Productivity Measurement Using Work Sampling Method on Torque Flow Assembly Station of Heavy-Duty Dump Truck at XY Remanufacturing Company

Noni Oktiana Setiowati[1], Sigit Rahmat Rizalmi[2], Abdul Alimul Karim[3]
[1)] Safety Engineering Department, Institut Teknologi Kalimantan
Jl. Soekarno Hatta KM 15 Balikpapan Kalimanran Timur
Email: noni.oktiana@lecturer.itk.ac.id
[2,3)] Industrial Engineering Department, Institut Teknologi Kalimantan
Jl. Soekarno Hatta KM 15 Balikpapan Kalimanran Timur
Email: sigit.rahmat@lecturer.itk.ac.id, alim@lecturer.itk.ac.id

ABSTRAK

PT XY Remanufaktur merupakan perusahaan yang bergerak di bidang perakitan kembali dan perbaikan komponen alat berat. Salah satu komponen pada truk alat berat yang diremanufaktur pada perusahaan tersebut adalah *torque flow* yang termasuk dalam kategori *power train*. Akan tetapi pada proses remanufaktur tersebut, terdapat waktu tidak produktif yang mengakibatkan semakin bertambahnya waktu produksi serta menurunnya efisiensi perusahaan. Tujuan dari penelitian ini adalah untuk mengukur prosentase kegiatan produktif dan non produktif serta menentukan waktu baku dalam proses perakitan *torque flow* menggunakan pengukuran ***w**ork sampling*. Dari hasil penelitian ini, waktu standar untuk menyelesaikan satu komponen *torque flow* adalah 25.07 jam dengan waktu normal 17.17 jam dan waktu siklus sebesar 11.45 jam. Persentase kegiatan produktif selama proses perakiran *torque flow* sebesar 80.5% dan persentase kegiatan non-produktif sebesar 19.5%. Aktivitas paling produktif yang dilakukan oleh mekanik selama proses perakitan adalah perakitan sebesar 32.7% dari total aktivitas, sedangkan aktivitas non-produktif tertinggi adalah *non-job description* dengan 5.3% dari total aktivias, diikuti oleh mengobrol sebesar 4.6% dan menunggu mekanik sebesar 4.4%. Rekomendasi perbaikan yang diberikan untuk menghilangkan aktivitas non-produktif adalah menginstal konverter sebelum proses perakitan untuk menghilangkan aktivitas *non-job description* serta meningkatkan dispilin mekanik dengan cara menerapkan program *reward and recognition,* menghilangkan semua hal yang menyebabkan distraksi, dan melakukan pelatihan SOP untuk menghilangkan aktivitas mengobrol dan mencegah mekanik datang terlambat.

Kata kunci: remanufaktur, *work sampling*, non-produktif

ABSTRACT

XY Remanufacturing is a company engaged in rebuilding and repairing components of heavy equipment. One of the remanufactured components of heavy-duty dump truck is torque flow which is included in the power train category. However, in the remanufacturing process, there is unproductive time that causing increased production time and decreased company efficiency. The purposes of this study are to measure the percentage of productive and non-productive activities, also to determine the standard time in the torque flow assembly process using work sampling measurement. From the result of this study, the standard time to complete one component of the torque flow is 25.07 hours, with a normal time of 17.17 hours, and a cycle time of 11.45 hours. The percentage of productive activities during the torque flow assembly process is 80.5% and the percentage of non-productive activities is 19.5%. The most productive activity carried out by the mechanics during the assembly process are assembling with 32.7% of total activity, while the highest non-productive activity is non-job description with 5.3% of total activity, followed by talking with 4.6% and waiting for the mechanics by 4.4%. Recommendations given to eliminate non-productive activities are installing converter before the assembly process to eliminate non-job description activity, also to improve mechanics' discipline by implementing reward and recognition program, removing all distractions, and conducting SOP training to eliminate the talking activities and to prevent the mechanics from arriving late.

Keywords: remanufacturing, work sampling, non-productive

Introduction

XY Remanufacturing is a company engaged in remanufacturing and assembling heavy equipment components such as engines, torque flow transmission, converters, power modules, final drives and many other components. Remanufacturing is an activity that repairs tools or components of an equipment that have been damaged in order to meet the standards of reusability. Components that are no longer suitable for use and not in accordance with the usage standards will be refabricated or reassembled so that these components could meet the previous standards and could be used again. One of the remanufactured components at XY Remanufacturing Company is torque flow of heavy-duty dump truck which is included in the power train category. The remanufacturing process of a heavy equipment such as torque flow will take a long time for the sub-components to be assembled into a complete component. However, in the remanufacturing process at XY Company, there are unproductive times that caused the increase of production process time and the decrease of company efficiency. These unproductive times need to be identified and measured in order to detect the causes. One of the tools that can be used to measure production process length is time study.

Time study is a method to determine the length of work time required by a worker or a machine to complete a specific job at a normal work speed level in the current work environment. There are direct and indirect methods to measure the working time of an activity. The direct methods are stopwatch time study and work sampling, meanwhile the indirect methods are standard data and MTM. Stopwatch time study are usually applied to measure jobs that take place briefly and repetitively. Meanwhile, work sampling is a technique for measuring work directly by observing the activities of machines, operators or processes where observations are made randomly according to the law of probability (Wignjosoebroto, 2000).

Assembling a torque flow is a long-hours process so the right method of direct time study for this research is work sampling. Besides, work sampling also could be used to measure the workers' productivity. Productivity is the key of sustainability of a business process. Productive is where the human resources have high work productivity and can achieve the goals or targets that have been determined and can be responsible for completing the job on time (Putu *et al*., 2018). Employee productivity is a benchmark for every company in carrying out its business activities both in terms of product quality and quantity (Baiti *et al*., 2020). Several research using work sampling methods to measure workers' workload at drilling company (Diniaty & Febriady, 2015), at furniture manufacturing company (Jono, 2015), at gas station (Fitra *et al*., 2020), at photo studio company (Sanria & Hilman, 2021), housing project (Yanti, 2017), processing crum rubber company (Ernita *et al*., 2019) and grocery store (Muntaha *et al*., 2022).

The purposes of this study are to measure the percentage of productive and non-productive activities, also to determine the standard time in the torque flow assembly process using work sampling method. To obtain workers' productivity rate, work sampling was carried out by observing the workers at random times whether the operator is working or idle. Meanwhile to obtain the standard time, workers' performance rating and allowances are determined using Shumard Rating and ILO Recommended Allowances table. After using work sampling to measure workers' productivity, this study categorizes non-productive and productive element activities into several groups using symbols. Pareto chart will be used to identify the root cause of non-productive activities. Thereafter, recommendations to solve the non-productive activities will be given to increase the company productivity.

Methods

Work Sampling

Work sampling is a statistical method for figuring out how much time is spent on each subject (worker or machine) (Groover, 2007). There are three steps in the work sampling process: (1) Preparing for work sampling, (2) Performing work sampling, (3) evaluation and visualization of work sampling results. At the preparing stage we define the problem and identify each one activity

to be measured. we discuss work activities that fall into the categories of productive and unproductive. At the performing work sampling stage, we conducted a pilot study to determine how many observations are needed to achieve the specified level of accuracy. we use a table of random numbers, to determine the interval and observation period.

Cycle time determined as follow:

$$Cycle\ time = \frac{(\text{Total observation time}) \times (\%\text{productive activity})}{\text{Production Quantity}} \quad (1)$$

Normal time determined as follow:

$$Normal\ time = \frac{(\text{Total observation time}) \times (\%\text{productive activity}) \times (\text{performance rating})}{\text{Production Quantity}} \quad (2)$$

Standard time determined as follow:

$$Standard\ time = \frac{\text{Normal time}}{1 - \text{Allowance}} \quad (3)$$

Data Adequacy Test

In determining the adequacy of data using the following formula:

$$N' = \frac{k^2(1-p)}{S^2 p} \quad (4)$$

Where:
N' = number of observations required
k = index price (depending on the level of confidence used)
p = Productive percentage
s = degree of accuration

The level of confidence used is 95%, so the index price (k) is 2.

Performance Rating

Performance Rating is obtained from considering if operators work at an unnatural speed, so the results time measurement need to be adjusted or normalized. the method used in determining the performance rating is the Shumard method. The Shumard rating method provides benchmarks assessment through work performance classes where each class has its own value. assessment of work performance class is carried out by the direct supervisor. Table 1 shows the Shumard Rating.

Table 1. Shumard Rating (Sutalaksana, 2006).

Class Category	Adjustment
Superfast	100
Fast +	95
Fast	90
Fast -	85
Excellent	80
Good +	75
Good	70

Class Category	Adjustment
Good	65
Normal	60
Fair +	55
Fair	50
Fair -	45
Poor	40

Allowance

Allowances are an interruption to an ongoing productive activity, it can be Personal Allowance and Fatigue Delay (unavoidable or avoidable) Allowance. In this study, we made several discussions with the company supervisors to determine the allowance time using the standards of the International Labor Organizations (ILO).

Result and Discussion

Data Adequacy Test

Data adequacy test was performed before, during, and after the sampling observations to determine the minimum number of observations.

Table 2. Data Adequacy Test

Day	N	Cumulative N	N'
1	117	117	218
2	138	255	198
3	170	425	232
4	116	541	288

The number of observations taken in this study is 541 sampling observations had met the minimum number of observations which is 388 sampling observations (N>N').

Performance Rating

The following are the performance rating and the mechanics that were given by the supervisor and the power train manager using Shumard Method towards two mechanics of torque flow assembly station.

Table 3. Performance Rating

Mechanics	Class category	Score
1	Fast -	85
2	Fast +	95

From the scores above, then the average calculation is carried out to get the overall performance rating of the mechanics who carry out the assembly process. The results obtained can be seen below:

$$Performance\ Rating = \frac{\text{Average performance scores}}{60}$$
$$= \frac{(85+95)/2}{60} = 1.5$$

Performance rating was calculated using Shumard Method towards 2 mechanics and the result is 1.5 which means that the mechanics are working faster than average workers.

Allowance

The following are the results of determining allowances for the mechanics in the torque flow assembly process using ILO Standards:

Table 4. Allowance

Factors	Allowance %
Energy expended	10
Work position	2
Work movement	0
Eye fatigue	6.5

Temperature conditions	7
Atmospheric conditions	3
Environmental conditions	2
Personal needs	1
Total	**31.5%**

The allowance was determined by the company supervisors using ILO Standard, the total allowance from all factors combined is 31.5% for the assembly process.

Cycle time

The cycle time required to complete the torque flow components:

$$Cycle\ time = \frac{(\text{Total observation time}) \times (\%\text{productive activity})}{\text{Production Quantity}}$$

$$= \frac{28.45 \text{ x } 0.805}{2}$$

$$= 11.45 \text{ hours}$$

Normal time

The normal time required to complete the torque flow HD components:

$$Normal\ time = \frac{\begin{array}{c}(\text{Total observation time}) \times \\ (\%\text{productive activity}) \times (\text{performance rating})\end{array}}{\text{Production Quantity}}$$

$$= \frac{28.45 \text{ x } 0.805 \text{ x } 1.5}{2}$$

$$= 17.17 \text{ hours}$$

Standard time

The standard time required to complete the torque flow components:

$$Standard\ time = \frac{\text{Normal time}}{1 - \text{Allowance}}$$

$$= \frac{17.17}{100 - 20\%}$$

$$= 25.07 \text{ hours}$$

The cycle time of the torque flow assembly process is 11.45 hours. The normal time after performance rating added is 17.17 hours, meanwhile the standard time obtained for the torque flow assembly process is 25.07 hours. It means that the standard time to complete the assembly of one torque flow is 25.07 hours after adding the performance rating and allowance time.

Productive and non-productive activities

The following are the results of sampling observations towards the mechanics:

Table 5. Percentage activities

Day	Productive	Non-productive
1	88%	12%
2	90%	10%
3	84%	16%

4	60%	40%

Based on the sampling observations, the average percentage of productive activity is 80.5% and the average percentage of non-productive activity is 19.5%.

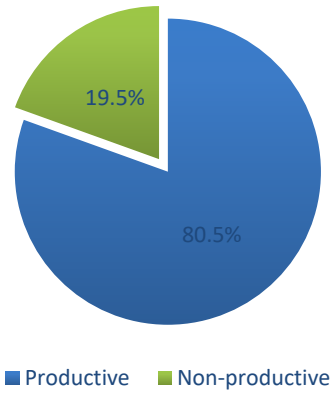

Figure 1. Percentage of productive activity

The following table are the classification of productive and non-productive activities in the torque flow assembly process:

Table 6. Productive and non-productive classification

Productive Activities		**Non-productive Activities**	
Symbol	**Activity**	**Symbol**	**Activity**
O	Hold and Transport Loaded	PT 1	Go to Toilet
S	Select	PT 2	Drink
U	Use	PT 3	Pray
A	Assembly	PT 4	Make a phone call
I	Inspection	PT 5	Daydreaming
IC	Input check sheet	PT 6	Leaving work station
D	Technical discussion	PT 7	Briefing
		PT 8	Talking
		F	Fatigue
		NJ	Non-job description
		ID 1	Waiting for tools and equipment
		ID 2	Waiting for components
		ID 3	Waiting for mechanics

The following pareto diagram is the classification of productive element activities in the torque flow assembly process:

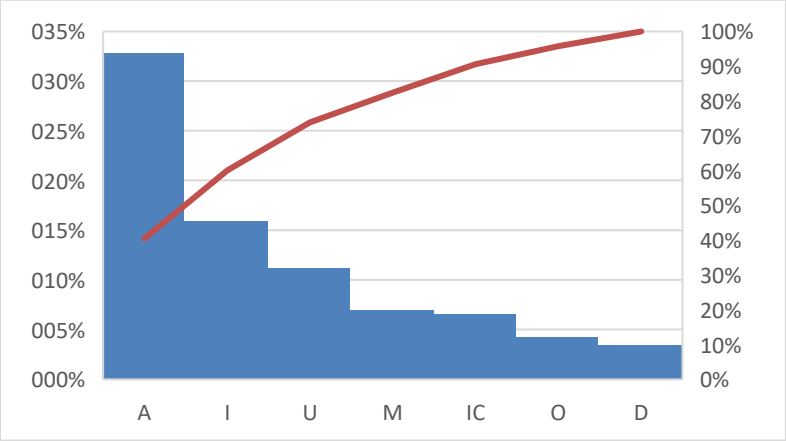

Figure 2. Classification of productive activity

Based on the pareto diagram, the most productive activity carried out by the mechanics during the assembly process are assembling with 32.7% of total activity, followed with inspection of 15.93%.

The following pareto diagram is the classification of non-productive element activities in the torque flow assembly process:

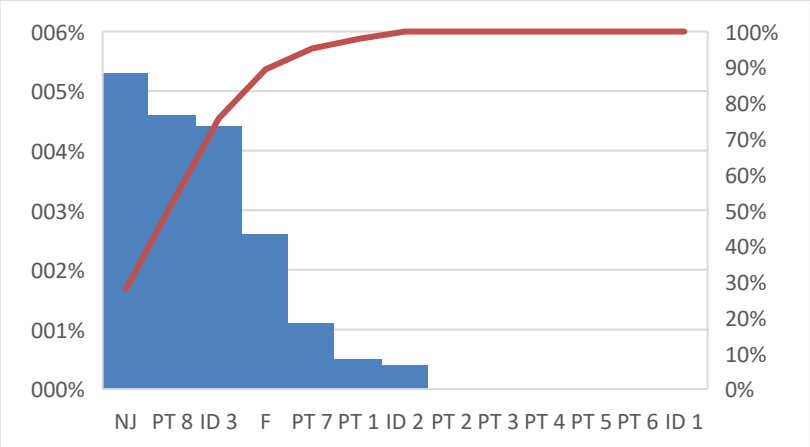

Figure 3. Classification of non-productive activity

Based on the pareto chart above, non-productive activities were caused by three most significant factors and four less significant factors. The highest non-productive activity was caused by non-job description (NJ) with 5.3% of total activity. Where non-job description is a job carried out by mechanics outside of the observed components. At that time, the mechanic was installing a torque converter on the grader unit. This can be solved by installing the converter before the assembly process.

Hereafter, the second and third highest non-productive activities were talking (PT 8) by 4.6% and waiting for the mechanics (ID 3) by 4.4%. These avoidable delays could be reduced by increasing the mechanics' discipline behavior using several methods such as introducing rewards and recognition program, remove all distractions, and SOP training program.

Conclusion

From the result of this study, the standard time to complete one component of the torque flow is 25.07 hours, with a normal time of 17.17 hours, and a cycle time of 11.45 hours. The percentage of productive activities during the torque flow assembly process is 80.5% and the percentage of non-productive activities is 19.5%. The most productive activity carried out by the mechanics during the assembly process are assembling with 32.7% of total activity, while the highest non-productive activity is non-job description (NJ) with 5.3% of total activity, followed by talking (PT 8) with 4.6% and waiting for the mechanics (ID 3) by 4.4%. Recommendations given to eliminate non-productive activities are installing converter before the assembly process to eliminate non-job description activity, also to improve mechanics' discipline by implementing reward and recognition program, removing all distractions, and conducting SOP training to eliminate the talking activities and to prevent the mechanics from arriving late.

References

[1] Baiti *et al*., 2020. Produktivitas Kerja Karyawan Ditinjau dari Motivasi, Disiplin Kerja dan Lingkungan pada PT Iskandar Indah Printing Textile Surakarta. Jurnal Ilmiah Edunomika, Vol 4, No.1.
[2] Diniaty, D., Febriadi, R. 2015. Analisa Beban Kerja dengan Menggunakan Metode Work Sampling. Jurnal Teknik Industri UIN Suska, Vol 1 No 2.
[3] Ernita *et al.,* 2019. Pengukuran Beban Kerja Karyawan Pada Lantai Produksi dengan Metode Work Sampling (Studi Kasus PT. Teluk Luas). Jurnal Saintek, Vol 3, No.1.
[4] Fitra *et al.,* 2020. Perhitungan Waktu Baku dengan Metode Work Sampling pada SPBU XYZ di Kota Dumai, Jurnal Buletin Utama Teknik, Vol 15, No.3.
[5] Jono, 2015. Pengukuran Beban Kerja Tenaga Kerja Dengan Metode Work Sampling (Studi Kasus di PT. XY Yogyakarta). Jurnal Spektrum Industri, Vol 13, No 2.
[6] Groover, Mikell P. 2007. Work Systems and the Methods Measurement, and Management of Work. Amerika: Pearson Education Inc.
[7] Muntaha *et al.,* 2022. Analisis Produktivitas Pekerja menggunakan Metode Work Sampling di Toko XYZ. Jurnal Satuan Tulisan Riset dan Inovasi Teknologi, Vol 6, No 3.
[8] Putu *et al*., 2018. DENPASAR AGUNG Fakultas Ekonomi dan Bisnis Universitas Udayana, Bali, Indonesia Keberhasilan organisasi perusahaan tergantung pada produktivitas karyawannya sehingga produktivitas menjadi pertimbangan sangat penting dalam mencapai tujuan organisasi. 7(10), 5379–5406.
[9] Reynolds, J.M. 1998. An Introduction to Applied and Environmental Geophysics. New York: John Wiley and Sons.
[10] Roeva, O. 2012. Real-World Applications of Genetic Algorithm. In International Conference on Chemical and Material Engineering (pp. 25–30). Semarang, Indonesia: Department of Chemical Engineering, Diponegoro University.
[11] Sanria *et al.,* Analisis Beban Kerja Pegawai dengan menggunakan Metode Work Sampling untuk Menentukan Jumlah Pegawai Optimal. Jurnal Industrial Galuh, Vol 2, No 2.
[12] Sutalaksana, 2006. Teknik Tata Cara Kerja, Departemen Teknik Industri ITB, Bandung.
[13] Wignjosoebroto, S. 2000, Ergonomi, Studi Gerak dan Waktu Teknik Analisis untuk Meningkatkan Produktivitas Kerja, Jakarta: PT Gunawidya.
[14] Yanti, G. 2017. Produktivitas Tenaga Kerja dengan Metode Work Sampling Proyek Perumahan di Kota Pekanbaru. Jurnal Teknik Sipil Siklus, Vol 3, No 2.