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ScienceDirect

Procedia Engineering 150 (2016) 318 – 323

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Industrial Engineering, ICIE 2016

Estimation of Truck Frame Fatigue Life under Service Loading

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Abstract

The article presents the methods for experimental and theoretical research of vibration loads and dynamic stresses of automobile frame. The comparative analysis of the finite element stress and acceleration is performed with SolidWorks and Ansys software with the use of resistive strain gages and g-meters data obtained during automobile road tests. Frame fatigue life calculation of using multibody dynamics model in FRUND software is given. Load-carrying structures of automobiles undergo external loads which are time- and frequency-variable, depending on velocity, current weight, road profile and other factors. Such loading mode provokes the occurrence of fatigue cracks, and their promotion can entail fracture. Thus, frames and load-carrying structures are subjects of cyclic loading tests purposed to estimate stress level and reliability of the structures and detect possible failures. The motion was considered for following road types: concrete road, smooth cobblestone road and special cobblestone profile. Road types and automobile velocities are corresponding to input data for dynamic simulation in FRUND multibody dynamics system.

Peer-review under responsibility of the organizing committee of ICIE 2016

Keywords: multibody dynamics; finite element method; frame analysis; fatigue life; spectrum loading.

1. Introduction

A pilot study of a frame is usually conducted on the durability route during the movement of the car or its running gear. At the same time data collection is made, namely tension and accelerations, it is allowed to estimate vibroloading and vibrointensity of a design. After the test, an analysis of a platform is carried out for existence of

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Peer-review under responsibility of the organizing committee of ICIE 2016
doi:10.1016/j.proeng.2016.07.020

damages by methods of nondestructive control. Having a sequence of ordinates of a microprofile, definitions on the proving ground can be replaced by bench tests of the car [2] and under known levels of loading they can be attached directly to a frame by using of rather simple system of servo mechanisms.

A theoretical research of the frame assumes the final and element analysis. In the absence of sequence of lading, it is resorted to a static final-element calculation. Levels of tension as a result of such calculation are usually a little higher, than in the process of analytical calculation, as the frame model for analytical calculation, which is consisting of straight beam of frame rails and cross-arms of simple direction, doesn't consider concentration of tension near openings, filleted corners, chamfered edges and other geometrical nonlinearities. However modern approach to an assessment of reliability of a frame means use of sequences of loading. In this case, a final-element calculation is passed in a format of solution to a quasistatic or dynamic task. The dynamic task demands considerable computing and time expenditure, besides, it can be solved rather precisely in heavy CAD, for example, in Ansys or in Abaqus. In view of bigger distribution of average CAD, for example, SolidWorks or Inventor, it is considered a quasistatic task during designing. However, regardless of a class of a task, existence of the sequences of loading, which are imitating loading of a frame during the movement on the road of a certain profile is required. The simplest solution of this problem is application of the standard ranges or sequences, which are received earlier for similar cars, but the accuracy of such research leaves much to be desired. It is the most rationally to receive sequence of loading by dint of program complexes of an assessment of dynamics, for example, Adams, FRUND or the Universal mechanism. Necessity is also caused by the fact, that loadings during the movement depend not only on a profile of the road, weight and speed, but also from the stiffness and inertial characteristics of a design [3].

2. Experimental

In the present paper the truck frame is an object of research. The ladder frame, riveted of stamped details, with internal amplifiers of side-members[4]. Side-members and amplifiers are made from low-carbonaceous high-strength steel DIN S600MC durability (thermally strengthened hire, σ_y=600 MPa), and cross-arms are made from low-carbonaceous steel 20GYuT (σ_y=480 Mpa).

It is supposed to use FRUND for receiving ranges of loading, [5] for an assessment of dynamics of the movement of the car - SolidWorks, and for calculation of tenability, fatigue life and accelerations of a frame of the car — Ansys [6]. The dynamic model of the car created in the FRUND program complex is shown in fig. 1. The frame model for final-element calculation is shown in fig. 2a.

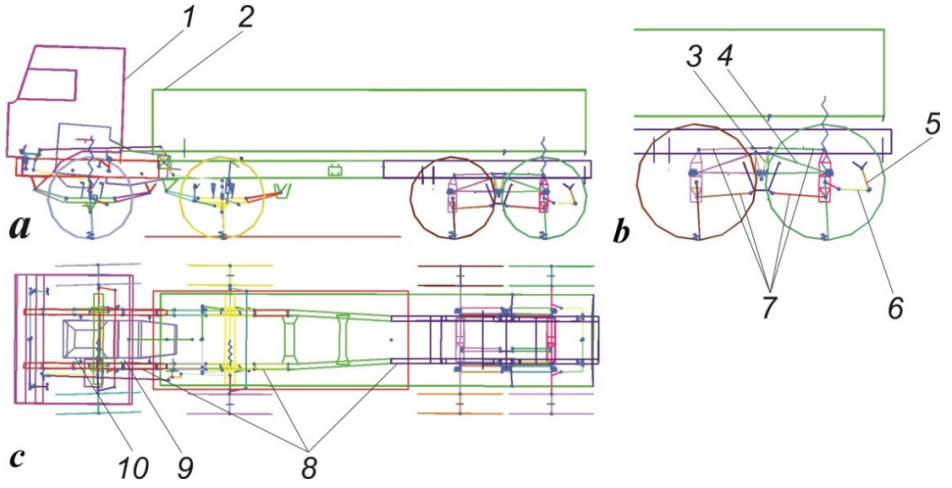

Fig. 1. Dynamic model of system of bodies of the truck in FRUND and it's basic elements: 1 – cabin; 2 – float body; 3 – equalizer beam; 4 – spring of the balance truck; 5 – lever of the back stabilizer; 6 – back stabilizer; 7 – torque arm of a bracket III and IV bridges; 8 – departments of the bearer frame; 9 – transmission; 10 – engine