Decrease of dynamic loads in mobile energy means

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Abstract. The increase in the productivity of machine and tractor units is possible due to the increase in operating speeds, this leads to the emergence of increased dynamic loads in the system "engine-transmission-propulsion unit-soil", which worsens the performance of machine-tractor aggregates. To reduce fluctuations in the "engine-transmission" system, special vibration dampers are used, which installed in close proximity to the engine and protect well the transmission from uneven engine operation; however, such dampers practically do not eliminate the oscillations of external loads. Reducing dynamic loads on the transmission and the mobile power engine (MPE) is an important issue directly related to improving the performance, reliability and durability of the tractor, as well as reducing the slippage of the drive wheels. In order to reduce effectively dynamic loads on the transmission and on the MPE, it is necessary to introduce resilient damping elements closer to the sources of oscillations, namely, to the driving wheels. At the same time, the elastic-damping element should provide accumulation of vibration energy caused by external influences and have a large energy capacity. The installation of an elastic-damping element in the final link of the tractor transmission ensures a reduction in the magnitude of external influences, thereby protecting the engine and transmission from large dynamic loads, and allows one to reduce the slippage of the propellers, which has a positive effect on the traction and energy characteristics of the tractor. Traction tests of the LTP-55 tractor on a concrete road showed that the use of an elasto-damping drive makes it possible to increase the maximum tractive power from 33.5 to 35.3 kW and to reduce the slipping of propellers by 12-30%, the specific fuel consumption by 6-10%. When driving on stubble, the use of an elastic-damping drive increases the maximum tractive power from 25 to 26 kW, reduces the skidding of propellers by 10-28%, and the specific fuel consumption by 10-12.5%.

1. Introduction

The increase in the productivity of mobile power engines (MPEs) due to increased engine power and operating speeds causes additional dynamic and resonant loads in the transmission, adversely affecting both power performance and acceleration and braking performance. At the same time, it is difficult to realize the capabilities of MPEs, primarily in terms of coupling properties and reducing the destruction of soil by propulsors.

To improve the overclocking qualities of MPEs, to eliminate dynamic and resonant modes in the transmission and to reduce the effect of the uneven traction of the aggregates and the rolling surface roughness, it is advisable to introduce an elastic-damping drive (EDD) closer to the driving wheels [1-5].
Let us analyze the most promising elastic-damping drives that were installed on experienced tractors. The design of wheel drives in the form of a torsion is known, which was installed at the MPE of Minsk Tractor Plant. Torsion connects the final drive with the wheel disc. The disadvantage of this design is the large dimensions, linear characteristic of the torsion landing on the hard stops, which causes dynamic loads in some modes.

Voronezh State Agrarian University named after Emperor Peter I together with the Lipetsk Tractor Plant developed a series of EDD, built into the final gears, as well as the semi-axle MPE. These drives were implemented on separate lots of tractors LTP-55.

Figure 1 shows the final drive gear with EDD. Outer crown 1 is mounted on splined hub 2 with the possibility of rotation relative to each other due to the deformation of bracket springs 12 and elastic members 7 installed in recesses 8 and 9 between the hub and the ring gear. Springs 12 have support ends 13. Inside springs 12, additional springs 14 are installed. The presence of spring packs 12 and 14 provides a non-linear characteristic of the EDD.

When the torque is transmitted from the final drive gear to toothed ring 1, elastic members 7, 12 and 14 are compressed, and toothed crown 1 is rotated relative to hub 2. After springs 12 and 14 are compressed, support ends 13 come into abutment against the stop. thrusters at starting, and at the moment of dispersal of the tractor to give the stored energy by elastic elements 7, 12 and 14 of semiaxis 1.

Damping of vibrations in the on-board transmission during the movement is due to internal friction in the packages of the bracket springs 12, 14 and external friction at the points of contact of the elastic elements during the rotation of the ring gear 1 relative to the hub 2. This allows one to reduce dynamic loads in the engine-transmission-engine system, slippage of propellers, to increase the accelerating qualities of the tractor unit, which increases productivity, and therefore efficiency and reduces fuel consumption. Similarly, this EDD can be installed in the planetary reducer of the final gear.

**Figure 1.** Final transfer of tractor LTP-55 with EDD: 1 - crenellated crown; 2 - the hub; 3 - semiaxis; 4 - splines; 5, 6 - bearings; 7 - rubber elastic elements; 8, 9, 10, 11 - notches; 12 - bracket springs; 13 - supporting ends; 14 - additional springs; 15 - fixing plates.
The hydraulic drive hydraulic actuator not only reduces the dynamic loads in the transmission components, but also allows the accumulation of energy during braking and starting. Such EDD is supplied with additional gas-hydraulic accumulators.

The gas hydraulic EDD consists of hub 2 on which driving wheel 1, two gas-hydraulic accumulators 11 and 17 are fastened, as well as the hydraulic valves of direct 22 and the reverse action 23. Hub 2 is mounted on the drive axle on the bearings. Inside hub 2 has a cavity divided into two parts 4 and 5 by blade 6 connected to driving semi-axis 3. On both sides of blade 6, there are fixed soft rubber stops 7 and 8 and on the supporting surface of hub 2, there are also rubber stops made in the form of bellows 9 and 10. Gas-hydraulic accumulator 11 is divided by two diaphragms made of rubber into three cavities 12, 13 and 14. Two cavities (12 and 13) are connected by hydraulic lines 15 and 16 to cavities 4 and 5, and cavity 14 between the diaphragms is gas. Gas-hydraulic accumulator 17 is divided by a diaphragm into gas cavity 18 and cavity 19 connected by hydraulic lines 20 and 21, respectively, to the hydraulic valves of direct 22 and backward action 23. In the hydraulic valves, there is a rod with two pistons spring-loaded with spring 24, one of which is movable on the rod.

![Figure 2](image_url)

Figure 2. A gas-hydraulic elastic-damping drive of the driving wheels of tractor LTP-55: 1 - wheel; 2 - the hub; 3 - semi-axis; 4, 5 - the cavity of the hub; 6 - the blade; 7, 8 - rubber stops of the blade; 9, 10 - rubber stops of a nave; 11 - two-chamber gas accumulator; 12, 13, 19 - hydraulic cavities of gas-hydraulic accumulators; 14, 18 - gas cavities of gas-hydraulic accumulators; 15, 16, 20, 21 - the hydro-highway; 17 - single-chamber gas accumulator; 22 - direct hydraulic valve; 23 - return hydrovalve; 24 - the spring.

When starting, a torque is applied to driving axle 3 and blade 6 is applied to the working fluid of cavity 4 and guides it along line 15 to cavity 12 of gas accumulator 11 and hydro-valve 23 of the reverse action. In this case, the working fluid is expelled from cavity 13 of gas accumulator 11 and flows along line 16 to hub cavity part 5. At the initial moment of the action of blade 6 on the working fluid of cavity 4, the liquid flows over line 15 into cavity 12 of gas accumulator 11 and compresses through the diaphragm, the gas is found in chamber 14. With further rotation of blade 6, the working fluid pressure, bones increases significantly and opens hydrovalve 23 of the reverse action by compressing spring 24, while the liquid flows through line 21 into cavity 19, compressing the gas in cavity 18, this allows the accumulation of energy. At the end of the start and the beginning of the tractor's acceleration, the driving torque acting on axis 3 and blade 6 decreases several times and the pressure in hub cavity part 4 decreases, and the liquid from cavity 19 of geo-hydraulic accumulator 17...
coMPE under high pressure along lines 21 and 15 through return valve 23 to hub 4 of the hub. There, the working fluid that accumulates in the cavity 12 arrives along the highway 15. This makes it possible to further increase the acceleration characteristics and reduce the dynamic loads in the "propulsion unit-transmission-engine" system.

After the transfer of the working fluid is completed, the pressure in the cavity of check valve 23 is reduced and, under the action of the force of spring 24, it moves to the left, blocking line 21. In the case of braking or backing, the blade 6 acts on the working fluid of cavity 5, and it flows along line 16 into cavity 13 of gas accumulator 11 and direct-acting hydraulic valve 22. At the initial moment of the action of blade 6 on the working fluid, the latter compresses by the diaphragm the gas in chamber 14, and with further rotation of blade 6, the pressure of the working fluid rises significantly and the hydraulic valve of direct action 22 opens, overcoming the resistance of the spring 24, while the working fluid enters through the magics strut 20 into cavity 19 of gas-hydrogen accumulator 17 and compresses the gas located in cavity 18 (while accumulating the braking energy). At the same time, the working fluid displaced from strips 12 of gas accumulator 11 flows along line 15 to hub cavity part 4.

2. Materials and methods

Traction tests of the tractor LTP-55 were carried out when driving on a concrete road and stubble. As a basis for the research methodology, the requirements of GOST 27.503-81 were adopted. Before carrying out the tests, the regulatory characteristic of the tractor engine was removed. The experiments were carried out in triplicate.

During the operation of the MPE, the following parameters were recorded on the oscillograph: tractive effort; engine speed, driving wheels and a speedometer; torque on the clutch shaft and semiaxes of the tractor; fuel consumption by the engine during the experience. In the behavior of the tests, strain gauging was performed using the K-12-22 oscilloscope and the PIN-703 amplifier. The strain gauge was placed in the tractor cab.

Estimates obtained from the results of the studies were determined according to well-known formulas.

3. Results and discussion

Evaluation studies of traction properties of the LTP-55 tractor with various drives were carried out on a concrete road and stubble (Figure 3).

Traction tests of the tractor unit on a concrete road showed that the LTP-55 tractor with a rigid drive develops a maximum traction power of 33.5 kW at a speed of 8.3 km / h. The tractor, equipped with an EDD with spring-loaded springs in the final gear, has a tractive power of 35.3 kW at a speed of 8.9 km / h (Figure 3a).

The analysis of the test results also showed that the use of an elastic-damping drive reduces the slipping of propellers by 12-30%, with a change in Pcr from 7 to 15.25 kN, the specific fuel consumption also decreased by 6-10%.

This is due to the reduction of dynamic loads in the system "propulsion unit-transmission-engine" by 25-35% and allows one to stabilize the engine speed, to interact smoothly the propulsors with the soil when moving the MPE.

Experimental studies of the traction properties of the tractor LTP-55 during the movement on stubble (Figure 3b) showed that a rigid-drive tractor develops a maximum hook power of 25 kW when driving at a speed of 10.2 km / h, while a tractor with EDD has this power equal to 26 kW at a speed of 11 km / h. Due to the installation of the EDD, the slippage of propellers decreased from 10 to 28% with a change in Per from 7 to 12.5 kN. Specific fuel consumption is 10-12.5% lower compared to a rigid drive.
**Figure 3.** Traction characteristics of the tractor LTP-55: a - when driving on concrete; b - when driving on stubble; 1, 2, 3, 4, 5 - the number of gear.

4. **Conclusion**

The developed designs of wheel drive UDD mounted on tractor LTP-55 allow one to reduce the dynamic loads by 25-35% in the "propulsion unit-transmission-engine" system, which increases the traction and coupling qualities and improves the fuel and economic indicators by 6-12.5% and also increases the productivity of MPE by 5.5-9.5%.

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