INVESTIGATION INTO THE ROLE OF VARIOUS LAYOUT DESIGNS IN THE CELLULAR MANUFACTURING SYSTEM- A CASE STUDY

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ABSTRACT :-

Cellular manufacturing is defined as a manufacturing philosophy that works based on the Groups technology principles. In Cellular manufacturing, the layout of the factory is meaning how to arrange the equipments, facilities, staff,… etc. in the factory area. A good layout leads to reduce the production cost, increase the productivity and improve the quality. This study aims to design the best layout of the machines on the shop floor of the factory. Therefore, the current paper attempt to investigate the optimum layout design in the State Company for the Mechanical Industries, which is located in Iskandaria/Iraq. The simulation by using Arena software was applied to help selecting the optimal layout design. Five different layout designs were suggested to compare: (linear single row, linear double rows, linear multi rows, L shape and U shape). However, according to use of the simulation outcomes, the linear layout, with double rows is found to be the best layout design. It showed better performance in the terms of average waiting time, average work in process time and average total time where it recorded the lowest values with 3.9317 minutes, 11.1370 minutes and 12.9597 minutes respectively.

KEYWORDS : **Cellular manufacturing , Groups technology , Layout design , Simulation , Arena software**

التحقق من دور تصاميم مختلفه من التخطيط الداخلي في نظام التصنيع الخلوي-دراسة تطبيقية

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الخلاصة :-

نظام التصنيع الخلوي يعرف كفلسفة تصنيع مستندة على مبادئ تكنولوجيا المجاميع. قي نظام التصنيع الخلوي ؛ ان التخطيط الداخلي للمصنع يعني كيفية ترتيب المكائن؛ الالات ؛ العمال.....الخ على ارضية المصنع . ان التخطيط الداخلي الجيد يؤدي الى تقليل التكاليف؛ زيادة الانتاجيه وتحسين النوعيه . تهدف الدراسه الحاليه الى تصميم افضل تخطيط داخلي للمكائن على ارضية المصنع لذلك فان الورقة الحالية تحاول تحقيق تخطيط داخلي مثالي للشركة العامة للصناعات الميكانيكيه في الاسكندريه. في هذا البحث استخدمت طريقة المحاكاة بمساعدة برنامج (Arena Software) لاختيار التصميم الامثل حيث تم اقتراح (5) تصاميم هي (خطي صف واحد؛ خطي صفين؛ خطي متعدد الصفوف؛ حرف L؛ حرف U). وبالاعتماد على نتائج المحاكاة تبين ان التصميم الداخلي على شكل خطي ذو صفين هو افضل تصميم حيث اظهر افضل النتائج من ناحية متوسط وقت الانتظار؛ متوسط وقت العمل تحت التنفيذ ومتوسط الوقت الكلي حيث سجل اقل القيم وهي بشكل متسلسل (3.9317 دقيقة؛ 11.1370 دقيقة؛ 12.9597 دقيقة) .

الكلمات المفتاحيه: التصنيع الخلوي؛ تكنولوجيا المجاميع؛ تصميم التخطيط الداخلي؛ المحاكاة ؛ برنامج (Arena)

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1 - INTRODUCTION :-

Cellular Manufacturing (CM) is a production concept that operates based on the Groups Technology (GT) principles (Houshyar et al., 2014). CM goes to achieve positive advantages related to the cost, time and productivity (Pan, 2014). In this manufacturing system each group of parts are located in one family based on the similarities in the design and production features .

On the other hand, each dissimilar group of machines that used to perform all the operations of one family of parts are located in one cell (Prasath and Johnson, 2015; Bharamgude, and Telsang, 2014; Karim and Biswas, 2015). CM found to be the best alternative manufacturing system that deals with the customer demand and market competition (Dixit, and Goyal, 2015).

Thus, it is very important to change the existing traditional layout to a cellular layout in the way that leads to obtain an optimistic impact. The present paper used a simulation method by Arena software to examine different types of the layout designs. On the other hand, the State Company for the Mechanical Industries, which is located in Iskandaria / Iraq was selected to carry out the current research.

The residual sections of the current paper involve the review of the related literature, problem identification, methodology, company description, simulation models for various layout designs, discusses the obtained results and lastly the conclusion.

2 - LITERATURE REVIEW :-

Cellular layout means the fixing up of the cells along the shop floor in order to minimize the inter-cell movement while, the machine layout means the fixing up of the machines inside each cell in order to minimize the intra-cell movement (Arkat, 2012). Patel and Patel, 2014 reviewed most of the approaches that used to solve the problem of cell formation, cell layout and machine layout. These approaches focused on the benefits of applying the cellular layout instead of the functional layout.Prajapati, 2012 applied U line balancing with different demand levels as alternative layout of the traditional linear layout. They employed the principles of just in time to improve the efficiency. Sirovetnukul and Chutima, 2010 identified the impact of the walking time on the single U-shaped assembly lines with the consideration of the worker allocation.

There are many types of machine layout such as: linear shaped layout with (single, double and multi) rows of machines, L shape, U shape, S shape, Semicircular shape and Static Machine Cellular Layout (SMCL) (Anbumalar et al., 2014). Nowadays to deal with the demand fluctuations, it is very important to apply the Dynamic Machine Cellular layout (DMCL) (Anbumalar et al., 2015). The selected layout should minimize the total moving cost, reduce the throughput time, increase the productivity, reduce the setup times (Yellale et al., 2014). Today, several studies used a simulation as a good technique to select the best, optimal or near optimal layout design (Savory and Williams, 2010; Krishnan et al., 2013; Eltawil, and Amer, 2014).

Özgürler et al., 2010 have designed and analyzed U shaped cellular manufacturing in Turkish company, their study involved some real life factors such as: overtime durations, cycle time, security buffers, profit, labor, number of shifts and manpower. Tjahjono et al., 2009 used six sigma and simulation to illustrate the principles of design the assembly lines also to demonstrate the capacity of six sigma in enhancing the process.Dal et al., 2013 have analyzed the current production lines of ready wear industry, then applied the lean manufacturing methods with the shirt production lines. From the results of this study, an improvement was achieved in the lead time, the quality and the productivity. Eltawil and

Amer, 2014 have implemented a discrete event simulation in a home appliance conveyor based assembly line. After implementing this technique, they obtained 20%, increasing in the throughput of the production line.

Krishnan et al., 2013 have compared two methods: ranked positional-weight and line balancing with variability in processing time, then their model extended for worker allocation and further line balancing. The aim of this study is to fill-in the gap between the previous two methods in an uncertain environment.

Montazer and Peterson 2001 have simulated the existing real life information (product mix, monthly requirements, existing layout and machine capacities) in foil cutter production line. They used Arena software for this purpose. The obtained results refereed that, it is rattling significant to apply cellular manufacturing to increase the throughput of the selected factory.

3 - PROBLEM IDENTIFICATION :-

The selected company was located in Iraq and established in 1970. Its output is agricultural products. It observed that the machine layout design in the selected company is arranged as a job shop. This is the type of layout that associated with several disadvantages such as complex scheduling, long setup times, long throughput time, low productivity and bad quality. In the current study, An attempt has been acted to work out these problems where different types of layout designs have been modeled by simulation based computer technique. Hence, to apply and complete this work, one product known as (Ditcher) was taken to modify the functional (job shop) layout to cellular layout.

The sequence of operations of the selected product (Ditcher) is as follows: (cutting, heating, pressing, drilling, cutting and milling), this sequence of operations is same for all types of the selected layout designs. After that a comparison between the different layout designs has been carried out to select the best one which leads to reduce the production lead time.

4 - METHODOLOGY :-

The methodology of the current paper started by Identifying the sequence of operations for the selected product (Ditcher). Then five different layout designs of machines have been proposed. Afterwards that, a simulation technique using Arena software (12.00 CPR 9) was used to model each layout design separately. The details about the simulation models were described in the following sections. In conclusion, the outcomes of the simulation based on some performance measures were analyzed and compared to pick out the best layout design. The performance measures that utilized for this function are: the average waiting time, the average transfer time, the average work in process time and the average total time.

a. Company Description

The selected company produces different types of the agricultural products. The existing layout of the selected company is a job shop oriented. This case of layout caused many troubles to this company which reflected in the productivity and quality. Thus the management policy in the future will be to vary this type of layout and establish a new production line for each product based on the CM principles. So, the current study will be a guide and starting point for this company to complete its project in the future.

b. Simulation technique (Arena software)

The simulation models built for all the five selected types of layout designs (linear with single row, linear with double rows (parallel lines), Multi parallel lines, U-shape, L-shape). The Arena models for all the five layout designs includes: (Create module) for the chosen product (Ditcher), (Process module) for each machine, (Route module) for each station, (Station module) for each machine, (Dispose module) to obtain the output.

Furthermore, one feature called Process Analyzer from Arena software has been utilized to compare between the results to select the best layout design. On the other hand, the rest information on Arena models are same for all types of the layout. The simulation models are as explained in details in the following section.

c. Different types of layout designs (Arena models)

The first selected layout design known as linear shaped layout with single row, where the required machines arranged in the same sequence of operations of the product: (cutting, heating, pressing, drilling, cutting and milling). The selected layout design is modeled by Arena software as a simulation model Figure (2). The second selected layout design is also a linear shape, but (parallel lines with double rows). The simulation model of this type is as depicted in Figure (3). The third selected layout design is arranged as linear (multi parallel lines) and the simulation model is as illustrated in Figure (4). The forth selected layout design is a U shape where the simulation model is as shown in Figure (5). The fifth selected layout design is an L shape and it's simulation model is equally revealed in Figure (6). In the end, the calculations of the various types of times related to manufacturing processes for all the selected layout designs by the Arena software are recorded. Figure(1) refers to the methodology steps, including the simulation flowchart.

5 - RESULTS AND DISCUSSION :-

In the current research, five types of layout plans were analyzed later on applying the simulation with the assistance of the Arena software (12.00 CPR 9). Grounded along the outcomes of the simulation technique that showed in Table (1), the linear layout with double rows showed the lowest value of the average waiting time with 3.9317 min which means this type is the best one. In conditions of the average transfer time, also the linear machine layout showed the lowest value, but with the single row where it recorded 2.5000 min and appeared as the best. Again the linear layout design with double rows showed the lowest values for both factors: the average total time and the average work in process time. It recorded 12.9597 min and 11.1370 min respectively which means that, this type of layout performed better than the other four types of layout. From the five selected types of layout designs, L- shape showed the highest values for all the selected performance factors which means it investigated bad results. Nevertheless, the U-shape and the linear multi parallel lines showed the same values for all the four selected comparison factors. So it is clear that the linear machine layout with double rows showed the best results for the most performance factors. Figures (7, 8, 9) refer to the best scenario for the five selected layout designs by using the option known as a Process Analyzer of Arena software. Figure(7), expressed the second scenario (the linear layout design with double rows) is the best layout design because it entered the lowest value of the average waiting time. However, from Fig 8, the first scenario (the linear layout design with single row) is the best layout design. On the other hand, again the second scenario considered as the best layout design as shown in Figure(9). Overall, based on the obtained results of the simulation technique, it can be observed that the linear layout design with double rows is the best layout for the selected company .

6 - CONCLUSIONS :-

The main aim of this article is to select the best layout design from the various available layout designs. The proper layout design was chosen based on the results that obtained from the application of simulation technique by Arena software (12.00 CPR 9). The obtained results show the effectiveness of the linear layout design with double rows. This type of layout considered as the best design based on the following outcomes:

1. Got the lowest average waiting time, where it was recorded 3.9317 min
2. Investigated the lowest total time with 12.9597 min
3. Created the lowest average work in process time, where it was registered 11.1370 min.

Furthermore the results of the different layout designs were compared with the assistance of the Processes Analyzer option of the Arena software. Overall, most of the results refereed that, the best layout design is the linear layout with double rows as indicated in Table (1) and Figures (7and 9).

7 - RECOMMENDATIONS FOR THE FUTURE WORK :-

For the future work, it is advised to:

1. Study other real life production factors such as the material handling cost, setup cost, number of shifts and manpower.
2. Utilize further shapes of the production lines such as S shape and Semicircular shape.
3. Focus on the assembly lines rather than the manufacturing lines.
4. Apply other modules of the simulation by the Arena software such as Priority, Set and Scheduling.

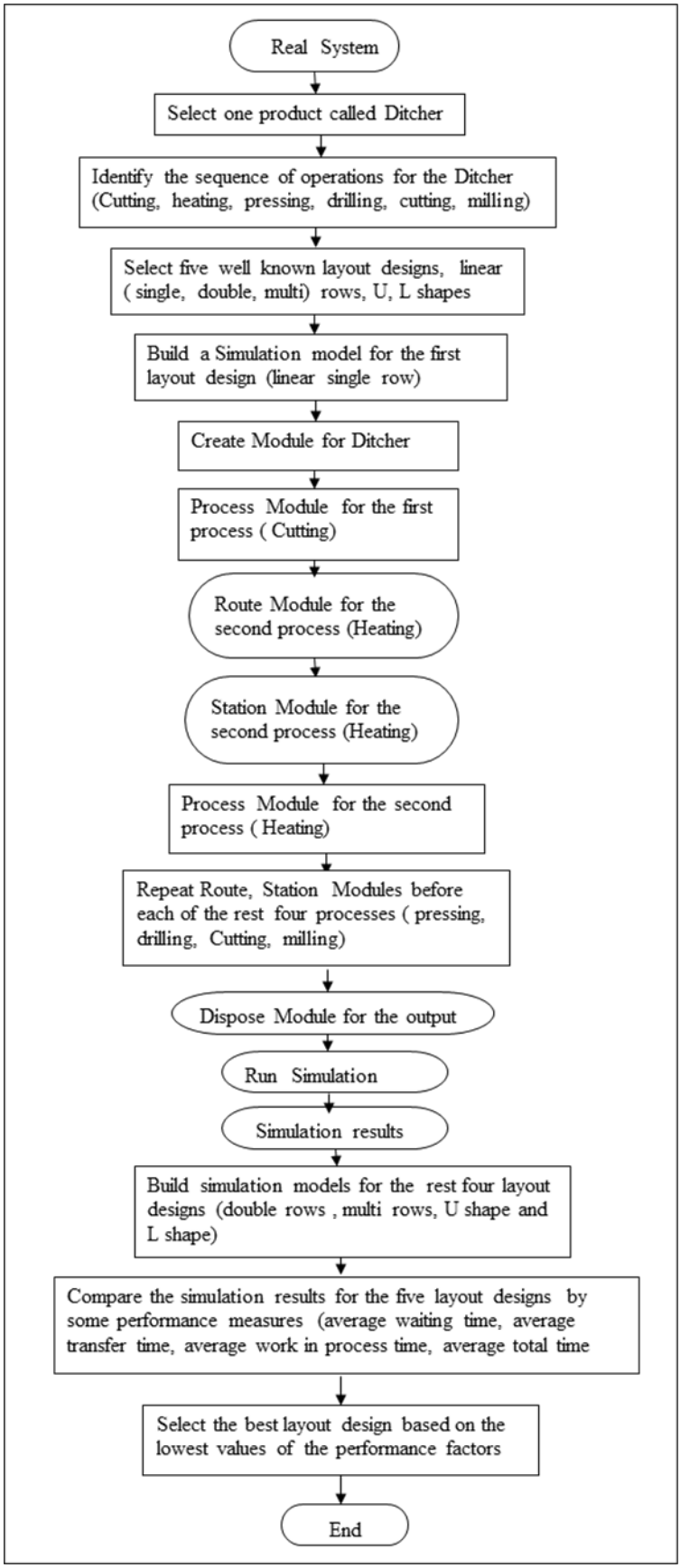

Fig. 1: The Methodology including the simulation flowchart

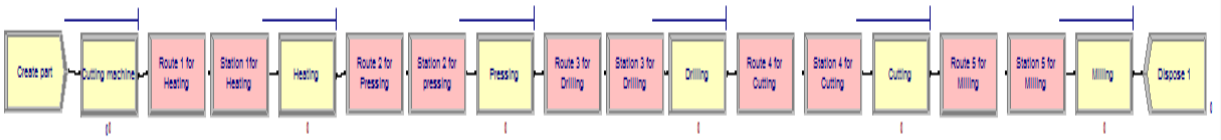

Fig. 2: Simulation model of the linear shaped layout (single row), using Arena software

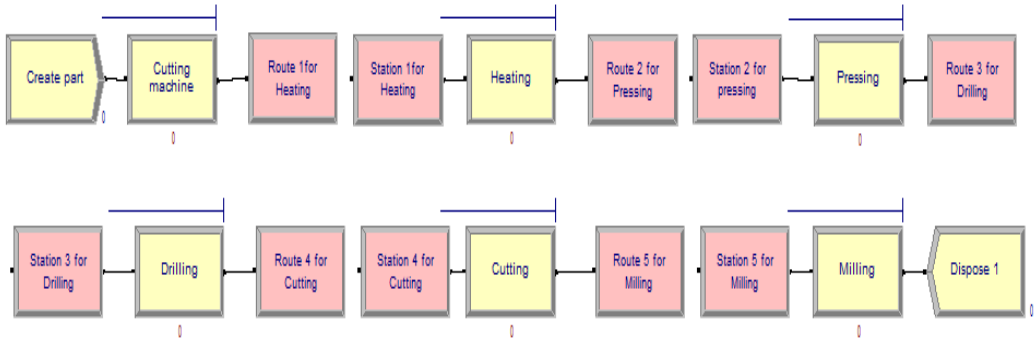

Fig. 3: Simulation model of the parallel line layout (double rows)) , using Arena software

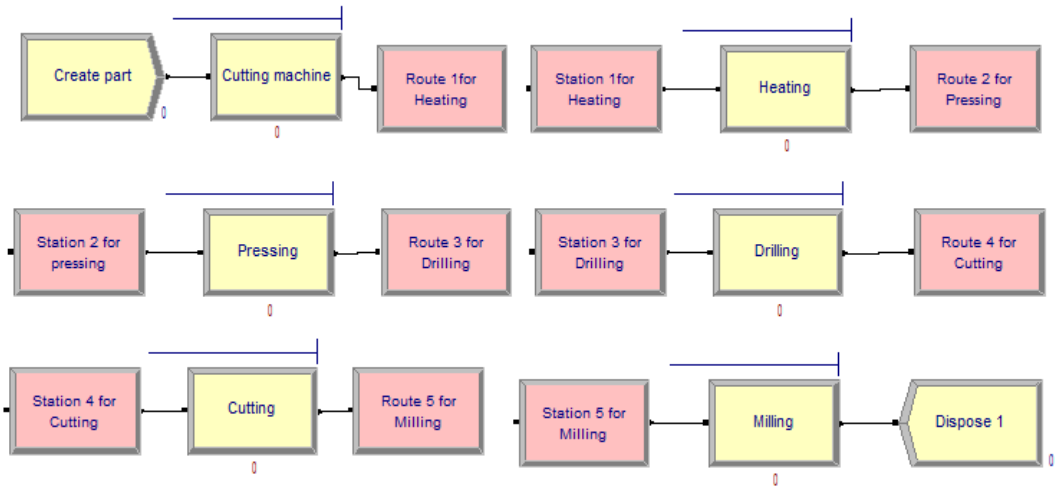

Fig. 4: Simulation model of the multi parallel line layout , using Arena software

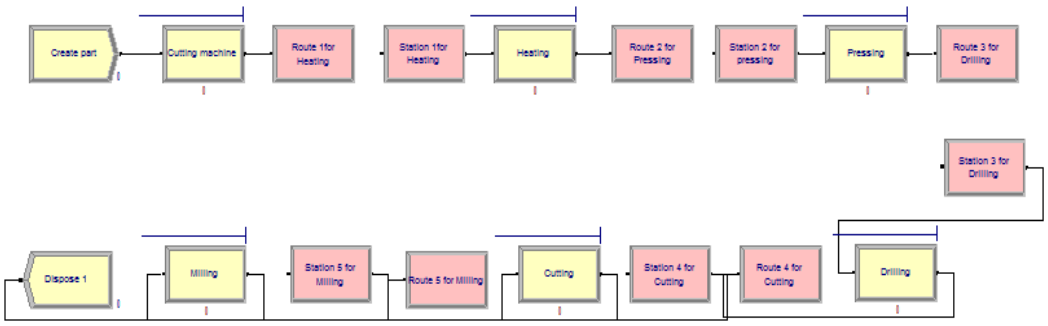

Fig. 5: Simulation model of the U shaped layout, using Arena software

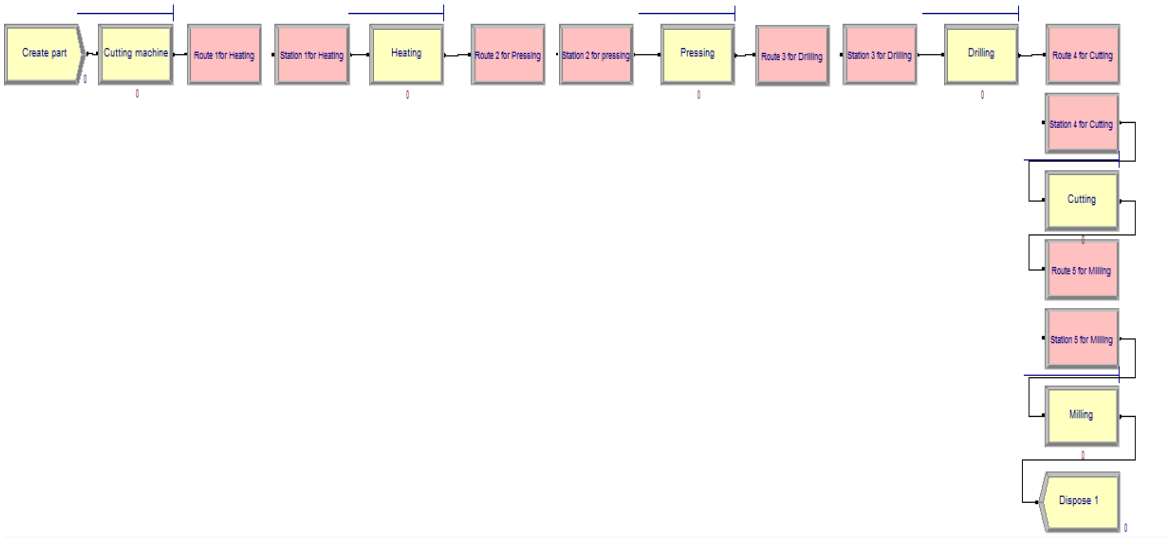

Fig. 6: Simulation model of the L shaped layout, using Arena software

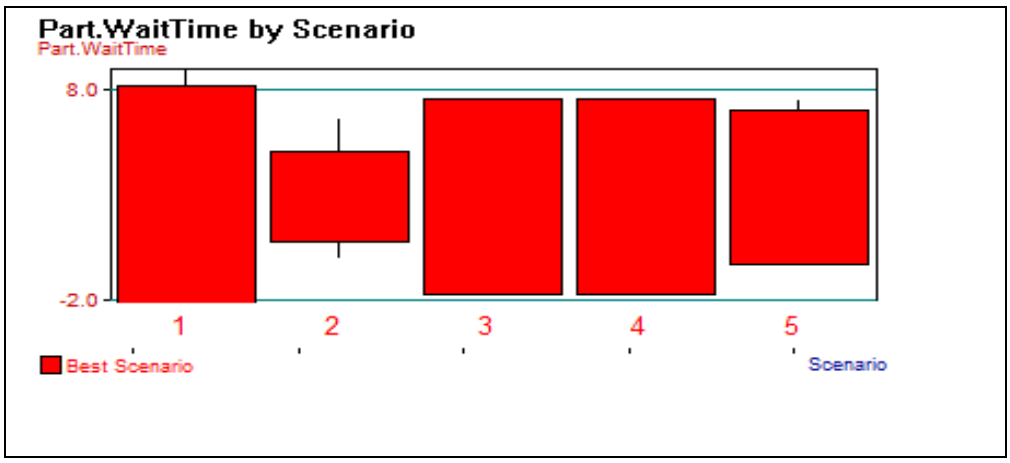

Fig. 7: The best results of the average waiting time of the five types of layout design using, Processes Analyzer of Arena software

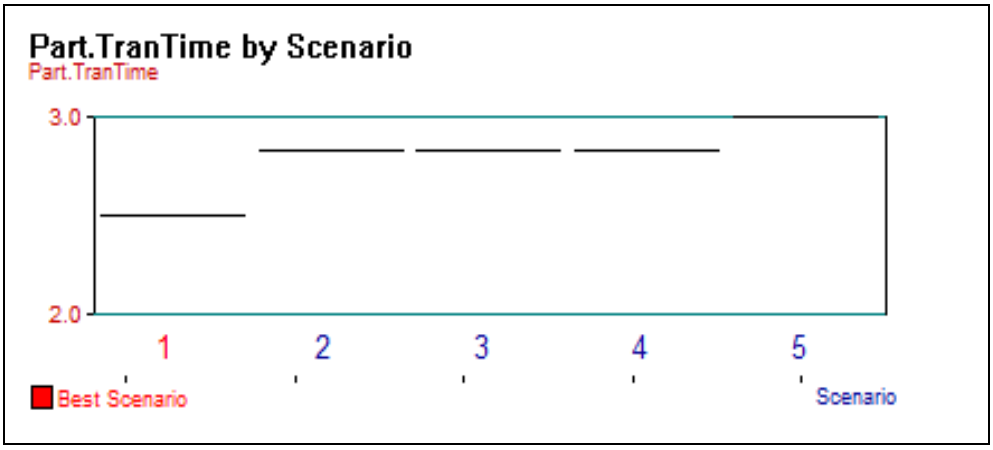

Fig. 8: The best results of the average transfer time of the five types of layout design- using, Processes Analyzer of Arena software

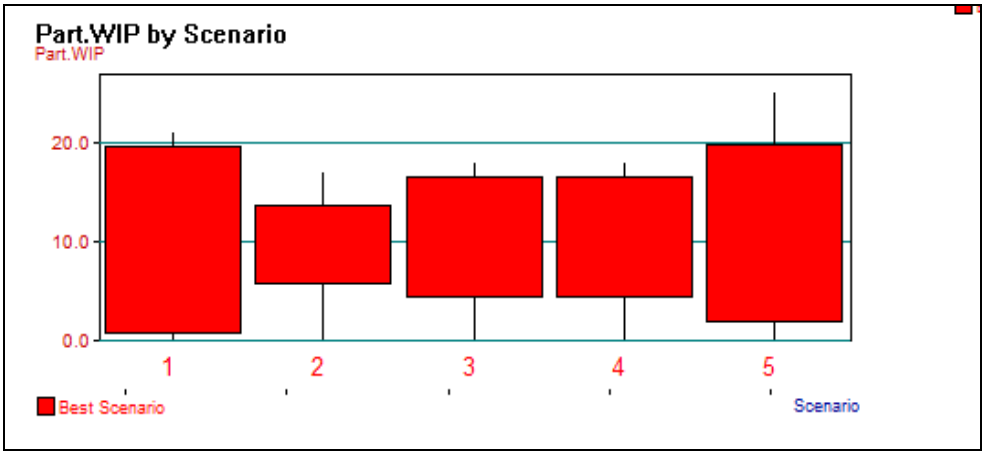

Fig. 9: The best results of the average work in process of the five types of layout design- using, Processes Analyzer of Arena software

Table 1
The simulation results of the five types of layout designs

S/N	Layout Type	Average Waiting Time (min)	Average Transfer Time (min)	Total Time (min)	Average Work in Process Time (min)
1	Linear/Single row	5.3099	2.5000	14.0588	14.5373
2	Linear/Double rows	3.9317	2.8333	12.9597	11.1370
3	Linear/Multi rows	3.9409	2.8333	12.9805	11.7615
4	U-shape	3.9409	2.8333	12.9805	11.7615
5	L –shape	5.0194	3.000	14.2574	15.1170

REFERENCES :-

A. B. Eltawil, and L. E. Amer, Improving Home Application Assembly Line Throughput Using Discrete Event Simulation and Cellular Manufacturing, International Journal of Emerging Technology and Advanced Engineering, Vol. 4, n. 7, pp 768-774, 2014.

A. N. Houshyar, Z. Leman, H. P. Moghadam, and R. Sulaiman, Review on Cellular Manufacturing System and its Components, International Journal of Engineering and Advanced Technology (IJEAT), Vol. 3, n. 6, PP. 52-57, 2014.

B. Tjahjono, P. Ball, J. Ladbrook and J. Kay, Assembly Line Design Principles using Six Sigma and simulation, Proceedings of the Winter Simulation Conference M. D. Rossetti, R. R. Hill, B. Johansson, A. Dunkin and R. G. Ingalls, eds, 2009, .pp. 3066-3076.

G. Pan, A Quantitative Analysis of Cellular Manufacturing in Apparel Industry by Using Simulation, Journal of Industrial Engineering and Management, JIEM, Vol. 7, n. 5, pp. 1385-1396, 2014.

I. Dixit, and K. K. Goyal, Comprehensive design of Cellular manufacturing system: A Review, International Journal For Technological Research In Engineering (IJTRE) Vol. 2, n. 7, pp 1172-1179, 2015.

J. Arkat, M.H. Farahani, and L. Hosseini, Integrating cell formation with cellular layout and operations scheduling. Int J Adv Manuf Technol, Vol. 61, n. 5, pp. 637–647, 2012.

J. N. Patel, and S. V. Patel, Approaches to solve cell formation, machine layout and cell layout problem: A Review, Transactions on Machine Learning and Artificial Intelligence, Vol. 2, n. 5, pp. 80-96, 2014.

K. A. Prasath and R. D. J. Johnson, Concept of Group Technology Accomplishment in the Field of Cellular manufacturing Systems, International Research Journal of Engineering and Technology (IRJET),Vol. 2 n. 6, pp. 991-996, 2015.

K. K. Krishnan, M. Shokoufeh, and P. S. M. Solaimuthu, Heuristic for Combined Line Balancing and Worker Allocation in High Variability Production Lines, Journal of Supply Chain and Operations Management, Vol. 11, n. 1, PP. 47-63, 2013.

M. A. Montazer and A. J. Peterson, A Feasibility Study for Implementing a Cellular Manufacturing Solution for a Foil Cutter Production Line, Proceedings of the 12th Annual Conference of the Production and Operations Management Society, POM, March 30 – April 2, 2001, Orlando, Fl. pp. 1-8.

M. B. Yellale, S. R. Jadhav, and S. S. Kulkarni, Resource Balancing for Manufacturing System using Cellular Production System, International Journal of Advanced Engineering Research and Studies, Vol. III, n. II, pp. 95-96, 2014.

P. Savory and R. Williams. Estimation of cellular manufacturing cost components using simulation and activity-based costing, Journal of Industrial Engineering and Management (JIEM), Vol. 3, n.1, pp. 68-86, 2010.

P.S. Bharamgude, and M.T. Telsang, Design, Analysis and Performance Simulation of Cellular Manufacturing System- A Case Study. International Journal of Mechanical And Production Engineering, Vol. 2, n. 6, pp. 74-77, 2014.

R. Karim and S. K. Biswas. A literature review on cell formation problem in a batch oriented production system, International Journal of scientific research and management (IJSRM), Vol. 3, n. 2, pp. 2187-2192, 2015.

R. Sirovetnukul and P. Chutima, The Impact of Walking Time on U-Shaped Assembly Line Worker Allocation Problems, Engineering Journal, Vol. 14, n. 2, pp 53-78, 2010.

Ş. Özgürler, B. Gülsün, A. F. Güneri, B. Gülsün and O. Yılmaz, Design A Simple U-Shaped Production Line and Analysis of Effectiveness. 14th International Research/Expert Conference "Trends in the Development of Machinery and Associated Technology"TMT, Mediterranean Cruise, 11-18 September 2010, pp. 253-256.

U. K. Prajapati, U-Shaped Production Flow Line Based on Standard Operation Chart, International Journal of Engineering and Social Science (IJESS),Vol. 2, n. 11, PP 146-156, 2012.

V. Anbumalar , R. Mayandy, D. Sivasankar, Dynamic Cellular Manufacturing under Multiperiod Planning Horizons, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, special issue n. 3, pp. 43-49, 2015.

V. Anbumalar, R. Mayandy, and K. A. Prasath Implementation and Selection of Optimum Layout Design in Cellular Manufacturing for Process Industry-A Case Study, International Journal of Innovative Research in Advanced Engineering (IJIRAE), Vol. 1, n. 6, pp 258-262, 2014.

V. Dal, E. Akçagün, and A. Yilmaz, Using Lean Manufacturing Techniques to Improve Production Efficiency in the Ready Wear Industry and a Case Study, Fibres and Textiles in Eastern , Vol. 21, 4, n. 100, pp. 16-22, 2013.