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ANALYSIS THE EFFECTIVENESS OF CNC TURNING MACHINES TYPE XTRA 420 USING THE OVERALL EQUIPMENT METHOD EFFECTIVENESS (OEE)

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Abstract The development of the manufacturing industry is increasing every year, of course this makes competition in the manufacturing industry increasingly stringent. This research was conducted at PT. Tjokro Bersaudara Gresik, focused on CNC Turning machines with the type CNC Lathe Machine XTRA 420, namely machines used to produce various types of automotive parts and based on data collected regarding the effectiveness of the machine, it shows that the machine has not fully worked effectively. This is indicated by the presence of downtime data, engine speed reduction data, and product data that does not meet specifications. To find out how good the effectiveness of a machine is, it can measure the OEE value of the machine.. It can be concluded that the effectiveness rate (OEE) of CNC Turning machines in the January-August 2022 period is between 54.16% to 59.91% with an average of 57.55% (still below the ideal OEE value of 85%) with a percentage six big losses of 42.45%.

Keywords: Overall Equipment Effectiveness (OEE), Defect Product, CNC Lathe Machine XTRA 420

1. Introduction

The development of the manufacturing industry is increasing every year, of course this makes competition in the manufacturing industry increasingly stringent. Every company must make efforts to improve from several factors, for example increasing the effectiveness of the equipment used as best as possible [1]. The machine used must be in good condition in order to work optimally. To maintain the condition of the machine so that there is no damage or disturbances that cause the production process to stop, good maintenance is needed so that the results can increase the effectiveness of the machine and damage to the machine can be avoided [2], [3].

Overall Equipment Effectiveness (OEE) is a product of operating activities with six big losses in machines or equipment [4]. The six factors in the six big losses can be grouped into three main components in OEE to be used. In measuring machine/equipment performance, namely, downtime losses, speed losses and defect losses. OEE is a comprehensive measure that identifies the level of machine/equipment productivity from theoretical performance. This measurement is very important to find out which areas need to be increased in productivity or efficiency of machines or equipment and can also show bottleneck areas in the production line. OEE is also a measurement tool for evaluating and improving the right way to guarantee increased productivity in the use of machines or equipment[5]. OEE is a "best practices" way to monitor and improve the effectiveness of manufacturing processes (i.e. machines, manufacturing cells, assembly lines). OEE is simple and practical. It takes the most common and important sources of manufacturing productivity loss, places them into three primary categories and distills them into metrics that provide an excellent gauge for measuring where you are and how you can improve [6]. Proposed the use of OEE to improve the efficiency of production equipment under consideration of the following three points: (1) the relevant indicators of the periodic maintenance schedule, (2) the ability to solve machine failure, and (3) characterizing the manufacturing process through the machine process. [7]. The OEE helps in the systematic

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analysis of the production processes while continually identifying potential problematic areas affecting the use of the machines[8].

To find out how good the effectiveness of a machine is, it can measure the OEE value of the machine. OEE measurement is carried out by taking into account three important things, namely the availability rate, performance rate, and quality rate. These three types of factors are generally translated into several types of losses, namely breakdown losses, set up and adjustment, idle and minor stoppage, reduce speed, process defects, and reduce yield. The use of OEE has the main objective to maximize the effectiveness of the equipment. The assessment related to machine OEE following global standards is 90% for the value of the availability rate, 95% for the performance rate, and 99% for the quality rate or 85% for the OEE value of an equipment [1]. The shape of the attachment components produced by CNC Turning machines varies quite a bit both in shape and size, so this has the potential to raise problems related to the machine's availability factor. Quite a variety of attachment components produced by CNC Turning machines if not addressed properly has the potential to cause long setup times and reduced availability of time for production.

This research was conducted based on the process at one of Fabrication and Machining factory in Indonesia. Many innovations and improvements have been made to the company so as to provide efficient, reliable and high-quality services to customers. This research was focused on CNC Turning machines with the type CNC Lathe Machine XTRA 420, which are machines used to produce various types of automotive parts, such as pistons, gears, etc. Automotive parts are a product that is produced and ordered more than any other product, and based on the data collected regarding the effectiveness of the CNC Turning machine, it shows that this machine has not fully worked effectively. This is indicated by the presence of downtime data, engine speed reduction data, and product data that does not meet specifications. The repairs that have been made are in the replacement of bearings, power packs, pump motors, cooling fans. Apart from that, there are examples of products that are very clearly damaged when the production process is finished, namely gears. The condition of the gears, there is wear and tear on the inner circle of the teeth, the teeth become chipped, and wear and tear on the ends of the teeth.

2. Literature review

2.1 CNC machining

CNC stands for Computer Numerically Controlled, which is a machine tool that is equipped with a computer-based mechanical and control system capable of reading code instructions N, G, F, T, etc., where these codes will instruct the CNC machine to work according to program workpiece to be created. In general, the workings of CNC machine tools are no different from conventional machine tools. The function of the CNC in this case replaces the operator's work in conventional machine tools. For example the work of setting the tool or adjusting the chisel movement until it is ready to cut, the cutting movement and the movement back to the initial position, and so on. Likewise, setting the cutting conditions (cutting speed, feed speed and depth of cut) as well as other regulatory functions such as changing the tool, changing the power transmission (number of revolutions of the main shaft), and the direction of rotation of the main shaft, clamping, adjusting the coolant and so on. In machining process, the company wants machine to work efficiently. An efficient company will produce a greater number of quality products with less waste, using less energy and other resources during a given period as compared to an inefficient one [9].

2.2 Preventive maintenance

Preventive Maintenance is a kind of physical inspection of equipment to prevent equipment damage and extend the life of the equipment [1]. So from some of the opinions above it can be concluded that preventive maintenance activities are activities to prevent damage during the production process, so that every facility that receives preventive maintenance will ensure its smooth operation because it is always attempted in a condition or condition that is ready for use. for each operation or production process at any time [10].

Total Productive Maintenance (TPM) is Target to achieve the maximum equipment efficiency (overall efficiency) [11]. The activities of TPM are identical in observing the value of OEE or Overall Equipment Effectiveness which in OEE has some diseases that cause a decrease in value At this stage to find

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the main cause factor waste/loss due to low effectiveness on the machine [12].

2.3 Breakdown Maintenance

Breakdown Maintenance is a maintenance activity carried out if the equipment or production facility is damaged or the product results are not as planned. At first glance, it can be seen that Breakdown Maintenance activities are much cheaper than Preventive Maintenance [2]. Because corrective maintenance is carried out in the event of damage at any time to the equipment or production facilities. However, if damage occurs to production equipment or facilities during the production process, a Preventive Maintenance policy must be implemented to prevent damage during the production process [13]. So that in this case the company needs to consider the policies carried out in the maintenance of its facilities or equipment so that efficiency in maintenance can be fulfilled[2].

2.4 Overall equipment effectiveness (OEE)

The overall equipment effectiveness (OEE) was first introduced by Nakajima1 in the context of total productivity maintenance (TPM) as a metric of equipment efficiency. As a well-known measurement method, OEE can fully reflect the equipment condition in the production site, and it is widely used in the manufacturing industry to analyze equipment efficiency[14]. Using OEE for performance measurement purposes is common in manufacturing across the globe, and the scientific community has paid attention to OEE, both in its own and as a part of lean [15]. According to Chun Wu (2003), significant differences in transportation performance exist between lean and non-lean companies [16].

The performance of a machine can be calculated by calculating the value of Overall Equipment Effectiveness (OEE), which is a total measurement of performance related to the availability of productivity and quality processes [4]. Overall Equipment Effectiveness (OEE) is a tool for monitoring how manufacturing resources' time is allocated and identifying those margins available for improvement [17]. OEE measurement shows how well a company uses its resources including equipment, workers and the ability to satisfy consumers in terms of delivery according to quality specifications according to consumers.

The information provided by the OEE can be given at variable periods (shift time of labour, a day, a week or a longer duration), according to the TPM or any other associated improvement approach requirement [18].

The basic formula for calculating OEE is written as:

OEE = Availibility x Performenance efficiency x Quality rate (1)

Where availability is defined as a ratio of planned production time minus downtime (breakdowns and changeovers) over planned production time. Performance efficiency is the ideal cycle time times the number of products produced over actual runtime. The quality rate is the ratio between accepted products over number of products produced [19]. The total OEE is an indication of how effectively your machine has been used compared to how its use could theoretically be maximized [20].

2.5. Pareto Chart

Statistically, a Pareto chart is simply a frequency block diagram displaying the relative frequency of different attributes in descending order. This classification is an essential step that must precede taking the corrective measures of differentiation and allocation. [21]. The Pareto chart is useful for non-numeric data, such as 'cause', 'type' or 'classification' and is useful to prioritize where action and process changes should be focused and are commonly used for identifying the downtime and other wastages. It uses bar diagrams to sort problems based on frequency, severity, nature, or source and displays them size which problems are vital ones [22](Benjamin, Marathamuthu, & Murugaiah, 2015) [23].

3. Methods

In looking for problems to be studied it is very necessary to make observations of the problem. Preliminary observations or studies carried out aim to find out more details about the information needed to determine research variables. Based on this information, the stages of solving the existing problems are obtained so that the discussion in this study becomes directed. The steps taken include:

a. Orientation to the company by means of surveys and interviews.

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b. Determine the theme of the problem to be examined by conducting a literature study to find and explore the theory concerned with the chosen theme.
c. Carry out an initial survey in the field, which in this case was carried out directly by interviewing the company regarding the actual situation and taking data in the field and adjusting it to the theory that has been studied.
d. Searching for data from companies by collecting as much information as possible about engine damage data related to the research theme, namely overall effectiveness equipment (OEE).

To find out how good the effectiveness of a machine is, it can measure the OEE value of the machine. OEE measurement is carried out by taking into account three important things, namely the availability rate, performance rate, and quality rate. These three types of factors are generally translated into several types of losses, namely breakdown losses, set up and adjustment, idle and minor stoppage, reduce speed, process defects, and reduce yield. The data needed in this method are:

a. Machine working time is the total effective time a printing machine operates in producing products.
b. Planned downtime is time allocated to carry out scheduled maintenance activities so that the condition of machines and other production equipment is in good condition.
c. Failure and repair is the time spent without producing output due to machine or equipment damage and the time needed to repair the machine.
d. Setup and adjustment is the time needed to start production.
e. Data on the number of products per day, is data on the number of products that the company can produce every day.

Data on the number of reject and rework products, is data on the number of products that are defective during the production process.

3. Results and discussion

3.1. OEE Calculation

The following is a recap of data on OEE values for the period January – August 2022 which can be seen in table 1. The results of calculating the OEE value of the CNC Turning machine in the period January - August 2022 can be seen in Table 1. The availability value of the CNC Turning machine is between 77.81% to 81.97% with an average of 80.40%, and overall it is still below the ideal availability value (90%).

In this case in table 1, the CNC Turning machine is between 75.93% and 81.07% with an average of 78.29%, and overall it is still below the ideal performance efficiency value (95%).

In this case, the CNC Turning machine has not worked according to the speed set by the company, so it is still possible to increase the value of performance efficiency by analyzing and improving the idling factor and minor stoppage losses and reduced speed losses of CNC Turning machines.

The rate of quality products for CNC Turning machines is between 90.68% and 91.67% with an average of 91.42%, and overall is still below the ideal rate of quality products (99%). In this case, the CNC Turning machine still produces products outside the company's

Table 1. Data for calculating OEE values for the period January – August 2022

Month	Machine working Time (Hours)	Planned downtime (Hours)	failure & repair (Hours)	Setup & adjust (Hours)	processed amount (unit)	reject (unit)	cycle time (Hours)
January	180	5	0,4	2,6	95	8	1
February	180	5	0,4	2,6	104	12	1
March	180	5	1	2,6	91	5	1
April	189	5,25	0,4	2,7	113	8	1
May	162	4,5	0,3	2,3	116	12	1
June	189	5,25	1,3	2,7	102	10	1
July	171	4,75	0,3	2,4	110	12	1
August	180	5	0,4	2,6	119	12	1
Total	1431	39,75	4,6	20,5	850	79	8

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specifications, so it is still possible to increase the value of the rate of quality products by analyzing and improving the process defect losses and reduced yield losses of the CNC Turning machine.

The OEE value which depicted in the table 2 show that the percentage is between 54.16% to 59.91% with an average of 57.55%, and overall it is still below the ideal OEE value (85%). In this case, there are large room for improvement to increase the OEE value by increasing the value of availability, performance efficiency, and rate of product quality.

3.2. Six Big Losses

The results of calculating six big losses for CNC Turning machines in the period January – August 2022 can be seen in table 2. The total time lost during the production process of CNC Turning machines in the January – August 2022 period was 188.19 hours (42.45% of the loading time). Setup and adjustment losses have the largest contribution with a percentage of 43.69% (82.22 hours), followed by idling and minor stoppage losses of 31.23% (58.76 hours), process defect losses of 10.56% (19.88 hours), reduced speed losses of 9.88% (18.60 hours), breakdown losses of 2.48% (4.67 hours), and reduced yield losses which have the smallest contribution of 2.16% (4 .06 hours).

3.3 Discussion

3.3.1 Rate of quality

The following are the results of data processing presented in Fig 1.

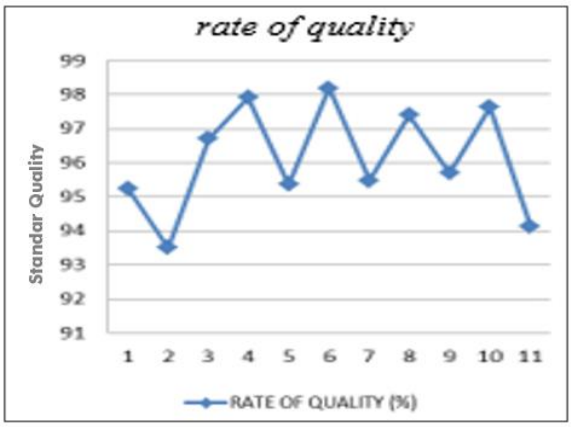

Fig 1. Part graphic rate of quality

From Fig. 1. it can be concluded that the highest ROQ value is located in month 6 and the lowest is located in month 2 which is 93.5%. Even so, the comparison of products produced without defects was almost 100%, so it was concluded that the ability to cut steel plates was in the perfect category.

3.3.2. Performance efficiency

Fig. 2 is the result of processing performance efficiency data which is presented graphically. Based on Fig. 2. it can be concluded that the lowest point is located in the third month, which is 75.49% in the third month and the highest point is 97.96% in the fourth month. However, overall performance efficiency can be said to be normal.

Tabel 2. OEE values for the period January – August 2022

Month	Availability Ratio (%)	Performance Efficiency (%)	Quality Ratio (%)	OEE (%)
January	79,83	76,94	91,53	56,22
February	79,32	81,07	92,32	59,37
March	80,6	78,32	91,37	57,67
April	81,53	77,15	90,84	57,14
May	80,7	78,16	91,56	57,75
June	77,81	75,97	91,63	54,16
July	80,51	79,61	91,58	58,69
August	81,86	77,33	91,09	57,67
Average	80,4	78,29	91,42	57,55

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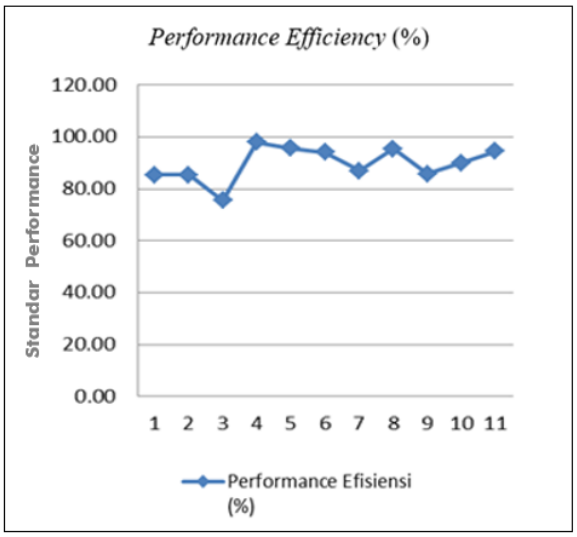

Fig. 2. Graph of performance efficiency

3.3.3. Availability Ratio

Fig. 3 is the result of Availability ratio data processing which is presented graphically.

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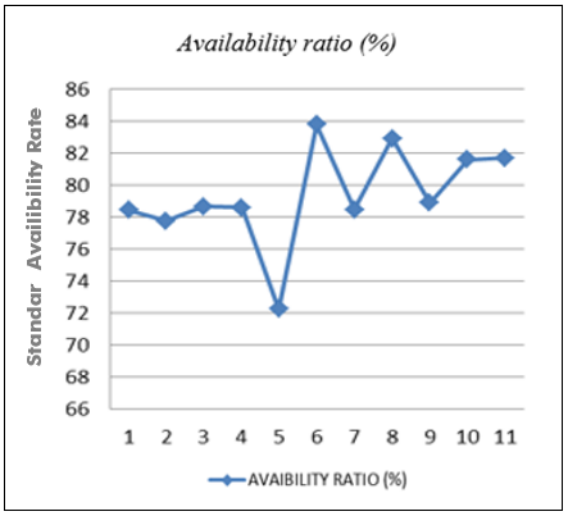

Fig. 3 Graph of Availability ratio

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Based on Fig. 3, the lowest point is in month 5, which is 72.24% and the highest point is in month 6, which is 83%. With an average of 79.37%, in general, the downtime of the machine must be repaired immediately so as not to interfere with the cutting production capacity. One of the causes of the low availability ratio is placing the workpiece into the machine which takes quite a long time, which can reach 20-30 minutes. And another cause is the time taken for the finished cut workpiece which must be left for at least 30 minutes.

3.3.4. Overall Equipment Effectiveness

Fig. 4 presents a graph of the results of data processing of Overall Equipment Effectiveness.

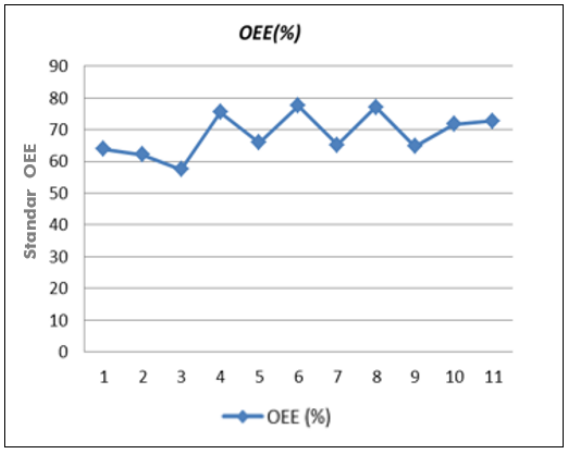

Fig. 4 OEE Graph

From Fig. 4, the lowest point is in the third month, which is 57.43% and the highest is in month 6, which is 77.4%. with an average of 68.48%.

The following is a classification of OEE values and the consequences that will result:

a. OEE < 65% is unacceptable. There are important economic losses. Very low competitiveness.
b. 65% < OEE < 75% standard. Accepted only if it is in the process of being repaired. Economic loss. Low competitiveness.
c. 75% < OEE < 85% acceptable. Continue improvement above 85% and move towards world class. Slight economic loss. Competitiveness is a bit low.
d. 85% < OEE < 95% Good. world class value, Good competitiveness .
e. OEE > 95% Excellent. world class value. Perfect competitiveness.

The following are some of the problems that cause the level of effectiveness of CNC cutting machines to fall into the standard category

a. Operator knowledge is still low on how to properly compose gas and oxygen.
b. The placement of the steel plate into the CNC Cutting machine takes a very long time, because the material handling system is still not good
c. The operator is less reliable when positioning the nozzle at the start of the cut
d. The preheating process is not according to the standard, namely for 60 sec, but in reality it is

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only done for 25-30 sec. thus causing the steel plate is not cut.

e. The steel plate expands easily during the cutting process.
f. The sandblasting process is imperfect so that it still leaves rust. As a result, steel plate is more difficult to cut.
g. The scheduling process is not good so that sometimes the machine is idle for days. Sometimes there is a delay in the cutting process not according to schedule.
h. CNC operator staff is still lacking because there is no cleaning service on duty to clean up the remaining pieces of steel plate so that the operator leaves time to clean the CNC.
i. Replacement of the CNC Cutting mat may take about 4-5 days
j. There is no fan so that sometimes operators get tired more quickly because the room temperature is quite hot

The process of taking the workpiece that has been cut takes too long, which is around 30-60 minutes so that it cools down. thereby hindering the further cutting process.

4. Conclusions

The results of the study concluded that the Overall Equipment Effectiveness (OEE) value ranged from 65% <OEE <75%. That the level of effectiveness of the CNC Cutting machine is in the standard category, and can be considered reasonable if it is still in the repair stage or the operator training period. But from an economic point of view the company will suffer losses. The results of this study suggest to the company to pay more attention to the factors of using production time, work according to standards, operator knowledge, and machine maintenance. By taking into account these factors, it is expected that the company's productivity will increase and the production process will run effectively and efficiently.

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