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The Automobile Design Element Fatigue Life Modeling Due To Its Dynamic Model

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Abstract

The finite element method (FEM) analysis was conducted for the structural element of the automobile suspension during variable loading, taking into account the different nature of the road surface. Loading spectra on this construction were obtained based on its dynamic model made in FRUND program. A finite element calculation of the structural element was made using the obtained load spectrums for different types of the road surface with the calculation of the predicted service life. The possibility of replacing the material of this construction with a cheaper one, which provides the necessary strength and fatigue properties of the structure, is shown. The possibility of replacing the material this construction for cheaper materials providing the required strength and fatigue properties of the structure was shown.

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Keywords: rainflow; Solidworks; load spectrums in FRUND; automobile suspension.

1. Introduction

In modern automobile industry widespread this kind of suspension double wishbone as torsion suspension. Torsion suspension has several advantages - reliability, compactness, low specific quantity of metal, low noise, easy adjustment, so that it uses among automobiles with high and off-road capability. One of the disadvantages this suspension is relatively high cost of components, especially torsion [1]. For the production of torsion in the domestic automobile industry are used expensive materials such as steel 60C2A, 50HFA [2].

The automobile suspension, especially all-terrain vehicle plays an important role in ensuring not only productive and safe operation of the automobile, but also the comfort of the passengers and the driver, incurring significant

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variable in magnitude, frequency, direction of the loads application, which by the force of its elastic-damping properties are minimized and transmitted to the sprung parts of the automobile. For this reason, the suspension can be subject to formation of cracks and fatigue damage, which causes the need for a fatigue analysis.

Taking into account the above-mentioned features there is a question about the possibility of using cheaper materials in the production of the lower arm and torsion shaft such as for the most loaded elements of the torsion double-lever suspension, when you save its ability to resist fatigue crack. By way of these materials are offer to use a cheaper steel, also employing in the automobile suspensions construction: 40X, 45.

This kind of tasks are successfully solved with the implementation of the finite element analysis by means of middle level of computer-aided design system (SAD), such as SolidWorks. So, in the work [3] was made a comprehensive study of the factors affecting on its fatigue destruction with the use as a photoelastic method for the life test using the Woehler durability diagram $\sigma - \mathrm{N}$, so as a displacement method, showing the best results when the stresses concentration can lead to the local accumulation of plastic strain. In the SolidWorks, chosen for this study, available to the photoelastic method only commonly used in the automotive industry. It should be considering that in the event of local stresses that are close in meaning to the yield strength of the material, the photoelastic method forecasts the service life is 3-4 times longer [4] than a displacement method and in the work [5] recommended for safety reasons during the photoelastic method use the limiting value cumulative degree of fatigue damage D=0,3 instead of D=1.

The photoelastic method is a classical method of grade fatigue useful life. Under this method the fatigue useful life depends first of all from loads, cyclical properties of the material, geometry and environmental features that are accounted the curve $\sigma - \mathrm{N}$. The relation between nominal stress amplitude and fatigue useful life, describing curve $\sigma - \mathrm{N}$, reduces to equalization [6]:

$$N_f = \left(\frac{\sigma_{-1}}{\sigma_a} \right)^m N_0 \tag{1}$$

where σ_a – stress amplitude; – number of cycles before the destruction; m – exponent, defined by a durability line in coordinates $\lg\sigma - \lg \mathrm{N}$.

The multiaxial state of stress usually arises in elements of real constructions. Most of the experimental data underlying the calculation of the fatigue life, obtained during the uniaxial symmetric loading. Therefore, to describe the use of the external action of the stress tensor components according to the dangerous point of time should execute the following algorithm: 1) make the transition from multiaxial to uniaxial state of stress; 2) schematize the history of loading reducing accidental loading to the regularly block; 3) consider the impact of the medium voltage based on a curve of ultimate amplitudes [7].

2. Results and Discussion

It was cleared up in this work [5] that the most contribution in damageability makes high-frequency loading, determined the road relief, so it is advisable to use the modeling dynamic technique utilizing real profiles of road and their models. The research was limited to the imitation of rectilinear motion on various types of roads with different, but constant rate. The mathematic model of automobile performance used for the obtain load spectrums of the structural elements, established in the FRUND medium [8]. In the design scheme of model includes major components, mechanisms and nodes inherent in the layout of the automobile. The disturbance of the road bears on the automobile through the tires, transmitting 3 powers and 1 stabilizing moment (about the vertical wheel axle). In the software package FRUND, which was worked out at the Volgograd State Technical University, Russia, spectrums of loading suspension were generated during operation on road surfaces: asphalt, smooth rubble, rubble with hollow spots and mounds, matching to roads proving ground NAMI (Russian proving ground, center for scientific research). Some spectrums used in this work are shown on the figure 1. In each case of loading used spectrums vertical and horizontal loading from the road, and also spectrum of compression load from shock-absorber. We considered four cases of loading, with three cases, using the generated spectrum for an asphalt, the