航空学报
ACTA AERONAUTICA ET ASTRONAUTICA SINICA
ISSN 1000-6893
CN 11-1929/V

航空学报 » 2012, Vol. 33 » Issue (11) :2093-2105 DOI:

基于损伤标尺的电子设备预测维修决策优化

徐玉国[1,2], 邱静[1], 刘冠军[1], 吕克洪[1]

1. 国防科学技术大学 机电工程与自动化学院 装备综合保障技术重点实验室, 湖南 长沙 410073;
2. 装甲兵工程学院 技术保障工程系, 北京 100072

Optimal Predictive Maintenance Decision of Electronics Based on Canaries

XU Yuguo[1,2], QIU Jing[1], LIU Guanjun[1], LU Kehong[1]

1. Laboratory of Science and Technology on Integrated Logistics Support, College of Mechatronics Engineering and Automation, National University of Defense Technology, Changsha 410073, China;
2. Department of Technical Support Engineering, Academy of Armored Force Engineering, Beijing 100072, China

摘要 基于故障预测信息进行维修决策是预测性维修等新型维修模式的主要特征之一,可以有效提高装备使用可用度、降低寿命周期费用。面向单部件电子系统,针对故障预测中的损伤标尺方法,在完美换件维修的假设下,以单位时间成本、平均使用可用度与平均效费比为指标,提出了一种预测维修决策优化模型。对于与外场可更换单元(LRU)寿命独立的损伤标尺,选择预测距离与Weibull分布的形状参数为决策变量,对于与LRU寿命相关的损伤标尺,选择累积损伤因子与随机标准差为决策变量,应用Monte Carlo方法仿真研究了各个决策变量对维修效能指标的影响。结果表明:应用与LRU寿命独立损伤标尺的预测维修策略的效果优于事后维修策略,但劣于年龄换件策略,揭示了该方法的本质特性;应用与LRU寿命相关损伤标尺的预测维修策略的效果在一定条件下优于年龄换件策略。最后分析了维修决策的优选方法。

关键词： 状态监控 故障预测与健康管理 损伤标尺 维修优化 更新过程 Monte Carlo方法

Abstract： Predictive maintenance based on prognostic information is an emerging maintenance mode which can decrease life cycle cost and increase operational availability effectively. This paper focuses on the prognostic approach based on canaries which can be divided into two categories: line replaceable unit(LRU)-independent canaries and LRU-dependent canaries. Under the perfect replacement assumption, a predictive maintenance decision model is proposed based on the renewal reward theorem, which can evaluate the benefit of the use of canary devices from the long-run average cost rate, average operational availability and average effectiveness-cost ratio. For LRU-independent canaries, the prognostic distance and shape parameter of Weibull distribution are chosen to optimize the maintenance decision, while for LRU-dependent canaries, the accumulated damage factor and stochastic standard deviation are chosen as decision variables. Finally, this model is demonstrated with a numerical implementation example using Monte Carlo simulation. The results show that the predictive maintenance policy with LRU-independent canaries is better than the corrective maintenance policy but worse than the age replacement policy, which exhibits an essential characteristic of the method. Furthermore, the predictive maintenance policy with LRU-dependent canaries is better than the age replacement policy in some conditions and the optimal parameters of canaries for maintenance decisions are chosen.

Keywords： condition monitoring prognostics and health management canaries maintenance optimization renewal process Monte Carlo methods

Received 2011-11-29;

Fund:

国家自然科学基金(51175502)

Corresponding Authors: 邱静 Email: qiujing@nudt.edu.cn

引用本文:
徐玉国, 邱静, 刘冠军, 吕克洪. 基于损伤标尺的电子设备预测维修决策优化[J]. 航空学报, 2012, 33(11): 2093-2105.

XU Yuguo, QIU Jing, LIU Guanjun, LU Kehong. Optimal Predictive Maintenance Decision of Electronics Based on Canaries[J]. Acta Aeronautica et Astronautica Sinica, 2012, 33(11): 2093-2105.