New method of reorganization machines on a group technology to improve their performances

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Abstract: Group technology represents an important technique in the planning of manufacture that allows the advantages of flow production organization to be obtained.
Production flow analysis is a method of group technology, developed by Burbidge that is relatively simple to be implemented and can be applied to the reorganization of existing and new manufacturing systems. This paper presents the existing methods as well as new methods relevant in problems of machine-component group, in order to improve the global performance of entire manufacturing system.

Keywords: group technology, machine-component grouping, production flow analysis, rank order clustering algorithm, similarity coefficients, binary weights, decimal equivalent, bottleneck machines

I. INTRODUCTION

Group technology is an important technique in the planning of manufacture that allows the advantages of flow production organization to be obtained in what otherwise would be jobbing or batch manufacture. The approach is to arrange separate machine groups with appropriate internal group layout to suit the production of specific component families, formed in accordance with the similarity of operations that are to be performed on them.
Production flow analysis is one such method of group technology, developed by Burbidge, which has particular appeal in that it requires no special part coding system, is relatively simple to implement and can be applied to the reorganization of existing, as well as the design of new manufacturing systems. The method involves a number of stages, which are discussed in more detail elsewhere by Burbidge (1975), but may briefly be described as follows. A large scale application of production flow analysis is also described by Schofield and Masey (1974).

II. METHODS OF FLOW ANALYSIS

The two most widely used method of sorting components into groups are Component Coding and Classification (CCC) and Production Flow Analysis (PFA).

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CCC looks at similarities in the geometry of the component but ignores the method of manufacture and the existing component flow. PFA was chosen since the routing information was readily available and it avoided the problem of encoding a large number
of components with a large number of features. PFA charts the flow of the components in a machine/component matrix which shows which parts visit which machine see Fig.1.

Component

M/C		1	2	3	4	5	6
	A	X				X	
	B		X	X	X	X	X
	C		X			X	
	D		X				X
	E			X			

Fig.1 Machine/component matrix in flow of the components.

The rows and columns are interchanged to form blocks along the diagonal (Fig.2).

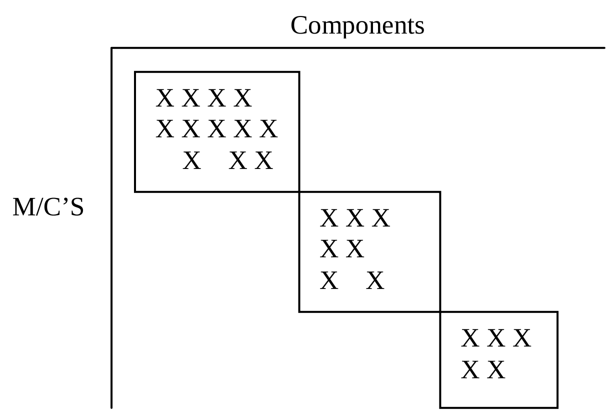

Fig.2 Cells arranged in a blocks.

The blocks shown in Fig.2 represent cells. Each block represents a mutually exclusive machine/ component group. With a large number of machines and components, manual sorting is not practical. There are several methods of processing the matrix mathematically that can produce a solution more quickly than manual trial and error. The two main methods are cluster analysis and rank order clustering.

In cluster analysis, the similarity between pairs of parts or machines is calculated. Grouping is then based on those parts or machines that have the highest similarity index. The method was not used because of the computational complexity; however, a paper has since been published on "Commonality Analysis" which is claimed to be fast, simple and quite flexible. The second main method is rank order clustering (ROC) that interprets the rows and columns as binary numbers and sorts them into ascending order. This was the chosen method for clustering.

III. RANK ORDER CLUSTERING

The ROC technique was tried first manually and later using a computer. The rows and columns are read as a binary word and then arranged in order of decreasing value. Many iterations may be required. The process rearranges the randomly ordered matrix into one containing discrete blocks along the diagonal, known as block diagonal form. The process is illustrated in Fig.3

.

1) Ranking rows

	Components								Binary	Decimal	Rank
		t	u	v	w	x	y	z	value	value	
Machines	a		1		1	1	1		0101110	46	4
	b	1		1					1010000	80	2
	c	1		1				1	1010001	81	1
	d		1		1		1		0101010	42	5
	e	1						1	1000001	65	3

2) Rows after reordering

	Components								Binary	Decimal	Rank
		t	u	v	w	x	y	z	value	value	
Machines	c	1		1				1	1010001	81	1
	b	1		1					1010000	80	2
	e	1						1	1000001	65	3
	a		1		1	1	1		0101110	46	4
	d		1		1		1		0101010	42	5

3) Column ranking

	Components							
		t	u	v	w	x	y	z
Machines	c	1		1				1
	b	1		1				
	e	1						1
	a		1		1	1	1	
	d		1		1		1	
	Rank	1	4	2	4	7	4	3

4) Columns after reordering

	Components							
		t	v	z	u	w	y	x
Machines	c	1	1	1				
	b	1	1					
	e	1		1				
	a				1	1	1	1
	d				1	1	1	
	Rank	1	2	3	4	4	4	7

Fig.3 ROC technique as block diagonal form.

Research and the first attempts of using this method have shown that ROC suffers from two major drawbacks:

1) The last iterative solution is not always the best;

2) Changing the initial order of the data representation affects the final outcome even though the actual data remain the same. The result of this is that well structured data may not result in block diagonal form.

Modified rank order clustering was developed to overcome these limitations and provide a better result. The procedure is as follows:

1) Use the ROC algorithm and perform two iterations on the rows and columns of the matrix;

2) Identify a block of 1's in the top left corner;

3) Store this component family and machine cell;

4) Slice away columns corresponding to block;

5) Returns to step 1 until all columns are grouped;

6) Generate similarity lower triangular matrix;

7) Locate highest and join cells;

8) Join the corresponding component families;

9) Update the lower triangular matrix;

10) Return to step 7 until only one group remains.

This method still has its drawbacks, however, and certain modifications are required. Dominant machines, i.e. those that the majority of components go through, affect the solution. These machines need to be excluded from the analysis. Inexpensive machines can also be excluded since their duplication would be a small price to pay for improved component flow. Also step 6 to 10 require lengthy calculations in order to achieve a result. There are two options. The first is to reduce each block identified into a single column and repeat the ROC algorithm gradually combining the columns (or "cells") until only one remains. The results are then analysed to determine the best number of cells. The second method is to examine the whole matrix arranged in block form and to identify cells heuristically. This second method was the one used to identify cells after the first proved fruitless.

The ROC method still suffered from drawbacks which were not overcome, namely the order that the components were machined and whether a component went to a particular machine more than once.

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