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Modifications Mold Design Based on Evaluation Results Calculation of OEE in Cikarang Plastic Packaging Industrial Company

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Abstract:- Plastic packaging industry in Indonesia is growing as the technology develops. The growing plastic packaging industry demands increased competitiveness of firms to survive global competition. One of the processes that can be used to make plastic packaging is the process of Injection Molding. Mold is an important element in the manufacture of products in the plastic packaging industry using Injection Molding process. Mold that has good performance will be able to produce good products in a long time so it will benefit the smoothness of the production process. To prevent mold failure, OEE (Overall Equipment Effectiveness) measurement is performed as an implementation of TPM (Total Productive Maintenance). OEE measures the mold of 3 metrics: Availability, Performance & Quality. Measurements were made in the period January - March 2018 where after OEE measurements obtained results to analyze the effectiveness of the mold. The result shows that there is a decrease of Performance Rate in February caused by low Cavity Efficiency. Low Cavity Efficiency is due to defect in mold. To eliminate the defect is done modification of the mold design. After the modification of the mold design, the Performance Rate in March experienced an increase that impacted the increase of OEE Mold in March. Given the precise analysis with OEE methods, accurate results are obtained to measure the performance of the mold and the correct method of improvement to improve performance.

Keyword:- *TPM, OEE, mold, Availability Rate, Performance Rate, Quality Rate.*

I. INTRODUCTION

Plastic packaging industry is an industry that process raw materials in the form of plastic seeds through the molding process by using mold so that the finished goods in the form of plastic packaging. Plastic packaging industry in Indonesia itself continues to grow in line with rapid technological developments. The market value of the packaging industry in Indonesia reached 6.7 billion USD in 2016 and reached 7.1 billion USD in 2017. The plastic packaging industry is predicted to continue to grow due to the growing food technology. One of the ways to produce plastic packaging products is by Injection Molding process. Injection Molding is a process of making plastic mold by injection process of plastic molten into mold and then given certain pressure at certain temperature until molten plastic to form product according to mold shape. In the process of making plastic packaging using Injection Molding process requires 3 important elements, namely: (1) Injection Machine, (2) Plastic Injection Materials, (3) Mold Injection Molding.

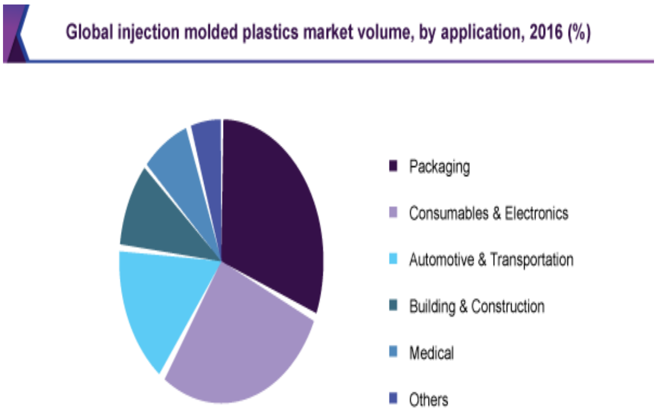

Fig 1:- Pasar produk Injection Molding berdasarkan aplikasi produk

Based on Grand View Research, in 2016 globally there is a volume segmentation of products generated through the Injection Molding process and obtained the result that plastic packaging products control most of the market globally compared to other products.

FGH Company is an Indonesian company engaged in plastic packaging manufacturing industry. The market segment of plastic packaging made by FGH company is lube oil packaging, cosmetic packaging, food & beverage packaging, agrochemical packaging and chemical packaging. The types of products produced by FGH company are: bottle, cap, tube, jerrycan, and pallet.

Increasing competitiveness among Indonesian companies engaged in the plastic packaging industry makes FGH companies must have a strategy to stay ahead and dominate the market. One of the ways to do is FGH company must always be able to meet customer demand so that customers do not move to other suppliers. Mentioned before that mold is an important component in the process of making plastic packaging, then the mold used must always be in top condition and reliable. Reliability means that an opportunity of the system to perform as specified.

Reliability is a major requirement for a machine tool system to work properly, and the production process can run in accordance with the plan.

As a plastic packaging company that has a wide market, FGH company has many customers, where one of the customers is CSN company. Based on data in the period of January-March 2018, CSN company is a customer who controls about 20.4% of the overall product made by FGH company.

	Sales of CSN Product from January-March 2018			
	January	February	March	Average
CSN Product Quantity (pcs)	10454155	10218569	8923983	9865569
Overall Product in 1 month	52413208	45738145	47090627	48413993
CSN Product Percentage	19.9%	22.3%	19%	20.4%

Table 1. CSN Product Percentage from January- March 2018

One of the CSN products is the CAPSCWCBL200ml product, where the CAPSCWCBL200ml product is a CSN product manufactured at the FGH company using the injection molding process. The CAPSCWCBL200ml product is a long run CSN product in the FGH company.

OEE measurements were performed to determine the performance of the CAPSCWCBL200ml mold as an evaluation material from the mold department. The OEE measurements were conducted in the period from January to March 2018. The purpose of this study is as the initial implementation of Total Productive Maintenance (TPM) and determine the best solution to improve the productivity of CAPSCWCBL200ml mold.

II. LITERATUR REVIEW

Total Preventive Maintenance (TPM) identifies the seven types of waste (Muda), and then works systematically to eliminate them by making improvements, primarily through the incremental approach of Kaizen. TPM also has eight pillars of activity, each being set to achieve a “zero” target. These pillars are.

1. Focused improvement (Kobetsu-Kaizen): It is aimed at eliminating waste.
2. Autonomous maintenance (Jishu-Hozen): In autonomous maintenance, the operator is the key player. This involves daily maintenance activities carried out by the operators themselves that prevent the deterioration of the equipment.
3. Planned maintenance: for achieving zero breakdowns.
4. Education and training: for achieving zero breakdowns.
5. Early equipment/product managemen: to reduce waste occurring during the implementation of a new machine or the production of a new product.
6. Quality maintenance (Hinshitsu-Hozen): This is actually “maintenance for quality.” It includes the most effective quality tool of TPM: *Poka-yoke* (which means mistake proofing or error proofing), which aims to achieve zero loss by taking necessary measures to prevent loss, due to human intervention in design or manufacturing or even both.
7. Safety, hygiene, and environment: for achieving zero work-related accidents and for protecting the environment.
8. Office TPM: for involvement of all parties in TPM because office processes can be improved in a similar manner as well.

In the final analysis, TPM is “Success Measurement.” This means that it is a set of performance metrics that is considered to fit well in the overall equipment effectiveness (OEE) methodology for improvement (Stamatis D.H., 2010).

OEE the gap between the actual performance and the potential performance of a manufacturing unit. OEE is effective tool to benchmark, analyze, quantifying, monitoring and improve the effectiveness of any manufacturing processes. It helps drive improvement through a better understanding of losses and also provides an objective way to set improvement targets and track progress towards reaching those targets. OEE is broken down into three measuring metrics of Availability, Performance and Quality i.e., performance metric compiled from data on Machine Availability, Performance Efficiency and Rate of Quality that is collected either manually or automatically (Sowmya K. and Chetan N., 2016).

According toVijaya kumar et al. (2014) research about improvement of overall equipment effectiveness (OEE) in injection moulding process industry. For a good manufacturing plant, the most recommended thing is quality, efficiency and operating cost. These parameters depend on the function of the equipments used in the industry. Nowadays a remarkable improvement has taken place in the maintenance management of the physical assets and productive systems to reduce the wastage of energy and resources. Because of this, the organization should introduce a maintenance system to improve and increase both the quality and productivity continuously. It is essential for a company to improve the production rate and quality of the products. In order to achieve this, the Overall Equipment Effectiveness was improved with low machine breakdown, less idling and minor stops time, less quality defects, reduced accident in plants, increased the productivity rate, optimized process parameters, worker involvement, improved profits through cost saving method, increased customer satisfaction and increasing sales.

Sowmya K. and Chetan N., (2016) reports a review on effective utilization of resources using overall equipment effectiveness by reducing six big losses. OEE is broken down into three measuring metrics such as Availability, Performance, and Quality; these help gauge the plant’s efficiency by categorizing the key losses that affects the manufacturing process. In this review, it is seen that total productive maintenance methodology is implemented to achieve OEE nearing to world class standards. It is seen that downtime losses are not the only influencing parameter but ideal run rate of a machine is another factor that adds to the variation in OEE. It is evident from one of the examples that OEE percentage can be improved substantially by implementing Total Productive Maintenance tools such as 5S, Jishu Hozen, Kaizen etc in a manufacturing firm. While calculating OEE, the factors influencing it are identified and performance improvement measures are undertaken and through this, OEE percentage can be improved. This concept can be applied to manufacturing industries, plastic industry, petrochemical processes and pharmaceutical industry.

Ayane N. and Gudadhe M. (2015) report the importance and benefits of calculating the overall effectiveness of the equipment to achieve total productive maintenance for construction equipment. According to this paper, the success of any construction company relies on the production of operations with the effective use of men, materials and machinery. As a result, the use of effective construction equipment is a major factor in distinguishing construction companies as heavy or low construction companies. To maintain the effectiveness of this construction equipment, OEE for this equipment needs to be calculated. 6 major failures are identified based on availability, performance and quality and minimize damage losses, improve performance and quality.

III. METHODOLOGY

Data processing is done to solve the problem under study. The steps performed in the processing of data, including:

A. The calculation of the value of availability rate

Availability rate calculations based on data from the operating time and the time of loading. This calculation determines the extent of the machine's willingness to operate or the utilization of the equipment.

The AR calculation is performed by the following equation.

$$AR = \frac{Available\ Time - Downtime}{Available\ Time}\ x\ 100\%$$

Description.

- Available Time obtained from the number of production hours available in 1 period
- Downtime is the hour when mold does not produce a product
- Operating Time is the time when mold produces products

B. The calculation of the value of performance rate

Performance rate calculation based on available time, output produced, total cavities in mold,and ideal cycle time. This calculation determines the effectiveness of the production activities

The PR calculations are performed using the following equation:

$$Target\ Production\ Quantities = \frac{Available\ Time x\ Total\ Cavities}{Cycle\ Time}$$

$$PR = \frac{Output}{Target\ Production\ Quantities}\ x\ 100\%$$

Description

- Output is the amount produced in a period
- Cycle time is the time needed in the first cycle of the product
- Total cavities represent the number of products produced in one cycle
- Target Production quantities represent the number of products that must be produced according to any available time

C. The calculation of the value of quality rate

The rate of quality calculation is based on the number of inputs and the number of defects. This calculation determines the effectiveness of production based on the quality of the product produced.

Rate Calculation of Quality (QR) is performed by the following equation.

$$Rate\ of\ Quality\ (QR) = \frac{Output - Defect}{Output}\ x\ 100\%$$

Description

- Defect represent the number of defective products produced within 1 (one) period
- Finish good is the number of products that meet the specified quality

D. OEE calculations

OEE calculation is a multiplication of the three calculations above. Serves to know the amount of productivity that makes it easy in searching for errors to be done an improvement

OEE Factors	OEE World Class
AR %	90
PR %	95
QR%	99
OEE %	85

Table 2. World Class OEE Percentage

This research was conducted by direct observation to determine the condition of mold design and calculation of OEE. In addition to direct observation, literature studies are also conducted to support the OEE calculation process, ranging from factors that must be considered in OEE calculation, calculation of machine availability value, performance rate ratio and quality rate ratio of mold.

IV. RESULT AND DISCUSSION

After the initial calculation, the OEE mold calculation table shows the formula for determining Availability (Table 3), Performance Rate (Table 4), and determining the value of Quality Rate (Table 5) and OEE calculation (Table 6)

Availability Rate				
Period	Available Time (s)	Downtime (s)	Operating Time (s)	AR (%)
January	1486800	338400	1148400	77.2%
February	1490400	300960	1189440	79.8%
March	1173600	101232	1072368	91.4%

Table 3. Availability Rate Calculation

Performance Rate					
Period	Output (pcs)	Cycle Time (s)	Total Cavities (pcs)	Target Production Quantities (pcs)	PR (%)
January	959264	18	16	1321600	72.6%
February	866714	18	16	1324800	65.4%
March	977620	18	16	1043200	93.7%

Table 4. Performance Rate Calculation

Quality Rate				
Period	Output (pcs)	Defect (pcs)	Finish Good (pcs)	QR (%)
January	959264	29753	929511	96.9%
February	866714	9017	857697	99.0%
March	977620	13073	964547	98.7%

Table 5. Quality Rate Calculation

Period	AR(%)	PR (%)	QR (%)	OEE (%)
January	77.2%	72.6%	96.9%	54.3%
February	79.8%	65.4%	99.0%	51.7%
March	91.4%	93.7%	98.7%	84.5%

Table 6. OEE Calculation

Based on the OEE calculation results, we found that OEE in February decreased by 51.7% and is still a distant number of World Class OEE of 85%. Through table 6, it can be seen that the factors that cause OEE in the month of February low is the low Performance Rate.

The next step is to analyze the cause of low Performance Rate by using Cause & Effect Diagram / Fishbone Diagram analysis. By using Fishbone Diagram analysis, the factors that cause low Performance Rate of 5 factors are Man, Machine, Material, Method, and Environment.

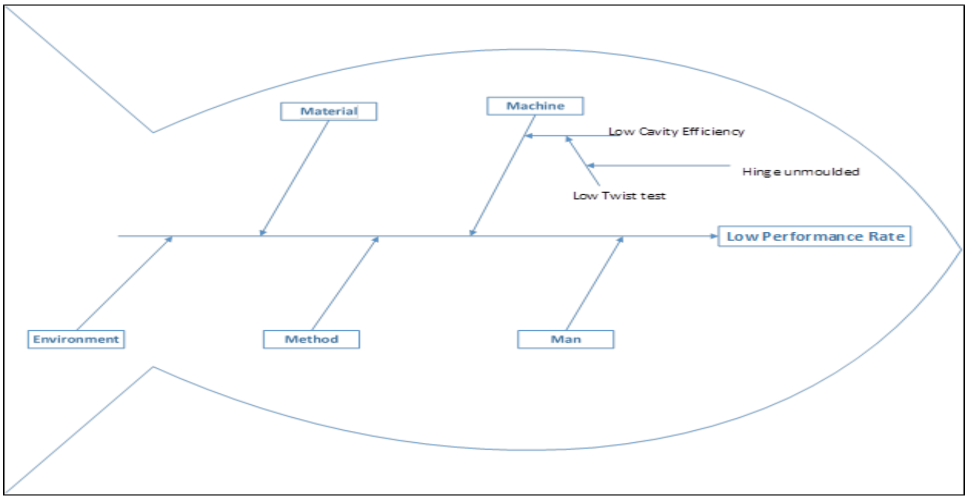

Fig 2:- Fishbone Diagram

Based on the fishbone diagram, it was found that the cause of the low Performance Rate was caused by the Low Cavity Efficiency Machine. Cavity Efficiency is a measure of how effectively the number of products produced in 1 cycle. For example, if a mold with 16 cavities will be able to produce 16 products in 1 cycle, if the resulting 16 cavities, means the Cavity Efficiency of the mold is 100%.

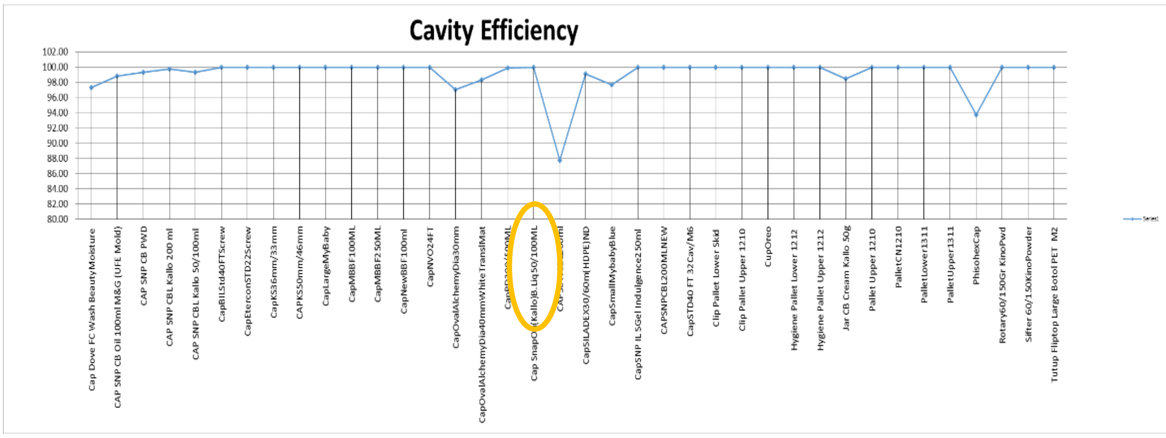

Fig 3:- Calculation of Cavity Efficiency

Based on the calculation of cavity efficiency, the results obtained that CAPSCWCBL200ml mold has the lowest number compared to other molds, namely the number 87.71%. Mold CAPSCWCBL200ml has 16 cavities, or it can be calculated that the average of 16 cavities is owned, only 14 cavities produce the product. Reduced efficiency of cavities used due to 2 cavities remaining blocked due to resulting product defect so as to reduce defects caused, 2 cavities are blocked and resulted in decreased eficiency cavities.

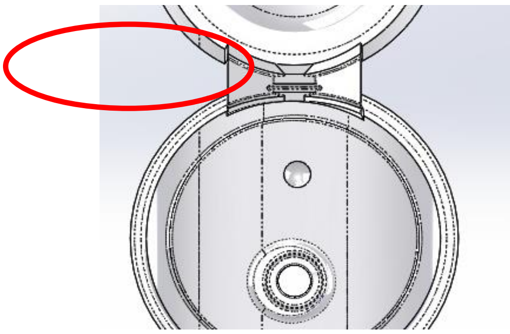

Fig 4:- Hinge area that modified

Based on the results of analysis and data collection, 2 cavities are blocked because when testing the twist test, the resulting product does not meet the standard twist test that should be. Twist test is a test of product resistance to torsional load. The torque should be checked to determine the flip top cap resistance. A low test twist resulting from the hinge portion of the product has a low thickness. The low cross section of the hinge area results in a low twist test.

CAVITIES	Twist Test (min 1.50 kgf)
1.1	2.18
1.2	1.92
1.3	1.76
1.4	2.02
1.5	2.16
1.6	1.83
1.7	1.5
1.8	-
1.9	1.88
1.10	1.85
1.11	1.89
1.12	-
1.13	1.91
1.14	1.86
1.15	2.02
Average	1.91
Min	1.5
Max	2.18

cavities	thickness left hinge (mm)	thickness right hinge (mm)
1.1	0.27	0.3
1.2	0.26	0.29
1.3	0.26	0.29
1.4	0.29	0.29
1.5	0.27	0.28
1.6	0.31	0.31
1.7	0.26	0.29
1.8	-	-
1.9	0.3	0.31
1.1	0.28	0.31
1.11	0.3	0.3
1.12	-	-
1.13	0.3	0.3
1.14	0.28	0.28
1.15	0.27	0.29
1.16	0.28	0.29
AVERAGE	0.28	0.3

Table 7. Measurement of Twist Test and Hinge Thickness before modification

Based on the analysis in Table 7, it was found that modifications were required in the hinge area for CAPSCWCBL200ml mold with the aim of reinforcing the hinge area to produce a higher twist test. The modification process is done by using EDM (Electrical Discharge Machine) process in hinge area as thick as 0.08 mm. EDM process is done in FGH company and done in Mold Department. The purpose of the EDM process is to form a new hinge contour that has an effect on adding hinge thickness to the product.

cavities	thickness left hinge (mm)	thickness right hinge (mm)
1.1	0.31	0.38
1.2	0.28	0.36
1.3	0.28	0.32
1.4	0.32	0.34
1.5	0.32	0.35
1.6	0.32	0.35
1.7	0.27	0.34
1.8	0.28	0.3
1.9	0.32	0.36
1.10	0.3	0.31
1.11	0.32	0.32
1.12	0.32	0.32
1.13	0.32	0.36
1.14	0.35	0.29
1.15	0.34	0.31
1.16	0.34	0.32
AVERAGE	0.31	0.33

CAVITIES	Twist Test (min 1.50 kgf)
1.1	2.63
1.2	2.43
1.3	2.45
1.4	2.68
1.5	2.47
1.6	2.34
1.7	2.43
1.8	2.55
1.9	2.84
1.10	2.34
1.11	2.63
1.12	2.53
1.13	2.35
1.14	2.47
1.15	2.61
1.16	2.57
Average	2.52
Min	2.34
Max	2.84

Table 8. Measurement of Twist Test and Hinge Thickness after modification

Based on table 8, we can see that modifications can improve the twist test of the product. In addition it can be seen as in table 6, where in March there was an increase in OEE and Performance Rate after modification.

V. RESULT AND DISCUSSION

Based on the research conducted, it can be concluded as follows:

1. The results of machine effectiveness measurement using OEE method on CAPSCWCBL200ml mold in January - March 2018 period were 54.3% in January, 51.7% in February and 84.5% in March.

2. Decrease in OEE in February due to low Perfomance Rate of 65.4%

3. Decrease in OEE in February due to low Cavity Efficiency in the number 87.71% resulting from the defect in the form of a low twist test on the mold resulting in cavities must be blocked.

4. Modified the mold design resulting in increased performance rate at 93.7% and increased OEE at 84.5% in March.

By OEE measurement using the appropriate method, can be analyzed the cause of the problem specifically and can be determined appropriate improvement process so as to improve the reliability of the mold. Mold that has good reliability will give good performance and produce good product so that will give satisfaction to customer.

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