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Series Title	
Chapter Title	Design Justification of Half-Track Propulsor of Traction and Transport Vehicle
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Abstract

The article presents the results of the research work of the joint team of technical departments of university on improving the running systems of traction and transport vehicles. The necessity of creating running systems with improved performance is substantiated. A patent search and analysis of the existing design of the running systems of vehicles are carried out. As a result of the research work, a half-track propulsor of the traction and transport vehicle design with the corresponding operational qualities has been developed. The use of this design of a semi-track propulsor will reduce the tension of the track and reduce the pressure on the path surface. In addition, the use of reinforced rubber track allows the vehicle to operate on asphalt and concrete pavements without destroying them, and also have a lesser impact on the soil by 25–30% compared with metal tracks of the same width. Research in the area was a part of an initiative search topic: “Improving the running systems of wheeled vehicles” implemented on the basis of a business contract with DAFA Firm LLC.

Keywords (separated by '-')	Running system - Performance - Half-track propulsor - Rubber track - Pressure on the surface

Design Justification of Half-Track Propulsor of Traction and Transport Vehicle

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1 Introduction

The transport industry of Kazakhstan is one of the main components of the economy; the sustainable development of it largely determines the successful development of any of its regions and country as a whole. The development of the industry itself depends on the degree of its equipping with traction vehicles and the efficiency of its implementation. Traction and transport vehicles of various types and designs with different technical characteristics have been created for operation in various conditions. The type and purpose of the machine determine the design of its chassis.

The modern development of traction and transport vehicles is characterized by an increase in their power, traction and coupling qualities, pass ability, increased reliability and others. The indicated tendencies in the development of traction and transport machines can be backed up by creating new models of machines or modernizing existing designs of individual units and assemblies of machines. The modernization of tracked traction and transport vehicles is due to an increase in the energy saturation of the

A. A. Radionov and V. R. Gasiyarov (eds.), *Proceedings of the 7th International Conference on Industrial Engineering (ICIE 2021)*,
Lecture Notes in Mechanical Engineering, https://doi.org/10.1007/978-3-030-85230-6_50

propulsion, which leads to an increase in the weight of the machine itself, without significant improvements in the design of the chassis. This leads to a more intense impact of machine propulsors on the ground, to the destruction of its structure and, as a result, to a significant decrease in the traction efficiency of the machine.

Based on the above, it is required to improve the performance of the running systems of wheeled traction and transport vehicles, which characterize the interaction of the propulsive device with the support base.

One of the urgent tasks in the transport industry has always been the issue of increasing the efficiency of using transport equipment, and a large role in the solution of which belongs to the improvement of its running systems. Practice demonstrates that insufficiently high traction and coupling qualities of traction transport machines, a decrease in machine performance, and an increase in fuel consumption and deterioration in other operational properties of the machines are recorded.

To accelerate the solution of this problem, it is necessary to ensure the creation of running systems with reduced resistance to movement and slipping, reduced specific pressure in the contact as well as with an increased coefficient of adhesion, which will help to significantly increase the performance of traction and transport vehicles, reduce fuel consumption and reduce the compaction effect of vehicle propulsors on the ground. This in turn, will contribute to more efficient operation of the machine.

One of the solutions to this problem is the use of a replaceable half-track propulsor, which will expand the functionality of wheeled traction and transport vehicles and increase its annual load. Therefore, research work on the development of a replaceable semi-tracked vehicle mover is an actual direction today [1–7].

2 Main Part

In 2020, a joint team of technical departments of universities developed the design of a half-track propulsor of a traction and transport vehicle. Prior to the development of the half-track propulsor, the analysis of the existing running systems design was carried out [8–10].

The most famous one is the half-track propulsor (Fig. 1) that is an endless rubber-metal track with stamped grousers covering the rear drive wheel of the tractor and an additional idler mounted in front of it [11].

When using this propulsor, the rolling resistance and rotation of the tractor are increased, and additional losses occur in the track mover. The main disadvantage is the uneven distribution of specific pressure along the length of the supporting surface of the track, which significantly affects the pass ability in soils with weak bearing capacity.

A common option is a propulsor, consisting of half-tracks with a triangular contour, replacing the rear drive wheels. A distinctive feature of the triangular track contour is that the drive wheels are located above the supporting surface of the traction and transport vehicle and removed from the abrasive wear zone.

Consider some designs of propulsors made according to this scheme and analyze their advantages and disadvantages.

There is a semi-track propulsor [12] containing a track contour made in a triangular pattern (Fig. 2).

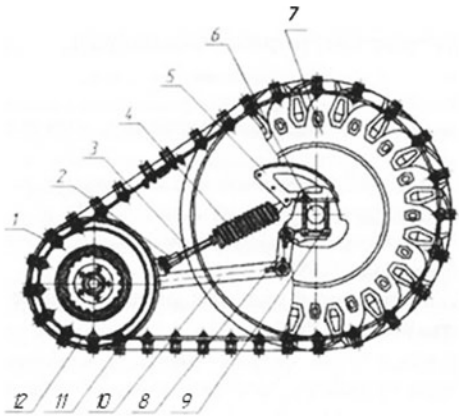

Fig. 1 Half-track propulsor with rubber-metal track and stamped grousers. 1—carrying idler; 2—nut; 3—adjusting screw; 4—spring; 5—support-bracket; 6—semi-axis; 7—rear wheel; 8—suspension link; 9—support-bracket; 10—guide rod; 11—steel grousers; 12—rubber-fabric belt

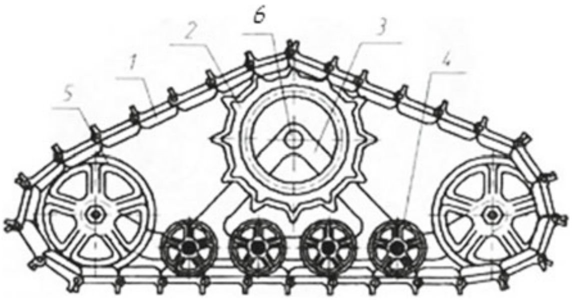

Fig. 2 Semi-track propulsor with a triangular track contour. 1—track contour; 2—driving wheel; 3—tracked carrier; 4—track rollers; 5—guide wheel; 6—axis

The half-track design provides an optimal load distribution diagram. The disadvantage of this semi-track propulsor design is the rigidity of the chassis, which negatively affects the performance of the traction and transport vehicle on soils with low-bearing capacity.

To solve this problem, semi-track propulsor [13–18] containing a front guide wheel with a tension mechanism mounted on a lever that is mounted on a tracked carrier was proposed (Fig. 3). The tracked carrier is connected to the skeleton of the vehicle using a trailing arm. The semi-track propulsor is equipped with a track metal chain engaged with the drive wheel.

This design of the semi-track propulsor improves the traction and speed qualities of the vehicle. The disadvantage of this design of the semi-track propulsor is that when the vehicle moves, the tension of the tracks increases. This results in friction loss in the track joints at areas around the rear track roller and the drive wheel. The consequences are also an increased pressure on the surface of the path.

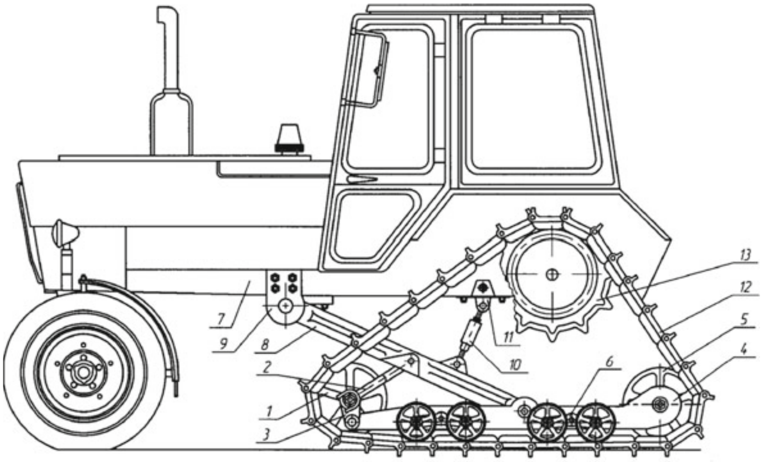

Fig. 3 Semi-track propulsor with a trailing connecting arm. 1—front guide wheel; 2—tension mechanism; 3—lever; 4—tracked carrier; 5—rear guide wheel; 6—balance carrier; 7—skeleton of the vehicle; 8—trailing arm; 9—support-bracket; 10—spring damper; 11—support-bracket; 12—track chain; 13—driving wheel

As a result of the analysis, the team of authors proposed the design of a semi-track propulsor, see Fig. 4.

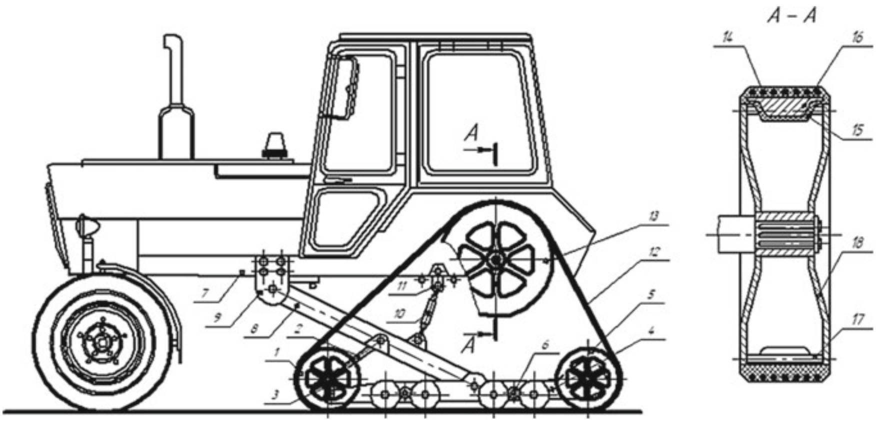

Fig. 4 Semi-track propulsor with reinforced rubber track

The semi-track propulsor contains the front guide wheel 1 with the tension mechanism 2, set on the lever 3, mounted on the tracked carrier 4. The tracked carrier is also mounted with rear guide wheel 5 and balance carrier 6 with track rollers. The tracked carrier 4 is connected to the skeleton of the vehicle 7 via the trailing arm 8. The trailing arm 8 with its one end is hinged to the tracked carrier 4, and to the skeleton of the vehicle 7 with the other end via the support-bracket 9. In the middle part of the trailing arm 8 the tension mechanism 2 and the spring damper 10, connected to the skeleton of the vehicle 7 via the support-bracket 11 is hinged.

The semi-track propulsor is equipped with reinforced rubber track 12, tangled with the driving wheel 13. The reinforced rubber track is solid construction reinforced with steel hawsers 14, vulcanized into cord rubber belt. On the inside of tracks, the rubber cogs are shaped 15 with metal embedded details inside 16.

The transmission of torque is carried out by engaging the rubber cogs with the drive wheel, which instead of cogs has transverse pipes 17 and made in the form of two inter-hardwired flanges 18.

The semi-track propulsor operates as follows. The drive wheel 13, the axis of which is mounted in the vehicle body engages with the reinforced rubber track 12 and sets them in motion. The tracked carrier 4 is rolled by track rollers along the lower branch of the track lying on the soil.

As a result of the analysis of the existing design of the running systems, it was found that the efficiency of the half-track propulsor also depends on the type of tracks. A promising direction for improving the tracked running system is the use of reinforced rubber tracks [19–21], which are widely used in the designs of tracked machines abroad.

Currently, the largest companies such as John Deere, Caterpillar, Claas, Case IH, New Holland and others are conducting experimental development and serial production of machines on reinforced rubber tracks, which allows in comparison with the traditional for Western countries wheeled equipment, to reduce the harmful effect on the ground and improve traction and coupling qualities of machines.

Studies carried out at the University of Iowa (USA) have shown that when machines are equipped with rubber tracks, the pressure on the soil is more than 2 times lower than using conventional tires [22].

In addition to the noted advantages, tracked running systems with reinforced rubber tracks allow:

- increasing the physical and environmental pass ability in soils with low-bearing capacity;
- maintaining roads and securing asphalt surface;
- decreasing the maximum pressure and compaction effect axon the soil by 2.5 times in comparison with a metal track $U = 73.1$ kN/m, which is below the safe limit for soils ($U = 75$ kN/m);
- reducing of vibration and noise, which ensures an increase in the service life of the components of the running system and machine units, improves the working conditions of the operator;
- a reduction in the labor intensity of maintenance of the running system and ensuring the resource of running systems for mobile machines for at least 12 years;
- increasing in the resource to the limiting state of a reinforced rubber track in comparison with a metal track by 4–5 times (20,000 km for a reinforced rubber track, 4500 km for a metal track).

Traction and transport vehicles with a replaceable half-track propulsor can be used to perform work in the spheres of agriculture, construction, industry, as well as in many sectors of the economy.

3 Conclusion

The use of this design of a semi-track propulsor will reduce the tension of the track and reduce the pressure on the path surface. In addition, the use of a reinforced rubber track allows the vehicle to operate on asphalt and concrete pavements without destroying them, and also have a lesser impact on the soil by 25–30% compared with metal tracks of the same width.

Acknowledgements. Authors express their gratitude to R.B. Mukanov and A.N. Baltabekova who have articles published in similar journals [23, 24], for their assistance in preparing and formatting this article.

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