GROUP REPLACEMENT MODEL FOR SCHEDULING OF TOOLS REPLACEMENT CONSIDERING QUALITY COST, PREVENTIVE AND FAILURE REPLACEMENT COST

Dadang Arifin[1], Rinto Yusriski[2], Dwi Putri Ramasari[3]

[1, 2]Lecture, Jenderal Achmad Yani University, Bandung Indonesia,
[3]Alumnus of Jenderal Achmad Yani University, Bandung Indonesia
dadangarifin@yahoo.co.id

ABSTRACT

This study aims to determine the replacement schedule of chisels (tools) that exist on a machine. Generally in the computerize numerical control machine installed several different types of cutting tool. If the chisel is replaced in long time, it will affect the low quality of the products, meanwhile when the chisel replaced often will increase replacement cost and the losses due to interruption of the machine frequently. In general, replacement models have been developed only consider the replacement cost of preventive and corrective replacement costs. At the phenomena occurring in the replacement chisel there are three costs to be considered in determining the replacement schedule that is a quality costs, preventive replacement costs and corrective replacement costs. Based on the model that's developed by Jardin, in this research will develop the model considering the three of costs. The company where this study was conducted in Majalengka manufacturing company, PT. WIKA Industry and Construction. The output of the study is in the form of an optimization model to determine the replacement schedule tools in combination (group replacement), and the optimal schedule for the replacement of existing tools in the enterprise.
Keywords: Group Replacement, Optimalization Model, and Maintenance Management.

1. INTRODUCTION

Production equipment as one of the factors that have a huge role in achieving the maximum performance of a company. A company will not be able to meet demand in a timely and appropriate number of partner companies if these factors are not reliable. Unreliability of the equipment will have a major impact on the profitability of the company and will lead to a huge waste for the company. Even the damage that occurs in a one of equipment will have an impact to another equipment so the amount of idle time will increase. High reliability of all equipment owned by the company will be an important part in achieving the maximum performance of the company. The efforts of the maintenance of the equipment owned by the company should be maximized as appropriate.

Some of research on maintenance have been carried out in previous studies. The concept of methodology adopted from of the concepts developed by Jardine, in the book Maintenance Replacement and Reliability. In this study the researcher will formulate a group replacement model for multiple different items by considering three types of costs, the cost of product quality, the cost of prevention replacement and the cost of failuer replacement. The problems that inspired this research is the replacement of tools (chisel) on a CNC machine. Of phenomena, the authors assumed that if the chisel is replaced exceeded the time limit, the performance of the machine will decrease. It will increase cost of quality, and costs of failure replacement. But on the other hand will decrease the cost of preventive replacement. The are a trade-off the cost. The problem is when the replacement should be done so the total cost is minimum.

2. THEORITICAL BACKGROUND

Group replacement of the same items are often cheaper and easier to do than in one by one. A simple example is a replacement of highway lights, lights on the roof of buildings, which is not very efficient to

replace the bulbs one by one. The model developed for this problem is based on the assumption that the policy of the group replacement is done at fixed intervals and failure replacement is done if needed. The result of the model is getting the optimum interval in the replacement group to minimize the total cost of the replacement cost of preventive and failure replacement cost per unit time (Jardine, p 98).

The model for individual replacement is

$$C(t_p) = \frac{C_p + C_f . H(t_p)}{t_p} \qquad (1)$$

Where:
C(tp) = total cost if the replacement is done in intervals tp.
Cp = the cost or preventive replacement
H(tp) = expected amount of damage that occur in the intervals (0, tp)
Cf = the cost of failure replacement
tp = interval of replacement

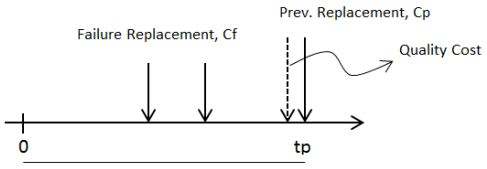
The group replacement model is

$$C(tp) = \frac{NCg + NH(tp).Cf}{tp} \qquad (2)$$

where:
C(tp) = total cost if the replacement is done in intervals tp.
N = the total number of similar items in the group
Cg = The cost of *replacing* one items under condition of group replacement
H(tp) = *expected* amount of damage that occur in the intervals (0, tp)
Cf = the *cost of failure replacement*
tp = *interval* of replacement

3. DEVELOPMENT MODELS

The model optimization for replacement chisel by considering the three of cost; cost of quality, preventive replacement cost, and the failure replacement cost can be formulated as ilustration belows.



Figur 1. Model illustration

So the total cost becomes:

Total Cost = Cost of quality + Preventive replacement cost + Failure replacement cost

The total cost can be illustrated as a trade-off from three of cost, in this figures

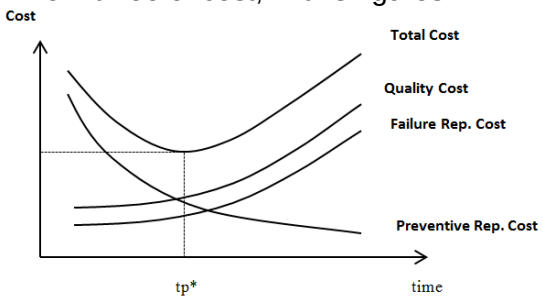


Figure 2. Trade-off cost model

3.1 Induvidual replacement models

When the replacement is done individually, by using replacement block replacement system can be formulated as follows.
Lets:
TC(tp) = total cost per unit time if a replacement was made during tp
f(tp) = function that describe the relationship between the number of failed product with replacement time tp.
Cq = cost of quality as a number of failed product per unit
H(tp) = expectation of amount of damage that occurs in the interval (0, tp)
Cp = cost of preventive replacement
Cf = cost of failure replacement
From figure 1 and 2, we can define the total cost as

$$C(t_p) = \frac{Total\ \ Cost\ \ in\ \ Interval\ \ (0, t_p)}{Length\ \ of\ \ cycle} \qquad (3)$$

From equetion 1 and 3, we can add the quality cost to the formula.

$$TC(t_p) = \frac{Cq.f(tp) + C_p + C_f . H(t_p)}{t_p} \qquad (4)$$

3.2 Group replacement models

Suppose that the *i th* component will have a replacement at the time tp, where i = 1, 2,... N. So the total cost is the accumulation of costs arised by all components, so the optimization model can be formulated as follows:

$$TC(tp) = \frac{\sum_{i=1}^{N} Cq_i . f(tp)_i + \sum_{i=1}^{N} Cg_i + \sum_{i=1}^{N} H_i(tp).Cf_i}{tp} \quad (5)$$

4. RESULT AND DISCUSSION (Implementation of the models)

Implementation of the model is done in PT. WIKA West Java by Ms. Dwi Putri Ramasari. On the machines are installed six type of chisel (tools), that is drill type, tap, chamfer, borring, facing, and reamer with an average ages respectively 77, 62, 130, 83, 112, and 85 hours. Replacement cost and the probability distribution of all six chisel follow Weibull distribution with two parameters.

Table 1. Weibull parameters and the cost of replacement

Subjects	α	B	Cp	Cf
Reamer	84,33	59,92	Rp. 930.959	Rp. 1.625.829
Facing	89,67	63,55	Rp. 865.959	Rp. 1.560.829
Tap	63,06	59,93	Rp. 1.060.959	Rp. 1.755.829
Drill	77,86	62,99	Rp. 1.030.959	Rp. 1.725.829
Borring	83,47	68,97	Rp 960.959	Rp 1.655.829
Chamfer	110,32	96,24	Rp 1.600.959	Rp 2.295.829

4.1 Determination Replacement Schedule One item (reamer);

Determination chisel replacement schedule is computed using the Block Replacement by combining the cost of quality are:

$$C(t_p) = \frac{Cq(a + b(tp)) + C_p + C_f . H(t_p)}{t_p}$$

where:

- *a* and b are the intercept of regression coefficient between the number of defects that occur with changing time *tp,* if they have linear relations between the number of defects produced at the time of replacement.
- *H (tp)* is the expected amount of failure in interval [0, t]. Calculation of *H(tp)* will use the approach developed by WeibullROCOP (Prabhakar Murthy, p.27), $H(t_p) = \left(\frac{t}{\alpha}\right)^{\beta}$

The research has done by Dwi Putri Ramasari (2014), for Reamer type obtained as follow *a* = 2,82 and *b* = 0,026, and Cq = Rp. 71445 per unit.

$$C(t_p) = \frac{Cq(a + b(tp)) + C_p + C_f . H(t_p)}{t_p}$$

$$C(81) = \frac{71445(2,28 + 0,026(81)) + 930959 + 1625829x0,009537}{81}$$

$$C(81) = 15125$$

Tabel 2. Total cost for some tp

Tp	Cq	Cp	Cf.H(tp)	C(tp)
79	275.778	930.959	3.271	15.317
80	277.207	930.959	7.158	15.192
81	*278.636*	*930.959*	*15.505*	*15.125*
82	280.064	930.959	33.256	15.174
83	281.493	930.959	70.647	15.459

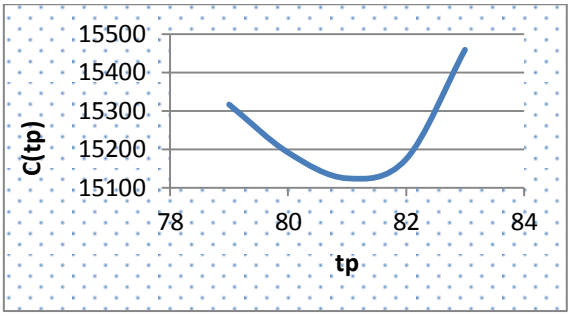


Figure 3. Optimum curve for 'reamer' chisel

The optimumal interval of replacement is 81 hours, which result minimum cost Rp.15125 per unit time.

4.2 Group replacement (six chisels)

$$TC(tp) = \frac{\sum_{i=1}^{N} Cq_i . f(tp)_i + \sum_{i=1}^{N} Cg_i + \sum_{i=1}^{N} H_i(tp).Cf_i}{tp}$$

Tabel 3. Total Cost for some tp

tp	TC(tp)
57	138957,2
58	136839,6
59	135019,1
60	133854,2
61	134272,8
62	138629,4
63	152799,2

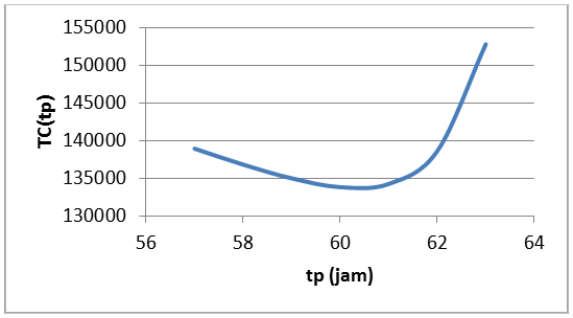


Figure 4. Group replacement

5. CONCLUSIONS

The test results of the six distributions chisel has a Weibull distribution, this gives informations that there is a phenomenon that failure rate a lot of equipements have Weibull distribution.

The change interval which gives the minimum total cost is 81 will resulting cost Rp. 15.125 per unit time.

The replacement interval that gives the minimum total cost for group replacement shorter than the average lifetime of a component, it can give you the sense that quality and failure replacement cost will impact to the total cost. Meanwhile the preventive replacement cost will have big impact to the total cost when it's cost is hight.

6. REFERENCES

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AUTHOR BIOGRAPHIES

Dadang Arifin is a lecture in Department of Industrial Engineering, Faculty of Engieering, Jenderal Achmad Yani University. He received from Bandung Institute of Technology (ITB) in 2000. His research interest are in the are of Operasion Research, Statistical Quality Control, and Maintenance Engineering. He is as secretary of Industrial Engineering Department, Jenderal Achmad Yani University. His email adress is dadangarifin@yahoo.co.id, or arifinddg@gmail.com