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Simultaneous Optimization of Design and Maintenance through a Hybrid Process Using Genetic Algorithms

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Abstract : In general, issues related to design and maintenance are considered in an independent manner. However, the decisions made in these two sets influence each other. The design for maintenance is considered an opportunity to optimize the life cycle cost of a product, particularly in the nuclear or aeronautical field, where maintenance expenses represent more than 60% of life cycle costs. The design of large-scale systems starts with product architecture, a choice of components in terms of cost, reliability, weight and other attributes, corresponding to the specifications. On the other hand, the design must take into account maintenance by improving, in particular, real-time monitoring of equipment through the integration of new technologies such as connected sensors and intelligent actuators. We noticed that different approaches used in the Design For Maintenance (DFM) methods are limited to the simultaneous characterization of the reliability and maintainability of a multi-component system. This article proposes a method of DFM that assists designers to propose dynamic maintenance for multi-component industrial systems. The term "dynamic" refers to the ability to integrate available monitoring data to adapt the maintenance decision in real time. The goal is to maximize the availability of the system at a given life cycle cost. This paper presents an approach for simultaneous optimization of the design and maintenance of multi-component systems. Here the design is characterized by four decision variables for each component (reliability level, maintainability level, redundancy level, and level of monitoring data). The maintenance is characterized by two decision variables (the dates of the maintenance stops and the maintenance operations to be performed on the system during these stops). The DFM model helps the designers choose technical solutions for the large-scale industrial products. Large-scale refers to the complex multi-component industrial systems and long life-cycle, such as trains, aircraft, etc. The method is based on a two-level hybrid algorithm for simultaneous optimization of design and maintenance, using genetic algorithms. The first level is to select a design solution for a given system that considers the life cycle cost and the reliability. The second level consists of determining a dynamic and optimal maintenance plan to be deployed for a design solution. This level is based on the Maintenance Free Operating Period (MFOP) concept, which takes into account the decision criteria such as, total reliability, maintenance cost and maintenance time. Depending on the life cycle duration, the desired availability, and the desired business model (sales or rental), this tool provides visibility of overall costs and optimal product architecture.

Keywords : availability, design for maintenance (DFM), dynamic maintenance, life cycle cost (LCC), maintenance free operating period (MFOP), simultaneous optimization
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