Value Added and Non-Value Added Activity Analysis in Disassembly Process for Productivity Enhancement during Covid-19 Pandemic

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Abstract

Reduction of working hours and termination of employment became a big issue during the COVID-19 pandemic. This was affected by social restrictions which had a direct impact on decreasing product demand. Remanufacturing companies surely must have the right strategy to lower the company losses due to decreased productivity and the cost of using human resources to remain stable. The company's strategy is to do efficiency by eliminating non-value added activities in the remanufacturing process. In remanufacturing, the disassembly process is one of the main processes and differentiates it from manufacturing companies. Therefore, the researcher intends to analyze non-value added activities to increase the efficiency of the disassembly process and influencing the company's efficiency. The method to be used is work sampling. It results in a value analysis methodology and non-value added for the disassembly process. The methodology developed is simple and can help decision makers to increase the productivity of remanufacturing companies. The result is known that the seven non-value added activities had measured, can reduce the productivity of the company. By eliminating it, the company can achieve the output target in the disassembly process and reduce the burden on companies due to the COVID 19 pandemic.

Keywords:
Disassembly, Non-Value Added Activity, Productivity, Value Added Activity, Work Sampling.

1. Introduction

The dissemination of the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-COV2) or known as Coronavirus Disease 2019 (COVID 19) occurs in several countries, including Indonesia. The increase in the spread of COVID 19 has prompted the government to carry out various strategies in prevention, one of which is limiting community activities. This strategy has a significant impact on economic aspects in various productive sectors. The report of Statistics Indonesia (BPS) in the second quarter of 2020 regarding the growth rate of the Manufacturing Industry, which shows that the growth of the processing business field contracted -6.19% in the second quarter of 2020 based on Gross Domestic Product. The report states that the decline in business field growth can be seen in the phenomenon of decreasing production and sales figures in several manufacturing business sectors.

The degenerate in economic performance aspect also has an impact on companies engaged in remanufacturing. Even though the remanufacturing industry has developed well in this 20th century because it contributes to a green economy, job creation, and price stabilization (Ng et al., 2014). This shows that the remanufacturing industry should have good prospects in the economic sector. However, due to a decrease in product demand, it encourages companies to reduce the amount of production with the aim that productivity can be maintained at a certain level. A decrease in the amount of production should be accompanied by a decrease in the amount of input consisting of direct/indirect materials, direct/indirect labor, and production costs. Nevertheless, if it is unable to reduce input, then increasing efficiency and productivity cannot be done effectively. This is because the amount of productivity is interpreted as a comparison of the amount of output produced by several inputs used in the re-manufacturing process (Shou et al., 2020). Therefore, under these conditions there is a need for studies that can increase productivity as a strategy to overcome the impact of decreased production due to the COVID-19 pandemic.

The disassembly process is the main process and differentiates between manufacturing and remanufacturing processes. According to Priyono et al., (2016) the disassembly process has many uncertainties including the uncertainties that exist before disassembly, the uncertainties that occur during disassembly, and the uncertainties that are found in other processes after disassembly. Uncertainty can be in the form of the type of product to be disassembly, the condition of the product, the stages of disassembly, and so on. Coupled with the disassembly process is done manually which is possible, not cost-effective. This is because the disassembly design is less efficient for many products (Soh et al., 2014).

Value Added (VA) and Non-Value Added (NVA) approaches were conducted to increase efficiency. The analysis is a lean thinking concept which aims to increase productivity through waste elimination (Seth et al., 2008). The waste consists of 7 categories, namely waiting, defects, over-processing, transportation, universal motion, over-production, and over-inventory (Mcmanus, 2005). These categories are the waste that occurs in the manufacturing process that is Non-Value Added. Thus, for productivity to increase, it is necessary to have a Non-Value Added analysis of all these waste categories. Based on the problems, this research intends to develop a methodology for the analysis of Value Added and Non-Value Added activities in the disassembly process. This analysis model is expected to help decision makers in efforts to increase productivity during the Covid 19 pandemic.

2. Literature Review

By definition, the concept of lean thinking is a business and production philosophy that aims to shorten the time between order placement and product delivery by eliminating waste from the product value stream (El-Namrouty, 2013). Whether an activity contributes to the form, suitability, or function of the production flow, the activity is considered to have added value (VA), Otherwise, the activity is categorized as unnecessary waste (NVA) (Mcmanus, 2005). Furthermore, several researchers have conducted Value Added and Non-Value Added analyzes to increase productivity including Faridah & Lestari (2016), Jeong & Yoon (2016), Tabanli & Ertay (2013), Ng et al. (2014), Mehta (2017), and Shou et al. (2020).

Continuous performance in manufacturing companies can be determined easily. However, it is different from the remanufacturing process, especially in the disassembly process. The disassembly process has uncertainty in processing time caused disassembled product depending on the quality of the end of life (EOL) of the input product (Bentaha et al., 2014). If the quality of the input product is low, it will require more effort and time in the processing process. Therefore, the disassembly process is more challenging than the assembly process.

The definitions of VA and NVA are no longer means to physical transformations between manufacturing processes (Mcmanus, 2005). Because the principles of lean thinking have been applied in various sectors, both manufacturing and services. Based on Table 1, several studies on value added and non-value added analysis has been conducted in all business sectors. The analytical models cannot be fully used for the disassembly process which has its characteristics. Research Faridah & Lestari (2016) was conducted on the manufacturing industry as a whole using the value stream mapping method to visualize the overall analysis effort. Likewise in research conducted by Ng et al. (2014), Shou et al. (2020), and Jeong & Yoon (2016). Meanwhile, Mehta (2017) analyzed with a different approach, namely the Process Cycle Efficiency for all information system projects. Another research that can be the basis for building an analytical model in the disassembly process is the research of Poornashree & Ramakrishna (2019) which has conducted a non-value added analysis in the disassembly process. The research using time study to measure the assembly process time. It requires a long time if carried out on a process that has a high level of uncertainty in processing times and a long cycle time.

According to a few of the research descriptions above, this study attends to analyze the analytical model intended for the remanufacturing industry, more specifically the disassembly process, which has special characteristics and is certainly easy to apply by decision makers.

Table. 1 Previous research

Authors	Objectives	Industrial Type	Method
Ng et al. (2014)	Waste identification for increasing productivity cost.	Manufacture (semiconductor industry)	VSM, trend charts, basic Pareto chart, process flow chart and process flow
Hartanti (2016)	Work measurement in assembly process	Manufacture	Time Study
Faridah and Lestari (2016)	Waste identifications	Manufaktur (Wood Manufacturing)	VSM
Jeong and Yoon (2016)	Waste identifications	Service (Perusahaan IT)	VSM
Mehta (2017)	Decrease the non-value added time	Proyek (Sistem Informasi)	Process Cycle Efficiency
Mandal & Nigam (2018)	Value added and non-value added analysis in the inspection process	Bracket Manufacturing Process	Cross Functional Team (discusssion)
Poornashree & Ramakrishna (2019)	Non-value added in assembly process	Otomotif industry	Time Study, VSM
Shou et al. (2020)	Develop classification models, validity, and benefits of VA and NVA activities	Project (project of maintenance)	VSM, FGD
This Research	Develop the VA and NVA analysis model	Disassembly process, Remanufacturing (heavy equipment)	Work Sampling

3. Methods

This research was conducted in 4 stages of methodology including the preparation stage, the breakdown process stage, the data collection, and processing stage, the analysis stage.

1) Preparation Stage
   This study takes a case study on a remanufacturing company (heavy equipment). As a preparation stage, the first thing to do is define the work to be measured. Measurements were made on the disassembly process carried out by 3 operators. Furthermore, the elements of disassembly work are described by interviewing the three operators.
2) Breakdown Stage
   The breakdown stage was conducted with the supervisors and production managers' consideration which is grouping work elements into 2 categories, namely value added and non-value added. Value added activities are divided into main jobs and supplemental jobs. The main job is activities that have a big and direct effect on

the products produced. On the opposite, supplemental jobs are the activity that does not have a direct effect on results but is needed to carry out operations as well as support the main job.

3) Data Collection and Processing Stage
The data was collected by observing 3 operators for three days. After the observational data is generated, the data uniformity test is carried out by plotting the data into a graph that has determined the upper and lower limits of several data. The next test is testing the adequacy of the data with Equation 1:

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

Where N 'is the number of observations that should be made, k is the data confidence index, p is the probability of value added occurrence, and s is the index of the level of accuracy. The probability of the occurrence of value added can be calculated with the following Equation 2:

$$\text{Value Added Probability} = \frac{\text{Number of observations of value added events}}{\text{number of observations}} \quad (2)$$

If N' < N means the data can be declared sufficient and the data can be continued in the next data processing. The next data processing is determining the foreign standard time for each operator. In determining the standard time, it is necessary to determine the cycle time and the previous normal time. Cycle time is the completion time of one production unit starting from the beginning of the product being processed. The cycle time can be calculated using the following Equation 3:

$$\text{Cycle Time} = \frac{\text{Amount of Time}}{\text{Number of Products Produced}} \quad (3)$$

Normal time is the time for the completion of work completed by workers in reasonable conditions and of average ability. to determine the normal time can be calculated by the following equation 4:

$$\text{Normal Time} = \text{Cycle Time} \times \text{performance rating} \quad (4)$$

The performance rating is obtained from Westing House System's Rating Method which based on yang 4 criteria including skill, effort, condition, and consistency. Thus, the standard time can be obtained by equation 5.

$$\text{Standart Time} = \text{Normal Time} \times \frac{100\%}{100\% - \%\text{Allowance}} \quad (5)$$

4) Analysis Stage
At the end of the research stage, an analysis was conducted regarding the productivity analysis of the disassembly process in the existing conditions and conditions when the NVA in the disassembly process was eliminated. This analysis will be a reference for the company in determining further decisions, including the determination of technical policy strategies for the workforce to improve performance. In addition, it serves as a reference for companies regarding policies regarding processes that need to be overtime.

Table 2. Work elements of the disassembly process

No	Work Element	Value Added Activity		Non Value Added Activity
		Main Job	Suplemental Job	
1	Handling by hand	v		
2	Handling by crane	v		
3	Turning over by crane	v		
4	Pulling by hand	v		
5	Pulling by puller	v		
6	Pressing by palu	v		
7	Loosing by impact	v		
8	Loosing by high impact	v		

9	Loosing by setwrench	v		
10	Measuring		v	
11	Attaching by mata impact		v	
12	Attaching by kabel		v	
13	Transfer by walk		v	
14	Transfer by crane		v	
15	Transfer by forklift		v	
16	Cleaning		v	
17	Reposition crane		v	
18	Looking document		v	
19	Marking		v	
20	Other		v	
21	Searching tool			v
22	Overmoving			v
23	Waiting Engine			v
24	Unavailable Operator			v
25	Motionless			v
26	Talk to others			v
27	Resting			v

4. Data Collection

The result of interviewing 3 operators, can be identified as 27 working elements in the disassembly process (Table 3). Work elements are grouped into 2 categories, value added and non-value added. The grouping resulted in 20 value added work elements consisting of 9 main job elements and 11 supplementary job elements. Non-value added work elements were obtained by 7 work elements. To determine the length of time for value added and non-value added in the disassembly process, then direct observations were made to 3 operators who conducting the work on the disassembly process for 3 days (Figure 1).

Table 3. Number of activity based on observation result

Operator	Activity	Days		
		1st	2nd	3rd
1	Value Added	166	161	173
	Non Value Added	74	79	67
2	Value Added	161	173	165
	Non Value Added	79	67	75
3	Value Added	165	170	165
	Non Value Added	75	70	75

The number of observations made by each operator was 240 for 7.75 hours (Table 3), so that the number of observations per operator was 720 observations. Then the overall total of observations in 3 days is 2160 observations. In addition, it can be seen how the difference in the number of value added and non value added activities of each operator per day.

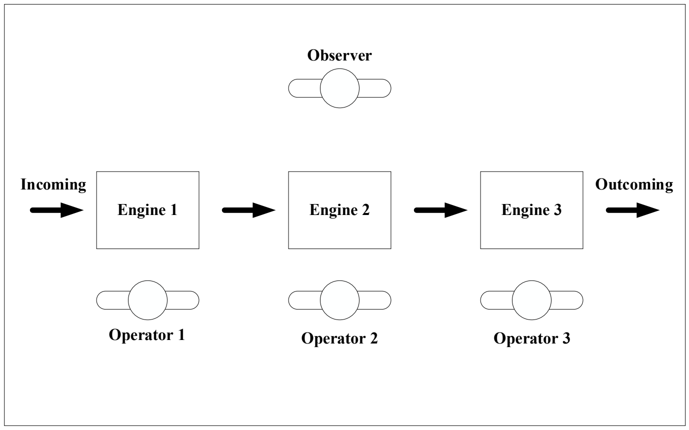


Figure 1. Observation Process

5. Results and Discussion

Based on the number of observations that have been made to the three operators, the probability of value added events can be generated. This probability indicates the possible value of value added activities from a number of observations made in the disassembly work process.

Table 4. Probability of value added and non-value added

Operator	p	1-p
1	0,694	0,306
2	0,693	0,307
3	0,694	0,306

Table 4 shows that operator 1 has a probability of 0.694, this shows that 69.4% of the work done by the operator has the value added category, while 30.6% of the work has the non-value added category.

5.1 Data Preparation

The results of the uniformity test using the confidence level α = 95% and the value of k = 2 on the data for the three operators stated that the data were uniform. From Figure 2 it can be seen that the observation data for the 3 operators are uniform. The data shows that it is between UCL and LCL, or in other words that there are no observational data for the 3 outlier operators. Furthermore, the adequacy test is carried out to determine whether the observed data sample of 720 data is sufficient.

(a)

(b)

(c)

Figure 2. Uniformity test graph

The results of the calculations shown in table 5 show that the value of N 'for each operator is 705, 709, and 705 respectively. The value of N' which shows the amount of observation data that must be taken for each operator is smaller than the amount of actual observation data taken. (N). Therefore, the number of observational data taken as much as 720 data is sufficient and can represent the entire work in the disassembly process, so there is no need to retrieve observational data in the process.

Table 5. Results of the data adequacy test

Operator	N	N'	Note
1	720	705	Sufficient
2	720	709	Sufficient
3	720	705	Sufficient

5.2 Work Measurement

The average lead time for engine disassembly work takes 7,75. Measurement of work in this study was conducted for 3 days. With the data, it can be determined the standard working time of one engine unit. From the calculation, the existing standard time for operator 1 is 9,503 hours/unit (Table 6). Determination of this standard time takes into account the performance rating of 1,03 while the performance ratings for operators 2 and 3 are 1,05 and 1,03. In addition, the standard time has also taken into account the allowance for each operator in which the allowance value of each operator is 16%, 25%, and 21%. The allowance is considering by ILO (International Labor Organization) setting with grouping into the constant allowance and variable allowance. Based on calculations on the existing conditions, the resulting total standard time is 30,457 hours/unit. Thus, the standard output of all operators in the disassembly process is 0,0328 units/hour. That means that all operators can complete the disassembly of 1 engine unit in 30,46 hours.

Table 6. Standard Time dan Output Existing Standard

Operator	Cycle Time (Hours/Unit)	Normal Time (Hours/Unit)	Standard Time (Hours/Unit)	Output Standard (Unit/Hours)
1	7,75	7,9825	9,503	0,0328
2	7,75	8,1375	10,850	
3	7,75	7,9825	10,104	

If the determination of standard time is only done by accommodating the probability of value added work elements, then the standard working time of operator 1 is reduced by 2,904 hours to work on the disassembly process to 6,599 hours/unit (see Table 7).

Table 7. Standard Time and Standard Output Based on Value Added Working Elements

Operator	Cycle Time (Hours/Unit)	Normal Time (Hours/Unit)	Standard Time (Hours/Unit)	Output Standard (Unit/Hours)
1	5,382	5,543	6,599	0,047
2	5,372	5,640	7,520	
3	5,382	5,543	7,017	

There is a change in output standard for each operator, make it will change every hour. The standard output of all operators increases to 0.047 units/hour. The difference in standard change in output of all operators is 0.0145 units/hour.

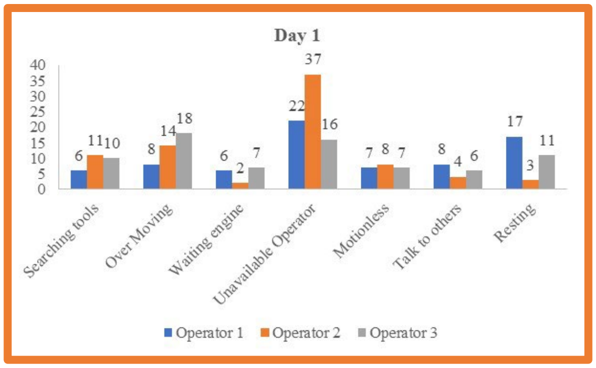
Based on the company's information, the disassembly department has a target output of 60 engines for a month. Currently, the company has 5 lines of disassembly processes with the same lead time. After calculating the existing conditions, every 8 hours the five disassembly lines can produce an output of 1,313 units/day. This means producing 60 engine units in the disassembly process takes 46 days that equals 368 hours. Because the company has two work shifts, the existing condition needs to overtime for 48 working hours (20 working days) to achieve the production target. Meanwhile, if non-value added activities are eliminated, the resulting standard output is 1,893 units/day for the five production lines. So, to produce 60 engine output takes 32 days or the equivalent of 256 hours.

5.3 Work Element Analysis

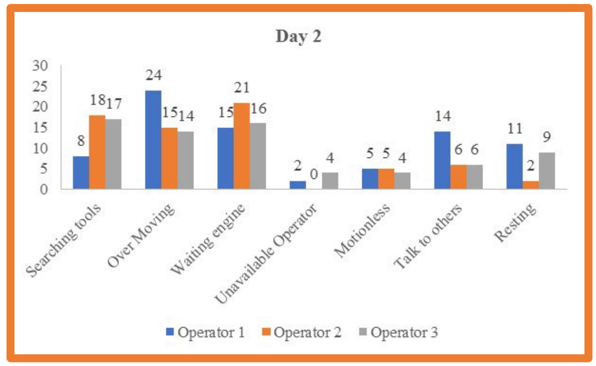
Based on analysis using work sampling, it is obtained elements of value added and non value added activities, the percentage of operator productivity, standard time and standard output. On average 69.37% of the disassembly process contains value added processing elements. It means that 30.6% of work elements can be categorized as non-value added activities. Non-value added activities include searching for equipment used to dismantle engine components such as hammers, screwdrivers, and bolt locks. The number of equipment search activities performed by each operator during the observation was 6 times, 11 times, and 10 times on the first day (see Figure 2a). This activity is classified as the third largest after the activity is running without doing something such as not moving or transferring components from one place to another. However, on the second and third day of observation, the activity of searching for this equipment seems to be increasingly being carried out, even being the second largest after over-moving activities. From Figure 2b and Figure 2c, this over moving activity has an average of 17.67 times on the second day and 15.6 times on the third day for the three operators.

The availability of operators in the disassembly process is also a non-value added activity that has a high average number on the first day of observation with an average number of 25 times but decreases on the second and third day of observations. The observation on the third day of activity of this unavailable operator is lack compared to other activities. Meanwhile on the third day of observation, the average activity was the same as the searching tools activity, namely 13.3 times. That number does not say that it is affected by all the same operators, because on the third day only the number of unavailability of operators 1 and 2 has high unavailability. This mismatch also occurs in resting activities (see Figure 2c) where the operator is silent, without moving, and not doing any processing. In resting activities, operator 3 performs this activity 17 times and this number is equal to 2 times more than operators 1 and 2.

Other activities conducted by operators but categorized as on-value added activities are motionless. Motionless is operators do not do any work due to fatigue, but this activity is different from resting activities because it only takes a short time of about 15 seconds. From the observations, motionless activity is the activity most rarely performed by operators from the first day to the third day, approximately 1 to 8 times. Other activities that are categorized as non-value added activities talk to others, which means that the operator stays for a moment and talks to another operator. From the observation, operators discuss how to dismantle a component that is considered difficult. The disassembly process has its challenges because it has to work on an engine that is already in use, so it is possible for components that are difficult to disassemble due to rust or the installation of bolts that are too strong. Talk to others activities often occur on the third day, which is about 7 to 17 times.



(a)



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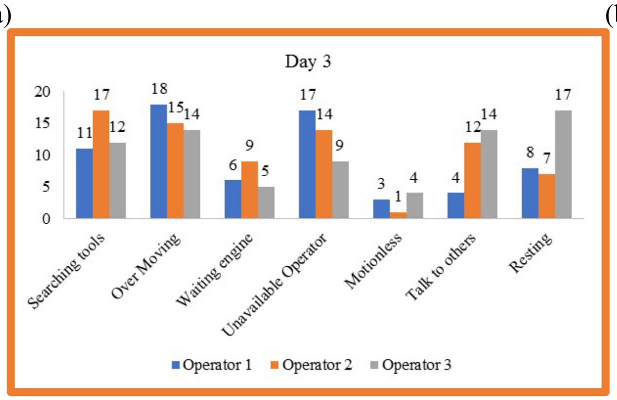

(c)

Figure 3. Number of non-value added activity

Waiting is an activity performed by the operator after completing his work on the first machine and waiting for the next engine to arrive is also an activity categorized as non-value added. This activity is certain to occur, but according to management, it should be eliminated using an engine that has been prepared by the handling operator before the previous engine has been dismantled. Based observation on the second day, waiting activity is classified as frequent compared to other days is 15 times for operator 1, 21 times for operator 2, and 16 times for operator 5. The number of waiting activities is even the second highest after over moving activity. Therefore this waiting activity needs to be considered to be eliminated if there is a solution that can be implemented by the management.

5.4 Discussion

The disassembly process is an activity that plays an important role in the remanufacturing industry. Based on the research of Soh et al., (2014) the disassembly process needs to be analyzed more deeply because almost all activities are done manually. So it will be very prone to ineffective activities. To enhance productivity, it is necessary to make efficient the disassembly process. The way to do by analyzing value added activities and trying to eliminate non value added activities (Poornashree & Ramakrishna, 2019). This study proves that the analytical model can be used to analyzing the value added and non value added activities by measuring work sampling. The results of the analysis that conducted in the disassembly process show that there are 20 value added activities and 7 non-value added activities as shown in Table 2. The activities are searching tools, over moving, waiting for engine, unavailable operator, motionless, talk to others, and resting. Based on this research, it was found that after the non-value added activities were eliminated, the average standard time for 3 operators became smaller, being 7 hours/unit, which previously with non-value added was 10.15 hours/unit (Table 6&7).

6. Conclusion

Based on this research, it can be concluded that the analytical model can be used to analyze value added and non value added activities by measuring work sampling. The results of the analysis conducted on the disassembly process indicated that there was 20 value added activities and 7 non-value added activities. The observation shows that the average percentage of value added activities is 69.40% so that 30.60% of activities are categorized as non-value added. These activities include searching tools, over-moving, waiting, unavailable operators, motionless, talk to others, and resting. If this non-value added activity exists, the standard output conditions for the existing disassembly process will not fulfill the output target of the remanufacturing company in every month. This is because to complete the output of 60 units, the disassembly department must complete it in 46 days. In other words, the disassembly department must complete its work for 368 hours during 1 month out of 320 normal working hours (20 workdays per month). This shows that there needs to be overtime for 48 hours or the equivalent of 2 working days. During the Covid 19 pandemic, the company experienced a decline in demand and did not reduce employees, so a possible strategy is to reduce operator work hours and implement no overtime. Therefore, another strategy that can be carried out by management is to reduce or eliminate non-value added activities that occur in the disassembly process. This is based on the results of the analysis which shows that eliminating 7 non-value added activities can reduce the time for disassembly to be 32 days. This result is very significant because it reduces 14 working days on the disassembly process. Thus, in addition to the company being able to reduce overtime, the company can also implement a strategy to reduce operator work time due to the impact of the Covid 19 pandemic.

7. Limitation and Recommendation

This study is close to several limitations that are known through observations throughout the study. The shortcomings felt by the researcher need to be disclosed for the sake of the perfection of further research in the same discussion. Among them is the need to measure further regarding the actual non-value-added time. This is because in this study the standard time measurement is based on the percentage of the amount of value-added and non-value-added time. In other words, the result obtained is an estimated value. Therefore, another approach is needed to determine how much time is actually wasted from non-value-added activities.

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