WASTE ANALYSIS TO INCREASE PRODUCTIVITY OF METAL PRESS LINE IN MOTOR CYCLE DISC BRAKE INDUSTRY USING WORK STUDY AND LEAN MANUFACTURING METHODS

DAMSIAR, CHOESNUL JAQIN & HASBULLAH

Master Industrial Engineering, Mercu Buana University, Indonesia

ABSTRACT

The motorcycle component industry as part of the national strategic industry has made a significant contribution to the country's economic growth. The problems still facing are the availability of most of raw material still imported, mastery of the latest technology, and still low fulfillment of production targets. Based on previous studies, among the main reasons are the effective use of machine time is still low and low work productivity which is the cause of incorrect production system selection and poor machine layout, causing a lot of waste which leads to high production process time. This paper aims to help remove the waste that appears in the metal pressing line by using analysis of work studies, production systems, machine layout, line balancing, and application of lean manufacturing principles. As a result of the improvements made, the valueless activity waste can be reduced by 15 activities which affects the increase in machine efficiency by 21.5%, machine utility by 18.2%, and work productivity by 27%. As a result, production targets increased from 85.2% to 94.7% and other benefits from production cost savings.

KEYWORDS: Productivity, Work study, Lean manufacturing & Production system

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INTRODUCTION

The motorcycle component industry is one of the strategic industries that the government relies on to make a significant contribution to the country's economic growth through the sale of its products and the provision of employment for the community. However, on the other hand, the industry still faces many problems in its development, including the availability of steel raw materials, most of which are still imported, import duties, rising wages while labor productivity remains low. At the company level, the problem components encountered are much more complex, which causes companies to need strategies to increase efficiency and productivity in the use of machines with limited resources so that there is no waste. One of the parts in the production process that causes a lot of waste is Line Metal Press. Based on existing theories and research, one of the most effective concepts to reduce waste that arises in the production process is to carry out work research and lean manufacturing and with various improvement tools contained in it, such as study methods & measurement work, flow system, layout, line balancing. The purpose of this paper is to help reduce the waste that arises using these methods and tools by increasing the efficiency and utility of machines, increasing work productivity so as to increase the achievement of production targets which currently only reach 85.2%.

METHODS

According to Mali (1978) in Nursim (2017), is the quantitative relationship between what we produce and we use as a source to produce it, which is the arithmetic ratio of the amount produced (output) to the sum of resources (input),

Mali (1978) suggests that “productivity is a combination of effectiveness and efficiency”. He further states two concepts of productivity as follows:

- Productivity is a measure of the amount of resources that must be used, as well as how many benefits in contributing output.
- Productivity states the level of effort expended to achieve the highest production yield with minimal resources.

Method study and work measurements are part of the work study. Part of the method study is motion study, work measurement is also referred to as time study (Kumar & Suresh, 2008). According to Willian (2006) is a group of equipment and methods designed to eliminate waste, reduce waiting time, improve performance, and reduce costs. Lean examines the workflow or task from design to product accepted by the consumer in order to run smoothly and not experience termination or return due to defect or waste (Muhsin, *et al.*, 2018). The purpose of applying lean manufacturing philosophy is to reduce operating costs by disposing of garbage. Waste is anything that does not add value to a product or service (Womack and Jones, 1996) and by wasting waste, will ultimately increase the value of the production system to produce good quality products aimed at customer satisfaction (Moayed and Shell, 2009; Sanchez and Perez, 2001), unnecessary processing steps, movement of unnecessary materials or people, waiting times, excess inventory, and overproduction (Evans and Lindsay, 2005; Womack, *et al.*, 1990; Monden, 1983). Each type of production system exhibits different characteristics and requires different conditions to be born and function effectively (Lockyer, *et al.*, 1987). According to Gitoshudarmo (2002) is the optimal choice of placement of machinery, factory equipment, workplace, storage, and service facilities, along with determining the shape of the factory. According to Gaspersz (2004), is the balancing of the assignment of task elements from the assembly line to the workstation to minimize the number of workstations and minimize the total idle time price at all stations for a given output level. While line balancing according to Subagyo (2000) is the process of division of work into workstations in such a way as to obtain the balance of each workstation. Efficient balance is the balance that completes the required installation, follows specified orders, and maintains free time for each minimum workstation (Heizer and Render, 2001)

The first step in analyzing the cause of the problem is to analyze the correlation by using the multiple linear regression method between the factors of production, namely the production result(Y) with work productivity (X_1) and available effective time (X_2), then look at the causes of low values of factors X_1 and X_2 is to find causes of the problem using fish bone diagram analysis, 5W1H, and why-why analysis. From the results of the analysis it is found that the biggest cause of these two factors is due to the emergence of diverse waste at each stage of the production process in metal press line. Further, analyze the causes of various wastes using the analysis of method study and work measurements which are work study tools. The first step is to create a process flowchart to see how many types of waste of activity occur between each production process to facilitate line efficiency analysis by eliminating the most types of process activities and those that do not provide added value (non added value / necessary non added value), both of the type of activity, travel distance, and processing time required. Measurement of processing time using time study technique, that is by measuring the processing time (activity) that has been described in the flow chart using a stopwatch. Afterwards, use lean manufacturing tools in the form of process flow analysis of selected production systems and layouts and line balancing between workstations to see the relationship between waste and its causes. The next step is to make gradual and systematic improvements to eliminate waste that occurs based on priority based on the priority effect of the problem that occurs. If we summarizes flow of the problem analysis, methods and results of improvements made in this paper can be explained as

follows:

Figure 1: Research Process Flowchart

Based on some examples of previous studies that increased newspaper productivity is influenced by the following: Research from Trislianto, et al (2018) concluded that it can increase the production of Suzuki KLX 50 motorcycle exhaust production by 0.092% by reducing waste that occurs using lean manufacturing concept by relayout on production areas, standardizing procedures by adopting PDCA concept, increasing employment and supply of raw materials, improving 5S conditions and scheduling by adopting Shortest Processing Time (SPT) method to minimize presence of WIP stock. While, Setyastuti, *et al.* (2017) concluded that waste that affects productivity is waste defect of 37.50%, inventory waste of 25%, waste processing of 15%. By making improvements by using the concept of slim manufacturing can reduce waste and produce a reduction in production lead time of 15.73 minutes. In another study Lam, *et al.* (2016) by using lean line balancing concept, the quality of electronic assembly lines can be improved in terms of line balance index, overall labor effectiveness, productivity, and waste elimination. Human resources can be reduced by 25%. This research shows that there is a lot of waste can be disposed of with a simple leantools.

RESULTS

Based on the calculation using SPSS for linear multiple correlation analysis obtained the number R 0.979 which indicates that there is a strong relationship between employee productivity (X_1) and usage of effective machine time (X_2) on production result (Y_1), while for Anova Test, because F counts is 103,634 greater than table of F 4.26, then H_0 is

subtracted, which means that there is a significant influence between worker productivity factors and effective machine working hours together on production output. Similarly, for the t test of the factor X_1 variable, because the t value of 13.709 is greater than the t table of 2.26, this means that H_0 is subtracted. This means that part of employee productivity has a positive effect on production output, while the value of t count factor X_2 is 8,301 greater than table t 2.26 means H_0 is rejected. This means that a semi-effective machine time (X_2) has a positive effect on production results (Y)

For the analysis of the causes of low productivity value and effective machine working time, based on the fishbone diagram analysis, the results are as shown in the following table.

Table 1: Fishbone Diagram Analysis

Factors	Causes Analysis
Man	High turnover of man power
	Lack of maintenance skills
	Lack of teamwork
Material	Material dimensions are sometimes ignored in calculation of the engine load, so causing energy waste
Machine	Machine layout is irregular, not in accordance with order of production process
	1 Dies used for 1 process
Method	Production process using WIP stock system, not one flow system
Environment	Working space conditions are less comfortable, hot and noisy
Measurement	Engine load formulation is not given enough attention
	Production controls are still manual and partial
	Measurement of engine capacity is of rarely used

Then continue to use the why-why analysis to find the causes of these two factors of production, as explained in the following table:

Table 2: Why-why Analysis

Problem	Why	Why	Why	Why	Why	Improvement
Production still requires a long Processing time	Waste processing occurs	Dies setting time too long	Long time taking dies	Distance between machine and dies rack too far		Reset dies rack position (Machine)
			Maintenance skill still low	New operator (Lack of experience)	Lack of training	Special training of dies setting for preparation man and maintenance (Man)
	Waste movement occurs before and after machine process	Individual Operator Target	Sequence of production process is not according to sequence of machines position	Production planning make for each machine	Production system use WIP stock system	Change production system into one flow system (Method)
				Machine installation less attention to sequence of processes	Wrong initial machine installation	Change machine layout. Re-layout (Machine)
				Production based on idle machines	There are no special line settings for certain types of materials	Determine special lines based on product type (Export/Local) (Methods)
		Engines /	Change	Machine load	The machine	Optimization of

		Tools are frequently damaged	dies often according to the model will be produced	does not match with type of material to be produced	loading does not match with required tonnage formula	press machine loading formula to match the material specifications (Material) / (Mesurement)
			Machine maintenance is not optimal	Maintenance schedule is not consistent	Prioritizing production	Preventive maintenance schedule is made consistent (Machine)
	Waste transportation / Waste inventory occurs	Sequence of production process is not according to sequence of machines position	Production planning make for each machine	Production system use WIP stock system	There is no connecting system between machines	Making a special conveyor for the connection between machines (Machine)
Low employee productivity	Waste movement and processing occurs	Lack of teamwork	Work rhythm is not same	Work individually	Production plan made for each machine (not related between machines)	Production plan is made for each line (one flow system) (Method)
		Operator speed is still low (uneven speed between machines)	New Employee	High employee turn over	Shortly working contract	Maximized employment contract (3 years) (Man)
			Less training	Short duration of training hours		Training orientation hours added (Man)
		Work speed decreased	Operator fatigue	Unfavorable workspace conditions	Hot and noisy work area conditions	Repair of the air ventilation system (Environment)
		The use of dies is not optimal	1 Dies just for 1 process	Lack of dies innovation	The ability of the R&D department is lacking	Training Skill up Engineer R&D and Recruitment Engineer baru (Man)
					Facilities and infrastructure for making dies are not support	Fulfillment of supporting facilities and infrastructure (Programs, computers, machines) (Machine)
		Machine capacity measurements are not carried out continuously	Assumption that production is full capacity	Operators do not want to add their workload than usual	Work based on habits	Educate operators about measuring production capacity (Measurement)/ (Man)

To facilitate the analysis of the cause of each waste, the analysis was performed using 5W1H as shown in the following table:

Table 3: 5W1H Approach

Type Waste (What)	Place of Waste(W here)	Person in Charge (Who)	Time of Waste (When)	Cause of Waste (Why)	Improvement (How)	Improvement Status
Processing (Process people / machines are not qualified)	Press machine	Dandory man / maintenance	When setting dies, before the engine process	1 Dies setting time is too long (+/- 30 minutes)	Conduct training for Dandory man / maintenance	Done
	Press machine	R&D	Core process of machine (forming process)	For 1 type of forming process using 1 dies, there is no merging	<ul style="list-style-type: none"> - Merging 2 processes into 1 process (1 dies) - Training and recruiting of potential new workers for R&D - Provision of R&D facilities 	Done step by step (Gradually)
	Trimming process	Operator /Leader	Saat proses produksi	Use of machines that exceed the standard capacity. Because it uses less standard tonnage formulas for machines. Energy waste occurs	<ul style="list-style-type: none"> - Optimization tonnage formula - Balancing machine usage plans according to machine tonnage 	Done
Over Production (Too much production, too early so that the WIP is over stock)	Mesin press	Manager PPIC / Produksi	<ul style="list-style-type: none"> - Initial production plan - During the production process 	<ul style="list-style-type: none"> - Production capacity is not optimal - Production plans are not aligned between machines - Unilateral decision from the production leader / operator 	<ul style="list-style-type: none"> - Re-calculate the capacity of each machine - Creating a production plan based on a one flow system - Tighter control over production plans 	Done
Inventory (Excess material, WIP product or end product)	WIP products between Machine process	Leader production / PPIC	After production process	<ul style="list-style-type: none"> - Machine layouts that do not match the process flow - Production based only on empty machines and delivery targets 	Re-layout machine so that it can support the one flow system process from start to finish	Part of it has been implemented (gradually)
Defect (Product defects, rework)	Production area	Operator	Before, during, or after machining	<ul style="list-style-type: none"> - Not following procedures / Not checking - Too many transportation processes 	<ul style="list-style-type: none"> - Confirmation of SOPs back to the operator - Reduces transport process 	Has been done (Defect is still below the target set)

Movement (Unnecessary movements)	Press machine	Operator	During the process of taking and placing material in the machine	- Too many material transfer processes before and after machining	- Eliminates unnecessary movements by changing the place or order of process - Create a special conveyor	Done
Waiting (Material waiting to be used, Time used is ineffective)	- Stock WIP area - Press machine	Operator / Leader	The beginning of the 2nd process etc.	- The machine next to it does not work on the same model and type (Part no is different). - Take stock from the WIP stock area	- Changing the production system from a WIP Stock system to a one flow system - Change the production plan according to the new system	Done
Transportation (Movement of material too far)	Machine and stock area	Operator / Leader	Before and after process	- Material stock area and WIP far from machine - Production process does not use the one flow system principle	Relayout production area (machine and WIP stock area)	Some have been implemented (gradually)
Resource (The available resources are not used optimally)	All machines	Supervisor	- When machine loading is not standard - When there is product repair and machine setting	- Less optimal using engine tonnage formula - Work based on habits	- Optimizing the production plan based on the tonnage capacity of the machine - Maintenance training to improve competence	Done

Based on results of the above analysis, process flow analysis is then performed and corrected to reduce the waste that occurs. The results of the process flow improvement made in the process flow diagram can be seen in the figure below

SUMMARY																WORK : Press Disc Brake							
ACTIVITIES		CURRENT						PROPOSED						DIFFERENT						CHART NO	Khusus		
		PREPARATION		CORE PROCESS		FINISHING		PREPARATION		CORE PROCESS		FINISHING		PREPARATION		CORE PROCESS		FINISHING		MAN	MATERIAL	✓	
		NO	TIME	NO	TIME	NO	TIME	NO	TIME	NO	TIME	NO	TIME	NO	TIME	NO	TIME	NO	TIME	CURRENT	PROPOSED	✓
OPERATION	5	2,00	20	18,50	0	0,00	5	1,00	20	18,52	0	0,00	0	-1,00	0	0,02	0	0,00
INSPECTION	0	0,00	5	7,50	0	0,00	0	0,00	5	8,00	0	0,00	0	0,00	0	0,50	0	0,00
TRANSPORTATION	10	4,36	20	21,95	10	13,12	7	1,10	20	23,15	4	4,71	-3	-3,26	0	1,20	-6	-8,41
WAITING	0	0,00	0	0,00	5	396900,00	0	0,00	0	0,00	2	105840,00	0	0,00	0	0,00	-3	-291060,00
STORAGE	0	0,00	0	0,00	5		0	0,00	0	0,00	2		0	0,00	0	0,00	-3					
TOTAL DISTANCE		169,0		17,5		75,6		109		20,5		42		-60		3		-34					

DESCRIPTION OF ACTIVITIES	1 ST Process	2 ND Process	3 TH Process	4 TH Process	5 TH Process
	SYMBOL	SYMBOL	SYMBOL	SYMBOL	SYMBOL

Preparation
Core Process
Finishing

Figure 2:Flow process of improvement

Based on the improvements that have been made in the table above, which have been made gradually, systematically and based on the priority scale of the problems that have occurred, the following results are obtained. Adjustment of machine loading so as to reduce wastage of electricity consumption, as seen in the table below.

Table 4. Reduce of electricity consumption waste

Item	Process Stage	Before Improvement	After Improvement	Result
Machine composition based on load required (Ton)	Process 1	630	630	
	Process 2	500	500	
	Process 3	630	630	
	Process 4	160	160	
	Process 5	500	150	Adjustments are made based on tonnage requirements, so as to save energy

Reduce in non value added activities that occur in the production process. In this case, it can reduce waste activity (non value added/necessary non added value) by 15 activities (18.75%), as seen in the data below.

Table 5: Reduce of non value Added Activities

Item	Process Stage	Before Improvement	After Improvement	Result
Reduction of Total Activity (Process)	Process 1	16	12	(4)
	Process 2	16	11	(5)
	Process 3	16	11	(5)
	Process 4	16	15	(1)
	Process 5	16	16	-
	Total	80	65	(15)

Reduce of transportation waste by reducing transportation distance. In this case, it can reduce the transportation distance by 91.6 meters (34.9%), as seen from the data below.

Table 6: Reduce of Transportation Waste

Item	Proces Stage	Before Improvement	After Improvement	Result
Reduction of Total Transportation Distance (meter)	Process 1	59,5	21,5	-38,0
	Process 2	49,5	19,5	-30,0
	Process 3	28,5	22,5	-6,0
	Process 4	59,5	42,5	-17,0
	Process 5	65,1	64,5	-0,6
	Total	262,1	171	-91,6

Reduce of processing time waste. In this case, the average processing time is 2.3 seconds for each piece, or 686.82 in 1 pallet (300 pieces).

Table 7: Reduce of Processing Time

Item	Process Stage	Before Improvement		After Improvement		Result	
		@ pcs	@ box (300pcs)	@ pcs	@ box (300 pcs)	@ pcs	@ box (300 pcs)
Reduction of Process Time (second)	Process 1	12,67	3800,00	10,13	3040,47	-2,54	-759,53
	Process 2	14,37	4310,29	10,3	3074,47	-4,12	-1235,82
	Process 3	12,00	3598,77	10,26	3077,90	-1,74	-520,87
	Process 4	15,21	4562,00	12,3	3695,61	-2,89	-866,39
	Process 5	13,70	4109,40	13,53	4057,90	-0,17	-51,50
	Average	13,59	4076,09	11,298	3389,27	-2,29	-686,82

Improve line balancing conditions between workstations to reduce waste of lead time from 7.5 days to 2 days, and reduce WIP waste stock from 33,750 pcs in each line to 9,000 pcs in each line.

Table 7:Line Balancing Improvement

Item	Description	Unit	Before Improvement	After Improvement	Result
Result of Line Balancing Improvement in work station / machine	Transporation Time	second	45,44	34,98	(10,46)
	Hand Time	second	15,01	14,01	(1,00)
	Machine Time	second	7,50	7,50	-
	Stasiun Time	second	67,95	56,49	(11,46)
	Smoothness Index		4,44	3,84	(0,60)
	Lead Time	Second	396.900,00	105.840,00	(291.060,00)
		Days	7,50	2,00	(5,50)
	WIP Stock	Piecess	33.750	9.000	(24.750,00)

The effect of the various improvements mentioned above will certainly affect the achievement of production targets each process (workstation) per shift. In this case there is an increase in the achievement of production targets per

workstation (machine) with an average of 16.9%.

Table 8: Target of Achievement

Item	Process Stage	Before Improvement	After Improvement	Result
Achieving targets/shift (2500pcs)	Process 1	85,2%	106,6%	21,4%
	Process 2	75,1%	105,3%	30,2%
	Process 3	90,0%	105,2%	15,2%
	Process 4	71,0%	87,6%	16,6%
	Process 5	78,8%	79,8%	1,0%
	Average	80,0%	96,9%	16,9%

The purpose of this study is to see how impact of the above improvement on increasing production achievement of the set targets, efficiency of machines and machine utilities, as well as increased productivity of metal press workers in general, can be seen in the following table.

Table 9: Production of achievement

Item	Before Improvement	After Improvement	Remark
Production planning (pcs/year)	4.590.554	5.026.570	
Production result (pcs/year)	3.913.105	4.758.312	Increase 22,0%
Achieving production target (%)	85,2%	94,7%	Increase 9,4%
Machine efficiency (%)	76,7%	98,2%	Increase 21,5%
Machine Utility (%)	65,2%	83,4%	Increase 18,2%
Productivity (pcs/man.hour)	47,4	60,2	Increase 27%
Overtime (hours/month)	37,6	33,5	Increase 11%

From the various repair activities above that have been done in stages based on the priority scale of the existing needs, it is found that all the improvement efforts that have been done can be improved in 2 situations that are the main cause of problems that arise: Reduce and eliminate non value added process which results in unnecessary waste in terms of transportation distance and the number of processes that arise, so as to reduce production process time to be shorter and the effective use of machine time increases. This has a positive effect on the increase in engine efficiency by 21.5% and the increase in engine utility by 18.2% of the specified engine capacity. The work speed of the workers has increased, which is shown both in terms of reduced necessary non value added movement which is a source of waste and faster machine setting speed, as well as a reduction in overtime. This has a positive impact on an increase in employee productivity of 27.0%, and a decrease in overtime of 11% per month. With the improvements mentioned above, it can finally affect the increase in production volume by 22.0% and achieve the production target of 9.4%. From the various improvements that have been made, in addition to the results described above, for the companies where the research is conducted, the results of this study have a positive effect both direct and indirect process. The direct effects felt by the company are as follows:

Table 10: Direct and Indirect Process Effect

Item	Before Improvement	After Improvement	Saving	
			Monthly	1 Year
Stok WIP area (m ²)	125	40	85	85
Reduce WIP Stock (Rp/year)	48.000.000	12.000.000	-36.000.000	-432.000.000
Cost of machine maintenance etc	139.000.000	97.000.000	-42.000.000	-504.000.000

(Rp/month)				
Electrical (Rp/month)	291.000.000	194.000.000	-97.000.000	-
Overtime (Rp/month)	15.563.317	6.917.856	-8.645.461	-103.745.532
Total Saving			183.645.461	2.203.745.532
Improvement cost Investation				1.270.000.000
Total Net saving (Rp)				-933.745.532

Therefore, the direct benefits felt by the company where the research is done with this increase managed to obtain a direct savings of Rp 933,745,532 million per year.

CONCLUSIONS

From all the above discussions, the final conclusion of this study is that all the improvement efforts that have been done by using the principles of work study and lean manufacturing and its tools successfully answer the problem formulation posed and can achieve the objectives of this research well, as evidenced by improvement achievement improvement. Production output was 22.0%, production target rose 9.4%, machine efficiency rose 21.5%, machine use 18.2%, and productivity rose 27%. Although not all of the improvements that have been made can be implemented and the results can be seen, due to limited research time. Given the limitations in this study and not all suggestions for improvement can be implemented, the authors provide the following suggestions: For companies where research is conducted, it should continue improvements that have not been done, because calculations can be done and will provide real benefits in addition to the benefits mentioned above. For other researchers, this research can be used as a basis to conduct new research or continue this research, especially on the limitations found in this study. In connection with the advent of the 4.0 era, especially in the manufacturing industry, it is recommended that future studies emphasize the analysis of the effectiveness of the use of automation technology in the production process of printing machines and the problems that arise in it.

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