Abstract

Increasing global competition and changing customer needs are forcing the manufacturers to improve the efficiency, flexibility, and productivity of their production activities with minimum incremental investment of time and capital. Cellular manufacturing (CM), which is an application of group technology principles to production, has been recognized as a promising alternative to the traditional manufacturing systems, such as job shops and flow lines, in meeting the requirements of competitive markets currently prevailing world-wide. The research work reported in this thesis has been carried out to address a few design- and implementation-related critical issues in CM. Specifically, the research has been directed towards (i) assessing the status and scope of CM in Indian manufacturing companies, (ii) development of an appropriate methodology for evaluation of cell formation methods, and (ii) development of an efficient multi-objective cell formation (MOCF) method that can be applied in a real-life situation.

Despite the extensive research carried out in the area of CM, it has not yet been very well adopted in developing countries like India. An attempt has been made in this thesis, through a questionnaire survey conducted among Indian manufacturing companies, to assess the present status and scope of CM implementation, and the factors responsible for its success or failure. In this survey, the first of its kind in India, opinions from both CM implementers and non-implementers, from across the country, have been sought. Several issues such as motivation/reasons for establishing/not establishing cells, difficulties faced in early stages of implementation, procedures used for forming cells, extent of cellularization, labour-related issues, and benefits obtained from implementation have been addressed. A

detailed statistical analysis of the survey responses is presented indicating usefulness of the survey results to the companies contemplating implementation of CM in near future.

The first step in the design of cellular manufacturing systems (CMS) is cell formation (CF) that deals with the identification of family of parts, and the groups of machines on which these parts are to be processed. The cell formation problem in cellular manufacturing has been addressed by a large number of researchers, and several CF methods, capable of addressing a number of different aspects, have been developed over the years. Selection of an appropriate CF method, from among the available ones, requires a methodology that simultaneously considers multiple factors, such as grouping effectiveness, computational ease, and several other production-related factors. In this thesis, an Analytic Hierarchic Process (AHP)-based framework for evaluation of the cell formation techniques is proposed. The framework is explained with the help of an illustrative example wherein five widely used CF techniques have been evaluated and ranked.

Although the real CF problem is a multi-objective one, prior to 1990s, the majority of the formulations of CF problems had been based on achieving a single objective. Realizing their inadequacy in addressing many real-life issues, the research focus has shifted to multi-objective cell formation (MOCF), and the design of manufacturing cells considering multiple objectives has become a relevant research topic. In this thesis, an improved MOCF method, called CFPGA (Cell Formation using Pareto-based Genetic Algorithm) that incorporates three important objectives pertinent to cell formation, and which does not require the cell designer to specify weights or priorities for these objectives *a priori,* is developed. The method results

in a set of non-dominated solutions from which cell designers can choose the cellular configuration that best suits their requirements. For selecting an appropriate solution from amongst the non-dominated solutions, a scheme, based on the normalization of various objective function values, is also suggested. Solutions of some published problems with CFPGA indicate that the proposed algorithm is a better alternative to the existing MOCF methods, and can be effectively used for cell formation in a multi-criteria environment.

Whereas the problems encountered in the real-life manufacturing systems are usually quite large in size, the majority of the existing CF methods have been tested on problems with small size data sets. There is a need to test the applicability of any proposed algorithm for the solution of CF problem with real-life case data. In view of this, any proposed cell formation method needs to be verified and validated with data from a real-life case. The verification and validation of the proposed CFPGA method, with data set from a representative manufacturing plant, ascertains its application potential in real-world situation.

Key words: *Cellular Manufacturing, Group Technology, Cell Formation, Grouping Efficiency, Evaluation, Analytic Hierarchic Process, Multi-objective Cell Formation, Genetic Algorithm, Pareto-optimality, Non-dominated Solutions..*