Advanced System-Level Reliability Analysis and Prediction with Field Data Integration

T. MEYER, J. BERG, A. PALLADINO, A. SARLASHKAR, S. HUSSAIN and D. LAMB

ABSTRACT

As the acquisition, operating and support costs rise for mission-critical ground and air vehicles, the need for new and innovative life prediction methodologies that incorporate emerging probabilistic lifing techniques as well as advanced physics-of-failure durability modeling techniques is becoming more imperative. This is because of interest in not only extending the life of current structures, but also in optimizing the design for new components and subsystems for next generation vehicles that are smaller, lighter, and more reliable with increased agility, lethality, and survivability.

The component level physics-based durability models, although widely adopted and used in various applications, are often based on simplifying assumptions and their predictions may suffer from different sources of uncertainty. For instance, one source of uncertainty is the fact that the model itself is often a simplified mathematical representation of complex physical phenomena. Another source of uncertainty is that the parameters of such models should be estimated from material-level test data which itself could be unavailable, noisy or uncertain. At the system level, most modeling approaches focus on life prediction for single components and fail to account for the interdependencies that may result from interactive loading or common-cause failures among components in the system.

In this paper, a hybrid approach for structural health prediction and model updating for a multi-component system is presented. This approach uses physics-of-failure and reliability modeling techniques to predict the underlying degradation process and utilizes field data coming from findings of scheduled maintenance inspections (or potentially, a real-time onboard health monitoring data) as feedback to update the model and improve the predictions. The integration of field data and model updating is realized via the Bayesian updating technique. The approach is being evaluated by an OEM to a ground vehicle suspension design enhancement.

Two different failure mechanisms, corrosion and thermal mechanical fatigue, are taken into consideration for physics-of-failure modeling. Finite element analysis (FEA) is performed on the components to calculate the stress values needed as inputs to the life prediction models. Once the expected life of individual components is calculated (considering multiple failure modes and composite of usage profiles), a

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439

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Ключевые слова:

Содержание.