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Comparative evaluation of the vibration isolation properties of a suspension with different flywheel dynamical absorbers of the car body oscillations

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Abstract

The article is researching the vibration isolation properties of a flywheel dynamical absorber of the vehicle body oscillations. It is noted that the authors have previously proposed additional flywheel dynamical absorbers with mechanical drives and it is proved that they have improved the vibration isolation properties of the suspension system. However, such dynamical absorbers are heavy. That is why there is being developed a flywheel dynamical absorber with hydraulic drive containing a hydraulic cylinder and a hydraulic machine with a flywheel. The theoretical research identifies the parameters of the hydraulic drive, providing the minimum value of the sprung mass oscillation amplitude in the area of low-frequency resonance, and it is found out that the flywheel dynamical absorber with the hydraulic drive features a lower suspension mass and better vibration isolation properties than the flywheel dynamical absorber with a mechanical transmission.

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Keywords: dynamical vibration absorber; flywheel; hydraulic machine; hydraulic cylinder; vibration isolation properties; car.

1. Introduction

In the monograph [1] published in 1976, it's referred to the using appropriateness of the dynamical vibration absorbers of the car wheels in the form of additional spring-loaded weight. Conducted theoretical and experimental research of such absorbers [2-12] showed their effectiveness. However, for damping car body oscillations such the dynamical absorbers are not applicable due to their large mass.

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The flywheel dynamical absorbers of the body oscillations in which the flywheel is driven in rotation by a mechanical transmission (Fig. 1, a) are proposed and studied in [12-24]. To avoid locking of the suspension at high frequencies in such a drive the clutch with optimal parameters is used [13-22]. In [23, 24] it is shown that to reduce the mass of the flywheel it’s necessary to increase the gear ratio of the mechanical transmission. However, it’s also increases the mass of the transmission, which limits the possibility of reducing the mass of the absorber as a whole. Finding ways to reduce the mass of the flywheel absorber of the body oscillations has led to the idea of using hydraulic machine, connected by pipelines with a hydraulic cylinder (Fig. 1, b) as a flywheel drive [16, 25-30].

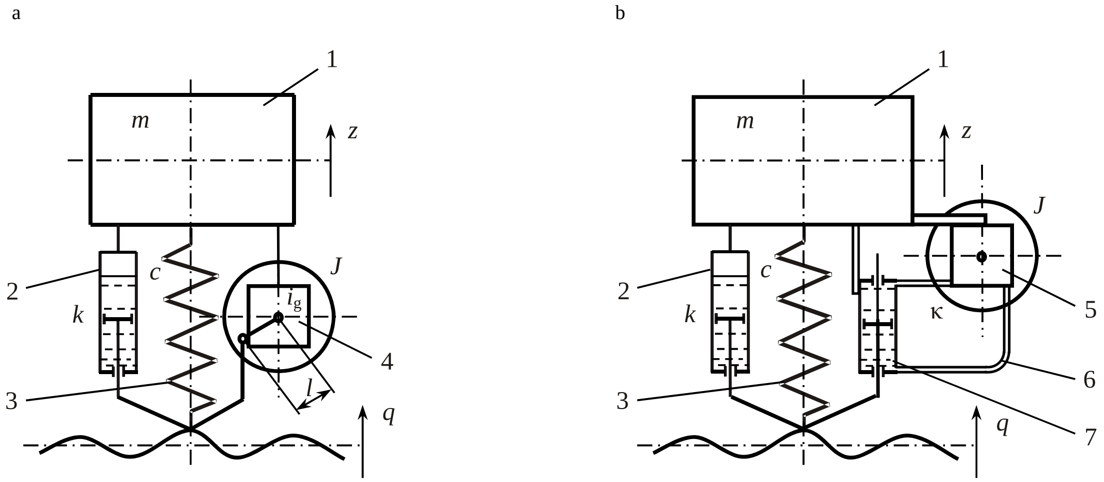

Fig. 1. (a) design schemes of suspensions containing flywheel dynamical vibration absorbers: with mechanical transmission of motion to the flywheel, (b) design schemes of suspensions containing flywheel dynamical vibration absorbers with hydraulic transmission of motion to the flywheel

This article is devoted to comparative evaluation of the vibration isolation properties of the considered flywheel dynamical absorbers.

2. Mathematical model

Any hydraulic machines have volumetric leakages. If we assume that the volumetric leakages of the working fluid in hydraulic motors and pumps are not available, so a constant volume (volume of fluid passing through the hydraulic machine during one revolution of the shaft) of the hydraulic machine is connected with the stroke of the piston in the cylinder by the dependence:

$$Q = F_a x_t \qquad (1)$$

where F_a is the cross sectional area of the annular cavity in the hydraulic cylinder of the vibration absorber, x_t is the stroke of the piston for one revolution of the flywheel.

The dependence of the flywheel rotation angle φ from suspension deformation x can be determined by the formula

$$\phi = 2\pi \frac{x}{x_t} = 2\pi \cdot F_a \cdot \frac{z-q}{Q} \qquad (2)$$

We denote a tranfer coefficient from the suspension deformation to the flywheel rotation: