Scheduling Preventive Maintenance on Auto Rooting Machine at Toys Manufacturer Company

Anastasia Lidya Maukar [1*], Ineu Widaningsih Sosodoro2 [2], Rhiza Adiprabowo3 [3]

[1*,2,3)] Faculty of Engineering, Industrial Engineering Department, President University,

Jl. Ki Hajar Dewantara

Kota Jababeka,Cikarang, Bekasi - Indonesia 17550

email : almaukar@president.ac.id, inesosodoro@yahoo.co.id, rhizadiprabowo203@yahoo.com[]

Abstrak

Maintenance cost becomes one of the problems that manufacturing company is facing nowadays due to lack of maintenance system. The main objective of this research is to reduce the maintenance cost on auto rooting machine in toy manufacturer by developing a scheduled preventive maintenance. Data of machine breakdowns and costs related to maintenance, components, and the interval time of failure for each machine were collected. To develop a preventive maintenance system, the interval of component replacement must be determined. The minimum cost model is attained by finding the right interval time. The result of this research shows that by implementing proposed maintenance schedule the machine reliability has 45% increase and maintenance cost decreases by 48%.

Abstrak

Tingginya biaya pearwatan mesin merupakan salah satu masalah yang dihadapi oleh suatu perusahaan. Hal ini dapat disebabkan oleh sistem perawatan mesin yang kurang terencana dengan baik, Oleh karena itu dilakukan penelitian yang bertujuan untuk menurukan biaya perawatan mesin *auto rooting* pada perusahaan pembuat boneka dengan mengusulkan suatu penjadwalan pearwatan pencegahan. Langkah awal dari penelitian ini adalah dengan mengunpulkan data kerusakan mesin, jenis kerusakan, biaya perawatan, macam-macam komponen, dan waktu antar kerusakan. Dari hasil pengolahan data, didapatkan suatu usulan jadwal perawatan mesin yang dapat meningkatkan keandalan mesin sebesar 45% dan penurunan biaya perawatan sebesar 50%.

Kata Kunci: perawatan mesin,jenis kerusakan, waktu antar kerusakan, biaya perawatan, keandalan

1 Introduction

PT X Indonesia, one of the leading toy manufacturer, is a subsidiary of the worlds largest toy manufacturer, located at El Segundo, California. This company produces variety of toys. One of the companys vision is to be a globally competitive manufacturer or premier toy brands. Thus, the company must deliver the high quality products to meet the customers satisfaction.

The research was conducted in one of the machines in full auto rooting area. Full auto rooting machine is used for rooting the yarn becomes the hair doll. Based on historical data, auto rooting machine downtime achieved around 50.42 hours or 1.43% from working hours during July 2013 until December 2013. The production loss due to machine breakdown was around IDR 12,000,000.

The machine broke down due to broken components. The failure makes costs increase and one of them is maintenance cost. Currently, no preplan schedule, the machine is only maintained for break fix. Thus, if the machine does not have any failures, the mechanic will not maintain at all. It leads to unpredictability of the mechanic availability. The downtime create pro-

*Korespondensi Penulis

duction loss and profit loss. This type of process is called a corrective maintenance. Based on that condition, it is important for the company to develop preventive machine maintenance schedule.

In manufacturing company, maintenance is as important as the other functions such as production activity. As the equipment and machine are employed for production process for a certain period of time, in order to keep them work well, it is needed to perform a regular maintenance. However, maintenance is related to the cost of maintenance. If it is conducted too often, it will lead to the cost increase (Mulyono et al, 2009).

According to Dhillon (2002), maintenance is a function that must be performed under normal or stress environment in order to restore the equipment back to its operational state. Maintenance that is not performed regularly or periodically can give a bad impact into machine or equipment, leads to broken machine or equipment, which will obstruct the production process or even stop the production process. As result, profit will go down due to incapability to fulfill customer demand.

There are two most general kind of maintenance in industry, corrective and preventive one. Corrective maintenance is carried out after a failure exist on the equipment or facility where it cannot function properly (Dhillon, 2002). Preventive maintenance is one of the system that commonly used by production team and mechanic to avoid machine breakdown. By having a good preventive maintenance system, it can be ascertained that the machines and equipment are in a good condition during the production process. Then, a good machine and equipment will help the workers in doing their job and also produce good quality items. On the other hand, having a good machine and maintenance also can reduce the production cost.

Considering the condition that appear in PT X Indonesia, preventive maintenance becomes really important to be implemented. By having a scheduled preventive maintenance, it can reduce the breakdown while machine is working. Some methods have been used to support the step to develop a preventive maintenance scheduled such as reliability machine, failure distribution, minimum cost that can be achieved, and etc.

2 Methodology

Data of occurrence numbers of machine and machine downtime were collected from auto rooting from July to December 2013. The components of machine failure were identified to determine the critical components using Pareto chart. The critical components were observed later in this research.

Distribution of failure is a basic information about lifetime of the equipment in a population. It has many varieties in the shape. Thus, the next step is to calculate time to failure (TTF) for each critical component. To identify an appropriate distribution of TTF for each critical component, fitting statistical data distribution will be conducted.

By determining expected time to failure, mean time to failure can be estimated. Mean Time To Failure (MTTF) is one of basic measurement of reliability for non-repairable systems (Stanley, 2011). It is the mean time expected until the first failure of a piece of equipment. MTTF is a statistical value and is meant to be the mean over a long period of time and a large number of units. The MTTF is needed for each component because the three critical components are simply thrown away and replaced, if they fail (Chisa et al, 2015). For preventive maintenance, the replacement will be conducted before the expected failure. The minimum cost model of preventive maintenance was attained by finding the right interval time.

It is also desirable to distinguish the performance of curremt system and after the introduction of preventive maintenance. The first step is to develop a schedule for preventive maintenance system. The, comparison between two systems are performed by calculating the maintenance cost.

3 Result and Discussion

Data of occurrences of machine component breakdowns were collected as shown in Table 1. From this table, it was known that top frequency of critical component causing machine failures were needle, cutter and looper.

The interval time to failure data are presented as Table 2. Interval time to failure (TTF) data are obtained from the machine re-operates again after having a maintenance until the machine has the next failure in the same component.

The statistics distribution of TTF and parameter each component is shown as Table 3. Each components TTF has follows several distribu-

Tabel 1: *The Occurrences of machine component breakdowns*

Component	*Freq*	*Cum Freq*	*Cum (%)*
Needle	32	32	40%
Cutter	21	53	65%
Looper	14	67	83%
Bearing	6	73	90%
Timing Belt	2	75	93%
Needle Shaft	2	77	95%
Looper Shaft	2	79	98%
Yarn Censor	1	80	99%
Clamper	1	81	100%

Tabel 2: Time to failure data

Needle					
No	TTF	No	TTF	No	TTF
1	112.25	12	87.25	23	123.25
2	113.16	13	97.5	24	134.5
3	154	14	107.5	25	107.25
4	66.16	15	66.41	26	123.16
5	113.91	16	86.25	27	96.58
6	72.06	17	59.75	28	121.25
7	126.75	18	122.25	29	192.5
8	173.25	19	125	30	96.5
9	97.5	20	167.25	31	92
10	108.7	21	90.5		
11	86.25	22	99.5		
Cutter					
No	TTF	No	TTF	No	TTF
1	162.17	8	158.08	15	197.5
2	172.58	9	173	16	169
3	160	10	172.75	17	159.91
4	155.03	11	152.16	18	172.32
5	188.83	12	151.25	19	157.5
6	159.75	13	176	20	195
7	149.5	14	184.33		
Looper					
No	TTF	No	TTF	No	TTF
1	202.17	5	309.5	9	236.75
2	394.83	6	296.75	10	265.25
3	163.5	7	178.25	11	265.75
4	267.08	8	266	12	211.16
				13	250.16

tions, such as log normal, normal and exponential. A normal distribution is chosen for all of failure times of the components. Normal distribution is chosen because it is the common distribution and also has a simple calculation. In addition, Normal distribution is really suitable to be used in modeling fatigue and wear out phenomenon. The parameters are mean (μ) and standard deviation (σ)

4 Maintenance Cost Analysis

Preventive maintenance involves a basic trade-off between the costs of performing maintenance activities and the savings achieved by reducing the overall rate of occurrence of machine failures (Savsar, 2013). The total preventive (Cp) and corrective (Cf)maintenance cost are computed using following Eq.1 and Eq.2 respectively.

$$Cp = component\ price + (replacement\ time\ (hours)\ x\ salary\ of\ mechanic\ per\ hours) + (production\ rate\ (units/hour)\ x\ replacement\ time\ (hours)\ x\ loss\ production\ per\ doll\ head) \tag{1}$$

$$Cf = price + (downtime\ (hours)\ x\ salary\ of\ mechanic\ per\ hours) + (production\ rate\ (units/hour)\ x\ downtime\ (hours)\ x\ loss\ of\ production\ perdollhead) \tag{2}$$

Then, calculation of component replacement interval will be performed. Replacement model that will be used at an interval of time (t) which also consider the probability of the components will have a failure in that interval time of (t) (Ebeling, 1997). Then, the total expected cost of interval [0,t] is the cost of conducting preventive maintenance and failure replacement cost. The probability density function f(t) and cumulative density function F(t) of normal distribution are found using mathematical Eq.3 and Eq.4 respectively,

$$f(t) = \frac{1}{\sigma\sqrt{2\pi}} exp\left[-\frac{1}{2}\frac{(t-\mu)^2}{\sigma^2}\right] \tag{3}$$

$$F(t) = \phi\left(\frac{(t-\mu)}{\sigma}\right) \tag{4}$$

By knowing F(t), the reliability function R(t) is found using Eq.5 and the cumulative hazard function H(t) can be computed using Eq. 6.

$$R(t) = 1 - F(t) \tag{5}$$

$$H(t) = \int_0^t \lambda(t) = \int_0^t \frac{f(t)}{R(t)} dt \tag{6}$$

Tabel 3: *Time to failure distribution and MTTF*

Component	Distribution	Parameter	MTTF (hours)
Needle	Normal	μ =110.327	110.327
		σ = 30.4	
Cutter	Normal	μ =168.33	168.33
		σ = 14	
Looper	Normal	μ =254.396	254.396
		σ = 58.2	

Tabel 4: *Total preventive and corrective maintenance cost*

Component	C_p (IDR)	C_f (IDR)
Needle	54,761.54	218,340.10
Cuuter	80,884.62	151,794.50
Looper	66,761.54	175,282.40

Using H(t), the Cost per unit of time is found as follows:

$$C(t) = \frac{C_p + (C_f \times H(t))}{t} \quad (7)$$

The detail calculation of cost per unit time for needle components is shown in Table 5.

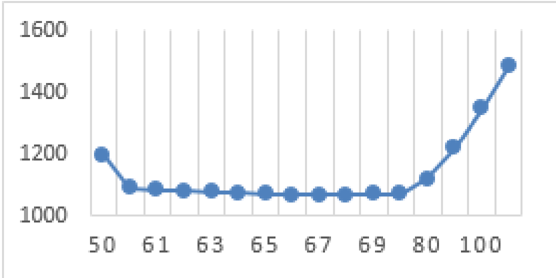
Tabel 5: *Calculation of replacement interval time of needle component*

t (hours)	f(t)	F(t)	R(t)	H(t)	C(t)
50	0.00183193	0.02360336	0.977	0.023	1195.66724
60	0.00333357	0.04891222	0.951	0.049	1091.00343
61	0.00351824	0.05233761	0.948	0.052	1083.85616
62	0.00370912	0.05595078	0.944	0.056	1080.46107
63	0.00390613	0.05975789	0.940	0.060	1077.17376
64	0.00410915	0.06376504	0.936	0.064	1073.98918
65	0.00431805	0.06797816	0.932	0.068	1070.90259
66	0.00453266	0.07240305	0.928	0.072	1067.90953
67	0.00475280	0.07704533	0.923	0.077	1068.26462
68	0.00497823	0.08191041	0.918	0.082	1068.60927
69	0.00520872	0.08700348	0.913	0.087	1068.94393
70	0.00544399	0.09232945	0.908	0.092	1069.26902
80	0.00797868	0.15923700	0.841	0.159	1118.47027
90	0.01049424	0.25185896	0.748	0.252	1219.81394
100	0.01238734	0.36703974	0.633	0.367	1348.92371
110	0.01312234	0.49570883	0.504	0.496	1482.34773

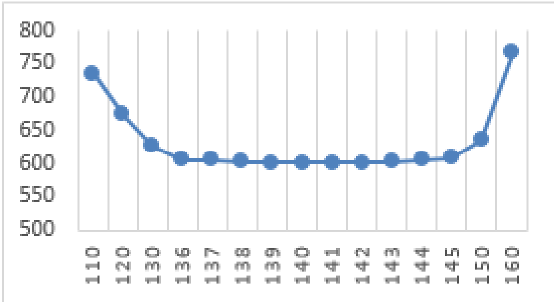
From the calculation of C(t) above, the lowest price will be achieved at time of 66 hours. In 66 hours, needle component costs the IDR 1,067.91 per doll head. Using same calculation, the lowest C(t) for other components are gained. Relation between interval replacement time and the cost per unit of time (C(t)) for each component is shown in Figure 1,2, and 3.

Table 6 shows a summary maintenance interval of each component including the cost per unit of time.

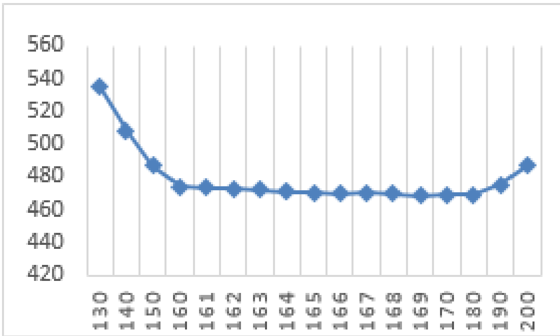
After getting preventive maintenance interval, the comparison between initial maintenance (corrective) and proposed preventive mainte-



Gambar 1: Cost per unit for needle component



Gambar 2: Cost per unit for cutter component



Gambar 3: Cost per unit for looper component

Tabel 6: *Summary of C(t) calculation*

Component	Needle	Cutter	Looper
Maintenance Interval (hours)	66	141	169
C(t), IDR	1067.91	600.57	468.48
R(t),%	92.7	97.45	92.88

nance systems are performed. Total maintenance cost can be reduced by 48% on average. Hereby the summary table of maintenance cost per year (assumed 300 working days).

Tabel 7: *Comparison of total yearly maintenance cost*

Component	Current	Proposed	Saving (%)
Needle	14,187,000	5,969,008	57.93
Cutter	6,376,375	4,125,115	35.31
Looper	4,568,889	2,299,985	49.66
	25,132,264	12,394,108	48

5 Conclusion

The objective of this research is to reduce maintenance cost by providing a preventive maintenance schedule. The preventive maintenance schedule is designing for replacing the three critical components causing the auto rooting machine failures.

The three critical components are needle, cutter, and looper which contributes 90% from all of downtime. The calculation of appropriate replacement of each component is performed. Using the interval time, a preventive maintenance has been proposed and reduction of maintenance cost can be achieved. The total reduction is from IDR 25,132,256 to IDR 12,394,108 per year or by 48%.

For the further research, it is suggested to develop the algorithm for integrating the production schedule and preventive maintenance schedule.

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