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Optimal performance of a multi-state system under an inspection and repair policy

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Abstract

In this paper, an inspection strategy of a multi-state system is proposed. This system can be in a nominal operating mode, a degraded mode or a failure mode. The system state is known only after inspection. A maintenance action is undertaken when at a predetermined moment, an inspection reveals that the system is in failure mode. This maintenance action restores the system in its nominal operating mode with a certain probability. For this study, the inspection strategy of periodic type is used. It aims at maximizing the productivity of the system which can occupy one of the three states identified above. Analytical and numerical results were obtained.

Keywords : *Reliability, Optimization, Inspection, Production rate, multi-states*

1 Introduction

Technological systems are characterized more and more by the permanent complexity of their structure. In the Reliability engineering, the study of these systems functioning was often realized by binary approach, where only two states are permitted : nominal functioning and complete failure. However, several works in literature consider many situations during systems life, favouring the multiplicity of their states. Such systems are called multi-states systems (MSS). MSS and their components behaviour is modelled by more than two states with different performance levels associated to each of these states (Zaitseva, 2003) (Lisnianski and Levitin, 2003). In the literature, MSS structural configurations are varied. Several works study unit, series, parallel, bridge or *k*-out-of-*n* multi-states configurations (Huang and Zuo, 2000) (Lisnianski and Levitin, 2003) (Pham *et al*., 1997). The main evaluation methods of MSS performance indices do not have the same efficiency, but, are often used according to structure specificity (Billinton and Allan, 1990). Indeed, the stochastic process method is often applied to small size MSS because a system states grow strictly with the increase of the system components number (Aven, 1993) (Dimitrov *et al*., 2002) (Pham *et al*, 1997) (Levitin and Lisnianski, 2001). The structure function approach is not so rapid and does not allow analyzing the MSS dynamic behaviour (Barlow and Wu, 1978) (El-Neweihi and *al*., 1978) (Zaitseva, 2003). In (Huang and Zuo, 2000), this approach is used to evaluate the reliability of MSS *k*-out-of-*n* structure, where to maintain at least a state level of a system; it is necessary that a certain number of system components are in a state or beyond. One considers that the required components number depends on the studied system state level. Monte Carlo simulation can permit a rather realistic modeling of complex functioning of industrial multi-states systems (Zio and Podofillini, 2004), but the main drawback of this technique is the time and costs implied by its development and execution (Aven, 1993). Universal generating function approach (UGF) is generally used for its robustness. Besides, this method allows determining the MSS total performance distribution while being based on the distributions of its components performances (Lisnianski and Levitin, 2003). However, although effective for a MSS performance indices