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ANTI-SLIP WHEEL DEVICES

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RESEARCH ARTICLE

ABSTRACT: Slippage of wheeled and tracked vehicles negatively affects the operation of transmission elements, increased tread wear. Existing methods and means of combating slippage are widely known at the present time: the use of twin and widened wheels, the installation of spikes, putting on chains, lugs, etc. The traction control device proposed by us is activated only at the time of slipping. In normal mode, it is easily placed on the wheel disk, repeating with the lower end the envelope surface of the wheel tread. The weight of the device is 2 kg. Calculations have shown that to ensure the movement of the wheel on loose soil without slipping, the proposed device is placed in an amount of 2 to 6 pcs. in diametrically opposite ends of the wheel, protruding beyond the surface of the tire. Their number can be regulated by pneumatic actuator.

KEY WORDS: *slip, wheel, vehicle, device*

UREĐAJI PROTIV KLIZANJA TOČKOVA

REZIME: Proklizavanje vozila sa točkovima i gusenicama negativno utiče na rad elemenata sistema prenosa snage i povećano habanje gazećeg sloja. Postojeći načini i sredstva za suzbijanje klizanja danas su široko poznati: upotreba dvostrukih i proširenih točkova, ugradnja eksera, stavljanje lanaca, ušica itd. Uređaj za kontrolu proklizavanja koji smo predložili aktivira se samo u slučaju klizanja. U normalnom režimu rada lako se postavlja na disk točka, poravnavajući se sa donjim krajem površine omotača gazećeg sloja točka. Težina uređaja je 2 kg. Proračuni su pokazali da se za osiguranje kretanja točka na rastresitom tlu bez klizanja, predloženi uređaj postavlja sa 2.do6 kom. na dijametralno suprotnim krajevima točka, koji su ispupčeni izvan površine pneumatika. Njihov broj se može regulisati pneumatskim aktuatorom.

KLJUČNE REČI: *klizanje, točak, vozilo, uređaj*

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INTRODUCTION

When moving tracked or wheeled vehicles off-road, due to the low grip of the wheel with the ground or snow, slippage increases, which makes the use of the machine ineffective or completely impossible. Slippage occurs when the traction force exceeds the force of adhesion of the wheel or track to the surface of the road or ground. Slippage can begin after an increase in torque or a decrease in adhesion associated with a change in the properties of the road surface (layer of water, dirt, ice) and wheel load (usually due to maneuvering) (fig. 1).

Figure 1 Towing of wheeled and tracked vehicles

Slippage leads to the failure of the transmission elements. This is due to the fact that when stalling, the engine of the machine works at high speeds, leading to overheating of the flywheel of the engine (clutch) and gearbox (boxes), gearboxes, friction pads (Fig. 2), failure of the cardan shafts (Fig. 3). Given the fact that when slipping, as a rule, the angular speeds of rotation of the wheels are different, there is a failure or failure of the gears of the differential, which are not designed for a large difference in wheel speeds.

Figure 2 Fracture and overheating of the pressure disc with constant slippage of the clutch

Figure 3 Failure of the driveshaft

To bring the machine into a state of motion when stalling, the power of the engine is not enough, so various methods and devices are used to increase the useful power of the engine.
One of the directions for improving the adhesion characteristics of wheeled vehicles (CTS) is the use of various techniques, as well as the modernization of mechanisms and systems in order to increase the installed engine power in useful operation. In addition to this drawback, slipping leads to wear of the tread and its replacement, which entails significant economic costs. For example, for machines widely used in forestry and agriculture [1, 2, 3, 4], arched and twin tires are used [5, 6], or wide-profile tires comparable to a twin wheel are used, installed instead of conventional ones, which increase the permeability of the machine on soils with low bearing capacity, during the spring-autumn mudslide and snow drifts.
With twin tires, the second wheel is installed using a special spacer that provides a gap between the sidewalls of the tires. In addition to such a time-consuming solution, the most common is the method of changing the pressure in the tires, leading to an increase in the spot of contact of the wheel with the road.
Sometimes, to increase adhesion on pneumatic tires, a half-track stroke is installed, the weight is increased by attaching additional cargo (water cylinders, metal) [7]. A theoretical confirmation of this technique is that the grip strength of the PCC depends on the coupling weight of the Gk car, i.e. the vertical load on the drive wheels. (The greater the vertical load, the greater the grip force):

$$P_{fa} = \varphi G_k, \quad (1)$$

whear P_{fa} – the force of adhesion of the wheels to the road, H;

- φ – coefficient of adhesion;
- G_k – coupling weight, N.

The condition of movement without towing of the wheels $P_k < R_{fa}$, i.e. if the traction force Pk is less than the clutch force of the Rsc, then the driving wheel rolls without slipping. If a pulling force greater than the clutch force is applied to the drive wheels, then the car can only move with the drive wheels slipping. As soon as the traction force exceeds the adhesion force, the wheels will rotate around their axis and the vehicle will stand still. This method has the disadvantage associated with the fact that with an increase in mass, the depth of the track and soil compaction increase. To reduce the depth of the track, jacks are used, raising the wheels by the amount of their separation from the soil. The adhesion coefficient is also affected by the tread pattern of the tire [8].
With a complete slip of the tire on the road (slipping of the drive wheels or the south of the braking wheels), the value of the f can be 10 ... 25% less than the maximum. The coefficient

of transverse adhesion depends on the same factors, and it is usually taken to be equal to 0.7φ. Average adhesion coefficient values range widely from 0.1 (icy coating) to 0.8 (dry asphalt and cement-concrete pavement). To avoid slipping of the drive wheels when driving in first gear, the following inequality must be met:

$$\frac{M_{max}\eta u_1 u_2 u_3}{G_a r_k} \leq D_{сц} = \frac{m_{p2} G_{a2} \varphi_x}{G_a} \quad (2)$$

where M_{max} – torque on the drive wheels, N·m;

- η – coefficient of efficiency;
- G_a – total weight of the car, H;
- r_k – static radius of the wheel, m;
- u_1 – transmission gear ratios;
- D_{fa} – dynamic factor of the car in grip, m;
- m_{p2} = 1,20…1,35 – coefficient of change of reactions on the rear drive wheels;
- G_{a2} – the weight of the car falling on the rear wheels of the car with a full load, H;
- φ_x – coefficient of adhesion of the wheel to the road.

TECHNIQUES TO REDUCE WHEEL SLIP

Various tricks to reduce wheel slip were taken from the personal experience of drivers. These illustrations are borrowed from Internet resources. To exclude the possibility of slipping when starting from a standstill on deep snow, you should choose in advance a lower gear that would exclude stopping the vehicle. As a rule, to bring the machine out of a state of rest, the force of two three people is used, who, simply put, push the machine out. Or the simplest and most commonly used is digging up the machine with a regular shovel. Often, in order to pull out the machine, the method of a rope-block device is used, where instead of blocks, free-standing trees and a cable are used (Fig. 4).

Figure 4 Method of using the rope-block device

To increase traction, various devices installed on wheel tires (fig. 5) are also widely used, increasing the tread depth (spikes (fig. 5, a), chains (fig. 5, b), linings (fig. 5, c)).

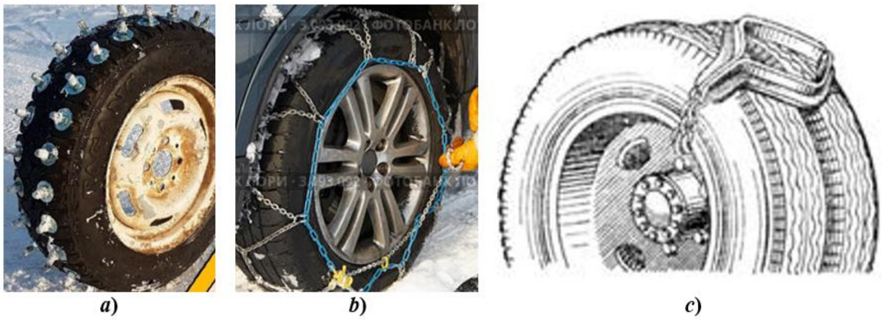


Figure 5 Devices for increasing adhesion

DEVICES TO REDUCE WHEEL SLIP

The device is already the principle of upgrading the wheels to reduce their slippage. They are removable (Fig. 6) and stationary.


Figure 6 Removable devices to reduce begging

To increase the grip and cross-country ability of the vehicle with ease of manufacture and increase reliability, a wheel with retractable lugs is used (Fig. 7) [9].

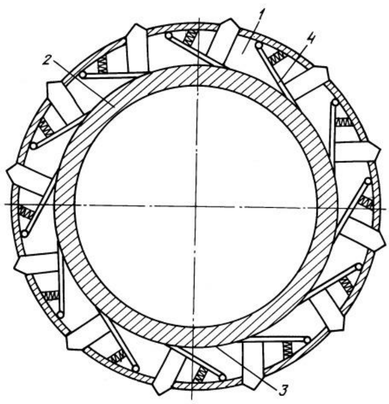
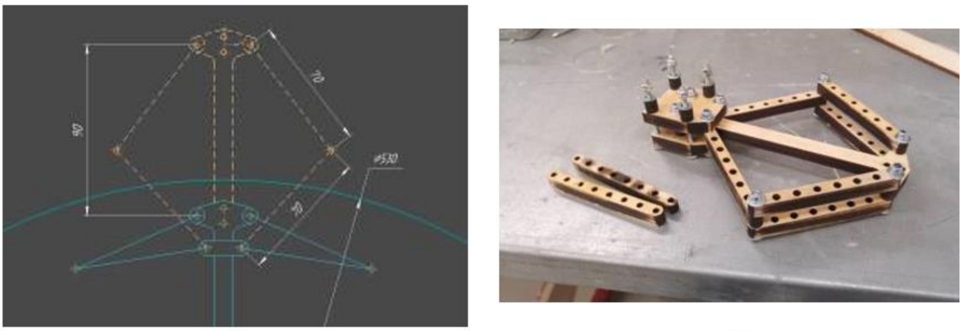


Figure 7 Device to increase the adhesion and cross-country ability of the vehicle

In the device (Fig. 7), the auxiliary wheel 1 with retractable hooks is made in the form of a hollow equiradial drum type wheel 2 of a light alloy material, which is attached to the main wheel 3 and contains hinged shoulder arms 4 hinged at points on the inside of the outer periphery of the wheel, spring-loaded at point 1/3 of the total length. Between the pneumatic chamber and the shoulder arms of the lugs is installed a protective metallized rubberized ring with a thickness of at least 1.5 cm with a width corresponding to the width of the working drum of the wheel. The rim of the wheel and lugs are equipped with holes in which studs are inserted to fix the hooks. The working part of the lug can be made in the form of spikes of various profiles (balls, cones, cylinders, etc.). They are usually located on the periphery of the clip installed on the rim of the wheel. When the wheel moves on loose ground, the value of the shear and cut forces increases. Obviously, when the driving wheel moves, its lugs shift and cut the ground in the direction opposite to the movement. Stopping the lugs in the ground, shearing and cutting are possible only with the full use of frictional forces, i.e. when there is a slippage of the wheel. We offer a traction control device, presented in Fig. 8.



a) *b*)

Figure 8 Traction control device offered by the authors

The device offered by us refers to the chassis on a pneumatic course and is designed to reduce wheel slip. A pneumatic cylinder is fixed to the wheel hub, to the piston of which a fixed guide is attached in the piston cavity, moving freely through the hole, and on the guide there is a hub rigidly fixed to the guide, to which the rods are attached with free ends and, the other free ends of which are connected respectively by hinges and with rods and, the free ends of which are connected by a hinge to the guide, and on the guide in the piston cavity between the inner the base of the hydraulic cylinder a and the piston are an elastic element. It is activated only at the time of stalling. In normal mode, it is easily placed on the wheel disk, repeating with the lower end the envelope surface of the wheel tread. Weight of the device – 2 kg. Consider the operation of the lug when slipping. At the moment of slipping during the transmission of the driving torque, the axle of the wheel moves some distance back, which leads to a decrease in the translational speed of the wheel. The reason for this is the direct movement of the points of the wheel on the supporting surface of the soil when the lug leaves it and moves to the surface of the wheel. At this point, the lugs are located in the ground at different depths, which leads to uneven ground shear forces under the lugs.

Extension of lugs is possible due to an additional pneumatic drive device when air is discharged from the wheel. Calculations have shown that in order to ensure the movement of the wheel on loose soil without slipping, the proposed device is placed in an amount of 2 ... 6 pcs. in diametrically opposite ends of the wheel, protruding beyond the surface of the tire.

CONCLUSIONS

To combat towing of wheeled vehicles, the most effective means are additionally installed on the wheel removable or stationary traction control devices, manufactured at the suggestion of the authors and allowing to increase adhesion to the ground and bring the machine out of the stalling mode.

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