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The Effectiveness Level Analysis of Flask Less Molding Machine Using Overall Equipment Effectiveness (OEE) as An Improvement of Machine Productivity

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Abstract. *CV. Okabawes Karya Logam is a metal foundry company in Ceper, Klaten, Central Java, Indonesia that uses automatic moulding machines. This company has implemented Total Productive Maintenance which is useful for increasing the overall effectiveness of the company. The use of Flask Less Horizontal Moulding Machine in production to make product moulds is one of the breakthroughs to achieve this effectiveness. However, the usage of the Flask Less Horizontal Moulding Machine cannot be maximized due to several problems. This research was conducted on the Flask Less Horizontal Molding Machine due to the large number of defects and downtime that often occur on machines which aim to measure the value of effectiveness by collecting some supporting data. This research begins by measuring the Overall Equipment Effectiveness (OEE) value, then identifies the root of the problem with the Fishbone Diagram which has 5 main factors that influence it and continues to provide solutions to the five root causes of the problem. The results showed that the Overall Equipment Effectiveness (OEE) value on the Flask Less Horizontal Moulding Machine was 58,53%, this value is below the standard because the Japan Institute of Plan Maintenance (JIPM) set a standard of 85%. There are also 5 main root causes of the Fishbone Diagram identification that have been given solutions.*

Keywords: *no idle permutation flow shop, energy efficiency, metaheuristic, grey wolf optimizer algorithm*

I. INTRODUCTION

In the current era, daily production plants are experiencing capacity problems and have decided to add overtime, buy new equipment, and add shifts (More et al, 2016). Therefore, it is necessary to make appropriate observations to reduce these things which are also related to product defects to human resources who lack above average capabilities (Gabahne et al., 2014). Increasing productivity in the company needs to be done because it is an important factor in order to compete with competing companies, to master it requires several strategies that are appropriate to get quality and customer satisfaction (Agung et al, 2018). With several supporting machines such as automatic printing machines that can run without human power, it is one solution in facing the current era which has entered the era of efficiency by using machines as a tool to be able to compete (Patil and Prasad, 2019).

CV. Okabawes Karya Logam is a company engaged in metal casting by producing products in the form of water pipe connections, street lights, to other metal-related accessories. Drinking water pipe connections and accessories (PDAM) are one of the main products produced by the company. The shape, size, and function of each product vary. In this company, production is carried out for 8.5 hours / day and with only 1 shift. The production equipment used for printing already uses an automatic tool called a flask less horizontal molding machine, which is a tool that can replace human labor in order to achieve high production targets for productivity.

CV. Okabawes Karya Logam has had a flask less horizontal molding machine (shown at Fig. 1) since 2019 but the company has not been able to use it to its full potential due to several things such as stopping the engine due to the lack of wind pressure entering the wind tank, changing

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mats/product molds for the machine which requires sufficient time. long time, until workers are less reliable in understanding the use of the flask less horizontal molding machine. That thing of course has an impact on decreasing the productivity of these machines to produce large quantities of products.

Figure 1. Flask Less Horizontal Moulding Machine

With Overall Equipment Effectiveness (OEE) to analyze the effectiveness of the flask less horizontal molding machine, it is hoped that it can improve the effectiveness and efficiency of the machine. Overall equipment effectiveness is a method or one of the important elements in Total Productive Maintenance (TPM) which is one of the concepts to improve company performance (Sunaryo and Nugroho, 2015). Overall equipment effectiveness can also be said to be a method to see the level of effectiveness of the manufacturing process in the hope that it can be developed or improved (Adrian and Octavia, 2015). The overall equipment effectiveness calculation is very general and can be applied to any manufacturing company (Vijayakumar and Gajendran, 2014). Overall equipment effectiveness measurement is done by taking into account 3 things, namely machine availability (availability rate), number of products produced (performance rate), and quality produced from the product (quality rate) (Bilianto & Ekawati, 2016). These 3 things have different standard values using the JIPM (Japan Institute of Plan Maintenance) standard which defines if it meets the standard availability ratio value of 90%, the performance ratio value is 95%, the quality rate is 99%, and the overall equipment effectiveness value by 85% (Nakajima, 1998). After obtaining these values, an analysis is needed to find the cause of the low effectiveness of using the machine using a fishbone diagram (Anggraini and Saputra, 2018). Fishbone diagram serves to identify and sort out the causes that arise from specific problems (Murnawan and Mustofa, 2014). Besides, the fishbone diagram can be said to be one of the methods / tools to improve quality (Putri and Gusman, 2017).

II. Research Method

This research was conducted at CV. Okabawes Karya Logam towards 1 flask less horizontal molding machine during working hours. In this study, production data for the last 3 months from June to August 2020 were taken.

Data collection was carried out in the following way. Observations that make direct observations on the printing process of the flask less horizontal molding machine during the practical work period. Interviews were conducted with the head of the production department and production staff who described several influences that resulted in less effective machine performance.

Data collection consists of taking directly on the production floor and indirectly. Direct retrieval is carried out to obtain cycle time data on the flask less horizontal molding machine and indirect retrieval is obtained in the recap of CV production. Okabawes Karya Logam is carried out to obtain data on production results, the number of prints, working hours, downtime, and defective products every week from June to August 2020.

Data processing is carried out by calculating the availability rate, performance rate, quality rate, and overall equipment effectiveness as the final result that determines the value of its effectiveness and continues the analysis using a fishbone diagram with 5 problem points such as machines, methods, people, raw materials, and work environment (Jannah et al, 2017). This can

provide clearer solutions to the root problems found (Nursanti and Susanto, 2014).

III. Result and Discussion

Research Results

In calculating the overall equipment effectiveness, there are availability rates, performance rates, and quality rates that require the following data:

1. Total Production (Pcs)
2. Number of Defective Products (Pcs)
3. Ideal Cycle Time (Hours / Unit)
4. Working Hours (Hours)
5. Downtime (Hours)

The data that has been collected can be processed as follows. Table 1 shows the data and calculation results of the availability rate on the flask less horizontal molding machine. Based on data and calculation results from June to August, it can be seen that the average availability rate for 3 months or 12 weeks still does not meet the index standard set by the JIPM (Japan Institute of Plant Maintenance) at 90%. It can be seen that the highest availability rate is on the 4th week of June at 87.25% and the lowest is on the 4th week of August at 84.31%. Therefore, there is a need for improvements to increase the availability rate.

Table 2 shows the data and performance rate calculation results on the flask less horizontal molding machine. Based on data and calculation results from June to August, it can be seen that the average performance rate for 3 months or 12 weeks still does not meet the index standard set by the JIPM (Japan Institute of Plant Maintenance) at 95%. It can be seen that the highest performance rate value is found on the 4th week of July at 59.15% and the lowest is on the 1st week of August at 54.75%. Therefore, there is a need for improvements to increase the value of

Table 1. Data and Availability Rate Calculation Results

Month	Week	Working Time (hrs)	Down time (hrs)	Operation Time (hrs)	Avail-ability Rate
June	1	51	7.40	43.60	85.49%
	2	51	6.60	44.40	87.06%
	3	51	7.20	43.80	85.88%
	4	51	6.50	44.50	87.25%
July	1	51	7.60	43.40	85.10%
	2	51	7.70	43.30	84.90%
	3	51	6.90	44.10	86.47%
	4	51	7.30	43.70	85.69%
August	1	51	6.60	44.40	87.06%
	2	51	6.90	44.10	86.47%
	3	51	6.80	44.20	86.67%
	4	51	8.00	43.00	84.31%
				Availability Rate	86.03%

Table 2. Data and Calculation Results of Performance Rate

Month	Week	Oper. Time (hrs)	Prod. Quantity (pcs)	Cycle Time	Perform Rate
June	1	43.60	5148	0.005	59.04%
	2	44.40	5148	0.005	57.97%
	3	43.80	4994	0.005	57.01%
	4	44.50	5214	0.005	58.58%
July	1	43.40	5016	0.005	57.79%
	2	43.30	5082	0.005	58.68%
	3	44.10	4994	0.005	56.62%
	4	43.70	5170	0.005	59.15%
August	1	44.40	4862	0.005	54.75%
	2	44.10	5060	0.005	57.37%
	3	44.20	5016	0.005	56.74%
	4	43.00	4862	0.005	56.53%
				Perform Rate	57.52%

Table 3. Data and Quality Rate Calculation Results

Month	Week	Prod. Quantity (pcs)	Good Product (pcs)	Defect Product (pcs)	Quality Rate
Juni	1	5148	4840	308	94.02%
	2	5148	4840	308	94.02%
	3	4994	4695	299	94.01%
	4	5214	4902	312	94.02%
Juli	1	5016	4716	300	94.02%
	2	5082	4778	304	94.02%
	3	4994	4745	249	95.01%
	4	5170	4912	258	95.01%
Agustus	1	4862	4522	340	93.01%
	2	5060	4807	253	95.00%
	3	5016	4766	250	95.02%
	4	4862	4571	291	94.01%
				Quality Rate	94.26%

the performance rate.

Table 3 shows the data and the results of calculating the quality rate on the flask less horizontal molding machine. Based on data and calculation results from June to August, it can be seen that the average quality rate value for 3 months or 12 weeks still does not meet the index standard set by JIPM (Japan Institute of Plant Maintenance) of 99.9%. It can be seen that the highest performance rate value is on the 3rd and 4th week of July at 95.01% and the lowest is on the 1st week of August at 93.01%. Therefore, there is a need for improvement to increase the value of the quality rate.

Table 4 shows the data and calculation results of the overall equipment effectiveness at the flask less horizontal molding machine. Based on data and calculation results from June to August, it can be seen that the average overall equipment effectiveness value is 46.65%, which can be said to have not reached the global standard with a value of 85%, therefore it is necessary to make improvements to increase the overall equipment effectiveness value for improve engine performance better.

Discussions

The following is an identification of the problem with the fishbone diagram on the flask less horizontal molding machine in Figure 2.

Based on interviews that have been conducted with some of the employees concerned, it is found that the fishbone diagram above can be seen as the cause of ineffective machine performance. With this, we can get the root of the problem from each of the main causes of the problem which can be seen the possible causes (Atmaja et al, 2018). The data obtained were then analyzed with various literatures to provide a solution (Hidayat et al, 2019). The causes and solutions to some of the engine performance problems are less effective as

Table 4. Data and Calculation of Overall Equipment Effectiveness

Month	Week	Avail-ability Rate (%)	Perform-ance Rate (%)	Quality Rate (%)	OEE (%)
June	1	85.49	59.04	94.02	47.45
	2	87.06	57.97	94.02	47.45
	3	85.88	57.01	94.01	46.03
	4	87.25	58.58	94.02	48.06
July	1	85.10	57.79	94.02	46.24
	2	84.90	58.68	94.02	46.84
	3	86.47	56.62	95.01	46.52
	4	85.69	59.15	95.01	48.16
August	1	87.06	54.75	93.01	44.33
	2	86.47	57.37	95.00	47.13
	3	86.67	56.74		46.73
	4	84.31	56.53	94.01%	44.81
		86.03	57.52	94.26%	46.6

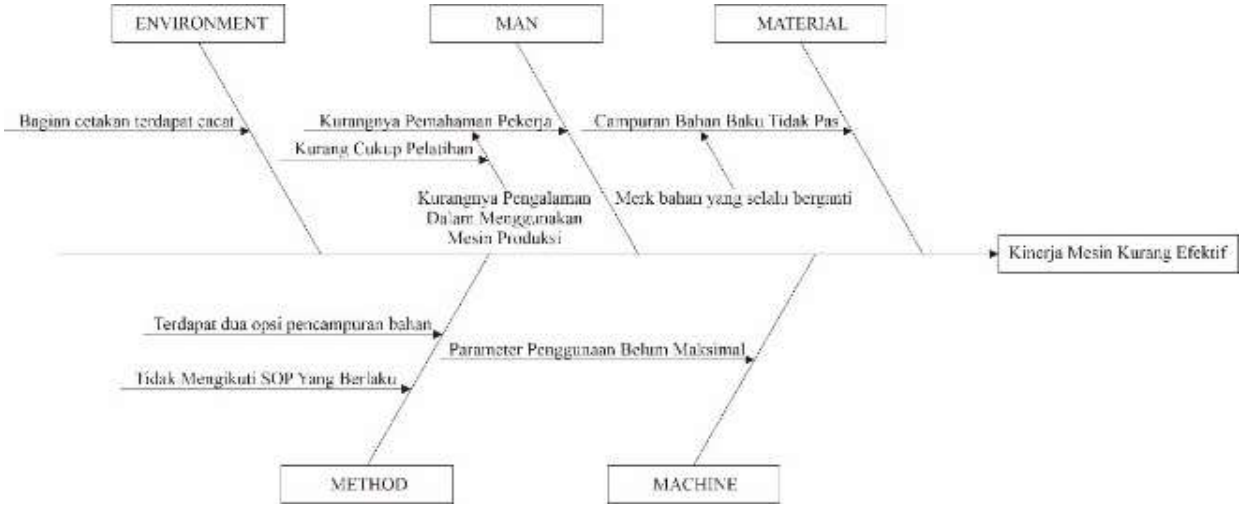

Figure 2. Problem Identification with Fishbone Diagram

follows.

Brands of materials are always changing. The brands of materials that are always changing are one of the main root causes of materials. At CV. Okabawes Karya Logam, when mixing raw materials, sometimes experiences a composition mismatch due to frequent changing brands of the mixed material. The replacement of the bentonite brand as a mixture for reinforcing white sand is very influential because the composition of each brand used in the mixing is different. The bentonite used is the Volclay and Raychem brands. According to the head of the production department during interviews and direct observations in the process of mixing white sand, bentonite, and water with the same volume of volclay, it gives the characteristics of a strong mold and does not stick to the flask, while Raychem provides the characteristics of a mold that has many cracks and sticks to the flask. With this, there is still a mixture of raw materials that is not suitable for the product to be printed using a flask less horizontal molding machine. Therefore the solution given is the need to purchase one brand of goods in purchasing materials by increasing the consistency of buying from the same supplier to focus on material problems that occur will help overcome the main root problem.

Not maximum usage parameters are one of the main root problems of the machine. When using a flask less horizontal molding machine, there is a problem that always refers to the time parameters on the machine. The parameters used are always not optimal in the use of printing, not the maximum that is obtained, such as printing that takes more than 1 minute per print, which should have a time of less than 1 minute per print. The appropriate parameters are currently in the testing phase with 18 to 20 seconds per print. Therefore the solution given is the need for a deeper understanding of machine use by studying the existing manual on the flask less horizontal molding machine or experimenting with various parameters to find the best results will help solve the main root of the problem.

Lack of sufficient training is one of the main root problems of workers. Human resources who have the capability to use machines at CV. Okabawes Karya Logam is still average. The understanding obtained is still limited to experiences that have occurred, although with experience it will not be enough if you face obstacles that have never been met. However, relying on a few capable workers who are able to understand the machine will have better results. Workers who have average capabilities, of course, still need to learn a lot with experience and of course need to be given special training on these machines in order to get a deeper understanding of the machines. Therefore, the solution given is that it is necessary to conduct special training on certain days with experienced mentors so that they are more focused on common problems and can overcome problems that have never existed before will help overcome the main root of the problem.

There are 2 mixing options and not following the soup which applies to the two main root causes of the method. There are 2 mixing options where the first option has a composition of 200 Kg of white sand, 2% Water from the weight of white sand, and 4% Bentonite from the weight of white sand and the second option with a composition of 200 Kg of white sand, 2% Water from the weight of white sand, and 3 % Bentonite by weight of white sand. With this, of course, the mixture for the mold will be different so that it can cause defective molds. Then not following the SOP that applies a lot to each use of these machines such as using different modes, there are 2 modes on the machine, namely auto continue and auto one cycle which have different functions. Auto continue is a mode that runs continuously by itself without the need to press the start button every single print, while auto one cycle is a mode that runs continuously by itself by pressing the start button every single print. This results in some mold defects such as lack of sand in the mold and cracks in certain parts because the sand is always not full when the mode is always changed. Therefore, the solution given is that it is necessary to determine one option that is able to provide maximum printing results. By evaluating defective and non-defective products on each mold that uses a mixture of compositions

between the 2 options, it will help solve the two main root causes.

The Mould part has a defect. The part of the mold has a defect to be one of the main root causes of the environment. The defects that occur are always in the corner of the mold. This of course makes the mold unable to be used in casting because when pouring a solid and tight mold is needed to avoid the liquid coming out of the mold and of course, the production floor on the conveyor belt for the product mold will be hampered for pouring metal liquids. Therefore the solution given is to provide a different conveyor belt path for defective and non-defective product prints, so that the receipt of the mold after the machine does not experience a bottleneck. With the addition of a special line for defective product molds and it will not be easier to deal with defective products, it will help solve the main problem.

IV. CONCLUSION

Based on the results of data processing overall equipment effectiveness for flask less horizontal molding machine, the value of availability rate, performance rate, quality rate, and overall equipment effectiveness has not met the standards set by JIPM (Japan Institute of Plan Maintenance) and in the fishbone diagram there is a root cause of the problem. The 5 factors, namely the brand of materials that are always changing, the usage parameters are not optimal, there is not enough training, there are 2 mixing options and do not follow the applicable SOP, and the mold part has defects and solutions that can be given are the requirement need to purchase one brand of goods, the requirement need for more understanding In the use of machines, it is necessary to carry out special training on certain days with experienced mentors, it is necessary to determine 1 option that is able to provide maximum printing results, and to provide different conveyor belt lines for defective and non-defective product prints.

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