

Chapter 12

Condition-Based Maintenance: Capital Goods Industry

Hao Peng

Academy of Mathematics and Systems Science, China

ABSTRACT

Condition-Based Maintenance (CBM) is one type of preventive maintenance policy. CBM has attracted lots of attentions of both academia and industry due to the development of advanced sensor technology and measurement devices. The proper implementation of CBM can reduce the frequency of random failures and the expected cost of maintenance during the lifecycle of a system. In this chapter, a brief overview of different maintenance strategies is first provided for the readers who are not familiar with maintenance optimization models. Then several elementary models about CBM will be introduced to help the readers get a general idea of the optimization models in this field.

INTRODUCTION

In capital goods industry, the availability of systems is crucial to provide the needed functions or services to customers/users. Aircraft, trains, wafer-steppers, and magnetic resonance imaging (MRI) scanners are examples of such systems. The inconvenience of trains and/or aircraft not running when needed (and planned) is a great inconvenience to travellers, but also a significant loss of revenue for airlines and railway operators. Wafer-steppers are used in the bottleneck production step of semi-conductor manufacturing. When a wafer-stepper is down, it causes the standstill of an entire semi-conductor factory. For the case of wafer steppers, these costs are in the order of magnitude of 100000 EURO per hour. The unavailability of MRI-scanners is perhaps the most costly as it can lead to the loss of human life under some circumstances. All these examples illustrate that keeping capital assets up and running is of critical importance.

On the other hand, the cost of maintenance to keep the systems up and running is very high. Oner et al. (2010) estimate that the costs of maintenance and unavailability of a capital asset over its lifetime (typically one to several decades) is typically three to four times the acquisition cost of capital assets. In fact, in 2003 spare part sales and services (mostly maintenance) accounted for 8% of the gross domestic

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Condition-Based Maintenance

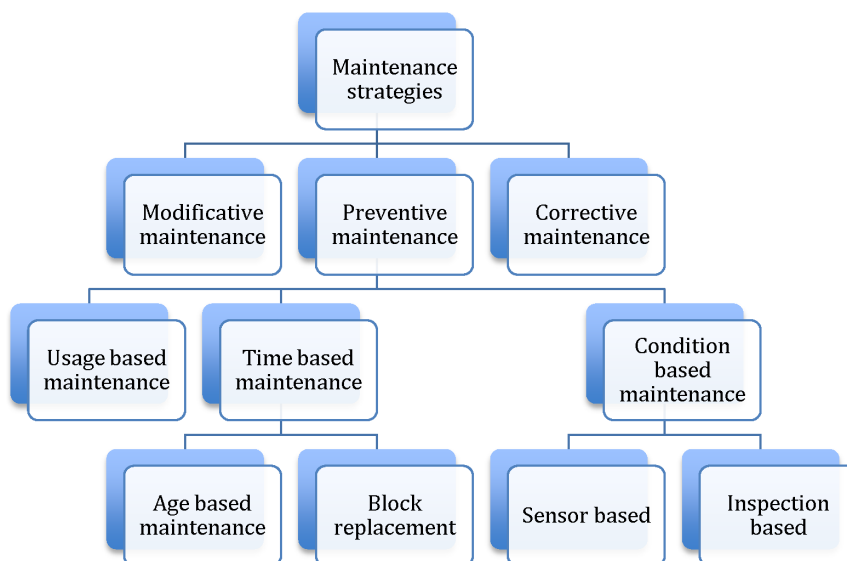
product in the United States (AberdeenGroup, 2003). More recently, US bancorp estimated that the yearly expenditure in the US on spare parts amounts to 700 billion dollars which is 8% of the US gross domestic product (Jasper, 2006).

How to create optimal maintenance policies and schedule the tasks of maintenance efficiently becomes a challenging problem, since we not only need to reduce the total cost of ownership but also have to achieve a high level of system availability and reliability. Many maintenance strategies have been proposed to tackle this problem. Figure 1 gives an overview of maintenance strategies. Different from regular production operations, maintenance operations are not instigated by demand from an outside customer, but by the need for maintenance of equipment. The needs of maintenance can come from machine degradations, failures, or technology upgrades. If a maintenance activity is initiated by technology upgrade, it has been defined as modificative maintenance. Modificative maintenance concerns interchanging a part with a technically more advanced part in order to upgrade the equipment. This form of maintenance is usually project based and non-recurring.

The maintenance strategies that occur most often are preventive and corrective maintenance. Under a corrective maintenance strategy, a part is not replaced until it has failed, while under a preventive maintenance strategy, it is possible to replace parts before unexpected failures occur. To determine which strategy should be used, the information about reliability behaviors of systems plays an important role. Corrective maintenance is an attractive option for parts that do not wear, such as electronics. For parts that do wear, it can be beneficial to follow a preventive maintenance strategy.

Preventive maintenance strategies can be further divided into time, usage and condition based maintenance. Under time based maintenance, the ages of systems or calendar times will be the variables that determine the executions of maintenance activities. For example, an age based maintenance policy will optimize the age limit after which a system will get preventively maintained. Block replacement policy has a fixed maintenance interval to optimize, which specifies the time points at which a system will get

Figure 1. Maintenance strategies



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