Materials and Design 32 (2011) 1001–1005

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Technical Report

Durability of automotive jounce bumper

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ARTICLE INFO

Article history:
Received 30 March 2010
Accepted 10 August 2010
Available online 14 August 2010

ABSTRACT

This study was carried out to predict the durability of automotive car jounce bumper using Finite Element Analysis (FEA). Fatigue life correlations were taken from literatures and it was incorporated into FEA codes. The simulated results were validated with experimental work. The FEA results showed good agreement with the experiment conducted on the jounce bumper in term of load–displacement response. In term of the durability of the component, the fatigue life predicted shows agreement at lower fatigue strains. However, the error becomes larger as the fatigue strains become higher. The differences between the predicted fatigue life and the experimental fatigue life were discussed. Finally, the predicted crack initiation side was also validated in the experiment.

1. Introduction

Automotive vehicle such as planes, cars and trains have a number of rubber components. These components are important because they are normally used to absorb energy, vibration and sound due to excessive movement of the vehicle during operation. Due to prolonged exposure to forced vibration, the rubber components are prone to fatigue failures. In cars, the most common rubber component is the jounce bumper, as shown in Fig. 1. The life of these components is an important aspect to be determined, since their failure can provide discomfort during the ride and lead to the failure of other mechanical components. Therefore, a number of studies have been conducted to predict the life cycles of the rubber components, for examples Saintier et al. have proposed fatigue life criterions and these criterions were validated with experimental work on rubber specimen [1,2]. Kim et al. and Woo et al. also have conducted studies on fatigue life of rubber components with maximum Green-Lagrange strain as one of the fatigue parameters [3,4]. Other studies that related to rubber components have been conducted by Luo and Wu which was focused on the crack initiation of an anti-vibration rubber spring [5] while Li et al. study the fatigue life of rubber engine mounts [6]. In these studies, the most common method to predict the lifespan is by using the crack nucleation method [7]. This method predicts the crack initiation based on the maximum values of quantities such as stress, strain, and strain energy density. In a recent literature survey, Mars and Fatemi [7] mentioned that the most commonly used quantities are the maximum principal strain and the strain energy density. Over the last few decades, several studies [3,8] have been involved in comparing the accuracy of both quantities and correlating their values with fatigue life. However, all the results showed that the maximum principal strain proved to be a more accurate indicator than the strain energy density.

On the other hand, Mars and Fatemi [9,10] proposed a new indicator of determining the crack initiation, which is the crack energy density (CED). To prove the accuracy of the indicators, fatigue life experiments [8] have been conducted on natural rubber (NR) specimens and styrene–butadiene rubber specimens (SBR). The indicators that have been compared and correlated with the fatigue life are the maximum principal strain, maximum normal strain, peak strain energy density (SED), normal strain range, and peak crack energy density. The results showed that CED had the best correlation with fatigue life for both the NR specimens and SBR specimens. It was followed by maximum principal strain, peak SED, maximum normal strain and normal strain range.

The mechanical constitution of rubber led to a correlation of deformation energy with the rubber elongation, as given in the following equation [11,12]:

$$U = f(\lambda_1, \lambda_2, \lambda_3) \tag{1}$$

where U is the deformation energy and λ_i is the stretch ratio in the i direction.

For a simple and common shape like a dog-bone specimen or a block shape specimen, it is trivial to determine the value of stress, strain and other parameters, provided that certain assumptions are followed. Due to the given equation, the integration of the equation with respect to stretch ratio is required to calculate the stress. Therefore, it is difficult to solve this equation manually for a shape as complex as the rubber engine mount. Thus, FEA is normally used to assist in calculating the stress, strain and energy density. The

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doi:10.1016/j.matdes.2010.08.017