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IMPLEMENTATION OF MAINTENANCE COST AND DOWNTIME MODEL FOR UNIVERSITY HOSTEL FACILITY MAINTENANCE

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Abstract:

This paper is part of an on-going research on the development of intelligent optimal replacement model for Hostel facility maintenance in Malaysia where the case study is conducted at Kolej Universiti Islam Melaka (KUIM). The model is developed to analyse the total cost and downtime for various values of the uncertain parameter by using Artificial Intelligence (AI) method, namely, Ant Colony Optimization (ACO), noting the effect of this variation on the optimal solution. The decision areas addressed is based on the replacement action. The study is aimed to assist maintenance engineers in deciding an appropriate replacement policy. This is usually useful to plot the total cost and downtime per unit time curve. The advantage of the curve is that, along with giving the optimal value, it shows the total cost and downtime around the optimum. If the curve is fairly flat around the optimum, it is not really very important that the maintenance engineers should plan for the replacements exactly at the optimum. However, if the curve rapidly decreased, then the maintenance decision should be made to find the optimal solutions. The result shows that the weeks to decide a replacement is during the semester break, which is suitable because students are not in the hostel.

Keywords: Hostel facilities maintenance, intelligent optimal replacement model.

1 Introduction

General, replacements will cost money in terms of component and a balance is required between the money spent for replacements and savings obtained to reduce the operating cost [1] and [2]. Thus, this study aimed to determine an optimal replacement policy that will minimize the sum of operating, replacement costs and downtime per unit time [3] and [4]. The goal of this research is to present a model that can be used to optimize component replacement decision.

Equipment has followed through preventive replacement of critical component within the system. Thus, it is necessary to be able to identify which component should be considered for preventive replacement and which should be left to run until they fail. The primary goal addressed in this study is that to make a system more reliable through preventive replacement [3] and [4].

2. Optimal Preventive Replacement

An item, sometimes termed a line replaceable unit or part, is subject to sudden failure and when failure occurs, the item has to be replaced. Since failure is unexpected, it is not unreasonable to assume that failure replacement is more costly than a preventive replacement [5] and [11]. For example, a preventive replacement is planned and arrangements are made to perform it without unnecessary delays, or perhaps a failure may cause damage to other equipment. In order to reduce the number of failures, preventive replacement can be scheduled to occur at specified intervals. However, a balance is required between the amount spent on the preventive replacement and their resulting benefits that is reduced failure replacements [6]and [9].The conflicting cost and downtime are happening and their resolution is by identifying the total cost and downtime curve. The replacement policy is one where preventive replacement is performed at fixed intervals of time. Failure replacement is needed whenever necessary and the optimal interval between the preventive replacement is determined to minimize the total expected cost and downtime when replacing the equipment per unit time [5] and [8]-.

2.1 Cost Model

When dealing with optimization problems, in general, this study aimed to optimize some measure of performance over a long period. In many situations, this is equivalent to optimize the measure of performance per unit time [4]. This approach is easier to formulate mathematically when compared to develop a model in optimizing a measure of performance over a finite horizon [5]and [10]. The model construction is as follows.

Construction of the Model:

1. *c(t)* is the operating cost per unit time at time *t* after replacement

2. *C*, is the total cost of a replacement.

3. The replacement policy /to perform replacements at interval length.

4. The objective is to determine the optimal interval between replacements to minimize the total cost of operation and replacement per unit time by using ACO [7].

The total cost per unit *C (t)* for replacement at time *t,* is

C(t)= total cost in interval (0,t) length of interval

To use the equation $c(t_r) = C(t_r)$, it requires that the trend in operating costs is an increasing function, which in practice is a very reasonable assumption. Any costs, such as production losses incurred due to the duration of the replacement which needs to be incorporated into the cost of the replacement action. Otherwise, a numerical solution is required as in Equation (1):

$$C\left(t_r\right) = \frac{\int_0^{t_r} c\left(t\right) dt + C_r}{t_{r+T_r}} \qquad (1)$$

Models are developed whereby, for particular assumptions, the optimal interval between the replacements can be obtained. In practice, there may consider difficulty in scheduling replacements to occur at their optimum time, or in obtaining the values of some of the parameters required for the analysis [5]-[12].

2.2 Case Study – (Cost Model)

The hostel building maintenance data are gathered from ICYM in a certain period of time. By using Eq (1), in discrete form, Table I is obtained from which it is seen that the optimal replacement age is 10 months, and the associated cost per month is MYR 17.14.Table I also show the deteriorating trend from month 1 to 12 and increase again from 10 to 11 .The associated graph of cost per month versus time is provided in Fig. 1, which includes the calculation of the optimizing criterion $c(t) = C(f_r)$ when the trend in operating cost is discretized. Therefore, by replacing at the end of month 10, since next period's do operations and maintenance cost, c (t = 10), is higher than the average cost to date (MYR 17.19).

Table 1: Replacement Cost for Door

Month	1	2	3	4	5	6	7	8	9	**10**	11	12
MYR*	17.99	17.81	17.71	17.64	17.54	17.38	17.35	17.27	17.23	**17.19**	17.2	17.25

*MYR- Malaysia Ringgit

Cost Vs. Time Model

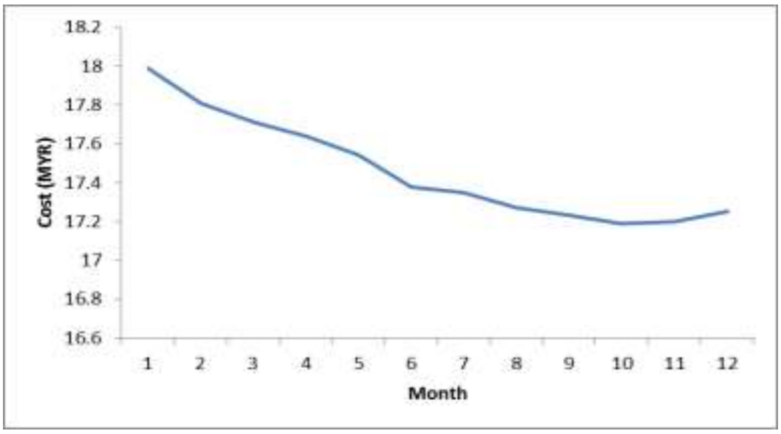

Figure 1: Replacement cost for door

2.3 Downtime Model

The purpose of downtime model is to minimize the total downtime per unit time. In some cases, due to difficulties in costing or the desire to get maximum throughput or utilization of equipment, the replacement policy required may be one that minimizes total downtime per unit time or, equivalently, maximizes availability. The problem is to determine the best times at which replacements should occur to minimize total downtime per unit time. The basic conflict are that as the preventive replacement frequency increase, there is an increase in downtime due to these replacement, but a consequence of this is a reduction of downtime due to failure replacements, and the aim is to get the best balance between them.

The model is developed to determine the optimal replacement interval between preventive replacements in order to minimize total downtime per unit time by using AG and ACO. The policy is illustrated in Figure 2.

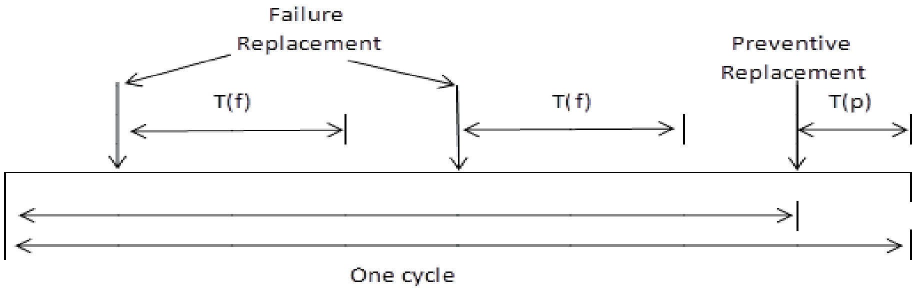

Figure 2: Downtime minimization: optimal interval.

The total downtime per unit time, for preventive replacement at time t_p, denoted as D(t_p) is in Equation (2)

$$D(t_p) = \frac{\text{Expected downtime due to failures + downtime due to preventive replacement}}{\text{Cycle length}} \quad (2)$$

Downtime due to failures = number of failures in the interval (0, t_p) × Time required to make a failure replacement = H(t_p) × T_f. Downtime due to preventive replacement = T_p. Therefore Equation (3) is

$$D(t_p) = \frac{H(t_p)T_f + T_p}{t_p + T_p} \quad (3)$$

This is a model of the problem relating replacement interval t_p to total downtime D(t_p).

2.4 Case Studies (Downtime Model)

The method applied to the downtime model, where the corresponding curve of *D(T)* in Table 2 for the preventive replacement and presented graphically in Figure 3. The remarks that can be concluded are that the assumption verified by the curve that the preventive replacement plotted above, the best time for the replacement of component hostel facility maintenance. It also shows that when the value increased, the curve will go nearer to perfect replacement from 6.7 hours of downtime, if the quality of preventive replacement downtime, means that the more downtime detected, the downtime will reduce due to fewer breakdowns occurred during operations. Details of the percentage of the expected downtime to fit the status quo point are also shown in Table 2 and Figure 3.

Table 2: Replacement Downtime for Door

Month	1	2	3	4	5	6	7	8	9	10	11	12
Downtime (Hour)	132.7	72.8	36.5	19.3	11.6	7.9	6.7	7.8	8.5	13.6	24	41.5

Downtime Vs. Time Model

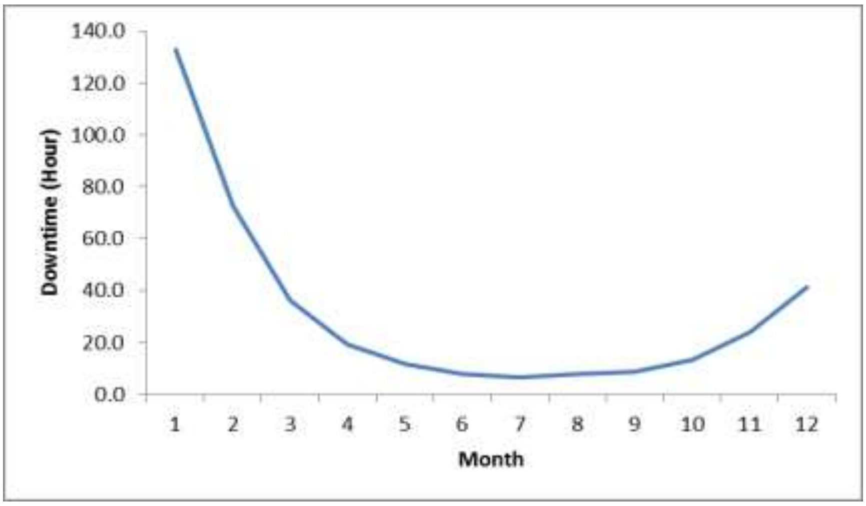

Figure 3: Replacement Downtime for Door

3. Conclusion

Intelligent optimal replacement model for hostel facility maintenance shows that the total cost and downtime curve is not fairly flat around the optimum and rising rapidly on both sides. This is then the optimal interval should be adhered to all possible circumstances. If there is uncertainty about the value of the particular parameter required in the analysis, then the evaluation of the total cost and downtime curve for various values of uncertain parameter could affect the optimal solution. In order to further assist maintenance engineers in deciding what appropriate replacement policy should be, it is useful to plot the total cost and downtime per unit time curve. The advantage of the curve is that, along with giving the optimal value of *t*, it shows the total cost downtime around the optimum value. If the curve is fairly flat around the optimum, it is not really very important that the maintenance engineers should plan for the replacements to achieve the optimum value, thus giving some leeway in scheduling the work. The goal is to develop a model that related to the inspection frequency to profitable cost. The way in which the model was developed such that to establish the optimal inspection frequency to minimize total cost. Then the same result would have been obtained. The most important point of this problem is that it is concerned with identifying the best level of preventive maintenance (in the inspections and replacement) when the failure rate of equipments is constant. When necessary the replacement duration can be incorporated into the replacement model, as is required when the goal is the minimization of total downtime or equivalent and the maximization of item availability. This research has presented a model with the hybrid of AI that can be used to establish the optimal time, which discard the decision if the goal is to identify the interval of preventive replacement policy. For future improvement, the model can be combined together of cost and downtime to get the more meaningful information. Moreover, the data mining technique can be embedded to increase its accuracy.

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