Improving effectiveness and efficiency of assembly line with a stopwatch time study and balancing activity elements

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Abstract. Background: The rapid industrial development requires companies, especially those engaged in manufacturing, to keep growing and compete to maintain their business. Generally, companies want a short work time to meet production targets and increase profitability. However, some small and medium enterprises tend to overlook the time standards in their production activities, which causes time and labor waste. This research was conducted to determine the standard time and provide recommendations for achieving the balance of assembly lines. Methods: This study used work time measurement techniques using the time study method with stopwatch. Primary data collection is carried out directly to workers at assembly company. Data is processed by testing data uniformity and data adequacy. Furthermore, the data is used to determine the rating factor, normal time, standard time, and the recommended balance of assembly lines. Results: The results showed that the measurement of working time had a significant impact on the effectiveness and efficiency of production activities by reducing costs for workers by 6.67\% and working time to 1.45 seconds faster, as well as achieving the amount of production exceeding the production target. Conclusion: Working time measurement techniques with the time study method using stopwatch can be further investigated and applied to both large industries and small and medium enterprises.

1. Introduction

The rapid industrial development at this time, especially for industries engaged in manufacturing, demanding the company to keep growing and compete in maintaining its business. Competition is one of the trigger factors for company to keep increasing its productivity. Generally, a company wants a short work time to meet production targets and increase profitability. However, to be able to maintain its business, a company must have superiority compared to other similar businesses and carry out activities effectively and efficiently. To support this, a measurement of work time is needed.

Every company needs working time measurement, especially small and medium enterprises. Companies at this level tend to overlook working time standard in their production activities. The absence of working time standards causes production activities become to ineffective that impact to waste of time and labor. Working time measurement is done by observing the activities of production process and operations in the company, including the length of time to make a product or carry out
services and the amount of time needed to carry out the certain activities under normal conditions (work standards) (Rully & Rahmawati, 2015).

Ghozali & Hermansyah (2016) said that the working time was one of the important factor and needed more attention in production system. Working time plays a role in determining work productivity and becomes a benchmark to determining the best work method in completing a job. Work time measurement is related to the effort to set the standard time needed to complete a job (Febriana, Lestari, & Anggraini, 2015). According to Tarigan (2015), standard time is the time needed by a worker who has skill for doing a job in a normal level of speed and conditions, added with the time allowed to rest, personal needs, and other needs.

Based on these, working time measurement is one method that needs to be developed and applied to company because it can establish a balance between the human lane contributed with the output units produced. The implementation of this working time measurement method aims to overcome the problems that arise during production activities and help the activities implementation become more effective and efficient.

2. Methods
2.1. Type of Research
This research was conducted using time study method that was proposed by Adam and Edbert (1992). In this study, time study analysis was carried out using stopwatch.

2.2. Location of Research
This research was held in Assembly Company in Sumatera Utara, Indonesia.

2.3. Object of Research
This study focuses on the elements of work including the amount of labor, the time needed by workers in normal condition, and work movement.

2.4. Measurement
In this study, work time measurement is done by collecting primary data directly to operators who work at the company. Data is processed using data uniformity and data adequacy test to find out that the obtained data has been uniform and sufficient to be the research basis. Then, the data used to determine the rating factor, normal time, standard time, and recommendations on the balance of assembly line (adjusting the amount of labor and work time to the work station). This recommendation intends to accelerate the production cycle time.

2.5. Conceptual Framework
The conceptual framework consist 2 variables;
1. Independent Variable such as cycle time, allowance, and rating factor
2. Dependent Variable such as standard time

2.6. Research Procedure
The following are working time measurement implementation steps by stopwatch.
3. Results and Discussion

Based on primary data collection that was carried out directly to operators who was working at the company, the obtained data are described in Table 1.

**TABLE 1. Identification Data of Work Elements**

| Work Element                    | Observation (s) | Operator |
|--------------------------------|-----------------|----------|
|                                | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
| Preparation                    | 3   | 3   | 3   | 3   | 2   | 3   | 3   | 3   | 3   | 1   |
| Engine Installation            | 6   | 6   | 6   | 7   | 7   | 6   | 6   | 5   | 6   | 7   |
| Ring & Nuts Installation       | 7   | 7   | 8   | 7   | 8   | 8   | 6   | 7   | 9   | 9   |
| Clockhand Installation (3 pcs) | 6   | 7   | 6   | 5   | 6   | 7   | 6   | 6   | 6   | 4   |
| Glass Installation             | 3   | 3   | 3   | 3   | 2   | 3   | 3   | 3   | 3   | 3   |
| Frame Installation             | 5   | 4   | 5   | 6   | 5   | 6   | 4   | 4   | 5   | 6   |
| Packaging                      | 8   | 7   | 8   | 10  | 8   | 7   | 8   | 9   | 8   | 10  |

Based on the data in Table 1, it can be seen that the completion time of each work element has time variation. Furthermore, the data is processed by data uniformity and data adequacy test. The results show that the data has been uniform and sufficient to serve as research basis. Then, the data is used to determine rating factor and allowance to obtain normal time (Wn), standard time (Ws) and assembly line balance recommendation relating to the allocation the amount of workers and the station time (Wst) efficiency as shown in Table 2. Recommendations calculation based on Takt Time calculations.
Table 2 shows that the production activities at assembly company can be more effective and efficient through reducing 1 worker and allocating 1 other worker, and by combining several work stations. Based on the data above, the total time needed to complete a product is 1.45 seconds faster and saves the costs for workers by 6.67%.

However, the effectiveness and efficiency of production activities are also influenced by workers motivation. In this case, the rating factor is used to calculate the amount of incentives for workers who contribute and work well in the company beyond their work standards. The provision of incentives is one of the factors that can increase the workers motivation to work better which will impact on increasing the amount of production as described in Figure 2.
Laweyan, Central Java. The implementation of this method has shown a reduction costs of industrial expenditure by 12%. Reddy, Rao, and Rayjalakshmi (2016) also implemented the time study method using stopwatch in one of the Small Solar Equipment Industries in India. The study showed an increasing number of production and the production processes become faster, which has an impact to industry costs and profits.

By implementing the work time measurement method, the company can carry out its production activity be effectively and efficiently. In addition, work time measurement will produce standard time. According to Ghozali & Hermansyah (2016), standard time is used as reference for determining the best work method.

4. Conclusion
Work time measurement is one method that can be applied to obtain standard time so that production activities are achieved effectively and efficiently. The time standard becomes a benchmark to determine the best work method in completing a job. Based on the results of processing data and several studies that have carried out by applying time study method using stopwatch, it can be concluded that the measurement of work time has an impact on the effectiveness and efficiency of production activities, and the amount of company’s production. By implementing this method, production activities can be faster by 1.45 seconds and suppress down the costs for worker by 6.67%. Therefore, this method can be further researched and developed, and applied to both large scale industry and small and medium enterprises.

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