Global Journals LaTeX JournalKaleidoscope™
Artificial Intelligence formulated this projection for compatibility purposes from the original article published at Global Journals. However, this technology is currently in beta. *Therefore, kindly ignore odd layouts, missed formulae, text, tables, or figures.*

A Thesis Report on the Application of Preventive Replacement Strategy on Machines in Perspective of Cement Industry in Bangladesh

M.M Israfil Shahin Seddiqe[1], Avizit Basak[2] and Md. Rifaul Islam[3]

[1] kushtia polytechnic institute

Received: 7 December 2013 Accepted: 1 January 2014 Published: 15 January 2014

Abstract

The operation of a particular component in deteriorating condition will lead to a high machine downtime. This is due to the failure of component at unexpected time. As a result it will increase cost of maintenance and production lost. One of the solutions to this matter is to use Preventive Maintenance (PM). In industries, Preventive Maintenance (PM) is not a new practice to minimize the sudden breakdown of production machine. PM will be performed at predetermine intervals to provide a balance between failure cost and component utilization (aging). Therefore, the objective of this paper is to introduce the preventive maintenance strategy for determining an optimal replacement time for component that deteriorates over time. In this thesis we consider a particular type of machine (Gear Motor 7.5 KW.) from Holcim Bangladesh ltd. where machines are subject to maintenance. To maximize the benefit from operating the machine two replacement models are used. Among them, one model is used to determine an optimal replacement policy which tells us, when equipment reaches a particular age, whether or not it should be replaced or continue to be operated to minimize the total operating cost. Another model is used to determine the optimal interval between the preventive replacements to minimize the total cost and to operate the machine to the time which is determined by first model. We have determined to find the preventive replacement cost and also the maximum time at which we can use the machine without replacing it. Some time it is more economical to replace the machine rather than maintenance it. So it is most important to find out the age at which the replacement will be most economical to replace rather than maintenance.

Index terms— preventive replacement, mitigate degradation, etc.

1 Introduction

hat is maintenance and why is it performed? Past and current maintenance practices in both the private and government sectors would imply that maintenance is the actions associated with equipment repair after it is broken. The dictionary defines maintenance as follows: "the work of keeping something in proper condition; upkeep." This would imply that maintenance should be actions taken to prevent a device or component from failing or to repair normal equipment degradation experienced with the operation of the device to keep it in proper working order. Unfortunately, data obtained in many studies over the past decade indicates that most private and government facilities do not expend the necessary resources to maintain equipment in proper working order. Rather, they wait for equipment failure to occur and then take whatever actions are necessary to repair

or replace the equipment. Nothing lasts forever and all equipment has associated with it some predefined life expectancy or operational life.

The need for maintenance is predicated on actual or impending failure -ideally, maintenance is performed to keep equipment and systems running efficiently for at least design life of the component(s). As such, the practical operation of a component is timebased function. If one were to graph the failure rate a component population versus time, it is likely the graph would take the "bathtub" shape shown in Figure **??**.1.1.

In the figure the Y axis represents the failure rate and the X axis is time. From its shape, the curve can be divided into three distinct: infant mortality, useful life, and wearout periods. The maintenance is mainly two types and they are planned and unplanned maintenances. And these two types of maintenance are divided into some other types of maintenance.

Planned maintenance: It is an organized maintenance work carried out as per recorded procedures having control.

Breakdown maintenance: It is an emergency based policy in which the plant or equipment is operated until it fails and then it is brought back into running condition by repair. The maintenance staff locate any mechanical, electrical or any other fault tor correct it immediately.

Corrective maintenance: It is a maintenance task performed to identify, isolate, and rectify a fault so that the failed equipment, machine, or system can be restored to an operational condition within the tolerances or limits established for in-service operations.

Routine maintenance: It refers to maintenance work that is normally planned for, and performed on a routine basis. Most of the time, routine maintenance can be, and is frequently, carried out without locking out a machine. It involves minor jobs such as cleaning, lubrication, inspection and minor adjustment. It needs very little investment in time and money.

Preventive maintenance: Actions performed on a timeor machine-run-based schedule that detect, preclude, or mitigate degradation of a component or system with the aim of sustaining.

2 b) Benefits of Maintenance

? Increase functional reliability of production facilities.

? Enables product and service quality to be achieved through correctly adjusted, serviced and operated equipment. ? Maximize the useful life of the equipment.

? Minimize the total production or operating costs directly attributed to equipment service and repair. ? Minimize the frequency of interruptions to production by reducing breakdowns. ? Maximize the production capacity from the given equipment resources. ? Enhance the safety of manpower.

3 II.

4 Problem Statement

Holcim Bangladesh ltd. is one of the leading cement manufacturing companies in Bangladesh. They have a number of heavy machines these machines are subject to maintenance according to traditional approach. The used traditional maintenance is actually scheduled maintenance and due to this practice a lot of problem occurs. Loss of production, repair and replacement cost, low productivity, long lead time and low reliability of plant machineries result from this type of maintenance.

Due to production loss productivity decreases and which results in the decrease of profitability. Repair/Replacement cost is required to restore the equipment in functioning condition. Since equipments are subject to breakdown then the reliability of the equipments to remain in functioning condition is low. Lower reliability and loss of production lead to take longer lead time of delivery. Moreover bottlenecking and more work in process inventory occur due to this practice.

In Holcim Bangladesh ltd. the total activity is divided into three stages and they are the unloading system, cement production system and packing and delivery system. In these three stages there are many machines required. The machines in these three systems are Hydraulic crane, Belt conveyor, pay loader, motor 1000kw and packer machines. Most of the machines are consisted of different number of Gear motor 7.5kw. All the failures happen in the industry are more often failure of this motor. So here we have chosen to this motor in our calculation.

Maintenance practice is required to overcome above problems which removes loss of production, increase reliability of the equipment, decreases repair/replacement costs and leads the company towards success. Planned maintenance practice is one of those practices which can overcome above problems.

5 a) Objectives

The objectives of this paper is ? To investigate the economic advantages in implementing appropriate replacement process of equipment with physical impairment,

? To find out an optimal preventive maintenance interval based on the cost.

6 III.

7 Theoretical Background a) Optimal replacement policy for equipment whose operating cost increases with use (finite time horizon). (A.K.S JARDINE) i. Construction of model

? I = age of the equipment (in years) since last replaced with n periods of time to go until the end of production plan.

? J = age of the equipment (in years) since last replaced with (n-1) periods of time to go to the end of production plan.

? C(a) = operating cost (in Taka) for one period when the equipment is of age 'a' since last replaced at the start of the operating period. ii. Construction of model

? ?? ?? is the cost of a preventive replacement.

? ?? ð ??"ð ??" is the cost of a failure replacement .

? ð ??"ð ??"(??) is the probability density function of the equipment's failure times.

? The replacement policy is to perform preventive replacements at constant intervals of length ?? ?? , irrespective of the age of the equipment, and failure replacements occurs as many times as required in interval (0, ?? ??).

? The objective is to determine the optimal interval between preventive replacements to minimize the total expected replacement cost per unit time.

The total expected cost per unit time, for preventive replacement at time?? ?? , denoted by ??(?? ??) is The objective of this policy is to perform replacements in such a way that the total cost of operating & replacing the motor over next 3 years is minimized having age I=1 years at the start.??(?? ??) = ?????????? ????????????????

8 Data Analysis and Calculation

Under this policy the relevant data are considered as follows-Age of motor since last replaced, a in years0 1 2 3

Operating cost* for one period C(a) in Tk. The cost of operating a motor in a year = 54000*8 = 432000 Tk. per year This is taken to be the electricity bill for the first year of operation.

Hence, total operating cost:

For First year, operating cost = 432000 +5760 = 437670 Tk.

9 Similarly,

Taking different values of the per unit rate for 2 nd , 3 rd & 4 th year i.e. 9 Tk., 10Tk. & 11 Tk. respectively, the total cost can be calculated as above-For second year, operating cost = (54000*9) + 6720 = 492720 Tk.

For third year, operating cost = (54000*10) + 7200 = 547200 Tk.

For fourth year, operating cost = (54000*11) + 8160 = 602160 Tk.

10 c) Calculation

Cost matrix For 0 year to go, f 0 (I) = 0 for all possible values of I. For 1 year to go, J I 0 1 2 3 0 ? 4,37,670 ? ? 1 ? 5,f 1 (0) = min j [C(0,J)] = min ? ? ? ? ? ? ? ? ? ? ? ? ?) 3 , 0 ( ) 2 , 0 ( ) 1 , 0 ( ) 0 , 0 (C C C C = min ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? 4,37,670 f 1 (1) = min j [C(1,J)] = min ? ? ? ? ? ? ? ? ? ? ? ? ?) 3 , 1 ( ) 2 , 1 ( ) 1 , 1 ( ) 0 , 1 (C C C C = min ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? 4,92,720

11 5,87,670

Similarly for I = 2, 3 the values of f 1 (2), f 1 (3) can be determined & can be computed and shown in a table as below-Table **??** : For 1 year to go I (year)0 1 2 3 J (year) 1 2 3 1

Action to take at start of period For 2 years to go,C C C R f 1 (I)f 2 (I) = min j [C(I,J) + f 1 (J)] When I =0, f 2 (0) = min j [C(0,J) + f 1 (J)] = min ( ) ( ) ( ) ( ) ? ? ? ? ? ? ? ? ? ? ? ? ? + + + + 3) 3 , 0**(2) 2 , 0 (1) 1 , 0 (0) 0 , 0 (1 1 1**1 f C f C f C f C = min ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? 930390

In similar process as used for table 1, tables can be made for 2, 3 and 4 years to go-Table **??** : For 2 years to go I (year)0 1 2 3 J (year) 1 2 1 1

Action to take at start of period Action to take at start of period C C R R f 2 (I)C C R & C R f 3 (I)C = continue & R = replace

The replacement policy can be summarized as below-Periods to go (year) For t p = 1 month, For t p = 5 months, V.H (1) = [1+ H (0)] ? 1 0) (dt t f = ? 1 0) (dt t f = ?(-5.25) -?(-4.43) = 0 C (1) = 17000 +41167 ×0 1 =17000 Tk. For t p = 2 months, H (2) = [1+H (1)] ? 1 0) (dt t f +[1+H(0)] ? 2 1) (dt t f = [1+0]×0+[?(-3.49)-?(-4.43)] = 0+ [3.6 × 10 ?4 -0] = 3.6 × 10 ?4 C (2) = 17000 +41167 ×3.6×10 ?4 2 = 8507 Tk. For t p = 3 months, H (3) = [1+H (2)] ? 1 0) (dt t f +[1+H(1)] ? 2 1) (dt t f + [1+H(0)] ? 3 2) (dt t f = 1.00036×0 +1×.00036+ [?(-2.(4) = [1+H (3)] ? 1 0) (dt t f +[1+H(2)] ? 2 1) (dt t f + [1+H(1)] ? 3 2) (dt t f + [1+H(0)] ?**4**H(5) = [1+H(4)] ? 1 0) (dt t f +[1+H(3)] ? 2 1) (dt t f + [1+H(2)] ? 3 2) (dt t f + [1+H(1)] ? 4 3) (dt t f +[1+H(0)] ?**5**

12 Limitations

The thesis activity performed here is not out of limitations. The identified limitations are: ? The research is based on history data and not on real time data. ? The research is made up with failure data not failure modes. ? The mathematical formulations did not take into account the time it requires to perform preventive replacements because the model assumed that time to be very short, compared to the mean time between replacements. ? The calculated value of mean (??) is not 100% accurate because of lack of the data of failure occurs. ? For these type of model application, it is necessary to know the characteristics of the machines over a long operating time i.e. performance of machine, number of failure occur during operating etc. ? The model of replacement decisions are developed by A. K. S. Jardine in separate conditions but this thing is neglected in this thesis.

13 VI.

14 Conclusion

From the above model machine will be replaced after 2 years since the age of machine is 1. And the total cost of replacement and operation to the three years would be 15, 73,110 Tk.

According to the above method the optimal preventive replacement is to perform at 4 months interval.

VII.

15 Recommendations

The following recommendations are forwarded for the industry and related Bangladeshi industries that are executing maintenance work in their regular activity ? Replacement or repair cost, benefit from operating the equipment, labor cost etc. should be collected with high degree of accuracy. ? Statistical analysis of the data should be done frequently. ? Proper documentation of each activity should be kept. [1]

111 

Figure 1: Figure 1 . 1 . 1 :

[1] © 2014 Global Journals Inc. (US)

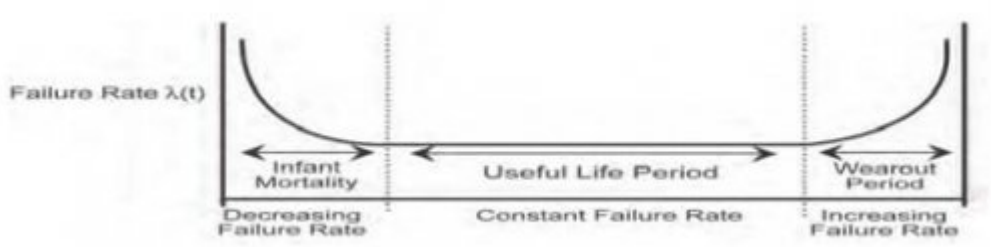

Figure 2: ?

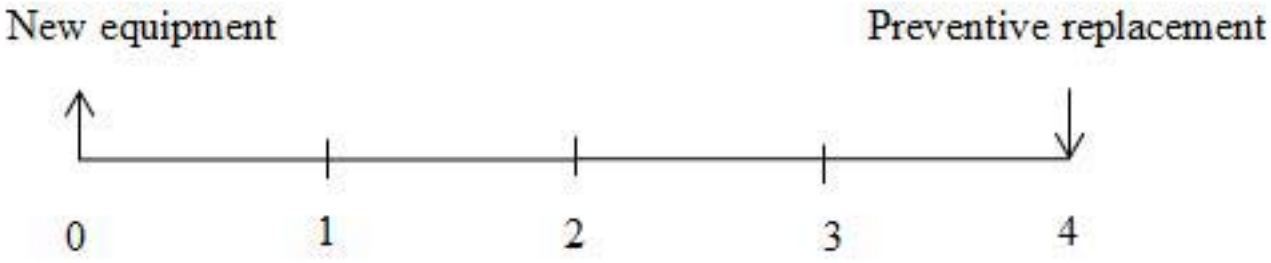

Figure 3:

:

Machine name	No of failure (1year)	Total repair time (min/hours) 1 yr)	Total failure (incost (1 year)	Year 2014 J Data collection time
Gear Motor (7.5KW)	02	45 hrs	20000	(15/01/2011-15/01/2012)
Hydraulic Crane	03	24 hrs	50-100K	(15/01/2011-15/01/2012)
Chain Conveyor	04	32 hrs	100-500K	(15/01/2011-15/01/2012)
Bucket Elevator	02	40 hrs	50-100K	(15/01/2011-15/02/2012)
Water Pump	02	20 hrs	10-20K	(15/01/2011-15/01/2012)
From the above chart For Gear Motor (7.5KW):				

[Note: a) Optimal replacement policy for equipment whose operating cost increases with use (finite time horizon)]

Figure 4: Table :

d) Optimal interval between preventive replacements of equipment subject to breakdown
Labor cost per maintenance per personnel in a month =

16750 Tk.
Spare parts (Accessories) cost (Ball bearing / bearing
Sleeve) in a year = 3000 Tk. (1500*2)
Spare parts (Accessories) cost (Ball bearing / bearing Sleeve) in a month = 250 Tk. (3000/12)
Production rate = 30 tons (3000kg) per hour = 60 bag (3000/50) per hour
Net income per bag = 100 Tk.
Failure maintenance time in a year = 45 hrs
Failure maintenance time in a month = 3.75 hrs (45/12)

Failure maintenance cost in a year = 20000 Tk. Failure maintenance cost in a month = 1667 Tk. (20000/12
?? ?? = 17000 ????.

C = continue & R = replace	??(?? ??) =	?? ?? + ?? ð ??”ð ??” ??(?? ??) ?? ??
Decision	3 Continue (Table 3)	

[Note: A]

Figure 5:

[Reliability Engineering and System Safety] , *Reliability Engineering and System Safety* 51 (3) p. .

[Martand Telsang. Industrial Engineering and Production Management] , *Martand Telsang. Industrial Engineering and Production Management*

[Bullinger Clarence and Economy ()] , E Bullinger Clarence , Engineering Economy . 1958. New York: McGraw-Hill Book Co., Inc.

[European Journal of Operational Research ()] , *European Journal of Operational Research* 2007. 183 p. .

[Sherwin ()] 'A note on block and bad-as-old renewal of components with limited system time horizon'. D Sherwin . *Journal of Quality Maintenance Engineering* 1997. 3 (2) p. .

[Dekker et al. ()] 'A review of multi-component maintenance models with economic dependence'. R Dekker , F Van Der Schouten , R Wilderman . *Mathematical Methods of Operational Research* 1997. 45 (3) p. .

[Canto ()] 'Application of Benders' decomposition to power plant preventive maintenance scheduling'. S V Canto . *European Journal of Operational Research* 2006. 184 (2) p. .

[Dekker ()] *Application of maintenance optimization models: A review and analysis*, R Dekker . 1996.

[Hartman and Murphy] *Finite Horizon Equipment Replacement Analysis*, Joseph C Hartman , Alison Murphy . Leigh University, USA.

[Kardon and Fredendall ()] 'Incorporating overall probability of system failure into a preventive maintenance model for a serial system'. B Kardon , L D Fredendall . *Journal of Quality in Maintenance Engineering* 2002. 8 (4) p. .

[Jardine ()] K S Jardine . *Maintenance, Replacement, and Reliability*, 1973.

[Das et al. ()] *Machine reliability and preventive maintenance planning for cellular manufacturing systems*, K Das , R S Lashkari , S Sengupta . 2007.

[Westman and Hanson (2000)] 'Manufacturing production scheduling with preventive maintenance in random environments'. J J Westman , F B Hanson . *Proceedings of the 2000 IEEE international conference on control applications*, (the 2000 IEEE international conference on control applicationsAnchorage, USA) 2000. September 2000. p. .

[Thi and Yeung Bruno Castanier ()] 'Optimal Maintenance and Replacement Decisions under Technological Change'. P.Khanh Nguyen Thi , Thomas G Yeung & Bruno Castanier . *European Safety and Reliability* 2010. 2010. ESREL 2010. 2010.

[Panagiotidou and Tagaras ()] 'Optimal preventive maintenance for equipment with two quality states and general failure time distributions'. S Panagiotidou , G Tagaras . *European Journal of Operational Research* 2007. 180 (1) p. .

[Miescke ()] 'Optimum replacement policies for using the most reliable components'. Klaus J Miescke . *Journal of Statistical Planning and Inference* 1990. 26 p. .

[Kamran et al. ()] 'Preventive maintenance and replacement scheduling for repairable and maintainable systems using dynamic programming'. S Kamran , John S Moghaddam , Usher . *Computers & Industrial Engineering* 2011. 60 p. .

[Vaughan ()] 'Production, Manufacturing and Logistics Failure replacement and preventive maintenance spare parts ordering policy'. Timothy S Vaughan . *European Journal of Operational Research* 2003. 2005. 161 p. .

[Russell ()] *Progress in Operations Research*, Ackoff Russell , L . 1961. New York: John Wiley and Sons Inc.

[Budai et al. ()] *Scheduling preventive railway maintenance*, G Budai , D Huisman , R Dekker . 2006.

[Kamran et al. (2011)] 'Sensitivity analysis and comparison of algorithms in preventive maintenance and replacement scheduling optimization models'. S Kamran , John S Moghaddam , Usher . *Journal of the Computers & Industrial Engineering* 2011. 27 February 2011. 61 p. .

[Ahmad Kamaruddin Mokthar Indra Putra Almanar ()] 'The Application of Preventive Replacement Strategy on Machine Component in Deteriorating Condition -A Case Study in the Processing Industries'. *Proceedings of International Conference on Man-Machine Systems*, Rosmaini Ahmad, Shahrul Kamaruddin, Mohzani Mokthar, Indra Putra Almanar (ed.) (International Conference on Man-Machine Systems) 2006. 2006.