Technology for processing of logging residues for bioenergy

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Abstract. The article presents the results of modeling technological processes for the development of forest bioresources for bioenergy using soft containers. The technology of collecting, storing and transporting fuel chips in soft containers is proposed. Conventional trucks can be used to transport fuel chips using soft container technology. The proposed technology allows to increase the productivity of the machine system: mobile chipping machine + truck by 1.5-2 times. The designed technology allows you to separate the work of the mobile chipping machine and the truck. The projected technology requires the equipment of additional storage areas for containers.

1. Introduction

In agriculture and forestry, renewable bioresources are increasingly being used to generate energy. In particular, for energy production in forestry, logging residues in the form of tops, twigs and branches, which are waste from logging and often remain in the cutting area, has found applications [1-3].

For use in bioenergy, logging residues is processed into fuel chips, for which mobile chipping machines with a hopper trailer are used. According to this technology (figure 1), the chipping machine moves along the cutting area and with the help of a manipulator 2 collects the logging residues 1 and sends it to the chipping device 3. As a result, fuel chips are loaded into the hopper trailer 4. After filling the hopper with chips, the chipping machine is sent to the loading area 6, where the chips from the hopper are reloaded into the removable body 5. The roller container, after filling with wood chips, is taken by the roll-off truck 7, working on the "multi-lift" system.

The disadvantage of the existing technology using mobile chipping machines and roll-off truck with roller container is that after filling the roller container with wood chips and the absence of a truck, the chipping machine with a full hopper will stop working.

This article discusses an improved technology for the production of fuel chips in the cutting area. To eliminate these downtime, the chipping machine is equipped with special soft containers that are placed in the hopper [4-5].

A general view of a mobile chipping machine with a trailer-hopper and soft containers, as well as loading and unloading operations with them are shown in figure 2.

The proposed device should eliminate downtime of the chipping machine if the hopper trailer and roller container of the roll-off truck are filled with wood chips, and the truck is not available. In this case, the soft container filled with wood chips is unloaded at the loading area, where it is stored with other soft containers.

The technological scheme of operation of a mobile chipping machine with soft containers on the loading area is shown in figure 3.
In contrast to the existing technology (figure 1), in the proposed technology, wood chips from the chipping device are fed into a soft container 5, which is located in the hopper 4 of the chipping machine. After filling the container 5 with wood chips, the machine takes it to the loading area and unloads it in a stack. Instead of the discarded container with wood chips 5, an empty container is put inside the bunker and the chipping machine returns to the cutting line. The truck picks up containers with wood chips 5 from the stack and takes them to the consumer.

2. Materials and methods

In the considered technologies (figures 1 and 3) the leading equipment is a mobile chipping machine. To analyze these technologies, it was decided to compare the performance of a mobile chipping machine using two technologies. Also important is the length of the queue of soft containers at the loading area, which is formed as a result of the absence of a truck. The research was carried out on mathematical models [6-10].
The simulation was carried out for the joint operation of one chipping machine and one truck. The distance of transportation of wood chips by truck was assumed to be 50-100-150 km. The average distance of the chipping machine from the cutting area to the loading area is 300 m. The volume of the roller container is 30 m$^3$, the volume of the trailer-hopper is 15 m$^3$.

3. Results and discussion

The simulation results are shown in the graph in figures 4 and 5.

As can be seen from Fig. 4, the hourly productivity of the chipping machine and the truck depends on the distance of transportation of wood chips by truck. Note that according to the existing technology, the performance of the chipping machine and the truck are almost identical (figure 4, curves 1 and 2). This is because the machines operate sequentially. The performance of the chipping machine + truck system will depend on the performance of each machine.

In the designed technology with soft containers, the chipping machine and the truck work in parallel. The truck does not affect the performance of the chipping machine. Therefore, the performance of the chipping machine will not depend on the vehicle (figure 4, curve 3). The performance of the vehicle depends on both the distance and the performance of the chipping machine (Fig. 4, Curve 4). The highest productivity of the chipping machine + truck system is achieved by reducing the transport distance and matching the performance of the machines.

Note that for any distance of transportation of wood chips, the productivity of the technology using soft containers is significantly higher than that of traditional technology, which is due to the lack of downtime of the chipping machine on the loading area. Thus, with a transport distance of 50 km, the performance of the chipping machine + truck system according to the existing technology is two times less than that of the projected technology. With a transport distance of 150 km - about 1.5 times less.

In the case when the productivity of the chipping machine is higher than the productivity of the truck, according to the designed technology, containers will accumulate on the loading platform. So, for example, the number of containers per shift at a transport distance will be less than one. With a transport distance of 150 km, more than 6 pieces will be accumulated per shift. When working in several shifts, the number of accumulated containers on the loading area can be significant. For example, when working for 30 shifts and with a transport distance of 150 km, a platform is needed to accommodate 189 containers. The requirement to equip additional space for storage of containers is a
disadvantage of the designed technology. The advantage of the designed technology, in addition to the higher performance of the machine system, is the possibility of separating the work of the chipping machine and the truck. At the same time, the truck can be general-purpose.

![Graph showing productivity and distance](image1)

**Figure 4.** Dependence of the hourly productivity of the chipping machine for different technologies: 1 – chipper in the existing technology; 2 – truck in the existing technology; 3 – chipper in the design technology; 4 – truck in the design technology

![Graph showing accumulation of containers](image2)

**Figure 5.** Dependence of the accumulation of the number of containers on the loading area on the distance of transportation.

### 4. Conclusion

The technology of production of fuel chips by a system of machines: mobile chipping machine + truck using soft containers has a number of advantages compared to conventional technology. The
productivity of the chipping machine increases by 1.5-2 times. There are no downtime of the chipping machine and truck. Conventional trucks with manipulator can be used to transport wood chips in soft containers. Soft container technology may require a large loading area.

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