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TRACTOR AND VEHICLE STABILITY

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Abstract
The stability of mobile power units (MPU) is characterized by their ability to operate on longitudinal and transverse gradients without overturning and sliding. In this regard, a distinction is made between longitudinal and transverse stability. Rolling of a wheeled tractor standing on an uphill slope is prevented by braking force Ptand rolling resistance moment, Various ways of increasing not only longitudinal stability, but also controllability of MPU are used, such as reducing the vertical coordinate of the center of gravity ts (in the case of low-clearance tractors), attaching weights to the front of the tractor, increasing the longitudinal base of machines, and to increase af - drive all wheels from the transmission.

Keywords: Stability, overturning, parking brakes, overturning

Introduction

Longitudinal stability. The stability of MPU is characterized by their ability to operate on longitudinal and transverse gradients without tipping and sliding. In this connection there is a distinction between longitudinal and transverse stability. Rolling of a wheeled tractor standing on a rise is prevented by the braking force $P_т$ and rolling resistance moment L_T, its overturning can occur around the point O_2 (Fig. 1, a) provided that the front wheels are completely unloaded and the weight is taken up only by the rear wheels. Thus, as a criterion of static longitudinal stability against overturning on an uphill slope, the value of normal soil reaction on the front wheels is taken, which must satisfy the condition $У_п>0$.

The maximum static lift angle a_{Um} is the largest lift angle at which the machine can stand without tipping over.

The equilibrium equation of moments with respect to the point O_2 at M_{fK}~0 has the form:

$$G_a \cos \propto_{lim} = Gh_s \sin \propto_{lim} \qquad (1)$$

where a – is the longitudinal coordinate of the center of gravity; h_u – is the vertical coordinate of the center of gravity; whence

$$tg \propto_{lim} = \frac{a}{h_s} \qquad (2)$$

It is obvious that the tractor overturning will start when the vector of gravity force G passes to the left of point O, and the moment $G\cos\propto_{lim}$ will take a negative value.

The limiting static slope angle is the angle $\propto_{lim}$ (Fig. 1, b) corresponding to the tractor position at $Y_п = 0$. The force diagram and other conditions are similar to the case when the tractor is standing on an uphill slope.

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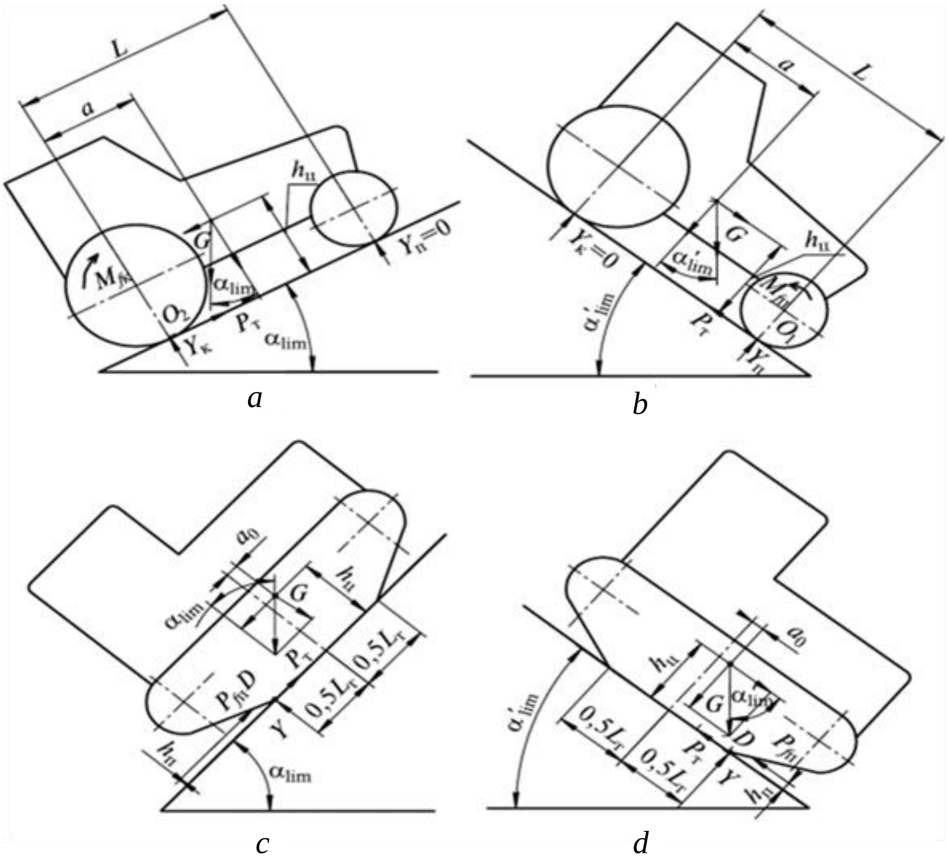

Fig. 1. Scheme of forces acting on the stopped tractor: *a* - wheeled tractor on the limit rise; *b* - the same, on the limit slope; *c* - crawler on the limit rise; *d* - the same, on the limit slope; hп - shoulder of force application

Let's make the equation of equilibrium of moments with respect to the point

$$G(L-a)cos \propto_{lim} = Gh_s \sin \propto_{lim} \quad (3)$$

where

$$tg \propto_{lim} = \frac{L-a}{h_s} \quad (4)$$

From the expressions $tg \propto_{lim}$ and $tg \propto'_{lim}$, we can see that the limiting angles of lift and slope depend mainly on the position of the tractor's center of gravity. The lower the center of gravity, the more stable the tractor and vehicle are. The further the center of gravity is from the tipping point, the more stable the vehicle is from tipping.

For tractors of wheel formula 4K2 and cars with cargo in the body $\propto_{lim}$ = 35...40°, $\propto_{lim}$ = 60°.

The largest angle of ascent and gradient at which the braked vehicle can stand without sliding is denoted by afand $a_ф$ and a'. The limiting position on the rise from the conditions of sliding is characterized by the equality of the component of the gravity force (Ysin∝ and the traction force of the braked wheels with the soil. The parking brake system is usually a central brake integrated in the transmission and acting only on the drive wheels. Then the force preventing the tractor (vehicle) from sliding down will be equal to the ultimate grip force of the driving wheels with the

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soil or road, i.e.

$$P_{\varphi} = Y_k \varphi = G cos \propto_{\varphi} \gamma_T \varphi \quad (5)$$

where $Y_{T,}$ – is the load factor of braking wheels, equal to the ratio - G (γ_T – is the weight applied to the braking wheels). The equation of equilibrium of a retarded machine has the form

$$G sin \propto_{\varphi} = G_T \gamma_T \ cos \propto_{\varphi} \varphi \quad (6)$$

or tg∝ =A-T_{cp} (uphill) and tg∝=XT(downhill). For a tractor or vehicle with parking brakes on all wheels, = *I.* If the parking brakes are applied to the rear wheels only, < 1. In this case on the rise the limiting angle from the condition of tractor sliding is higher than on the slope, i.e. $\propto'_{\varphi} > \propto_{\varphi}$. The physical meaning of this phenomenon is that on the rise the braking rear wheels of the tractor are unloaded by the normal force, and on the slope they are unloaded from it. When the wheels are overloaded, their grip force increases, and when they are unloaded, it decreases.

At the tipping limit slope ($\propto_{lim}$) the tractor cannot be held against sliding by its own brakes, because the rear wheels do not have the traction force necessary for holding the tractor ($Y_K = 0$).

A tractor or vehicle with parking brakes on all wheels has the same traction on uphill and downhill grades.

The coefficient of adhesion $\phi_к$ asphalt road is 0,6...0,8. Consequently, for a machine equipped with brakes on all wheels, the limiting angle from the condition of longitudinal sliding $\propto_{lim}$=31...39°.

The longitudinal stability of the crawler tractor is determined by the position of the center of pressure relative to the crawler chain. For a tractor with semi-rigid running system braked without a trailer, the limiting angle of lift will correspond to the position when the center of pressure D (Fig. 1, c) moves to the rear edge of the track support surface. On a slope, the stability limit state will occur at the moment when the center of pressure is located at the front edge of the track support surface (Fig. 2 d).

The equation of moment equilibrium with respect to the tractor's center of pressure, respectively, on an uphill and downhill slope can be written as follows:

$$G(0.5L + a_0) cos \propto_{lim} = G h_s sin \propto_{lim}$$

$$G(0.5L - a_0) cos \propto_{lim} = G h_s sin \propto_{lim}$$

From where

$$tg \propto_{lim} = \frac{0.5L_T + a_0}{h_s} \quad (7)$$

$$tg \propto_{lim} = \frac{0.5L_T - a_0}{h_s} \quad 8)$$

As can be seen from these expressions, the limiting static angle of longitudinal stability of a caterpillar tractor on a slope is smaller than on an uphill slope. This is due to the fact that crawler tractors are designed in such a way that its center of gravity is displaced relative to the center of

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pressure forward by the value $\propto_0$ (see subsection 2.9).

If the angle of elevation or slope exceeds $\propto'_{lim}$ and $\propto_{lim}$, the tractor will turn relative to the outer edge of the track at point D until the front or rear inclined branch and the guide or drive wheel strike the ground.

Limit angles of $\propto'_{lim}$ and $\propto_{lim}$ of longitudinal stability of tractors with two-axle balancer suspension are determined in the position when the center of pressure moves to the middle of the carriage. It is assumed that tipping of such a tractor occurs around the axis of the balancer. Therefore, in expressions for determining the limiting tilt angle L_T is replaced by L_K - longitudinal base of the balancer carriages.

Tractors with semi-rigid suspension are more stable (at $\propto_{lim}$ =35...45°) than tractors with suspension. ($\propto_{lim}$=35...45°). Tracked tractors have high traction properties due to the developed soil contact patch surface and low pressure q.

Their anti-slip stability is higher than the longitudinal tipping stability. It is therefore sufficient to check only the tipping stability . When parking on an uphill (or downhill) slope, braking is performed by both brakes of the slewing gear, if there is no parking brake.

The considered indicators affecting the ultimate stability of vehicles refer to their static state. During movement, stability is additionally influenced by: rolling resistance moment (or force) M_{fK}; hook pulling load $P_{кр}$; weight of the transported attached machine or part of the weight of the working machine, transferred by hydraulic loading devices to the rear wheels of the tractor; inertia forces arising from uneven movement. Angles of elevation (or slope) at which the stability of machines is violated are called critical acres. As a rule $\propto_{lim}$

Various methods are used to increase not only longitudinal stability, but also controllability of MPU. These are reduction of vertical coordinate of the center of gravity (in case of low-clearance tractors), attaching weights to the front of the tractor, increasing the longitudinal base of machines, and to increase $\propto_{\varphi}$ - all wheels are driven from the transmission.

Conclusions

The stability of MPU is characterized by their ability to operate on longitudinal and transverse gradients without tipping and sliding. In this connection there is a distinction between longitudinal and transverse stability. Rolling of a wheeled tractor standing on an uphill slope is prevented by braking force $P_т$ and rolling resistance moment.

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