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Condition-based spares ordering for critical components

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ABSTRACT

It is widely accepted that one of the potential benefits of condition-based maintenance (CBM) is the expected decrease in inventory as the procurement of parts can be triggered by the identification of a potential failure. For this to be possible, the interval between the identification of the potential failure and the occurrence of a functional failure (P-F interval) needs to be longer than the lead time for the required part. In this paper we present a model directed to the determination of the ordering decision for a spare part when the component in operation is subject to a condition monitoring program. In our model the ordering decision depends on the remaining useful life (RUL) estimation obtained through (i) the assessment of component age and (ii) condition indicators (covariates) that are indicative of the state of health of the component, at every inspection time. We consider a random lead time for spares, and a single-component, single-spare configuration that is not uncommon for very expensive and highly critical equipment.

1. Introduction

The main principle behind the use of condition monitoring techniques for the maintenance of industrial equipment is that of anticipating the occurrence of failures. When condition-based maintenance programs are in place, the removal of a component from operation is ideally triggered by the detection of a degradation process within the equipment (when resistance to failure has started to decrease). If we are able to detect the start of this failure process (i.e. the occurrence of a potential failure) early enough so that the expected lead time to receive a spare part on-site is less than the expected time to failure, then there is no need to stock a spare component. Using reliability-centered maintenance (RCM) terminology (see Ref. [1]), when the P-F interval is longer than the lead time there is no need to stock a spare. This idea constitutes a widely accepted potential benefit of condition-based maintenance (CBM) policies (see e.g. [2,3]), and creates an opportunity for the optimization of the ordering time of spares when demand can be anticipated. Gains can be important as in several industries, spare related holding costs are huge. For example, the commercial aviation industry has more than 40 billion dollars worth of spare parts on stock [4].

The use of condition monitoring techniques in industry has largely increased over the last few years [5]. The use of the condition information collected in the determination of optimal spare parts ordering could therefore generate significant savings in stockholding related costs. The latter statement is of particular importance to the case of expensive, complex components. However, the incorporation of condition information in the spare parts stockholding decision (i.e. the impact of condition-based maintenance policies in spare parts inventories) has seldom been approached in the literature. In fact,

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