quality parts/products with low cost and high speed. Analysis of a manufacturing system is a complex work which consists of determination of necessary workstations, calculation of MLTs and utilization of workstations, grouping of parts/products according to their geometrical and/or processing similarities, constituting manufacturing cells for grouped parts/products, apportioning workstations into these cells and sequencing workstations in the cells. Analysis can be performed using physical, analytical and simulation based methods. In this problem, analytical method is used to calculate above mentioned parameters.

Analytical bottleneck model and rank order clustering techniques are used in the calculation and analysis of the system. Manufacturing cells are constituted for similar parts to simplify the analysis of the system and to efficient use of workstations. Sequence of workstations in each cell is determined using Hollier Wild technique to minimize transport of work-in-processes (WIP) and thus lowering MLTs and costs.

Bottleneck model is a simple and intuitive deterministic approach that can describe FMS performance mathematically [3]. The purpose of the analysis is to determine necessary number of server at each workstation to fulfil the production rates by calculating the workloads of all stations as follows;