Decision Support Systems In Cell Manufacturing

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Abstract

The emergence of Cellular Manufacturing Systems has resulted in significant productivity improvement in manufacturing systems. The Cellular Manufacturing System has received wide attention and is well documented in the literature. This study demonstrates the use of Decision Support Systems (DSS) to cellular manufacturing.

1. Introduction

Group Technology (GT) has emerged as an important scientific philosophy in improving the productivity of manufacturing systems. GT philosophy offers a systems approach to the reorganization of traditional complex job shop and flow shop manufacturing systems into cellular or flexible manufacturing systems. The main objective of this philosophy is to achieve benefits for manufacturing systems. These benefits include: (1) simplifying the flow of parts and tools, (2) reduction in set-up times, (3) reductions in average material handling time, (4) reductions in work-in-process, and (5) reductions in throughput time. The benefits of implementing the GT manufacturing philosophy have been discussed extensively in the literature [1]. There have been several approaches proposed for manufacturing cell formation in GT. A comprehensive review and discussion on different approaches in machine-part families formation in GT can be found in Offodile et al. [2], Singh [3], and Miltenburg and Zhang [4]. They provide concise reviews of the usefulness and limitations of existing methods for machine-part families formations in GT. The production-based approach, due to Burbidge [5, 6] is one of the earlier solutions to the group technology problem. The purpose of this approach is to group parts that share common processing requirements. It utilizes machine-part incidence matrices (Fig. 1) consisting of binary (0,1) identifier used to record the routing manufacturing sequence and processing for part and machine components. A machine-part incidence matrix is rearranged to identify machine cells and part families (Fig. 2). The matrix consists of binary entries of zero or one, where an entry "1" indicates that machine i is used to process part j. Whereas, an entry "0" indicates that machine i is not used to process part j. Rearranging rows and columns in Figure I results in Fig. 2 (a more structured form). In Fig. 2, two machine cells and two part families are formed. Machine cell one (MC-1) consists of machines 2 and 4. Machine cell two (MC-2) consists of machines 1 and 3. Whereas, part family one (PF-1) consists of parts 1 and 3 and part family two (PF-2) consists of parts 2, 4, and 5. The process of rearrangement to achieve machine-part families is difficult and sometimes subjective.

Machines \ Parts	1	2	3	4	5
1		1		1	1
2	1		1		
3		1		1	
4	1		1		

Fig. 1: Machine Part Incidence Matrix

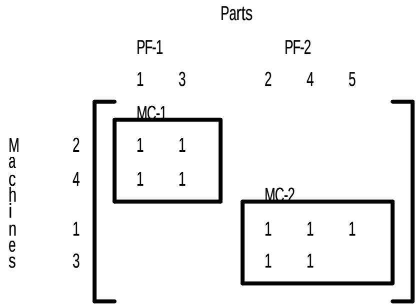

Fig. 2: Structured Machine Part Incidence Matrix

To alleviate rearrangement problems, systematic approaches have been developed to identify machine-part families. One of the most widely used methods is known as the similarity coefficient method (SCM). Compared to other methods, SCM enjoys the greatest research following due to its simplicity, flexibility and the fact that it can lends itself to computer implementations [7, 8]. When SCM is employed, the problems of improper machine assignment and machine chaining may occur. These problems were investigated and discussed by Seifoddini [8] and Chow et al. [9]. Seifoddini [8] investigated the problem of intercellular movements due to improper machine assignments. Seifoddini recommended the use of average linkage clustering method (ALC) since it may reduce the chance of an improper machine assignment. In GT, when dealing with SCM, one will have to re-arrange part components from the machine-part incidence matrix in order to form the part-families. The SCM provides the formation of machine families not the part families' counterpart. The present paper presents the concept of applying Decision Support Systems (DSS) to machine cell and part family formation. The DSS will provide systematic guidance to form machine cells and part families in cell manufacturing.

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2. Problem Formulation

In GT, when dealing with SCM one will have to re-arrange part components from the machine-part incidence matrix in order to form the part-families. The formation of part-families is based on the part-components that involved the largest processing requirement. The resulting 'eye-ball' method of assignments is very subjective, especially when dealing with a large M x N machine-part incidence matrix. Further, it may result in an improper part-components assignment into part-families. The improper part-component assignment may produce bottleneck parts and often generate unnecessary intercellular movements.

The Decision Support Systems was coded by adopting Seifoddini's [8] method machine cells formation and Ang's [10] method of part families formation. Seifoddini's method of machine cell formation measures all pairwise similarity coefficients between machines. Seifoddini's defined "the similarity coefficient between two machines as the number of components visiting both machines divided by the sum of the number of components visiting both machines and the number of components visiting one or the other machines but not both." Ang's algorithm [10] of part families formation works by first identifying all parts operated on by any machine in a given machine-cell. The algorithm then classifies each part by the number of operations performed on that part by machines within the group under consideration and number of operations performed on that part by machines within the group under consideration and number of operations performed by machines outside the group. By including any part in the first group's part family when within group operations exceed outside group operations, inter machine-cell operations will be kept to a minimum. For simplicity, ties are awarded to the machine group under consideration. The Decision Support Systems is coded in C++ programming language and capable of guiding the user to cluster machine cells and part families.

3. The Decision Support Systems

To illustrate the application of the DSS, consider the following example in Fig. 3. When the DSS is executed, the Main Menu is shown such as in Fig. 4.

Parts

Machines	1	2	3	4	5	6	7
1	1			1	1		
2	1	1	1				1
3	1			1			
4				1			
5			1		1	1	

Fig.3 Five Machines Seven Parts

Welcome To Cellular Manufacturing Cell Formation

Main Menu

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1. **Machine-Part Incidence Matrix Data Entry**
2. **Manufacturing Cell Formation**
3. **Exit**

Enter Selection (1/2/3):

Fig. 4 The Main Menu

The user must select entry 1 from the Main Menu (Fig. 4) to enter data in Fig. 3. After entering selection 1, the following screen is shown.

Enter or Retrieve Machine-Part Incidence Matrix (E/R):

The DSS will allow the user to retrieve (enter R) the data that previously entered which is stored on the disk or hard disk. The user can also enter E to enter data. The user will now enter E in order to input the machine-part incidence data such as shown in Fig. 3. The computer will prompt the user with the following questions:

Enter number of Machines: 5 Enter number of Parts: 7

The user must now enter the number of machines and parts to be used. For example, in Fig. 3, 5 machines and 7 parts are entered. Once the numbers are entered, the DSS will display the machine-part incidence matrix for the user to input the processing operation sequences such as in Fig. 5. (enter 1 or blank). After inputting the data, the DSS will go back to the Main Menu as shown in Fig. 4.

Machines \ Parts	1	2	3	4	5	6	7
1	1			1	1		
2	1	1	1				1
3	1			1			
4				1			
5			1		1	1	

Fig. 5 Data Entry Matrix

The user can now begin to execute Menu Selection 2 in the following Main Menu (Fig. 4).

Welcome To Cellular Manufacturing Cell Formation

Main Menu

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1. **Machine-Part Incidence Matrix Data Entry**
2. **Manufacturing Cell Formation**
3. **Exit**

Enter Selection (1/2/3):

Table 1 will appear, inform the user in a table as the number of similarity levels and the number of machine cells that were formed.

Table 1: Numbers of SL and Machine-Cells

Similarity Level (SL)	No. of machine-cells
1.00	5
0.67	4
0.42	3
0.17	2
0.09	1

The DSS will provide the user of next screen (Table 2) that shows the number of machine cells and machine members in each cell at the different similarity levels.

Table 2: The Number of Machine Cells and Machine Members

1. SL 1.00	There are 5 machine cell(s):	Machine member(s):
	Machine cell 1	3
	Machine cell 2	1
	Machine cell 3	4
	Machine cell 4	2
	Machine cell 5	5
2. SL 0.67	There are 5 machine cell(s):	Machine member(s):
	Machine cell 1	3 1
	Machine cell 2	4
	Machine cell 3	2
	Machine cell 4	5
3. SL 0.42	There are 5 machine cell(s):	Machine member(s):
	Machine cell 1	3 1 4
	Machine cell 2	2
	Machine cell 3	5
4. SL 0.17	There are 5 machine cell(s):	Machine member(s):
	Machine cell 1	3 1 4
	Machine cell 2	2 5
5. SL 0.09	There are 5 machine cell(s):	Machine member(s):
	Machine cell 1	3 1 4 2 5

At this point, the user will be asked to select the desired similarity level. The user may enter any similarity level.

Please enter similarity level.
Similarity Level: 0.17

If a level of 0.17 is entered, 2 machine cells and 2 part families are formed as indicated in Table 2. The final machine-part incidence matrix (Fig. 6), including machine-part families and their members that formed, are presented to the user as follow:

Machines \ Parts	01	04	05	02	03	06	07
1	1	1	1				
3	1	1					
4		1					
2	1			1	1		1
5			1		1	1	

Part family	Part membe
No. 1:	1, 4, 5;
No. 2:	2, 3, 6, 7;

Machine cell	Cell membe
No. 1:	1, 3, 4;
No. 2:	2, 5;

Fig. 6 The Final Machine-Part Incidence Matrix

4. Conclusions

Machine-cell and part-family grouping problem are critical element of the cellular manufacturing system. The DSS developed in the present paper has concentrated on forming machine cells and parts families. The DSS is intuitively appealing and can be used with step by step in handling of large complex machine-part incidence matrix. In addition, the advantage of having such DSS is that with a convenient means of forming machine cells and parts families, the industrial practitioner can devote more time to studying the efficiency of alternative ways of forming machine groups or devising efficient ways of handling bottleneck-parts that create inter cellular movements.

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