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Design of Dynamic Cellular Manufacturing Systems

by

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A thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy on September 13, 2000.

Qualified on January 02, 2001

ABSTRACT

Existing approaches to the cell formation problem concentrate on simultaneous part family formation and machine sharing. A fundamental problem faced when part families and independent cells are desired is that two or more cells may share a machine type. Then, an integer assignment to each cell, subject to total machine availability constraints, leads to underutilisation or overloading of the important machines in the cells. Practical shopfloor conditions such as machine failures, fluctuations in part mix or demands may also make cells unstable. These methods do not use flow data. Hence, they cannot solve together the machine grouping, machine sharing, intracell layout, intercell layout and handling subproblems. Beyond the logical grouping of the resources, another important aspect of manufacturing system design is the physical placement of these resources on the shop floor, which defines the actual flow patterns of parts.

This dissertation addresses, for the first time, an analytical approach to the integrated problems of designing the dynamic cellular manufacturing (*DCM*) system layout concurrently with its material flow (handling) requirements, in such a manner that minimises the material handling within the system. The proposed strategy encourages the design of a dynamic layout to identify simultaneously the machine groups, economical machine distribution, and intracell and intercell layouts.

Thus the proposed mathematical models are based on network analysis and graph structures for flowline decomposition of machine groupings, and flowline layout design of dynamic cellular manufacturing cells. To minimise travel distances for forward, and backward material flow arcs, the derived model minimises total travel distances and machine duplications. Consequently, stages I and II of this research generates machine groups, identifies a flowline layout for each group, indicates which flowlines must be placed adjacent to each other to minimise intercell distances, and an approximate configuration of the aisles. Thus by capturing the directionality embedded in the operation sequences of a variety of parts produced, the associated facility floor area can be optimised. It is concluded that the classification of flow arcs used is effective for assessing whether material handling and layout, or machine sharing, is necessary to minimise intercell or intracell material travel distances respectively.

As a development from stages I and II, stages III and IV outlines the associated economics of machine

distribution and layouts of a dynamic cellular manufacturing facility. Furthermore, by employing simulated annealing *(SA)* algorithms the design (machine placement) of the shop layout for these dynamic cells can be optimised.

Illustrative case study material demonstrates that the sequential use of these proposed stages effectively integrates machine grouping and layout design requirements into dynamic cell configurations. It is established that these evolved dynamic cells have a superior utilisation of resources, when compared with equivalent classical cellular systems employing traditional design methods such as clustering analysis, operation sequence clustering and graph based layout techniques. In addition, parametric analyses of the proposed *SA* algorithm procedure shows an improvement in the cells responsiveness and effectiveness, with respect to the reported mean values of the material flow cost function. Furthermore, examples are utilised for both equal and unequal resource dimensions, with the average value of the material flow cost comparable with other methodologies. It should be appreciated however, that the *SA* algorithm was programmed in *MATLAB*, and has matrix and graphical interface outputs, which is again a further step forward in this research area.

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