Optimum Lead Time Based On Productivity Rate of Workers in PT. Universal Tekno Reksajaya Plant Jakarta

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ABSTRACT

Human resources is one of the most important production factors and plays a key role in a manufacturing process. Therefore, it is necessary to improve the performance of human resources as optimal as possible by reducing the unbalanced workload of each element of the existing work. With the increased productivity of human resources, it will also create the productivity of the company. One of the methods used is with work sampling. Work sampling is a technique for analyzing productivity from machine, process, or worker activity. This method is a method of measuring work directly because the observations made directly to the object of observation. The selected object of observation is mechanical PT. Universal Tekno Reksajaya Plant, and the average mechanical productivity is 53.67%.

CCS Concepts

•Applied system →research computing methodologies → decision and analyzing

Keywords

Productivity, workload, work sampling

1. INTRODUCTION

Human resources is one of the most important production factors and plays a major role in a manufacturing process. Human resources that can work well will produce high and good output. Therefore, to obtain high outputs there should be an optimum performance improvement of existing human resources by reducing the unbalanced workload of each work element. This workload reduction aims to increase the productivity of human resources owned by the company.

Work productivity is a measure that shows considerations between inputs and outputs issued by firms as well as the role of labor held by unity of time (sunyoto, 2012). Through this research is expected to provide solutions in improving the productivity. Productivity of a worker influenced by several factors, such as workload experienced by the worker

According to Hart & Staveland (1998) in Tarwaka (2015) the workload is something that arises from the interaction between the demands of tasks, work environment, skills, behavior, and employee perceptions. Generally the optimum workload is achieved when there is no overwhelming tension and strain both physically and mentally. According to Cristensen (1991) and Grandjean (1993) in Tarwaka (2015) states that the light weight of the workload that occurs can be measured in several ways such as measuring worker's pulse and worker oxygen consumption. If the value of the pulse or oxygen consumption is greater, then the workload that occurs the higher, and vice versa.

PT. Universal Tekno Reksajaya (UTR) Plant Jakarta is a company engaged in remanufacturing engines of various heavy equipment. Currently PT. UTR is facing the issue of workerproductivity that causes the length of lead time required to process a ready-to-repair engine (Mardiyan, 2015). Silver Et A1. Defined lead time as the time spent that elapses between the placement of an order and the receipt of the order into inventory. Lead time may influence customer service and impact inventory costs. In an attempt to reduce lead time, business and organizations found that in reality 90% of the existing activities are non-essential and could be eliminated. Harrington propose by eliminating the non-value adding activities from the process and streamlining the information flow significant optimization results can be realized.

One of the factors causing the length of lead time that occurs in PT.UTR is the low level of productivity of UTR workers. This low level of productivity occurs due to the heavy workload received by UTR workers. Generally, UTR workers perform jobs with poor work postures and high workloads. This can lead to high work fatigue so that it can lead to the possibility of musculoskeletal disorder. Low productivity levels can lead to long lead times because if the level of productivity is lower, then the time required to complete a job becomes longer, so the required lead time is also longer. So from the above explanation we can understand that the relationship that occurs between the lead time and the level of productivity is a relationship inversely proportional.

This article will discuss the lead time that occurs on the UTR based on the productivity levels of the UTR workers. The level of productivity of the workers will be compared to the workload experienced by the workers and the level of work fatigue that occurs based on work postures performed by the workers in their work. This article will measure the level of worker productivity using work sampling method and measure the level of workload and work fatigue through the subjective method of the Nordic body

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map questionnaire and through the objective method of pulse measurement, and the last measurement work posture using RULA calculation through the help of CATIA software.

2. METHODS

The first measurement is to measure the level of workload performed by workers and measure the level of fatigue experienced to obtain the value of the possibility of musculoskeletal disorder in the workers. This measurement is done subjectively and objectively. Subjectively measurements were made using the Nordic body map questionnaire. In this questionnaire the workers were asked to choose a score level based on the pain felt on a particular body part. The Nordic body map questionnaire measures the value of pain in a total of 27 body parts from the top of the neck to the sole of the foot. A score of 0 - 280 obtained from this questionnaire can show the degree of risk of musculoskeletal disorder that can occur.

After a subjective measurement, objective measurements are made to support data obtained through subjective measurements. The subjective measurement is done by measuring the rate of the worker's pulse. The worker's pulse is measured after the worker does his work, so that the pulse measurement time is equal to the time of filling the Nordic body map questionnaire by the workers. The pulse rate can determine the level of workload performed by the workers. Generally workers with normal loads will have an average beats of 75 beats per minute. Workers with moderate workloads will have a pulse rate of 101 -125 beats per minute. Workers with heavy workloads will have an average beats of 126 to 150 beats per minute. Workers with very heavy workloads will have an average beats of 151 - 175 beats per minute. Workers with an average rate of more than 175 in each minute are categorized in workers with very heavy workloads (Nurmianto, 2004).

Measurement of worker productivity is measured by work sampling method. The first step is to conduct a preliminary sampling of the workers. Preliminary sampling is done at random clock hours that have been determined to see if the workers are working productively on hours of observation or not. After conducting a preliminary sampling, a uniformity test of data is held for later testing of data adequacy. If the sampling data has sufficient or more than the test data sufficiency, then the data is said to have valid and feasible to use. However, if the sampling data is still less than the test data sufficiency, it is necessary to do additional sampling until the data has been said enough.

After obtaining the average productivity level of UTR workers, the calculation of lead time required by the company to perform the PC-200 repair engine work. The lead time of the calculation will be compared with the lead time of the management to later obtain the result of optimal lead time which is the middle point where the workers are not feel burdened with the lead time and the company can generate huge profits with the lead time. Based on the data provided by the management, it can be seen that the lead time given to repair engine PC-200 is a total of 16 working days starting from

The engine stage is accepted until finally the engine handed back to the consumer. In addition to the lead time of the

Management, also obtained the value of actual lead time by comparing the time required workers to complete the work with the productive time of the workers. From the results of this calculation, the value of the actual lead time of workers based on their productivity level is then compared with the lead time provided by the management in completing one engine PC - 200.

After obtaining the level of productivity and lead time required by the worker to work on a PC-200 engine unit, RULA calculations are performed with the help of CATIA software to determine whether the work posture performed by the workers is a good posture or not. This is done to determine whether the work posture of the workers is related to the productivity level of the workers. CATIA designs are made in accordance with the original size with the original load according to the work done so that the results obtained from the software is a valid result.

3. RESULT

3.1 Workload Measurement

Workload level measurements were made using Nordic body map questionnaires and worker pulse measurements. Here is the result of measurement recapitulation. Table 1 is shown as follows:

Table 1. Workload Measurement

Worker	Age	Working time	Initial score	Final score Nordic	Final Score Heart Pulse	Risk level Nordic	Risk Level Heart Pulse
Worker 1	30	13	33	37	88	Medium	Low
Worker 2	31	10	41	135	124	Fatal	high
Worker 3	26	7	22	40	85	medium	Low
Worker 4	24	5	84	96	128	Fatal	High
Worker 5	30	8	49	55	93	high	Low
Worker 6	28	8	18	20	84	Low	Low
Worker 7	30	11	15	37	91	Medium	Low
Worker 8	35	9	37	95	137	Fatal	High
Worker 9	31	11	36	73	132	Very High	High
Worker 10	30	7	62	63	135	Very high	High
Worker 11	26	8	32	53	95	High	Low

Based on the above measurements, it is found that subjective and objective measurements support each other. However, in some mechanics different results are obtained between subjective and objective measurements. As with worker 3, based on Nordic body map, the workload is medium, whereas based on pulse measurement results it is found that the risks of the work performed are low.

The differences that occur are generally due to fatigue in the body parts perceived by the workers and filled in questionnaires Nordic body map may be a fatigue caused by work that has been done before. Therefore, in order to accurately measure the level of workload, objective measurements are also made through the measurement of the worker's pulse. From the research data obtained, it is known that the average worker has work load at medium to high level.

3.2 Productivity Measurement

Productivity level measurement was conducted for six days using work sampling method on three UTR workers. The following is the

Result of recapitulation of work sampling measurements on three workers. Table 3 is shown as follows:

Table 3. Productivity Level

Day	Productive			Observation			%Productive		
	P1	P2	P3	P1	P2	P3	P1	P2	P3
1	8	9	5	15	15	15	53	60	33
2	8	7	8	14	14	14	57	50	57
3	5	4	4	12	12	12	42	33	33
4	10	10	10	17	17	17	59	59	59
5	6	5	5	9	9	9	67	56	56
6	9	9	9	14	14	14	64	64	64

From the table above, it is known that the percentage of productive work done by the worker in the day, for example, can be seen that on the first day there were 15 observations for the three workers and it is known that in 15 times the observation, the 1 worker only productive on 8 observations, the worker 2 only works productive at 9 appointments, and worker 3 only productive work on 5 out of 15 observations. From the data it can be seen that worker 1 has a productivity level of 53% on the first day, 60% productive for workers 2, and 33% productive for workers 3.

From the level of daily productive percentage, the total productivity level of each worker will be calculated before the average productivity level of the three workers will be calculated. With the average calculation in general, it is known that worker 1 has a productive average of 57% of the total work. Then worker 2 has an average productivity presentation of 53.67% in the overall work. While worker 3 has the lowest average productivity level that is 50.33% from all work done.

Based on the above productivity measurement, it can be seen that the average productivity of the three workers is 53.67%. The level of productivity is included in the category of low enough because the value is close to the middle value. This level of productivity leads to the actual length of lead time occurring at the UTR, the difference being explained in the lead time subspace.

When getting the average value of worker productivity, keep in mind the cause of the low level of productivity of the workers. In the results of this study, most workers do not work productively because of non-avoidable delay and fatigue experienced by workers. In addition, it is also known that workers have to wait at some time before they can continue their work.

Non avoidable delay experienced by workers is generally a nuisance when company officials such as plant heads, plant managers, or supervisors come to the workers while they are working. The company's top brass came to the worker to question the worker about the machine being processed and so on. In addition, other non-avoidable delay factors that often occur is the number of pending parts that cause the machine cannot be in the process so that workers cannot continue the work.

In addition to non-avoidable delay factor, fatigue factor is also the main reason workers do not work productively. Fatigue that occurs is generally caused by high workload must be accepted by workers, in addition to fatigue also occurs due to the many errors of posture in work, for posture errors in work will be discussed in other parts of this study.

The last factor that causes the low productivity of the workers is the workers often have to wait for the equipment needed to complete the work, another thing that often happens is the workers have to prepare various tools and needs required in processing one engine entry for repair in the company.

To overcome some of the above factors are the main cause of the low level of productivity of the workers. This research suggests the company to use the tools in some work process and change worker's work posture so that the workers do not get tired at work, besides, it is also suggested that the workers do work sharing in completing their work.

After knowing the level of average productivity, the data uniformity test is done by calculating the value of BKA and BKB as well as making a control map of each worker. In the calculation of BKA and BKB required an average value of observations that amounted to 13.5 obtained from the results between the numbers of observations by day observation.

The value of BKA and BKB from the control chart is calculated by the general calculation so that it is found that from the three workers, no data is found outside the control limit, but in each worker the exact value is in the lower control limit value which can be said that the productivity of the workers at that time are at a minimum productivity level. Here is a control chart of the two workers. Figure 1 is shown as follows:

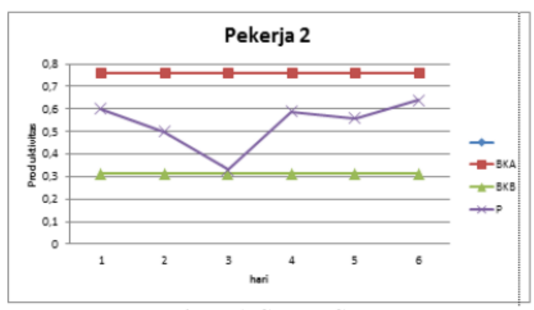

Figure 1. Control Chart

After conducting the uniformity test and making a control map of each worker, calculation of data adequacy test with general formula of data adequacy test. The data adequacy test is used to test whether the data has represented the existing population or not. For one worker obtained the results of the test data adequacy of 53 data required, 57 data for workers two, and 61 data for workers three. Based on the above test results note that the data owned has been enough because this study has had 81 data. The data adequacy test used 90% confidence level and 85% accuracy

3.3 Lead-time

The lead time problem that occurs in UTR is the occurrence of a gap between the actual lead time and the lead time provided by the management. Based on interview results known that the lead time of the management to work on a PC engine unit - 200 is 140 hours or 18.47 days due to the worker's daily worker's daily work time is 7.58 hours. In addition to the lead time data from the management, interviews were also made to the workers about the time required to work on one PC engine unit - 200. The interview results are described in the form of Gantt chart picture 2 as follows:

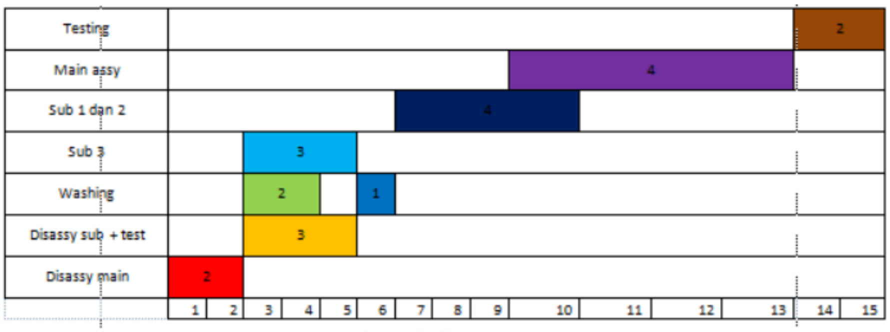

Figure 2. Gantt chart

Based on the Gantt chart above can be seen that the time required to work on one unit of PC engine - 200 according to the worker is 15 days. In addition, based on the calculation results obtained that to meet the Gantt chart above, the workers must work with productivity level 81.31%, so that workers must work productively for 6.16 hours per day from 7.58 hours of work time. The remaining 1.42 hours can be used as allowances for the personal needs of individual workers such as washing hands before break time. In addition to the level of productivity of 81.31%, it is also important to meet the above chart Gantt is not allowed pending part of the engine being processed. So all components must be declared ready when work begins.

Having known lead time given management and lead time according to the workers, this study examines the actual lead time that occurs in the PC-200 repair engine process to get the gap that occurs between the actual lead times with expected lead time. Actual lead time is obtained from the average productivity level of the worker is 53.67% obtained through work sampling. Based on the level of productivity owned, it is known that the productive time owned by workers every day is 4.07 hours. And the time required to work on one PC engine unit - 200 according to data from the worker is for 15 days or 92.4 hours productive. From the above two data can be calculated actual lead time that occurs by using the following formula according to Santoso

$$LT = \frac{Time\ needed}{Productive\ time} \quad (1)$$

Using the formula it is found that actual lead time is 21.54 days and gives a considerable gap between the actual lead time with the lead time from the management and the lead time required by the workers. Gaps that occur between lead times is generally due to the pending on one part of the engine being worked on so that it cannot work on the engine and must be idle. In addition, the gap is also caused by workers often feel fatigue due to work done, this fatigue occurs because the workload received by workers including heavy caterer and the happening of many postures that are less good when workers are working.

Lead time gaps that occur at PT. UTRs cause additional costs that companies need to incur in processing one engine unit. Generally, the additional costs that need to be incurred is the additional service cost that is given to the consumer due to the delay of the process and cause the delay of acceptance of the engine to the consumer. In addition, generally to prevent the delay in production process, the company performs an overtime work system on the workers. The overtime work system that the company performs usually depends on the type of work and the level of complexity of work performed.

After getting some lead time data, it is known that the actual lead time that happened and the lead time given by the company is not optimal lead time because according to the optimal productive percentage is the productive worker 75% of the total working time so the employee has an idle time of 25% of the total time work that is owned so that workers do not experience fatigue work. With 75% productivity, optimal lead time is 16.25 days. From these lead time workers are required to work productively for 5,685 hours from 7.58 hours per day and have an idle time of 1,895 hours per day. This optimal lead time can be achieved with some conditions that are not allowed to happen any pending part during the process of engine work, worker productivity must be maintained in the average value every day, and all engine components must be ready when the work begins.

3.4 Working Posture

Based on the work sampling result, the average worker productivity is 53.67% and the required lead time is 21.54 days from 18 days lead time available. This low productivity occurs because of the high level of work fatigue that occurs. This is evidenced by the results of heart rate measurements and the results of the Nordic body map questionnaire whose results have been mentioned previously. Working fatigue that occurs in workers is generally due to poor work posture, especially in the main assembly line.

Working posture that is often done by worker is bending and squatting posture, while the work load that accepted is a heavy work category. This is the main cause of work fatigue in workers. After being investigated by RULA method with the help of CATIA software, obtained from two samples of work studied, both get the value of RULA with high category that is the value of 6/7 and 7/7. Based on the above calculations, it can be concluded that the work posture that workers often do is a bad posture and needed immediate improvement because it can cause work fatigue and potentially cause musculoskeletal disorder. Here is given the work postures examined. Figure 3 and 4 are shown as follows:

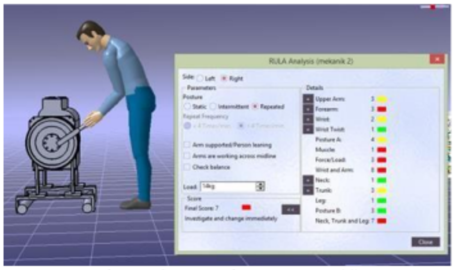

Figure 3. Working Posture (1)

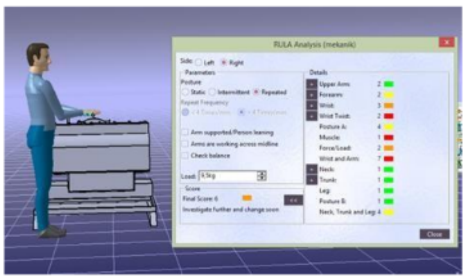

Figure 4. Working Posture (2)

Posture above on Figure 3 is a working position when doing tock rain work on the fly wheel engine with heavy tock rain is done is 15kg and done repeatedly. Based on the calculation of RULA using CATIA software above, it is known that the posture is bad posture, especially in the forearm, muscle, work load received, wrist and arm, and on the neck of the worker. To eliminate the poor work posture, it is advisable to use tools such as automatic impact to the work load received by the workers to be lighter

Posture above on Figure 4 is a working position also when doing tock rain work on the cylinder head of engine with heavy tock rain is done is 9kg and done repeatedly. Based on the calculation of RULA using CATIA software above, it is known that the posture is bad posture, especially in the wrist twist, muscle, wrist and arm, and on the neck of the worker. To eliminate the effect that caused by this posture. This research recommend to do work sharing between all workers because an automatic tools is cannot used for this process

4. CONCLUSION

In conclusion, we present several important factors that lead to the length of lead time that occurred at UTR Plant Jakarta. Based on work sampling result of UTR Plant worker of Jakarta work with average productivity level 53.67%. The low level of productivity leads to a gap between actual lead time and the lead time given by the management. However, low productivity is due to high workload and high fatigue factors experienced by workers. This is evidenced based on the results of the Nordic body map questionnaire and the results of fatigue calculations using RULA method with the help of CATIA software. Future research will discuss what will happen if workers are given additional tools in work and enforced work sharing system to marginalize workload and possible work fatigue that can occur.

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