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Modeling Tractive Effort Torque of Wheel in Deformation Movements of Pneumatic Tire Wheel

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Abstract

The article is devoted to the simulation of torque moment through the deformation motion of the pneumatic wheel. Despite the fact that the dependence of torque moment of the vehicle from the slip value which can be interpreted as a vertical and angular deformation of pneumatic wheels, has been well studied, there are no adequate mathematical models. The article presents the results of a mathematical model and its numerical simulation which leads to the conclusion about the validity of the proposed approach for the description of the appearance of deformations in the pneumatic wheels and their connection with the vehicle driving torque. The mentioned three-dimensional interpretation of the simulation results is broadly consistent with the results of the experimental data.

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Keywords: Model; deformation; torque moment; contact patch.

1. Introduction

The peculiarity of the interaction of the vehicle with the environment, is that this interaction, except for the effects of aerodynamic losses occur in the comparatively small area formed between pneumatic wheels loaded with the radial force of the vehicle and a support. The mentioned contact area (*contact patch*), has different forms for different versions of vehicles and their wheels [1-7], but the main effects associated with the formation of the contact area and its destruction when the vehicle is moving, are the same.

The main active force, resulting in the movement of modern vehicles is a motive force, which is realized in the contact wheel and the road surface. The peculiarity of the formation and evaluation of the action of this force is that

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it seems as a complicated non-linear function in the coordinates which characterizes the speed of the vehicle. The difference between the present angular velocity of the wheel and the speed of the vehicle, referred in the English-language sources as creep, is the argument of this function. However, this experimental approach [8,9], and interpolative modeling of these characteristics [10,11] still requires interpretation in the coordinates of the vehicle wheels.

In modeling of processes in machine tools, there is a widespread approach to the description of the power reaction that occurs in the cutting zone – an integral operator from a superposition of the tool speeds relative to the workpiece [12-20]. In this study we have attempted to use this approach for modeling the processes occurring in wheeled transport systems.

2. Basic mathematical model

It should be noted that the mechanics also distinguishes coefficients of static friction (static) and slipping (kinetic). In actual cases of friction the total characteristic can be close to the meaning, represented by figure 1.

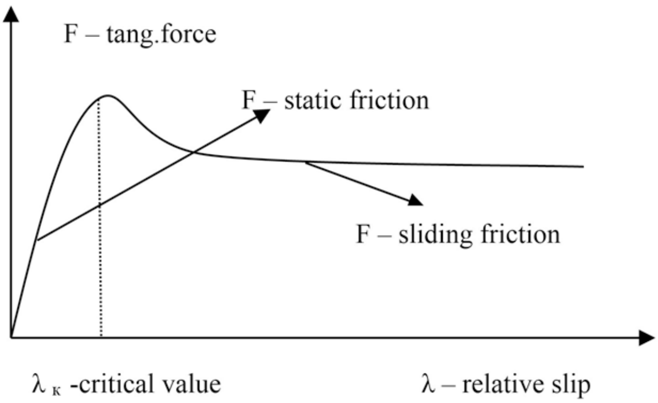

Fig. 1. The dependence of friction force upon the relative slipping.

Presented in Figure 1, the friction characteristic is very general, but at the same time it is quite a good illustration of the processes occurring in the contact of interactive surfaces. This characteristic can be explained as follows: if two contacting bodies, the contact of which is caused by some applied pressing force, exert another force in tangential direction, then there will begin a relative motion of the bodies, which in Figure 1 is denoted as λ, the result of this process will be the occurrence of forces opposing this motion. At the initial time this opposition and this movement will occur within the elastic changes in contact until the time when the relative motion does not exceed the critical value (λ to -critical value), the value of the tangential force at this point is called a force of frictional rest (static friction). After passing the point which characterizes the critical value of slipping, then the value of the frictional force is falling and friction coefficient, which with all other incremental values λ does not change and it is commonly referred to as a coefficient of slipping friction.

The contact patch appears as a result of the vertical deformation of the wheel base at the point of its contact with the road [1-7]. This results in some area of contacting surfaces, the size of which will depend on the normal applied load to the wheel and its radial stiffness. For the case of the vehicle, the normal static wheel load is less than that for the train wheel, but still the radial stiffness of a wheel is even less, than the contact patch is greater than in the case of rail.

From the standpoint of the formation of the control of movement of vehicles, the peculiarity of which will be a relative sliding of the wheel along the way, the angular interpretation of the contact patch, shown in Figure 2, is of great interest.