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CREATION OF DIFFERENT CELL LAYOUTS USING PART ASSIGNMENT PROCESS FOR MANUFACTURING A TRACTION DRIVE SPEED REDUCER

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Abstract: Cellular manufacturing is an advanced technique to improve the manufacturing efficiency. This paper is comparing the efficiency of three different layouts for manufacturing self-actuating traction drive speed reducer proposed by Flugrad and Qamhiyah in 2005. The original layout which was used to produce the speed reducer and two modified layouts based on part assignments. The second layout was made so as to minimize the sum of voids and exceptions. Then it is modified to take into account processing times of different parts of that speed reducer. Twenty six parts and ten different manufacturing processes were used in the analysis. A third layout was made for two manufacturing cells only instead of three found as optimum in the second layout. A comparison between the second and the third layout shows that the second layout is the best layout according to minimum sum of voids and exceptions, while the third layout is the best according to maximum sum of processing times inside the formed manufacturing cells. In conclusion, adopting cellular manufacturing has a great consequence on for both the design and optimization of any production system.

Key words: Traditional layout, Cell formation, Manufacturing cells, Empty cell, Processing times, Exceptional elements and voids.

1. INTRODUCTION

To validate the simulation results and practical application of the proposed model for speed reducer traction drive by Flugrad and Qamhiyah (2005) [1], that traction drive was manufactured from aluminum with the optimum dimensions found numerically by Abu Jadayil and Mohsen (2010) [2]. A principal objective of this invention proposed by Flugrad and Qamhiyah (2005) [1] was to provide a traction drive speed reducer which is self-actuating. That speed reducer proposed here as a case study was designed by Abu Jadayil and Mohsen (2010) [2] so that the configuration of the rolling elements creates the needed normal force in response to the torque exerted back on the system by the downstream loading. Thus the device is self-actuating.

Worldwide competition, global manufacturing and market requirements are very important issues related to batch production, which exist nowadays in the most of the factories which needs a quick solution. Batch production system has the greatest frequency among other production systems. For that batch production system suffers from several drawbacks including lead times, high work-in-process inventories, complicated production planning and control, and quality control problems as found by Kaku and Krajewski (1995) [3]. The traditional approach to the organization of production is to use line layout for mass production and process layout in other cases. Murthy and Srinivasan (1995) [4] and Liange and Taboun (1995) [5] found that with traditional methods of manufacturing, a reduction in batch sizes would result in higher manufacturing costs due to increased cost of set-ups. To overcome the above problems related to batch production and follow up with technological improvements, it was found by Miin-Shen and Jenn-Hwai (2008) [6] that group technology (GT) provide an opportunity to re-organize and re-examine the existing facility structure, which will give better enhancement to the existing facility. GT is defined as a manufacturing philosophy for improving productivity in batch production system. Burgess *et al.* (1993) [7] stated that the cellular manufacturing system which is based on the concept of GT philosophy aims at increasing productivity and production efficiency by reducing throughput times. The main idea of GT is to identify similar manufacturing processes and features was proposed by Iraj *et al.* (2007) [8], where machines are grouped into machine cells based on their contribution to the production process. Cellular manufacturing involves processing a collection of similar parts (part families) on a dedicated cluster (or cell) of machines or manufacturing processes. The cell formation problem is the decomposition of the manufacturing systems into cells. Part families are identified by Behnam *et al.* (2004) [9] such that they will be ideally processed within a machine cell. Murugan and Selladurai (2005) [10] found that the basic information required to solve a machine cell problem is the Machine-Part Incidence Matrix, which consists of values of 0’s and 1’s, where 1 in any entry denotes that the corresponding coordinate of a part that requires the service of that machine, or 0 otherwise. Incidence matrix include, some times, more detailed like part demands, sequence and duration of operations, alternative process plans, machine capacities, intercell transportation costs, machine acquisition costs, part subcontracting, Processing times, etc as introduced by Adenso-Diaz et al. (2005) [11]. Prabhaharan *et al.* (2005) [12] indicated that most cell formation studies have focused on the independence of clustered cells, and the number of intercell movements is commonly viewed as an indicator of that. That means that most studies take into consideration one or two criterion. Nowadays there has been pressure on the manufacturing industries in the world market competition to improve their performances with regard to such measures as shorter delivery lead-times, wider range of products, shorter set-up times, and of course lower prices. Mansouri et *al.* (2000) [13] found that from a system designer's point view it is very desirable to achieve an optimal solution with respect to all the criteria considered individually by researchers, but this is impossible because of the conflicts between various criteria. Mansouri et *al.* (1993) [13] findings agreed with Min and Shin (1993) [14] findings, that physical, technological, organizational, economical factors, cell size, labor relations and available space are considered other constraints, which make it impossible to achieve an optimal solution with respect to all the above criteria.

The objective of this paper is to convert traditional process layout into manufacturing cells with respect to, two main criteria. First, maximize the processing times inside the cells. Second, minimize the intercell movements between the cells. Then it is left to the facility designer, to choose between the two objectives. Methods of producing the traction drive speed reducer and the choosing the right material have been investigated by many researchers [15-29]. That traction drive is used in this research as a case study to implement the cellular manufacturing principles on producing it.

2. METHODOLOGY

Abu Jadayil and Mohsen (2010) [2] could achieve the optimum dimensions of the traction drive speed reduced using the pro/Engineering software. Then the manufacturing processes stage started. The parts of the traction drives were fabricated based on the optimum dimensions obtained from the simulation models in the design stage. The output member of the traction drive was fabricated by sand casting process. Casting is most often used for making complex shapes that would be otherwise difficult or uneconomical to make by other methods. Moreover casting is the easiest way to manufacture parts. In manufacturing the traction drive it is required to have the outer ring and output shaft as one piece to avoid any slippage and stress concentration there. The easiest and most economical way to do it is by casting. Midplate was fabricated by casting process because of its complex shape. To separate the motion of input member from the fixed midplate, a bearing was used. The cylindrical rollers were fabricated from extruded rods of Aluminum. The extruded rod was cut to the specified dimension of the rollers and using the lathe machine the solid rollers were drilled for the center pin. The total number of fabricated parts was twenty six parts, and using ten different manufacturing process techniques, a model for the self-actuated traction drive could be made as shown in Figure 1. The fabricated parts of the speed reducer and the manufacturing processes used are shown in Table 1, where the 1 indicates using that manufacturing process to fabricate the corresponding part, whereas the 0 indicates not using that manufacturing process to fabricate that corresponding part. To simplify the analysis of this manufacturing problem, it was converted to production planning layout as shown in Table 2.

Fig. 1. The fabricated speed reducer after assembled

The process layout is the original layout that has process plan which was executed on the machines as one factory by Abu Jadayil and Mohsen (2010) [2]. Table 1 shows the transformation of the original process plan into part-machine matrix which is then shown in Table 2. In Table 1, P refers to Part, and M refers to Machine or Process used to produce that part. Where P1 is the external cup, P2 is the cover, and so on till the last part P26 which is the Rod 56. M1 is the casting process, M2 is the extrusion and so on till the tenth process which is assembling. Time used was the actual time for processing those parts. Figure 2 shows the distribution of the manufacturing processes required to produce each part of the speed reducer.

According to that process layout, the lead time was high, that transferring parts between the ten manufacturing processes within the one factory consumes a lot of time.

No specialization in machines, and so the quality was affected. For any modification needed in the final product of the speed reducer, the setup times of the machines were high, and so time needed to satisfy customer need will be high. Table 2 represents the first layout. The main objective of this work is to convert this traditional process layout shown in Table 2 into manufacturing cells based on minimum inter-cell movements and processing times.

Table 1. Manufacturing process used to fabricate the speed reducer parts

	Machine	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Part		Casting	Extrusion	Metal Cutting	Sheet Metal Cutting	Machining	Grinding	Drilling	Boring	Welding	Assembling
P1	Ext. Cup	1	0	0	0	1	1	0	0	1	1
P2	Cover	1	0	0	0	1	0	1	0	0	1
P3	Central roller	0	1	1	0	0	1	1	1	1	1
P4	Input Shaft	0	0	0	0	0	0	0	0	1	1
P5	Output Shaft	0	0	0	0	0	0	0	0	1	1
P6	Roller 1	0	1	1	0	0	1	1	1	0	1
P7	Roller 2	0	1	1	0	0	1	1	1	0	1
P8	Roller 3	0	1	1	0	0	1	1	1	0	1
P9	Roler 4	0	1	1	0	0	1	1	1	0	1
P10	Roller 5	0	1	1	0	0	1	1	1	0	1
P11	Roller 6	0	1	1	0	0	1	1	1	0	1
P12	Rubber 1	1	0	0	0	0	0	0	0	0	1
P13	Rubber 2	1	0	0	0	0	0	0	0	0	1
P14	Rubber 3	1	0	0	0	0	0	0	0	0	1
P15	Rubber 4	1	0	0	0	0	0	0	0	0	1
P16	Rubber 5	1	0	0	0	0	0	0	0	0	1
P17	Rubber 6	1	0	0	0	0	0	0	0	0	1
P18	Plate 12	0	0	0	1	1	0	1	1	1	1
P19	Plate 21	0	0	0	1	1	0	1	1	1	1
P20	Plate 34	0	0	0	1	1	0	1	1	1	1
P21	Plate 43	0	0	0	1	1	0	1	1	1	1
P22	Plate 56	0	0	0	1	1	0	1	1	1	1
P23	Plate 65	0	0	0	1	1	0	1	1	1	1
P24	Rod 12	0	1	1	0	0	0	0	0	1	1
P25	Rod 34	0	1	1	0	0	0	0	0	1	1
P26	Rod 56	0	1	1	0	0	0	0	0	1	1

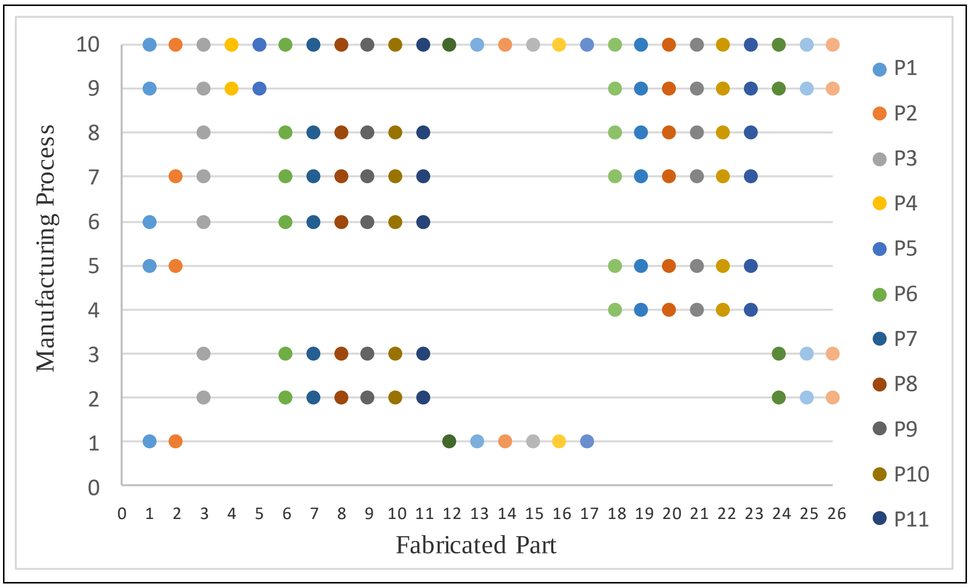

Fig. 2. Manufacturing processes required to produce each part

Table 2. The part-machine incidence matrix (Process layout)-first layout

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25	P26
M1	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
M2	0	0	1	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
M3	0	0	1	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
M4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0
M5	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0
M6	1	0	1	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M7	0	1	1	0	0	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0
M8	0	0	1	0	0	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0
M9	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
M10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

The processing time of each part with respect to each manufacturing process is stated in Table 3.

Table 3. The part-machine incidence matrix with processing times

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25	P26
	Processing times (min)																									
M1	60	60	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	0	0	0	0	0	0	0	0	0
M2	0	0	6	0	0	5	5	5	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3
M3	0	0	2	0	0	2	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
M4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	0	0	0
M5	20	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	7	7	7	7	0	0	0
M6	10	0	7	0	0	5	5	5	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M7	0	9	3	0	0	3	3	3	3	3	3	0	0	0	0	0	0	4	4	4	4	4	4	0	0	0
M8	0	0	4	0	0	4	4	4	4	4	4	0	0	0	0	0	0	3	3	3	3	3	3	0	0	0
M9	5	0	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	4	4	4	4
M10	1	1	1	1	1	3	3	3	3	3	3	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1

2.1 Convert the process layout into manufacturing cells

In order to reach the objective of this paper, it is needed to compare between different layouts based on part assignments. And so, cell formation has to be done first. Similarity coefficients between these machines will be determined by using MaxSc approach proposed by Shafer and Rogers (1993) [30]. The similarity coefficients matrix is shown in Table 4. After that part assignment will be done using two different ways in order to convert the traditional layout into two different manufacturing cells based on minimum inter-cell movements and with the presence of processing times.

2.2 Part assignment with minimum inter-cell movement

The best distribution for these machines is to form three cells. Part assignment is then done so as to minimize the sum of voids and exceptions. The final distribution of machines and parts is shown in Table 5, which represents the second layout.

2.3 Part assignment with the presence of processing times

Table 6 shows the best distribution of machines according to time matrix proposed by Mukattash *et al*. (2002) [31]. It is clear that, cell three which contains machines four, whereas seven and eight is considered to be an empty cell, since it contains no parts. For that cell formation and part assignment has to be done again. The best distribution is to form two cells, and then part assignment is done again. Table 7 below represents the final distribution, which is the third layout.

Table 4. The similarity coefficients matrix

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
M1		0.000	0.000	0.000	0.250	0.125	0.125	0.000	0.125	1.000
M2			1.000	0.000	0.000	0.875	0.700	0.7000	0.400	1.000
M3				0.000	0.000	0.875	0.700	0.7000	0.400	1.000
M4					1.000	0.000	1.000	1.000	1.000	1.000
M5						0.125	0.875	0.750	0.875	1.000
M6							0.875	0.875	0.250	1.000
M7								1.000	0.538	1.000
M8									0.538	1.000
M9										1.000
M10										

Table 5. Manufacturing cells layout with minimum intercell movements-second layout

	P1	P2	P4	P5	P12	P13	P14	P15	P16	P17	P3	P6	P7	P8	P9	P10	P11	P24	P25	P26	P18	P19	P20	P21	P22	P23
M1	1	1	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M5	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
M9	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
M10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
M2	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
M3	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
M6	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
M4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
M7	0	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1
M8	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1

Table 6. Three cell formation according to processing times with an empty cell

	P1	P2	P4	P5	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25	P26	P3	P6	P7	P8	P9	P10	P11
M1	60	60	0	0	5	5	5	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M5	20	16	0	0	0	0	0	0	0	0	7	7	7	7	7	7	0	0	0	0	0	0	0	0	0	0
M9	5	0	5	5	0	0	0	0	0	0	4	4	4	4	4	4	4	4	4	5	0	0	0	0	0	0
M10	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	3	3	3	3	3	3
M2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	6	5	5	5	5	5	5
M3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2	2	2	2	2
M6	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	5	5	5	5	5	5
M4	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	0	0	0	0	0	0	0	0	0	0
M7	0	9	0	0	0	0	0	0	0	0	4	4	4	4	4	4	0	0	0	3	3	3	3	3	3	3
M8	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	0	0	0	4	4	4	4	4	4	4

Table 7. The best distribution of machines according to processing times-third layout

	P1	P2	P3	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P24	P25	P26	P4	P5	P18	P19	P20	P21	P22	P23
M1	60	60	0	0	0	0	0	0	0	5	5	5	5	5	5	0	0	0	0	0	0	0	0	0	0	0
M2	0	0	6	5	5	5	5	5	5	0	0	0	0	0	0	3	3	3	0	0	0	0	0	0	0	0
M3	0	0	2	2	2	2	2	2	2	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
M5	20	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	7	7	7	7
M6	10	0	7	5	5	5	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M10	1	1	1	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
M4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5
M7	0	9	3	3	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	4
M8	0	0	4	4	4	4	4	4	4	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3
M9	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	4	4	4	5	5	4	4	4	4	4	4

3. RESULTS AND DISCUSSIONS

3.1. Analysis of the second layout for manufacturing processes of speed reducer

To avoid such issues of process layout, the new layout consists of three cells with minimum sum of voids and exceptions. Using this distribution will be more efficient that it will minimize the lead time for producing the speed reducer. Moreover, the setup time for each specialized machine will be less. The quality control will be much better. According to this distribution, the problem of exceptional elements will be solved by creating a virtual cell (service department). Since machine 10 (The Assembly Process) is considered to be a common machine in all parts, it is recommended to duplicate that machine.

This distribution has three main cells. The first cell includes the casting, machining, welding and assembling processes. The second cell includes the extrusion, metal cutting and grinding processes. The third cell includes the sheet metal cutting, drilling and boring processes. Based on this distribution the external cup, the cover, the input and output shafts and all rubbers from 1 to 6 all are worker out in the first cell machines. In the second cell machines the central roller, roller 1 to 6, rod 12, rod 34 and rod 56 are going to be processed there. The six plates: 12, 21, 34, 43, 56 and 65 are going to be processed in the third cell machines.

3.2 Analysis of the third layout for manufacturing processes of speed reducer

In production scheduling, the processing time is very important. So, processing time was taken into consideration in forming the manufacturing cells layout. The third proposed layout is a time matrix, where the process layout is reorganized according to processing times. According to time matrix, three manufacturing cells have to be formed according to time matrix proposed by Mukattash *et al.* (2002) [16]. Table 6, is the best layout distribution concerning the processing times. It is noticed that the third cell, which contains machines 4, 7, and 8, is an empty cell (machines without parts). The three manufacturing cells resulted are as follow:

Cell 1: Machines (M1, M5, M9, M10).
Parts:[P1,P2,P4,P5,P12,P13,P14,P15,P16,P17,P18,P19,P20,P21,P22,P23,P24,P25,P26]
Cell 2: Machines (M2, M3, M6).
Parts: [P3, P6, P7, P8, P9, P10, P11]
Cell 3 (empty cell): Machines (M4, M7, and M8), without parts

To avoid the problem of having an empty cell, cell formation and part assignment has to be done again. The best distribution is to form two cells, then part assignment is done again. Table 7 represents the final distribution (the third layout). In this distribution it can be also duplicate machine 10 (the assembly process). Duplication of machine 10 might be needed in two cells only instead of three cells as the previous case based on minimum sum of voids and exceptions. So it is economically more efficient.

Cell 1: Machines (M1, M2, M3, M5, M6, M10)
Parts:[P1,P2,P3,P6,P7,P8,P9,P10,P11,P12, P13,P14,P15,P16,P17,P24,P25, P26]
Cell 2: Machines (M4, M7, M8, M9)
Parts: [P4, P5, P18, P19, P20, P21, P22, P23]

In this distribution it is guaranteed that time is maximized inside the two cells, since cell formation for the two cells is based on minimum sum of voids and exceptions.

3.3 Comparison between the three different layouts

The original layout shown below in Figure 3 shows how all machines are included in one factory, acting as one manufacturing cell. Some processing machines are far from others in case consecutive processes are needed on these two machines, transfer time will be very high. During moving parts between processing machines, many crossing happen, and delay and disturbance for processes may occur. Some parts might need to go for welding after being machined for example, and then come back again for grinding, then again for assembling. The total lead time for producing the final product is expected to be high, besides low quality and product transfer between machines are expected. Since all processes occur in one place, some processes and may be people might be under risk.

Comparing the second layout with the third layout, it can be concluded that the two layouts completely different and part assignment is different too. Physically the 3-cell and the 2-cell layouts are shown below in Figures 4 and 5.

3.4 Comparison between the 2-cell and 3-cell layouts

Comparing the 2-manufacturing cell layouts with 3-manufacturing (Figure 5 and Figure 4) cell layouts show that the main difference is in the total lead time required. It is expected to have much less lead time to produce the speed reducer in case of 2-cell layout rather than using the 3-cell layouts.

The 3-cell layouts have many manufacturing issues which are avoided in the 2-cell layouts. The first issue concerning having the welding and casting in same manufacturing cell. These two processes are risky and it is preferred to separate them in two different cells. The second issue, it is preferred to have the assembling in different manufacturing cell rather than the one has the welding, the most risky and dangerous process. The third issue, in case the 3-cells layout, the machining and grinding were located in two different cells, which is inconvenient. This issue was taken into consideration too when two cells only were form in the 2-cell layouts.

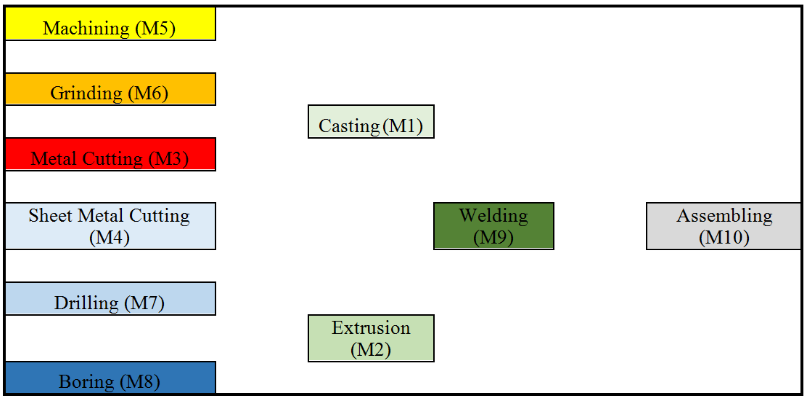

Fig. 3. Original Layout used to manufacturing the speed reducer with single one factory (One Manufacturing Cell)-First Layout

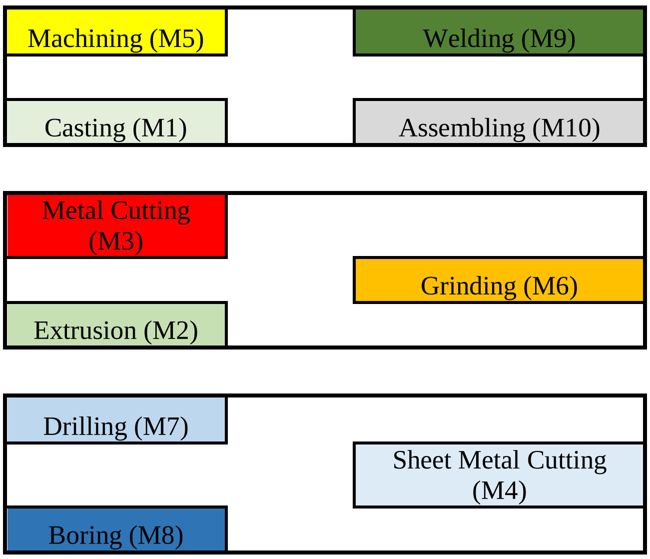

Fig. 4. The Second Layout with three manufacturing cells

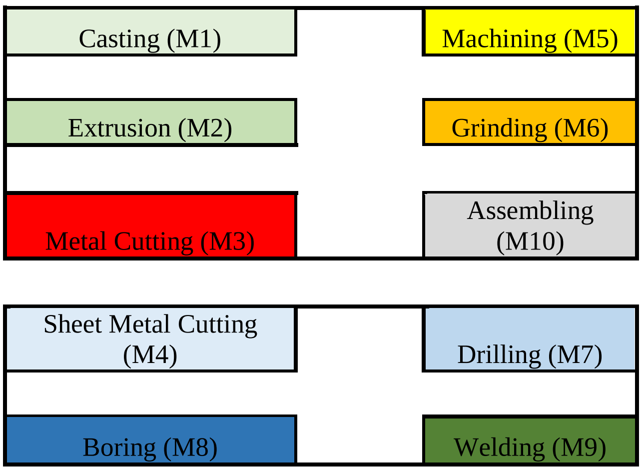

Fig. 5. The Third Layout with two manufacturing cells

4. CONCLUSIONS

This work presents two new layouts for producing the self-actuated traction drive proposed by Flugrad and Qamhiyah (2005) [1] and manufactured by Abu Jadayil and Mohsen (2010) [2] using the part assignment with minimum sum exception and voids and with the presence of processing times of parts. Based on the produced layouts, the following conclusions can be drawn:

-It is noticed that, part assignment when converting traditional process layout into manufacturing cells based on processing times may lead to an empty cell. The empty cell can be defined as a cell without machines or a cell without parts. In this case cell formation and part assignment has to be done again.

-Comparing the original layout used to produce the traction drive speed reducer with the second and third layout, shows that converting process layout into manufacturing cells will lead to minimizing the lead times and optimizing the processing times.

-Moreover, converting traditional process layout into manufacturing cells, according to two different ways of part assignment will give flexibility to the facility designer in order to decide and choose between the two layouts. This decision is generally based on several factors such as number of cells and physical, technological, organizational, economical factors, cell size, and labor relations. Moreover, available space, visible control requirements and low utilization of the cell's handling and loading equipment are factors that make it necessary to control the cell size.

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