Process Value Analysis for Wood-Based Furniture Company in the Philippines using VA/VE Approach

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Abstract

Wood-based furniture is a well-known leisure item in a household for it can be utilized or can be further improved to meet customer standards with wood as the main material. Value Analysis and Value Engineering is used to improve the process and lower the cost of the product but maintain its quality. The process VA/VE and Design of Facility is used to optimize the existing processes of a wood manufacturing company in the current application of the woodworking processes in the existing facility layout. This paper demonstrates the application of ProModel Simulation, process VA/VE and Design Layout in the existing processes of the woodworking company in the current application of the woodworking processes in the existing facility layout. In order to analyze the two designs of the recommended design of facility the researchers applied ProModel simulation. The results aim to satisfy the proposed VA/VE approach. Overall the existing layout was able to generate an increase of 80% in production.

Keywords
Effectiveness, Efficiency, Process Layout, Simulation, U-Shape Layout, Wood-based Furniture, Value Analysis, Value Engineering

1. Introduction

Wood is being used by the humankind as the oldest renewable natural resources and the most environmentally-friendly ecological material. It is the most well-known natural material that exists and has one of the most important roles in developing the human society due to the influential promotion of environmental protection in the current society. It is primarily used in making furniture because of its relatively easy to gather materials and easy to work with. In current generation, wood in modern design houses helps make the indoor design more environmental, resource saving, sustainable development and pollution reduction. [1] Furthermore, it is published that one of the biggest business between the years 1995 to 2000 the furniture business for it grew faster than world merchandise trade. The furniture contains local curved-based businesses and it has conventionally been a supply and intensive labor in the industry. [2] In addition, woodworks furniture constructors preserved their principal role in the marketplace which is mostly for expensive, high-end and project products. These produced products manage to acquire the local industry while mass producing the large volume of products that are sold for export and locally.

In the Philippines, 95% of furniture companies in the country are considered as small and medium enterprises. But, it still ranked as fourth from the top five most exported products in terms of wood furniture industry, with recorded $3.334 million of export as of years 2014 to 2015 but instantly dropped to $3.128 million resulting to 6.2% potential profit loss. [3] Wood furniture industry is considered to be one of the four key contributors to the Philippine export with a 5.6% of percent share to the total receipt of, yet recent data shows that export sales reversed a downward trend. To be able to solve the problem this paper considered the mentioned industry to help small and medium scale enterprises using a VA/VE approach that can eventually help the society at large. [4] Furthermore, it is used in different kinds of application for the company where it will further help the workers to be more creative. Value

Planning, Value Analysis, Value Management will help to organize the organizations within. This paper were able to gather an average of 40.07% underutilized production time due to improper process layout design which results to unnecessary motions done by the production workers, causing production inefficiencies resulting with a profit loss of $24,212.100 annually. This paper propose a standard process layout in order to increase overall productivity, utilize production time, minimize the unnecessary activities, and increase profit in the current application of the present process layout with the help of VA/VE and ProModel simulation.

2. Review of Related Literature and Studies

Selection of the company layout design is one of the important decision making in any product manufacturing organization. The incremental increase of productivity within the company, output products may increase, the company will have a standardized operation time, delay will be possibly eliminated, and the flow process of the operation will be efficient. Systematic Layout Planning (SLP) is an established way of producing a layout which can result to multiple alternatives. The computed total transportation distance for each alternative is one way in determining the best alternative. The best alternative layout is the traveled distance with the least total of the transportation. Considering the quantitative criteria such as the transportation traveled distance by the products, it is considered as one of the major problem in the traditional methods. Measures which are considered as a very difficult variable to quantify such as flexibility of the products and alleviate of continuance must not be neglected during the selection of ideal manufacturing layout of the company.[5] A well-reviewed combinatorial optimization problem which arises in numbers of problem is calling Facility Layout Problem (FLP). FLP deals with the problem such as layout design of schools, airports and hospital; circuit board design, warehouses; etc. [6] Improving the existing business process within the company will help to optimize the present layout, which will help to meet the new standards of quality used in the process improvement as a part of organizational improvement. [7] Being left behind in the neighboring countries in the Southeast Asia in terms of the production of shoes in the shoe manufacturing industry in Marikina City which is considered as the shoe capital of the Philippines. Analysis tools were utilized to examine the existing process of the business. Such as time and motion study, Ishikawa diagram, ISO flow process, flow process chart, process layout, cost benefit analysis, and statistical computation. The layout machine that's been proposed will help to increase the production output by 13.11% as the result shows. Using the tools, the improvement of time is 12.54% faster and the distance is 208.80% shorter in each process in the new layout given. New machines introduction will help to speed up the production manufacturing without loosing the products quality.

Value Analysis (VA) is an applied cost cutting tool that makes products more reasonable and competitive. Many scholars and professional practitioners have theorized and apply new concepts, methods and alternative applications for VA methodology. There is a vast opinion among professional practitioner on how to apply some decision-making tools in the field of Value Management (VM). Notwithstanding the advantage of such nonconformity in the application of the methods and tools in the disciplines of Value Management, Value Analysis, and Functional Analysis (FA), led to settled variations in the practice of some of those methods. [8] Attempting to legitimize standards of furniture plan and development whose target work is to the minimization of material and amplification of the quality of components and development material, an examination venture was embraced with the goal to work out, compose and test the viability of a program intended for unbending nature quality investigation of furniture side edges developments. The territories of cross areas of the components to be joined should increment from 18 to 45%. However, dowel associations can supplant ligaments and joints achieving a similar quality. The quality of associations and their measurements don't constitute the capacity of the position of the interfacing part in the seat and the inflexibility of the seat side edge depends straightforwardly on the position of the interfacing part and increments as the position of this component is brought down. Fast and different unbending nature quality examination of furniture outline developments made of wood are created in PC program. [9] Changing to U-shaped assembly line and from straight-line assembly line creates a major layout change in terms of design and investment for assembly operations. [10] U-shaped assembly line offers benefits in labor productivity that sometimes serves as the main reason why organization consider altering their assembly line than the straight-line assembly. It indicates that sometimes labor productivity will significantly increase under definite situations when changing the layout from a straight-line layout to a U-shaped layout but not in all cases.

A product or service is considered to have good value if it has appropriate performance with minimal cost and a reverse definition is said that a product or service is considered to have bad value if it has inappropriate performance with a very high cost and therefore value gradually increases as the cost decreases and if the performance suits the

customer needs, wants and is willing to pay for the improved performance [11]. CMMI or Capability Maturity Model Integration is a tool that can be used in conjunction with other tools such as simulation software, product lifecycle, process improvements, etc. This can be used in industrial engineering tools such as software engineering, systems engineering and acquisition of different variables mainly data. This model helps the user to get content on which parts of the process, product or system that needs improvement [12]. The importance of global connectivity for third world countries under the scrutiny they are experiencing especially in development studies. Enhancements are needed by third world countries in order to bridge the gap between access to global markets and internet connectivity. E-commerce technologies are also important especially to South African wood furniture sector because of the integration and an added value chain in the global market [13]. Simulation is very important in business practices and manufacturing processes, simulation has a wide coverage, broad scope and its focus and application in the real-world, it is heavily used to pursue a lean type of process in manufacturing. Moreover, simulation models are also used in scheduling as a means to cope with complex enterprise-wide systems [14].

3. Methodology

This study utilized the VA/VE approach in analyzing the assembly of wood-based furniture optimization based on its intended functions and corresponding costs. Process VA/VE techniques such as quality-cost relationship between the existing and proposed data were adapted. Human error probability and its reduction were also used to further assess errors that are occurring in the assembly line.

3.1 Information Phase

1. Data Collection – identify types of data needed to determine the present issues in the assembly line.

3.2Functional Analysis Phase

2. Functional Analysis – review and function and specifications
3. Cost Identification – determine the operating, improvement and labor costs.
4. Current Quality Determinants – determine the product and the process current quality an how it can be improved

3.3Creative Phase

5. Desired Value Expectation – Explore other ways of getting the desired value and Examine Critical functions and improvement
6. Costs of the Improved and Proposed Process/Layout – determine the cost associated with improving the overall layout and process and other material cost needed to improve the product and process.

3.4Evaluation Phase

7. Functions Evaluation- in evaluating the increase in productivity, simulation was used in order to have an alternate solution in the process
8. Efficiency Evaluation – in evaluating

3.5 Development / Implementation Phase

9. Execution and Implementation of Selected Ideas

3.1.1 Information Phase

The subject company is a medium sized wood-based furniture manufacturing company in the Philippines. It is recognized as one of the key distributors of wood-based furniture to other furniture manufacturing companies with its commitment in producing high quality wood-based furniture.

The processes in the wood furniture making industry are subdivided into 2 sub processes and 6 main processes. Sub processes include the cutting and drying of wood; this is classified as a sub process mainly because these processes are optional and the company can start production provided that these processes are done already. The 6 main processes include marking, jointing, sanding, re-cutting, assembling and finishing. This paper conducted on-site observations and interviews with the workers inside the assembly department and finishing department, this was done to determine the problems and its effects inside the production line. The company also has occasional inspections in order to manage and control errors and its problems.

In the Table 1 below; upon conducting the observations and interviews the following problems were being observed. This paper conducted a rating system based on company feedback and actual observations. The rating was 1 being low and 5 being the highest occurrence with the most impact.

Table 1. Observed Problems

		Rate (1-5)	***%***
Littered Work Area		1	
Saw Dusts		1	
Work Place is Dim		1	51.61
Hot Environment		1	
PHYSICAL ENVIRONMENT ISSUE	**(TOTAL)**	4	
No PPE		3	
No generator		5	
Fire extinguisher is out of reach		3	35.48
ACCIDENT OCCURRENCE	**(TOTAL)**	11	
Unorganized Layout		5	
No Floor Layout		5	
Assembling Department and Finishing Area are in Different Buildings		5	12.90
Assembly Area is near Households		1	
INEFFICIENT PROCESS LAYOUT	**(TOTAL)**	16	
	OVERALL TOTAL	31	100

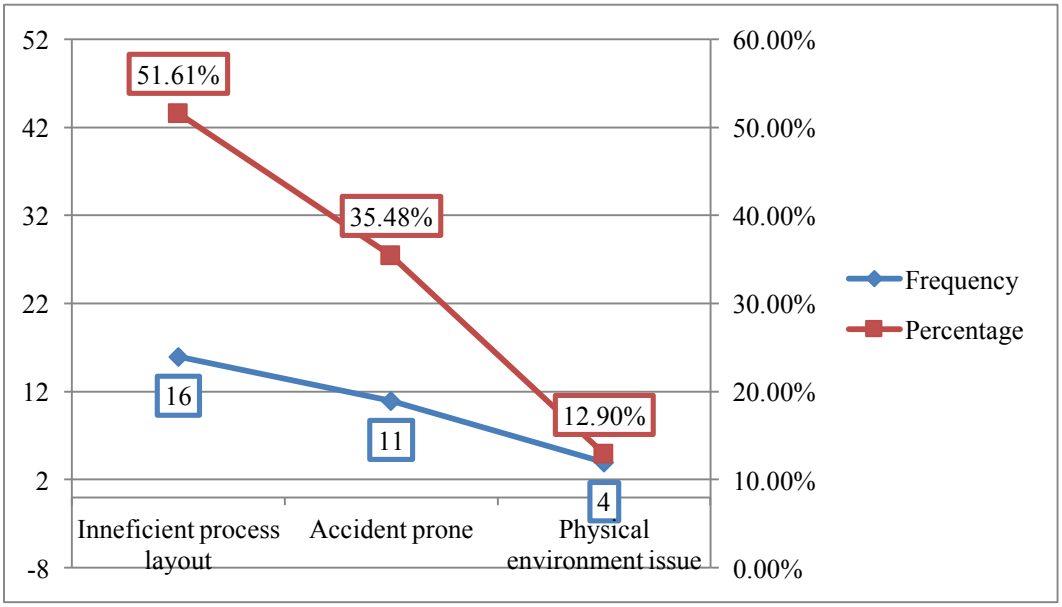


Figure 1. Observed Problems Chart

In the Figure 1 above, it shows the relationship and significance of the observed problems inside the production line. Inefficient Process Layout was the main problem and it which creates a workplace that is accident prone and can be a physical environment issue. It demonstrates that 51.61% (16) of the overall inefficient process layout contributes

to the 35.48% (11) accident prone and 12.90% (4) physical environment issue and it overall affects the production of wood-based furniture in the company.

3.2.1 Function Analysis

The Function Analysis System Technique (FAST) is a systematic diagram that identifies the relationship of the various processes and its corresponding function(s). This will be a guide in determining the shared understanding of the project, missing functions, problem clarifications and its basic functions. It shows the basic operations for manufacturing wood-based furniture from (F1) Marking of Cut Wood to(F6) Finishing of Product along with its corresponding inspection.

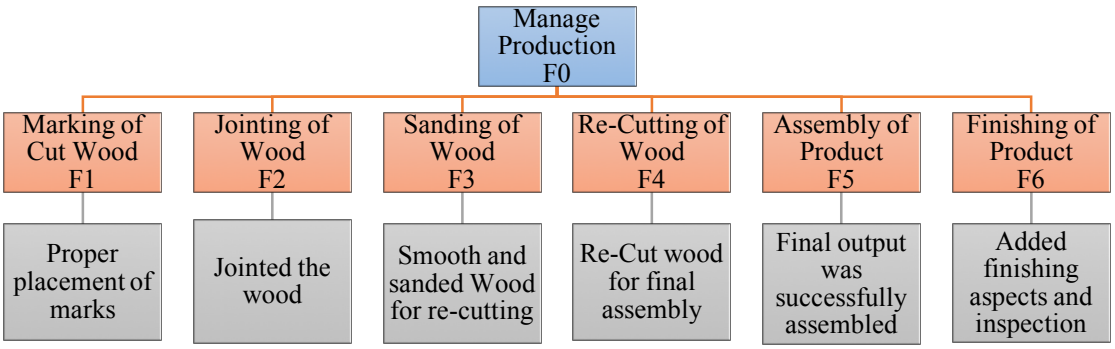


Figure 2. FAST Diagram of Wood-Based Furniture Production

Two technical experts in the production of wood-based furniture are requested to rate the basic functions of operations that are based on the level of importance of it in the corresponding tasks that can add up to the observed problems shown in Table 1. Moreover, to compute for the function importance coefficient compute for the average score divided by the total score.

Table 2. Weight of Basic Function

Number	Basic Function	Expert 1	Expert 2	Total Score	Average Score	Function Importance Coefficient
1	Marking of Cut Wood (F1)	20	10	30	15	0.15
2	Jointing of Wood (F2)	10	20	30	15	0.15
3	Sanding of Wood (F3)	10	10	20	10	0.10
4	Re-Cutting of Wood (F4)	25	25	50	25	0.25
5	Assembly of Product	25	25	50	25	0.25

	(F5)					
6	Finishing of Product (F6)	10	10	20	10	0.10
7	Total	100	100	200	100	1.00

3.3.1 Cost Analysis

Value engineering cost analysis is used to assess the overall total production cost (C) and it includes the sum of labor cost (C_h) and operation cost (C_o).

$$C = C_h + C_o \quad (1)$$

Therefore, the computation for cost modulus (KC_i) can be formulated:

$$KC_i = \frac{(C_{hi}+C_{oi})}{(\sum C_{hi}+\sum C_{oi})} \quad (2)$$

Table 3: Calculation of Production

Function	Amount of Labor (Person)	Labor Cost 1 Wk. (PHP)	Operation Cost 1 Wk.(PHP)	Total Cost (PHP)	Function Cost Coefficient
F1	3	8,642.97	983.79	9,626.76	0.20
F2	3	8,642.97	983.79	9,626.76	0.20
F3	3	8,642.97	983.79	9,626.76	0.20
F4	3	8,642.97	983.79	9,626.76	0.20
F5	1	2,880.99	327.93	3,208.92	0.07
F6	2	5,761.98	655.86	6,417.84	0.13
Total	**15**	**43,214.85**	**4,918.95**	**48,133.80**	**1.00**

The above collected data from the management of the company shows the labor cost of PHP 2,880.99 per worker and operation cost per manpower efficiency is PHP 327.93 for a whole week of production of wood-based furniture.

3.4.1 Value Analysis of the Operations of Production

Value engineering and its operations of production can be expressed as:

$$V = F/C \quad (3)$$

Table 4. Value Coefficient of Wood-Based Furniture Production

Function	Function Importance Coefficient	Function Cost Coefficient	Value Coefficient

F1	0.15	0.20	0.75
F2	0.15	0.20	0.75
F3	0.10	0.20	0.50
F4	0.25	0.20	1.25
F5	0.25	0.07	3.57
F6	0.10	0.13	0.77
Total	**1.00**	**1.00**	

Table 4 shows that the most affected operation is the assembly itself, because it generated a value of 3.57 which is the highest among the other value coefficients.

3.5.1 Process VA/VE

The assembly of the wood-based furniture is the most critical section of the production line and will need the most improvement since the flow of the operations is continuous from one operation to the other until final finishing and inspecting of the product. Moreover, the assembly has the least value coefficient but, since the flow of operations is continuous from start to the assembly the costs accumulates up until that part of the production and will have the most significant effect. Furthermore, to show this the researchers will utilize time and motion study to determine the normal and standard times within the operations.

Table 5. TMS Summary Process in the Production of Wood-Based Furniture

Job Category	Function Verb	Function Noun	Rating Factor	Normal Time (Minutes)	Allowance Factor	Standard Time (Minutes)	Outputs per Hour
Preparation	Measuring	Wood	110%	5	15%	5.75	10
Preparation	Cutting	Wood	110%	7.5	15%	8.6	7
Preparation	Re-Measuring	Wood	110%	3	15%	3	20
Preparation	Re-Cutting	Wood	110%	10	15%	10	6
Preparation	Marking	Wood	110%	8	15%	9.2	7
Preparation	Sanding	Wood	110%	80	15%	92	2
Assembly	Jointing	Wood	110%	8	15%	9.2	7
Assembly	Jointing	Wood	110%	4.5	15%	5	12
Assembly	Gluing	Wood	110%	7	15%	8.05	7
Assembly	Nailing	Wood	110%	10	15%	11.5	5
Preparation	Re-Marking	Wood Furniture	110%	45	15%	51.75	1
Finishing	Carving	Wood Furniture	110%	145	15%	167	1
Finishing	Cleansing	Wood Furniture	110%	10	15%	11.5	5
Finishing	Painting	Wood Furniture	110%	90	15%	103.5	1
TOTAL			**110%**	**433**	**15%**	**496.05**	**3-5 Wood Furniture**

Table 5 shows the time and motion study conducted. The performance rating of the workers is at 110% due to a fast paced flow of work and an allowance factor of 15% due to 5% Unavoidable Delays, 5% Unnecessary Activities of the Workers and 5% Special Allowances.

4. Results and Discussion

The process VA/VE shows that the company itself should focus on the overall assembly of the product since the overall assembly is at a continuous flow and will have a significant effect from one operation to another. The overall summary of the results are as follows:

1. Production Time was decreased from 1000 minutes to 600-800 minutes or 20%
2. Suggested U-Shape layout upon simulation generated an output increase from 1 to 5 outputs or 80% increase in productivity and increase in profit and;
3. Overall efficiency was optimized since the U-Shape layout will propose a smooth flow of operations.

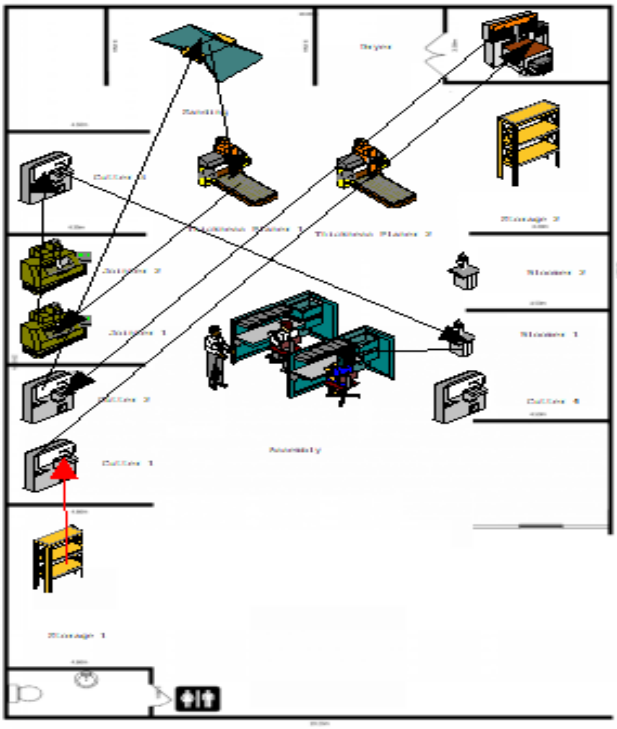
5. Recommendations

A. Suggested Improvement in the Overall Assembly Line of the Company

Based on the gathered data and applications of various equations and analysis; this paper developed the following solutions in the production of wood-based furniture:

1. Process time improvement in the preparation time.
2. Minimization of unnecessary activities of the workers
3. Implementation and use of Personal Protective Equipment (PPE's)
4. Increase in ventilation to decrease heat experienced by the workers
5. Application of U-Shape Layout to smoothen the flow of the operations and;
6. ProModel Simulation to test whether proposed U-Shape Layout is beneficial to the company.

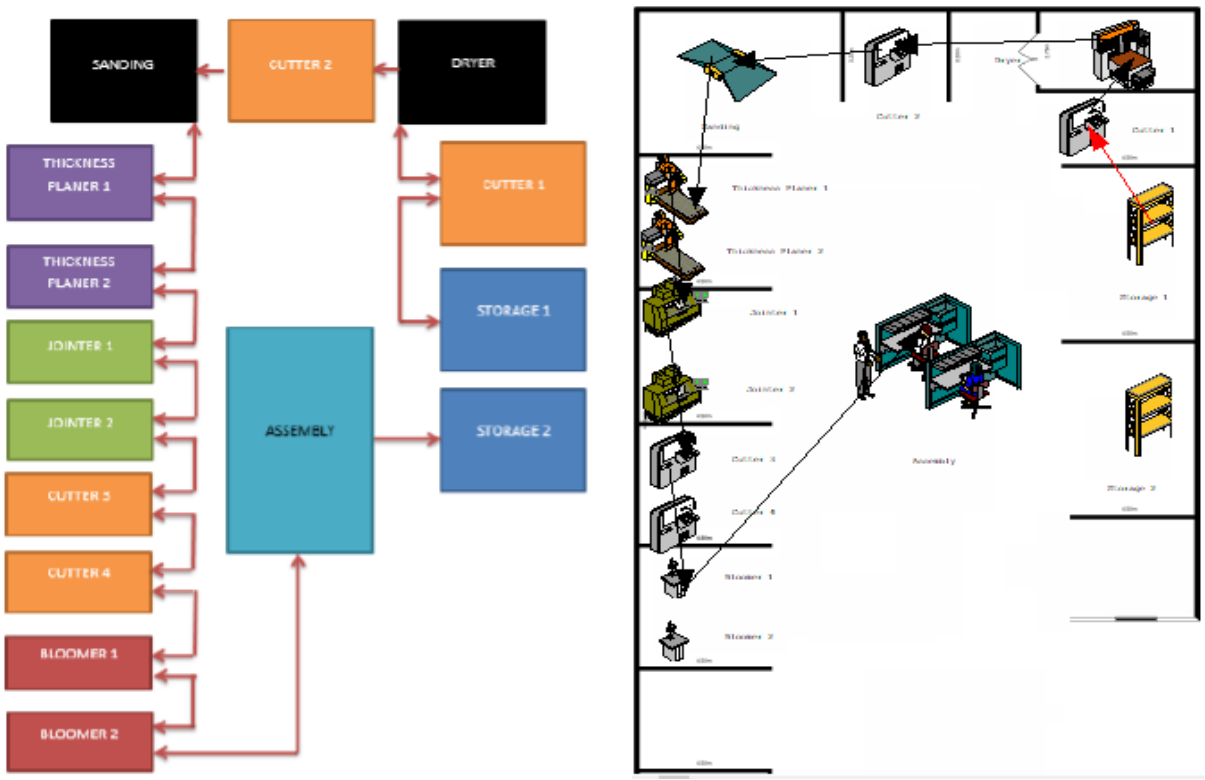
B. Validation through Simulation



Name	Total Exits	Average Time In System (Min)	Average Time In Operation (Min)
Wood	1.00	1,149.73	1,149.73

Figure 3. Present Layout Simulation Model

Figure 3 shows the existing process of the company. Due to inconsistencies in the layout of the assembly area it only generated one output for the whole work schedule and it accumulated an average time of 1,149.73 minutes or 19 hours.



Name	Total Exits	Average Time In System (Min)	Average Time In Operation (Min)
Wood	5.00	868.79	628.79

Figure 4. Proposed U-Shape Layout and its Simulation Model

Figure 4 shows the proposed U-Shape Layout of the company. With this proposed layout, the company will have an overall amount of time decreased from 1,149.73 minutes to 868.79 minutes or 24.43% time savings. Also, this layout will help increase the productivity of the company and its profit, the proposed layout aims to increase it from single finished wood furniture up to five finished outputs. Furthermore, the company does the work for two whole days and stated that they aim to make three finished products for two days. Also, it shows the present layout simulation that generated an output exit of 1 wood furniture which has a value of PHP 5,000 and is at 1,149.73 minutes, the proposed flow layout through U-Shape layout implementation and it generated an output exit of 5 wood furniture which is equivalent to PHP 25,000 and with an average time of 868.79 minutes in the system and an average time of 628.79 minutes in operation.

6. Conclusions

The paper utilized possible industrial engineering tools to improve and optimize the operations within the company. By using VA/VE approach the researchers were able to determine the part of the production that needed the most attention and improvement. Overall the proposed layout gave a significant increase in productivity, decrease in production time and overall increase in profitability.

References

[1] Lin, C., The Application of Wood in Modern Interior Design, vol.9, pp. 103-107, 2015
[2] Kaplinsky, R., Memelovic, O., Morris, M., and Readman, J., The global wood furniture value chain: what prospects for upgrading by developing countries? The case of South Africa", pp. 1, 2003
[3] Philippine Statistic Authority (July 2016): Foreign Trade Statistic Philippines 2015 Available: https://psa.gov.ph/content/foreign-trade-statistics- philippines-2015, 2015
[4] Aether Consulting: Value Analysis/Value Engineering Available: http://www.aetherconsulting.com/consulting-services/122/value-analysis-value-engineering-va-ve/
[5] Bacudio, L., Esmeria, G.J., and Promentilla, M.A., A Fuzzy Analytic Hierarchy Process Approach for Optimal Selection ofManufacturing Layout, *DLSU Research Congress*, pp. 7-9, March 7, 2016
[6] Singh, S.P., and Sharma, R.P.K., A review of different approaches to the facility layout problems, *The International Journal of Advanced Manufacturing Technology,* vol. 30, no. 5-6, pp. 425-433, September 2006.
[7] Marcelo, M.T., Avila, G.V., Cruz, M.A., and Navarro, M., Process improvement and utilization of machines in the production area of a shoe manufacturing company, *International Conference on Industrial Engineering,* 2016
[8] Fernandes, M.T., VALUE ANALYSIS: Going into a further dimension, *Engineering, Technology and Applied Science Research,* vol. 5, no. 2, 2015
[9] Smardzewski, J., Numerical analysis of furniture constructions, *Wood Science and Technology,* vol. 32, no. 4, pp.273-286, August 1998
[10] Aase, G., Olson, J., Schniederjans, M., U-Shaped Assembly Line Layouts and their Impact on Labor Productivity: An experimental Study, *European Journal of Operations Research,* vol. 156, no. 3, pp. 698-711, August, 2004
[11] Miles, L., Techniques of Value Analysis and Engineering, vol. 3, 1989
[12] Chrissis, M.B., Konrad, M., and Shrum, S., CMMI Guidelines for Process Integration and Product Improvement, 2003
[13] Moodley, S., Global Market Access in the Internet era: South Africa's Wood Furniture Industry, *Internet Research*, vol. 12, no. 1, pp. 31-42
[14] Olsen, J., and Sabroe, S., A case-reference study of neuropsychiatric disorders among workers exposed to solvents in the Danish wood and furniture industry, *Scandinavian Journal of Social Medicine, Supplementum*, vol. 16, pp. 44-49, January 1, 1980
[15] Jahangirian, M., Eldabi, T., Naseer, A., Stergioulas, L., and Young, T., Simulation in Manufacturing and Business: A review, *European Journal of Operations Research*, vol. 203, no. 1, pp. 1-13, May 2010

Biographies

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