Job Productivity Enhancement through Plant Facility Layout Improvement in Company XYZ using ProModel Simulation

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Abstract. Work improvement is an essential key for workload difficulties, thus good facility layout reduces unnecessary movements for a smooth and continuous operation. Delays in the production is considerably due to unorganized facility interrelationship among departments. Utilizing work sampling, workers' performance in the present plant facility layout is considered to be 94.4% efficient, incurring PhP 43,200 weekly total income loss for a single production line. This study aims to minimize unwanted elements through proposing an adequate facility layout. Recommendations on improving the facility layout for the ease of workers' job flow improves the production productivity by at least 10-15%.

Keywords: work improvement, productivity, methods engineering, facility layout.

1. INTRODUCTION

Job productivity is the ability to perform a specific task given by the company in order for the worker to produce a product (Freivalds 2014).Work improvement is an essential key to improve the worker's ability to perform each task at a given layout designed in operation and good facility layout design reduces unnecessary movements for a smooth and continuous operation thus increasing job productivity and also the ability of the worker to perform a specific task through the use of the tools, techniques and other existing resources assigned for each process makes them efficient in their performance.

Certain garments manufacturing companies use the facility layout design as basis for job enhancement for the workers to perform each task efficiently. Stephens and Meyers (2010) stated that facilities layout design is the organization of the company's physical assets for efficient use of resources such as people, material, equipment and energy. It includes plant location, building design and material handling systems.

An efficient layout design results to a rapid process of producing goods considering the position of equipment and movements of the workers in the production. Thus, layout design significantly affects the productivity of each worker and helps maximize resources and minimize the time consumed in the production.

This study shows enhancements on the subject company's production facility layout design and how it affects the workers' efficiency in performing certain tasks.

1.1 Problem Statement

The facilities needed for each process play an important role in the production of quality goods. According to the company's records, due to improper layout design of the production line for 900 garments, it causes inefficiency in the performance done by the workers, incurring PhP 43,200 total income loss in a week.

1.2 Objectives of the Study

This study aims to improve the worker's productivity in Company XYZ throughout the entire process of the garment. Coming up with a satisfactory layout for the operations along with the improvement of the flow process procedure targets an increase in the production of garments.

This study specifically sought to:

1. Determine the factors that causes of delays in production through process charts.
2. Evaluate the workers' productivity and how it affects the whole production line through work sampling.
3. Decrease the time of producing the goods from one process to the other through time and motion study.
4. This study also shows the efficiency of the workers in doing the task with the elimination of unwanted elements at a given production layout.
5. Use queuing theory through pro model simulation.
6. Develop the optimal facility design that will

enhance the job productivity of each worker of the full production through methods engineering, and facilities planning and design.
7. Assess the improvement towards lean manufacturing through simulation.
8. Determine the proper arrangements of each process, beginning from storage to finishing and utilizing the spaces available for each process.
9. Create ergonomically designed hand and body movements considering the arrangement and position of each machine and equipment.

1.3 Scope and Limitations of the Study

This study will focus on the production of goods done by Company XYZ and is subject to the following conditions:

1. This study will only focus on the cutting, printing and sewing process of the operation since delays were seen weekly on these departments.
2. This study will be considering the worker's wage as basis for cost benefit analysis.
3. The simulation process will be performed on the spaces available for the cutting, printing and sewing process of the operation.
4. Due to time constraints, this study will only be conducting 20 observations for each process of production and as basis for analysis on worker's movements.
5. Considering the current layout design of the production, this study will not be suggesting for an additional space for the recommended layout design.

2. LITERATURE REVIEW

Based on a study conducted by Ofreneo (2012), the Philippines Garments industry was the 5th largest exporter of garments to the United States it grew rapidly under the implementation of the quota system. However, it has been continuously collapsing due to its weak competitiveness and lack of strategic industrial policies. Recovering from the loss of the Garment industry in the country, maximum productivity and elimination of impediments is implemented through rearrangement of the plant layout which leads to efficient production and decrease of the distance and time consumption in flow of material and accidents (Watanapa et. al, 2011).This plant layout is the arrangement of machines, workstations and facilities in a systematic way that contributes improvements on the efficiency of production Gogi et. al (2014). Similar to a survey conducted by Drira et. al (2007), difficulties encountered by several manufacturing industries are plant layout problems wherein locations of machines and departments are essential in the production. In this case, good placement of facilities would contribute to the overall efficiency of operations. Due to workers travelling long distances from one department to another, smooth material flow of the production is hindered which leads to unwanted costs. Effective facility planning will reduce operational costs and will improve the performance in the production line. Through the reduction of the distance throughout the cycle between the workflow and smooth flow of material, total handling costs were saved by 38.75% that made the layout used in the production to be systematic (Hossain et. al, 2014).

In order to establish a satisfactory layout, Systematic Layout Planning is applied as a tool that identifies areas with high frequency usage and aids for production which lessens material handling, utilizes manpower and efficiency in the productivity. Hossain, et. al (2014) added that by using different studies of the plant layout such as operation process chart, flow process chart, and Systematic Layout Planning (SLP), the significances between the area and materials were identified. Systematic Layout Planning was utilized to form a layout in the most efficient manner. The study illustrates that using this tool, small and medium firms can be improved. Research on plant facility layout problems provides basis that can be generalized into five elements: (1) product (2) quantity (3) route (4) supporting service and (5) time. These elements were identified to be key factors that can improve facility layout Tak and Yadav (2012). Systematic Layout Planning (SLP) created a continuous work flow by arranging the significant sections with high frequency procedure by reducing unnecessary movements. Considering the usage of the tool, the present and proposed layout were compared which revealed a significant improvement and decrease of distance between each department based on the usage of the facility and the location's performance Shah, et. al (2013) and Siddiq (2010). Systematic Layout Planning (SLP) can be incorporated with the assist of Pro-model Simulation in confirming whether the plant layout is efficient or is only causing delays. Tearwattanarattikal, et. al (2008).

Delgado and Carlos (2015) found out that even facility layout improvements that focus on ensuring smooth flow of operations are useless whenever operational inadequacies occur due to worker's health and safety. Ergonomics and plant layout simulation are used in creating an extensive analysis to assure improvements on both efficiency and productivity of the operation and the workers. As a result the proposed layout improved the total units produced from 51 units to 146 units, 95 increased the percentage of In-Operation from 20.53 to 97.90 and decreased the total cycle time from 268.86 minutes to 41.14

minutes. Through ergonomics, layout improvement design, stress and cycle time reduction, and elimination of non-value adding activities, leads to the efficiency and productivity of the workers. Shinde, et. al (2012).

3. RESEARCH DESIGN AND METHODOLOGY

3.1 Data Collection and Analysis

The initial observation conducted in the whole process of the production of garments in Company XYZ with a normal production time of 8 hours (480 minutes) out of 16 operational hours (960 minutes) in (2) two days in a week. This study used the work sampling technique, 87 observations were made to obtain the total time consumed by the workers. Figure 1 shows the observed data resulting to 94% productive time (1,120 productive components) out of 1164 and 6% unproductive time (44 unproductive components).

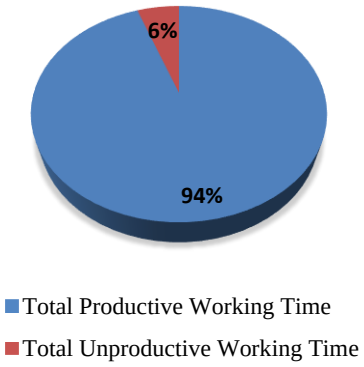

Figure 1. Proportion of Worker's Timing Hours

$$n = \left(\frac{z}{e}\right)^2 p(1\text{-}p) \qquad (1)$$

Normal Time is defined as recorded time done by the workers doing a specific task at a normal pace. It is used to identify how long it takes for a process to be done.

$$\textbf{N.T. = E.A. x P.R.F} \qquad (2)$$

Where:
E.A. = Elemental Average
P.R.F = Performance Rating Factor
Standard Time is defined as time required by an average skilled worker to perform a task given. It is also used as basis for the company jn determining the amount of time consumed for a process to be done.

$$\textbf{S.T. = N.T. (1 + Allowances)} \qquad (3)$$

Where:
N.T. = Normal Time
Allowances = ***E.A. x 0.11***

4. RESULTS AND DISCUSSION

Table 4.1a Present Normal and Standard Time of Cutting Process

Process	EA	PF	NT	ALL	ST
1	0.11	1	0.11	0.01	0.11
2	0.18	1	0.18	0.02	0.18
3	0.81	1	0.81	0.09	0.88
4	0.14	1	0.14	0.02	0.14
Total			1.24		1.31

Table 4.1b Present Normal and Standard Time of Printing Process

Process	EA	PF	NT	ALL	ST
1	0.03	1	0.03	0.003	0.03
2	0.28	1	0.28	0.030	0.31
3	0.08	1	0.08	0.009	0.09
4	0.10	1	0.10	0.011	0.11
5	0.09	1	0.09	0.010	0.10
6	0.23	1	0.23	0.025	0.26
7	0.08	1	0.08	0.009	0.09
8	0.19	1	0.19	0.021	0.21
9	0.07	1	0.07	0.008	0.08
10	0.21	1	0.21	0.023	0.23
11	0.21	1	0.21	0.023	0.23
12	0.09	1	0.09	0.010	0.10
Total			1.66		1.84

Table 4.1c Present Normal and Standard Time of Sewing Process

Process	E.A.	PF	NT	ALL	ST
1	0.04	1	0.04	0.004	0.04
2	0.02	1	0.02	0.002	0.02
3	0.05	1	0.05	0.005	0.05
4	0.04	1	0.04	0.004	0.04
5	0.06	1	0.06	0.006	0.06
6	0.04	1	0.04	0.004	0.04
7	0.17	1	0.17	0.019	0.17
8	0.19	1	0.19	0.021	0.19
9	0.08	1	0.08	0.008	0.08
10	0.18	1	0.18	0.020	0.18
11	0.13	1	0.13	0.014	0.13
12	0.15	1	0.15	0.016	0.15

13	0.15	1	0.15	0.016	0.15
14	0.20	1	0.20	0.022	0.20
15	0.30	1	0.30	0.033	0.31
16	0.37	1	0.37	0.041	0.39
17	0.27	1	0.27	0.030	0.28
18	0.29	1	0.29	0.032	0.30
19	0.32	1	0.32	0.035	0.33
20	0.30	1	0.30	0.033	0.31
21	0.43	1	0.43	0.047	0.45
22	0.38	1	0.38	0.042	0.40
23	0.48	1	0.48	0.053	0.51
24	0.46	1	0.46	0.051	0.48
25	0.26	1	0.26	0.029	0.27
26	0.45	1	0.45	0.050	0.47
27	0.16	1	0.16	0.018	0.16
28	0.28	1	0.28	0.031	0.29
29	0.04	1	0.04	0.004	0.04
30	0.02	1	0.02	0.002	0.02
31	0.20	1	0.20	0.022	0.20
32	0.11	1	0.11	0.121	0.12
Total			6.62		6.83

Table 4.1d Summary of Normal and Standard Time

	Normal Time	**Standard Time**
Cutting Process	1.24	1.31
Printing Process	1.66	1.84
Sewing Process	6.82	6.83
Total:	9.72	9.98

Tables 4.1a, 4.1b, 4.1c, 4.1d presented above shows present normal times and standard times of the work done by the workers for each process at the cutting, printing and sewing department of production, respectively. The researchers computed the normal times and the standard times plus allowances it takes for each process to be done.

4.2 Efficiency

Efficiency is the ability to produce without wastage of materials, time, energy and doing things right the first time around. The efficiency of a worker is a vital point in a company's strive for success through avoiding any unwanted costs leading to a loss of profit for the company. It is obtained using the formula:

$$Efficiency = (Output \times ST) / (WH \times n \times 60) \quad (4)$$

Where:

ST = Standard Time

WH = Working Hours

n = Number of workers on each process

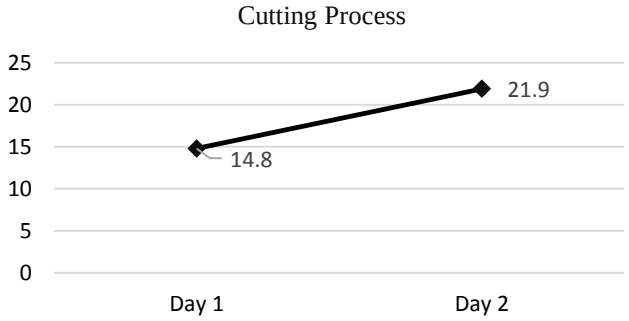

Figure 1. Efficiency of Workers in Cutting Process

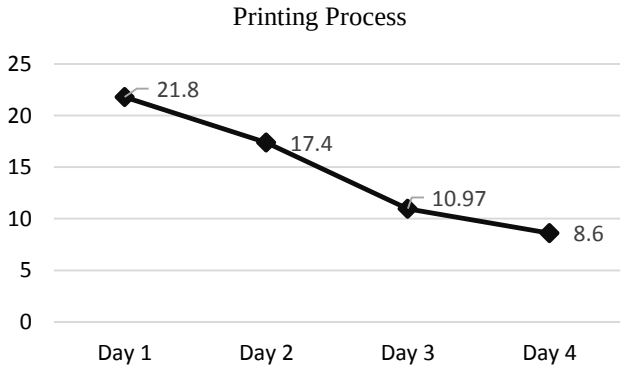

Figure 2. Efficiency of Workers in Printing Process

Figure 3. Efficiency of Workers in Sewing Process

Figure 1, 2, 3 shows the efficiency of the workers for each process done for each department considering the standard times in doing each process, the number of available workers and the required number of working hours each day. It shows that certain process needs to be prioritized and more time must be allotted in order to maintain efficiency in the production.

Table 4.2 Summary of Proposed Normal and Standard Time

	Normal Time	Standard Time
Cutting Process	0.86	0.90
Printing Process	1.12	1.12
Sewing Process	5.99	6.19
Total:	9.72	9.98

The table presented above shows the proposed normal time which determined the proposed standard time for each process. The merging of processes were proposed in order to decrease the time of work and unnecessary movements but still maintaining efficiency of the workers in the production.

4.3 ProModel Simulation

ProModel is a tool that is used for visualization, simulation and analysis. It shows the whole operation in the production line and how each process is done in succession. The result after simulation shows the breakdown of each process and shows the efficiency level then pinpointing which specific process is identified to be the bottleneck that causes a delay in production. Identifying bottlenecks would then make it easier to address the situation and then lead to the improvement of the overall productivity and efficiency.

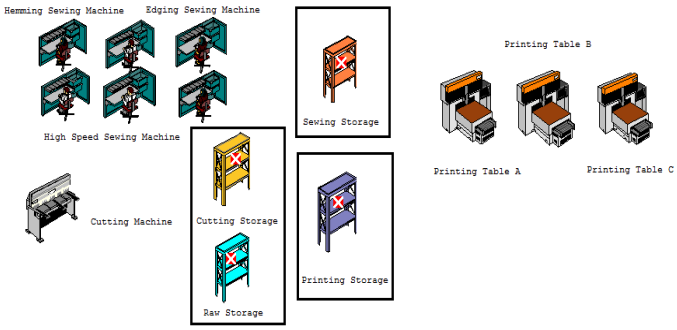

Figure 3. Promodel Simulation

Table 4.3.1 Equipment and Entity

EQUIPMENT	QUANTITY (unit)
Storage	4
Cutting Machine	1
Printing Machine	3
Sewing Machine	6
Fabric (Entity)	900 (total pieces)

A simulation model has been established based on flow of the processes. The model (Figure 3) has been built using ProModel that is made accordingly to the actual location and the gathered data. Locations are associated to fourteen locations and an entity with 900 units (Table 4.3.2)

Table 4.3.2 ProModel Process Flow

FLOW	PROCESSING TIME	DISTRIBU-TION
Raw Storage	UNLOAD 900	-
To C. Machine	T(0.06, 0.13, 0.82)	Triangular
To C. Storage	WAIT 16 HR	-
To Printing Table 1	T(0.03, 0.09, 0.21)	Triangular
To Printing Table 2	T(0.03, 0.09, 0.21)	Triangular
To Printing Table 2	T(0.03, 0.09, 0.21)	Triangular
To P. Storage	WAIT 48 HR	-
To E.S. Machine 1	T(0.02, 0.07, 0.19)	Triangular
To E.S. Machine 2	T(0.09, 0.14, 0.33)	Triangular
To H.S. Machine 1	T(0.24, 0.30, 0.34)	Triangular
To H.S. Machine 2	T(0.37, 0.45, 0.53)	Triangular
To H.S. Machine 3	T(0.16, 0.28, 0.45)	Triangular
Hemming S.M.	T(0.02, 0.13, 0.20)	Triangular
To Sewing Storage	E(5)	Exponential

Where:
C. Machine = Cutting Machine
C. Storage = Cutting Storage
P. Storage = Printing Storage

E.S. Machine = Edging Sewing Machine
H.S. Machine = High-speed Sewing Machine
Hemming S.M. = Hemming Sewing Machine

4.4. Simulation Outcome

Table 4.4.1 Current Layout and Proposed Layout Outputs and % Utilization

FLOW	TOTAL OUTPUTS (hr)		UTILIZATION PERCENTAGE	
	CL	PL	CL	PL
Cutting Machine	46	67	0.02%	0.01%
Printing Table 1	33	54	96.4%	96.2%
Printing Table 2	33	51	88.9%	82.2%
Printing Table 3	33	51	88.9%	82.2%
Edging Sewing Machine 1	47	61	96.4%	5.38%
Edging Sewing Machine 2	54	46	93.7%	6.11%
High Speed Sewing Machine 1	46	48	95.6%	6.15%
High Speed Sewing Machine 2	31	37	96.4%	6.46%
High Speed Sewing Machine 3	47	57	37.6%	5.94%
Hemming Sewing Machine	143	143	85.9%	3.07%

Where:
CL = Current Layout
PL = Proposed Layout

Table 4.3.3 shows the comparison of the total outputs and the utilization percentage between the current layout and the proposed layout. The current layout shows that higher percentage of utilization means entity stayed for long and bottlenecks are visible. The use of Promodel is to beneficial in determining whether to accept a new layout design, the simulation outcomes is consider accepted and should adopt the new layout design to reduce bottlenecks, improve efficiency and increase productivity.

5. CONCLUSIONS AND RECOMMENDATIONS

The proposed method that the researchers came up with stated the elimination of unnecessary operations and unnecessary transportations by re-arranging the plant layout avoids long distance movement from one major department to another resulted in a significant decrease in the standard time taken to finish the whole process.

Through this study, the whole process set by the company would be improved upon implementation of the proposed method due to the shorter time it will then take to finish the tasks throughout the whole operation. The proposed standard time would also be beneficial for the workers because they would not have to keep their efficiency through each process for longer yielding to an increase in the company's profitability through maximum utilization of workers attaining the desired outputs and delivering within a shorter amount of time. (See Figure 4).

5.1 Process Improvement and Cycle Time Reduction

Time study conducted by the researchers identified through the observed time and performance rating factor that there were needs for improvement in the company's standard existing process by eliminating non-value adding activities also the re-arrangement of the facility layout. The elimination of certain tasks and the re-arrangement of the plant layout, wherein there was a significant distance from two major departments, were recommended in order to maintain an efficient but faster production among workers.

Table 5.1 Proposed Normal and Standard Time

Process	EA	PF	NT	ALL	ST
1	0.89	1	0.89	0.098	0.988
2	0.002	1	0.002	0.002	0.004
3	0.22	1	0.22	0.024	0.224
4	0.002	1	0.002	0.002	0.004
5	0.75	1	0.75	0.083	0.883
6	0.16	1	0.16	0.018	0.178
7	0.04	1	0.04	0.004	0.044
8	0.22	1	0.22	0.024	0.244
9	0.09	1	0.09	0.009	0.099
10	0.03	1	0.03	0.003	0.033
11	0.05	1	0.05	0.005	0.055
12	0.19	1	0.19	0.021	0.21
13	0.03	1	0.03	0.003	0.033
14	0.06	1	0.06	0.006	0.066
15	0.27	1	0.27	0.021	0.291
16	0.07	1	0.07	0.007	0.077
17	0.09	1	0.09	0.009	0.099
18	0.03	1	0.03	0.003	0.033
19	0.03	1	0.03	0.003	0.033
20	4.35	1	4.35	0.479	4.829
21	3.59	1	3.59	0.3949	3.984
22	0.28	1	0.28	0.0308	0.311
Total			11.444		12.72

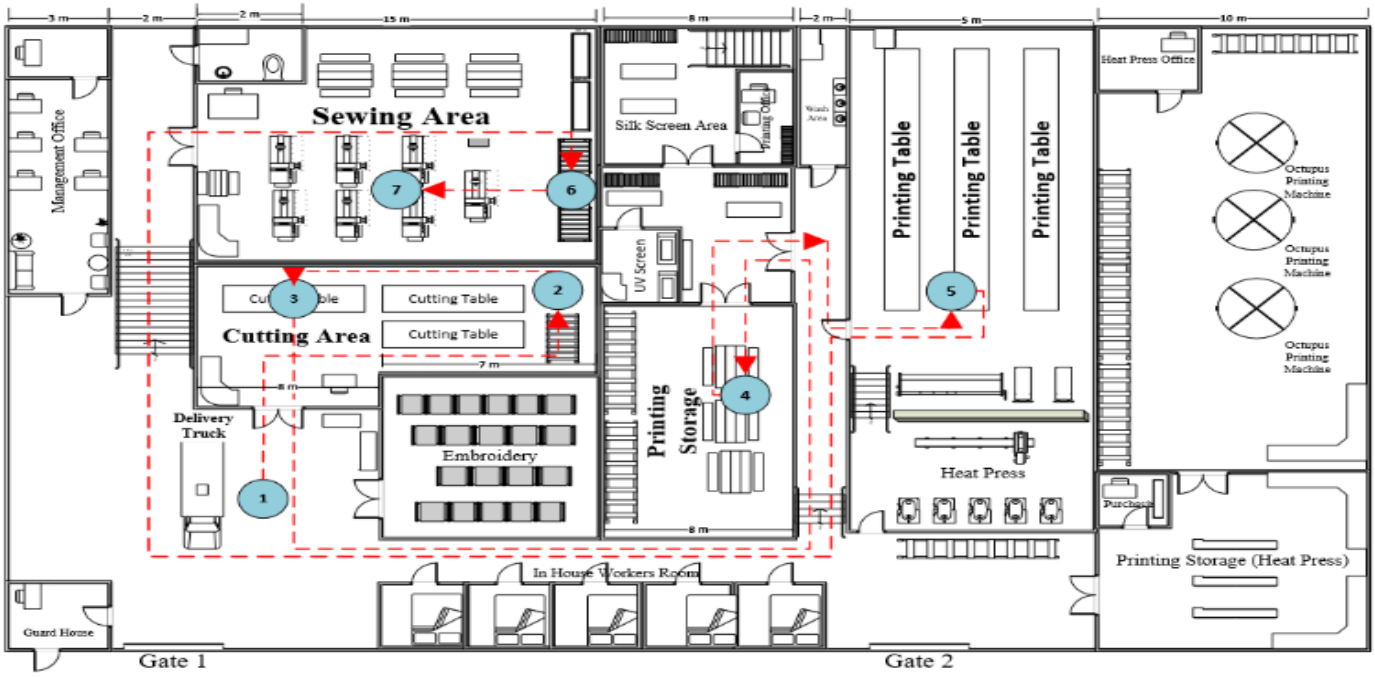

Figure 4. Proposed Facility Layout

Table 5.1 The proposed normal and standard time by eliminating of tasks and re-arrangement of the production area increase the efficiency and productivity leads to better performance of the worker and output in the Company XYZ.

Figure 4 shows the proposed layout design and flow process of the Company XYZ. Using this new layout model the production area lessen the elapsed time of the production, lesser cost, reduce bottlenecks, increase in efficiency and increase productivity. Lastly, through this facility layout design, ergonomic factors like lighting, sitting, material handling, storage deals with how workers beings sit in posture, hear, motion to understand and react in their work environment and also fatigue can be evaded since less travel time and distances are being implemented.

5.2 Cost-Benefit Analysis

Improvements on processes done by the workers, producing garments, exhibited a significant drop in the cost of production compared to the existing process. The analysis made comparing the existing method and proposed method would propel the implementation of the proposed method of production.

Present Cost of Labor Production

$$440 \text{ min} \times \frac{\text{PhP}42.18}{\text{hour}} \times \frac{\text{hour}}{60 \text{ min}} = \text{PhP}309.32$$

Proposed Cost of Labor Production

$$(440\text{-}16.38) \text{ min} \times \frac{\text{PhP}42.18}{\text{hour}} \times \frac{hour}{6\ min} = \text{PhP}297.80$$

Cost Savings = PhP11.52

A worker is required to work 8 hours a day within 6 days a week. Proposed method shows that the company would save 16.38 minutes for every production of garment which can lead to a total savings of PhP11.52 for every piece of garment. The cost savings can be utilized and spent for other expenses of the company especially on the layout.

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