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Energy Analysis of Vehicle Suspension Oscillation Cycle

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Abstract

This article is devoted to conducting the energy analysis of the oscillation cycle in vehicle suspension based on the research of the dynamics equations of the linear single-support single-mass vibrating system with fixed elastic and damping characteristics at harmonic kinematic disturbance. The characteristics of the relative energy flows in the oscillation cycle of the suspension, taking into account the shock absorber inefficient work are received. The physical meaning of the overall characteristic point to the series of the sprung mass amplitude-frequency characteristics is identified. Analysis of vibration isolation properties of the suspension on the sprung mass amplitude-frequency characteristics and the frequency characteristics of the total width of the suspension ineffective work areas in the oscillation cycle is carried out in the damping regulation on the inefficient work areas and on different damping levels.

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Keywords: energy; oscillation cycle; suspension; shock absorber; spring; sprung mass; inefficient work area.

1. Introduction

One of the most perspective ways of increasing the vehicles smoothness is to control characteristics of the suspension elements in oscillation cycle. At present there are different principles for regulation of stiffness of elastic element and power of inelastic resistance of damping element [1-24]. However, many of them do not have a physical justification for using these methods of changing suspension characteristics in the oscillation cycle. In [25-29] it is shown that the damper effect in oscillation cycle is characterized by the presence of two areas in which its action is aimed at increasing the speed and amplitude of sprung mass displacement. In this connection it is necessary to carry out the energy analysis of oscillation cycle in the vehicle suspension.

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2. Mathematical modelling

For execution the energy analysis of the oscillation cycle in the vehicles suspension we need to consider the linear single-mass singly-support vibration system with fixed elastic and damping characteristics at harmonic kinematic disturbance (Fig. 1).

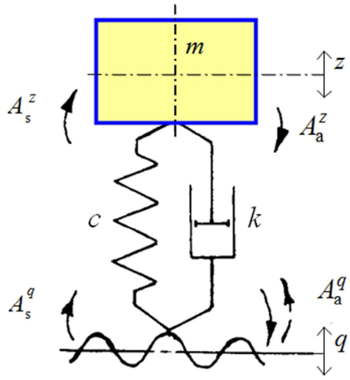

Fig. 1. Design scheme of energy flows in linear suspension:
m – sprung mass; *c* – stiffness of elastic element; *k* – inelastic resistance factor of damping element; *z* – displacement of sprung mass; *q* – kinematic disturbance; A_s^z and A_s^q – spring work to the coordinates *z* and *q*; A_a^z and A_a^q – shock absorber work on coordinates *z* and *q*.

The equation of the dynamics of this vibration system is as follows:

$$m\ddot{z} + k(\dot{z} - \dot{q}) + c(z - q) = 0 \quad (1)$$

where *m* – sprung mass; *k* – inelastic resistance factor of damping element (shock absorber); *c* – stiffness of elastic element (spring); *z* – absolute displacement of sprung mass; *q* – absolute displacement of disturbing ground (road surface irregularities).

After that it is necessary to consider the distribution of energy flows in oscillation cycle of linear suspension, taking into account the availability in oscillation cycle of inefficient work areas (IWA) of shock absorber [25-29]. Also we need to find out the physical meaning of the overall characteristic point *A* for the series of the sprung mass amplitude-frequency characteristics (AFC) of the absolute sprung mass displacement of the vehicle suspension (Fig. 2) [16].

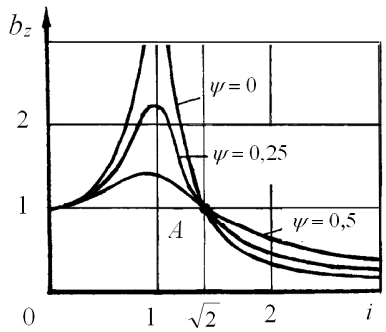

Fig. 2. The series of amplitude-frequency characteristics of the sprung mass vertical oscillations:
A – the overall characteristic point; *i* – relative vibration frequency; b_z – sprung mass dynamic factor; ψ – relative damping factor