A MACHINE GROUPING MODEL USING GENETIC ALGORITHM

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ABSTRACT

Group Technology principles leads to Cellular Manufacturing and it is suitable for producing small to medium batch sizes and a variety of products can be made in such a system. A model is proposed here for the design of cellular manufacturing systems with the machine part incidence matrix (MPIM) the input. The problem is a bi-objective model to minimize the number of exceptional elements and Heterogeneity of cells. The model uses a Genetic Algorithm based solution method for finding the optimum solution. Here a model is designed with the two conflicting objectives which lead to many solutions to the model. A separate heuristic is applied for part family formation. The new model is experimented with some problems which provide good results

Keyword : - *Cellular Group technology manufacturing systems, Genetic algorithm, Bi-objective model, Heterogeneity*

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1. INTRODUCTION

In today's competitive environment, Industries will try to achieve their existence by adopting many new strategies. Achieving maximum profit is always the motive of such companies. Hence Cellular Manufacturing (CM), a facilities planning method is adopted by industries after the Second World War and is one of the best methods for gaining maximum efficiency in an organization based on similarities of parts and manufacturing. Several models were developed in CMS for achieving the objectives. CM is a method that tries to manufacture a variety of parts with an aim to achieve an efficiency of a mass production system in a batch production environment. Grouping similar parts into families and the concerned machines into required cells makes the companies the required flexibility in manufacturing and satisfying customers. Cellular manufacturing system (CMS) combines the benefits of both product layout and functional layout. It has many advantages like reduced cycle time compared to functional layout, and better flexibility and superior job satisfaction when compared to functional layout. The proposed model is a bi objective model in the design of CMS

2. LITERATURE REVIEW

The group technology (GT) principles of manufacturing were first presented by Flanders in 1925 and Mitrofonov developed it as certain scientific principles of GT in 1959. Then Burbidge in 1960 proposed a systematic planning approach in this area called production flow analysis (PFA). Then grouping of machines and formation of art families become an area of research to improve the manufacturing efficiency. . Many of the CMS design models uses machine part incidence matrix(MPIM) [1] as the primary data for forming part families and machine groups and the aim everyone is to get an output matrix with a good block diagonal form.

These methods of CMS design can be categorized as such as (i) array-manipulation procedures [2], (ii) hierarchical clustering[[3], (iii) non hierarchical clustering[[4], (iv) mathematical models, [5] (v) heuristic based techniques [6]and other approaches. Generally, machine part incidence matrix is the input for these models. The objective of the CMS design is to get an output matrix with a maximum block diagonalisation.

The most earlier models were by Mc Cormic [7], King 1980 [2], Goncalves and Resende [1], Tarique et al. 2009 [6], Shiyas and pillai 2014 [5] are using MPIM as the input. Many models were also developed in this area considering attributes like sequence of operation by, Park an Suresh [8], dynamic demand and machine capacity by Wicks and Reasor [9], Pillai and Subbarao [10], and machine failures by Shang and Tadikamalla [11], Nair and Narendran [12]etc.

The concept of heterogeneity in operations assigned in a cell was used for modelling of dedicated cells [14] Heterogeneity of machines is a similar concept in which it is concerned with the machine types necessary for the processing of parts visit a cell [14]. It is similar to the. Here every part visiting a cell contributes to the heterogeneity in a cell. The heterogeneity caused by a part visiting a cell is the number of machine types present in a cell which are not necessary for the part to process. The heterogeneity of all cells formed is one of the objectives, which is required to be minimized in this model. The other objective of this model is to minimize the exceptional elements.

3. THE PROPOSED MODEL

The new bi-objective linear zero-one integer programming model has the objective function as the minimization of exceptional elements and heterogeneity of machines with weights assigned to each objectives for the given machine part incidence matrix. The model is bi-objective in nature since they are opposing each other. The model is described below.

Minimize $(\gamma)\, EE + (1-\gamma)\, Hm$

Where

EE= Number of exceptional elements in the system

Hm= Heterogeneity of machines in the system.

In this model, based on the value assigned to γ different optimum solutions will be obtained

4. GENETIC ALGORITHM

Genetic Algorithm (GA) is an evolutionary search methods that will provide optimal or near optimal solutions for the np hard problems. GA searches the solution space by identifying a population of feasible solutions in order to find optimal or near-optimal solutions. Compared to heuristic methods it has a fast convergence, Here a solution algorithm is developed based on GA

In this algorithm integer numbers are used to represent a chromosome representing a solution
Here in chromosome each gene represents a machine cell number and the position of a gene represents a machine type number. The length of a chromosome is equal to the number of machine types considered. For example, a chromosome '312332' represents a three cell solution with the following machines in each cell:

Cell 1: Machines 2
Cell 2: Machines 3, 6
Cell 3: Machines 1, 4 and 5

Here we use reproduction using stochastic sampling without replacement, two point crossover and bitwise mutation [14}. The algorithm terminates based on maximum generation rule.

Part assignment heuristic: Assign part to cells where it has maximum number of operations

The algorithm is as given below

The algorithm for determining manufacturing cells and grouping of parts is given below. GA is used to generate solution for the and the part assignment heuristic to develop part families

Step 1: Input the machine part incidence matrix, the GA parameters for the model, and γ value.
Step 2: Initialize the population randomly.
Step 3: Calculate objective function value for each chromosome and convert it into fitness value.
Step 4: Reproduction based on remainder stochastic sampling without replacement policy.
Step 5: two-point crossover
Step 6: Mutation is carried out.
Step 7: Evaluate the present generation.
Step 8: Go to step 9 if the termination criteria is met, else go to step 4
Step 9. Check for termination
Step 10: Select chromosome with best fitness.
Step 11: Assigning of parts to the cells to cells according to part assignment heuristic.

5. RESULTS AND DISCUSSIONS

The algorithm is experimented with a standard problem taken from the literature and the results are analysed. For a value of one for the parameter γ, only exceptional elements moves are considered for the design of CMS based on the model. The solution obtained for this γ value is a single cell which contains all machines and with no exceptional elements. This solution remain optimum for values nearer to and less than one and then the model will try to establish more than one cell. This is continued with less values for γ until a new solution is obtained. Hence if we decrease γ different solutions can be obtained. A value of γ close to zero means the importance for the exceptional elements is less and priority for the reduction of heterogeneity in the cells. Then it will result in a cell where the configuration has cells which are exclusively assigned to each machine.
Illustrative example

- Population size =4 times the length of chromosome
- Maximum generations = 10000;
- Probability of crossover = 0.85
- Probability of mutation = 0.05

Illustrative example is a situation where the model can give perfect solution where algorithm given without any intercell moves and voids. The input and output are given in Table1 and Table 2 respectively for a particular value of γ and gives the ideal solution. The results shows the model is performing as expected. For all values of γ the optimal solution is expected

Table 1: Input

		Parts								
Machine		1	2	3	4	5	6	7	8	9
	1	0	0	0	0	0	1	0	0	0
	2	0	0	0	1	0	0	1	0	0
	3	0	0	0	0	0	0	0	1	1
	4	1	1	1	0	1	0	0	0	0
	5	0	0	0	1	0	0	0	0	0
	6	1	1	1	0	1	0	1	0	0
	7	1	1	1	0	1	0	0	0	0

Table 2: Output

		Parts								
Machines		6	4	7	8	9	1	2	3	5
	1	1	0	0	0	0	0	0	0	0
	2	0	1	1	0	0	0	0	0	0
	5	0	1	1	0	0	0	0	0	0
	3	0	0	0	1	1	0	0	0	0
	4	0	0	0	0	0	1	1	1	1
	6	0	0	0	0	0	1	1	1	1

	7	0	0	0	0	0	1	1	1	1

6. CONCLUSION

A new model has been developed for machine cell and part family formation with machine part incidence matrix as the primary input. The solution methodology is based on based on GA. The model considers two conflicting objectives, namely, number of exceptional elements and heterogeneity of machines in the system. The magnitude of the two objective function values is controlled using a weighting factor, γ. By changing the value of this factor, it is possible to generate alternative machine groups in a structured manner. The model is experimented with some standard problems and is providing good results

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