Modernization of skidding and primary removal of wood in the Vologda Region through the use of relevant domestic solutions

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Abstract. In the paper on the basis of the analysis of technical indicators and the aggregates used of the applied and introduced forest machinery (multi-operational forest machines) a study was carried out on the efficiency of variants in the sorting of logs during the implementation of technological operations in skidding and primary timber transportation under typical natural and production conditions Totemsky Forestry - a branch of the company SAU Forestry of the Vologda region "Vologda Forestry Association" (Vologda region, Russian Federation). As a result of analyzing the ratio of torque and other given dimensional and qualitative indicators, recommendations are given on the use of wheeled picker "Trom 20" for more efficient work in conditions of insufficient bearing capacity of the forest harvesting area soil.

1 Introduction

At this stage of development of the production process in the timber industry of the Russian Federation (RF), the primary phase of harvesting is an important stage of the production process, which uses modern multi-operational forest machines (feller bunchers and wheeled sorting machines), working mainly according to the Scandinavian sorting technology, each unit of which is under the control of a logging equipment operator [1-6].

At this stage of science and technology development it is worth noting the high level of development of foreign solutions for sorting (dominant) and whip technology [7-10].

At the same time there are domestic solutions in the part of software for increasing the productivity of such technology, especially feller-delimber-buncher (FDB) [11-15].

In the current dynamically changing economic conditions the question of justification of the choice and operation of new logging equipment becomes the most actual. The market of logging machinery in the Russian Federation is almost 100% dependent on imports (John

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Deere, Ponsse, Komatsu, Rottne, Volvo, Logset, CAT). Traditional imported solutions for sorting Scandinavian logging technology are becoming unavailable for the Russian market for a number of reasons. Therefore, loggers in the Russian Federation at the moment consider both repair of existing equipment and purchase of new domestic or foreign equipment available on the market (produced mostly in the People's Republic of China, namely in 2023 SANY, SDLG, LIU GONG). At the moment the only competitor in the segment of Scandinavian sorting technology of products of foreign machine-building enterprises John Deere, Ponsse, Komatsu, Rottne, Volvo, Logset, CAT, SANY, SDLG, LIU GONG is the production of JSC "AMKODOR" (production of the Republic of Belarus).

Significant pressure on the traditionally undigitized and non-digitized forestry industry is exerted by problems with the Unified State Automated Information System of timber accounting and transactions with it LESEGAIS in terms of frequent interruptions in the system and non-improvement of interdepartmental interaction.

The logging industry is undoubtedly influenced by the dependence on the export of timber and its processed products. Traditionally, the forest industry of the Russian Federation is an export-oriented industry, so a significant reduction or lack of export of timber and wood products to the European Union countries has an unconditional negative pressure on the industry, leading to a reduction in the volume of timber harvesting and wood products. Increase in the cost of repair and maintenance of logging equipment due to the complication of the logistic chain of spare parts and consumables of foreign production increases the cost of 1 m$^3$ of harvested timber in round form, which along with high rental rates often makes logging economically unprofitable and leads to the closure of small logging enterprises and increase in the cost of products for the end consumer due to reduced competition and the traditional lack of effective demand for timber products. It is possible that the reorientation of export flows to countries that have the ability and resources to purchase timber from Russia, as well as the development of multi-storey wooden house-building in Russia will contribute to solving the problem of reducing the volume of timber harvested in Russia.

In connection with the dynamically changing market conditions of the logging industry in the Russian Federation, there is a clear trend of many enterprises of the industry related to logging, which is to reduce the cost of production of finished products. One of the important problems is the choice of equipment. Not all companies have new logging equipment, so there is a question of choosing optimal forest machines from the economic and operational points of view. At the same time, companies pay attention to soil conditions in which the machinery will work, its characteristics, cost and convenience of complex operation and maintenance. Harvesting can be carried out both by feller-buncher and bucking machines, and manual motorized tools, and the primary removal is carried out by wheeled pickers [16-19], accordingly, let us consider the options for choosing a wheeled picker (WP).

2 Materials and methods

In the conditions of the new economic reality, it is currently not possible to purchase machines of foreign and some domestic manufacturers due to the high cost of machinery and the presence of foreign components in the machines of Russian manufacturers. Therefore, the possibility of repair of such machines is limited or impossible, only replacement of expensive consumables and fuel and lubricants (FL), as well as oil and combustibles (OC) is possible.

It should also be taken into account that in the lease may be favorable for logging forests, to which unprepared equipment can not reach. In the end, we have a plot with
potential, which we do not use because we cannot get to the plot we need, which is idle and for which the lessee pays money, rent, Forest Land Use Plan (FLUP) and other lease payments obligatory according to the Forest Code of the Russian Federation.

In this case we are discouraged by the characteristic of soil conditions (SC) of forest areas, namely, areas of mature forest that can be allocated for harvesting (potential harvesting areas), which influences the choice of specific equipment (forest machines), the speed of movement of forest machines, and, consequently, the productivity and efficiency of the multi-operator forest machine as a whole in the typical natural and production conditions of a particular enterprise. For the Vologda Oblast of the Russian Federation (North-West Federal District) the Totemskiy forestry - a branch of the SAI Forestry Company of the Vologda Oblast is the most typical natural-production institution conditions of the Middle Taiga. It should also be taken into account that part of the operational forests of district forestries is located in wetlands [20, 21]. Accordingly, there are problems with the passability of such equipment, as well as there are cases when multi-ton equipment sinks. Problems with the cross-country ability of forest machines in natural and production conditions of the enterprise Totemsky forestry - a branch of SAI Forestry of the Vologda Oblast "Vologda Forestry Association" are shown in Figure 2. [20], with its fleet of vehicles and equipment. [20], has a wheeled picker (WP) "Amkodor 2661" with a hydraulic manipulator (HMP) Kesla 600 (shown in Figure 1). WP "Amkodor 2661" is equipped with units manufactured in other countries - rear axle axle by NAF (Production: Germany) and hydraulic manipulator (HMP) Kesla 600 (Production: Finland). In case of a serious breakdown, the company will not be able to properly service the equipment due to the difficult availability of parts for these units in the conditions of difficulty or impossibility of supplying spare parts and consumables in the conditions of the new economic reality.

![Fig. 1. Amkodor 2661 wheeled picker with Kesla 600 hydraulic manipulator.](image)

It should also be taken into account that part of the operational forests of district forestries is located in wetlands [21]. Accordingly, there are problems with the passability of such equipment, as well as there are cases when multi-ton equipment sinks. Problems
with the cross-country ability of forest machines in natural and production conditions of the enterprise Totemsky forestry - a branch of SAI Forestry of the Vologda Oblast "Vologda Forestry Association" are shown in Figure 2.

Fig. 2. Problems with passability of forest machines in natural and production conditions of the enterprise Totemsky Forestry - a branch of SAI Forestry of the Vologda Region "Vologda Forestry Association".

Figure 2 shows that the technical solutions used at the enterprise Totemsky forestry - a branch of SAI Forestry Vologda Forestry Association of the Vologda region do not contribute to the dynamic rhythmic development of the rental base of the enterprise [22], as forest machines (wheeled pickers of domestic and foreign production, agricultural machinery (adapted for forestry and forestry production) show negative passability in the absence of traditional winter and summer logging equipment This does not contribute to the fulfillment of the ready task of the enterprise on timber harvesting, which in turn determines the task of searching for technical solutions for intensive rhythmic development of the lease base of the enterprise in the phase of skidding and primary transportation of timber [23].

3 Results and discussion

As a result of scientific and patent search as a solution to the above-mentioned problems can be considered domestic solutions based on snowmobiling machinery, namely the use of wheeled picker (WP) Trom 20 with a hydromanipulator (crane-manipulator installation - HMP) Armada, the general view of which is shown in Figure 3, based on and being an evolution and receiver of solutions based on snow and swamp-going vehicle Trom 8.
Based on the above mentioned, there are certain specialized variants of Russian manufacturers of forest machines on domestic components, with increased cross-country ability. In order to determine the best configuration of characteristics, let's compare the technical characteristics and technical features of forest machine Amkodor 2661 with forwarder Trom 20, the results are summarized in Table 1.

**Table 1.** Comparative technical characteristics of Amkodor 2661 and Trom 20 wheeled pickers.

<table>
<thead>
<tr>
<th>WP brand model</th>
<th>Amkodor 2661</th>
<th>Trom 20 UES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load capacity, kg</td>
<td>12 000</td>
<td>10 000</td>
</tr>
<tr>
<td>Cargo compartment length, m</td>
<td>4.8</td>
<td>front 6, rear 4</td>
</tr>
<tr>
<td>Permissible length of assortments, m</td>
<td>up to 7</td>
<td>front up to 6, rear up to 4</td>
</tr>
<tr>
<td>HMP (hydraulic manipulator)</td>
<td>KESLA 600</td>
<td>Armada crane</td>
</tr>
<tr>
<td>HMP (hydraulic manipulator) boom outreach, m</td>
<td>8.2</td>
<td>7.3</td>
</tr>
<tr>
<td>Load torque, kNm</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>Diameter of the tree to be covered by the grapple, mm</td>
<td>75...600</td>
<td>up to 500</td>
</tr>
<tr>
<td>Engine</td>
<td>D-260.1 (Belarus)</td>
<td>YaMZ-534 (RF)</td>
</tr>
<tr>
<td>Torque, N*m</td>
<td>600</td>
<td>700</td>
</tr>
<tr>
<td>Rated power, hp (kW)</td>
<td>155 (130)</td>
<td>200 (150)</td>
</tr>
<tr>
<td>Wheel arrangement (wheels x drive wheels)</td>
<td>6x6</td>
<td>8x8</td>
</tr>
<tr>
<td>Transmission</td>
<td>Automatic transmission (Hydromechanical)</td>
<td>Manual gearbox (Hydrostatic)</td>
</tr>
<tr>
<td>Number of gears, forward/reverse</td>
<td>4/2</td>
<td>4/1</td>
</tr>
<tr>
<td>Travel speed, km/h:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>4.5</td>
<td>9</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>28</td>
<td>18</td>
</tr>
<tr>
<td>Console</td>
<td>Balanced drive axle (4x4) by NAF (Germany)</td>
<td>GAZ-66</td>
</tr>
<tr>
<td>Transport length, m</td>
<td>9.75</td>
<td>11</td>
</tr>
<tr>
<td>Wheel width, m</td>
<td>2.87</td>
<td>3.2</td>
</tr>
<tr>
<td>Height at the cabin roof, m</td>
<td>3.75</td>
<td>3.2</td>
</tr>
<tr>
<td>Operating weight, kg</td>
<td>15 500</td>
<td>8 000</td>
</tr>
</tbody>
</table>

The following conclusions follow from Table 1. It should be noted that the load capacity of WP Amkodor 2661 is greater, but WP Trom 20 is able to carry more weight of cargo relative to its own weight. At the same time, it has two bodies for assortments of different lengths (from 4 to 6 m).

In order to carry more than its own weight, the machine is equipped with ultra-low pressure wheels (0.1 - 0.5 atm). This allows the WP Trom 20 not to slip (i.e., not to get stuck) on poorly bearing overmoistened soils when overcoming such conditions.

In difficult conditions, the Trom 20 can reach speeds of up to 12 km/h. In case of timber transportation on reinforced roads it will be inferior to WP Amkodor, which is more adapted to it. If the Trom 20 gets stuck, active balancers or two front and rear mounted
Winches (5.5 tons of traction each) can be used to get the snowmobiler out of problem areas and traffic jams. It should be noted that the use of the Trom 20 wheeled sorting picker with domestic components will allow skidding and primary timber hauling on low-bearing soils of III and IV categories and other wetlands due to ultra-low pressure wheels and the ability to float (swim and overcome water obstacles). It should be noted that the Trom 20 has a lower height compared to the Amkodor 2661. Also, the width of the wheelbase of the Trom 20 snowmobile is larger. These factors give a lower center of gravity of the whole construction of the Trom 20 snowmobile, which affects the stability of this equipment on different surfaces. WP Amkodor 2661 is equipped with diesel engine D-260.1 (production: Republic of Belarus), Trom 20 is equipped with YaMZ-534 engine (production: Yaroslavl, Russian Federation). The Yaroslavl engine YaMZ-534 has the environmental standard EURO-5, while the Minsk engine has the standard EURO-3, which affects fuel consumption.

The torque and speed ratio of the D-260.1 engine (production: Republic of Belarus) installed on the WP Amkodor 2661 is shown in Figure 4.

![Fig. 4. Ratio of torque and speed of D-260.1 engine.](image)

Torque and speed ratio of the YaMZ-534 engine (production: Yaroslavl, Russian Federation) installed on WP Trom 20 is shown in Figure 5.

![Fig. 5. Ratio of torque and speed of the YaMZ-534 engine.](image)
Figures 4 and 5 show that with more power at higher optimum speeds the YaMZ-534 engine (production: Yaroslavl, Russian Federation) installed on WP Trom 20 produces more torque, which will have a positive effect on the dynamics of acceleration at low crankshaft speeds and will increase traction characteristics (will increase the carrying capacity of the forest machine and as a consequence its possibility).

4 Conclusions

As a result of research it should be concluded that the use of wheeled sorting picker Trom 20 on domestic components will allow skidding and primary timber removal on poorly bearing soils-soils of III and IV categories and other wetlands due to ultra-low pressure wheels and the ability to float (swim and cross water obstacles). Based on comparison of torque and speed ratio graphs of D-260.1 engine (production: Republic of Belarus) installed on WP Amkodor 2661 and YaMZ-534 engine (production: Yaroslavl, Russian Federation) installed on WP Trom 20 it should be concluded that YaMZ-534 engine installed on Trom 20 with EURO-5 environmental standard is more economical, which will positively affect the consumption of fuel and lubricants and fuels. Also, with its own weight of 8 000 kg WP Trom 20 is capable of carrying up to 10 000 kg of forest assortment (round timber). However, like all forestry machines, WP Trom 20 does not have the highest speed on asphalted road, but this type of asphalt is rarely found in typical natural conditions of the lease base of logging enterprises in Russia due to poorly developed road network and low density of different types of roads. At the moment WP Trom 20 is equipped with not the most powerful Armada crane-manipulator (HMP), but in the future it is planned to install a more powerful lifting and transportation mechanism. Also the power plant will undergo an evolution, it may be replaced by a YaMZ-536 engine (production: Yaroslavl, Russian Federation). The manufacturer is currently considering the installation of improved wheel equipment and a new operator's cab (more spacious and comfortable modified model). The combination of such factors indicates an increase in the speed of technological operations and operator comfort, which will lead to increased productivity of WP Trom 20 in natural production conditions Totemsky Forestry - a branch of SAI Forestry Vologda Forestry Association with the possibility of scaling the results for the Vologda region of the Russian Federation and all natural production conditions of the Middle Taiga of the Russian Federation (in particular, the North-West Federal District of the Russian Federation).

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