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Optimization of Downtime for Replcement Model of Hostel Facility Maintenance

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Abstract: This paper is part of an on-going research on the development of maintenance down time model for Higher Education Institution Hostel facility maintenance in Malaysia where the case study is conducted at International College Yayasan Melaka (ICYM). The model is developed to analyze the total downtime curve for various values of the uncertain parameter and noting the effect of this variation on the optimal solution. The decision areas addressed based on the replacement action that are assumed to be known with certainty. This is due to the item is not subject to failure but consider the operating cost and downtime with use. The study is aimed to assist engineers in deciding an appropriate replacement policy. This is usually useful to plot the total downtime per unit time curve. The advantage of the curve is that, along with giving the optimal value, it shows the total downtime around the optimum. If the curve is fairly flat around the optimum, it is not really very important that engineers should plan for the replacements exactly at the optimum. The model is proposed to guide and facilitate when dealing with optimization problems. If there is uncertainty about the value of the particular parameter required during the analysis, then the replacement cost downtime is unsure. Furthermore the evaluation of the total and downtime curve for various values of the uncertain parameter could in consequence affect the optimal solution

Key words: Hostel facility maintenance · Replacement Downtime model and Downtime Model

INTRODUCTION

Some equipment operates with excellent efficiency when it is new. But as it ages, the performance deteriorates. An example is the door components in International College Yayasan Melaka (ICYM).hostel facilities maintenance. When new, it is considered as the equipment is in good condition. However if there has a small crack, it will affect the quality of the equipment,. Is it economically justifiable-to repair or replace the lamp, thus reducing the operating cost downtime of the Hostel building? In 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[1-4]. Thus, this study aimed to determine an optimal replacement policy that will minimize the sum of operating and replacement downtime per unit time [5,6]. The goal of this research is to present model that can be used to optimize component replacement decision. The interest in this decision area is initiated by a common approach to improve the reliability of the system or the building [7, 8].

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 downtime preventive replacement and which should be left to run until they fail. If the component is selected for preventive replacement, then the subsequent question to be answered is-: What is the best time to perform maintenance? Bases the fact primary goal addressed in this study is that to make a system more reliable through preventive replacement [8, 9].

Replacement problem (and maintenance problem in general) can be classified as either deterministic or probabilistic (stochastic).Deterministic problem are those in which the timing and outcome of the replacement action are assumed to be know with certainty. For example we may have an item that is not subject to failure but whose operating cost increases with use [10,11]. To reduce this downtime cost, a replacement can be performed. After the replacement, the trend in operation cost downtime is decreased. This is a kind of example of component replacement problem that can be treated with a

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deterministic model. Probabilistic problem are those where the timing and outcome of the replacement action depend on chance. In the common situation the equipment may be described as being good or breakdown. The probability law describing changes from good to fail is described by the distribution of time where completion failure is a random variable whose distribution is termed as the equipment's failure distribution [12-14].

Optimal Replacement Time for Component: Some component/equipment operates with excellent efficiency when new as it ages the performance deteriorates. When on the increasing cost trend, is it economically justifiable to replace the equipment? In general, a balanced replacement cost downtime in term of material and wages- is required between the money spent on replacement and saving obtained by reducing the operating cost. Thus, to determine an optimal replacement policy is essential to minimize the sum of operating and replacement cost per unit time [13] and [14].

When dealing with optimization problem, in general, we wish to optimize some measure of performance over a long period. This is equivalent to optimizing the measure of performance per unit time. This approach is easier to deal with mathematically when compare to developing a model for optimizing a measure of performance over a finite horizon [11].

Usually the cost is conflicted and associated with optimization problem. It should be stressed that this class of problem can be termed as short term deterministic since the magnitude of the interval between replacements is weeks or month, rather than years. If the interval between replacements was measured in years, then the fact that money changes in value over time would need to be taken into account in the analysis. Such problem can be term as replacement.

Stochastic Preventive Replacement: Before proceed with the development of component replacement models, it is important to note that preventive replacement action is taken before equipment reaches a failed state. This requires two necessary conditions:

- The total downtime of the replacement must be greater after failure than before (if cost is the appropriate criterion, otherwise an appropriate criterion such as downtime is substituted in place of cost). This may be caused by a greater loss of production since replacement after failure is unplanned or failure of one piece of plant may cause damage to other equipment [12].
- The hazard rate of the equipment must be increasing. To the illustrate this point, consider an equipment with a constant hazard rate. The failures occur according to the negative exponential distribution or equivalent with the Weibull distribution, where the shape parameter â = 1.0. When this is the case, replacement before failure does not affect the probability that the equipment will fail in the next operation, given that it is good now. Consequently, money and time are wasted if preventive replacement is applied to equipment that fails according to the negative exponential distribution. Obviously, when equipment fails according to the hyper exponential distribution or the Weibull whose â value is less than 1.0, its hazard rate is decreasing and again component preventive replacement should not be applied. Examples of component where a decreasing hazard rate has been identified include quartz crystals, medium – and high quality resistors and capacitors and solid – state device such as semiconductors and integrated circuits.

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 [14]. 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 failure, 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 [14].The conflicting cost downtime consequences and their resolution by identifying the total cost and downtime curve. The replacement policy is one where preventive replacement occurs at fixed intervals of time. Failure replacement occurs whenever necessary and to determine the optimal interval between the preventive replacement to minimize the total expected cost downtime of replacing the equipment per unit time.

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.

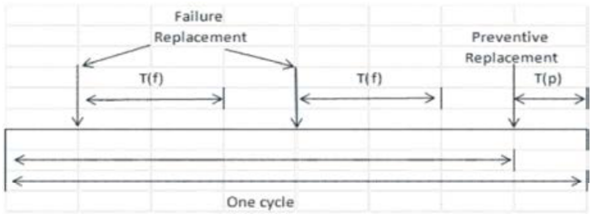

Fig. 1: Downtime minimization: optimal interval.

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 developing to determine the optimal replacement interval between preventive replacements in order to minimize total downtime per unit time. The policy is illustrated in Figure 1.

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

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

Downtime due to failures = number of failures in 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)

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

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

Case Study: The method applied from the downtime model, the corresponding curve of D(T) in table 1 for the preventive replacement and presented graphically in Figure 1. The remarks that can be concluded are that the assumption verified by the curve that the preventive replacement plotted above the best time to the replacement of component hostel facility maintenance. It also shows that when the 18 value increased the curve will go nearer to perfect replacement from 6.6 value 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 1 and Fig 2.

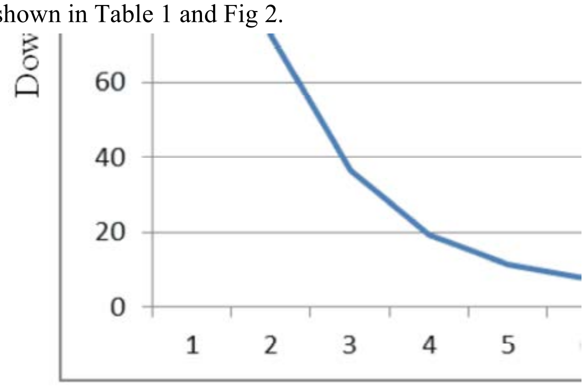

Fig. 2: Replacement Downtime for Window

Table 1: Replacement Downtime for Door

	To	Tp	lambda	f(t);if exponent	H(t); if exponent	
t	7	0.035	5.309	lambda*EXP(-lambda*t)	lambda*t	Downtime
1	25	0	5.309	0.026262939	5.309	132.725
2	34	3	5.309	0.000129919	10.618	72.8024
3	18	5	5.309	6.42694E-07	15.927	36.46075
4	14	12	5.309	3.17933E-09	21.236	19.3315
5	5	7	5.309	1.57277E-11	26.545	11.64375
6	3	7	5.309	7.7803E-14	31.854	7.889385
7	4	18	5.309	3.84881E-16	37.163	6.66608
8	11	60	5.309	1.90396E-18	42.472	7.752824
9	15	85	5.309	9.41864E-21	47.781	8.528883
10	31	120	5.309	4.65928E-23	53.09	13.583
11	40	90	5.309	2.30489E-25	58.399	24.01941
12	65	90	5.309	1.1402E-27	63.708	41.48059

CONCLUSION

The hostel facility maintenance model shows that the total cost downtime curve is not fairly flat around the optimum and rising rapidly on a 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 and, then the evaluation of the total cost downtime curve for various values of uncertain parameter, could affect the optimal solution. In order to further assist engineers in deciding what appropriate replacement policy should be, it is useful to plot the total cost 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 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 inspection frequency to profitable cost. The way in which the model was developed a such that to establish the optimal inspection frequency to minimize total cost, then the same result would have been obtained. The most important point from 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 equipment 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 that can be used to establish the optimal time based which discard decision if the goal is to identify the interval of preventive replacement policy for future improvement, the model can be hybrid that with Artificial Intelligence (AI) and data mining technique to increase its accuracy.

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