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Technical Report

Effect of the fatigue data editing technique associated with finite element analysis on the component fatigue design period

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ABSTRACT

The present study concerns development of accelerated fatigue design time based finite element analysis (FEA) through a combination of the fatigue data editing (FDE) technique and FEA. Country road, pavement and highway fatigue data histories were collected using a fatigue data acquisition system. The component durability was evaluated using both original and editing fatigue data signals. Both signals showed a large difference in the CPU time. Furthermore, the histories were successfully edited by presenting the predicted amount of the fatigue damage as the original histories. As a consequence of application for automotive lower suspension arm, this technique can be applied in performing a fatigue history editing, especially in compression of data set. Briefly, design time was saved based on FDE technique associated with FEA.

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1. Introduction

Fatigue damage analysis procedures for the design of modern structures, such as vehicle structural components, rely on techniques that have been developed over the last 100 years or so. One of the essential input variables is the load history. By necessity, vehicle development requires accelerated fatigue testing, which is often accomplished by correlating test tracks with public road data. Both road and test tracks generate variable amplitude (VA) load time histories [1]. The incorporation of fatigue life calculations into the finite element analysis (FEA) has brought significant advantages to the designer, not least of all is the ability to do up-front fatigue calculations long before a prototype exists [2]. For the laboratory fatigue test, VA loadings need to be edited by removing small amplitude cycles to reduce the analysis and test time in addition to the costs. Such a technique is known as fatigue data editing (FDE). Using this approach, large amplitude cycles that cause the majority of the damage are retained, and thus a shortened loading consisting of large amplitude cycles is produced [3].

Comprehensive surveys related to the FDE in the current decade are limited. All the studies were about the effect of FDE in the experiment tests while no available studies investigated the combination of this technique with FEA, which it is one of the most accurate and efficient methods. The trends of FDE emerged in this decade, when Oh [4] applied a method called wavelet transform technique. Comparisons of fatigue damage between the original and editing signals for four strain histories were made for the purpose of evaluation the editing technique. It is concluded that the used technique can be applied in performing a FDE, especially in denoising, spike removal and compression of data set. Yan et al. [5] investigated the small-load-omitting criterion using fatigue tests for three load spectra under VA loading. The results showed that the equivalent stress amplitude lower than or equal to the fatigue crack initiation threshold could be omitted in life prediction.

Ko et al. [6] investigated the effect of original and edited loadings on fatigue behavior of 2124-T851 aluminum alloy specimens. It is concluded that the amplitude-based editing technique can be applied to compress the original signal without changing the main history. Abdullah [1] summarised long records of fatigue road load data using a developed fatigue mission synthesis algorithm, called wavelet bump extraction (WBE). This algorithm has been used to extract fatigue-damaging events in the record that cause the majority of the fatigue damage whilst preserving the load cycle sequences. It is concluded that the WBE algorithm is suitable for accelerated fatigue tests. Another work by Abdullah et al. [7] discussed the study of the FDE technique in the time–frequency domain using the short-time Fourier transform (STFT) method. The STFT-based computational algorithm was developed to remove the low amplitude cycles, which were contained in the original signal. In terms of the applicability of the shortened signal, this kind of signal can be normally used in the durability laboratory scale fatigue test. Such a test is very important in the fatigue design criteria, especially for the task of accelerated fatigue testing. Finally, this method is suggested as an alternative technique in fatigue durability study, especially for the automotive engineering field.

In the present study, the role of the combination of the FDE technique with FEA on design time related durability assessment

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