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Performance Measurement Analysis of Injection Molding Machine JSW J450AD Using Methods Overall Effectiveness (OEE) And Failure Mode Effect Analysis (FMEA) In The Plastics Industry

Iwan Saputro, Erry Rimawan, Alib Sabaruddin, Wahyu Abadi
Mercu Buana University

Abstract:- PT. Bumimulia Indah Lestari is a manufacturing company that produces plastic packaging using injection molding machines. The problem faced by the company is the high downtime of the JSW J450AD machine. during the early semester of 2020, the total downtime of the machine was 18,060 hours. From these problems, the author tries to measure machine performance using the Overall Equipment Effectiveness method. OEE measurement results show an average of 72.35%. Based on the Pareto diagram analysis, the biggest causes of the low OEE number are reduced speed losses by 14%. After an analysis using FMEA, it was found that mold overheating was the biggest cause of failure with RPN 448. The recommendation for improvement given was to carry out routine inspections of the cooling system such as checking the condition of the hose, compressor chiller air pressure, and the condition of the nozzle.

Keywords:- *Injection Molding, Downtime, OEE, Reduced Speed Losses, Equipment Failure Losses, FMEA, Improvement.*

I. INTRODUCTION

Nowadays, there is a very rapid growth in the use of plastic products because they are very versatile and have high economic value. The Aromatile, Olefin, and Plastic Industry Association (Inaplas) predict that the national plastic industry will still grow 7% this year.

PT. Bumimulia Indah Lestari is a manufacturing company engaged in the manufacture of plastic packaging such as bottles, caps, jerrycans, pallets. The problem faced by the company is the high downtime of the JSW J450AD injection molding machine at plant 2. The following is the machine downtime data for the period from January 2020 to June 2020.

Table.1 Downtime Machine JSW J450AD

Month	***Changeover Mould*** **(minute)**	***Breakdown*** **(minute)**	***Mould Cleaning*** **(minute)**	**Total *Downtime* (minute)**
January 2020	960	2.790	270	4.020
February 2020	720	2.412	108	3.240
March 2020	582	1.782	156	2.520
April 2020	600	1.386	174	2.160
Mei 2020	840	2.568	312	3.720
June 2020	708	1.470	222	2.400
Total	4.410	12.708	1.242	18.060

(Source : Internal company data)

Based on table above, the total downtime data for the JSW J450 AD injection molding machine was very high during the period from January 2020 to June 2020, reaching 18,060 minutes and the highest downtime occurred in January 2020, which was 4,020 minutes. Downtime is one of the factors that affect the optimization of production machines (Prabowo & R, 2019). The effect of high downtime is a decrease in the speed and performance of the machine/equipment so that the output produced is not optimal and in the end will reduce the level of productivity. Various efforts such as repairs (maintenance) have been carried out by the company but the actual number of downtime is still very high. From these problems the author tries to provide a solution so that downtime can be reduced, namely by measuring machine performance with the Overall Equipment Effectiveness method. Measuring machine performance is very important so that we can find out how effectively the machine is used.

II. LITERATURE REVIEW

Maintenance is all activities that are important with the aim of producing a good product or to restore it to a satisfactory state. Maintenance can be defined as an activity needed to maintain or maintain the quality of maintenance of a facility so that the facility can function properly in a ready-to-use condition (Sudrajat, 2011).

1.1 Types of Maintenance

Up to now, there are three types of maintenance, namely planned maintenance, unplanned maintenance and autonomous maintenance.

1.1.1 Planned Maintenance

Planned maintenance is maintenance that is organized and carried out with future thinking, control and recording according to a predetermined plan. According to (Corder, Antony, K. Hadi, 1992) Planned maintenance is divided into two main activities, namely preventive maintenance and corrective maintenance.

➢ **Preventive Maintenance**

Preventive maintenance is a periodic inspection to detect conditions that might cause production to stop or reduce the function of the machine combined with maintenance to eliminate, control, these conditions and return the machine to its original condition or in other words self-detection and treatment of abnormal machine conditions before the condition. it causes damage or loss.

➢ **Corrective Maintenance**

According to Corder, Antony, K. Hadi, (1992), corrective maintenance is maintenance that is carried out repeatedly or maintenance carried out to repair a part (including adjustment and repair) that has stopped to meet an acceptable condition.

1.1.2 Unplanned Maintenance

There is only one form of unplanned maintenance, namely emergency maintenance (emergency/breakdown maintenance). Corder, Antony and K. Hadi (1992) define maintenance as requiring immediate action to prevent serious consequences, such as loss of production, major damage to equipment, or for work safety.

1.1.3 Autonomous Maintenance

Autonomous maintenance is an activity to increase productivity and efficiency of machines/equipment through activities carried out by operators to maintain the machines/equipment they handle themselves.

1.2 Overall Equipment Effectiveness

According to Nakajima (1988), OEE is a method that measures the level of effectiveness in the use of a machine/equipment or system by taking into account several points of view in the measurement process. OEE measures the overall effectiveness of the equipment by multiplying availability, performance, and quality.

1.3 Failure Mode Effect Analisys

FMEA was first used in 1940 by the United States military and began to be developed as a methodology for the aerospace and defense industry in 1960. Until now the FMEA method has been used as a tool to analyze potential failures that occur in the production process in industry.

Failure Mode and Effects Analysis (FMEA) is one of the failure analysis methods applied in product development, system engineering and operational management. FMEA is carried out to analyze potential errors or failures in the system or process, and the identified potentials will be classified according to the magnitude of the potential failure and its effect on the process. In eliminating these potential problems, it is necessary to do an assessment first by calculating the Risk Priority Number (RPN). To calculate the RPN value, we must first know the scores from the categories of impact (severity), frequency (occurance), and detection (detection). The formula to get the RPN value is as follows:

RPN = Severity x Occurance x Detection

Information :

Severity = Impact arising from failure Occurance = The rate of occurrence of failure Detection = Ability to possibly detect failure

Risk Priority Number (RPN) = Risk value obtained from the multiplication of severity, occurrence, and detection

III. RESEARCH METHOD

In this research, the writer uses descriptive quantitative research method/type. Quantitative research is a process of finding knowledge that uses data in the form of numbers as a tool to analyze information about what you want to know. This study uses a descriptive approach with the aim of describing the object and the results of the study. According to Sugiyono (2013), the descriptive method has a function to describe or describe the object under study through the data or samples that have been collected. This study uses the Total Productive Maintenance (TPM) method with the calculation of Overall Equipment Effectiveness (OEE). The purpose of this research is to find out how the current condition of machine maintenance is, whether it is optimal or needs improvement.

To facilitate the discussion in this study, the authors use the following framework:

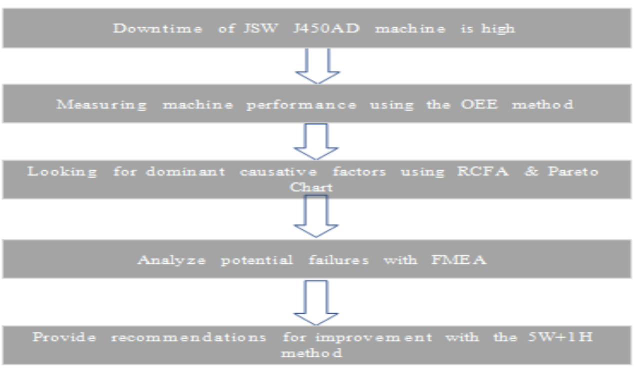

Figure 1. Framework of Research Source : Authors

IV. RESULT AND DUSCUSSION

➢ ***Availability***

Availability is a ratio that shows the time available to operate the machine.

Availability =

When :

Operation Time

Loading Time x 100%

Loading Time = Availability Time - Planned Downtime Operation Time = Loading Time –Downtime

Table.1 Availability Rate

Month	Operation Time (menit)	Loading Time (menit)	Availability (%)
January 2020	28.380	32.400	87,60
February 2020	33.120	36.360	91,09
March 2020	25.220	27.740	90,92
April 2020	20.940	23.100	90,65
Mai 2020	9.600	13.320	72,07
June 2020	33.660	36.060	93,34
Average			87,61

source : data processing

Performance

The performance rate indicates the machine's ability to produce a product over a given period of time. The data needed to calculate the performance rate are monthly operation time data, monthly production data, and ideal cycle time for 1 unit of product. In this study the author uses a cycle time that has been set by the company, which is 21 seconds.

Performance Rate =

Cycle Time x Total

Produksi x 100%

The following is the result of calculating the performance of the JSW J450AD engine for a period of 6 months:

Table.2 Performace Rate

Month	Operation Time (menit)	Operation Time (minute)	Cycle Time (second)	Total Product (shot)	Performance (%)
January 2020	28.380	1.702.800	21	71.040	87,76
February 2020	33.120	1.987.200	21	84.298	89,08
March2020	25.220	1.513.200	21	60.230	83,59
April2020	20.940	1.256.400	21	48.012	80,25
May 2020	9.600	576.000	21	18.053	65,81
June2020	33.660	2.019.600	21	90.208	93,80
Average					83,38

Source : data processing

Quality

According to Nakajima (1988) Quality Rate is the ratio of the number of good products (good products) to the all products processed.

Quality Rate =

Good Product (*pcs*)

All Product Processed (*pcs*) x 100%

Table.3 Quality Rate

Month	Good Product (pcs)	Reject Product (pcs)	Total Product (pcs)	Quality (%)
January 2020	3.354.338	55.582	3.409.920	98,37
February 2020	4.007.459	38.845	4.046.304	99,04
March 2020	2.878.320	12.720	2.891.040	99,56
April 2020	2.285.449	19.127	2.304.576	99,17
May2020	794.315	72.085	866.400	91,68
June 2020	4.293.090	36.894	4.329.894	99,15
Average				97,82

Source : data processing

Overall Equipment Effectiveness

After obtaining the availability, performance and quality values for each month, the Overall Equipment Effectiveness (OEE) is calculated with the following formula:

OEE (%) = Availability x Performance x Quality

Table.4 Result of OEE Calculating

Month	*Availability* (%)	*Performance* (%)	*Quality* (%)	OEE (%)
January 2020	87,60	87,76	98,37	75,62
February 2020	91,09	89,08	99,04	80,36
March2020	90,92	83,59	99,56	75,67
April2020	90,65	80,25	99,17	72,14
May2020	72,07	65,81	91,68	43,48
June2020	93,34	93,80	99,15	86,80
Average				72,35

Source : data processing

Based on the results of the OEE calculation in table 4 above, it is known that the average result shows the number 72.35%. This figure is still below the world-class OEE standard, namely ≥85%. So there needs to be improvement to the machine.

Six Big Losses Analysis

After knowing that the OEE results are below the standard, the next step is to analyze losses using a Pareto diagram. The purpose of this analysis is to determine the factors of the six big losses that have the most influence on the low OEE results.

Table.5 Recapitulation of the results of the calculation of losses

Month	*Equipment Failure Losses* (%)	*Setup & Adjustment Losses* (%)	*Idling And Minor Stopages* (%)	*Reduced Speed Losses* (%)	*Rework Losses* (%)
January 2020	2,96	8,6	0,83	10,85	0,34
February 2020	1,98	6,6	0,29	9,94	0,19
March2020	2,09	6,4	0,56	14,92	0,24
April2020	2,6	6	0,75	17,90	0,32
May2020	6,3	19,28	2,3	24,64	0,80
June2020	1,93	4,08	0,61	5,79	0,20
Average	8,49	2,98	0,89	14,00	0,35

Source : data processing

Table.6 Dominant causative factor

Type of losses	Average (%)	Persentage (%)	Cumulative Percentage (%)
Equipment Failure	8,49	31,8	31,8
Set up & Adjustment	2,98	11,2	43
Idling & Minor Stopages	0,89	3,3	46,3
Reduced Speed	14.00	52,4	98,7
Rework	0,35	1,3	100
Total	26,71	100	

Source : data processing

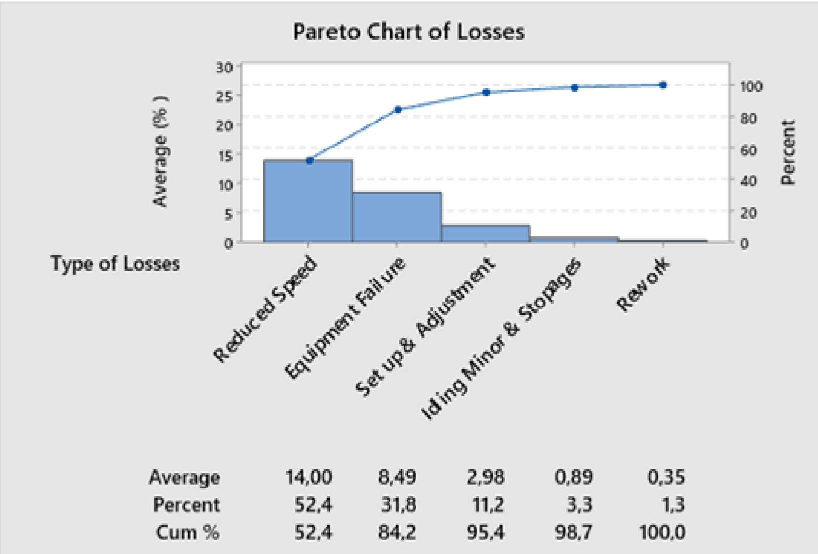

Figure.2 Pareto Losses Diagram for January 2020 to June 2020 Source : data processing

From the Pareto diagram above, it can be seen that the most dominant loss factor that causes low OEE is reduced speed with an average of 14%.

The next step is to find the cause of the reduced speed on the JSW J450AD machine with a fishbone diagram and root cause failure analysis (RCFA).

Table.7 RCFA Causative Reduced Speed of JSW J450AD Machine

Factor	***No***	***Why***	***Why***	***Why***	***Why***	***Why***
Man	1	Operator lacks of Knowledge	Have not receiving training	Busy of production schedule	Customer request	
	2	Human Error	tired	Operate more than one machine	Efficiency man power	
Machine	1	The machine often has a breakdown	Electrical short circuit often occurs	Less preventive maintenance	High of production loading	Customer request
	2	Mold Overheating	Chiller circulation is not optimal	Compressor air pressure is low	Leaky hose	Lack of regular checks
	3	Swing arm stuck	Gear worn	Lack of lubrication	Lack of regular checking of lubricating oil	
	4	Screw Barrel is not center	Bearing worn	Lack of lubrication	Lack of checking lubricating oil regularly	
	5	Need long time for replacement machine part	Parts Spare part stock is often empty	Spare part usage is not recorded	Spare part stock control tool	Not yet made
	6	Dirty Machine	Ralery cleaned regularly	WI about 5R machine is not available	Not yet created	
Material	1	Lumpy material	Material contaminated with water, dust, dirt	Raw material room dirty	Rarely 5R	No WI
Method	1	Long set up process	Work is not sequentia	Work equipment is not completed	Damaged or borrowed by other colleagues	Work equipment is not recorded properly

Source : Authors

- Man : Lack of knowledge causes the ability to overcome production problems to be not optimal. In addition, high production targets require operators to operate more than one machine, causing operators to be tired at work.
- Machine : machine conditions that often experience breakdowns due to engine damage or part failures such as mold overheating, swing arm stuck, screw barrels are not in the center resulting in machine downtime so that production time is reduced. engine breakdown caused by lack of periodic checks. In addition, the unavailability of spare parts stock results in the process of replacing spare parts when there is damage or during preventive maintenance to be long.
- Material : Poor material quality because the material is lumpy. clumping material is caused because it is contaminated with water, dust and dirt, it is caused by the dirty dirty material storage room because 5R is rarely done.
- the set up process takes a long time due to incomplete work equipment, this happens because there is no good data collection on the work equipment used.

After analyzing the causes of reduced speed using RCFA, the next step is to find the risk priority number using FMEA tools. After knowing the RPN of each failure mode, the highest RPN will be selected to be the priority for improvement.

Table.8 RPN calculation results with FMEA

Failure Mode	*Factor*	*Cause of failure*	*Effect of Failure*	S	O	D	RPN
Reduced Speed Loss	Man	Operator lacks of Knowledge	Problem solving ability in the field is not optimal	6	5	7	210
	Man	Human Error	Wrong machine parameter setting	7	6	7	294
	Machine	The machine often has a breakdown	Machine stops production so output is reduced	8	6	8	384
	Machine	Mold Overheating	The product sticks to the cavity	8	7	8	448
	Machine	Swing arm stuck	The autoclose mechanism does not work so the product cannot be pushed out	6	5	6	180
	Machine	Screw Barrel is not center	Plasticizing is not perfect So that the raw material is rough	8	5	6	240
	Machine	Need long time for replacement machine part	Machine stops operating	7	5	5	175
	Machine	Dirty machine	Decreased production quality	7	5	7	245
	Material	Lumpy Material	The platicizing process takes a long time	6	5	5	150
	Methode	Proses set up lama	Reduced production time	8	7	6	336

Source : data processing

Based on the calculation of the RPN in table 8 above, it is known that the cause of the highest failure is in the machine factor, namely mold overheating with RPN 448. Therefore, the mold overheating problem will be a priority for improvement. The tools used by the author to recommend improvements are 5W+1H .

Table.9 Proposed Improvements to Overcome Mold Overheating

Cusative Factor	*Root of Problem*	*What*	*Where*	*When*	*Why*	*Who*	*How*
Machine		Doing routine checks on the condition of the hose, chiller compressor air pressure, nepple condition	On JSW J450 AD injection injection molding machine	At the beginning of every shift	So that the chiller circulation can be maximized so that the mold temperature is stable	production operator	Make an examination form/sheet

Source : Authors

V. CONCLUSION AND SUGGESTION

➢ Conclusion

Based on the results of the discussion, data collection and processing that has been carried out by the author, the following conclusions can be drawn:

1. The average amount of Overall Equipment Effectiveness (OEE) achievement for the JSW J450AD injection molding machine during the period January 2020 to June 2020 is 72.35%. This value is still below the OEE standard from JIPM (Japan Institute of Plant Maintenance) namely 85% so that the performance of the machine is not optimal.
2. Based on the analysis of Pareto diagram calculations, it is known that the dominant factor affecting the low OEE of the JSW J450AD injection molding machine is the reduced speed loss of 14%. These losses cause the engine speed to decrease from the standard, thereby reducing the OEE.
3. The results of the OEE measurement show that the results are below the standard so it can be concluded that the JSW J450AD injection molding machine needs improvement. as for the proposed improvement to increase the effectiveness of the JSW J450AD injection machine is to make a form / sheet for checking the condition of the hose, chiller compressor air pressure, nepple condition.

➢ Suggestion

1. It is hoped that further research can examine OEE on the I-57 injection molding machine so that the effectiveness of the machine increases.
2. Make sure the operator and maintenance are always consistent in checking the condition of the machine according to the company SOP so that the machine's reliability is maintained.

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