Chapter XXXIV
A New Way to Reorganize a Productive Department in Cells

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ABSTRACT

The authors propose an algorithm for the reorganization of a production department in cells, starting from a situation of job shop, chasing the main goal of group technology (GT)—that is, to gather pieces with similar technological cycles and to associate every group of items (family) to a group of machines (cell) able to realize all the necessary activities. To get this result, a behavioral pattern has been developed, having its origin in the ants' way of sorting food, larva, and pupa in an anthill. As first results have shown, such an approach turns out to be interesting, provided that the algorithm parameters are adequately set.

GROUP TECHNOLOGY: AN OVERVIEW

Efficiency under every point of view is necessary for a company wanting to survive and thrive in today's competitive scenario. Among the various approaches that have been proposed to improve the efficiency in manufacturing, there is group technology (GT) (Callagher & Knight, 1973).

GT, which was born originally in Russia, can be defined as a manufacturing philosophy helping to manage diversity by identifying similarities in products and activities. It began exploiting these similarities on a single machine, allowing productivity to rise by 30-40%.

This concept was then widened to encompass more machines at the same time, and the new goal was to gather pieces with similar technological cycles and to associate every group of items (family) to a group of machines (cell) able to realize all the necessary activities (Optiz, 1970; Waghodekar & Sahu, 1984; Fazakerlay, 1974; Ham & Yoshida, 1985; Gallagher & Knight, 1986).

The cellular manufacturing system is a valid alternative to an organization based on process specialization, where in every department there are similar machines, able to realize only a part of the technological cycle. Long and uncertain throughput times are usually the major problems in the latter system. Other problems include an increase in inventory holding cost, untimely product delivery, and loss of sales (Cheng, Goh, & Lee, 2001).

It is widely agreed that GT is a management strategy which affects all areas of a company, like part design, production control, process planning, maintenance, and purchasing, and has a relevant impact on its productivity. The benefits of GT reorganization of manufacturing system, discussed by many authors (Burbidge, 1996; Sarker, 1996; Singh & Rajamani 1996), are the following:

- reduce material handling costs,
- reduce setup time,
- reduce throughput time
- improve delivery performances,
- reduce work-in-progress, and
- improve the quality level.

Nevertheless, Burbidge (1996) claims such advantages are not automatic. They are available, but action must be taken to achieve them.

When the variety and the need of its reduction does not concern only the products, but also the technological cycles, the cell formation problem, needing to be dealt with in order to achieve the above said objectives and concerning the identification of the family of parts and the group of machines on which these parts are to be processed, is very complex. These problems have been highlighted by Kusiak (1987), Nagi, Harhalakis, and Proth (1990), and Kusiak and Cho (1992).

If every end-item to produce had the same technological cycle, the management of the productive system would be rather simple: there would not be out-of-cell flows and the load could be well balanced, thus achieving superior performances. Unfortunately the real world is not so simple, and the problem of reorganizing in cells a productive department of average dimensions is notably complex (Selim, Askin, & Vakharia, 1998). For example there are more than 10^{15} ways to reorganize 15 machines and 45 end items in three cells of 5 machines and 15 end-items each, and the number is bound to explode if the number of machines and items in each cell is free to change.

A high number of GT approaches have been developed to decompose a large manufacturing system into smaller, manageable systems based on similarities in design attributes and manufacturing features.

Classifications of methods of cell formation have been proposed by several researchers. A possible classification is based on the type of solution methodology (Singh & Rajamani, 1996; Selim et al., 1998):

- classification approach using coding systems (hierarchical clustering algorithm, P-median model, multi-objective clustering);
- part-machine group analysis methods (rank order clustering—ROC, ROC2, modified ROC, direct clustering algorithm, cluster identification algorithm);
- algorithms based on similarity coefficients (single linkage clustering, complete linkage clustering, and linear cell clustering);
- mathematical models (quadratic programming, graph theoretic, nonlinear programming models); and
- techniques dealing with combinatorial optimization problems (genetic algorithms, artificial neural networks, adaptive fuzzy systems).

Other classifications can be based on the following dimensions (Singh & Rajamani, 1996):

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