CHAPTER 9

CONCLUSIONS AND FUTURE SCOPE OF THE WORK

9.1 INTRODUCTION

Cell formation is one of the most important steps in the implementation of the concept of GT in manufacturing, which is often known as cellular manufacturing systems. It is a long-term decision making problem and is combinatorial in nature. Several researchers have addressed this problem for the past three decades by manipulating the original work of Burbidge's production flow analysis. Several analytical and heuristic methods have been proposed by considering different objectives. Most of these objectives/presumptions are under dispute according to many empirical studies.

In almost all the reviews in the past, researchers have identified and listed several areas that require further investigation. From the literature survey it is found that there is a wide gap between academic research and industry practices. A flood of methods has been proposed for the design of CMS and they are associated with many limitations that made implementation more difficult. This is mainly due to the combinatorial nature of the problem and further it is problem specific. This aspect of the problem poses a challenging exercise for both academicians and practitioners. At this juncture, it is felt that the researchers should make use of the current practices while developing cells. The current study is an effort in this direction. CMS cell design problem is addressed by developing a new performance measure called, "Product
Ownership (POW)". based on the concept of owning vs sharing of resources. Other related issues are also addressed by developing suitable mathematical models and solution methodologies. The conclusions are presented below.

9.2 APPLICATION OF PRODUCT OWNERSHIP AS A PERFORMANCE MEASURE

From the literature review (Chapter 2), it is found that very limited work has been done using, industrial practices, the concept of manufacturing focus. This study addresses the aspect of manufacturing focus in CMS cell design by developing a suitable performance measure. In the first phase of the study, a new performance measure called "Product Ownership (POW)" for cell formation is proposed. This measure of performance is developed based on the concept of owning vs sharing of resources that is being used in the industries where CMS is implemented. This measure has been used as a surrogate for manufacturing focus, which is an important issue in focused manufacturing.

A suitable mathematical model with the proposed measure has been developed considering product-component-machine-time (PCMT) relationship in the form of interval data as well as binary data. Consideration of this type of input data with three dimensions (product-component-machine) is a deviation from the traditional cell formation methods. In view of the model complexity, a combinatorial optimisation technique, SA based heuristic is developed and employed to solve three industrial case problems with variable characteristics. The proposed method identifies cells such that each product's ownership is maximised. The algorithm is easy to implement.
This study is the first of its kind in the CMS literature. It demonstrates the successful application of SA algorithm to the cell formation problem using POW as a performance measure. The algorithm can be used to solve large size problems with higher capacity computers.

It is found that there is a need for high level of resource duplication to have acceptable levels of dedication at cell level and hence, maximum POW. In view of economic infeasibility, as an alternative to focused system, a system with a combination of regular cells and remainder cell is suggested. In CMS literature, system with combination of regular cells and a remainder cell is known as fractional cell formation. In fractional cell formation, parts are allowed to undergo operations in assigned GT cell and in remainder cell but not other GT cells. This will ensure better planning and control of activities across minimum number of cells. This issue has also been addressed in this study.

9.3 DESIGN OF CMS WITH REMAINDER CELL USING BINARY AND ORDINAL LEVEL DATA

Design of CMS with combination of regular cells and remainder cell is addressed. A mathematical model with the objective minimisation of weighted sum of inter cell and remainder cell moves is developed. In view of the model complexity, a hybrid heuristic is developed. The proposed hybrid heuristic is capable of identifying pure block diagonal structure (if exists), otherwise identify a system with combination of regular cells and a remainder cell. In this type of CMS, regular cell can interact with remainder cell but not with other regular cells. The proposed heuristic is modified to handle different types of input data.
The proposed hybrid heuristic is based on the principles of both SA and GA. A pool of feasible solutions is generated using a representation scheme similar to GA chromosomal representation. The pool of feasible solutions is improved using the concepts of both SA and GA. Three perturbation schemes (interchange, transfer and create) are used. From the neighbourhood solutions a non-inferior solution is taken into the pool in the place of current solution. During the perturbation procedure constant pool size is maintained. It does not require number of cells as a priori unlike in the conventional methods. It can offer a collection of satisfactory solutions and facilitate the decision-maker's choice. The heuristic is tested using 23 different data sets consisting of 172 problems. The data sets represent both small and large size problems in the form of binary and ordinal level data from literature. The proposed heuristic is employed to form cells by varying cell size constraints and by varying the weights in the objective function. The results obtained for the test problems are either equal (51.83% cases) or superior (48.17% cases). Statistical comparison showed that the results obtained are significantly better than the existing results.

The proposed heuristic is very flexible and can handle input data with varying face value. The performance of the proposed hybrid heuristic is evaluated using ordinal level data. Totally eleven different data sets resulting in 63 problems is tested using existing results. It is found that the proposed algorithm produces equal solution in 49 and superior solution in 10 cases and inferior solution in four cases which is within 2% from the optimal solutions. The performance of the heuristic is found to be superior than that of the existing algorithms (Boctor 1991, Sofianopoulou 1997, Srinivasan and Zimmers 1998 and Srinivasan 2000).
9.4 DESIGN OF CMS USING ALTERNATE PROCESS PLANS FOR PARTS AND MULTIPLE COPIES OF MACHINE TYPE

Literature review reveals that most of the researchers have addressed the cell design problem using binary data followed by interval and ordinal level data. Further, very few have addressed the issue of cell formation using multiple input information simultaneously. With the potential of combinatorial optimisation algorithms, it is convenient to consider the cell formation problem with higher face value input information, which is of practical importance. The hybrid heuristic described in section 5.5 is suitably modified to handle different type of input data with appropriate weights in the objective function. Usually, process plan is selected prior to cell formation among alternate process plans using suitable models. Whereas in this study, all possible process plans are considered simultaneously and cells are formed, thereby process plan is selected.

The modified hybrid heuristic is tested with data sets that are both well and ill structured. The data consists of unique process plan and single copy of each machine type along with alternate process plans for parts and unique copy of machine type and vice versa. Also input data with both alternate process plans and multiple copies of machine type is addressed with objective minimisation of inter cell and remainder cell moves with differential weights. The results obtained are encouraging and the method is capable of selecting suitable process plan while forming cells by storing all possible process plans. In summary, the proposed modified hybrid heuristic is a promising tool that can gainfully be used for the development of practical cell design problems with multiple input information simultaneously.
9.5 CONTRIBUTIONS OF THE RESEARCH STUDY

The following are some of the major contributions of the current study.

1) Various issues that affect cell design for implementation of GT concept in manufacturing have been identified by means of a comprehensive review of literature.

2) A new performance measure called "Product Ownership (POW)" has been developed which could be used directly for cell formation. It is based on the concept of owning vs sharing of resources that is being practiced by the organisations where CMS is implemented.

3) A mathematical model for cell formation with the objective of maximising POW with relevant constraints has been developed. In view of the model complexity, a simulated annealing (SA) based algorithm has been developed. This is implemented using real life data from three organisations. This is a pioneering work in this area.

4) Fractional cell formation problem has been modeled with differential weights and a hybrid heuristic is proposed to obtain solution. This can handle both binary and ordinal level data. The performance of this model has been evaluated and found that the heuristic out performed.
The proposed hybrid heuristic has been modified to handle data like well structured and ill structured matrices, operation sequence data with multiple copies of machine type, alternate process plan for parts and/or multiple copies of machine type. This modified heuristic has been tested with standard problems from the literature and found that the results are encouraging. It is to be noted that this type of work is not reported by many researchers.

9.6 FUTURE SCOPE OF THE WORK

The current study is a significant departure from many of the existing approaches. The proposed study presents a new performance measure to form cells using product-component-machine relationship explicitly. The study also addresses the practical objectives in the formation of cells with variable input data. However, it is possible to extend the current work in the following areas.

a) The mathematical model based on “Product Ownership (POW)” (Chapter 3), can be extended by including cost factors such as cost of resources, subcontracting cost, MH cost and machine duplication cost and other relevant costs. This algorithm with other performance measures could be evaluated.

b) Quantification of net benefits of focus and suitability of proposed performance measure to consider as a more suitable surrogate measure along with other important business constraints (Chapter 3) can be studied.
c) Cell formation problem (Chapter 3) can be formulated as a multi-objective model using factors that reflect manufacturing focus from internal and external environment point of view and suitable heuristics can be developed based on the concept of Neural networks and AI.

d) Design of CMS with combination of regular cells and a remainder cell (Chapter 5) can be modeled as a multi-objective model and combinatorial optimisation algorithms based on Neural networks can be tried.

e) Layout of cells and intra cell layout issues can be integrated with the cell design process (Chapter 3, 5 and 8) and suitable models can be developed.