Productivity Enhancement in a Wood Furniture Manufacturing Factory by Improving Work Procedures and Plant Layout

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Abstract: - The objective of this study is to improve productivity of a furniture manufacturing company. Motion and time study, process analysis and plant layout design were used as tools to improve the process. Simulation was carried out to evaluate the designed layout. Initially, production process was analyzed to evaluate process operation time. Preliminary survey showed that there were some redundant and duplicate processes, and many waiting periods. The existing production process was inefficient, showing bottleneck. New plant layouts were proposed to enable more balanced and smoother production process flow. From the proposed method, distance of the production flow can be shortened from 155 m to about 45 m. The production time can be reduced from about 260 min to 215 min, resulting in more than 15% increase in productivity.

Key Words: - Furniture factory, Motion and time study, Plant layout design, Process flow analysis

1 Introduction

Thailand's furniture manufacturing industry is well known for its superior production quality, innovative and modern styling, and flexibility in material use. Exports registered around US$ 1,500 million in 2005 with the principle destinations being Japan and the United States. The industry's exports declined to about US$ 1,100 million between 2006 and 2009. However, in 2010, growth was achieved as furniture exports were up almost 10% over the previous year [1]. The export of furniture from Thailand is dominated by wooden products, comprising around 70% of the total export figure. Thailand's wooden furniture industry faces considerable competition from Malaysia, Indonesia, Vietnam, Taiwan and China in particular. As rival countries improve their production quality, Thailand's furniture manufacturers and exporters are under increasing pressure to advance further.

Increased productivity is always considered to be the main driver of competitiveness in the price sensitive furniture market [2]. Management tools that can improve productivity such as total quality management (TQM), statistical process control (SPC), business process reengineering (BPR), supply chain management (SCM), lean manufacturing, and green manufacturing practices have been identified as critical to success in furniture manufacturing industry [3 – 5].

Other examples of productivity improvement adopted in furniture industry included Kaizen [6], and just-in-time (JIT) manufacturing [7]. Alternatively, simple-to-implement way to achieve improved production efficiency is by designing a better flow and layout for the plant production process. Design of plant layout, in which the best arrangement of physical facilities to provide an efficient operation is proposed, is normally adopted to enhance overall productivity and efficiency of the plant. It is to place machines, tools, accessories, labors and raw materials in the process at the right places [8]. Banerjee and Zhou [9] reported optimization of facilities design for a single loop layout. Lynn and Morrison [10] described how trade-off selection process was used to choose layout for the car plant. Fu and Kaku [11] formulated a plant layout for a shop manufacturing system to minimize average work in process. Bazargan [12] demonstrated application of recently developed multi-objective cell layout designs methodologies to a food manufacturing and packaging company. Solutions obtained were found to provide not only a safer shop floor but also significant reductions in material handling cost, waste, need for large capital investment and the number of lift-trucks needed on the shop floor. Pinto and Shayan [13] conducted a project to optimize the layout design of the production line at the shop floor of a furniture manufacturing company. It was shown that formal

ISBN: 978-1-61804-031-2

layout modeling approaches can be effectively used, leading to significant improvements.

As part of a productivity improvement program to a local furniture manufacturing factory, study was undertaken to review work process, improve process operation, and optimize layout design of the furniture production lines. In this work, motion and time study was used to study the process and many configurations to develop the process. Cause of furniture process is analyzed using seven QC tools. Line balancing was the tools that manage processes to the lowest bottom neck. Improved design will reduce production time, distance and the work instruction, as well as improve material handling and throughput.

2 Methodology

This section describes participated company, its process, and analysis methods involved in improvement of its productivity.

2.1 Case Study

A real case scenario from a local furniture manufacturing company in Chiang Mai, Thailand was studied. The Company is a leading wood furniture manufacturing company, engrossed in design development, production, and trade furniture industry. It is regarded as one of the biggest furniture exporters to the US, France, Japan, and Australia. The Company manufactures a number of different products, such as tables, chairs, book shelves, doors, windows, structure frames, etc. These products are made from many types of woods available locally such as Cassia garettiana, Lagertroemia, Pine tree, Delbergia sisoo, and variety of teaks and timbers. All furniture products follow similar sets of operation. Parts are produced internally in batches of various sizes in scattered areas. Movement of parts generates problems such as work in process, missing parts, shortages, bottlenecks, and wrong placement.

Each product goes through about 8 – 10 operations. Each assembly can be broken down into a number of subassemblies. Each subassembly operates independently, going through a fixed set of operations. From general observation, it can be seen that facilities of current layout are not placed according to the sequence of operations.

2.2 Process Overview

In this work, manufacturing of wooden table was considered, because its production volume represented the largest in the company.

At first, general conditions in the working areas were considered. Operating procedure and plant layout from the first until the finishing steps were closely looked into. Production subsystem of this particular product includes (i) material preparation from raw material storage to carpentry work area, (ii) wood cutting to required sizes, (iii) checking if the size in accordance with specification, rubbing and polishing, (iv) joint and connection making, (v) initial inspection for defects and repair, and trimming if necessary in trimming and shaping area (vi) to paint work area for coloring and coating with protective paints, (vii) assembly, and (viii) final inspection before handing to customers. It could be summarized as a process flow chart in Fig. 1. Fig. 2 shows typical finished product.

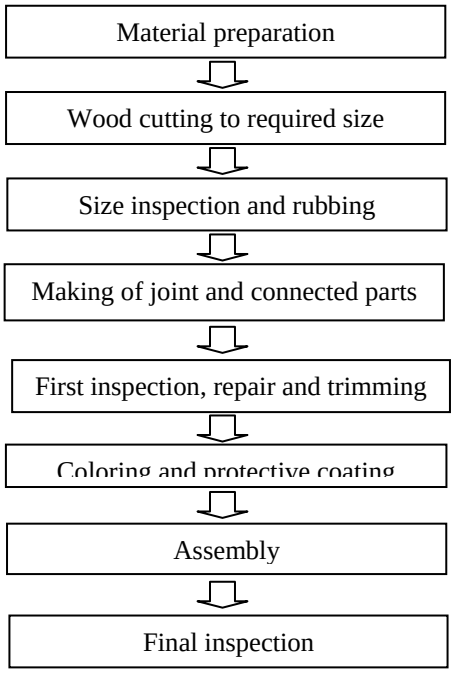


Fig.1 Typical process diagram of a wood table.

Fig.2 Finished wood table.

ISBN: 978-1-61804-031-2

2.3 Analysis and Simulation

Production lines were visually examined. Line balance sheet was studied. Floor managers and operators were interviewed. Data aided in developing the layout and process flow was gathered. Typical working time was evaluated. Motion and time study was adopted to analyze the current working procedure by means of investigating production and flow charts to identify potential problems. Motion and time study can lead to reduction of redundant operations, and elimination of repeated steps, eventually resulting in reduced operations step and average time. Another technique used was layout design. When redesigning the plant layout, several alternative solutions were developed to improve working procedure and plant layout using ARENA program. Simulation was carried out to suggest improved layout that increases performance and decreases the length for overall movement or working distance.

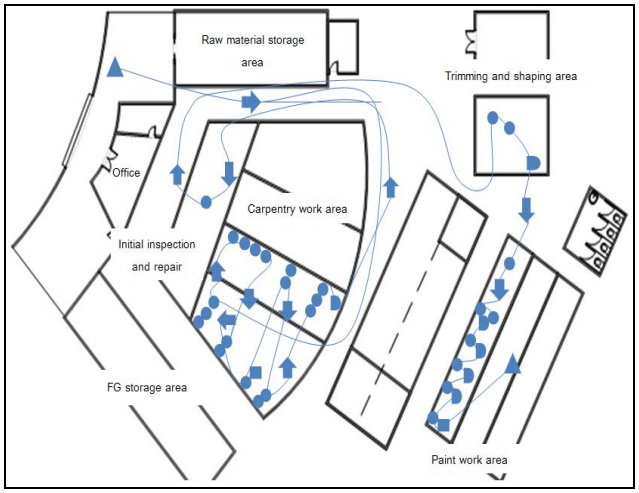
3 Results and Discussion

The results were presented into two parts. The first one was the analysis of flow process chart using the concept of motion and time study. With existing layout, decreased number of activities and assembling time are the main result from the first part. The second part was about the improvement of plant layout using From to Chart and ARENA simulation. Improved movement distance and overall assembling time after adjustment of plant layout are obtained.

3.1 Flow Process Improvement

Analysis of flow process chart was conducted. All activities of wooden table manufacturing were examined for existing plant layout, shown in Fig. 3 (i). From the diagram, data was collected by measurement of working time in each production step. Production diagram was analyzed to show production procedure or working method from the beginning to the end of production lines. From the existing production diagram, it was found that the current production procedure consists of 48 steps, divided into 27 working steps, 2 storage steps, 6 waiting steps, 2 inspection steps, 11 transportation steps, with overall working time of about 260 min.

Waiting times during the process were reduced by moving products in each step to the next process immediately. Redundant, repeated operations and non-value-added activities were identified. The existing process flow was revised and rearranged by removing these steps, with consultation from floor managers to ensure that delayed processes were minimized. Improved flow process was proposed, as shown in Fig. 3 (ii). It was demonstrated that number of activities can be decreased from 48 to 38 steps, reducing average operation time by 16.5%, summarized in Tables 1 and 2.



(i) current

(ii) improved

Fig. 3 Current and improved process flow facility layouts and process charts of the furniture manufacturing company.

Table 1 Improvement in average time in operation with rearrangement of flow process.

	current	improved	diff.	eff. (%)
Time (min)	260	217	43	16.5

ISBN: 978-1-61804-031-2

Table 2 Change in number of activities in flow process after improvement.

Activities	No. of activities			eff. (%)
	current	improved	diff.	
Operation ○	27	25	2	7.4
Storage △	2	2	0	0
Delay D	6	3	3	50
Inspection □	2	2	0	0
Transport ⇨	11	6	5	45.5
Total	48	38	10	20.8

3.2 Plant Layout Improvement

Based on Form to chart, current working distance was found to be about 155 m in total. This was a long distance to move. The facilities of the current layout are not positioned according to the sequence of operations. Hence, there is discontinuity in flow of materials. Revision of plant layout was conducted without modification to the existing activities of wooden table manufacturing. Three designs of plant layout were proposed;

(i) Improved layout by swapping between rubbing and trimming areas.

(ii) Improved layout by grouping repair and coloring areas together

(iii) Improved layout by combining (i) and (ii).

From simulation, these new layout designs were found to reduce movement and operation time. Results are shown in Figs. 4 and 5. Plant layout no. 3 appeared to gain best improvement. The best layout was found to significantly cut down movement from 155 m to 47 m, resulting in a reduction of average operation time from 260 to 245 min.

It was clearly demonstrated that productivity can be enhanced by improving flow process as well as plant layout design. When both techniques are utilized by the company, around 20 % reduction in operation can be achieved. The result was satisfactory to the company which has not seriously considered adopting industrial engineering approaches to improve productivity before. Plan is ongoing to implement other techniques such as 5S to further improve the production process.

This case study is a good example for other companies especially SMEs to adopt similar techniques as preliminary tools to enhance productivity and competitiveness, prior to adopting more complex management tools like TQM, SPC, BPR, SCM, lean, or JIT.

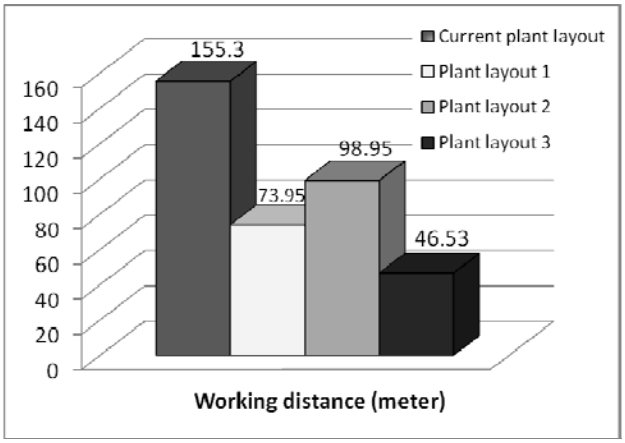


Fig. 4 Reduction in working distance with improved plant layout designs.

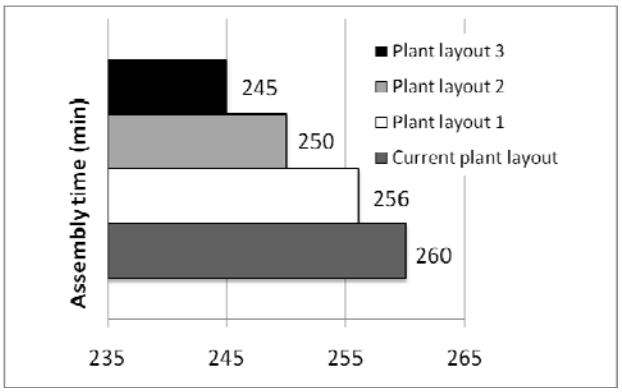


Fig. 5 Improvement in average time of operation with improved plant layout designs.

4 Conclusion

In this work, productivity improvement in a wood furniture manufacturing factory was demonstrated using motion and time study, process flow analysis, and plant layout design.

The result showed that efficiency was increased by more than 15% by removing unnecessary and duplicate working steps in production line. Improved plant layout was shown to increase efficiency and reduce working distance. It was demonstrated that overall movement can be reduced by more than 50%. The findings are useful in serving as a good example for SMEs, which do not normally apply scientific approaches to enhance their production, to review and implement industrial engineering and management tools to improve their performances.

ISBN: 978-1-61804-031-2

Acknowledgement

Support from Faculty of Engineering, Chiang Mai University is highly appreciated. Kind cooperation from Pun company is also acknowledged.

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