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Production Rate Improvement for Assembly Line in Sheet Metal Stamping Industry

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Abstract. In today's manufacturing industry, there is an increased focus to produce the right product at right time. This project is to study the process flow of Philips Fluorescents Lamp assembly line in sheet metal stamping company based on lines concept and factors influencing the production lines efficiency by analyzing the problem occurred in the process. The manual and automatic assembly has been analyzed for its influence on the assembly line. The transformation from manual to the automated assembly where the manual screwing and packing processes replaced by automated machines is studied. During factory visit, the average cycle time for manual and automated assembly process was taken in order to analyze it. The number of output of Fluorescents Lamp before and after the transformation was studied. Data collected used to simulate the current assembly line process using simulation software, DELMIA Quest. The layout where all process consists of manual assembly and after adding the machines have been designed and analyzed using this software. Based on the current layout analysis, a new layout was proposed in order to get a better process flow. The proposed layout shows an improvement of average production rate of at least 16% from the current assembly line.

1. Introduction

Production rate improvement is very crucial to industries mostly for the manufacturing sector. There are ways to improve the production rate growth as to compete better [1]. Wastes occurred during the manufacturing process called industrial waste. The wastes need to be eliminated in order to avoid production delayed, damage on product and much more [2]. Improvement can be made by analyzing capacity in order to search the areas that need to be improved [3]. One of the areas was an assembly line. The assembly line efficiency is one of the crucial factors that may influence the performance of the enterprises [4]. Advances in assembly line methods are created regularly as new and more effective solutions for achieving the goal of increased throughput (the number of products produced in a given period of time) are determined [5].With smooth process flow and appropriate assembly line, it will make the ability of enterprises is seen in a term to produce quality goods and services with an excellent production line. Simulation is a process that designs a model of the real system and conduct experiments of the operation of the system and by using the model to understand the behavior of the system or evaluate various strategies [6].The key area of this project was improving the production rate at the assembly line by using software, DELMIA QUEST. By doing some simulation of the current layout and process flow, the performance of industry can be improved [7].It is normally practiced by a major industry and mainly focuses on improving the assembly line to continually

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increase their effectiveness in order to ensure their competitive. Nowadays, it is necessary for the manufacturing industry to become more serious to improve the layout of the assembly line during their attempt to achieve their company goals.

2. Methodology

There are four stages involved to complete this project. First stage is the factory visit to sheet metal stamping company. The main manufacturing process is stamping process. A case study is done for Philip Fluorescents Lamp assembly line in this company. Figure 1 shows the processes required for the product. From the visit, a few obvious problems occurred in the assembly lines were recognized.

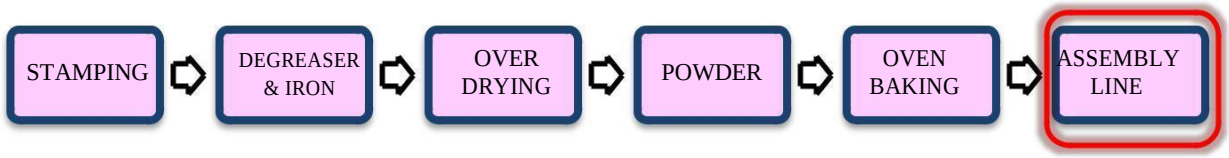


Figure 1 Fluorescent lamp assembly flowchart process

In the assembly lines, the company decided to automate part of assembly process to reduce human errors. The processes are automated as numbers of screws assembled by operators always less than it supposed to be. This situation reflected the quality of products and increased the time rework has to be done. In second stage, data related to the assembly lines were collected such as process involved in lines, the condition of related workstations, cycle time for all process included the manual and automated process, the details of the machine, the problems of the machines and output of the product for a few month. The layout of the assembly line also has been identified.

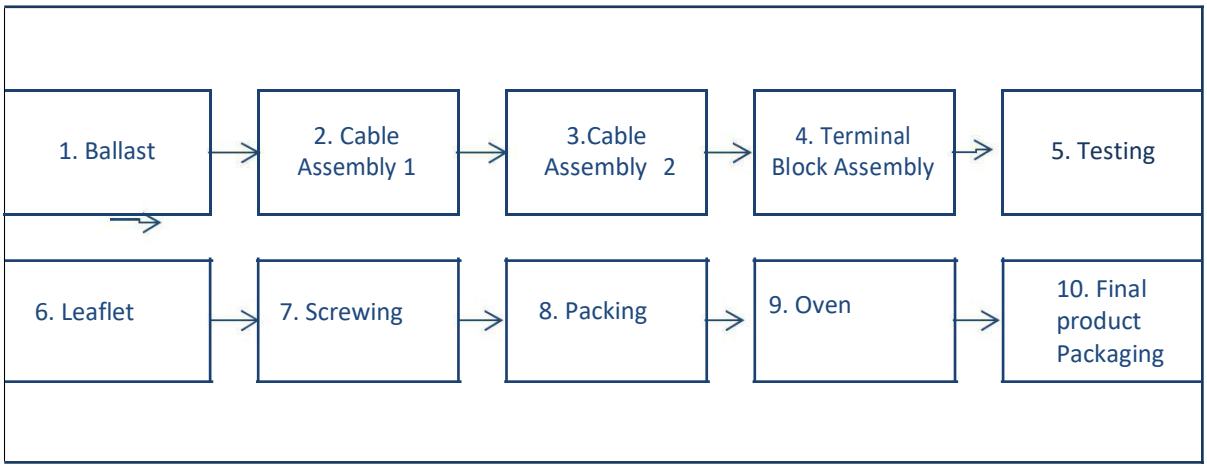


Figure 2. Process of Fluorescents Lamp assembly lines

The third stage was to design of the assembly line using simulation software, DELMIA Quest. This was done after analysing the current layout of the company. Three layouts were designed for comparison purposes. First was when the lines were contained all manual assembly. The cycle time of the simulation was changed according to the actual cycle times of the manual assembly. Second, the layout design where the company implements auto-screwing machine. The cycle time for screwing process was changed from manual to automated cycle. Third, the layout design when the company implements auto packing machine. The cycle time for packing process also changed. The third layout was the current layout in the company for the assembly line. All layouts were simulated and analysed.

In the fourth and final stage, the results from the third stage were taken into consideration to proposed layout was created in order to improve the process flow and production rate. After the simulation was done, the results obtained were analysed. Some discussions regarding the result were made.

2.1. Time Study Techniques

Work measurement methods called time study is used to record the times and rates of the specified conditions that carry out the specified job which performed the elements and in order to determine the necessary time for bringing out the job at a specified level of performance [8].

2.1.1. Cycle time calculation.

Cycle time is one of the crucial information of line balancing in any production line, the Cycle time is the time required to finish a process or the time the product enter the workstation until it moves to next workstation. Cycle time must be taken and analyze in order to fulfil customers demand on time. To Cycle times need to be taken many times in order to get the total average as it will be more accurate.

$$Cycle\ Time = \frac{Total\ Operating\ Time}{Quantity\ of\ Production\ Produced} \quad (1)$$

2.1.2. Average production rate calculation

Production rate for an individual handling or processing operation is normally expressed as hourly rate, that is, work units finished every hour.There is equation to calculated the batch and job shop production

Batch and job shop production

$$T_b = T_{SU} + QT_C \quad (2)$$

Average production time

$$T_P = \frac{T_b}{Q} \quad (3)$$

Average production rate

$$R_P = \frac{60}{T_P} \quad (4)$$

Where:

Tb= batch processing time(min)
TSU= preparation of the setup time
Q = batch quantity
TC= cycle time per work unit (min/cycle)
TP= average production time
RP= average production rate for machine

3. Result and Discussion

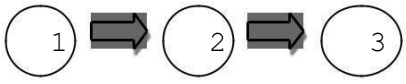
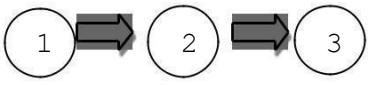
The results obtained from four stages listed in methodology were discussed in this section. There was one operator at each process. The additional operator is placed at bottleneck process during peak time. Cycle time had been observed for several times in order to get an average cycle time for each process. Table 1 showed average cycle time for all process for manual assembly line. It could be seen that the packaging process had the highest cycle time. It is followed by testing and labeling process, and screwing process. As mention in previous section, the company decided to automate the packaging and screwing processes to reduce human error. The automated machine is customized to complete both screwing and packing process. The screw is automatically counted to avoid missing screws in final products.

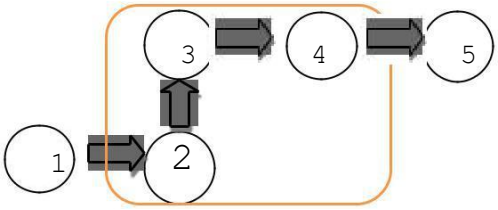
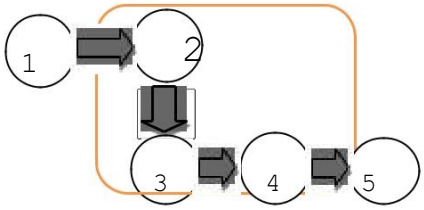
Table 1. Cycle time for manual assembly line

NO	PROCESS	AVERAGE CYCLE TIME(SEC/UNIT)
1	Ballast	3.825
2	Cable Assembly 1	9.800
3	Cable Assembly 2	7.897
4	Terminal block assembly	9.997
5	Testing & labelling	**12.58**
6	Leaflet	8.800
7	Screwing	**10.552**
8	Packing	3.833
9	Final product Packaging	**14.240**

Based on the data collection, Table 2 showed the comparison between manual and automated assembly for screwing and final product packaging processes. It could be seen that the cycle time for automated assembly in both processes was higher than for manual assembly. This is because more steps are required for automated assembly compared to manual assembly. Additional steps such as process 2 and process 3 where the product being placed in another section before start processing increased the processing time of automated sections.

Table 2.Comparison between manual and automated assembly for screwing and packaging processes

Process	Screwing	Packaging
Cycle Time For Manual	10.552s	14.240s
Cycle Time For Automated	**22.365s**	**72.22s**
Step For Manual	 - The product moved from the workstation 1, leaflet process to process 2, screwing process - The product being screwed manually - After that, the product then moved to next workstation which workstation 3, packing process.	 - The product moved from the workstation 1, oven process to process 2, packaging process. - The product was put in a box one by one until six pieces and then the box being taped. - From workstation 2, the product moved to store which in workstation 3.

Step For Automated Assembly		
	- The product moved from process 1, leaflet process to section 2 of auto screwing machine. - From section 2, the product then arranging by the machine to section 3. - Screwing process begins when the product flowed through section 3 to section 4.	- The product moved from process 1, oven process to section 2 of the auto packing machine. - At section 2, the product being arranged and taken into a box in section 3 one by one until 6 pieces - After complete 6 pieces, then the product went through section 4 and being stored - The product then stored in workstation 5

3.1. Simulation using DELMIA Quest

Based on data collected, the previous layout and current layout were designed using simulation software, DELMIA Quest. As shown in Figure 4, the layout designed based on the previous layout that consists of all manual assembly. The cycle time for the machine was according to the average cycle time for manual assembly. Moreover, as shown in Figure 5, the current layout was designed based on the current situation in Fluorescents Lamp assembly line. The cycle time for screwing and packaging process was changed from manual to the automated machine in order to determine the comparison of the production lines and analysed it.

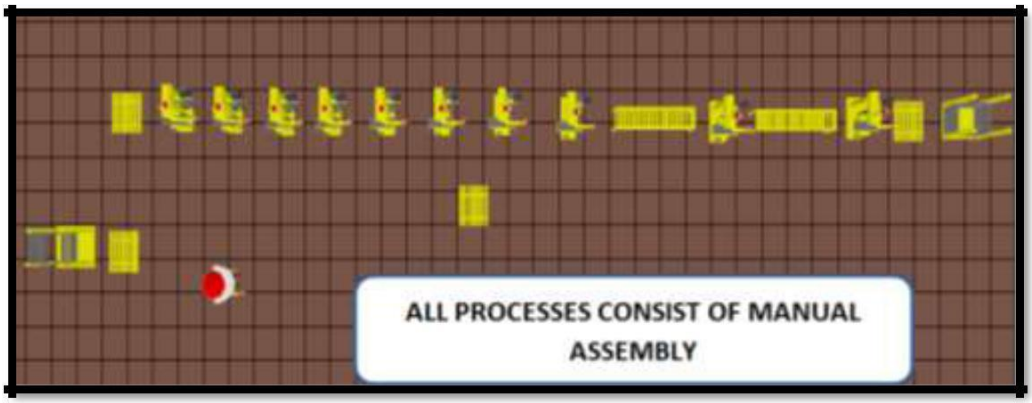


Figure 3. Previous layout (all manual assembly)

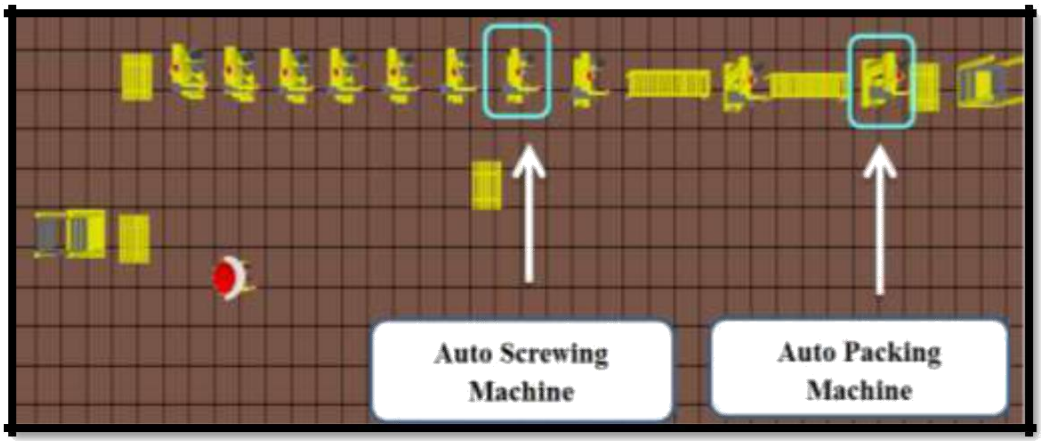


Figure 4. Current layout (auto screwing and auto packing were added)

3.1.1 The layout design analysis

After simulating the layouts using DELMIA Quest, they were analysed. Based on the analysis, the proposed layout was created as in Figure 6. It was created to make production more smooth and increased the production rate. A few processes were combined and all the machines were based on the manual assembly as the automated machine were not involved in this layout. After designing the layouts, the layout then simulated and the results were discussed.

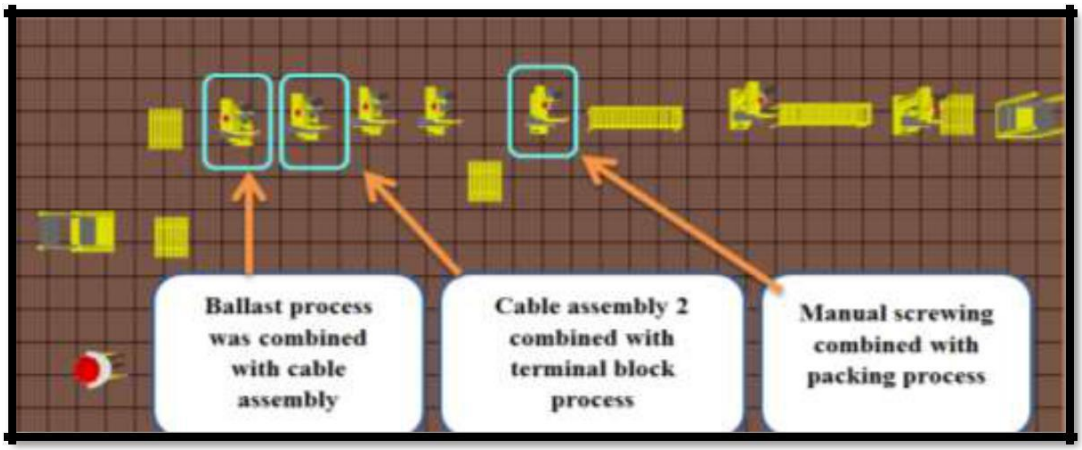


Figure 5. The proposed layout

3.1.2 The simulation result analysis

Results obtained from the simulation were shown in Table 3.

Table 3. Result Based On DELMIA Quest Simulation

Layout	Previous layout	Current Layout	The Proposed Layout
Finished Part	2016	397	1604
Total Manpower	10	8	7
Average Utilization Of The Machines (%)	62.83	57.499	75.196
Average Of Production Rate	272.775	191.825	**200.839**

As shown the simulation result in Table 3, the finished part went down drastically when the assembly started to implement the auto-packing machine. In addition, the proposed layout managed to be higher than the current layout in finished parts. Meanwhile, utilization for machines was decreased during implementation of the automated machine. However, by proposing a new layout, the machine utilization increased about 17.7%. Production rate also declines gradually from all manual assembly even to the proposed layout. The highest was during the previous layout but the differences of average production rate between proposed layouts were lower than the current layout that implements by the company. The manpower also lessens from current, 8 people to 7 people. This means the proposed layout was a better layout to improve the average production rate.

3.2 The calculation of average production layout.

By using a formula that had been stated in equation 2, 3 and 4, the average production rates were calculated and the result of the calculation was shown in Figure 7.

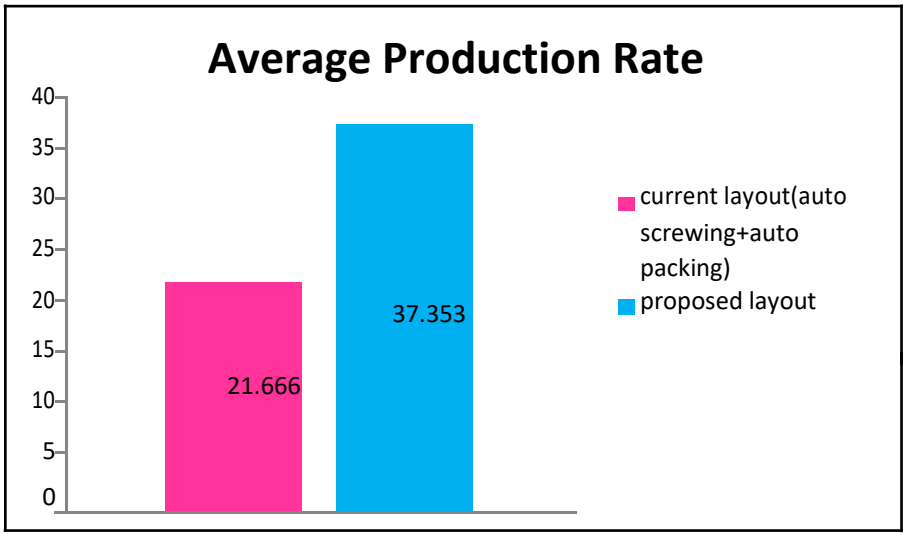


Figure 6.The Result of the Average Production Rate Calculation

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By calculated the average production layout based on the Equation 2, 3 and 4, the result obtained as in Figure 7. The average cycle time for current layout was 21.666 and for proposed layout, 37.353. It means that after proposed the new layout that rearranges the production lines and combined a few process without implementing automated machine, the average production rate could increase up to 15.687. It also is shown that the simulation result was compatible with the calculation as both showed average production rate may increase. The purpose of the creating the proposed a new layout to create

a line that managed to increase the production rate. Based on the average production rate that was calculated in Figure 7, it is shown that the proposed layout managed to increase the production rate more than current layouts that implementing the automated machine. However, the aim of the implementing the automated machine was to eliminate human errors. By creating the proposed layout, not only the production rate was higher, the manpower can be reduced.

4. Conclusion

Based on the finding, the proposed layouts combined processes and reduced manpower. From this result, it could be seen that rearrange the process flow was more important than implementing the automated machine. The purposes of implementing the automated machine were to eliminate human errors. However even though the intention was good, but there were some thing need to be considered. The average cycle time of the automated machine also needs to be considered. Besides, the step of processing the product also crucial and need to be observed as shown in the result, the automated machine required more time to assemble the products as it required more steps than manual assembly. As for auto screwing machine, the machine produced a lot of defects compared to the manual assembly. Because of those reasons, after implementing the automated machine, the average cycle time in whole production line increase, but the production rate decrased. The output of the product also became decreased which it was not helping the company to improve their production rate. Therefore, the implementation of automated machine will be able to improve the company's production rate of the lines if proper consideration is given to the process flow and other related factors to reduce process time.

5. Acknowledgements

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