FORMULATION AND SIMPLIFICATION OF DATA INPUT AND OUTPUT FOR GROUP TECHNOLOGY TECHNIQUE IN CELLULAR MANUFACTURING SYSTEMS

Dr. Zouhair I. A. Al-Daoud
Assistant Professor
Mechanical Engineering Department
College of Engineering, Baghdad University
Baghdad, Iraq

ABSTRACT

In most of the group technology approaches the formulation and simplification of data entry has been ignored. This has lead to difficulties and complexity for the end-user of the group technology, especially in the cases where the number of machines and components are large and complex. The way the data are inputted are in the form of a 0-1 matrix, which is quit difficult, troublesome, and error creation is possible in their entry, even with double-checking in their input. Also for output results, as it is given in the form of the 0-1 matrix and left to the end-user to interrupt instead of giving the result in a such a way that it could be used by the end-user directly.

In this paper, a systematic formulation of data input and output is introduced so as to make easier for the users to enter their data as simple as possible and with minimum error occurrence, especially in the cases where there are considerable number of machines and components to be dealt with. And also use the results directly without any further interpretation.

The proposed system for data entry and output interruption has been applied and then implemented in two different companies with easiness and apparition of end-user in terms of data input, minimum corrections, simple and direct usage of outputs without further interpretation.

الخلاصة

في معظم الدراسات الخاصة بتكنولوجيا لا يتم الاخذ بنظر الاعتبار تبسيط و برمجة ادخال المعلومات. ان ذلك ادى الى تصعيب و تعقيد الامور على المستعمل النهائي لمثل هذه الطرق، و خاصة في حالة كون عدد المكائن و الاجزاء كبير و معقد. ان ادخال المعلومات يكون اعتياديا على شكل مصفوفة (٠ – ١)، و الذي يكون في معظم الاحيان صعبا و ذات مشاكل معقدة و تحوي على بعض الاخطاء نتيجة الى الادخال الخطأ في المعلومات الخاصة بالاجزاء و المكائن بالرغم من التدقيق عند الادخال الى الحاسبة. و كذلك بالنسبة للنتائج، حيث انها ايضا تعطى كمصفوفة (٠ – ١) وتترك للمستعمل النهائي لترجمتها الى الواقع الحقيقي من مكائن و اجزاء و بالتالي صرف الوقت و الجهد الكثير على ذلك.

ولكن في الطريقة المقترحة سوف تكون المدخلات و النتائج مفهومة من قبل المستعمل النهائي مباشرة حيث تعرف الاجزاء و المكائن المستعملة، و ذلك من خلال ادخال المعلومات باسهل طريقة ممكنة مع تقليل احتمال الخطأ الى الحد الأدنى الممكن.

ان الطريقة المذكورة تم تجربتها على نوعين من المعلومات من احدى شركات التصنيع بسهولة وقبول من قبل العاملين من خلال ادخال المعلومات، العدد القليل من التعديلات، و البساطة و الاستعمال المباشر للنتائج من قبل العاملين في الشركة من دون اي تغيرات أو تحويرات تذكر.

KEY WORDS

Group technology. Cellular manufacturing. Production flow analysis. Cluster analysis. and Data analysis.

INTRODUCTION

Cellular manufacturing (CM) has been recognized as an effective and advanced manufacturing technology and thus applied to many manufacturing environments successfully. CM has been the focus of interests for many researchers and practitioners. The main objective of designing a cellular manufacturing system is the identification of part-families and machine groups for the creation of cells, in which the parts are processed with minimum movement into other cells. The benefits of implementing CM are significant. Among them, simplification of work to end-user, reducing set-up times, minimization of flow, higher utilization of machines, improved through put time.

The simplification of work to the end-user has, in most cases, not given required emphasis. In past works concerning the different approaches of group technology models and methods of they're solutions, on how data are entered and the result are outputted so as to generate the families of parts and groups of machines used in their processing. Production flow analysis is one of the most reliable methods (Burbidge, 1963), (Sehotield and Masey, 1974), analyze production flow of components through machines and therefore resulting into the decomposition into a number of major machine-component groups. The data are entered in the form of route-cards prepared for this purpose in a certain form (Burbidge, 1975), from which the 0-1 matrix is formed. The outputted results are not interrupted so as it could be used directly by the user without further interpretation. Clustering approaches: 1. Exchange algorithm, (McCormick and others, 1972; Bhat and Haupt, 1976); 2. Sorting algorithm (King, 1980; King and Nakornchai, 1982; Kusiak, 1987); 3. Constructive algorithm (Vannelli and Kumar, 1986; Chandrasekharan and Rajagopalan, 1986); 4. Relaxation algorithm (Stanfel, 1991) uses the 0-1 matrix for the input data and also for output data without further interpretation for the user.

Classification and coding methods takes each of the different design attributes of a component e.g. dimensions, overall shape, raw material characteristics, accuracy, surface finish, type of internal and external shape features, etc. are represented by a single code number. Families of components would posses identical code numbers. The machine tools are selected by analyzing the route cards of those components. This method is an indirect approach to the creation of an elaborate data base which provides a weak connection between components features and machine tool grouping beside it requires a lot of time and work not need by other methods (Browne and others 1984, Burbidge 1975, Gallagher 1973).

In this work a systematic approach is used to input data directly by the user as information available for the processing of the components on machines in term of the technological process route as designed by the technological department in the company by a use of a prepared form to enter the required information so as to be processed by a computer program designed for this purpose to formulate the 0-1 matrix. Then by applying one of the group technology methods to the 0-1 matrix a solution is achieved, which then interrupted to the user in term of components and machines so as to

be used as easily as possible by the work-shop for scheduling and loading of components on machines according to the plan of production.

ALGORITM OUTLINE

The algorithm outline is as follows and as shown in **Fig. (1).**

1- Take the basic data from the route cards for each component prepared by the technology department in the company.
2- Simplify the data given in (1), so as to be inputted to the computer program. This called the simplified data.
3- Then the computer program will compute the simplified data into *process data* so as to be used in the program with minimum computation.
4- After that the computer program will form the component code conversion so as to make it easy for the User to use in the shop floor.
5- Then the computer program will form the machine code conversion so as to make it easy for the User to use in the shop floor.
6- From the above data the computer program will process the original 0-1 matrix, which is used later on to form the component-machine groups.
7- Then the computer program, by using one of the methods of Group Technology, will form the 0-1final matrix.
8- This is then by the re-assignment method will give the final group matrix indicating the groups which are formed by which the work shop is re-organized.

BASIC DATA

The basic data needed to generate the group technology solution is in the form of the technological process route prepared by the technological department of the company. For each component, the data usually consist of:

component name
component code
operations performed on machines
machine name
machine code
time for performing each operation

These are formulated as per the form shown in **Table (1).**

Table (1) Basic Data

Component Name: abc			Component Code: 315112	
Operation No.	Operation Name	Machine Name	Machine Code	Operation Time
5	Turning	CNC turning	1105	25

To make this easy for the User, a table of machine-component for each group is computed.

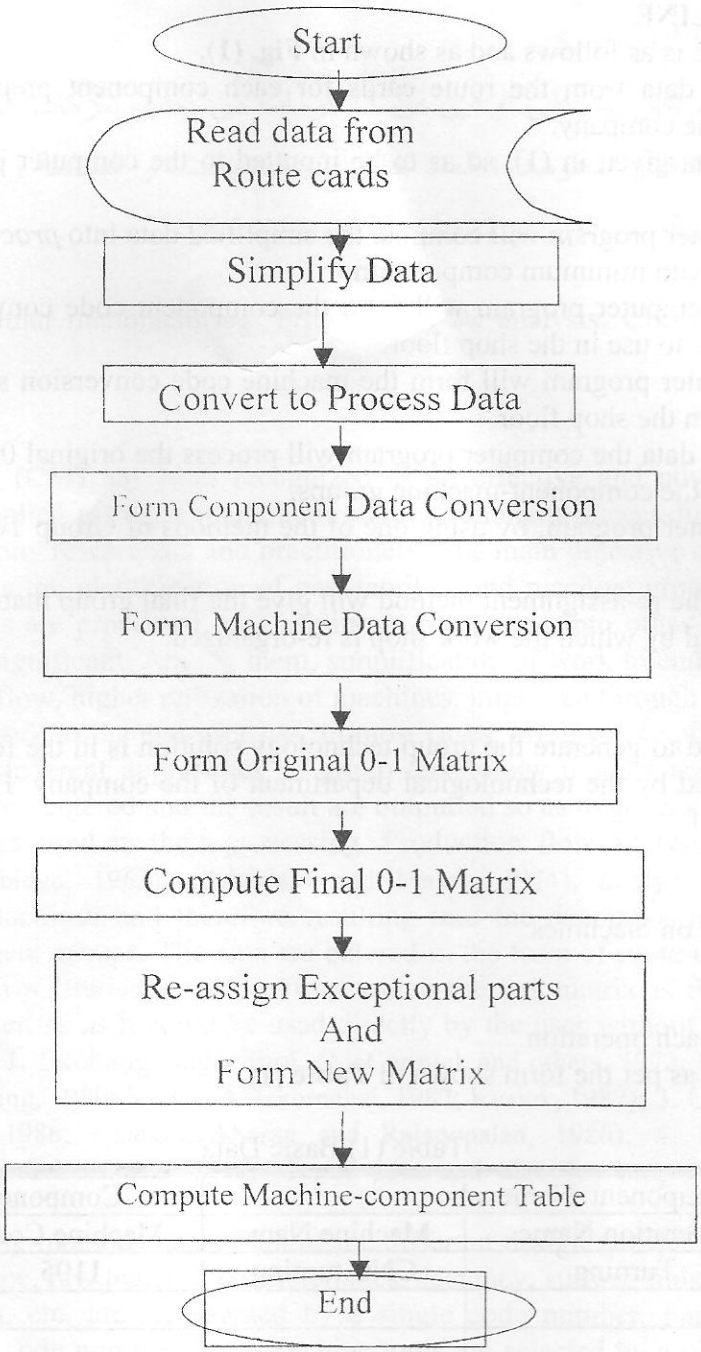


Fig. (1): Algorithm Outline

Simplification of Data

This is usually converted to easier form to be inputted to the computer by using the form:
Number (No.): the reference number given by the program.
Number of operations (No. of Opr.): this gives the number of operations that the component needed for processing according to process route.
Operation Number (Opr. No.): this is the operation number given by the technologist.
Operation Time (Opr. Time): this is the time for manufacturing 100 pieces (size of company batch) in minutes.
This is shown in **Table (1).**

Table (2) Simplification of data

Opr. Time	M/c No.	Opr. No.	Opr. Time	M/c No.	Opr. No.	Opr. Time	M/c No.	Opr. No.	Opr. Time	M/c No.	Opr. No.	Opr. Time	M/c No.	Opr. No.	No. of Opr.	No.
			1666	1159	24	1666	1330/3	22	0630	2152	20	1250	1610/1	2	4	١
															7	2
																3

Process data

Then this converted by the computer program, so as to store the information stated in table (2) in the form:
1st element in numeric form between 1 and 999, which is representing the component code stated by the route card.
2nd element in numeric form between 1 and 99 representing the number of operations needed to manufacture the component.
3rd to plus the number stated in {(b)-1}, i.e. if (b) is = 6 then from 3rd element to 8th element; in numeric form between 1 to 999 representing the code number of each machine needed for the production of the component.
Table (3) gives the list of converted data by the computer program, called the process data, for the example taken from one of the manufacturing companies.

Table (3) Process Data

4,6,1158,1156,2411,1158,1360,1117
5,2,1156,1340
7,2,1613,1613
8,1,1316
9,9,1610,1140,1221,1221,1216,1156,1156,1340,1216
10,2,1143,1216
11,2,1132,1416
12,2,1156,1216
13,5,1143,2211,1112,1123,1310
14,3,1156,1216,1340
16,3,1143,1216,1338

17,4,1156,1340,1215,1216
18,2,1127,1112
20,2,1613,1310
21,2,1127,1112
22,2,1127,1112
23,1,2117
24,3,1156,1215,1215
25,1,1127
26,1,1156
27,4,1156,1156,1216,1216
28,2,1310,1316
31,9,1160,2152,1146,1146,1220,1159,1430,1117,1118
33,5,1143,1123,1112,1316,1338
34,5,1610,1144,1157,1157,1157
35,2,1132,1416
36,2,1132,1416
41,3,1158,1216,1216
42,1,1156
44,3,1146,1424,1156
45,3,1143,1216,1338
48,3,1143,1145,1340
49,3,1156,1221,1338
50,2,1156,1360
51,2,1132,1416
64,6,1610,1145,1221,1221,1157,1157
65,1,1143
66,3,1143,1216,1360
67,1,1143
68,3,1143,1123,1360
69,3,1610,1144,1157
70,2,1143,1338
71,2,1132,1416
74,1,1143
77,3,1143,1216,1216
78,1,1143
79,1,1156
80,1,1143
82,2,1143,1216
83,3,1610,1215,1310
86,4,1615,2113,4129,2113
87,1,1156
88,3,1610,1144,1123
89,4,1610,1310,1310,1216
93,1,1216
102,2,1157,1360
103,3,1156,1221,1157
91,2,1132,1416
97,2,1127,1112
95,2,1157,1316
100,3,1610,1144,1616
99,2,1157,1361
104,2,1157,1360
109,4,1615,2120,2114,2120
111,1,1143
112,2,1615,2113

113,3,1615,2113,2113
115,2,1615,2113
117,3,1615,2113,2113
118,3,1615,2113,2113
119,3,1615,2113,2113
121,4,1615,1215,1427,1215

Component code conversion

This is also achieved by the computer program, so as to make it accessible by the User in an easy way as shown in **Table (4).** From **Table (4),** it is very simple to know which component is appearing in the 0-1 matrix by reading the component code under the serial number.

Table (4) Components Code Conversion to Computer Program Serial Number

Serial No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Comp. No.	4	5	7	8	9	10	11	12	13	14	16	17	18	20
Serial No.	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Comp. No.	21	22	23	24	25	26	27	28	31	33	34	35	36	41
Serial No.	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Comp. No.	42	44	45	48	49	50	51	64	65	66	67	68	69	70
Serial No.	43	44	45	46	47	48	49	50	51	52	53	54	55	56
Comp. No.	71	74	77	78	79	80	82	83	86	87	88	89	93	102
Serial No.	57	58	59	60	61	62	63	64	65	66	67	68	69	70
Comp. No.	103	96	97	95	100	99	104	109	111	112	113	115	117	118
Serial No.	72	73												
Comp. No.	119	120												

Machine code conversion

This is also achieved by the computer program, so as to make it accessible by the User in an easy way as shown in **Table (5)**. From **Table (5),** it is very simple to know which machine is appearing in the 0-1 matrix by reading the machine code under the serial number.

Table (5) Machine Code Conversion to Computer Program Number

Serial No	1	2	3	4	5	6	7	8	9	10
M/c No.	1158	1156	2411	1360	1117	1340	1613	1361	1610	1140
Serial No	11	12	13	14	15	16	17	18	19	20
M/c No.	1221	1216	1143	1132	1416	2211	1112	1123	1310	1338
Serial No	21	22	23	24	25	26	27	28	29	30
M/c No.	1215	1127	2117	1160	2152	1146	1220	1159	1430	1118
Serial No	31	32	33	34	35	36	37	38	39	40
M/c No.	1144	1157	1424	1145	1615	2113	4129	1616	1361	2120
Serial No	41	42								
M/c No.	2114	1427								

ORIGINAL MATRIX

The original 0-1 matrix is formed from the Processed Data given in **Table (3),** by the use of the computer program.

Table (6) Original Machine-Component Matrix

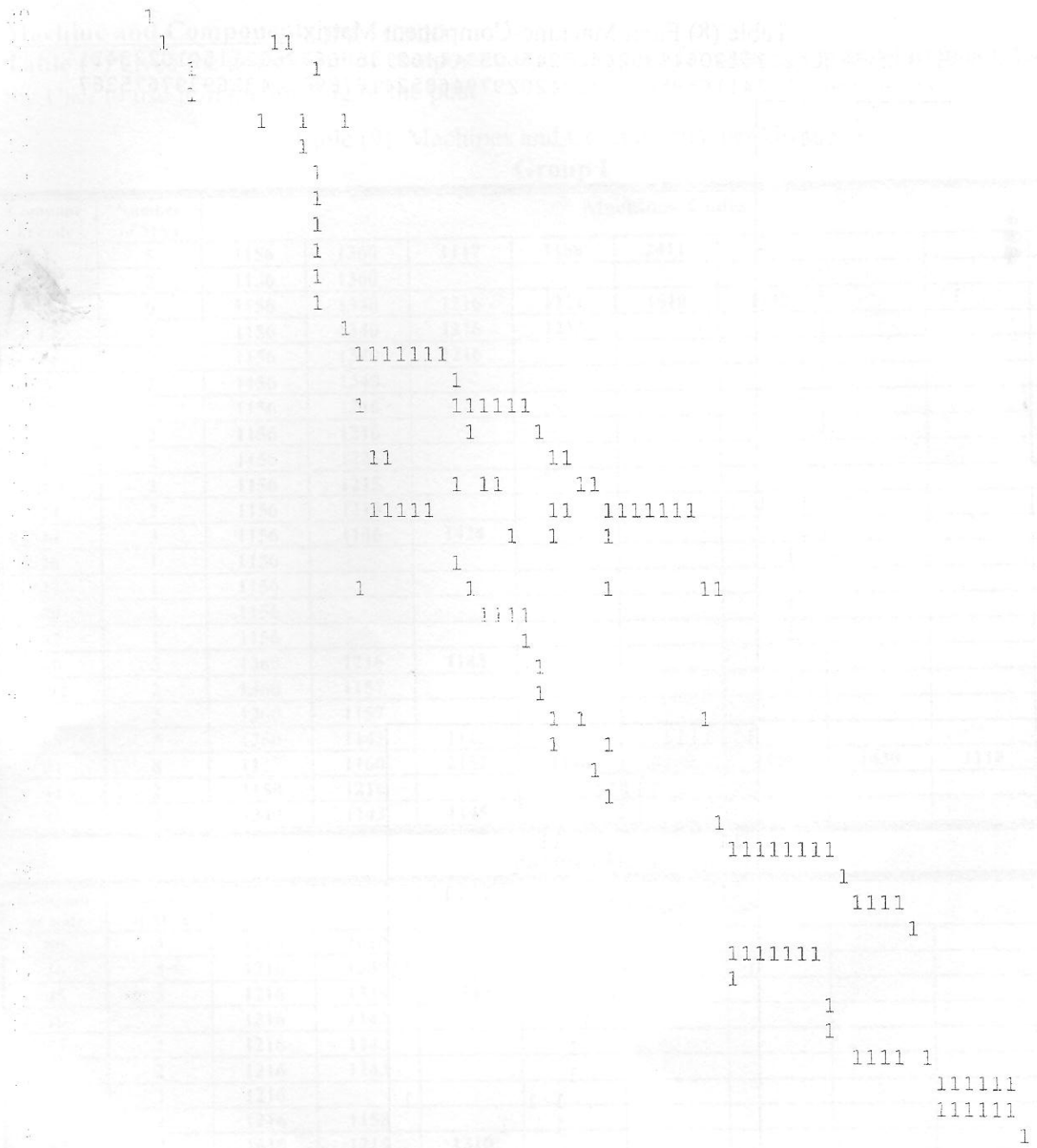
```
00000000001111111111222222222233333333334444444444555555555566666666667777
00123456789012345678901234567890123456789012345678901234567890123456789012
011                          1
0211  1  1 1 1     1 11       11  11            1    1    1
031
041                                1   1 1               1      1
051                     1
06    1    1 1                   1
07  1          1
08   1                 1 1                                   1
09    1                    1         1    1        1  11      1
10    1
11    1                           1  1                    1
12    11 1 111        1      1  1      1      1   1    11
13     1  1 1            1      11    1111 1 111 11               1
14      1                  11       1       1              1
15      1                  11       1       1              1
16        1
17        1   1 11       1                                  1
18        1              1               1            1
19        1    1       1                           1   1
20          1            1      1 1        1
21           1     1                               1                     1
22            1 11  1                                       1
23                1
24                      1
25                      1
26                      1      1
27                      1
28                      1
29                      1
30                      1
31                        1               1           1       1
32                        1          1    1              11  1 11
33                             1
34                               1   1
35                                                  1            1 1111111
36                                                  1              111111
37                                                  1
38                                                            1
39                                                             1
40                                                               1
41                                                               1
42                                                                       1
```

THE RESULTANT 0-1 MATRIX

The resultant 0-1 matrix is achieved by the use of the computer program by using one of the methods stated in the Introduction.

Table (7) The Resultant Matrix after the Application one of the Group Technology Algorithms

```
00030110023513224535642235130445352456724660334446215666677601115010223451
00145202813780097286303824116595605131242029794685241678901443569397675387
02111111111111111111
0411                1111
051                      1
011                       1
031
06   1111                  1
12   111 11         1     1
11   1     11
09   1
10   1
21    1       1
```



THE FINAL 0-1 MATRIX

The final 0-1 matrix is achieved by the re-assignment of exceptional parts to one of the formed groups whenever is possible.

Table (8) Final Machine-Component Matrix

Machine and Components per Group

Table (9) gives the assortment of component and machines for each group so as to make it easy for the User to use it in the loading of the plan.

Table (9) Machines and Components per Group

Group I

Compone nt code	Number of M/cs	Machines Codes								
4	5	1156	1360	1117	1158	2411				
50	2	1156	1360							
9	6	1156	1340	1216	1221	1610	1140			
17	4	1156	1340	1216	1215					
14	3	1156	1340	1216						
5	2	1156	1340							
12	2	1156	1216							
27	2	1156	1216							
49	2	1156	1221							
103	2	1156	1215							
24	2	1156	1215							
44	3	1156	1146	1424						
26	1	1156								
42	1	1156								
79	1	1156								
87	1	1156								
66	3	1360	1216	1143						
102	2	1360	1157							
104	2	1360	1157							
68	3	1360	1143	1123						
31	8	1157	1160	2152	1146	1220	1159	1430	1118	
41	2	1158	1216							
48	3	1340	1143	1145						

Group II

Compone nt code	Number of M/cs	Machines Codes								
89	3	1216	1610	1310						
16	3	1216	1338	1143						
45	3	1216	1338	1143						
10	2	1216	1143							
77	2	1216	1143							
82	2	1216	1143							
93	1	1216								
11	2	1216	1158							
83	3	1610	1215	1310						
34	3	1610	1157	1144						
69	3	1610	1157	1144						
88	3	1610	1123	1144						
100	3	1610	1144	1616						
123	3	1215	1615	1427						
33	5	1123	1143	1112	1316	1338				
70	2	1143	1338							
95	2	1157	1316							
99	2	1157	1361							
10	2	1216	1143							
65	1	1143								
67	1	1143								
74	1	1143								
78	1	1143								
80	1	1143								
111	1	1143								
28	2	1316	1310							
20	2	1310	1613							

Group III

Compone nt code	Number of M/cs	Machines Codes								
86	3	1615	2113	4129						
112	2	1615	2113							
113	2	1615	2113							
115	2	1615	2113							
117	2	1615	2113							
118	2	1615	2113							
119	2	1615	2113							
109	3	1615	2120	2114						
8	1	1316								
18	2	1127	1112							
[illegible]	2	1127	1112							
22	2	1127	1112							
97	2	1127	1112							
7	1	1613								
25	1	1127								
11	2	1156	1216							
35	2	1132	1416							
36	2	1132	1416							
51	2	1132	1416							
71	2	1132	1416							
91	2	1132	1416							
23	1	2117								

CONCLUSION

It can be concluded from the work done the following:

1- The input data was organized in a such way that its enterance to the program was easy and little time consuming by the end user in the work shop.

2- The program was set in a such a way that will conver the input data into a form understood and usable by most of the group technology formulation methods.

3- the output from the program was as easy and understandable by the end user in the work shop.

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