REPORT ON MANUFACTURING SYSTEMS

Manufacturing Facility Design for WayFor Manufacturing Company

Created by

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EXECUTIVE SUMMARY

Dear WFMC,

We at AMC, as per your request, have just concluded with our year-long survey of the plant and resources and managed to come up with a design approach which is designed and catered to suit and fulfill your needs and satisfy your firm's primary objectives as stated.

A detailed analysis of the approaches, given the resources WFMC currently possess and the demand forecasts predicted for 2017 has been carried out, the main objectives have been considered and thorough detailed explanations with assumptions and procedural steps have been listed explicitly.

WFMC's objective has been kept in mind while designing and laying out the facility of the plant to **achieve feasible production rates** without letting the throughput times go beyond limits and keeping the queue lengths as short as possible. The design has been made in a way that the demand is at least met by the production rate for each part.

This main objective is also backed up by subsequent objectives such as **maximizing average machine utilizations**, **minimizing the flow of parts between groups** so as to reduce material handling and **minimizing setup time**.

We employ the technique of **group technology** so as to incorporate the various different types of products belonging to different families which are manufactured on different machines. The group formation is followed by assignment of products to machines. **Queueing analysis** is conducted next to analyze the performance of the system, which is followed by **cost analysis** and **facility layout**. Some important **assumptions** kept in mind throughout the report are:

1) 1 shift of 8 hours each day is considered. It is also assumed that there are no breaks within the system.

2) Production is considered for 5 days a week i.e Monday - Friday (No production on Weekends). It is considered in a way that, workers and employees work thoroughly and vigorously for 5 days a week, followed by a well-deserved break for 2 days on the weekends. We suggest WFMC to follow the the idea of '**Work less, but Work Well!**'.

3) For calculation purpose, a day is calculated as 8 hours of production and demand in all cases is the forecasted demand for 2017.

4) A set of different groups have been created for Machine 'M' and Machine 'Q', as these machines are most frequently visited by the various part types.

5) All machines are continuously working in the 8 hour shift.

6) All machine groups are considered in such a way, that every group of parts assigned to a machine group has all the machines required by all parts in that part group, thereby reducing intergroup movement of parts.

SOLUTION APPROACH

We first order the machines with the corresponding part types by taking into consideration the group technology approach. The basic approach in group technology stems from the fact that throughput times can be reduced considerably if the product types only visit a set of machines on which they are operated upon, instead of the whole system. We find this approach intuitively feasible. The next step is the grouping of various machines with the part types on the basis of utilizations that are calculated. This gives us the basis for running various other models such as queuing and is the building block for the facility layout.

GROUP TECHNOLOGY:

The steps taken to implement this procedure are as follows:

Group formation:

We select the binary ordering algorithm to check the visiting order of product types with the machines.

	M	A	Q	E	B	C	L	D	K	R	O	P	G	J	I	F	H	N
2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
5	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
11	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
12	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
15	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
37	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
40	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
10	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
14	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
4	1	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
8	1	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
9	1	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
13	1	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
18	1	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
24	1	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
25	1	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
30	1	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
33	1	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
36	1	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
38	1	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
6	1	1	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0
22	1	1	0	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0
23	1	1	0	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0
28	1	1	0	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0
17	1	0	1	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0
43	1	0	1	0	1	0	0	0	0	0	0	0	1	1	1	0	0	0
34	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0
35	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0
41	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0
21	1	0	1	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0
3	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
7	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
31	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
26	1	0	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0
27	1	0	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0
29	1	0	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0
32	1	0	0	1	0	0	0	1	0	1	0	0	0	1	0	0	0	0
39	1	0	0	1	0	0	0	1	0	1	0	0	0	1	0	0	0	0
20	1	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0
16	1	0	0	0	1	0	0	0	0	0	0	0	1	1	1	0	0	0
19	1	0	0	0	1	0	0	0	0	0	0	0	1	1	1	0	0	0
42	1	0	0	0	1	0	0	0	0	0	0	0	1	1	1	0	0	0

The following observations are made from the above calculations:

The ordering above gives us reasonably good groupings of products and machines, although there were some products that were tricky and have to be routed to particular groups

- Groups of parts have been made in such a way that that intergroup movement of parts is avoided so as to save time and increase the productivity although this might result a bit in increase of machines in some groups.

- As mentioned before, separate groups for machine types M and Q have been provided because many parts visit both those machines.

Group	Parts	Machines
1	2,5,11,12,15,37,40	A E B
2	1,4,8,9,13,18,24,25,30,33,36,38	A C D K
3	10,14,6,22,23,28	A E C L R O
4	34,35,41,21,3,7,31	R P G F
5	16, 42B, 19,42	B G I J
6	17,26,27,29,32,39,20	E D P R J

GROUP ANALYSIS:

The analysis for each group was conducted next. The primary steps taken were to calculate the lower bound on each machine type considering just the processing time, which was followed by constructing the machine utilization matrix for each product type in the group.
The machine utilization matrix takes into consideration the loading/unloading time and the processing times, but no setup time between the products on the machines. The formula used is to calculate the utilization u_{im} of product i on machine m is:

$$U_{im} = [(D_i) + (t_{im}D_i)]/Q_iR_m$$

where D_i is the demand of product i per day, t_{im} is the processing time of one part of the product type i on machine m and R_m is time available per machine per day.

We then assigned the product types to the machines using the utilization matrix. In doing the assignment, we kept the following points into consideration:

- Assignment of the whole batch of a product type to the same machine was done as far as possible as it eased up the material handling process.
- We tried to assign product types whose utilization was below the average utilization (U). As soon as the average utilization was breached, we opened up a new machine of that type.
- All this while, we also tried to maximize the utilization on each machine, so that we wouldn't need to open up a new machine unnecessarily Therefore, if time was available on a machine and even if the U value was breached, we would go ahead and assign the

product to that machine instead of opening up a new machine to save the machining cost.

- In the assignment tableau, the total utilization column is calculated by summing up the previous value of total utilization for that machine, the utilization of the new product type and the setup time while changing the product type.

All the results of the calculation are shown in the appendix.

The assignment of products to the machine types exposed some new problems. These problems and their solutions are as mentioned below

I. As per the calculations, it was observed that the total Utilizations all the parts on Machine A came out to be 4.33 that tells Us that the minimum number of machines of A required in group one should be 5 although it can be seen that the last machine A will now be utilized to its maximum but rather than sending one of the part of group one to other group just for one process will increase the throughput time. Hence, we have avoided that, giving more priority to production and meeting the demand.

II. In group 2, utilizations of certain product types on machine D were exceeding 1.Hence we decided to divide the demand of those product types into two(or more) batches. Hence, 37 parts of product 9 were operated on D2 and the rest 25 were operated on D3.

III. Similarly Utilizations for all the parts for group 3 are calculated and and it is observed that machine O has the least utilization but still we have to allot one O machine to this Group.

IV. In group 4, utilization of part 21 on some machines is greater than 1 and hence we decided to divide the demand of those products into batches like 49 orders of part 21 are made on F3 and rest on F4.

V. The groups for machine M and Q were created separately and a separate space is dedicated to them in the facility layout. This indicates that all the product types which require operations on M and Q will be routed to these groups. Instead of the utilization matrix, we have assigned products to machines taking into consideration the time available. Our main objective in assigning products to M and Q was to reduce the setup time and maximize the utilization on each machine opened.

Hence, in our calculations, we have proceeded further with 25 machines of M and 4 of Q. A definite risk involved in analysing the system otherwise will be to make assumptions of great uncertainty, which we have avoided. In combining parts of different product types, we would definitely save a lot of money on machines and operators.

The group analysis step yielded the following result. The table shows the number of machines of each type in each group, the total number of machines of each type required and the total machines of all type in the system.

Machine	Group 1	Group 2	Group 3	Group 4	Group 5	Group	M	Q	TOTAL MACHINES
A	5	3	2						10
B	2				1				3
C		3	1						4
D		10				1			11
E	3		2			1			6
F				5					5
G				6	3				9
I					1				1
J					1	1			2
K		6							6
L			1						1
M							25		25
O			1						1
P				1		1			2
Q								4	4
R			1	2		1			4

QUEUEING ANALYSIS:

After the assignment of parts to the machines in each group, the next step was to analyse the system using the queueing model. Assuming a closed model seems convenient in this case because it allows us to model the system effectively. With the assumption of a closed system, we know that we will start producing another part only when the current part type is finished and comes out of the system.

All the 8 groups were analysed separately using the mean value analysis technique on the MVA software to obtain the throughput times, queue lengths, production rates and the machine utilizations of the group. All the results are shown in the appendix.

The most important aspect of the analysis was to decide upon the number of parts of each product type that were to be kept constantly in the system. The number of part types had a significant effect on the throughput times and the production rates. One of the limitations of the MVA software is that, the number of parts for a given part type in the system at a time, should be less than 50.

The daily demand of some of the part types exceeded 50 and therefore had to be taken care of. To fix these values for each part type, we divided all the demands of the part types in a certain ratio and kept those values as the number of parts (Num). For example, if a group had 10 parts of part 1, 8 of part 2 and 6 of part 3, we kept the number of parts as 5 for part 1, 4 for part 2 and 3 for part 3.

Other important observations and aspects while analysing the queueing models were:

I. The MVA model gives us values for throughput times, production rates, queue lengths and machine utilizations. In general, higher production rates and machine utilizations and lower throughput times and queue lengths give us a good model. The number of parts value were taken in proportion for most of the group families and therefore we would not expect the results from the software to be perfectly accurate. By considering such tradeoffs and taking into account the assumptions, we have set certain parameters for this analysis.

II. Our main objective was to achieve a production rate value which would satisfy the demand requirement for a product in one day. Upon getting stable and reasonable values for production rates, we would then concentrate on minimizing the throughput times and queue lengths. The last aspect to be considered was machine utilizations.

III. The machine utilizations came out to be very similar to the ones that we calculated in the group analysis using the utilization matrix. This shows that the analysis conducted gave us a near optimal model.

IV. It was observed that the production rates for many parts come out to be slightly greater than the demand required. It is therefore implied that the plant is producing more than necessary and there's a lot of inventory getting stacked up. Excessive inventory is always an issue because we incur inventory holding costs. This can be minimized by considering some options such as adding buffers between the machines could be considered. However, in the process of producing more, we have maintained a fine balance between the throughput times and production rates and not let the throughput times go sky-high.

V. We have considered that the transportation of parts between machines and between groups is done by carts. Each cart can hold 4 tote bins. On an average, since each tote bin could carry
5 parts of any product, we assume each cart can carry 20 parts at any time.

VI. Since the MVA software doesn't allow users to input setup or L/U time, we have incorporated that in the mean service time for a product type on a machine. From the sequence obtained in assigning products to the machines, we know which product type will get operated when on a machine. This knowledge was sufficient enough to distribute the L/U time and setup time among the mean service time for product types.

FINANCIAL ANALYSIS:

The detailed cost analysis considering the operator cost and the machining cost has been given in the appendix. The final annual values are tabulated below:

ANNUAL EXPENSES	FIXED COST($)	VARIABLE COST	TOTAL
MACHINING COST	566640	8878236.08	9444876.08
SALARY EXPENSES			5725296
		Total Cost	15170172.08
annual earning	77647761		
Profit	62477588.92		

The important considerations and steps taken to calculate the profits are as follows:

I. The number of operators required have been calculated groupwise. It is assumed that an **operator can look after more than one machine** during his shift. Some of the machines require operator supervision 20% of time, so operators have been assigned machines taking into consideration the supervision time required for each machine type within the group.

II. It is assumed that **70% of the operators are highly experienced** and paid wages at the rate of $50/hr. The other **30% of operators are assumed to be newly-recruited** and hence provided $28/hr as given in the problem description.

III. 1 lead machinist is required for every 10 operators. So a total of **5 lead machinists** are taken into consideration. Also, a total of **20 labourers** are considered for **moving the carts within the groups and in between the groups**. These labourers are assumed to be paid **$20/hr**.

IV. The annual wages for operators are calculated considering only **8 hours of work** per day. The same is done for lead machinists and labourers.

V. The machining cost has been subdivided into two parts – annual fixed machining cost and annual machining cost. Both are calculated separately initially and then summed up to obtain the total annual machining cost. All the machining cost has been done group wise as shown in sheets in the appendix.

VI. Since the selling price of product types vary between **$80 to $500**, we have generated random values of selling prices keeping in mind a very crucial and reasonable assumption. We have assumed that the **price of a product whose demand is very high is considerably lower as compared to some products whose demand is quite low**.

VII. Material handling costs (carts, tote bins, etc) has not been taken into consideration and shall be added as deemed necessary.

FACILITY LAYOUT

The key aspects considered while doing the facility layout are:

I. The quality testing area has been included within the manufacturing area.

II. The manufacturing area is assumed to have a total of 450 X 400 sq. ft. that gives a total area of 180,000 sq feet as mentioned in the description.

III. The main objective was to minimize the flow of parts between different groups.

IV. Keeping in mind the inter-group flow, we have kept group 1 and 2 close to each other, 4 and 5 close to each other and so on. The groups closest to M group are 1 and 2.

V. Clear boundaries are made for the groups. Machines are not stuck to the boundaries of the group. If this is done, the maintenance of machines would become considerably harder. An area of 5 X 10 sq. ft. is kept on an average in between the machines as well as between the machines and the walls.

VI. The aisle spaces have been arranged considering the dimensions of a tote bin. The tote bin dimensions ensure that the carts wouldn't occupy more than 4 X 4 sq. ft. during their movement. However, to provide enough room for and incoming and outgoing cart simultaneously, the width of aisles is kept at 10 ft. This is done within the group as well as between the groups.

VII. Anticipating great amount of cart movement simultaneously around the M group, aisles with width 20 ft. have been provided.

VIII. The input and output points for each group have been given according to the from-to chart. This is done to minimize the distance travelled by the carts. It is to be noted that distances are not calculated considering the centroid locations of the groups, but the input and output points of the groups.

IX. The quality testing area has been provided at the south side of the manufacturing area. This is done because quality testing is the last operation for most of the products, and the distance between the testing area and the assembly area is minimized.

The detailed facility layout is provided in the appendix.

CONCLUSIONS AND RECOMMENDATIONS

Our analysis considers a lot of assumptions, some of which are very practical but quite risky at the same time and lead to exaggerated results.

Risk: One of these assumptions lead to our result that 25 machines of type M will be required.

Mitigation technique: If somehow, a batch is allowed to consist of parts from different product types and different families and requiring different processing times, a batch of 6 parts requiring processing time of 2.5 hours and 4 parts requiring processing of 1.2 hours could be made. A scheme has to be formulated to insert and remove parts requiring only 1.2 hours without affecting the other 6 parts, and also the temperatures need to be maintained in a way that both the product types are heat treated properly. If this is done somehow, drastic reduction in the number of machines of M could be achieved. The number of M machines could come down from 25 to as low as 15. With 15 machines, the throughput times for all the products will decrease significantly. More importantly, the annual cost would come down by approximately $6 million, a 30% decrease in annual cost could be achieved. This is an important aspect which should be looked upon.

Risk: The labor cost required for moving the carts around is estimated to be around $5.7million as shown in the appendix.

Mitigation technique: We believe a conveyor system could be installed if it costs less than $1.5 million so that considerable savings could be made in labor. Since the machines are all fixed, a conveyor system would be a good idea. The facility layout has been laid out in a way that installing a conveyor system should be quite feasible with the aisle spaces.

Risk: Another major risk involved with the analysis is stacking up of inventory, especially in group 1 since the production rates exceed the demand required for all products. The holding cost for inventory has to be considered in that case.

Mitigation technique: One way to reduce the production rates in some of the groups for some product types would be to install buffers in between the machines. This would ensure optimal production rates and less inventory.

APPENDIX

1. ASSIGNMENT OF MACHINES TO PART TYPES:

Group	Parts	Machines
1	2,5,11,12,15,37,40	A E B
2	1,4,8,9,13,18,24,25,30,33,36,38	A C D K
3	10,14,6,22,23,28	A E C L R O
4	34,35,41,21,3,7,31	R P G F
5	16, 42B, 19,42	B G I J
6	17,26,27,29,32,39,20	E D P R J

2.UTILIZATION MATRICES & ASSIGNMENT OF PARTS TO MACHINES:

GROUP 1:

MACHINE UTILIZATION MATRIX:

Product No. / Machine	A	E	B
2	0.879752272	0.44491742	0.370935771
5	0.847499684	0.428606308	0.357336899
11	0.354478718	0.179270644	0.149461207
12	0.647749458	0.327586557	0.273114889
15	0.625688208	0.316429514	0.263813059
37	0.513283744	0.259583165	0.216419221
40	0.465624252	0.235480314	0.196324234
Machines utilisation	4.334076336	2.191873922	1.827405279
No. of machines	5	3	2

GROUP 1 PART ROUTING:

Group 1 Part routing:		
MACHINES	PARTS	Utilizations
A1	2	0.879752272
A2	5	0.847499684
A3	11,15	0.980166
A4	12	0.647749458
A5	37,40	0.97809766
B1	2,5,11,	0.877773096
B2	12,15,37,40	0.949671
E1	2,5	0.8735237
E2	11,12,15	0.8232867
E3	37,40	0.4950637

GROUP 2:

MACHINE UTILIZATION MATRIX:

Product No. / Machine	A	C	D	K
1	0.14991519	0.105252235	0.513203567	0.252197184
4	0.235097548	0.165056939	0.358037045	0.395496544
8	0.078341848	0.055002129	0.119309129	0.131791804
9	0.586159752	0.411530172	1.67242149	0.986076452
13	0.433508358	0.304356907	1.648790614	0.729276246
18	0.532047713	0.373539272	1.821355022	0.895045624
24	0.142498636	0.100045232	0.406574796	0.23972057
25	0.101239557	0.071078118	0.28885506	0.170311835
30	0.046479469	0.032632237	0.176778397	0.078190817
33	0.220660471	0.154920977	0.33605039	0.371209543
36	0.326832395	0.229462005	1.243062968	0.549818932
38	0.143650722	0.100854087	0.546356162	0.241658685
M utilisation	2.99643166	2.103730311	9.130794639	5.040794235
No. of Machines	3	3	10	6

GROUP 2 PART ROUTING:

Group 2 part routing		
MACHINES	PARTS	Utilizations
A1	1,4,8,24,25,30,33	0.974232
A2	13,18	0.9655
A3	9	0.5861597
C1	1,4,8,9,24,25	0.940597
C2	13,18,30,33	0.86544
C3	36,38	0.330316
D1	1,4,8	0.9905
D2	9(37 parts)	0.95
D3	9(25 parts)	0.676
D4	13(24 parts)	0.95
D5	13(18 parts)	0.718
D6	18(30 parts)	0.95
D7	18(27parts)	0.862
D8	24,25,30	0.8722
D9	36(13 parts),38	0.9999
D10	36(23 parts)	0.792
K1	1,4,8	0.777
K2	9	0.986
K3	13,24	0.9689
K4	18,30	0.973
K5	25,33	0.5413
K6	36,38	0.7914

GROUP 3:

MACHINE UTILIZATION MATRIX:

Product No. / Machine	A	E	C	L	R	O
10	0.351668596	0.591463613	0.296141975	0.296141975	0	0
14	0.041422214	0.069667104	0.034881865	0.034881865	0	0
6	0.471763001	0.79344773	0.397274106	0.397274106	0.238804657	0
22	0.053188524	0.0894566	0.044790336	0	0.026923831	0.044790336
23	0.064414545	0.108337394	0.054243827	0	0.0326064	0.054243827
28	0.050096866	0.084256809	0.042186835	0	0.025358845	0.042186835
M utilisation	1.032553746	1.736629249	0.869518944	0.728297946	0.323693733	0.141220998
No. of machines	2	2	1	1	1	1

GROUP 3 PART ROUTING:

Group 3 part routing:		
MACHINES	PARTS	Utilizations
A1	10,14,16,22,23	0.982
A2	28	0.05
C1	10,14,16,22,23,28	0.869518944
E1	10,14,22,23,28	0.9757
E2	6	0.79344773
L1	10,4,6	0.728297946
O1	22,23,28	0.141220998
R1	6,22,23,28	0.323693733

GROUP 4:

MACHINE UTILIZATION MATRIX:

Product No. / Machine	R	P	G	F
34	0.376757677	0	0.752992805	0.564875241
35	1.132405447	0	0.755111638	0.566464733
41	0.113335252	0	0.226513312	0.169924282
21	0	0.409406928	1.63422544	1.225952603
3	0	0	0.178890023	0.134198553
7	0	0	1.267162888	0.950592007
31	0	0	0.80515645	0.604007024
M utilisation	1.622498376	0.409406928	5.620052556	4.216014443
No. of machines	2	1	6	5

GROUP 4 PART ROUTING:

GROUP 4 Part routing:		
MACHINES	PARTS	Utilizations
F1	34,41,3	0.86888
F2	35	0.566464733
F3	21(49 PARTS)	0.95
F4	21(14 PARTS),31	0.878
F5	7	0.958
G1	34,41	0.9789
G2	35	0.755111638
G3	21(37 PARTS,)7 (25 PARTS)	0.9567
G4	21(26 PARTS,7 (18 PARTS)	0.86872
G5	7(5 PARTS)	0.2889
G6	31,3	0.98445
P1	21	0.409406928
R1	34,41,35(16 PARTS)	0.9912
R2	35(13 PARTS)	0.50222

GROUP 5:

MACHINE UTILIZATION MATRIX:

Product No. / Machine	B	G	J	I
16	0	0	0	0
42B	0.059974289	0.14981095	0.042771193	0.031696999
19	0.409773826	1.023582053	0.292233813	0.216569477
42	0.331877927	0.829004364	0.236681666	0.175400732
M utilisation	0.801626042	2.002397367	0.571686672	0.423667208
No. of machines	1	3	1	1

GROUP 5 PART ROUTING:

GROUP 5 PART ROUTING:		
MACHINES	PARTS	Utilizations
B1	42B,19,42	0.8016
G1	42B,42	0.97888
G2	19(30 parts)	0.95
G3	19(2 parts)	0.06375
I1	42B,19,42	0.423667208
J1	42B,19,42	0.571686672

GROUP 6:

MACHINE UTILIZATION MATRIX:

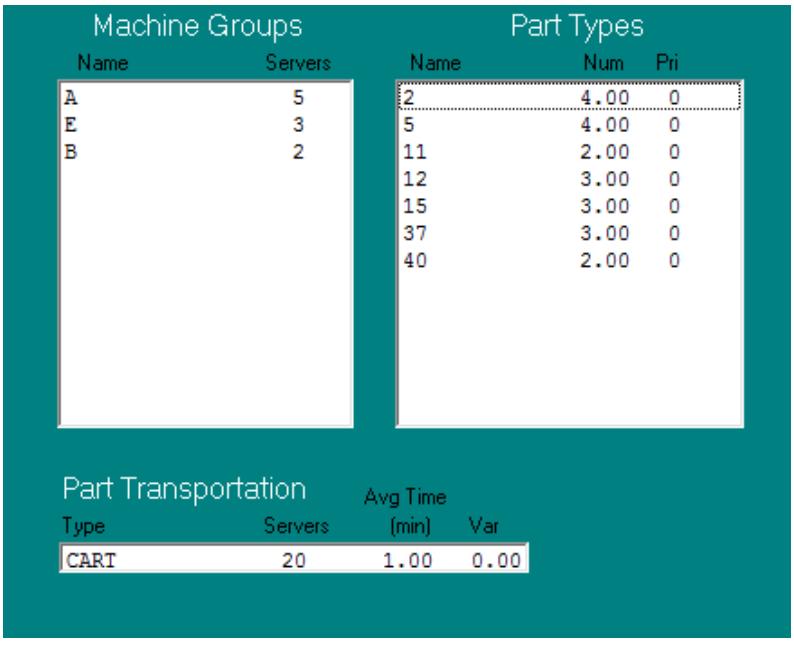
Product No. / Machine	E	D	P	R	J
17	0.215820702	0.183252562	0.269682368	0	0
26	0.11889935	0.100956999	0.148572671	0.059552707	0
27	0.10621352	0.090185508	0.132720881	0.0531988	0
29	0.103708675	0.088058653	0.129590909	0.051944206	0
32	0.23618267	0.200541834	0	0.118295999	0
39	0.075710969	0.064285904	0	0.037921092	0.350462131
20	0.009211367	0.007821337	0.011510217	0	0.112344515
M utilisation	0.865747252	0.735102798	0.692077046	0.320912804	0.462806646
No. of machines	1	1	1	1	1

GROUP 6 PART ROUTING:

GROUP 6 Part routing:		
MACHINES	PARTS	Utilizations
E1	17,26,27,29,32,39,20	0.865747252
D1	17,26,27,29,32,39,20	0.735102798
P1	17,26,27,29,20	0.692077046
R1	26,27,29,32,39	0.320912804
J1	39,20	0.462806646

3.QUEUING (MVA OUTPUT) :

GROUP 1:



MACHINE UTILIZATIONS (11 iterations)

Name	Utilization
A	0.63426
E	0.63426
B	0.79282
CART	0.07928

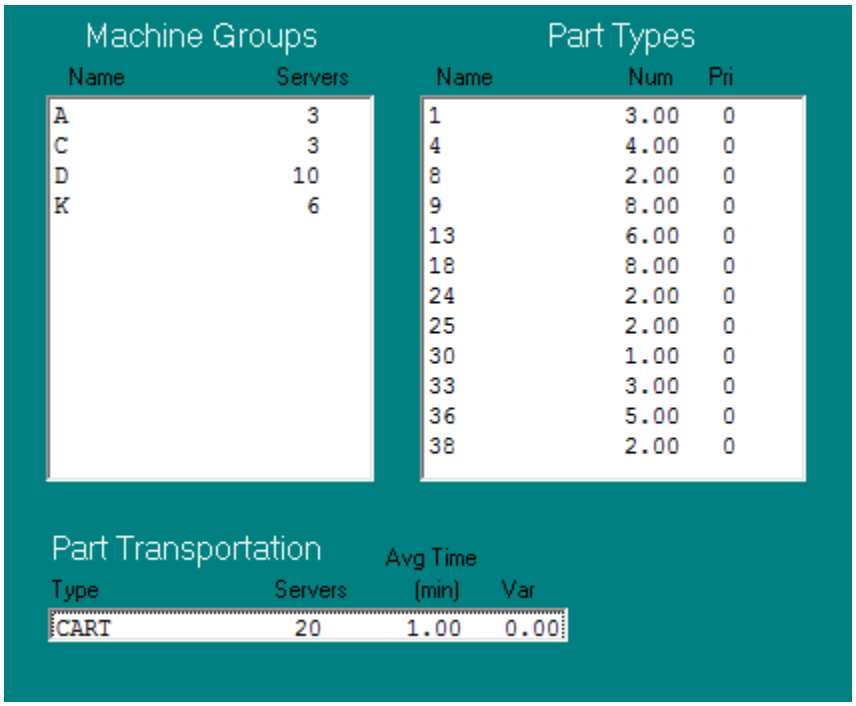
PART PRODUCTION RATE (11 iterations)

Part Type	Prod Rate (units/min)	Time In System (minutes)
2	0.10068	39.732
5	0.10068	39.732
11	0.05034	39.732
12	0.07551	39.732
15	0.07551	39.732
37	0.07551	39.732
40	0.05034	39.732

QUEUE LENGTHS (11 iterations)

	Part Types						
Machine Group	2	5	11	12	15	37	40
A	1.525	1.525	0.762	1.144	1.144	1.144	0.762
E	0.917	0.917	0.458	0.688	0.688	0.688	0.458
B	1.232	1.232	0.616	0.924	0.924	0.924	0.616
CART	0.327	0.327	0.163	0.245	0.245	0.245	0.163

GROUP 2:



Machine Groups

Name	Servers
A	3
C	3
D	10
K	6

Part Types

Name	Num	Pri
1	3.00	0
4	4.00	0
8	2.00	0
9	8.00	0
13	6.00	0
18	8.00	0
24	2.00	0
25	2.00	0
30	1.00	0
33	3.00	0
36	5.00	0
38	2.00	0

Part Transportation

Type	Servers	Avg Time (min)	Var
CART	20	1.00	0.00

MACHINE UTILIZATIONS (16 iterations)

Name	Utilization
A	0.74186
C	0.61821
D	0.58307
K	0.74186
CART	0.12364

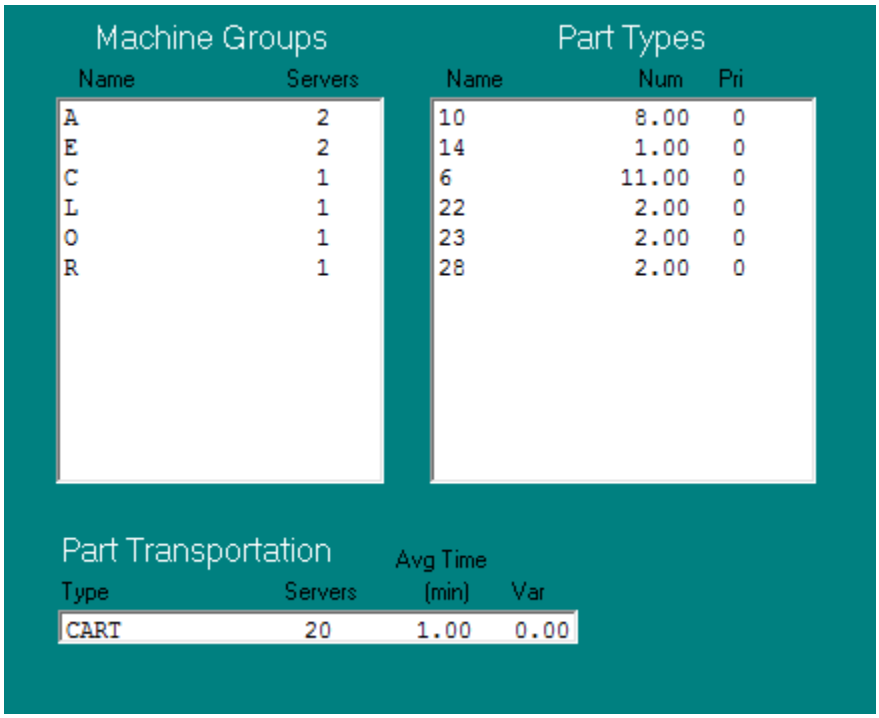
PART PRODUCTION RATE (16 iterations)

Part Type	Prod Rate (units/min)	Time In System (minutes)
1	0.03961	75.741
4	0.05723	69.899
8	0.02861	69.899
9	0.10811	73.995
13	0.07802	76.901
18	0.10562	75.741
24	0.02703	73.995
25	0.02703	73.995
30	0.01300	76.901
33	0.04292	69.899
36	0.06502	76.901
38	0.02601	76.901

QUEUE LENGTHS (16 iterations)

	Part Types											
Machine Group	1	4	8	9	13	18	24	25	30	33	36	38
A	0.521	0.752	0.376	1.422	1.027	1.390	0.356	0.356	0.171	0.564	0.856	0.342
C	0.301	0.434	0.217	0.821	0.593	0.802	0.205	0.205	0.099	0.326	0.494	0.198
D	0.959	1.055	0.527	2.431	1.979	2.558	0.608	0.608	0.330	0.791	1.649	0.660
K	1.038	1.498	0.749	2.834	2.046	2.769	0.708	0.708	0.341	1.124	1.705	0.682
CART	0.180	0.260	0.130	0.492	0.355	0.481	0.123	0.123	0.059	0.195	0.296	0.118

GROUP 3:



Machine Groups

Name	Servers
A	2
E	2
C	1
L	1
O	1
R	1

Part Types

Name	Num	Pri
10	8.00	0
14	1.00	0
6	11.00	0
22	2.00	0
23	2.00	0
28	2.00	0

Part Transportation

Type	Servers	Avg Time (min)	Var
CART	20	1.00	0.00

MACHINE UTILIZATIONS (29 iterations)

Name	Utilization
A	0.45031
E	0.90063
C	0.90063
L	0.68650
O	0.21412
R	0.35049
CART	0.06978

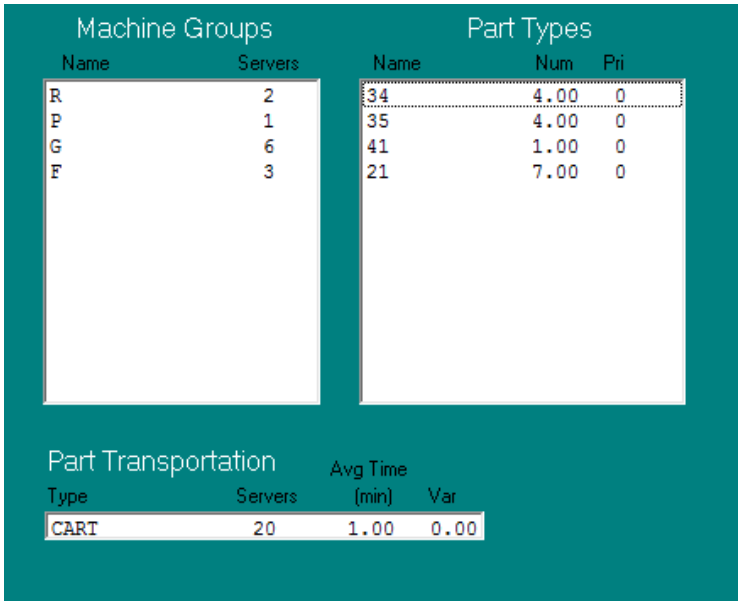
PART PRODUCTION RATE (29 iterations)

Part Type	Prod Rate (units/min)	Time In System (minutes)
10	0.09377	85.312
14	0.01172	85.312
6	0.12334	89.185
22	0.02379	84.063
23	0.02379	84.063
28	0.02379	84.063

QUEUE LENGTHS (29 iterations)

Machine Group	Part Types 10	14	6	22	23	28
A	0.496	0.062	0.653	0.126	0.126	0.126
E	4.183	0.523	5.511	1.061	1.061	1.061
C	2.110	0.264	2.780	0.535	0.535	0.535
L	0.808	0.101	1.065	0.000	0.000	0.000
O	0.000	0.000	0.000	0.087	0.087	0.087
R	0.000	0.000	0.331	0.064	0.064	0.064
CART	0.402	0.050	0.661	0.127	0.127	0.127

GROUP 4:



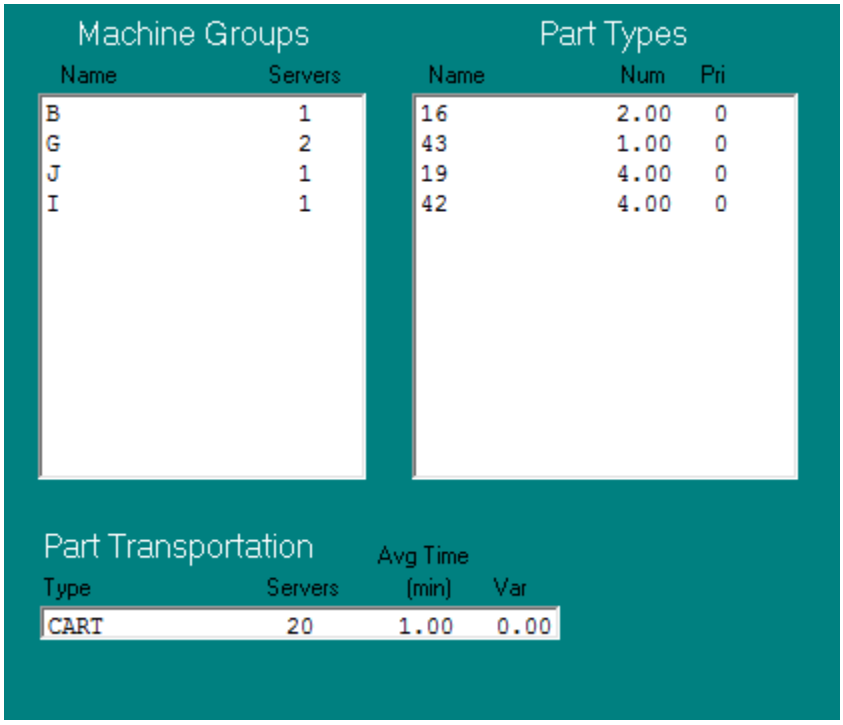
MACHINE UTILIZATIONS (10 iterations)

Name	Utilization
R	0.63057
P	0.53550
G	0.44296
F	0.70786
CART	0.03539

PART PRODUCTION RATE (10 iterations)

Part Type	Prod Rate (units/min)	Time In System (minutes)
34	0.05347	74.811
35	0.04741	84.362
41	0.01448	69.078
21	0.12060	58.046

GROUP 5:



QUEUE LENGTHS (16 iterations)

Machine Group	Part Types 16	43	19	42
B	0.327	0.164	0.654	0.654
G	1.380	0.690	2.760	2.760
J	0.119	0.059	0.237	0.237
I	0.090	0.045	0.180	0.180
CART	0.084	0.042	0.169	0.169

MACHINE UTILIZATIONS (16 iterations)

Name	Utilization
B	0.68235
G	0.85293
J	0.40941
I	0.34117
CART	0.02274

PART PRODUCTION RATE (16 iterations)

Part Type	Prod Rate (units/min)	Time In System (minutes)
16	0.02068	96.725
43	0.01034	96.725
19	0.04135	96.725
42	0.04135	96.725

GROUP 6:

Machine Groups

Name	Servers
E	1
D	1
P	1
R	1
J	1

Part Types

Name	Num	Pri
17	3.00	0
26	2.00	0
27	2.00	0
29	2.00	0
32	3.00	0
39	1.00	0
20	1.00	0

Part Transportation

Type	Servers	Avg Time (min)	Var
CART	20	1.00	0.00

MACHINE UTILIZATIONS (19 iterations)

Name	Utilization
E	0.94957
D	0.59348
P	0.80391
R	0.34115
J	0.38306
CART	0.03678

PART PRODUCTION RATE (19 iterations)

Part Type	Prod Rate (units/min)	Time In System (minutes)
17	0.04176	71.838
26	0.02610	76.625
27	0.02610	76.625
29	0.02610	76.625
32	0.04788	62.653
39	0.01596	62.653
20	0.01392	71.838

QUEUE LENGTHS (19 iterations)

Machine Group	Part Types 17	26	27	29	32	39	20
E	1.686	1.058	1.058	1.058	1.915	0.638	0.562
D	0.279	0.175	0.175	0.175	0.318	0.106	0.093
P	0.905	0.569	0.569	0.569	0.000	0.000	0.302
R	0.000	0.091	0.091	0.091	0.165	0.055	0.000
J	0.000	0.000	0.000	0.000	0.403	0.134	0.000
CART	0.130	0.108	0.108	0.108	0.198	0.066	0.043

GROUP M:

MACHINE UTILIZATIONS (19 iterations)

Name	Utilization
M1	0.99993
M2	0.99988
M3	0.99990
M4	0.99995
M5	0.99993
M6	0.99987
M7	0.99990
M8	0.99990
M9	0.99990
M10	0.99992
M11	0.99983
M12	0.99990
M13	0.99990
M14	0.99992
M15	0.99987
M16	0.99981
M17	0.50982
M18	0.98709
M19	0.94868
M20	0.95854
M21	0.96658
M22	0.96634
M23	0.96797
M24	0.48109
M25	0.94811
CART	0.01198

PART PRODUCTION RATE (19 iterations)

Part Type	Prod Rate (units/min)	Time In System (minutes)
1	0.00370	1080.113
2	0.01274	1020.060
3	0.00252	792.154
4	0.00555	1080.113
5	0.01666	720.084
6	0.00400	3503.996
7	0.00401	2743.758
8	0.00238	840.145
9	0.00398	3520.024
10	0.00425	2353.791
11	0.00490	1020.060
12	0.00926	1080.056
13	0.00393	2800.128
14	0.00185	1080.113
15	0.00937	960.063
16	0.00284	1056.069
17	0.00463	1080.113
18	0.00406	3202.428
19	0.00748	936.078
20	0.00083	1200.101
21	0.00406	3450.522
22	0.00252	792.154
23	0.00196	1020.119
24	0.00417	960.127
25	0.00389	770.845
26	0.00250	1200.101
27	0.00278	1080.113
28	0.00252	792.154
29	0.00250	1200.101
30	0.00185	1080.113
31	0.00648	1080.113
32	0.00595	840.145
33	0.00588	1020.119
34	0.00648	1080.113
35	0.00663	1056.115
36	0.00833	960.127
37	0.00741	1080.056
38	0.00417	960.127
39	0.00167	1200.101
40	0.00729	960.063
41	0.00167	1200.051
42	0.00641	936.078
42B	0.00126	792.092

GROUP M QUEUE LENGTH 1:

QUEUE LENGTHS (19 iterations)

Machine Group	Part Types 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
M1	0.000	12.987	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M2	0.000	0.000	0.000	0.000	11.983	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.995	0.000	0.000	0.000	0.000	0.000
M4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	9.991	0.000	0.000	0.000	0.000
M5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8.991	0.000
M6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M7	3.996	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M8	0.000	0.000	0.000	5.994	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.998	0.000	0.000
M10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.998	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.997
M14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M16	0.000	0.000	1.997	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.943	0.000	0.000	0.000	0.000	0.000	0.000
M18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8.610	9.049	0.000	0.000	0.000	0.000	0.000	0.000
M19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.382	0.000	0.000	0.000	5.271	0.000	0.000	0.000
M20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.721	0.000	0.000	0.000
M21	0.000	0.000	0.000	0.000	0.000	6.960	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M22	0.000	0.000	0.000	0.000	0.000	7.032	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M23	0.000	0.000	0.000	0.000	0.000	0.000	6.715	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M24	0.000	0.000	0.000	0.000	0.000	0.000	0.855	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
M25	0.000	0.000	0.000	0.000	0.000	0.000	3.417	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CART	0.004	0.013	0.003	0.006	0.017	0.008	0.012	0.002	0.008	0.009	0.005	0.009	0.008	0.002	0.009	0.003

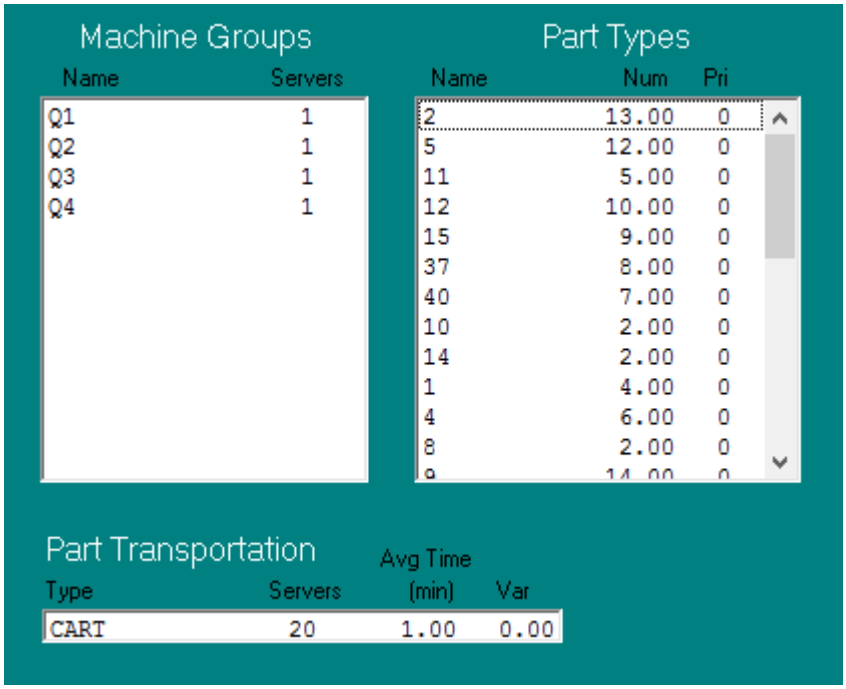
GROUP M QUEUE LENGTH 2:

17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
0.000	0.000	0.000	0.000	0.000	0.000	1.998	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.994	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.996	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.995	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.997	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	6.993
0.000	0.000	6.992	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.994	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.998	6.993	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.999	0.000	0.000	0.000	0.000	0.000	2.997	0.000	0.000	2.997	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	1.997	0.000	0.000	0.000	0.000	0.000	1.997	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	5.942	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	7.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	7.137	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	6.855	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.996	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.005	0.008	0.008	0.001	0.008	0.003	0.002	0.004	0.004	0.003	0.003	0.003	0.003	0.002	0.007	0.006	0.006	0.007

GROUP M QUEUE LENGTH 3:

34	35	36	37	38	39	40	41	42	42B
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	7.993	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	6.993	0.000	0.000	0.000
0.000	0.000	0.000	0.000	3.996	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6.993	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.994	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	6.993	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	1.998	0.000	1.998	0.000	0.000
0.000	0.000	7.992	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.999
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.007	0.007	0.008	0.007	0.004	0.002	0.007	0.002	0.006	0.001

GROUP Q:



MACHINE UTILIZATIONS (5 iterations)

Name	Utilization
Q1	0.99995
Q2	0.99994
Q3	0.99991
Q4	0.99979
CART	0.03384

PART PRODUCTION RATE (5 iterations)

Part Type	Prod Rate (units/min)	Time In System (minutes)
2	0.04404	295.210
5	0.04065	295.210
11	0.01694	295.210
12	0.03387	295.210
15	0.03049	295.210
37	0.02710	295.210
40	0.02371	295.210
10	0.00677	295.206
14	0.00677	295.206
1	0.01355	295.221
4	0.02032	295.221
8	0.00677	295.221
9	0.04402	318.019
13	0.03459	318.019
18	0.04088	318.019
24	0.01355	295.221
25	0.00943	318.019
30	0.00629	318.019
33	0.01887	318.019
36	0.02589	309.020
38	0.01258	318.019
17	0.01618	309.010
42B	0.00324	309.010
34	0.02265	309.030
35	0.02265	309.040
41	0.00647	309.020
21	0.04530	309.020
3	0.00833	240.051
7	0.04582	240.051
31	0.02916	240.051

GROUP Q QUEUE LENGTH 1:

QUEUE LENGTHS (5 iterations)

	Part Types															
Machine Group	2	5	11	12	15	37	40	10	14	1	4	8	9	13	18	24
Q1	12.954	11.958	4.982	9.965	8.968	7.972	6.975	1.993	1.993	3.986	5.979	1.993	0.000	0.000	0.000	3.986
Q2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	13.954	10.964	12.958	0.000
Q3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Q4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CART	0.046	0.042	0.018	0.035	0.032	0.028	0.025	0.007	0.007	0.014	0.021	0.007	0.046	0.036	0.042	0.014

GROUP M QUEUE LENGTH 2:

25	30	33	36	38	17	42B	34	35	41	21	3	7	31
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.990	1.993	5.980	0.000	3.987	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	7.973	0.000	4.983	0.997	6.977	6.977	1.993	13.953	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.991	10.953	6.970
0.010	0.007	0.020	0.027	0.013	0.017	0.003	0.023	0.023	0.007	0.047	0.009	0.047	0.030

NO. OF OPERATORS REQUIRED IN EACH GROUP TO FIND OUT TOTAL NUMBER OF OPERATORS:

No of operators required								
Machine	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	M	Q
A	1	0.6	0.4	0	0	0	0	0
B	0.4	0	0	0	0.2	0	0	0
C	0	1.5	0.5	0	0	0	0	0
D	0	2	0	0	0	0.2	0	0
E	0.6	0	0.4	0	0	0.2	0	0
F				5				
G	0	0	0	3	1.5	0	0	0
I					1			
J					1	1		
K		6						
L	0	0	0.2	0	0	0	0	0
M	0	0	0	0	0	0	12.5	0
O	0	0	0.2	0	0	0	0	0
P	0	0	0	0.5	0	0.5	0	0
Q	0	0	0	0	0	0	0	2
R			1			1		
	2	10	4	9	4	3	13	2

NO OF DIFFERENT TYPES OF OPERATORS:

operator	percentage	number of workers	wage/hr	no of working hours	annual wages
novice	30%	14	28	2088	818496
experienced	70%	33	50	2088	3445200
lead machinist		5	60	2088	626400
labour		20	20	2088	835200
				total salary	5725296

4.FIXED MACHINING COST:

Fixed Machining cost/mc	Group 1	Group 2	Group 3	Group 4	Group 5	Group	M	Q	annual fixed cost/mc	
A	25000	15000	10000	0	0	0	0	0	5000	
B	7000	0	0	0	3500	0			3500	
C		6000	2000						2000	
D		26500				2650			2650	
E	18900		12600			6300			6300	
F				1000					200	
G				28140	14070				4690	
I					1350				1350	
J					1600	3200			1600	
K		19500							3250	
L			2880						2880	
M							312500		12500	
O			1200						1200	
P				18675		18675			18675	
Q								4400	1100	
R			1000	2000		1000			1000	
total	50900	67000	29680	49815	20520	31825	312500	4400	566640	<==TOTAL

5.VARIABLE MACHINING COST:

Variable Machine Cost/mc	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	M	Q
A	75168	45100.8	30067.2					
B	571276.8	0	0	0	285638			
C		53557.2	17852.4					
D		2104704	0	0	0	210470.4		
E	148770	0	99180	0	0	49590		
F				39672				
G				2E+06	856915			
I					7516.8			
J					6681.6	6681.6		
K		1713830.4						
L			285638					
M							446310	
O			46980					
P				18714		18714.24		
Q								19600
R			1444	2888		1444		
	795214.8	3917192.4	481162	2E+06	1156752	286900.2	446310	19600

6.NO. OF OPERATORS REQUIRED IN EACH GROUP TO FIND OUT TOTAL NUMBER OF OPERATORS:

No of operators required								
Machine	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	M	Q
A	1	0.6	0.4	0	0	0	0	0
B	0.4	0	0	0	0.2	0	0	0
C	0	1.5	0.5	0	0	0	0	0
D	0	2	0	0	0	0.2	0	0
E	0.6	0	0.4	0	0	0.2	0	0
F				5				
G	0	0	0	3	1.5	0	0	0
I					1			
J					1	1		
K		6						
L	0	0	0.2	0	0	0	0	0
M	0	0	0	0	0	0	12.5	0
O	0	0	0.2	0	0	0	0	0
P	0	0	0	0.5	0	0.5	0	0
Q	0	0	0	0	0	0	0	2
R			1			1		
	2	10	4	9	4	3	13	2

7.NO. OF DIFFERENT TYPES OF OPERATORS AND THEIR RESPECTIVE WAGES:

operator	percentage	number of workers	wage/hr	no of working hours	annual wages
novice	30%	14	28	2088	818496
experienced	70%	33	50	2088	3445200
lead machinist		5	60	2088	626400
labour		20	20	2088	835200
				total salary	5725296

8.TOTAL COST PER PART TYPE PER DAY:

PRODUCTS	COST/PRODUCT	DEMAND/DAY	total cost/prod/day		
1	297	17	5049		
2	473	57	26961		
3	149	7	1043		
4	162	26	4212		
5	385	55	21175		
6	102	61	6222		
7	104	49	5096		
8	483	9	4347		
9	395	63	24885		
10	149	46	6854		
11	256	23	5888		
12	375	42	15750		
13	180	47	8460		
14	424	6	2544		
15	129	41	5289		
16	477	13	6201		
17	154	21	3234		
18	232	57	13224		
19	280	32	8960		
20	357	1	357		
21	310	63	19530		
22	439	7	3073		
23	476	9	4284		
24	98	16	1568		
25	125	11	1375		
26	450	12	5400		
27	320	11	3520		
28	360	7	2520		
29	153	10	1530		
30	246	5	1230		
31	211	31	6541		
32	167	23	3841		
33	369	24	8856		
34	200	29	5800		
35	238	29	6902		
36	174	35	6090		
37	450	33	14850		
38	146	16	2336		
39	455	8	3640		
40	300	30	9000		
41	489	9	4401		
42	158	26	4108		
42B	271	5	1355		
			297501	77647761	<==Total earning annually

9.NET PROFIT CALCULATION:

ANNUAL EXPENSES	FIXED COST($)	VARIABLE COST	TOTAL
MACHINING COST	566640	8878236.08	9444876.08
SALARY EXPENSES			5725296
		Total Cost	15170172.08
annual earning	77647761		
Profit	62477588.92		

10.FACILITY LAYOUT: