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电子整机加速贮存试验的Dirichlet分析方法

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Dirichlet Analysis Method for the Accelerated Storage Test of Electronic Machine

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摘要 针对电子整机系统结构复杂,失效机理众多,无法利用传统的加速模型外推对其寿命和可靠性特征进行分析的问题,提出一种基于顺序 Dirichlet分布的分析模型,利用多应力、多水平的环境应力,对每一阶段上的失效率建立指数分布模型。通过先验信息和基于反应论的修正加速模型,给出各应力水平上的失效率先验信息,利用多变量顺序Dirichlet分布描述先验失效率概率密度函数,并根据先验信息对Dirichlet分布参数进行辨识设计和对参数物理意义进行阐述。根据恒加定数试验特点,提出似然函数的解析步骤,利用Gibbs拒绝抽样方法对Dirichlet后验分布进行推断分析,得到后验信息。最后分析一个实例,给出抽样过程和几个分位点上的失效率估计值,并比较正常状态下先验和后验的可靠度变化趋势,验证算法具有一定的效率,为电子整机寿命预测与评估提供一种新方法。

关键词: 电子整机 加速贮存 Gibbs抽样 Dirichlet分布 阿伦尼斯模型

Abstract: System electronic machine level product has a complex structure and with many failure mechanisms, the method of using accelerated model to analysis the storage life and reliability is not correct. This paper presents a method based on the sequence Dirichlet distribution model. According to the acceleration model, electronic equipment experiences multiple-type, multiple-level environmental stresses, this model assumes that the failure rate is of exponential distribution at each stress level. Through priori information and the modified accelerated storage model based on the reaction theory, the priori message of failure rate is obtained. Then a multi-variable sequence Dirichlet distribution is applied to describe the probability density of priori failure rate. The parameters are calculated and the physical meaning is clearly stated. By analyzing the constant-stress experiment data, the likelihood function is generated. The Gibbs rejection sampling method is used to solve the posteriori inference problem and get the posterior modified message. A case study is then performed using this method. The sampling process and the quantile values of the failure rate are presented as a result of the case study. Through comparing the priori and posteriori reliability variation trend in the normal state, the effectiveness of this method is shown. Thus a new method of life prediction and evaluation for electronic equipment is developed.

Keywords: electronic machine accelerated storage Gibbs sample Dirichlet distribution Arrhenius model

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