Насимова Манижа Муминходжаевна
соискатель, преподаватель
Политехнический институт Таджикского технического университета
им. академика М.С. Осими
г. Худжанд, Республика Таджикистан

METHOD OF DETERMINATION OF THE SHOCK-SHIFTER SHIFT DEFORMATION OF COMPOSITE GEAR WHEEL TRANSMISSIONS

Аннотация*: в статье приводится новая схема и принцип работы зубчатой передачи с составными колесами, включающие амортизаторы-втулки из резины. Аналитическим методом получены формулы для расчета угловых сдвигов (деформаций) амортизаторов-втулок с учетом их толщины, модуля сдвига и параметров передачи.*

Ключевые слова*: зубчатая передача, амортизатор-втулка, сдвиг, момент, радиус, передаточное отношение.*

Abstract*: the article presents a new scheme and the principle of operation of the gear train with compound wheels including shock absorbers-bushes made of rubber. Analytical method was used to obtain formulas for calculating the angular shifts (strains) of bushing-bushings taking into account their thickness, shear modulus and transmission parameters.*

Keywords*: gear train, shock absorber-bush, shear, torque, radius, gear ratio.*

It is known that gears are widely used in technological machine drives [1]. The main disadvantage is the hard interaction of gears. A new gearing scheme was recommended (Pic.1), in which gear wheel 4 and gear wheel 1 are made composite. Gear 1 is installed on the shaft 2 by means of a shock absorber – sleeve 3, and gear wheel 4 is installed on the shaft 5 by means of a shock absorber sleeve 6. At the same time, the thickness of the shock absorber sleeves 3 and 6 are selected according to the gear ratio.

$$\Delta_1 = \frac{d_1 - d_1'}{2}, \quad \Delta_2 = \frac{d_2 - d_2'}{2},$$

Wherein

$$U_{12} = \frac{\omega_1}{\omega_2} = \frac{R_2}{R_1} = \frac{\Delta_2}{\Delta_1},$$

where, d_1, d_1'-the outer and inner diameters of the shock absorber sleeve 3 gear 1; d_2, d_2'- are the outer and inner diameters of the damper bush 6 of wheel 4, R_1 and R_2 are the radii of the main circles of gear 1 and wheel 4; ω_1 and ω_2 - the angular velocity of gear 1 and wheel 4; U_{12} gear ratio transmission.

Picture 2 presents the scheme for calculating the shear strain of the damper sleeve. When deriving the dependence of the angle φ_1 of rotation of the shock absorber sleeve on the magnitude of the external moment (driving moment on the shaft and, accordingly, the moment of resistance from the gear wheel when they engage), select a thin-walled tube with wall thickness and inner radius r in the sleeve. Due to the deformation of the rubber of this tube, the outer sleeve of the damper reinforcement rotates at a small angle, and for the shear angle of the rubber of the tube, the following equality holds [2]:

$$tg\gamma = \frac{\Delta\varphi_1 r}{\Delta r},$$

In this case, the shear surface area of the rubber of the selected tube:

$F = 2\pi rl$,

Where l – the length of the sleeve (gear).

The circumferential shear force acting in rubber is:

$$Q = GFtg\gamma = 2\pi rlG\frac{r\Delta\varphi_1}{\Delta r},$$

Where is G the shear modulus of rubber, N / m2.

The magnitude of the external rotating moment (from the shaft driving and from the wheel as the moment of resistance):

$$M_1 = Qr = 2\pi Glr\frac{3\Delta\varphi_1}{\Delta r},$$

From (5) you can get:

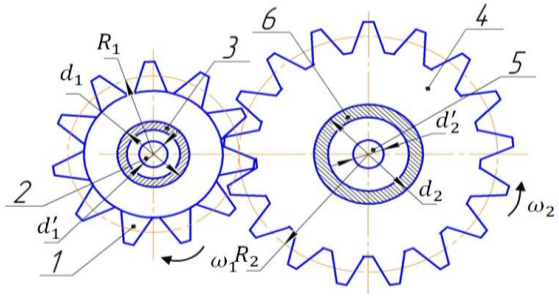
$$\Delta\varphi_1 = \frac{\Delta r M_1}{2\pi Glr^3}$$

Integrating (6) in the redistribution r_1' and r_1, can be obtained:

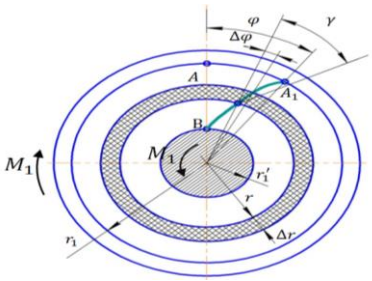
$$\varphi_1 = \frac{M_1}{2\pi G l}\int_{r_1}^{r_1}\frac{dr}{r^3} = \frac{M}{2\pi G l}\left[\frac{1}{2\,(r_1')^2} - \frac{1}{2\,(r_1)^2}\right] \quad (1)$$

Similarly, an expression can be obtained to defineφ_2:

$$\varphi_2 = \frac{M_2}{4\pi G l}\left(\frac{1}{r_2'^2} - \frac{1}{2r_2^2}\right) \quad (2)$$



Pic. 1. Gear transmission with compound rings and gears, including shock absorber bushings

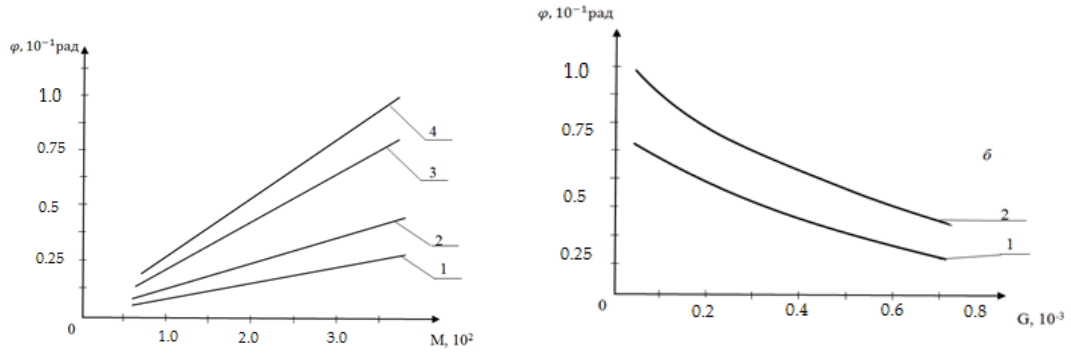


Pic.2 Scheme for calculating the shear deformation of the shock absorber sleeve of the gear gear

Based on the numerical solution (1) and (2) according to the following source data, M_1 = 8.2H, M_2 = 6.3Нм, π = 3.14, l = 24.2·10^{-3}м, r_1=3.8·10^{-2}м, r_2=5.6·10^{-2}м graphical dependences of changes in the deformations of the angular shift of elastic rubber bushings of gear gears on the variation of the values of the shear modulus of rubber and external torques (Fig. 3) are constructed.

An analysis of the graphical dependences shows (Fig. 3a) that with an increase in external moments M_1 and M_2 an increase in the deformations of the angular displacements of the rubber bushings of gear wheels, it is linear. So, with an increase M_1 and M_2 from 0.062·10^{2}Нм to 0.37·10^{2}Нмφ_1 increases from 0.094·10^{-1} to 0.24·10^{-1} when r_1=2.1·10–^{2}м, а при r_1=3.2·10–^{2}м, the angular shift increases up φ_1 to 0.402·10^{-1}.

Accordingly, for an elastic rubber sleeve, φ_2-the gear increases up to 0.71 · 10–1rad with r2 = 3.8 10^{-2}m, and with r2 = 5.0 10^{-2}m, φ2 = 1.03, · 10^{-1}.



Pic.3. Graphic dependences of the change in the deformations of the angular displacements of the shock absorbers-sleeves of the gear and transmission wheel from the variation of the torques on the shafts (a) and the shear modulus (b)

To reduce the impact interactions of the teeth when meshing due to large values and acceptable values of external moments are

Findings. Developed a new gearing scheme with compound wheels with rubber bushings. The analytical method obtained expressions for the calculation of the deformation of the angular displacements of the rubber bushings. Graphic dependences are built and transmission parameters are justified.

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