PLANT LAYOUT AND DESIGN THROUGH THE SIMULATION AND INCREASING THE CAPACITY OF METAL WORKSHOP OF A FURNITURE FACTORY

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Abstract: The objective of this study, to be able to increase the capacity by meeting increasing demand and product variety in Boytas-2 Plant of Istikbal-Boytaş Furniture Industry and Trade Company that is furniture Leader of Turkey, is to build a plant layout that provides productivity, flexibility and high competition. In this study, by making an efficient plant layout through the simulation of metal workshop, It have been provided capacity increasing and % 25 performance improvement based on material handling cost per unit in the new layout. In addition, by Promodel 4.2 software, current and new designed plant layout was compared in terms of operational costs according to 20 products. As a result, we show that average cost saving is about % 59 in the new designed system, by doing simulation study, the bottleneck in the machines (process) was determined and necessary precautions were recommended to remove it.

Keywords: *Simulation, Facility Layout, CRAFT, Modeling, Furniture*

1. Introduction

Under the manufacturing concept, facility layout may be defined as "the process of obtaining the optimal disposition of the physical facilities for a manufacturing unit" (El-Rayah and Hollier, 1970). With the increasing commercial pressure for industry to operate economically this imposes the requirement for the manufacturing facility to be designed for optimal economy, which infers the need for careful planning. The best to the plant layout problem is important for two reasons. Firstly, the material handling cost can comprise between % 30 and % 70 of the total manufacturing costs, dependent on whether the facility is planned on a product or process basis or the other types. Secondly, plant layout is a long-term, costly proposition, and any modifications or rearrangement of an existing plant represents a large expense both in terms of relocation and lost processing time and can often not be accomplished easily (Sule, 1994). The importance of the subject of plant layout and material handling is further suggested by Tompkins and White, who claim that:"It had been estimated that between % 20 to %50 of the total operating expenses within manufacturing are attributed to the material handling. Effective facilities planning can reduce these costs by at least % 10 to % 30 and thus increase productivity" (Tompkins and White, 1984). Cost reduction is provided better process control, elimination of waste and plant consolidations. Engineers are often assigned one of two major tasks: Either redesign an existing facility to meet current market demands, or design a new plant from scratch (Kyle and Ludka, 2000). One of the most effective methods for increasing plant productivity and reducing costs is to reduce or eliminate all activities that are unnecessary or wasteful. A facilities design should accomplish this goal in terms of material handling, personnel, equipment utilization, reduced inventories, and increased quality. Today, existing layout configurations will not meet the expectations and needs of the multi-product organizations (Askın et al., 1997) (Yang and Peters, 1998). It is a necessary that there is a need for a new generation of factory layouts that are more flexible, modular and more easily reconfigurable. Flexibility, modularity and reconfigurability could save factories the need to redesign their layouts each time their production requirements change. Relayout can be highly expensive and disruptive, especially when the entire factory has to be shut down and production stopped. The current choices of layouts, such as product, process, fixed position layout and hybrid layouts do not adequately address the above needs because they tend to be designed for a specific product mix and production volume, both assumed to last for a sufficiently long period. In addition to these layouts, there are some next generation layouts such as distributed layouts, modular layouts, reconfigurable layouts and agile layouts. As a result, layout performance tends to deteriorate significantly with fluctuation in design parameters such as product volumes, mix, routings or product life-cycles (Türkbey and Zeydan, 1995).

2. Problem Definition

There are 3 furniture manufacturers listed in the ISO (Istanbul Chamber of Commerce) 500 in 2002. Turkey furniture industry (sector) have been expanding very rapidly. There are a lot of important producers and exporters in Turkey such as İstikbal-Bellona, Yataş, İpek, Kelebek, Tepe Group, and so on.

We deal with plant layout and design through the simulation and increasing the capacity of metal workshop of Istikbal-Bellona group factory. Total Production area for metal workshop is approximately 2700 m^2. In the current plant, 23 different types of materials which comprises box, tube and eclips profile and other materials have been used. 1500 WIP products from these materials have been obtained and the materials have been come together with welding, resulting in about 300 finished goods. 1500 various types of materials pass from 98 different manufacturing process. In current facility area, there are 6 processing departments made up of (1). Profile storage area (2). Cutting (3). Bending (4). Drilling (5). Welding (6). Cleaning and Painting. Current plant layout is process (functional) layout. Most of today's fabrication facilities and those being designed for the near future use process layout configuration. A functional layout is notorious for its material handling inefficiency and scheduling complexity. Because of increasing demand, factory layout was not sufficient to meet coming demands. On account of this, they wished to buy new machines. Top management wished to know whether this decision is true or not and as a result, together with buying new machines, they wanted to make a new relayout. We made some capacity analysis in the factory. After determining the lack of capacity in the system (for some machines, there are some bottleneck for Capacity Utilization Ratio (CUR) and productivity), Top management made a decision to buy some machines. Current layout is given Figure 1. The main objective of this research project is efficiently (flexibility) improvement of layout to design a layout by using simulation consistent with organizational strategic objectives of company. The performance of the layout is measured in terms of the operating cost comparing the current operating cost and new operating cost through simulation. At the same time, the role of simulation as a tool for facility layout is exhibited in this study. This research project is carried out for a furniture factory producing 300 finished goods. Furniture manufacturing is an important component of Turkey manufacturing industry. However, the information used for conducting this project is real and not hypothethical. It is crucial to build a model of the system to use in the engineer's analysis to minimize errors in layout design, system behavioral assumptions, and capital costs. The furniture industry that is getting increased has begun to utilize ERP systems. Especially, they know before implementing the system must be evaluated the system performance in terms of layout design.

3. The Working Methodology

Only an efficient and productive organization can survive in today's competitive market. As we know, after the satisfaction of internal customer (Worker, employees) in a business, external customer (consumer) may satisfy completely. On account of this factor, firstly, we made a questionnaire whether the internal customer is satisfied or not in the business in terms of the working area; In order to prepare a new plant layout, firstly, below questions that was asked by ourselves and engineers in the firm had been answered, Meanwhile, below questions was taken into consideration to be able to make a suitable layout.

1. Is there a suitable layout consistent with product layout?
2. Are there bottleneck machines? Are there any machines creating bottleneck?
3. Is any unused area (location) available?
4. Is material handling equipment enough? Much more? If it is much more, can we reduce it? Can we reduce the number of trucks by transferring with airline (conveyor) the material handling?
5. Can the material handling be reduced?
6. Can the workers work in the machines consistently? Is the machine working enough?
7. Can the machine capacity work consistent to product flow with maximum productivity?

We have used a methodology to find these above questions

1. We made a questionnaire in the plant whether the workers, supervisors, shift engineers in the metal shop is consistent (satisfied) with working there or not.
2. In order to determine the process structure of manufacturing systems, we used process structure-manufacturing characteristics matrix.
3. After determining the process structure and manufacturing characteristics, it is established product part/machine matrix by grouping products and according to product groups, manufacturing lines are established. (Letjman et al., 2002)
4. To find the operational costs in the shop was used the simulation. Afterwards, We made a comparison between the current real system operational cost, new designed system operational cost. Cost minimization is a performance measure for an efficient layout.
5. In order to minimize material handling cost for new designed layout, CRAFT was used.

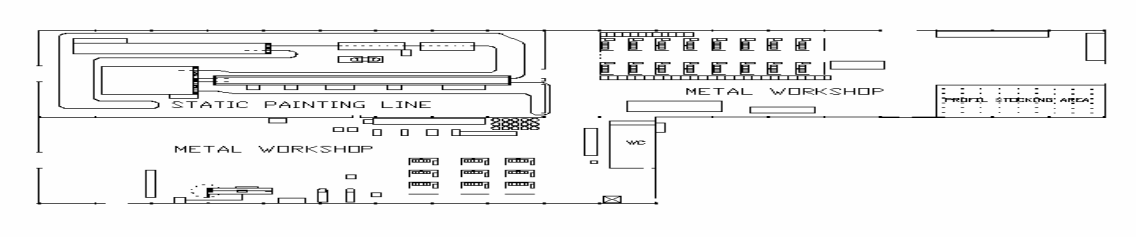

Figure 1. Current plant layout

4. Simulation Results

Simulation model, in the plant layout plan formed for some products, especially, for improving the productivity, to determine bottleneck resources from current resources and to find in operational costs is formed. Computer simulation was used as a validating tool for layout. Computer simulation has been constantly reported as a powerful and popular engineering and operations research tool to assist the organizations to achieve their goals (Law and Kelton, 2000). We built a simulation model according to products below. The parts that contribute approximately % 65 of the annual revenue of the plant are identified. Promodel 4.2 version was chosen to implement the simulation model due to its simplicity (Harrell et al., 2002). The simulation took under consideration the capacity of machineries and operational costs. After simulation model running, we got the results according to Table 1. Afterwards, the last step is to analyze the plant layout for material handling cost saving. We got a CRAFT solution after analyzing the Layout. According to CRAFT Solutions, Because machines is near to each one and is close to each one, we see very little changes. With CRAFT Algorithm, material handling cost is improved %25 in the new designed layout. The differences are given in Table 2 with comparison.

Table 1. Operational costs comparison table based on current and old plant layout

Production Name	**Old Layout Cost (TL)**	**New Layout Cost (TL)**	**Savings**
Champion Bunk Travers Metal	3,573,107	1,447,959	%60
Champion Bunk Ladder Metal	8,679,904	2,692,461	%69
Champion Bunk Base	1,436,223	365,367	%74
Champion Single Table Underside Metal	1,224,350	143,656	%88
Champion Double Table Underside Metal	396,715	128,408	%67
150x200 Baza	3,641,102	2,168,194	%40
Mira Double Chests Seat Profile	716,230	326,724	%54
Mira Double Chests Back Profile	713,215	592,606	%17
Mira Double Beds Leg Profile	1,842,422	630,194	%65
Mira Double Beds Wheeled Underside Frame	1,890,032	956,735	%49
Mira Double Beds Font Upper	1,845,732	791,321	%57
Mira Double Beds Seat Profile	1,879,521	579,274	%69
Mira Double Beds Back Profile	1,526,501	675,143	%55
Destina Single Metal Part Arm	349,777	120,474	%65
Destina Metal Part Seat	421,467	236,376	%44
Destina Metal Part Back	413,702	235,563	%43
Destina Double Metal Part Seat	429,449	286,055	%33
Destina Double Metal Part Back	429,449	286,316	%33
Destina Kanepe Metal Part Seat	475,578	286,300	%39
Destina Kanepe Metal Part Back	475,578	286,214	%39
Grand Total	32,360,054	13,235,340	%59

Table 2. Differences table

New Plant Layout of Current Condition	New Plant Layout of ImprovedCondition
Drill	Pipe Bending
Press	İmak-2
Imak-2 and Circular Saw 1	Press and Profile Bending
Profile Bending	Drill and Manual Profile Bending
Manual Profile Bending	Circular Saw 2
Pedrazolli	Imak-1

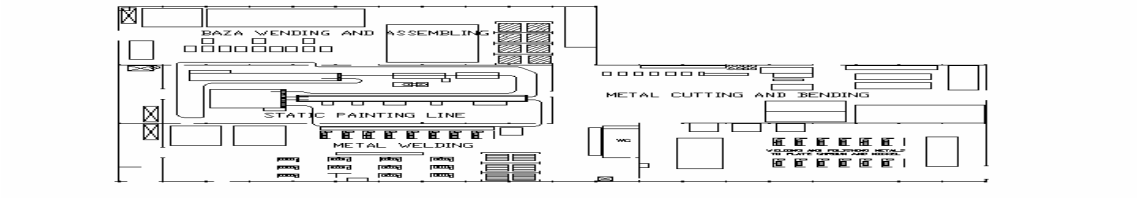

Figure 2. New designed layout

5. Recommendations and Conclusions

Now, in order to increase the new designed plant layout productivity as seen figure 2, we would like to propose for the system. These proposals are as follows;

The basics of ideal system approach from the productivity point of view

1. Quick Systems: Speed Changeover
2. Reliable Material Procurement
3. Decrease the Machine Breakdown: Total Productivity Maintenance
4. Quality and Just in Time Production
5. Continuous Improvement
6. Labor Motivation (Martinish, 1997)
7. By placing (hanging over) scoreboard (lightened board) over the sequencing machines, we can provide transformation to JIT production system (pull system), so, we can make a link between machines. This scoreboard is made up of the number of production that are planned to be produced per day, the number of production that are produced per day, time, how many product must be produced that hour, a scoreboard we can prepare, so the productivity of workers or production system may be increased. Thus, the production may be related to demand.
8. During welding process in the current condition, The workers make welding with the other hand while holding the welding mask with one hand. Instead of this, by fixing the welding mask, so, the worker can make the welding more efficient with two hands.
9. An Industrial Engineering Department must be formed immediately, so each time and cost studies can be done. In addition to that, by using together with BAAN (ERP Software) and preactor (scheduling software), Production planning and tracking can be more efficient.

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References

Askin, R. G.,N.H., Lundgren and F. Ciarallo., A material flow based evaluation of layout alternatives for agile manufacturing, In R. J. Graves, L.f. McGinnis, D.J.Medeiros, R.e.Ward and M.r.Wilhelm (eds.), *Progress in Material Handling Research*, Braun-Brumfield, Inc., Ann Arbor, MI, 71-90, 1997

El-Rayah, T. E., Hollier, R. H., A review of plant design techniques. *International Journal of Production Research*, 8(3), p. 263-279,1970.

Harrell, Charles, K. Ghosh, Birman, Bowden, *Simulation using PROMODEL* w/CD-ROM, McGraw-Hill, March 3, 2000.

Letjman, Y., Shayan, E., Nagarajah, R.. Design of a suitable production management system for a manufacturing company, *Computers&Industrial Engineering* 42, 169-174, 2002

Martinish, S. Joseph, *Production and Operations Management: An Applied Modern Approach*, John Wiley & Sons, Inc, 1997.

M.Law, Averill, Kelton, W. David, *Simulation modeling and analysis*, 3rd Edition, McGraw-Hill, 2000.

R. Sule, **D.**, *Manufacturing Facilities:Location,Planing and Desing*, 2nd ed., Boston, 1994.

Robert G. Kyle, Jr., R. Ludka, Christopher, Simulating the furniture industry, *Proceedings of the 2000 Winter simulation Conference*, J.A.Joines,R.R.Barton, K.Kang and P.A. Fishwick, eds., 2000

Tompkins, J.A. and White, J.A., *Facilities Planning*, Wiley, New York, 1984

Türkbey, O. and Zeydan, **M**., A new approach to facility layout. *XVII. National Congress YA/EM'95*, ODTU, Ankara, July 1995

Yang, T., and Peters, B.A., Flexible machine layout design for dynamic and uncertain production environments, *European Journal of Operational Research*, 108, 49-64, 1998