Fatigue life estimation of a non-linear system due to random vibration

James Guo, Brian Johanek and Doug Patterson

Robert Bosch LLC, Chassis Systems Control Division

Abstract: *Random response analysis is a linear approach, while most real life random vibrations involve nonlinear components. It is challenge to analyze a nonlinear system subjected to random vibration. This paper presents an Abaqus FEA approach on the fatigue life calculation of an automobile assembly with rubber isolators subjected to random vibration. Random loading is categorized using Power Spectral Density (PSD). An equivalent dynamic analysis or a random response analysis was used to obtain the maximum stress level and location from random vibration. A MATLAB routine was used to post process Abaqus PSD response to calculate the stress cycles/peaks and the fatigue damages were estimated. Hyperelastic behavior of the rubber isolator was derived from Abaqus materials module and the corresponding tests. Random vibration test results with the same PSD input were used to tune and verify the FEA model.*

Keywords: FEA, Fatigue, Random vibration, PSD, Mises stresses, frequency, damage, rubber

Introduction

A metal bracket is used to hold ABS/ESP hydraulic actuator over a vehicle's lifetime. Rubber isolators are interfaced between the hydraulic unit, bracket and chassis frame to dampen the noise generated by the brake hydraulic component and reduce the road load transfer to hydraulic actuator. Although bracket is a simple part, it is a challenge to design a cost effective bracket that can fulfill the above functions during the entire vehicle life, especially when it is subject to random dynamic loading and interfaced with nonlinear rubber components.

This paper outlines a practical approach that has been used for estimating fatigue life or durability of such a system. Figure 1 shows the flow of the analysis. When a load is applied to a system, the load is transferred through the system from one component to another. The durability of a component is governed by the loading environment to which it is subject, the stress/strain arising from that load, and the response of the material that made up the components. System level random vibration analysis is performed where the random loading and response are categorized using Power spectral density (PSD) functions and the dynamic structure is modeled as a linear transfer function.