UDC 630*6

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MOBILE DELIMBER-CROSSCUTTER UNITS FOR ROUND TIMBER HARVESTING IN BELARUS: EXPECTATIONS AND OPPORTUNITIES

The efficiency of operation of mobile delimber-crosscutter units for assortment logging instead of gasoline chainsaws is demonstrated. The technology and organization of assortment logging work is described for the case when these units are operated. The formula for calculation of capacity of delimber-crosscutter units and machines is proposed.

Introduction. Currently, gasoline chainsaws are primarily used for round timber logging at intermediate and principal fellings, including tree felling, delimbing and stem crosscutting to produce assortments. However, gasoline chainsaws are not effective for these operations, because they require manual labor, resulting in low output and high risk of injuries. Therefore, in recent years, several enterprises and forestry institutions started to use feller-delimber-crosscutter machines for round timber logging. These machines have high capacity, and they completely displace manual labor, but their cost is very high, 350…500 thousand US Dollars and more, varying from manufacturer to manufacturer. To reduce timber costs per unit, these machines are operated in two-shift mode if possible.

Application of feller-delimber-crosscutter machines for timber assortment logging grows slowly because high investments are necessary to buy these machines. Up to 2015, plans exist to buy 84 feller-delimber-crosscutter machines for principal fellings, and 121, for intermediate fellings; however, these are very small numbers for wide-scale implementation of mechanized logging. Meanwhile, the scope of mechanized assortment logging can be significantly increased very soon, if, for example, only half of planned number of feller-delimber-crosscutter machines would be purchased and saved money would be used to buy mobile delimber-crosscutter units that have sufficiently high capacity but several times cheaper than the feller-delimber-crosscutter machines. These units are manufactured and operated in Scandinavian countries and in the Russian Federation.

1. Delimber-crosscutter unit design and capacity. In Scandinavian countries, HYPRO 755, HYPRO 450 and other mobile attached delimber-crosscutter units (processors) are manufactured and operated; in the Russian Federation, this equipment includes SM-35 delimber-crosscutter machines.

The units made in Scandinavia include a basic machine and attached implements. The wheel tractor, with the engine power 60 kW or higher, can be used as a basic machine, such as Belarus MTZ-82 L, Belarus MTZ-1221 etc.; foreign currency is not necessary to buy these machines, and this is a very important factor. The unit's attached implements include a frame, a hydraulic single-drum reversible winch, a hydraulic arm, a delimbering head with chips-free cutting knives, a mechanism for tree dragging through the delimbering head, a stem crosscutting mechanism, a sawn assortment length measuring and logged timber recording mechanism, hydraulic systems, a unit control panel and a remote control console [1].

The mechanism for tree dragging through the delimbering head consists of two reverse cylindrical rollers mounted vertically.

The sawn assortment length measuring and logged timber recording mechanism includes a wide rotating roller and a mini-computer. While the tree stem is dragged through the delimbering head, this roller rotates to read the length of an assortment for which the sawing operation is in progress; the rollers in the dragging mechanism are used to read an assortment's diameter. The readings are processed in the mini-computer to calculate the volume of each logged assortment and the total volume; these data can be transmitted for further processing or stored in the mini-computer's memory. The hydraulic arm or the winch can be used to move the felled trees' butts to the delimber-crosscutter unit, depending on the distance between the butt and the unit. The hydraulic arm can be used to remove limbs and crowns from the unit if necessary. The maximum diameter of trees appropriate for processing is 50 cm. One operator must attend the unit.

In Scandinavian countries, grab-type delimber-crosscutter machines are also in operation. However, their capacity is only slightly higher than that for delimber-crosscutter units, but their cost is much higher.

For the Russian delimber-crosscutter machine, SM-35, the wheel tractor, TT-4M-01, is used as a basic machine [2]. The attached implements include a hydraulic manipulator mounted behind the tractor cab, a delimber-crosscutter unit pivotally mounted on the tractor's rear axle, a control system and a hydraulic system. All machine units are designed similarly to those in the delimber-crosscutter units manufactured abroad; the only difference is that the track-type mechanism is used

to drag a tree through the delimbering head. The maximum extension of the hydraulic arm is 8 m. The machine is designed to log assortments in the forest depots; it is capable to process the trees with the diameters up to 65 mm. The automated (software-controlled) mode is available; in this mode, the machine can saw at least 6 lenghts of assortments in any combination, and no adjustments are required to switch from one length to another. The implements are controlled remotely from the machine cab.

The general formula for the delimber-crosscutter machine or unit capacity is as follows:

$$C = \frac{(T - t_{p\text{-}f})\varphi_1\varphi_2 V_{st}}{t_1 + t_2 + t_3}, \qquad (1)$$

where T is the shift time (seconds); $t_{p\text{-}f}$ is the setup time including preparative and final operations (seconds); φ_1 is the labor utilization rate; φ_2 is the utilization factor for the delimber-crosscutter mechanism used for tree processing; V_{st} is the average stem volume (m^3); t_1 is the time necessary to grab the tree butt and to deliver it to the delimber-crosscutter mechanism (seconds); t_2 is the time necessary to drag the tree through the delimbering head (seconds); t_3 is the stem crosscutting assortment-making time (seconds).

However, the formula (1) must be described in more detail to take into consideration the natural and operational factors and the delimber-crosscutter machine process parameters affecting the capacity.

The work time recording methods (motion study or similar) shall be used to determine the time t_1 necessary to grab the tree butt and to deliver it to the delimber-crosscutter mechanism, because the design of the equipment used for this operation can be different. As a rule, t_1 = 20 s may be assumed for tree processing in a forest depot.

The time t_2 necessary to drag the tree through the delimbering head is a function of u, the dragging speed, and L, the average processed tree length minus the partial butt length l_b, about 1 m, and the crown length l_c that is a function of the tree species (for the diameter 3 cm, this length is about 1.5 m). The felling allocation data can be used to determine the average processed tree length. Thus,

$$t_2 = \frac{L - l_b - l_c}{u}. \qquad (2)$$

The stem crosscutting assortment-making time t_3 is a function of the stem length, the number of saw cuts per stem m_c, the average saw cut diameter d_{av}, and the saw mechanism's finish sawing capacity C_{saw}.

The number of saw cuts is a function of the stem length and the average sawn assortment length l_{av}:

$$m_c = \frac{L - l_c}{l_{av}}.$$

The finish sawing capacity is a function of the saw mechanism design, engine power and average speed of the saw mechanism moving on the stem (u_m). Thus, taking into consideration the descriptions listed above,

$$t_3 = \frac{d_{av} m_c}{u_m} \text{ or } t_3 = \frac{\pi d_{av}^2 (L - l_c)}{4\Pi_{saw}\varphi_s l_{av}}, \qquad (3)$$

where φ_s is the saw mechanism's finish sawing capacity utilization factor.

The equations for t_1 and t_3 from (2) and (3) shall be substituted into (1). The resulting formula is as follows:

$$C = \frac{(T - t_{p\text{-}f})\varphi_1\varphi_2 V_{st}}{t_1 + \frac{L - l_b - l_c}{u} + \frac{\pi d_{av}^2 (L - l_c)}{4\Pi_{saw}\varphi_s l_{av}}}. \qquad (4)$$

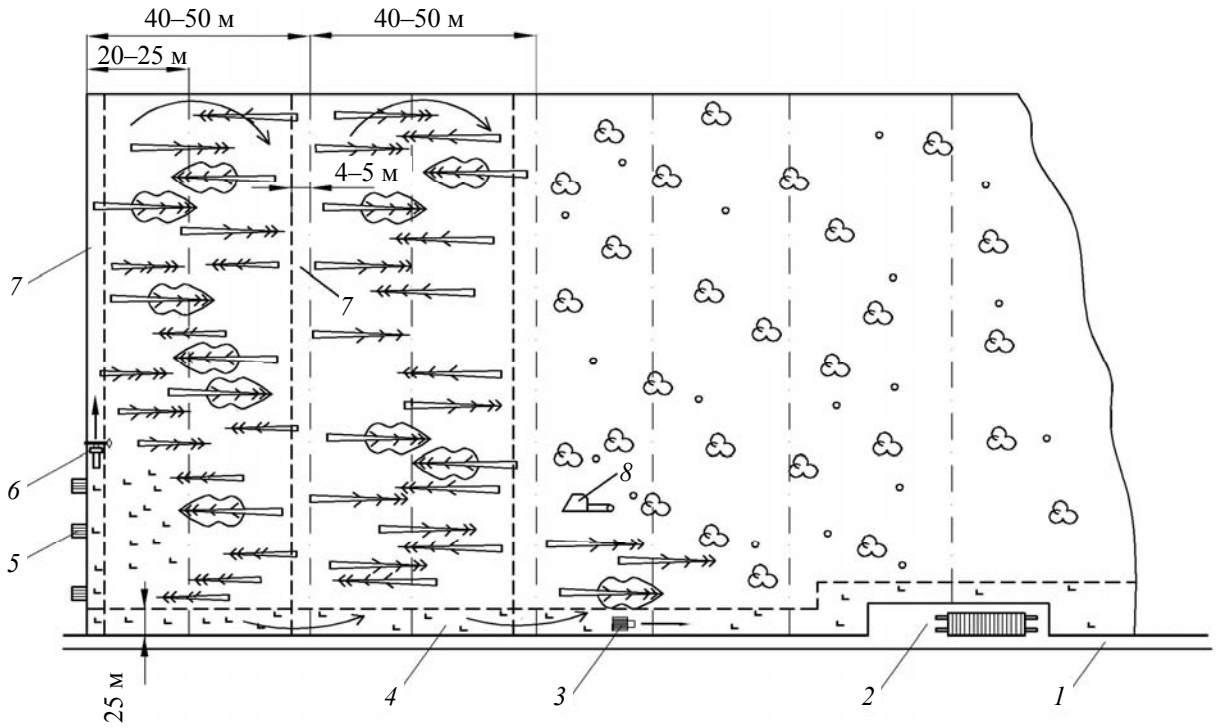
The equation (4) is a mathematical description of the assortment logging at the felling area and the forest depot when the delimber-crosscutter machines or units are used.

2. Delimber-crosscutter units operation: technology and organization of assortment logging work. First, the felling area shall be prepared appropriately: unsafe trees shall be removed, the felling area shall be subdivided into cutting blocks, skid roads shall be traced, the forest depot shall be arranged, and the spar road shall be prepared (see Figure).

Taking into consideration that the unit can take and drag the felled trees from sides, the cutting block width shall be about 40–45 m. Skid roads shall be at the cutting block boundaries.

At the first stage of the logging work, assortments are logged in the safe area, along the spar road and around the forest depot. For this purpose, trees are felled in each cutting half-block in the safe area, perpendicular to the skid road, with their butts facing the skid road. When the distance becomes safe, the processor is used to delimber and crosscut the trees; then, the assortments are collected, transported to the forest depot and stacked by the forwarder.

Upon completion of work in the safe area, the assortments are logged at cutting blocks, one by one, starting from the edge nearest to the spar road. The cutting block at the border of the area is processed first.



The felling area layout with a set of machines in operation including a gasoline chainsaw, a processor and a forwarder:
1 – spar road; *2* – forest depot; *3* – forwarder; *4* – safe area; *5* – assortments; *6* – processor (HYPRO 755 V); *7* – skid road; *8* – gasoline chainsaw

The gasoline chainsaw is used to fell trees perpendicular to the skid road (to the left skid road, in the left half of the cutting block, and to the right skid road, in the right half of the cutting block). When the distance becomes safe, the delimber-crosscutter travels in reverse along the skid road to process the trees. Then, the assortments are collected (and, at the same time, pre-sorted), transported to the forest depot and stacked by the forwarder.

Conclusion. 1. Operation of gasoline chainsaws for assortment logging at felling areas is ineffective. So, efforts are made to replace gasoline chainsaws with feller-delimber-crosscutter machines. However, high investments and long time are necessary to buy these machines.

2. The round timber harvesting can be mechanized sooner if, along with feller-delimber-crosscutter machines and within the funds allocated for mechanization purposes, mobile delimber-crosscutter units would be used, attached to the wheel tractors with the engine power 60 kW or higher. These units are several times cheaper than the feller-delimber-crosscutter machines or delimber-crosscutter machines, but they demonstrate almost the same capacity, and they are extensively used for assortment logging in Scandinavian countries.

3. The formula proposed for calculation of capacity of delimber-crosscutter units and machines operated at felling areas and forest depots is the mathematical description of the assortment logging process when this equipment is in use. This formula demonstrates what factors affect the capacity and how these factors affect it.

References

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