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Maintenance Analysis of Aida 800 Machine using a Total Productive Maintenance Method through an Overall Equipment Efficiency (OEE) Approach

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***Abstract* - Rapid globalization, shorter product lifecycles, customer-driven innovation, price competition, and technological advances are driving transformations in approaches and methodologies to production processes. The manufacturing sector is feeling the impact of fluctuating customer demand. The sector must have a dynamic ability to motivate them and adopt advanced tools and techniques to respond quickly to customer needs. One of them is PT Yorozu Automotive Indonesia, which uses the Total Productive Maintenance (TPM) method by calculating the Overall Equipment Efficiency (OEE). This article describes the efforts to increase the productivity of the AIDA 800 machine at PT Yorozu Automotive Indonesia by implementing the system and calculation methods in order to increase productivity and at the same time increase employee confidence and satisfaction in the workplace. In this report, some parameters are used to analyze production data. From the parameters used and the results of the analysis, it can be concluded that the AIDA 800 machine at PT Yorozu Automotive Indonesia meets the standards in Total Productive Maintenance and gets an Overall Equipment Effectiveness value above world standards, which is greater than 85%.**

Keywords: Productivity, Stamping, TPM, OEE.

I. INTRODUCTION

The term "maintenance" includes the combination of all technical, administrative, and managerial actions during the life cycle of an item that are intended to maintain or restore it to a state in which it can perform its required functions (Afnor, 20011). Industrial and process plants typically use two types of maintenance management: (1) run-to-failure, or (2) preventive maintenance (Mobley, R. K., 2004).

The principle of run-to-failure maintenance management is simple and straightforward. When a machine breaks down it is repaired. This method has been a major part of plant maintenance operations since ancient times. Plants that use run-to-failure management do not incur costs until the machine or system fails to operate. Run-to-failure is a reactive management technique that waits for machine or equipment failure before any maintenance action is taken. There are many definitions of preventive maintenance, but all preventive maintenance management programs are time-based. In other words, maintenance is based on elapsed operating time or hours. Some programs are very limited and consist of only minor lubrication and adjustments. A more comprehensive preventive maintenance program schedules repair, lubrication, adjustment, and tool reconditioning for all machines in the plant. What all preventive maintenance programs have in common are scheduling guidelines. All preventive maintenance management assumes that the machine will degrade in performance over time.

Manufacturing is the activity of converting raw materials, components, or other parts into finished goods that meet specification standards. Manufacturing industries are generally capable of producing on a large scale. In carrying out its production activities, the manufacturing industry uses company resources such as labor, machinery, and other equipment. Problems in the manufacturing industry in Indonesia include the disparity in the level of efficiency and productivity of each sub-sector of the manufacturing industry in Indonesia (Lestari, E. P. and Isnina, 2017).

With the current developments, challenges arise for the manufacturing industry in Indonesia (Kumar, R., Singh, K. and S. K. Jain, 2022). Rapid globalization, shorter product lifecycles, customer-driven innovation, price competition, and outdated technology are pushing manufacturing companies, one of which is PT Yorozu Indonesia, to transform so that their production methods and methods can increase the productivity of production equipment. By using the total productive maintenance (TPM) method and by calculating the overall equipment efficiency (OEE), it is one of PT Yorozu Automotive Indonesia's strategies to increase productivity. The definition of overall equipment effectiveness or OEE is a calculation carried out to determine the effectiveness of the

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available machines or equipment. OEE is one of the methods available in TPM or Total Productive Maintenance. As a rule, OEE can be used as an indicator of machine or system performance.

AIDA 800 stamping machine is one of the production equipment used at PT Yorozu Indonesia. The AIDA 800 machine on the production line is located at the front because this stamping machine functions to carry out basic production processes or initial formation of the material before being processed again in the next machine. Therefore, it is important to maintain this machine because the damage to the AIDA 800 stamping machine will affect the entire production line in the company considering its position at the front of the line.

PT Yorozu Automotive Indonesia in making products using the forming production process in the form of a stamping process where the material in the form of a metal plate is pressed above the elastic limit load assisted by a mold to get the required product geometry. PT Yorozu Automotive Indonesia uses several stamping machines from several brands such as AIDA, Komatsu, and KS-Tech. In this report the discussion is focused on the AIDA 800 stamping machine. Then in colloquial terms it is called AIDA 800 to distinguish it from the same machine with different loading capacities.

II. MATERIAL AND METHOD

Stamping machine maintenance at PT Yorozu Automotive Indonesia generally consists of preventive maintenance and corrective/run to failure maintenance. Preventive maintenance is carried out based on the time that has passed by a machine while corrective maintenance is carried out when the machine experiences unexpected/unplanned trouble/failure.

Total Productive Maintenance (TPM) is an important maintenance management approach that has been widely applied in the manufacturing sector since the 1950 (Tortorella, G. L., Fogliatto, F. S., Chauchik-Miguel, P. A., Kurnia S. and Jurburg, D. 2021). Total Productive Maintenance (TPM) is a proposed strategy to increase the productivity of a manufacturing company and also increase the efficiency of equipment during operation by involving contributions from all components (Nakajima, S.I, 1984).

Overall Equipment Effectiveness (OEE) is something that can be used as a performance indicator that requires a certain period of time, such as shifts, daily, weekly, monthly or yearly (Suliantoro, H. and Aulia, N. S., 2012). There are three elements of productivity and also equipment effectiveness that can be measured from OEE, namely availability, performance efficiency and rate of product quality. Availability is a ratio between the useful life of the company's machine and the desired useful life in the time available. This availability ratio is the level of effectiveness of the company's machine or system operation. Availability ratio is about the comparison between operation time and preparation time. Performance efficiency is a relationship between what should actually be in a certain time period or can be described as a comparison between the actual and expected production levels. Performance efficiency can be generated from multiplying a work speed and net operating activities or the ratio between the number of products that have been successfully produced and then multiplied by the ideal cycle time and the time available to carry out various production processes. While the Rate of Quality Product is a ratio between the number of good products and the total number of products processed. The level of product quality is able to show a product that can be accepted by all products produced (Mobley, R. K., 2004).

In conducting the analysis, it needs a framework or sequence of processes to be carried out to get a conclusion. Therefore, a research methodology was developed that describes the sequence of the process which consists of identifying problems in the field, determining research topics, collecting necessary data, calculating data and analyzing and getting conclusions.

As a case, in the preparation of this report, production process data is needed which is used to analyze and perform calculations in order to answer the problems discussed above. The following is table 1 which shows the work time and stop time data on the AIDA 800 engine at PT Yorozu Automotive Indonesia in the period on April to May 2022. In principle, work time involves working time, rest and dandori. Meanwhile, the stop time includes time for stop machines, dies, quality and others.

Table 1: Work Time and Stop Time of AIDA machine (On April and May 2022)

Date (April)	Work time (min)			Stop Time (min)			
	Working time	Rest	Dandori	Stop machine	Dies	Quality	Others
01	960	70	100	90			
04	1110	120	80	1			
05	960	80	110	10			

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06	730	120	116				
07	1060	140	82	15	10		
08	1080	150	135	10			
09							
10							
11	1110	120	118	30	20		
12	1260	150	136				
13	1260	150	156	4			
14	1120	140	90			10	
15	250	20				45	
16	290	20	10			10	
17							
18	910	100	104	10			
19	1110	110	116	15			
20	450		26			60	80
21	1230	130	82		45		
22	1230	180	96			15	
23							
24	630	60	36				
25	960	80	102				
26	960	80	106		10		
27	820	70	132				
28	480	50	50				
29	820	70	132				
30	480	50	50				

Date (May)	Work time (min)			Stop Time (min)			
	Working time	Rest	Dandori	Stop machine	Dies	Quality	Others
01							
02							
03							
04							
05							
06							
07							
08							
09	700	100	90	50		120	
10	980	140	100	25			
11	910	130	70	30		30	
12	975	150	65				105
13	1080	180	126			10	
14							
15							
16	1110	150	120	95			
17	1260	180	126	25			

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18	1260	180	141	25			
19	1110	150	132	70			
20							
21							
22							
23	1020	150	120	30			100
24	1110	150	100		15		
25	1110	150	120				
26							
27	1230	210	130	50	30		
28							
29							
30	950	120	105	20	20	15	10
31	150		25				

The required additional data to search for OEE is given in table 2 which is displayed per week. The additional data consists of:

a) Planned down time, which is the time required for machine inspection.
b) Down time, which is when the machine does not work because there is damage to the machine, the operator experiences problems with the machine, the machine suddenly stops, or other causes.
c) Processed amount is the number of products that are processed, so the machine produces how many products.
d) Defect amount is the number of products from the production process that are defective or fail.

Table 2: Additional data for finding the OEE (On April and May 2022)

Week (April)	Planned Downtime (min)	Downtime (min)	Processed Amount	Defect Amount
I	540	101	86296	64
II		85	144497	125
III		94	126156	198
IV		210	132208	113
V		0	28732	24

Week (May)	Planned Downtime (min)	Downtime (min)	Processed Amount	Defect Amount
I	0	370	125744	120
II		215	121087	182
III		225	110001	98
IV		65	23057	42

III. RESULT AND DISCUSSION

In this section, calculations will be carried out to determine the results of the overall equipment effectiveness analysis. Before looking for OEE, first the initial calculations are carried out to find loading time, operation time and ideal cycle time. These data are calculated by involving all field data during the production process of the AIDA 800 machine.

3.1 Initial calculation

The steps taken to get the overall equipment effectiveness value are by doing initial calculations to find the values of the variables needed first. The following describes the formula used in the initial calculation.

a. Loading Time

Loading time is the time obtained from working time minus the planned down time or given the following formula,

$$\text{Loading Time} = \text{Working Time} - \text{Planned Downtime}$$

b. Operation Time

Operation time is the time obtained from loading time minus downtime.

$$\text{Operation Time} = \text{Loading Time} - \text{Downtime}$$

c. Ideal Cycle time

The formula to find the ideal cycle time is following,

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$$\text{Ideal Cycle Time} = \left(\frac{\text{Loading Time}}{\text{Processed Ammount}}\right) \times \text{Effective work percentage}$$

While the percentage of effective work is formulated as follows,

$$\text{Effective work percentage} = \left(\frac{\text{Operation Time}}{\text{Loading Time}}\right)$$

After carrying out the initial calculations using the above formulas on the field data, the results are obtained as shown in table 3 below.

Table 3: Initial calculation result on April and May 2022

Week (April)	Working Time (min)	Loading Time (min)	Operating Time (min)	Ideal Cycle Time (min/unit)
I	3030	2490	2389	0.02768
II	5240	4700	4615	0.03193
III	4940	4400	4306	0.03413
IV	5460	4920	4710	0.03562
V	2600	2060	2060	0.07169

Week (May)	Working Time (min)	Loading Time (min)	Operating Time (min)	Ideal Cycle Time (min/unit)
I	4645	4645	4275	0.03399
II	4740	4740	4525	0.03737
III	4470	4470	4245	0.03859
IV	1100	1100	1035	0.04488

3.2 Calculation of an Overall Equipment Effectiveness

After finding the value of the required variables from the initial calculation, the overall equipment effectiveness (OEE) value can be found by first calculating the availability, performance efficiency and rate of quality values given by the following formula.

a. Availability Value

Availability (availability) of machines/equipment is a comparison between the operating time (operation time) to the production time (loading time) of a machine/equipment. The formula used to find the availability value is,

$$\text{Availability} = \left(\frac{\text{Operation Time}}{\text{Loading Time}}\right) \times 100\%$$

b. Performance efficiency

Performance efficiency is a measure of the efficiency of a machine's performance in running the production process. The formula used to find the performance value is,

$$\text{Performance efficiency} = \left(\frac{\text{Processed Amount} \times \text{Ideal Cycle Time}}{\text{Operation Time}}\right) \times 100\%$$

c. Rate of Quality

Rate of Quality is the ratio of the number of good products to the number of products processed. The formula used to find the rate of quality value is,

$$\text{Rate of Quality} = \left(\frac{\text{Processed Amount} - \text{Defect Amount}}{\text{Processed Amount}}\right) \times 100\%$$

d. Overall Equipment Effectiveness (OEE)

The formula used to find the rate of quality value is,

OEE=Availability Rate×Performance Rate × Quality Rate

To clarify how the dynamics of the overall equipment effectiveness value from time to time during the months of April to May 2022, the calculation results for OEE are shown in table 4 below,

Table 4: Calculation result of the Overall Equipment Effectiveness (OEE)

Week (Apr)	Availability (%)	Performance (%)	Rate of Quality (%)	OEE (%)
I	95.94378	100	99.92583	95.87
II	98.19149	100	99.91349	98.10
III	97.86364	100	99.84305	97.71
IV	95.73171	100	99.91452	95.64
V	100.00000	100	99.91646	99.91

Week (May)	Availability (%)	Performance (%)	Rate of Quality (%)	OEE (%)
I	92.03445	100	99.90456	91.94
II	95.46414	100	99.84969	95.32
III	94.96644	100	99.91090	94.88
IV	94.09091	100	99.81784	93.91

To clarify the appearance of the OEE value mentioned above, the calculated data in the form of availability, performance efficiency, rate of quality and overall equipment

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effectiveness value are given in the form of a bar chart from Figure 1 to Figure 4 below.

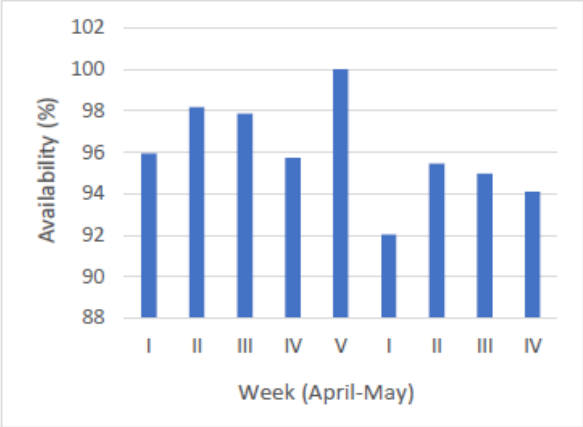

Figure 1: Availability

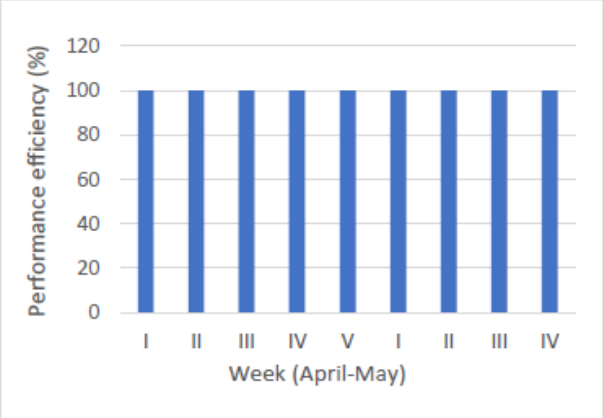

Figure 2: Performance Efficiency

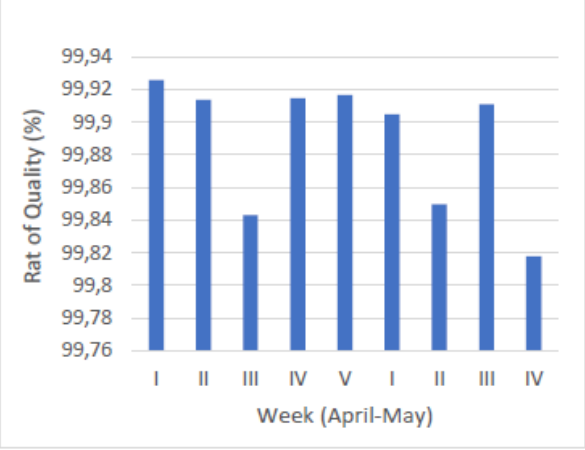

Figure 3: Rate of Quality

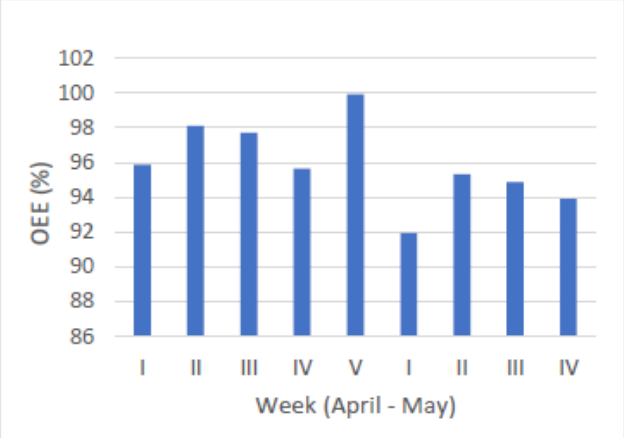

Figure 4: Overall Equipment Effectiveness (OEE)

From the results of the analysis above, it can be concluded that the AIDA 800 machine at PT Yorozu Automotive Indonesia meets the points in total productive maintenance and gets an overall equipment effectiveness value above world standards, namely all OEE values in each week exceed 85% (Lestari, E. P. and Isnina, 2017).

IV. CONCLUSION

Based on the analysis of maintenance and calculations using the Overall Equipment Effectiveness (OEE) method, it can be concluded:

a) The AIDA stamping machine in its maintenance has implemented optimal maintenance, namely preventive maintenance and corrective maintenance. In addition, data collection and archiving of maintenance files were also carried out well.
b) The lowest availability value is in the first week of May with a percentage of 92.03445% and the highest value is in the fifth week of April with a percentage of 100%.
c) Performance efficiency on April to May every week is of 100%.
d) The lowest rate of quality value is in the 4th week of May with a percentage of 99.81784% and the highest value is in the 1st week of April with a percentage of 99.92583%.
e) The lowest overall equipment effectiveness (OEE) value is in the 1st week of May with a percentage of 91.94661% and the highest value is in the 5th week of April with a percentage of 99.91646%.
f) From the parameters used and the results of the analysis, it can be concluded that the AIDA 800 machine at PT Yorozu Automotive Indonesia meets the points in total productive maintenance and gets an overall equipment effectiveness value above the world standard, which is greater than 85%.

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