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Intelligent Model for Optimal Hostel Replacement Maintenance Based on the Cost and Downtime Value

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Abstract: Best time in which replacement of the maintenance Hostel action to implement the requirements that will be set to reduce the amount of downtime and the cost per unit of time. Failure data gathered during the selected period of time and if not sufficient, subjective questionnaires and bootstrapping methods used to support the information is incomplete. Maintenance frequency is identified by developing smart model based on the optimal replacement costs and downtime. The results showed that the intelligent modelmaintenance staff has extra features to support their decision making maintenance.

Key words: Replacement model · Intelligentmodel · Hostel maintenance

INTRODUCTION

According to studies, the Hostel Maintenance Management (HMM) lacks a modelling method to identify the frequency of maintenance in a given period of time. The most important point of this problem is that it is concerned with identifying the best level of preventive maintenance (in this case, inspection and replacement). Whenever necessary, the replacement duration can be incorporated into the replacement model, as is required when the goal is the minimisation of total downtime or equivalent and the maximisation of item availability. There is a need to have an optimal maintenance strategy such as replacement, repair and inspection. Before any optimal maintenance strategy can be implemented, failure distribution and the parameters of the hostel component need to be identified [1].The balance is required between the money spent on replacement and savings obtained by reducing the operating cost. The problem is to determine the best times at which replacements should occur to minimize total downtime and cost per unit time for hostels in Malaysia.

The HMM model seldom uses AI in identifying the frequency of maintenance. The AI technique can be incorporated into the replacement model, as is required when they try to minimise the total downtime or equivalent and to maximum item availability. There is a need to have an intelligent maintenance strategy such as replacement, repair and inspection. By enriching the model with AI, it is believed the accuracy of the result can be improved.The aim of this research is to propose an intelligent optimal replacement model. The model will aim to find the optimal replacement frequency by referring to cost and downtime values [2].

Methodology: In order to identify the constraint and limitations of the clear boundaries of this research, the scope of this research need to be determined. To develop and apply an HMM, a detailed research design is needed. The research design framework for this research is adapted from previous studies [3-4]as shown in Figure (1).

Design Optimal Replacement Model: The cost of an inspection and repair keep on increasing. This methodology demonstrates the concept for the use of minimizing downtime and costs, setting maintenance intervals to achieve the optimum. The methodology also demonstrates the use of analysis for a potential catastrophe resulting from failure of a piece of equipment or a component. The model also takes into account whether the damage from such a failure is reversible and if so, at what cost. Information is gathered from historical data as well as expert judgement. Parameters are established from this information in order to develop the models [4-5].

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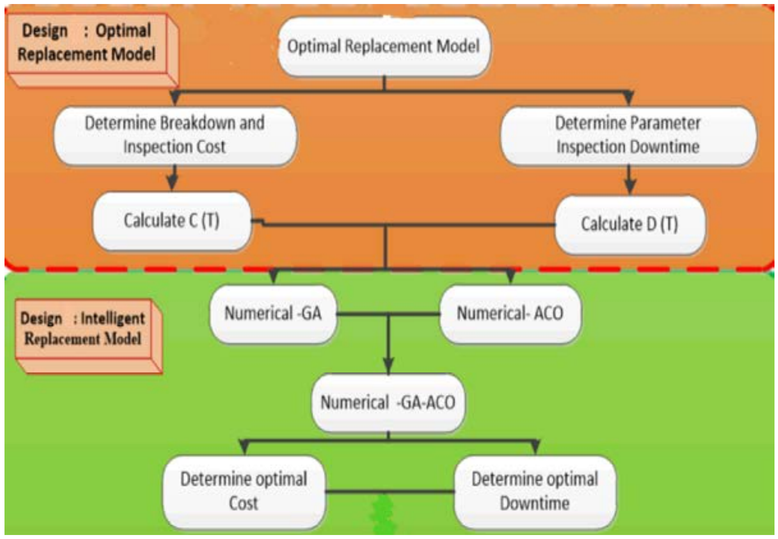

Fig. 1: The proposed Methodology

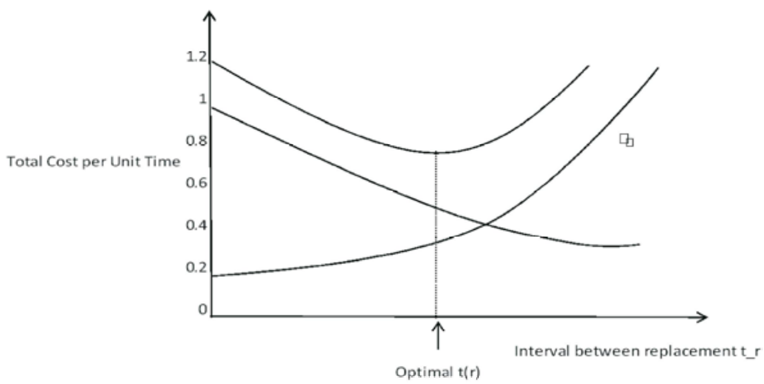

Fig. 2: Short-Term Deterministic Optimization

Establish a Cost model C (T): In general, a replacement costs money in terms of materials and wages. A balance is required between the money spent on replacement and savings obtained by reducing the operating cost. Thus, an optimal replacement policy can be determined to minimize the sum of operating and replacement costs per unit time.

The cost conflicts and associated optimization problem are illustrated in Figure (2). It should be stressed that this class of problem can be termed as a short-term deterministic since the magnitude of the interval between replacements is weeks or months, rather than years. If the interval between replacements is measured in years, then the fact that changes in monetary value over time would need to be taken into account in the analysis[5-6].

Construction of Model:

- C(t) is the operating cost per unit time at time t after replacement.

Fig. 3: A Replacement Cycle

- C_r is the total cost of a replacement.
- The replacement policy is to perform replacements at intervals of length. The policy is illustrated in Figure (3)
- The objective is to determine the optimal interval between replacements to minimize the total cost of operation and replacement per unit time.

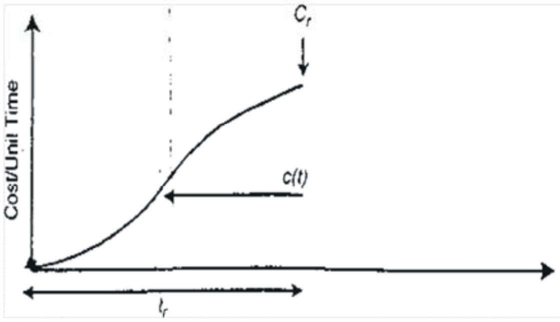

Fig. 4: Model Development: Short Term

The total cost per unit time C( ), for replacement at time, is Equation (1.1).

$$C(\ ) = \frac{\text{Total Cost In Interval}}{\text{Length of Interval}}(0, \text{tr}) \qquad (1.1)$$

Total cost in the interval = cost of the operating + cost of replacement, is in the Equation (1.2).

$$\int_0^{t_r} c(t)\,dt + C_r$$

Then, in the Equation (1.2) (1.2)

This is a model of the problem relating replacement interval to total cost per unit time C and development of the model is illustrated graphically in Figure (4)

The optimal replacement interval is that value of that minimizes the right-hand side of Equation 3.9 which can be shown by calculus to follow when

$$c(t_r) = C(t_r) \qquad (1.3)$$

Thus, the optimal replacement time is when the current operating cost rate is equal to the average total cost per unit time. In other words, the optimal time to replace is when the marginal cost equals the average cost.

In fact, if the trend in operating costs is linear, c(t) = a + bt, the optimal replacement interval t* is Equation 3.10.

$$t^* = \sqrt{\frac{2C_r}{b}} \qquad (1.4)$$

To use the equation c(t_r) = C(t_r) requires that the trend in operating costs be an increasing function, which in practice is a very reasonable assumption. If that is not the case and as time progresses the operating cost of a component becomes less, then Equation 1.1 needs to be solved using classical calculus (if the cost trend is simple); otherwise, a numerical solution will be required [6].

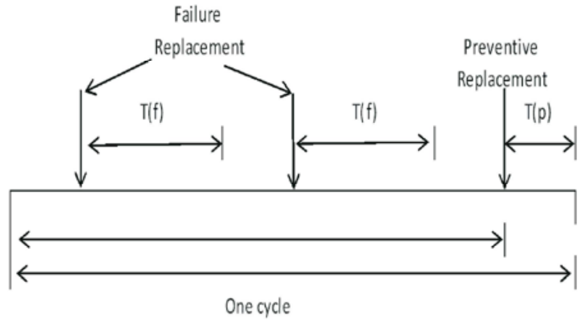

Fig. 5: Downtime Minimization: Optimal Interval

Establish a Downtime model D (T): The objective of downtime model D (T) is to minimize total downtime per unit time. In some cases, say 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 [7-8]. The problem of this section is to determine the best times at which replacements should occur to minimize total downtime per unit time. The basic conflict is that as the preventive replacement frequency increases, there is an increase in downtime due to these replacements, but a consequence of this, there is a reduction of downtime due to failure replacements and a wish to get the best balance between them [8-9].

Construction of Model:

- T_f is the mean downtime required to make a failure replacement.
- T_p is the mean downtime required to make a preventive replacement.
- F (t) is the probability density function of the failure times of the item.

Determination of the Optimal Preventive Replacement Interval

The objective is to determine the optimal replacement interval between preventive replacements in order to minimize total downtime per unit time. The policy is illustrated in Figure (5).

The total downtime per unit time, for preventive replacement at time, denoted as D ( ) is D ( ) =

$$D(t_p) = \frac{\text{Expected downtime due to failures + downtime due to preventive replacement}}{\text{Cycle length}} \quad (1.5)$$

Downtime due to failures = number of failures in interval (0, t_p) × Time required to make a failure replacement = H(t_p) × T_f

Therefore,

$$\mathrm{D}(t_p) = \frac{H(t_p)\, T_f + T_p}{t_p + T_p} \quad (1.6)$$

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

Intelligent Replacement Model: Artificial Intelligence (AI) is recognized by many researchers as a potentially powerful tool, especially when combined with OR techniques to overcome such problems. Indeed, there has been vast interest in the applications of AI in the maintenance area as witnessed by the large number of areas [10-11].

In this research, two AI techniques for optimal replacement model are applied. The techniques are Genetic Algorithm (GA) and Ants Colony Optimization. AI technique is dependent on case study and the objective is to get accurate and preventive replacement for HFM [10]:

Numerical – Genetic Algorithm (Num-GA): GA is vastly applicable in many optimization problems as this method solves problems in nature. In addition, this algorithm is possible to find the replacement and well adapted to the problem using numerical cost and downtime formula to find the replacement maintenance frequency.

Numerical – Ant Colony Optimization (Num-ACO): The particular type of probabilistic model used by ACO algorithms is the coupling of the structure called construction graph with a set of stochastic procedures called artificial ants. The artificial ants build solutions in an iterative manner using numerical cost and downtime formula to find the replacement maintenance frequency in HFM.

Numerical – Genetic Algorithm – Ant Colony (Num-GA-ACO): The hybrid algorithm, i.e. combination of the GA and the ACO methods for the model parameter of the process using cost and downtime numerical are proposed to find the replacement model in HFM.. Both intelligent techniques are applied to the numerical formula to produce output data and graphical data show the replacement maintenance.

Determine Optimal Cost: The hostel facility maintenance model shows that the total cost curve is not fairly flat around the optimum and rises rapidly on a side. 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 curve for various values of uncertain parameters could affect the solution. In order to further assist engineers in deciding what appropriate replacement policy should be, it is useful to plot the total cost per unit time curve [12-13].The goal is to develop a model that relates to inspection frequency to profitable cost.The advantage of the curve is that, along with giving the value of t, it shows the total cost 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 [14-15].

Determine Optimal Downtime: The method applied from the downtime model, the corresponding curve is D(T) for the preventive replacement. The remarks that can be concluded are that the assumption verified by the curve that the preventive replacement plotted is the best time to replace component of hostel facility maintenance. If the quality of preventive replacement downtime, it means that the more downtime is detected, the downtime will reduce due to fewer breakdowns occurring during operations [16-17].

In order to further assist engineers in deciding what appropriate replacement policy should be, it is useful to plot the total downtime per unit time curve. The advantage of the curve is that, along with giving the optimal value of t, it shows the total downtime around the optimum value. 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 the equipment is constant [18].

RESULTS AND DISCUSSION

The results and analysis structure of this part are shown in Figure (6).

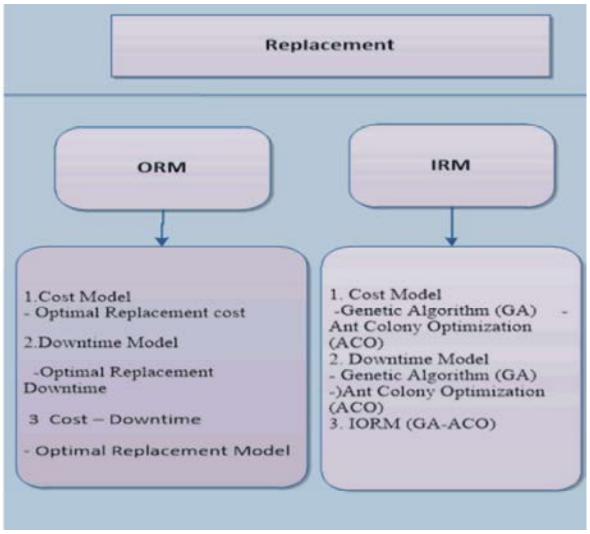

Fig. 6: Result structure

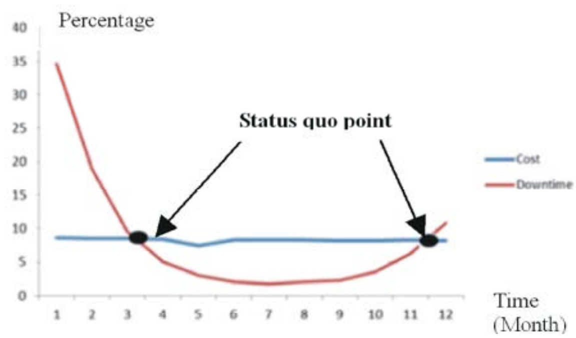

Fig. 7: Two Dimensional Graphs (2 D): Cost-Downtime Intelligent Optimal Replacement Model

Table 1 show the cost and downtime result respectively in Case Study. Meanwhile, It show the cost and downtime result in the Intelligent Replacement Model

Time(Month)	Cost (RM)	%	Downtime (Hours)	%
1	170.99	8.58	132.725	34.7
2	170.81	8.5	72.8024	19.01
3	170.71	8.45	36.46075	9.53
4	170.64	8.42	19.3315	5.04
5	170.54	8.36	11.64375	3.04
6	170.38	8.29	7.889385	2.05
7	170.35	8.27	6.66608	1.75
8	170.27	8.24	7.752824	2.03
9	170.23	8.22	8.528883	2.23
10	170.19	8.16	13.583	3.55
11	170.2	8.28	24.01941	6.27
12	170.25	8.23	41.48059	10.8
Total	2090.56	100%	382.8836	100%

The remarks that can be concluded are that the assumption is verified by the 2D curve that the best time for replacement cost and downtime plotted above the perfect replacement. It also shows that when the value from 19.33 to 170.64 and 13.583 to 170.19 the curve will go to the status quo point. If the quality of cost downtime is met, more faults are detected; the downtime will reduce due to fewer breakdowns occurring during operations.

CONCLUSIONS

By determining the relevant replacement models and inspection intervals that optimise the cost downtime, obviously can improve the maintenance policy. There is an apparent increase in using intelligent approaches and utilising their combined strengths. There is enormous potential for developments in many applications of AI in maintenance by combining Genetic Algorithms (GA) and Ant Colony Optimization (ACO) techniques. Intelligent management systems (IMS) are potentially powerful tools that can help creation best replacement models for HMM.

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