Restructuring Manufacturing Process Using Matrix Method

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*Abstract***:** *In modern days competition is increasing in industries so time and cost are important factors. In this paper we present case studies on matrix method, so that best sequence with minimum time, minimum cost and reduced penalty (job changeover time from one machine to another) recommended for a particular product manufactured is achieved. Here two cases on idler pipe and idler shaft are analyzed and best sequences are generated.*

*Index Terms***:** *Matrix method, cellular manufacturing, path matrix P_{ij}, total matrix T_{ij}..*

I. INTRODUCTION

Group Technology examines products, parts and assemblies. It then groups similar items to simplify design, manufacturing, purchasing and other business processes. In ungrouped parts it is difficult to see how these parts could be made with the same set of process but when grouped into families, the common processes become more obvious and we can begin to think of a set of machines, tools and skill for each family. Group Technology is the most effective technique available for addressing the variety demanded by today's customers. It allows customization of product with standardization of process [1]. Cellular manufacturing (CM) which is a manufacturing philosophy based on group technology (GT), is seen as a promising solution for the problems faced by the present day manufacturing systems. The formation of a CMS mainly consists of two important tasks: grouping of parts into families on the basis of their similar designs and processing requirements and grouping of machines into cells according to the processing requirements of corresponding part families. A group of parts can be called as a family if either their processing requirements are similar or they resemble each other in terms of size and geometric shape (Ham et al. [1985] [2], Groover [2008] [3]). Machines in each cell are placed in close proximity to each other thus saving time and cost (handling). Each cell is ideally responsible for the manufacturing of a particular part family which results in simplifying the flow of material and scheduling of the system. In contrast to Job Shop parts, in

CM have to travel less distances before their processing is completed. Also, having machines in close proximity the

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flow of one piece at a time is possible thus saving a lot of waiting time, which is

unavoidable in case of Job-Shop manufacturing. Another aspect of CM that causes a reduction in the overall production time is reduced setup times. It is because of the fact that each part family contains parts that have similar design attributes. CM in fact provides a system that has the combined advantages of both Job- Shop and Flow Line Manufacturing. Similar to Job-Shop CMS also utilizes general purpose machines and therefore has the ability to be reconfigured and produce a variety of products. Also, having machines in close proximity in each cell and dedicated to a particular part family efficient flow of material and higher rate of production, like a Flow Line Manufacturing system, can be achieved. Finally it can be concluded that wherever there is a requirement of producing a medium variety of products in medium quantity then CM can prove to be, comparatively, more economical, (Black J. [1983] [4]). In case where large volumes are to be produced then pure Flow Line Manufacturing is preferable. Similarly, in case where greater variety of products to be produced then pure Job-Shop Manufacturing can be more useful. CM over the years has been gaining popularity. Fry et al [1987] [5] observed that several US based manufacturers adopted CM instead of the conventional Job-Shop Manufacturing. The matrix method results in optimum selection of machine and sequence of operations. The selection and decision process is purely mathematical and is not affected by intuition or rules of thumb [6].

II. METHODOLOGY USED

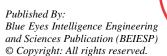We used matrix method, it consist 3 stages

Stage 1: Technology-The Theoretical Process Concept
The output of this stage is the priority and relationship constraints, and the parameters that were used to specify and compute the theoretical operations. Such data are specific for each type of processing and will be used in the transformation stage.

Stage 2: The Transformation Stages-Constructing a Matrix
The left side of matrix shows the operations and some constraints such as priority (PR) and relationship (Rel). On top right side of matrix all the candidate resources for each operation are listed. The content of the matrix is Tij, which is the time to perform operation i on resource j.

Stage 3: Decision (Mathematics) Stage

Given a list of operations to be performed and a list of available facilities, a decision is required as to which machine(or machines) to use, which operations to perform on each machine, what their sequence should be, and what cutting conditions to employ.

The optimization criterion is either maximum production or minimum cost. Extra expenses and time should be added to cover extra setup, chucking, transfer of parts between resources, additional complications in capacity planning, job recording, inspection, etc. These extra expenses are called a penalty. Two additional matrixes formed known as Zij total matrix and Pij path matrix. Path matrix tells us path of sequence.

III. MATRIX CONCEPT CASE STUDY

CASE 1:

We studies manufacturing of idler pipes. Operation done on it firstly pipe cut on band saw machine, after it pipe facing and boring done and in last pipe welding done. All machine-operation time, machine-cost, machine operation total matrix, path matrix shown in table below.

Table 1: Machine-Operation Time Matrix

Opera-tion	Priority	REL	M1	M2	M3	M4
010	010	0	2.38	99	99	99
020	020	0	99	1.68	1.52	99
030	030	0	99	3.80	3.52	99
040	040	0	99	99	99	1.04

Table 2: Machine-Operation Cost matrix Cij (multiplying time into relative cost 9.71, 25.57, 26.54, 21.33)

Oper-atio-n	Prio-rity	REL	M1	M2	M3	M4	Min. Cost
010	010	0	23.11	2531.43	2647.45	2111.67	23.11
020	020	0	961.3	42.96	40.34	2111.67	40.34
030	030	0	961.3	97.17	93.42	2111.67	93.42
040	040	0	961.3	2531.43	2627.45	22.18	22.18
Total		0					179.05

Maximum Production Criterion
Suppose a quantity of 1000 pipes ordered, and the setup times for a machine 40. The penalty for transferring job from one machine to another is 40/1000=0.04.
Minimum Cost Criteria
Suppose a quantity of 1000 pipes ordered, and setup cost and other expenses to machine the batch is 90.Thus a penalty for transferring job from one machine to another is 90/1000=0.09. Operation 3 on machine 1
S1=961.3+961.3+0=1922.6
S2=961.3+2531.43+0.09=3492.82
S3=961.3+2627.45+0.09=3588.84
S4=961.3+22.18+0.09=983.57
The minimum value of S is 983.57 and is on transfer to machine 4. Therefore Z_{31}=983.57 and P_{31}=4. Similarly all values calculated and two additional matrices built: Total Matrix Zij and the path matrix Pij,

Table 3: Machine-Operation Total Matrix Zij

Ope-ratio-n	Priority	REL	M1	M2	M3	M4
010	010	0	179.23	2687.55	2783.48	2267.79
020	020	0	1077.08	158.74	156.03	2227.45
030	030	0	983.57	119.44	115.69	2133.85
040	040	0	961.3	2531.43	2627.45	22.18

Table 4: Machine- Operation Path Matrix Pij

Operation	Priority	REL	M1	M2	M3	M4
010	010	0	3	3	3	3
020	020	0	3	3	3	3
030	030	0	4	4	4	4
040	040	0				

CASE 2:

Now study manufacturing of idler shaft. Operation done on it firstly shaft cut on band saw machine, after it shaft facing, turning, grooving, chamfering and milling done. All machine-operation time, machine-cost, machine operation total matrix, path matrix shown in table below.

Table 5: Machine-Operation Time Matrix

Oper-ation	Prio-rity	REL	M1	M2	M3	M4
010	010	0	2.04	99	99	99
020	020	0	99	2.86	1.12	99
030	030	0	99	8.34	2.24	99
040	040	0	99	0.86	0.36	99
050	050	0	99	0.20	0.05	99
060	060	0	99	99	99	6.20

Table 6: Machine-Operation Cost matrix Cij (multiplying time into relative cost 9.31, 43.70, 43.98, 38.81)

Ope-rati-on	Priority	REL	M1	M2	M3	M4	Mini. cost
10	10	0	18.99	4326.3	4354.02	3842.19	18.99
20	20	0	921.69	124.98	49.26	3842.19	49.26
30	30	0	921.69	364.46	98.52	3842.19	98.52
40	40	0	921.69	37.58	15.83	3842.19	15.83
50	50	0	921.69	8.74	2.2	3842.19	2.2
60	60	0	921.69	4326.3	4354.02	240.62	240.62
Total							425.42

Maximum Production Criterion

Suppose a quantity of 1000 shaft ordered, and the setup times for a machine 30. The penalty for transferring job from one machine to another is 30/1000=0.03.

Minimum Cost Criteria

Suppose a quantity of 1000 shaft ordered, and setup cost and other expenses to machine the batch is 60.Thus a penalty for transferring job from one machine to another is 60/1000=0.06.

Operation 5 on machine 1

$S1=921.69+921.69+0=1843.38$
$S2=921.69+4326.3+0.06=5248.05$
$S3=921.69+4354.02+0.06=5275.77$
$S4=921.69+240.62+0.06=1162.37$

Table 7: Machine-Operation Total Matrix Zij

Opera-tion	Prio-rity	REL	M1	M2	M3	M4
10	10	0	425.54	4732.85	4760.51	4248.74
20	20	0	1278.98	482.27	406.49	4199.48
30	30	0	1180.46	623.23	357.23	4100.96
40	40	0	1164.63	280.52	258.71	4085.13
50	50	0	1162.37	249.42	242.88	4082.81
60	60	0	921.69	4326.3	4354.02	240.62

The minimum value of S is 1162.37 and is on transfer to machine 4.Therefore $Z_{51}=1162.37$ and $P_{51}=4$. Similarly all values calculated and two additional matrices built: Total sum Zij and the path matrix Pij, as displayed in table

Table 8: Machine- Operation Path Matrix Pij

Oper-ation	Pri-ority	REL	M1	M2	M3	M4
010	010	0	3	3	3	3
020	020	0	3	3	3	3
030	030	0	3	3	3	3
040	040	0	3	3	3	3
050	050	0	4	4	4	4
060	060	0				

IV. RESULT AND DISCUSSION

Case 1: We find that operation 1 done on machine 1 and both operation 2 and 3 can be done on machine 3, operation 4 done on machine 4 with minimum time and minimum cost. Best operation sequence with time and cost given in table below.

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Table 9: The proposed process is shown in the table below

Mac-hine	Operation	Cost (Rs.)	Time (Minutes)
1	1	23.11	2.38
3	2,3	40.34+93.42=133.76	3.52+1.52=5.04
4	4	22.18	1.04

Case 2: We find that operation1 done on machine 1 and operation 2, 3, 4, 5 can be done on machine 3, operation 6 done on machine 6 with minimum time and minimum cost. Best operation sequence with time and cost given in table below.

Table 10: The proposed process is shown in table below

Mac-hine	Oper-ation	Cost (Rs.)	Time (Minutes)
1	1	18.99	2.04
3	2, 3, 4, 5	49.26+98.52+15.83+2.20 = 165.81	1.12+2.24+0.36+0.05 =3.77
4	6	240.62	6.02

V. CONCLUSION

We conclude that in case 1 we can reduce 1 transfer penalty (job changeover time from one machine to another) by doing both operation 2, 3 on machine 3. In case 2 we can reduce 3 transfer penalties by doing operation 2, 3, 4, 5 on machine 3. So transfer penalty reduced and sequence of manufacturing with minimum time and minimum cost generated.

VI. FUTURE SCOPE

We have studied constraints cases in which both operation 1, 4 in case1 done on machine 1 and machine 4 only and operation 1, 6 done on machine 1 and machine 4 only, in case 2. Our method can applied a problem where all machines can do all operations without any constraints.

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