Probabilistic Simulation Applications in Product Design

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Abstract: *Each year companies spend millions of dollars for developing new products with high quality and reliability. Highly reliable products require longer test times to verify, and usually takes a few iteration of design-test-fix cycle. Development time can be minimized by (1) doing accelerated testing (ALT) and (2) reducing the design-test-fix cycle by developing methods to predict and test for reliability in simulation environment. Finite element modeling and analysis provides an excellent alternative in evaluating designs to improve on reliability. In this paper, a probabilistic simulation methodology is proposed using a combination of simulation modeling and statistical techniques to predict and improve the drop reliability of a product under repeated random loading. Two examples are illustrated involving two failure modes in two different products a screw pull out and a magnesium housing cracking. Explicit dynamic finite element phone drop simulations were performed in Abaqus to predict the forces in the screw and the principal tensile stress on the housing for various simulation parameters. DOE and Response surface modeling was used to develop regression equations for stress as a function of drop angle. Using the statistical techniques, a probabilistic model was developed by combining the RSM model & statistical distribution of drop angle, to estimate the distribution of the stress. In conjunction, strength degradation models were developed to reflect the housing degradation with each impact. Finally, Monte Carlo Simulations are used in conjunction with the stress-strength interference theorem to predict product reliability. In conclusion, a powerful and practical methodology is proposed that integrates the FEA with statistical methods to predict up front, the reliability of a product*

Keywords: *FEA, Probabilistic Simulation, Design Of Experiments, Response Surface Modeling, Stochastic Simulations, Monte Carlo Simulations, Stress-Strength Interference Theorem, Reliability, dynamic probability density function, Strength degradation functions.*

1. Introduction

Each year companies spend millions of dollars while developing a new product. If the reliability expectation from the product is high, extensive testing is required to demonstrate that the product reliability meets the expectations. Testing requirements inevitably increases the development cycle especially for highly reliable products. One way to reduce this cycle time is to do Accelerated Life Testing (ALT) where test units are subject to high stress environments simulating the stresses that the product encounters in normal operating conditions.