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Implementation of Cellular Manufacturing in Pump Industry

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Abstract

Time is precious than anything. This work is done for an efficient time management in industry. Today's competitive world, the industries face to manufacture variety of products within short span of time. Now a day's cellular manufacturing plays a major role in batch production and to increase product accuracy in industries. It takes more time to form a cell manually. In this work cell formation is done through automation. The aim of automation is the elimination of manual cell formation and reduction of time. Earlier through Rank Order Clustering, matrix formation and cell formation are done manually; it took more time for forming a cell with huge data. The automation of matrix and cell formation through programming is done with a short span of time. As a result the time taken for the cell formation is reduced as much as compared to manual method.

Keywords: Cellular Manufacturing, Product Accuracy, Automation, Rank Order Clustering,

Matrix Formation

INTRODUCTION

In this work was discussed about the cellular manufacturing in pump industry. This work was done at EL VEE AIR COMPRESSOR PUMP & JET PUMP

COMPANY PROFILE

The work was done at EL VEE MACHINE WORKS, Jaihindpuram, Madurai. The pump company runs under Mr. L.Venkadachalam and he is in charge for all works. The company produces air compressor pump, and jet pumps. The company has lathe machine, grinding machine, hand press, drilling machine and punching machine with the labors. The pumps produced are taken to market by the dealers. They also supply the pumps to the new built homes directly through the contractors. They also have automatic on/off system for pump for filling the tanks. They have good dealers and good market value**.**

CELLULAR MANUFACTURING SYSTEM

Cellular Manufacturing is an approach that helps to build a variety of products with as little waste as possible. A cell is a group of workstations, machine tools arranged to create a smooth flow of families of parts can be processed progressively from one workstation to another without waiting for a batch to be completed [1]. Put simply, cellular manufacturing group's together machinery and a team of staff, directed by a team leader, so all the work on a product or part can be accomplished in the same cell eliminating resources that do not add value to the product [2].

Whether part families have been determined by visual inspection, parts classification and coding, or production flow analysis, there is advantage in producing those parts using group technology machine cells rather than a traditional process-type machine layout. When the machines are grouped, the term cellular manufacturing is used. Cellular manufacturing is an application of group technology in which dissimilar machines or processes have been aggregated into cells, each of which is dedicated to the production of a part or product family or a limited group of families. The typical objectives in cellular manufacturing are similar to those of group technology.

• To shorten manufacturing lead times, by reducing setup, work part handling, waiting times, takt time [7] and batch sizes.
• To minimize the exceptional elements and bottleneck machines [5, 10, and 11].

• To reduce work-in-process. Smaller batch sizes and shorter lead time reduce work-in-process.
• To improve quality. This is accomplished by allowing each cell to specialize in producing a smaller number of different parts. This reduces process variations.
• To simplify production scheduling. The similarity among parts in the family reduces the complexity of production scheduling. Instead of scheduling parts through a sequence of machines in a process-type shop layout, the parts are simply scheduled though the cell.
• To reduce setup times. This is accomplished by using group tooling (cutting tools, jigs, and fixtures) that have been designed to process the part family, rather than part tooling, which is designed for an individual part [9]. This reduces the number of individual tools required as well as the time to change tooling between parts.

TYPES OF MACHINE CELLS AND LAYOUTS

GT manufacturing cells can be classified according to the number of machines and the degree to which the material flow is mechanized between machines. In our classification scheme for manufacturing systems, all GT cells are classified as type X in terms of part or product variety. Here we identify four common GT cell configurations

1. Single machine cell
2. Group machine cell with manual handling
3. Group machine cell with semi-integrated handling
4. Flexible manufacturing cell or flexible manufacturing system.

As its name indicates, the single machine cell consists of one machine plus supporting fixtures and tooling. This type of cell can be applied to work parts whose attributes allow them to be made on one basic type of process, such as turning or milling.

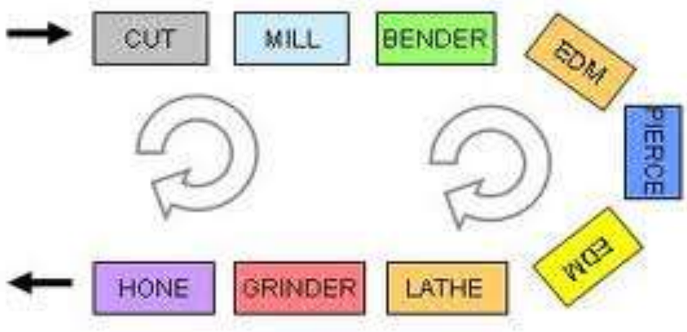

Figure 1.U-shaped machine layout

The group machine cell with manual handling is an arrangement of more than one machine used collectively to produce one or more part families. There is no provision for mechanized parts movement between the machines in the cell. Instead, the human operators who run the cell perform the material handling function. The cell is organized into a U-shaped layout, as shown in figure 1. This layout is considered appropriate when there is variation in the work flow among the parts made in the cell. It also allows the multifunctional workers in the cell to move easily between machines.

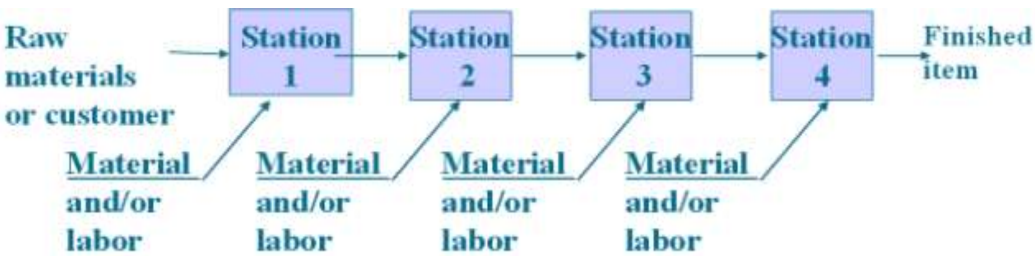

Figure 2. Inline layout

The group machine cell with manual handling is sometimes achieved in a conventional process type layout without rearranging the equipment. This is done simply by assigning certain machines to be included in the machine group and restricting their work to specified part families.

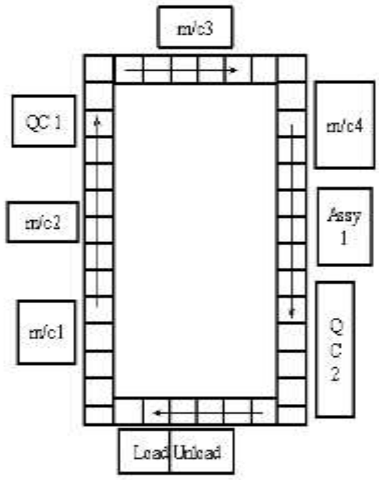

Figure 3. Rectangular layout

This forming of part family allows many of the benefits of cellular manufacturing to be achieved without the expense of rearranging equipment in the shop. Obviously, the material handling benefits of GT are minimized with this organization. The group machine cells with semi-integrated handling uses a mechanized handling system, such as a conveyor, to move parts between machines in the cell. The flexible manufacturing system combines a fully integrated material handling system with automated processing stations. The FMS is the most highly automated of the group technology machine cells.

A variety of layouts are used in GT cells. The U-shaped, as shown in figure 1, is a popular configuration in cellular manufacturing. Other GT layout include in-line and rectangular shown in figure 2 & 3 for the case of semi-integrated handling.

MACHINE CELL FORMATION

The group of similar parts is known as part family and the group of machineries used to process an individual part family is known as machine cell. It is not necessary for each part of a part family to be processed by every machine of corresponding machine cell. This type of manufacturing in which a part family is produced by a machine cell is known as cellular manufacturing. The manufacturing efficiencies are generally increased by employing GT because the required operations may be confined to only a small cell and thus avoiding the need for transportation of in-process parts

Part families collections are similar either because of geometric shape and size or because similar processing steps are required in their manufacture. The parts within a family are different but their similarities are close enough.

The problem basically consist of part family formation, machine cell organization and finally allocation of part family to machine cells in a manner that is performance measure is better than that of any other configuration. The machines were allocates to cells. Job sequence is based are assigned to the cells on the basis of similarity index as detailed in section. The operation sequence is based on the precedence relations and the machine on which an operation performed.

- Many firms utilizing cellular manufacturing have reported near immediate improvements in performance, with only relatively minor adverse effects.
- Cited improvements which seem to have occurred fairly quickly include reductions in work-in-process, finished goods, lead time, late orders, scrap, direct labour, and workspace.
- In particular, production and quality control is enhanced. By breaking the factory into small, homogeneous and cohesive productive units, production and quality control is made easier.
- Grouping of parts or products into sets or families reveals which ones are more or less amenable to continuous, coupled flow.
- Products that are low-volume, high variety and require longer set up times can be managed so that they evolve toward a line flow.

BENEFITS OF CELLULAR MANUFACTURING

- Reduce throughput time
- Reduce work-in-process
- Improve part and/or product quality
- Reduce response time for customer orders
- Reduce move distances
- Increase manufacturing flexibility
- Reduce unit costs
- Simplify production planning and control
- Facilitate employee involvement

- Reduce setup time
- Reduce finished goods inventory.

PROBLEM IDENTIFICATION

Now a day's no customer or consumer would like to have any item delayed to his requirement. Everybody wants everything in time. To meet the increasing demand from the customer, the company has to be in a position to increase its productivity. It has become difficult for the company to increase the productivity. Productivity in turn depends on time.

Hence the focus is on attention towards the actual production time and the measures needed to reduce it, so as to increase the productivity.

In the pump industries the mass production is possible only by cellular manufacturing. But in the cellular manufacturing, the rank order clustering and formation of cell is difficult because of manual method and take more time. There is a step by step procedure for finding the rank and grouping them into a cell manually. The manual method takes lot of time for cell formation and error may occur in the ranking method. The steps in rank order clustering and cell formation are

- Forming the component and machine incidence matrix.
- Compute the binary equivalent for each row.
- Rearrange the row of the matrix in rank wise.
- Check the matrix is arranged in rows correctly.
- Compute the binary equivalent of each column.
- Rearrange the column of the matrix in rank wise.
- Check the matrix is arranged in columns correctly.
- Sort the column and row in descending order to form final matrix.
- Create the cell for the matrix.

The above procedure in cell formation takes more time when done manually. The difficulties in the procedure of cell formation can be overcome by this project. The time will be reduced for cell formation and errors will be reduced.

PROBLEM DESCRIPTION

Automation is the technology by which a process or procedure is accomplished with little or without human assistance. Automation also reduces the process time and working time which increases productivity of the company. Cellular manufacturing plays a major role in batch production and to increase product accuracy in industries. It takes more time to form a cell manually.

AUTOMATION IN CELL FORMATION

In this task cell formation is done through automation. The aim of automation is the elimination of manual cell formation and reduction of time. Earlier through Rank Order Clustering, matrix formation and cell formation are done manually; it took more time for forming a cell with huge data. In the work automation is done using java programming.

Using the java program rank order clustering and cell formation is automated. The rank for each row and column is assigned and calculated automatically by the program. The binary values are found and arranged in descending order. Then the incidence matrix is formed by arranging the binary values of row and column. Then the cell is formed by using the matrix in short interval of time. Thus the time is reduced for cell formation automatically when compared to manual method.

COMPONENTS OF THE PUMP

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INTRODUCTION

This chapter has various parts of the pump manufactured in the production industry. Mainly parts of the pumps like body housing, impeller, bearing, coil winding, rotor, capacitor, etc., are discussed. Also focusing construction and working of the various parts of the pumps. The dismantled view of the pump is shown in the figure 4 and the parts list is given in the table 1.

Figure 4. Parts of the pump

List of parts in the pump are displayed in the table 1 below.

Sl. No.	PARTS	Sl. No.	PARTS
1	Suction Flange	14	Impeller
2	Non return Valve	15	Mechanical Seal
3	Threaded Plug	16	‘O’-Ring
4	Flange Gasket	17	Wound Stator
5	Vent Plug	18	Motor Housing
6	Vent Plug Washer	19	Power Supply Cable
7	Delivery Flange	20	Water proof Ring
8	Pump Adapter	21	Rotor
9	Terminal Block	22	Wavy Washer
10	Terminal Block Cover	23	End Cover
11	Capacitor	24	Tie Rod
12	Bearing	25	Fan
13	Pump Casing	26	Fan Cover

Table 1. Pump parts list

MACHINING OPERATIONS ON PUMP PARTS

This portion was discussed about the materials, manufacturing method and the manufacturing time involved in the production of the various parts of the pumps.

BODY HOUSING

The body housing is manufactured by means of casting. Suitable moulds are used to manufacture different size housing. Molten metal is poured into the mould and allowed to cool. After cooling, moulds are removed and the cots are painted which appears like aluminum coating and the housing is painted by suitable colure. After the housing is heated in the over at temperature of 2000c. In the oven, the housing is heated for nearly 45 minutes.

The housing is heated in the oven as a batch process. At a time nearly 75 housing can be heated at a time. The main reason for heating the coil is that the heating make the easy inserting of the coil winding inside the housing.

ROTOR

The rotor is manufactured in the CNC lathes and the rotor is made from stainless steel. The machining of the rotor is made into two stages. In the first stage, step turning and taper turning is carried out. The need for the taper in the rotor in to give clearance to the bearing. In the second stage, threading and grooving is carried out at the two ends of the rotor. After machining, bend test is conducted on the shaft to find out if there in any bend occurs during machining. Bend test is carried by means of out gauge. The while time taken for machining is 2 minutes and time needed to carry out the bend test is also 1minute

IMPELLER

An impeller is a rotating component of a centrifugal pump, usually made of iron, steel, bronze, brass, aluminum or plastic, which transfers energy from the motor. The impeller used in the pumps machined in the CNC lathe. At first centre hole are made and the teeth are cut on the peripheral. The impeller is made from bronze metal. The time taken to complete the machining of the impeller is 3 minutes.

COIL WINDING OPERATIONS

In a coil winding process five sequences are there,

- Automated coil winding operation
- Automated paper insertion operation
- Automated coil loading operation
- Automates coil pressing operation
- Automated coil broaching operation

AUTOMATED COIL WINDING OPERATION

The first stage of the process is coils are winding in the stators. The coil are taken by the number of turns. The automated coil winding machine winds the 5 coils in 1 minutes.

AUTOMATED PAPER INSERTION OPERATION

The second stage of the process is insertion of paper to the coil slotted part. The parts are having 24 slots for the purpose of inserting papers in slotted parts, which the coil elements are avoid from the coil and slotting parts by electrical flow.

AUTOMATED COIL LOADING OPERATION

The third stage of the process is coil loading process. In this process, separate the coil turns are feed

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through the CLM. The CLM have a stampings the 24 stampings are divide 6 parts. The 4 coil turns are inserted to the stampings. Finally press the slotted part of stamping arrangements, the turns are united.

AUTOMATED COIL PRESSING OPERATION

The fourth stage of the process is coil pressing operation. In this operation, the united coils are hold in the pressing machines wise. The head arrangements are press the down word passion from the top. The united coil windings are become the unique appearance.

AUTOMATED COIL BROACHING OPERATION

The fifth and the final stage of the coil winding process is broaching operation. In this process, the broaching machine has tied the coils which are united by the pressing machine. Another side of broaching machine arrangement has broaching the coil by the thread.

When coil are fully tied with the threads, the arrangements are adopt the rotor shaft. The automated coil broaching machines are suitable for broaching the mouth part of the slots after and shaping the auto starter motor stator embedding and shaping the auto starter motor stator and also it used for broaching the mouth part of the slots after embedding and shaping the auto starter motor stator.

MACHINE CELL FORMATION METHODOLOGY

This chapter was discussed about the formation of cells in pump industry by using rank order clustering algorithm. Formation of part families and machine cell is the first step towards the design of cellular manufacturing systems. The primary input data are derived from route sheets. This data are in the form of a zero-one matrix where the rows represent the machine and columns represent the parts. Algorithms that aim at forming the part families and machine cells essentially try to rearrange the rows and columns of the matrix to get a block diagonal form. The ideal situation is one in which all the ones are in diagonal block and all the zero are in the half diagonal block. However, the ideal case seldom occurs in a real shop floor problems [6]. The block diagonal form is usually far from perfect. This could be either due to the properties of the data are the inadequacies of the algorithm or both. A complete block diagonal matrix in which mutually independent machine components groups can be identified is ideal for the successful development of a cellular manufacturing system.

The methodology in this paper starts with preparing the data into the part machine matrix form (table 2), which is an important input for cell formation technique, next the same data set is calculated by Rank Order Clustering Algorithm, after that the result of the above algorithm are evaluated and the effective method is selected based on the grouping efficiency and grouping efficacy measures. This method is used to build the cellular manufacturing layout.

Parts / M/c	**Moulding**	**Buffering**	**CNC Lathe**	**Coil Winding machine**	**Hand Grinding machine**	**Conventional lathe**	**Hand press**
Body housing	1	1	0	0	1	1	0
Rotor	0	0	1	0	0	1	1

Bearing	0	0	1	0	0	0	1
Impeller	1	1	0	0	0	1	1
Casing	1	1	0	0	1	0	1
Bracket	1	1	0	0	1	0	1
Stator	0	0	1	1	0	0	1
Tie rod	0	0	1	0	0	0	1
Seal	0	1	1	0	0	0	1
Delivery port	1	1	0	0	1	0	1
Coil winding	0	0	0	1	1	1	1

Table 2. Initial machine components incidence matrix

RANK ORDER CLUSTERING (ROC)

ROC is the well-known clustering technique that attempts to create a block diagonal form by repeatedly reallocating the columns and rows of a machine part matrix according to binary values [8]. The binary values are calculated by reading the pattern of cell entries as a binary word. Each row and column is assigned a weight that is the decimal equivalent of its binary word. Although ROC is easy to apply, the quality of the results is strongly dependent on the initial disposition of the machine part matrix. Second, the binary value that is used for the reallocation restricts the size of the problem that the technique can handle. The step-by-step procedure shown as follows.

Step 1: Compute the binary equivalent of each row.

Step 2: Rearrange the rows of the matrix in rank wise (high to low from top to bottom).

Step 3: Compute the binary equivalent of each column and check whether the column of the matrix are arranged in the column of the matrix are arranged in the rank wise.

Step 4: Rearrange the columns of the matrix rank wise and compute the binary equivalent of each row.

Step 5: Check whether the rows of the matrix are arranged rank wise? If not go to step 2 otherwise go to step 6.

Step 6: Print the final machine component incidence matrix.

(a)Calculated the binary value of the each row

M/c	**PARTS**											**BINARY VALUE**	**RANK**
	210	29	28	27	26	25	24	23	22	21	20		
	1024	512	256	128	64	32	16	8	4	2	1		
	1	2	3	4	5	6	7	8	9	10	11		
1	1			1	1	1				1		1250	3

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2	1			1	1	1			1	1		1254	2
3		1	1				1	1	1			796	6
4							1					16	7
5	1				1	1					1	1121	4
6	1	1		1								1664	1
7		1	1	1	1	1	1	1	1	1	1	1023	5

Table 3. Binary value of each row

(b) Sort the row descending order

M/c	**PARTS**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
6	1	1		1							
2	1			1	1	1			1	1	
1	1			1	1	1				1	
5	1				1	1				1	
7		1	1	1	1	1	1	1	1	1	1
3		1	1				1	1	1	1	
4							1				1

Table 4. Row in descending order

(c) Calculate binary value for each column

BINARY VALUE	**M/c**	**PARTS**										
		1	2	3	4	5	6	7	8	9	10	11
26=64	6	1	1		1					1		
25=32	2	1			1						1	
24=16	1	1			1						1	
23=8	5	1									1	
22=4	7		1	1	1	1	1	1	1	1	1	1
21=2	3		1	1				1	1	1	1	
20=1	4							1				1
BINARY VALUE		120	70	6	116	60	60	7	6	38	62	5
RANK		1	4	9	2	5	5	8	9	7	3	11

Table 5. Binary value for each column

(d) Sort the columns in descending order

M/c	PARTS										
	1	4	10	2	5	6	9	7	3	8	11
6	1	1		1			1				
2	1	1	1		1	1					
1	1	1	1		1	1					
5	1		1		1	1					
7		1	1	1	1	1	1	1	1	1	1
3			1	1				1	1	1	
4									1		1

Table 6. Columns in descending order

CELL NUMBER 1

The process involved in body housing, rotor, impeller, casing, bracket and delivery port are grouped into one cell and the machines involved in these processes are arranged into a cell. This leads to the formation on cell No.1

M/c	PARTS					
	1	**4**	**10**	**2**	**5**	**6**
6	1	1		1		
2	1	1	1		1	1
1	1	1	1		1	1
5	1		1		1	1

Table 7. Cell No.1

CELL NUMBER 2

The process involved in stator, bearing, tie rod, seal and coil winding are grouped into one cell and the machines involved in these processes are arranged into a cell. This leads to the formation on cell No.2

M/c	PARTS				
	9	**7**	**3**	**8**	**11**
7	1	1	1	1	1
3	1	1	1	1	
4		1			

Table 8. Cell No.2

AUTOMATION

Automation is the technology by which a process or procedure is accomplished with little or without human assistance. It is implemented using a program of instructions combined with a control system that executes the instructions. To automate a process, power is required, both to drive the process itself and to operate the program and control system. Although automation can be applied in a wide variety of areas, it is most closely associated with the manufacturing industries. It was in the context of manufacturing that the term was originally coined by an engineering manager at Ford Motor Company in 1946 to describe the variety of automatic transfer devices and feed mechanisms that had been installed in Ford's production plants. It is ironic that nearly all modern applications of automation are controlled by computer technologies that were not available in 1946.

INPUT

The input values are binary numbers (1 or 0) and the enter in column wise [3, 4]

RUN:
ENTER 0 NUMBER
Sum is 0.0
ENTER 1 NUMBER
1 0 0 1 1 1 0 0 1 0 sum is 1250.0
ENTER 2 NUMBER
1 0 0 1 1 1 0 0 1 1 0 sum is 1254.0
ENTER 3 NUMBER
0 1 1 0 0 0 1 1 1 0 0 sum is 796.0
ENTER 4 NUMBER
0 0 0 0 0 0 1 0 0 0 0 sum is 16.0
ENTER 5 NUMBER
1 0 0 0 1 1 0 0 0 0 1 sum is 1121.0
ENTER 6 NUMBER
1 1 0 1 0 0 0 0 0 0 0 sum is 1664.0
ENTER 7 NUMBER
0 1 1 1 1 1 1 1 1 1 1 sum is 1023.0

OUTPUT

The output file first compute binary equivalent of each row and rearrange the rows of the matrix by rank. The second step, compute binary equivalent of each column and rearrange the columns of the matrix by rank. Then check whether the rows and columns of the matrix are arranged rank wise. Finally print the cells with the less exceptional element.

TABLE 1

1	0	0	1	1	1	0	0	0	1	0	sum is1250.0
1	0	0	1	1	1	0	0	1	1	0	sum is1254.0
0	1	1	0	0	0	1	1	1	0	0	sum is796.0
0	0	0	0	0	0	1	0	0	0	0	sum is16.0
1	0	0	0	1	1	0	0	0	0	1	sum is1121.0
1	1	0	1	0	0	0	0	0	0	0	sum is1664.0
0	1	1	1	1	1	1	1	1	1	1	sum is1023.0

TABLE 2

0	1	2	3	4	5	6	7	8	9	10	11
6	1	1	0	1	0	0	0	0	0	0	0
2	1	0	0	1	1	1	0	0	1	1	0

1	1	0	0	1	1	1	0	0	0	1	0
5	1	0	0	0	1	1	0	0	0	0	1
7	0	1	1	1	1	1	1	1	1	1	1
3	0	1	1	0	0	0	1	1	1	0	0
4	0	0	0	0	0	0	1	0	0	0	0

TABLE 3

0	6	2	1	5	7	3	4	0.0
1	1	1	1	1	0	0	0	120.0
2	1	0	0	0	1	1	0	70.0
3	0	0	0	0	1	1	0	6.0
4	1	1	1	0	1	0	0	116.0
5	0	1	1	1	1	0	0	60.0
6	0	1	1	1	1	0	0	60.0
7	0	0	0	0	1	1	1	7.0
8	0	0	0	0	1	1	0	6.0
9	0	1	0	0	1	1	0	38.0
10	0	1	1	0	1	0	0	52.0
11	0	0	0	1	1	0	0	12.0

TABLE 4

0	1	4	2	5	6	10	9	11	7	3	8
6	1	1	1	0	0	0	0	0	0	0	0
2	1	1	0	1	1	1	1	0	0	0	0
1	1	1	0	1	1	1	0	0	0	0	0
5	1	0	0	1	1	0	0	1	0	0	0
7	0	1	1	1	1	1	1	1	1	1	1
3	0	0	1	0	0	0	1	0	1	1	1
4	0	0	0	0	0	0	0	0	1	0	0

PROGRAM OUTPUT
CELL 1

0	1	4	2	5	6	10
6	1	1	1	0	0	0
2	1	1	0	1	1	1
1	1	1	0	1	1	1
5	1	0	0	1	1	0

CELL 2

0	9	11	7	3	8
7	1	1	1	1	1
3	1	0	1	1	1

4 0 0 1 0 0
BUILD SUCCESSFUL (total time: 1 minute 38 seconds)

CONCLUSION

The company initially follows the process with more time to develop the new product. From this project it is concluded that the time taken for the product development has successfully reduced by the grouping of machine through the automation of cell formation. It is successfully verified the cell structure through the program and suggest them to arrange the machines and tools in the order of automated cell structure. Changes in the product development or any introduction of new products and formation of new cell are done through the automation with a short period of time.

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