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Analytical Study of Cellular Manufacturing

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Abstract

An Industry must have a proper layout to analyses different physical configurations for smooth operations. Choosing correct layout for any industry is important one. In industry sectors, it is important to manufacture the products which have good quality products and meet customers demand. This action could be conducted under existing resources such as employees, machines and other facilities. However, plant layout improvement, could be one of the tools to response to increasing industrial productivity. Plant layout design has become a fundamental basis of today's industrial plants which can influence parts of work efficiency. It is needed to appropriately plan and position employees, materials, machines, equipment, and other manufacturing supports and facilities to create the most effective plant layout.

Keywords: *Industry layout, manufacturing ,plant layout,quality manufacturing,work efficiency,customer demand.*

1. Introduction

Cellular Manufacturing is a model for workplace design, and has become an integral part of , which seeks to take full advantage of the similarity between parts, through standardization and common processing The major advantage is that material flow is significantly improved, which reduces the distance traveled by materials, inventory and cumulative lead times Cellular Manufacturing employs setup reduction and gives the workers the tools to be multi process, operating multiple processes, and multi functional, owning quality improvements, waste reduction, and simple machine maintenance. Rather than processing multiple parts before sending them on to the next machine or process step (as is the case in batch-and-queue, or large-lot production), cellular manufacturing aims to move products through the manufacturing process one-piece at a time, at a rate determined by customers' needs. Cellular manufacturing can also provide companies with the flexibility to vary product type or features on the production line in response to specific customer demands. The approach seeks to minimize the time it takes for a single product to flow through the entire production process.

The first step in implementing cellular manufacturing is to break down the various items produced by the company into a number of part sets or families. The grouping process (group technology) involves identifying items with similarities in design characteristics or manufacturing characteristics, and grouping them into part families. Design characteristics include size, shape, and function; manufacturing characteristics or process characteristics are based on the type and sequence of operations required. In many cases, though not always, the two kinds of characteristics are correlated. Therefore design families may be distinctly different from processing families.

Cellular Manufacturing is the application to reorganize a manufacturing system into smaller machine cells and part families. Here, the machine cells contain functionally dissimilar machines that are grouped physically together so that they can manufacture entirely a set of parts called part family. Burbidge (1963) introduced the idea of Production Flow Analysis, a methodology to convert a functional layout into Group Technology systems. He proposed three methods - Factory flow analysis, group analysis and line analysis. In factory flow analysis, the organization decides the products to be made in each factory. In group analysis, the existing machines are divided into groups or machines cells and the parts required for the products are divided into part families. In line analysis, the capacities of the cells and the layout of the machines in the cells are studied.

2. Applications Of Cellular Manufacturing

One of the earliest applications of cellular manufacturing is well over 50 years old. Another early contribution was the book by Mitrafanov (1959) which traces the application of the principles in Russia. Another early work was that of Opitz and Weindahl (1971) who developed Classification and coding schemes. Early application of Group Technology was in developing classification and coding systems and creating part families from the codes. Burbidge (1992) reports applications of Cellular manufacturing in European countries. He also believes that every process organization can be converted to Cellular manufacturing.Wemmerlov and Hyer (1987) reported a survey of applications of Cellular Manufacturing. Among the 53 organizations surveyed from various industries 32 used CMS. They used Group Technology systems based on part similarities, dedicated equipment and manufacturing Cells. The extent of cellularization, defined as the percentage of business out of products manufactured in cells, varied from 0.2 to 88%. It is reported that 9 out of 32 firms that applied CMS, used algorithms such as PFA, ROC in the cell formation. There is a report of 1 instance of an unmanned cell. The average number of cells was between 3 and 6. 13 to 17 companies had less than 5% cellularization. The cell size varied 2 to 40 machines, next highest was 15 machines. The companies reported set up time reduction of 41%, throughput time reduction of 24%. There was a 10% increase in number of machines.In India, a variety of companies have implemented cellular manufacturing. One of the oldest applications in India is a public sector undertaking, which implemented this technique in the 1970s. With the advent of Maruti in India in the early 1980s, several auto manufacturers and automobile Ancillary Manufacturers applied this technique

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successfully. They realized the benefits of the joint implementation of Just-in-time manufacturing concepts and Cellular manufacturing. Other implementations are in Machinery Manufacturing, Valve Manufacturing, Earth moving Equipment manufacturing, Ceramics, Insulators, Grinding wheel manufacturers and in Fuel Injection Equipment. Today, every batch or discrete manufacturing organization uses the technique in some form or other.

3. Problem statement

To improve the machines layout at the machine shop by applying Cellular manufacturing techniques such as PFA algorithm and Rank Order Clustering."The plant under consideration is a production facility at Aralumoodu, in Neyyattinkara taluk, 16 kilometers south of Thiruvananthapuram. It is a Government owned and operated facility which manufactures three wheelers for passengers and goods carriers. study confines to the boundaries of the workshop floor of the facility which houses a net number of 32 machines and has a throughput of 40 parts that are entirely or partly manufactured in the facility.

3.1.Analysis of Present Layout

The present layout at the facility is shown here in the picture. The machines have been erected in a random fashion considering the arrival of each being equally random. The now completely functional plant need a change in design which can help it to be more leaner and more efficient. Our project lingers around the possibility of improving the effectiveness of the machines and infrastructure by using an improved layout.

Table 1: Present layout

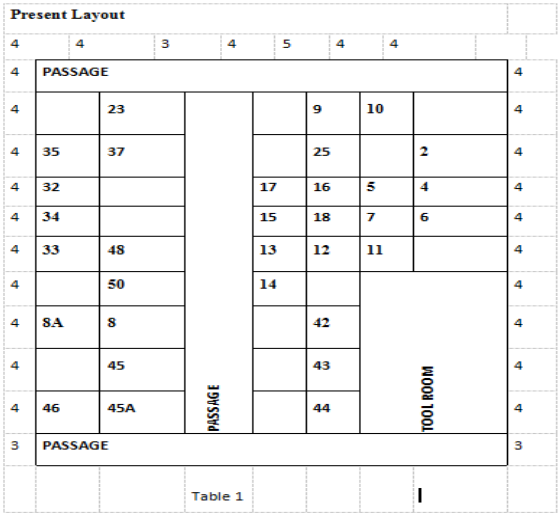


Fig. 1 Present layout

3.2 List Of Machines

3.2 List Of Machines

NAME	MACHINE CODE
CAPSTAN LATHE (4D2)	2
TURRET LATHE	4
ENTERPRISE CENTRE LATHE	5
COPYING LAIHE HINDUSTAN	6
FACING AND CENTERING MACHINE (FCM)	7
CNC TURNING LATHE (WELLER)	8
CNC TURNING LATHE (ECONO)	8A
CHIUCKMATIC LATHE	9
2D CAPSTAN LATHE NEW 2D 2	10
RADIAL DRILLING RD5O	11
RADIAL DRILLING RD 61	12
RADIAL DRILLING BALTIBOI RD 25	13
DRILLING MACHINE BATLIBOI RD 32 1	14
COLOUMN DRILLING MACHINE CD 401	15
ACCUMAX PILLAR DRILL	16
BENCHDRILL	17
AUTOMATIC TAPING MACHINE	18
HORIZONTAL MILLING	23
HMT VERTICAL MILLING	25
HMT CYLINDRICAL GRINDER (K130D-300P)	32
CYLINDRICAL GRINDER (G9)	33
AWH GRINDER (PLUNGE)	34
NEW SPIN SURFACE GH (GVS 30)	35
INTERNAL GRINDER (GIF-80)	37
GEAR SHAPER HMT NEW	42
GEAR HOBBING CUTTER	43
HMT BROACHING MACHINE	44
HMT VERTICAL MILLING VTC	45
V M C 800	45A
FINE BORING MACHINE 734	46
HONING MACHINE	48
ROLLING MACHINE	50

4. Solution Using PFA algorithm

This very popular algorithm for Cell formation was developed by Burbidge (1963, 1977). The input to this method is the machine component incidence relationship which is represented in the form of a zero-one or binary matrix. Burbidge used tick marks to capture the incidence relationship. Here, rows represent machine types and columns represent components (or parts). In this binary matrix, a 1 indicates that the component (or part) visits the corresponding machine. Each row corresponds to a machine type and multiple copies of the same machine are represented in a single row.Burbidge suggests a three stage procedure to solve the cell formation problem. These are:

- Factory flow analysis: Here, the various products that are made in a given factory are decided
- Group Analysis: Here, the reorganization of the production shop floor to machine cells and part families are made.
- Line Analysis: Here other factors such as layout, capacity planning, sequencing etc are considered and the cells are actually placed in the shop floor.

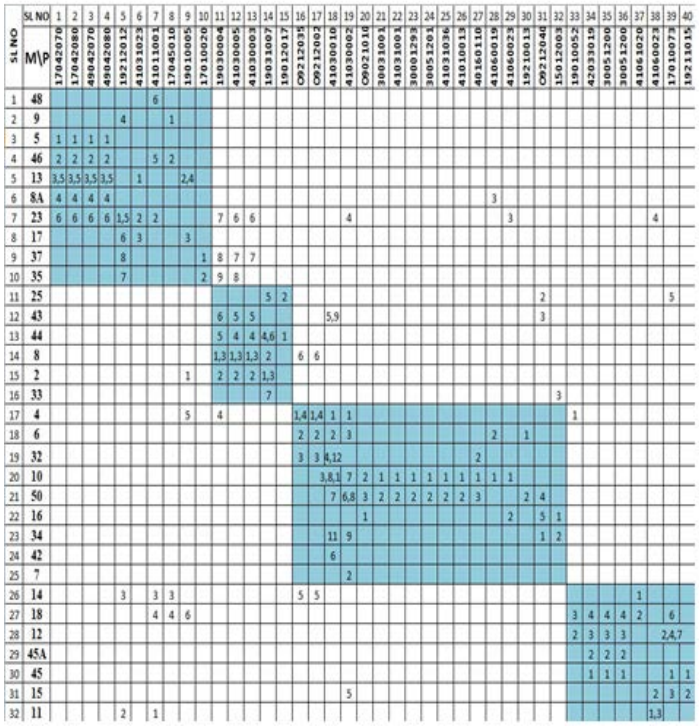
Stage 1

- Find the frequency of each machine (number of parts visiting each machine). Choose the machine with the smallest non zero frequency.
- Identify the parts associated with this machine. Identify all machines required to make these parts. Create a sub matrix which captures the incidence data. Reduce the frequency of parts for each machine.
- Repeat steps 1 and 2 till all parts are assigned to machines.
- Merge two groups if one group is a subset of another.

Stage 2

- Verify if removing a part or a machine and creating one inter cell move can reduce a machine in a group. If so, create an inter cell move.
- If the machine group formed after step 1 is a subset of another group merge the groups.
- Repeat steps 1 and 2 till no more saving can be obtained. Identify the machine cells, part families and inter cell moves.

FINAL SOLUTION



Sequence Matrix

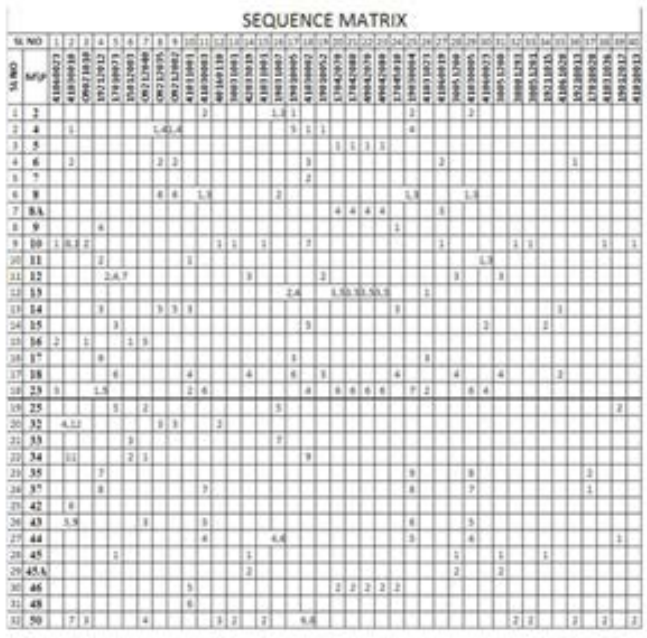
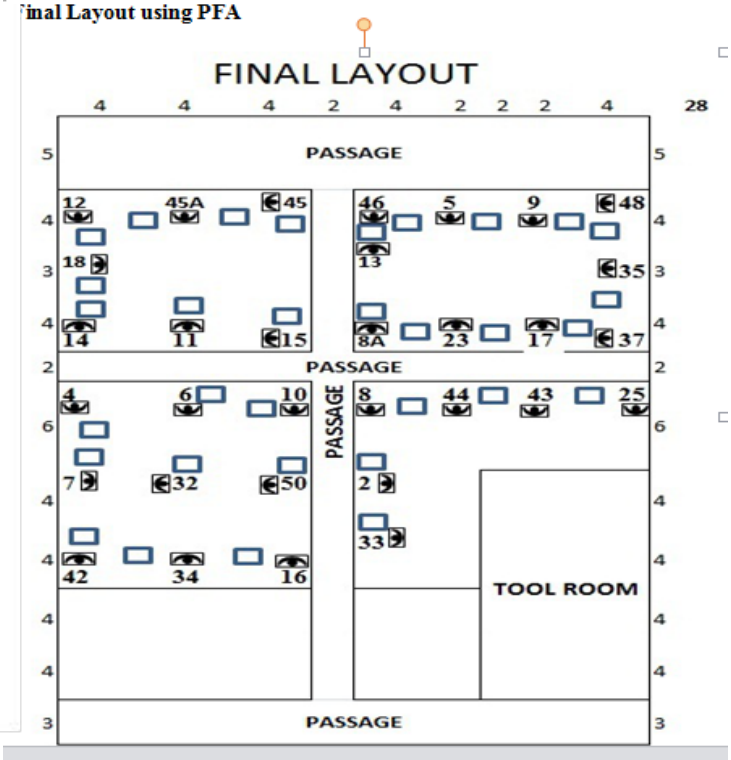


Table 2

Final Layout using PFA



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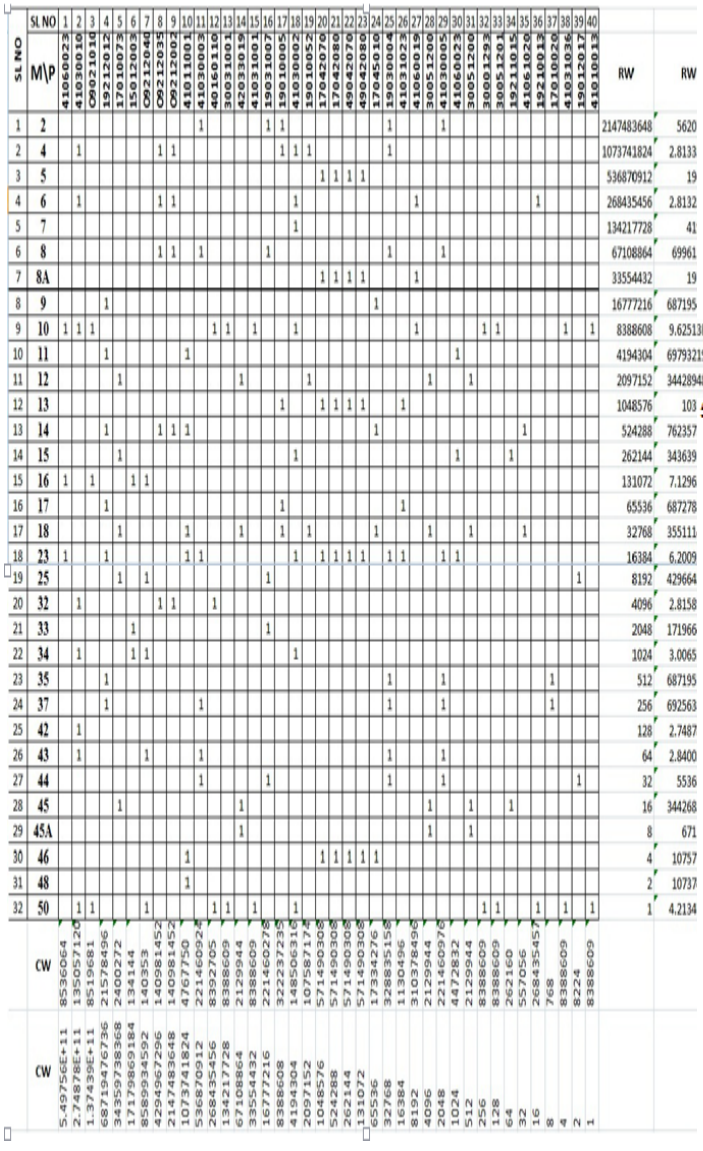
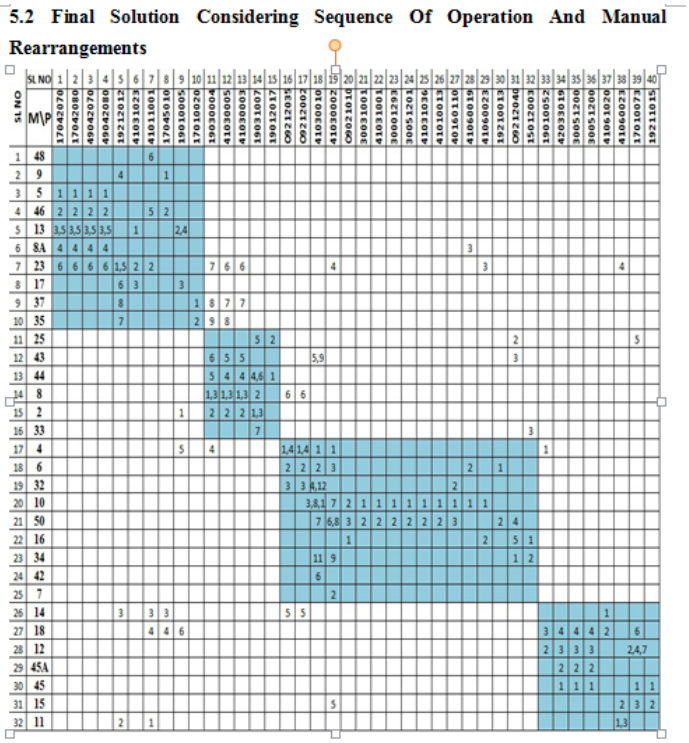
5. Solution Using Rank Order Clustering

This method was proposed by King (1980) to obtain part families and machine cells in Cellular Manufacturing. Here, we compute a weight for every row and sort the rows according to decreasing weights. We then compute a weight for every column and sort the columns according to decreasing weights.

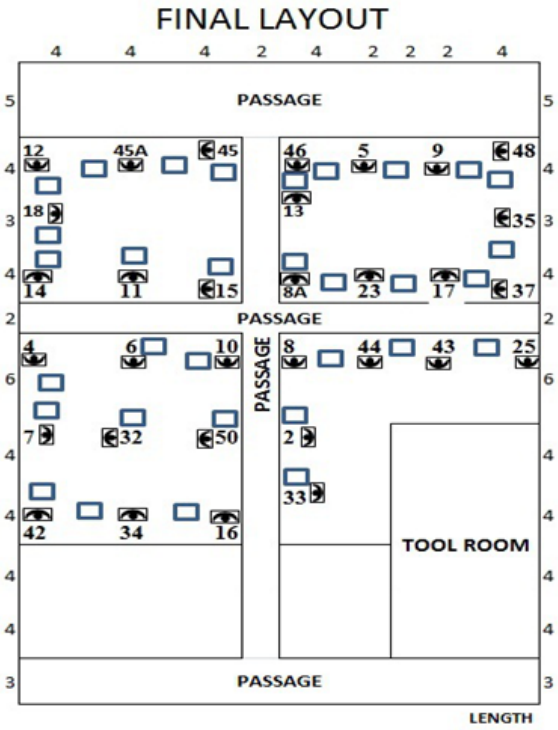
5.1. Incidence Matrix With Row And Column Weights



5.2 Final Solution Considering Sequence Of Operation And Manual Rearrangements



5.3 Final Layout using Rank Order Clustering



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- **Analysis of Modified Layout**

Now let us analyze the modified layout in comparison with the present layout. For the process the methodology adopted is to construct the distance matrix of the modified layout, calculate the net distance traveled for all the products taken together, for the initial layout and the modified layout. The difference in the amount of part travel can be considered as an indication of the change in efficiency of the layouts.

6.1.Initial Layout Part Travel Chart

SL NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
PARTS	17042070	17042080	49042070	49042080	19212012	41031023	41011001	17045010	19010005	17010020	19030004	41030005	41090003	19031007	19012017	09212035	09212002	41030010	41030002	09021010	30031001	41031001	30001293	30051201	41031036	41010013	40160110	41060019	41060023	19210013	09212040	15012003	19010052	42033019	30051200	30051200	41061020	41060023	17010073	19211015
MACHINE SEQUENCES	5	5	5	5	23	13	11	9	2	37	8	8	8	2	44	4	4	4	4	16	10	10	10	10	10	10	10	10	10	6	34	16	4	45	45	45	14	11	45	45
	46	46	46	46	11	23	23	46	13	35	2	2	2	8	25	6	6	6	7	10	50	50	50	50	50	50	32	6	16	50	25	34	12	45A	45A	45A	18	15	12	15
	13	13	13	13	14	17	14	14	17		8	8	8	2		32	32	10	6	50							50	8A	23		43	33	18	12	12	12		11	15		
	8A	8A	8A	8A	9		18	18	13		4	44	44	44		4	4	32	23												50			18	18	18		23	12		
	13	13	13	13	23		46		4		44	43	43	25		14	14	43	15												16							25		
	23	23	23	23	17		48		18		43	23	23	44		8	8	42	50																			18		
					35						23	37	37	33				50	10																			12		
					37						37	35						10	50																					
DISTANCES	36	36	36	36	24	16	24	40	17	1	32	32	32	32	24	1	1	1	1	4	28	28	28	28	28	28	20	8	4	20	16	12	8	1	1	1	4	5	16	16
	20	20	20	20	5	8	20	16	4		32	32	32	32		20	20	8	1	28							8	28	12		20	1	1	20	20	20		5	1		
	12	12	12	12	16		4	4	4		28	12	12	28		20	20	20	24												12			1	1	1		24	1		
	12	12	12	12	8		28		13		28	1	1	24		13	13	28	12												16							8		
	16	16	16	16	8		12		4		1	32	32	24		4	4	1	8																			4		
					8						32	1	1	24				8	28																			1		
					1						1	1						28	28																					
SUM	96	96	96	96	70	24	88	60	42	1	154	111	110	164	24	58	58	94	102	32	28	28	28	28	28	28	28	36	16	20	64	13	9	22	22	22	4	34	31	16

1793

PRESENT LAYOUT TRAVEL DISTANCE=1793m

6.1.Modified Layout Part Travel Chart

SL NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
PARTS	17042070	17042080	49042070	49042080	19212012	41031023	41011001	17045010	19010005	17010020	19030004	41030005	41090003	19031007	19012017	09212035	09212002	41030010	41030002	09021010	30031001	41031001	30001293	30051201	41031036	41010013	40160110	41060019	41060023	19210013	09212040	15012003	19010052	42033019	30051200	30051200	41061020	41060023	17010073	19211015
MACHINE SEQUENCES	5	5	5	5	23	13	11	9	2	37	8	8	8	2	44	4	4	4	4	16	10	10	10	10	10	10	10	10	10	6	34	16	4	45	45	45	14	11	45	45
	46	46	46	46	11	23	23	46	13	35	2	2	2	8	25	6	6	6	7	10	50	50	50	50	50	50	32	6	16	50	25	34	12	45A	45A	45A	18	15	12	15
	13	13	13	13	14	17	14	14	17		8	8	8	2		32	32	10	6	50							50	8A	23		43	33	18	12	12	12		11	15		
	8A	8A	8A	8A	9		18	18	13		4	44	44	44		4	4	32	23												50			18	18	18		23	12		
	13	13	13	13	23		46		4		44	43	43	25		14	14	43	15												16							25		
	23	23	23	23	17		48		18		43	23	23	44		8	8	42	50																			18		
					35						23	37	37	33				50	10																			12		
					37						37	35						10	50																					
DISTANCES	1	1	1	1	10	4	10	4	15	1	2	2	2	2	4	2	2	2	1	6	2	2	2	2	2	2	3	3	6	3	23	1	10	1	1	1	1	2	4	3
	1	1	1	1	2	1	14	12	7		2	2	2	2		3	3	1	3	2							1	9	15		1	7	1	1	1	1		2	5		
	3	3	3	3	20		1	1	7		14	1	1	4		3	3	3	10												11			1	1	1		10	5		
	3	3	3	3	7		12		19		18	1	1	4		4	4	14	6												2							25		
	4	4	4	4	1		8		9		1	2	2	4		14	14	24	8																			25		
					1						2	3	3	8				5	2																			1		
					1						3	1						2	2																					
SUM	12	12	12	12	42	5	45	17	57	1	42	12	11	24	4	26	26	51	32	8	2	2	2	2	2	2	4	12	21	3	37	8	11	3	3	3	1	14	65	3

MODIFIED LAYOUT TRAVEL DISTANCE =651

- **Comparison Of Efficiency**

As a decrease in travel distance can be considered as an improvement in the efficiency of the layout, the travel distance is used as a scale to measure the amount of improvement obtained by the rearrangement using the new proposed layout.

MODIFIED LAYOUT TRAVEL DISTANCE	=	651m
PRESENT LAYOUT TRAVEL DISTANCE	=	1793m
GAIN IN TRAVEL DISTANCE	=	1142m
PERCENTAGE GAIN IN TRAVEL DISTANCE=		63.67%

8. Conclusions

A gain of 63.67% is obtained in the amount of distance traveled by the parts in the case of the modified layout in comparison to the initial layout. Hence the modified layout improved the efficiency of part travel at the workshop floor by 63.67%.The amount of gain obtained by applying the cellular manufacturing technique to the shop floor is very high (as high as 63.67%). Therefore the factor of rearrangement cost considered as a disadvantage of cellular manufacturing can be written off in this case considering the large amount of saving it can provide.The two methods considered, the PFA algorithm and The Rank Order Clustering, provided the same result. This indicates the consistency of the method as proves that both the methods are based on the same general theory of operation.

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