Analysis of Calculation Overall Equipment Effectiveness (OEE) in the Implementation of Total Productive Maintenance (TPM) PC 200-8 Excavator Grab and Magnet Type Case Study in Cakratunggal Steel Mills Company

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Abstract— This study was conducted to analyze the implementation of TPM in order to determine the value of OEE on heavy equipment Excavator Komatsu PC200-8 Magnet and Grab Type in the Company. The company realized to guarantee quality and continuity of the company for the sake of resource management becomes very important, especially the manufacturing industry that is closely related to the production machine capabilities to support production of good productivity. The machine has components that should always be noticed because that machine requires maintenance on an ongoing basis. To find out how well the treatment machine to achieve the effectiveness of a machine, then the measurement of the value of OEE (Overall Equipment Efectiveness) of the machine. OEE measurement is done by taking into account three important things, namely availability rate, peformance rate and quality rate. Thus, in the study of the made necessary to add variable and adding weights to get a measurement of OEE values of real and refers to the standard method of assessment OEE good and measurements of the existing problems there so it will be found OEE on each tool before and after improvement with Autonomous Maintenance,5W1H,SMED and Continuous Improvement Method.

Index Terms— Excavator Magnet and Grab Komatsu PC200-8, Total Preventive Maintenance, Overall Equipment Effectiveness, Autonomous Maintenance, 5W1H,SMED and Continuous Improvement Method.

1 Introduction

The national economic growth lead to increased steel consumption, which is now Indonesia was ranked second as the country's largest iron and steel consumption in ASEAN. national steel demand reached 9-10 million tons, while national production capacity is only 6.3 million tons, the drawback is also filled by importing steel, including steel from China. So that this results in 2015 - now the company has a policy to make purchases semi-finished products (billet export) in order to carry out the efficiency of the production process in order to obtain concrete iron SNI standard. In the material handling activities from bonded warehouses (warehouse billet) in support by their heavy equipment to help perform material handling faster one is to PC 200-8 excavator tool that modification of the model becomes a model grab bucket and magnet for the fulfillment of production. In order to measure how well the condition of the tool then necessary to measure the value of OEE with TPM Implementation.

OEE measurement is done by taking into account three important things namely availability rate, peformance rate and quality rate. These three types of factors are generally translated into some kind of losses (losses), ie breakdown losses, set up and adjustment, idle and minor stoppage, reduce speed, process defects, and reduce yield. Repairs are done related to Continuous Improvement, 5W1H, SMED Method and Autonomous Maintenance.

2 Literature Review

TPM (Total Productive Maintenance) is a program for the development of the fundamentals of the maintenance function within an organization involving all of its human resources. If implemented in full., TPM dramatically increased productivity and quality, and lower costs. TPM is a productive maintenance carried out by all employees through small group activities are planned. In TPM the machine operator is responsible for the maintenance of the machine, in addition to its operations. Implementation of TPM can realize substantial cost savings through increased machine productivity. The greater the degree of factory automation, the greater the reduction in costs that were embodied by TPM (Nakajima, 1988). According to Sharma, Kumar and Kumar (2006), TPM is defined as a strategy-based care teams designed to maximize equipment effectiveness by developing production systems comprehensive maintenance that covers the entire life of the equipment, which includes all equipment related fields (planning, use and maintenance) and involve everyone in the organization.

Overall equipment effectiveness (OEE) is described as one performance-measurement tool to materialize the quest for perfection of lean manufacturing into daily practices. In a lean environment, the negative consequences of machine breakdowns and production disruptions cannot be accepted as they prevent the creation of value for customers and cannot be compensated anymore. Thus, a rigorously defined performance measurement system is indispensable to control such kinds of losses. This is the origin of the Total Productive Main-

tenance (TPM) concept launched by Nakajima (1988), who believes that it is imperative to continuously improve all operational conditions within a production system by stimulating the daily awareness of all employees. The objective of TPM is to achieve zero breakdowns and zero defects related to equipment, which could lead to improvements in the production rate, reduction in inventory, reduction in costs and eventually increases in labor productivity. As analyzed by Muchiri and Pintelon (2008), this is especially true of highly automated processes. According to Jeong and Phillips (2001), OEE is the amount of the core to measure success in the implementation of TPM program. Bulent et al. (2000) says that the OEE provides a systematic method to improve production targets and obtain a balanced view between availability (availability), performance efficiency (performance efficiency) and quality levels (rate of quality).

3 Research Methodology

This study uses two methods for data analysis using quantitative and qualitative methods. The quantitative data used was obtained by observation and analysis of data in the field, while the qualitative data used because there are variables associated with the actions and also the conditions that have to use the method. While the study design used was using exploratory and descriptive. Descriptive methods can be explained in terms of the optimal production increase with a variable form of production, labor efficiency and cycle time. While the method of exploratory himself explained that in getting a modification method related to OEE, SMED and the calculation in determining the variables and the calculation formula should be an assessment of how to solve a problem with the machine in order to obtain a good result and in accordance with the target.

4 Case Study

4.1 Case Study

The new policy by purchasing the export of semi-finished products (billets) in order to reduce production costs and by improving the efficiency of the company. So that existing equipment and look capable (PC 200-8 excavator) is forced to do service supply material with the modification of the model to the model of the grab bucket to fulfilling the production of reinforced concrete. In fact it was found that there is still a heavy equipment breakdown (breakdown unscheduled) are quite high on Excavator PC 200-8 as a major material handling tool that disrupts the supply of semi-finished materials to the warehouse rolling mills. And also need to do the analysis of the level of availability excavator number 4 unit because of a total of six special units that operated for handling billet is 4 units and the rest to all round. whereas in the same process excavator also assisted with equipment other (forklift 5ton 2 units) in order to speed up the process of loading the material so that it is necessary to review and measurements were taken of the OEE Excavators PC 200-8, where OEE on the device has not been previous measurements were taken so we do not know the effectiveness of all four units of the so researchers are trying to do the analysis OEE (Overall Equipment Efectiveness) on each excavator PC 200-8 effectiveness in fulfilling the heavy equipment.

TABLE 1
Object Research

No	Tipe Unit	Quantity	Type	Area	Year
1	Excavator PC 200-8 Komatsu	2 unit	Magnet	Bonded warehouse	2012
2	Excavator PC 200-8 Komatsu	2 unit	Grab	Bonded warehouse	2012

4.2 OEE March 2016

TABLE 2
Data Calculation of OEE All Excavator

	Exc Magnet 1			
	A	P	Q	OEE
Week I	98%	77%	90%	68%
Week II	98%	68%	85%	57%
Week III	96%	67%	98%	63%
Week IV	99%	73%	92%	66%
Week V	99%	68%	97%	65%
Average	97.8%	70%	92.4%	63%
	Exc Magnet 2			
	A	P	Q	OEE
Week I	98%	70%	94%	64%
Week II	98%	78%	86%	66%
Week III	97%	75%	99%	72%
Week IV	95%	66%	91%	57%
Week V	98%	75%	95%	70%
Average	97.2%	72%	93%	65%
	Exc Grab 3			
	A	P	Q	OEE
Week I	94%	68%	92%	59%
Week II	98%	75%	89%	65%
Week III	95%	76%	89%	64%
Week IV	96%	69%	95%	63%
Week V	95%	77%	92%	67%
Average	95.4%	73%	91.4%	64%
	Exc Grab 4			
	A	P	Q	OEE
Week I	95%	75%	91%	65%
Week II	92%	71%	93%	61%
Week III	95%	75%	89%	63%
Week IV	90%	75%	87%	59%
Week V	96%	73%	91%	64%
Average	93.47%	73%	90.2%	62%

From the results of the above table can be seen that there is one tool that has the lowest value when compared with other devices that are Excavators PC 200-8 with **Type Grab 4.**

TABLE 3
Loss Time Delay and Idle Excavators Type Grab 4

Month	W I	W II	W III	W IV	W V
Cleaning unit	0.10	0.15	0.50	0.30	0.45
Daily Maint	5.80	1.00	1.50	2.20	0.55
Checklist	0.30	0.50	0.35	0.00	0.20
Change Shift	0.40	1.00	0.35	0.00	0.00
Fuel	0.10	0.00	0.20	0.00	0.20
Rest and	0.00	0.10	0.00	0.00	0.00
No Sparepart	0.00	1.00	0.30	0.00	0.00
No Operator	0.00	0.00	0.00	0.00	0.00
No Location	18.2	0.40	4.15	21.3	11.15
No Support	0.00	24.0	22.1	0.00	9.40
Hazard	0.00	0.00	0.00	0.00	0.00
TOTAL	24.90	28.15	29.45	23.8	21.95

Table 4. Loss Time Delay and Idle Excavators PC 200-8

Loss time Delay	Exc No 4 Grab	
	Delay	Idle
Total	128.15	0.10

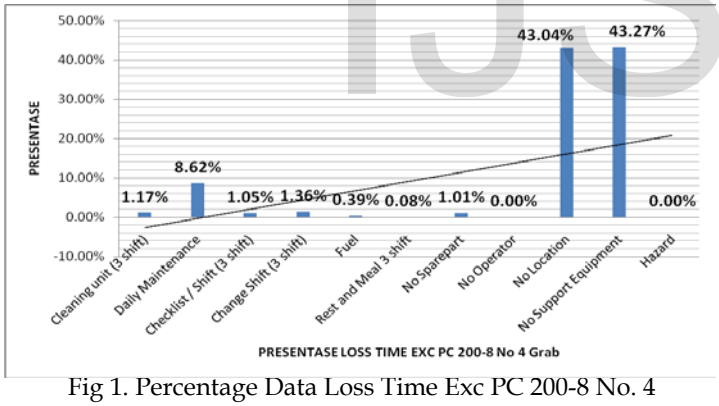

Fig 1. Percentage Data Loss Time Exc PC 200-8 No. 4

Delay time of the data loss and Idle above it can be seen that the third week of lost time is very high when compared with the other week is 29.45 hours where variable problems exist in the table above Table 5.7. If seen in Figure 5.6, it can be seen that the No. support equipment has a very high influence in the amount of 55.50 hours or dominated by 43.27% compared with the other variables in this Figure 5.7 show the percentage of data loss time exc pc 200-8 No. 4. Factors influencing the time of the loss include:

1.The tool supports (Truck trailers) damage / breakdown
2. Supporting tools Forklift being conducted daily checks
3. Location Charging billet there is still a material that has not been on a roll
4. The condition dirty undercarriage (crust remaining operations in the area slag)
5. Spare part being made reservations
6. There is no area that is suitable for handling billet do so we need a good removal of the equipment and the surrounding area.

4.3 Improvement Process

In this discussion as conveyed above it will be the idea of improvement to the performance of the tool, but to enhance the results of OEE better and is also beneficial for the future, we will add to improvement of availability to support the improvement of the Performance and also do repairs the TPM and SMED process.

4.3.1 Continuous Improvement

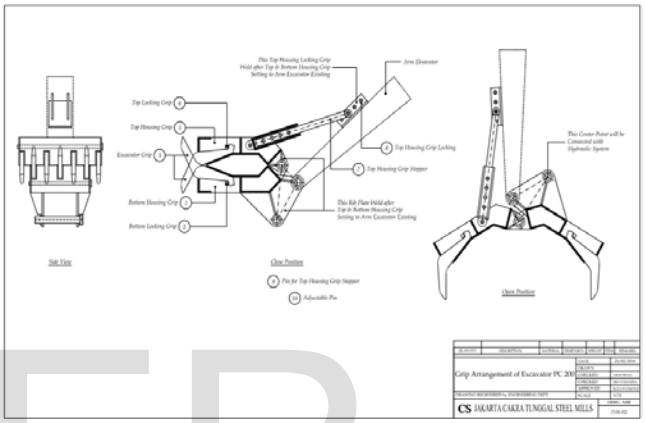

Fig 2. Type Grab No 4

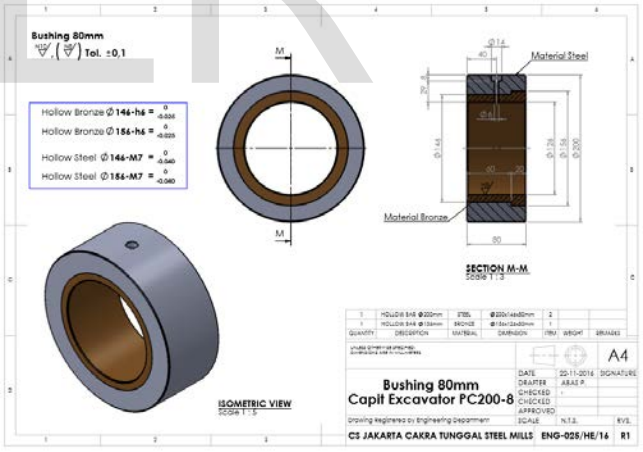

Fig 3. Type Grab with Bushing Improvement

Bushing material coated with the use of Bronze making an impact include: 1. The indirect Friction between iron bushings with steel shafts but between the iron layer material to the SC45 Bronze Type LG-2 which can reduce friction rough so it is more durable when used in the operation. 2. Model Bronze created shock models that will further simplify installation and replacement that does not require a long time (the old model must be dismantled all the unit so that it takes a long time) SMED.

4.3.2 Single Minutes Excange of Die (SMED)

TABLE 5
Average loss time Exc PC 200-8

Loss Time Delay	Average Hour/Day	Activity	Change Activity
Cleaning unit	0.30	Internal	Eksternal
Daily Maintenance	2.21	Internal	-
Checklist	0.27	Internal	Eksternal
Change Shift	0.35	Internal	Eksternal
Fuel	0.10	Internal	-
Rest and Meal	0.02	Internal	-
No Sparepart	0.26	Eksternal	-
No Operator	0.00	Internal	-
No Location	11.04	Eksternal	-
No Support	11.10	Internal	-
Hazard	0.00	Eksternal	-

From the above data can be found that there 3 Activity that can be done to a shift from internal becomes external unit that is Cleaning, Checklist / Shift and Shift Change. After a change it will be better standardization and substitution plan as in the table below.

TABLE 6
Standardize and Elimination Exc PC 200-8 No. 4

Loss Time Delay	Activity	Change Activity	Standard	Elimination Parallel
Cleaning unit	Internal	Eksternal	0.25	Parallel
Checklist	Internal	Eksternal	0.15	Parallel
Change Shift	Internal	Eksternal	0.30	Parallel
No Location	Eksternal	-	0	Eliminasi
No Support	Internal	-	0	Eliminasi

TABLE 7
Comparison Table Idea Implementation Repairs

MARCH 2016 LOSS TIME	Hour	APRIL 2016 LOSS TIME	Hour
Cleaning unit	0.30	Change Shift	0.66
Checklist / Shift	0.27		
Fuel	0.10		
Rest and Meal	0.02		
TOTAL	0.69		
No Location	11.04	Opname	9.97
No Support	11.10	Repair	10.55
OVERALL	**25.65**		**21.18**

From the data above, there is an impairment loss time from 25.65 hours to 21.18hours so that if presented to the impairment of 17.43%.

4.3.3 Total Productive Maintenance (TPM)

TABLE 8
TPM implementation results table

ACTIVITY	MAINTENANCE	OPERATION
Initial Cleaning & Inspection	A leak in the pipe, connections, holes and cracks Checking Cooling system	Check spills and seepage cleanliness of the cabins Checking radiator water level The addition of water to the radiator
Lubrication	Replacement of the amount of oil repair leaks	Check Oil Level Check Leaking Greasing
Hydraulic Pressure	Change Hose Check Pressure Check Control Valve Check Compression	Check Leaking Check firmness hose Check the cleanliness of the oil area Check Level Oil The addition of oil (if low)
Check Engine	Check Alternator Check ACCU Check Cylinder Head Check Hand Pump Check Exhaust emiissions Check Sound engine Check Temperatur engine	Check all components and report if abnormalities
Accessories	Replacement Fuse Replacement Lamp Replacement Glass Replacement Spion	Check lamp condition Check sign Check all support equipment
Undercarriage	Check shoe Check Track Check Bearing Check Idler Check Roller guide Check Wear	Cleaning undercarriage Level oil undercarriage Check noise undercarriage
Checklist	Check Total (1 x 1day) and cleaning unit plus make a order if any problem	Checklist light (3x / shift)
Other	Filling tires regulary Setting up the stock component	Help Maintenance repair

4.4 Result and Discussion

The results of the implementation is done for the next month then get that improvement results have an impact on both availability and performance so that the results can be seen in getting in ac-

cordance with the data below the tool exc No. 4 types Grab.

TABLE 9
TPM implementation Time Loss table comparison results in March and April 2016

Month	March 2016		April2016	
	Delay	Idle	Delay	Idle
Week I	24.90	0.00	23.25	0.00
Week II	28.15	0.00	23.27	0.00
Week III	29.35	0.10	29.30	0.00
Week IV	23.80	0.00	23.25	0.05
Week V	21.95	0.00	19.40	0.00
Average	25.65	0.02	23.69	0.05

So with such data can be calculated decrease time loss with impairment Delay average 7.65% .with previously was 25.65 hours and after improvement be 23.69 hours.

TABLE 10
Table Percentage Loss Time comparison results in March and April 2016

Minggu	Maret 2016	April 2016
Week I	75%	77%
Week II	71%	77%
Week III	75%	76%
Week IV	75%	77%
Week V	73%	76%
Average	73%	76%

From the above results it can be seen if the results of the percentage reduction in delay and idle combine the overall percentage has a 4% decrease.

Of the value of the improvement was done on both the availability and performance then it affects the quality of which targeted supply to do rolling into rebar SNI for the better. As the table below:

TABLE 11
Percentage Comparison of Quality of March and April 2016

	Exc Grab 4 March 2016		
	Target/Rod	**Actual**	**QualityRate**
W I	1875	1705	86%
W II	1875	1752	96%
W III	2250	1994	92%
W IV	1875	1637	92%
W V	1500	1363	94%
Total	**9375**	**8451**	
Average	**1875**	**1690**	**92%**

	Exc Grab 4 April 2016		
	Target/Rod	**Actual**	**Quality Rate**
Week I	1875	1606	86%
Week II	1875	1796	96%
Week III	2250	2072	92%
Week IV	1875	1734	92%
Week V	1500	1417	94%
Total	**9375**	**8625**	
Average	**1875**	**1725**	**92%**

From the data above, the increase in the number of billet supply to be increased and this has an impact on the value of the company's profitability increased as in the table below:

TABLE 12
Table Percentage Comparison of Profitability of March and April 2016

MARCH 2016	
Spesification	**Billet Import BJ TS 40**
Tonase / Rod (Kg)	980.00
Price Import (Every 1Kg)	Rp.5,300.00
Quantity Target Production (Rod)	9,375.00
Actual Achievement (Rod)	8,451.00
Average price 1 rod	Rp.5,194,000.00
Production Target	Rp.48,693,750,000.00
Actual Production Rolling Mills	Rp.43,894,494,000.00
Loss Target	Rp. 4,799,256,000.00

APRIL 2016	
Spesification	**Billet Import BJTS 40**
Tonase / Rod (Kg)	980.00
Price Import (Every 1Kg)	Rp.5,300.00
Quantity Target Production (Rod)	9,375.00
Actual Achievement (Rod)	8,625.00
Average price 1 rod	Rp.5,194,000.00
Production Target	Rp.48,693,750,000.00
Actual Production Rolling Mills	Rp.44,798,250,000.00
Loss Target	Rp. 3,895,500,000.00

Production (March 2016)	Rp. 43,894,494,000.00
Production (April 2016)	Rp. 44,798,250,000.00
Profitabilitas	**Rp.903,756,000.00**

TABLE 13
Percentage OEE comparison results

Month	March 2016				April 2016			
	A	P	Q	OEE	A	P	Q	OEE
W I	95%	75%	91%	65%	98%	77%	86%	65%
W II	92%	71%	93%	61%	97%	77%	96%	72%
W III	95%	75%	89%	63%	98%	76%	92%	69%
W IV	90%	75%	87%	59%	98%	77%	92%	69%
W V	96%	73%	91%	64%	97%	76%	94%	69%
Average	93%	73%	90%	62%	93%	76%	92%	65%

From the table above it can be seen that there is a change to the results improved, it can be seen that it is to increase the availability is long term so it can not be seen with a period of one month for life time modified to have a target in 3 months so memerukan longer to see results of these improvements. But in terms of the tools in a single month in the next month (April 2016) to the modification Exc No. 4 shows that the bushing can work well without damage dominant so it does not become a major factor that resulted in a decrease in the availability and still has the average value of 93% availability, This contrasts with the performance improvements with more so that the impact can be observed within 1 month, in which the performance of the value average 73% rising to 76%. Improved performance as much as 3.94%. and associated with quality improvements are not done because of the limited r search time and the amount of data in the get. From these values, it can be seen that the OEE heavy equipment Exc Take No. 4 moves up from 62% in March 2016-65% for the month of April 2016 so that the increase preentase in one month was 6.61% for the tool.

From the analysis and data in the getting was discovered in March 2016 the average OEE on Excavator 4 units 63.50% and for the month of April 2016 OEE data shown on only one unit of heavy equipment Exc Grab No 4 that the value of OEE lows in the previous month and later analyze the data and ideas so that repairs can improve OEE. the profitability of value in getting results suppy total billet in March 2016 is Rp. 43,894,494,000.00 to supply 8.451 stems achievements while in April 2016 Rp. 44,798,250,000.00 by achieving supply 8.625. Rod. So the total profit generated from the above differences is Rp. 903,756,000.00.

5 CONCLUSION

The use of tools can be improved and brought under control if the performance measurement system is used appropriately and accordingly. OEE is a known method for measuring the performance of the production equipment in the manufacturing industry and adapted for the steel smelting industry. It aims to identify the loss of productive time in the system and loss of time affects the availability, performance and quality. This paper has shown that in each tool with models of different assistive devices can affect the value of OEE on every instrument and of course this is influenced by other factors. Before and after the improvements, especially on one of the tools (pc200-8 Excavator no 4) which has the lowest value of OEE and do step by step improvement efforts using methods Improvement, TPM, SMED and 5W1H showed that the method can help increase the value of OEE and able to give a fairly good impact is an increase of 6.61% for pc200-8 Excavator No. 4. System of data collection were both very supportive in the calculation of OEE values generated because if the data is not precise simulated the accuracy of the implementation of the TPM with OEE measurement becomes accurate.

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