Implementation of Preventive Maintenance in Production Machine with Age Replacement Model in PT XYZ

Taswir Syahfoeddin[a*], Indra Yusuf R[b]

[a,b]Politeknik STMI, Central Jakarta, 10510, Indonesia

Abstract

Reduce the amount of damage time injection molding machine during production, required preventive maintenance maintenance system with age replacement model. The result of data processing and analysis of critical injection molding machine problem is Toshiba 220 Ton with damage time 2,195 minutes during July to December 2016. Toshiba 220 Ton injection molding machine obtained four spare parts which are damaged is screw, oil seal, and nozzle and hydraulic, where the nozzle has a high frequency of damage. The replacement time according to the age replacement model for spare-part nozzle is 52 hours (3 working days) and inspection time four times a month. Increased reliability spare-part nozzle, equal to 0.4244 or 42.44% from the previous 0.35 to 0.50.

Keyword: Preventive Maintenance, Age Replacement, Injection Molding

1. Introduction

Injection molding machine has an important role for the production process, because the injection molding machine of raw materials is processed into finished product that has added value. Continuous use of machines used can be dead or damaged. Dead or damaged engine problems related to maintenance and replacement of machine spare parts.

2. Method

2.1. Maintenance

Maintenance is an activity to maintain or maintain plant facilities and equipment, and make any necessary repairs, adjustments or replacements to obtain a satisfactory condition of production operation, as planned. In addition, according to Stephens maintenance is all the activities necessary to keep the system and all components work properly [1]. According to Corder maintenance is a combination of various actions taken to keep an item in, or to fix it until, an acceptable condition [2]. With the maintenance activities are expected all facilities and machines owned by the company can be operated in accordance with the plan. Treatment has a very decisive role in the production activities of a company concerning the smoothness or congestion of production.

2.2. Purpose of Maintenance

1. The ability to produce can meet the needs in accordance with the production plan.
2. Maintain quality at the right level to meet what is needed by the product accordingly and uninterrupted production activities.
3. To help reduce unnecessary usage and deviations and keep the capital invested in the company for the specified time in accordance with the company's policy on the investment.
4. To achieve the lowest level of maintenance costs possible, by carrying out maintenance activities effectively and efficiently.
5. Avoid maintenance activities that may endanger the safety of workers.
6. Conduct a close cooperation with other major functions of a company; in order to achieve the main objectives of the company is the level of profit or return of investment as possible and the lowest total cost.

2.3. Preventive Maintenance

Preventive Maintenance is generally done based on data damage in the past. Implementation of preventive maintenance on a regular basis so unexpected events that can disrupt the smoothness of the production process can be minimized. This preventive maintenance activity is very important because its utility is very effective in facing the production facilities which belongs to the 'Critical Unit' group. If preventive maintenance is implemented on the critical component then the maintenance task can be done with intensive planning for the unit concerned, so that the production plan can be achieved with the production of larger in a relatively shorter time.

** Corresponding author*

In practice according to Assauri preventive maintenance conducted by a factory company can be distinguished on [2]:

1. Routine maintenance is a routine maintenance and maintenance activities performed on a daily basis. For example, routine maintenance activities are cleaning of facilities or equipment, lubrication or checking the oil, as well as checking the contents of the fuel and possibly warming up the machines for a few minutes before being operated throughout the day.
2. Periodic maintenance is the maintenance and maintenance activities performed periodically or within a certain period. Periodic maintenance is done by using the length of working hours of the machine or production facility as a schedule of activities, such as one hundred hours of machine work once and so on. So, the nature of the maintenance is fixed periodically or periodically

2.4. Reliability

Reliability is the probability that a component or system can operate according to the desired function for a given time when used under predetermined operating conditions. The reliability value is between 0 - 1, where the value 0 means reliability is very low and the component cannot be used. While the value 1 indicates high reliability. In order to determine reliability in operational relation, a more specific definition is needed, i.e. a description of non-confusing and observable failures, identification of time units, and observed systems must be in normal environmental and operating conditions.

2.5. Downtime

According Nakajima (1998) downtime is divided into two namely, based on equipment failure and setup and adjustment. Equipment failure with examples such as damage and setup adjustment with examples such as mold replacement on injection molding machines. Downtime is the time when a unit can no longer perform its function as expected. This may occur when a unit experiences problems such as engine damage which may interfere with the performance of the engine as a whole including the quality of the resulting product or its production speed so as to require a certain time to restore the function of the unit to its original condition (Ebeling, 1997).

2.6. Damage Curve

This section describes the curve showing the pattern of instantaneous rate of damage that is common to a product known as the curve of the tub (curve) because of its shape. The system that has a function of this rate of damage at the beginning of the cycle of its use decreases the rate of damage (premature damage), followed by the rate of near-constant damage (wear life), then increases in damage rate (over the life). Curve shape can be seen in the following figure:

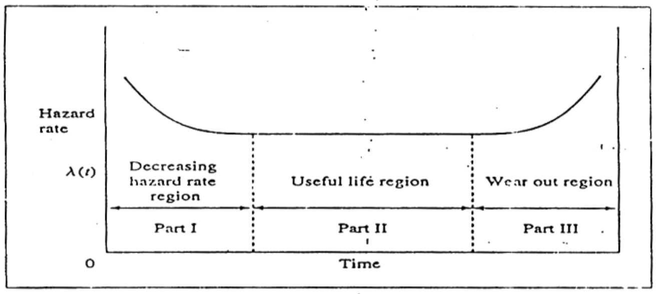

Fig 1. Bath Tub Curves
(Source: Ebeling, 1997)

Each time period has certain characteristics determined by each rate of damage that is:

1. Early Failure or Early Damage

   This area is often referred to as the Burn-in period. In this period the rate of deterioration decreases with time. Damage occurring at this time may be caused by several causes according to (Dhillon and Reiche, 1985):

   a. Unqualified quality control.
   b. Substandard material and labor performance.
   c. Errors arising during assembly.
   d. Human errors such as installation and set up.
   e. Packing error and material handling methods.

If there is damage, then replaced with a new product, then reliability will increase again. Damage to this phase can be satisfied with Weibull distribution.

2. Chance Failure or Useful Region or Normal Operation

This time period is marked by a constant rate of damage. This matterindicates that the instantaneous rate of damage will not increase with increasing component life, and the probability of damage to the component at any time is the same. Consequently, in an area of unexpected damage usually caused by sudden loading of magnitude beyond the capability of components or other extreme conditions. Some of the reasons causing damage to this phase according to Dhillon and Reiche (1985) are:

a. Unexplained damage causes.
b. Human error and natural damage.
c. Damage is inevitable, even with the most effective practical treatment measures though.

3. Wear Out Failure or Wear Out Period

This time period is marked by a sharply increasing rate of damage, due to deteriorating equipment conditions. This increase indicates the end of useful life of the product will begin to be in line with the worsening condition of the product. When a device has entered this phase, preventive maintenance should be taken to reduce the occurrence of more fatal damage. Some of the reasons causing damage to this phase according to Dhillon and Reiche (1985) are:

a. Inadequate care.
b. Fatigue due to wear caused by usage.
c. Fatigue due to age.
d. Overhaul error.
e. The occurrence of corrosion.
f. The design of life is short.

2.7. Determination of Optimal Prevention Replacement Time Interval With Machine Downtime Minimization

Preventative replacement is done to avoid cessation of the machine due to component malfunction. To perform this treatment action, it is necessary to know the time interval between the optimal replacement (tp) actions of a component so as to achieve maximum minimization of downtime.

1. Block Replacement

In this model, the replacement action is performed at a fixed time interval. So this model aims to determine the optimal preventive replacement time interval (tp) between replacement prevention to minimize downtime per unit of time. This model allows for replacement within the adjacent time period, where newly installed components after replacement damage must be replaced again at the time of arrival of preventive replacement times. The block replacement model can be seen in the following figure

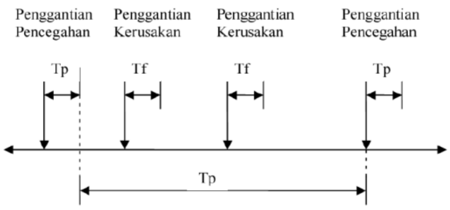

Fig 2. Block Replacement Model
(Source: Jardine, 1995) [4]

2. Age Replacement

In this model, the precautionary action is taken when the operation has reached the specified age, i.e. at tp, if in time interval tp no damage occurs. If the system is damaged before tp, then the replacement is done as a corrective action. The calculated life expectancy of tp starts from the beginning again with reference to the start of operation of the system again after the corrective maintenance measures are performed. The age replacement model more details can be seen in the following figure:

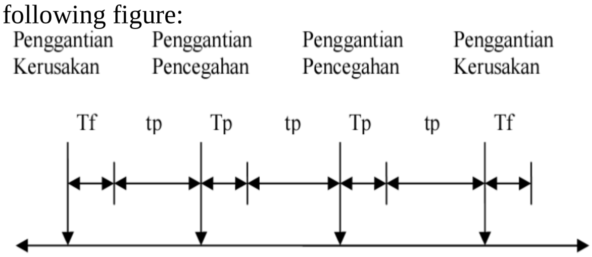

Fig 3. Model Age Replacement
(Source: Jardine, 1995) [4]

3. Result and Discussion

After conducting the data collection process, the next step is to perform data processing based on data that has been collected with the appropriate data processing methods.

3.1. Determination of Injection Molding Machine is Frequently Damaged

In this research will be discussed about the damage data on the injection molding machine, because the machine is a machine that serves as a converter from raw materials into products. Damage to injection molding machine can be seen in the following table

Teble 1. Damage Injection molding machine

No.	Machine	Total Damage (Minutes)	% Damage	% Cumulative Damage
1	Hattian 350 Ton	1.095	19,31	19,31
2	Toshiba 220 Ton	2.195	38,71	58,02
3	Futashin 100 Ton	1.175	20,72	100
4	JSW 100 Ton	1.205	21,25	79,28
Total		**5.670**	**100,00**	

Determination of critical machine is done based on the amount of total damage. Based on the largest total damage, injection molding machine Toshiba 220 Ton as the machine that experienced the highest damage of 38.7% during the period July to December 2016. Toshiba injection molding machine 220 tons will be done next data processing.

Selection of Frequent Spare Parts

The following is spare part damage on Toshiba 220 Ton injection molding machine. There are four spare parts that have been damaged in the period July to December 2016. Each of the damage spare parts on Toshiba 220 Tons injection molding machine can be seen in the following table:

Table 2. Damage of Spare Parts Injection Molding Machine

No.	Name Spare part	Frequency Damage	Total Damage (Minute)	% Damage	% Cumulative Damage
1	*Screw*	1	225	10,25	40,77
2	*Oil Seal*	9	670	30,52	30,52
3	*Nozzle*	25	1.170	53,30	94,07
4	*Hydraulic*	1	130	5,92	100
Total		**36**	**2.195**	**100,00**	

Selection of critical spare parts is done by making Pareto diagrams. From this Pareto diagram, it will show the most frequent spare part damage from July to December 2016. Pareto diagram for damage to spare parts injection molding machine Toshiba 220 tons can be seen in the following figure.

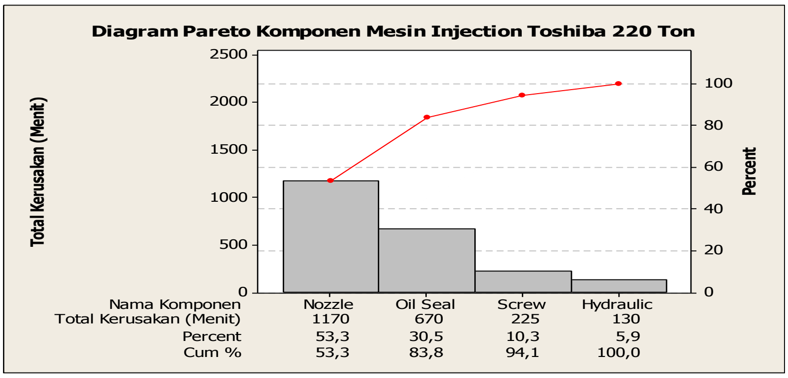

Fig 4. Pareto Diagram Damage Spare Parts Injection Molding Machine

Based on the Pareto diagram, it can be seen that the most dominant spare part damage that occurred on Toshiba 220 tons injection molding machine for six months from July to December 2016 was spare part nozzle (53.5%) and spare part oil seal (30.5%) then for both spare parts are selected for further calculation. On screw and hydraulic spare parts are not continued on the next calculation because the frequency of occurrence for each spare part only once.

Preventive Maintenance for Spare part Nozzle

At this stage will be done calculations that begin with the determination of critical spare part. Calculations are based on data collected during July to December 2016.

In the nozzle spare part, the time to fix the damage that varies with the longest time is 4 hours and the fastest is 0.167 hours, while the interval distance between the greatest damage is 215 hours, while the smallest is 12.83 hours. From the calculation it can be explained that at time t = 55 there is a replacement then R (t-nT) or prevention value will be close to 1 and the value of n will increase for each replacement and on average damage 74.27 reliability of 0.3482 or 34, 82% at the time without prevention and after the prevention of reliability obtained by 0.496 or 49.6%. From these results obtained that an increase in reliability of 42.44%

3.2. Critical Injection Molding Machine Analysis

Determination of critical injection molding machine based on the biggest downtime (damage) time during July-December 2016. In Pareto diagram injection molding machine Toshiba 220 tons has the largest percentage of 38.71% with a time of damage of 2295 minutes, then for Toshiba 220 tons.

Critical Spare-part Analysis on Injection Molding Machine

Damage to the injection molding machine Toshiba 220 tons consists of four spare parts, namely screw, oil seal, nozzle, and hydraulic. Determination of critical spare-part on Toshiba 220 ton injection molding machine is done by using Pareto diagram. Selection of critical spare parts is based on the time of damage and percentage. The selected spare-part is a nozzle with a break time of 1.170 minutes (53.3%).

3.3. Time to Failure (TTF) and Time to Repair (TTR)

Damage and repair data from July to December 2016. Injection molding machines are used in one day for sixteen hours and five days a week. The longest breakdown time for the nozzle spare-part is for 215 hours and the fastest damage time is 12.83 hours. At the time of the use of injection molding machine for spare-part nozzle there is the longest improvement that occurred on October 10, 2016 with a repair time of 240 minutes or 4 hours. Repairs lasted long due to unavailability of spare-part in the event of damage so that repair is waiting for the availability of spare-part nozzle. The fastest improvement for 10 minutes or 0.167 hours, the cause of the damage is the clogging of nozzles by objects that do not melt during heating

3.4. Analysis of Replacement Calculations With Age Replacement

The calculation of time interval of prevention turnover is done to find out how long the time interval of critical spare part is needed until the spare part must be replaced again. It aims to minimize the downtime (damage) that occur. The calculation of time interval for prevention is done using the age replacement model, where this model takes into account the optimal life of a spare-part. In the TTF data the distribution for each spare-part is lognormal and normal. Based on the main characteristics of spare-part damage if it is in lognormal distribution and normal then it will enter in IFR characteristic (Increasing Failure Rate). On these characteristics spare-parts need to be held preventive replacement. Spare-part Nozzle replacement time interval for 52 hours.

3.5. Analysis of Interval Inspection Calculation

The calculation of time interval checking aims to anticipate the occurrence of spare-part damage suddenly, so if found spare-part condition that is not good immediately can be done replacement to prevent things that are not desirable. This inspection process is part of the treatment action, because through this inspection process, the spare-part can operate optimally because the condition is checked periodically. Based on the calculation results obtained that spare-part nozzle examination conducted four checks each month. Examination is done based on several provisions that exist, among others, the amount of damage that occurred, the average time of repair and the length of time for each inspection activity set by the company.

3.6. Reliability Analysis (Reliability) With Preventive Maintenance And Without Preventive Maintenance

Reliability (reliability) is the probability of a spare-part or system to be able to operate in accordance with the desired function for a given period of time when used under prescribed conditions. (Ebeling, 1997). In addition to the increased availability rate, it is expected also with the Preventive Maintenance then the reliability level (reliability) of engine spare-parts can increase, the reliability level will be better when close to 1, which means the spare-part can operate optimally under the conditions set. The process of calculating this reliability differs based on the distribution that accompanies the machine's failure time data. Increased reliability spare-part can be seen in the following table:

Table 3. Reliability Table Before and After Preventive Maintenance during MTTF

Spare-part Critical	Reliability Before Preventive Maintenance (R (t))	Reliability After Preventive Maintenance (Rm (t))	Increase (%)
Nozzle	0,34822	0,49600	42,44%

R (t) is spare-part reliability before preventive maintenance is performed, while Rm (t) shows spare-part reliability after preventive maintenance. Based on the Reliability Table Before and After Preventive Maintenance At MTTF, it can be seen that after the preventive maintenance, when the spare-part enters MTBF, the reliability level tends to increase for all critical spare parts, this is because the spare parts have the damage characteristic with increasing rate (IFR). Can be seen that the level of reliability increased by 42.44% for nozzle when applied preventive maintenance by applying a good maintenance schedule the company will get some other advantages that the level of reliability of critical spare-part will increase, and extend the life of the spare-part.

4. Conclusion

Can be drawn his conclusions

1. The critical injection molding machine is the Toshiba 220 Ton injection molding machine with a break time of 2,195 minutes during the period July to December 2016, and four spare parts were damaged: spare-part oil seal, nozzle, screw and hydraulic. Based on the frequency of spare-part damage is a nozzle that has a large damage frequency.
2. The replacement time according to age replacement model for spare-part nozzle is 52 hours (3 working days) and inspection time for spare-part nozzle is four times in a month.
3. Increased reliability occurs in the nozzle spare-part, which is equal to 0.4244 or 42.44% from the previous reliability of 0.34822 to 0.496.

Acknowledgements

Thanks to all those involved in this writing, from research in the company, during the writing to be included in the seminar and the publication of this paper. Deficiency is a separate task for us. Thank you.

References

[1] Stephens, Matthew P., 2004, *Productivity and Reliability-Based MaintenanceManagement*, New Jersey: Pearson Education.
[2] Corder, Anthony, 1992, Teknik Manajemen Pemeliharaan, Jakarta: Erlangga Ebeling, Charles E., 1997, *Reliability and Maintanability Engineering*, Singapura: McGraw Hill, 1997.
[3] Assauri, Sofjan, 2008, Manajemen Produksi dan Operasi, Lembaga Penerbit Fakultas Ekonomi Universitas Indonesia.
[4] Jardine, AKS., 1995, *Maintenance, Replacement & Reliability*, Canada: Pittman Publishing Corporator.
[5] Nasution. M. N, 2001, Manajemen Mutu Terpadu, Ghalia Indonesia, Jakarta.