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Development of an autonomous energy supply system for harvesting wood resources based on wood fuel

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Abstract. A number of original technical solutions of energy supply system of technological processes of wood harvesting and production of chips in the cutting area and upper warehouse are presented. It is proposed to use generator gas from chips instead of traditional motor fuel. The autonomous power supply system includes a power plant with a DC motor and a hydraulic station, a power cable for transmitting electrical energy and a power plant. The power plant is installed on the chassis of the technological machine. The power plant equipment is located on a separate car trailer chassis. The power plant includes a battery of electrical energy, a DC generator, a heat engine on the generator gas, gas generators and a container with a fuel reserve. For cable rolling along the cutting area, special patented rollers are offered. The use of this system can save up to 870 liters of motor fuel from non-renewable resources per 1,000 cubic meters of harvested wood.

1. Introduction

One of the fundamental concepts of environmental engineering is the preservation of non-renewable energy sources [1-2]. The use of wood resources as renewable fuel to replace boiler, furnace and motor fuels in some cases can be a good solution to save non-renewable resources [3]. The problem situation is that at present, internal combustion engines on gasoline and diesel fuel are commonly used as power plants for logging equipment. Many factories for the production of boiler and oven fuel from wood - fuel chips, pellets, fuel briquettes, charcoal, biodiesel, etc. have mini-power plants on natural gas, diesel fuel and gasoline. Thus, the costs of non-renewable energy resources in the production of fuel from renewable wood resources can reach 10-30% depending on the final product (excluding transportation).

This study presents technical solutions for the autonomous power supply of the processes of harvesting wood resources and the production of fuel from wood resources, reducing the consumption of gasoline and diesel fuel in the relevant technological processes. It is proposed to use an electric motor with a hydraulic station as the power plant of the machine that performs the technological processes of harvesting and pre-processing of wood. The electric power required for the operation of the power plant in the form of direct current can be obtained using an energy module located also on the territory of the cutting area and transmitted via a power cable.

2. Modern technology in the field of energy supply of wood resources

Generator gas from wood was used as motor fuel in commercially available KT-12 skidders and trucks [4]. After 1956, due to the increase in oil production, mass production of gas-generating machines ceased. However, currently projects are being developed to improve the efficiency of gas-generating



internal combustion engines [5]. The use of generator gas in external combustion engines, such as Stirling engines [6] and gas turbines is very promising [5,7]. Currently, together with Stirling engines industrial power plants on generator gas from chips (gasification efficiency of 75% or more) with an electrical capacity of one unit up to 29 kW (in the form of a direct current of 415 V) are produced [7]. A large number of manufacturers of power plants produce Stirling engines for domestic and industrial use with a capacity of 1-7.5 kW for chips and wood pellets [9].

Use of the skidder with a traction motor is known [4]. The disadvantage of these devices is the use of electricity from an autonomous generator with a heat engine using a traditional motor fuel. This is, as a rule, due to the fact that in a cutting area there is no possibility of connecting to the network of centralized power supply, in contrast to agricultural machinery.

From the current level of technology a mobile installation for the production of chips for boiler, including a trailer with a hydraulic manipulator, hydraulic station, chipping machine, control panel and power supply from the power network of the boiler room is also known. Due to the lack of its own source of electrical energy, it is impossible to use this mobile unit in the cutting area. Placing the technological equipment on the standard chassis of the automobile trailer limits the scope of application of this device and makes it difficult to use it in the cutting area.

One of the latest developments is the Logset 12H GTE hybrid harvester, which includes a self-propelled chassis with articulated semi-frames, a manipulator with a working body, an operator cabin and a hybrid power plant made in the form of an internal combustion engine on diesel fuel with an electric machine operating alternately in engine and generator mode.

The disadvantages of this device is the use of an internal combustion engine on diesel fuel as the main power plant, and the electric drive only to compensate for the periodic load.

Nowadays Silvatec Grane 8325CH Chipper is also known which is a machine for cutting and chopping wood into chips, including a self-propelled chassis with articulated semi-frames, a hydraulic manipulator with a working body, a chipper for chopping wood trunks with a diameter of 350 mm, a pneumatic conveyor chips, an operator's cabin, diesel 205 kW engine, hydraulic station and body for chips of 20 m³ with a folding back side (Machine for cutting and chopping wood into chips).

The disadvantage of this machine is the use of a gasoline or diesel internal combustion engine as a power plant. This makes it impossible to use wood waste as a fuel for the operation of this power plant and makes the process of chip production dependent on the supply of expensive diesel fuel.

The prototype of the proposed device is a mobile technological line for the production of fuel chips, including a self-propelled chassis, a hydraulic manipulator with a working body, a chipper, a chip conveyor, an operator's cabin, a hydraulic station, an external combustion engine on the generator gas, an engine cooling device, a gas generator, a chip drying device, heat supply to which is carried out from flue gases and air, cooling the external combustion engine [10]. This device has power supply from an external combustion engine with a gas generator unit, which provides the possibility of autonomous operation when using part of the processed wood as fuel.

The disadvantage of this technical solution is placement of the Stirling engine and gas generator on a single self-propelled chassis together with all technological equipment, which increases the weight of the machine and, accordingly, increases the energy intensity of the process of moving the machine through the cutting area and the negative impact of the propeller on the fertile layer.

3. The proposed technical solution

The proposed device for the system of power supply of technological processes of wood harvesting and production of wood chips in a cutting area is illustrated in figure 1. In contrast to analogues, it is proposed to obtain electrical energy using a heat engine on the generator gas produced by gas generators from fuel chips. The claimed installation includes: a self-propelled chassis with articulated half-frames (1), a hydraulic manipulator (2) with a working body (3), a chipper (4) for shredding tree trunks up to 350-400 mm in diameter, an air conveyor chip (5), an operator cabin (6), a hydraulic station (7), an external combustion engine at gas generator (Stirling engine or gas turbine) (8) with a capacity of 230-300 kW, engine cooling device (9) with a capacity of 350-550 kW, gas generator installation (10) with a capacity

of 0.12-0.2 m³/s, container with (11) fuel capacity of 6 m³, a body for chips (12) with a volume of 20-25 m³ with a tailgate (13) and a power plant (14) with a power of 180-240 kW.

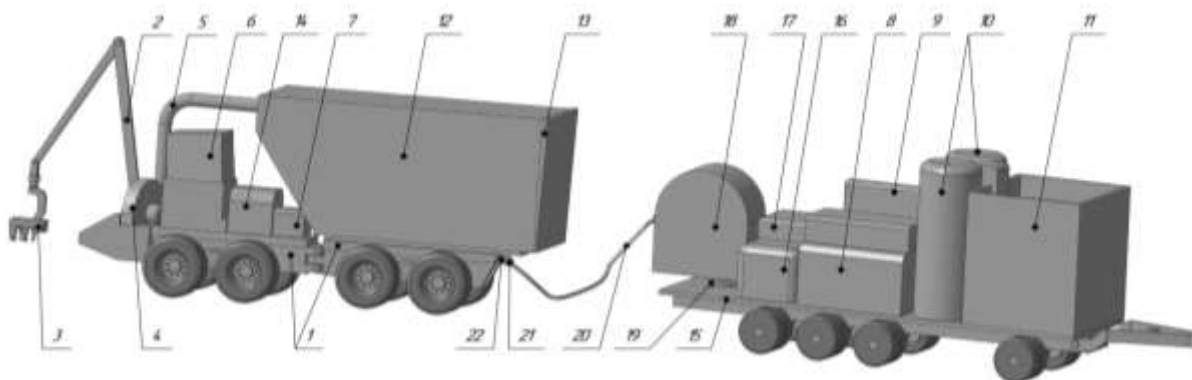


Figure 1. Autonomous power supply system from an external combustion engine on wood fuel of a machine for the production of chips: 1 - self-propelled chassis, 2 - hydraulic manipulator, 3 - working body of the hydraulic manipulator, 4 - chipper, 5 - pneumatic conveyor of chips, 6 - operator's cabin, 7 - hydraulic station, 8 - external combustion engine, 9 - engine cooler, 10 - gas generator unit, 11 - container with fuel reserve, 12 - body for chips, 13 - reclining board; 14 - power plant, 15 - power plant chassis, 16 - uninterruptible power supply with battery, 17 - electric generator, 18 - drum, 19 - turntable, 20 - power cable, 21 - electrical cable connector, 22 - electrical machine connector.

Unlike the prototype: as a power plant (14) of a technological machine, an electric DC motor is used, all equipment of the power plant is located on the chassis of an automobile trailer (15). The device additionally contains an uninterruptible power supply with a high-capacity electric energy storage battery (16), a DC electric generator (17) with a capacity of 195 255 kW, which receives torque from the heat engine (8). The device also contains a drum (18), mounted with a rotary platforms (19) on the trailer chassis (15), power cable (20) with a length of 200-500 meters, wound on a drum (18), electrical cable connector (21) and electrical connector (22) mounted on the chassis (1) of the technological machine.

For rolling the power cable across the cutting area, it is proposed to use patented rollers, the device of which is shown in figure 2.

The device works as follows. Technological machine and power plant are transported to the cutting area, short distances can overcome self-propelled chassis with a trailer independently. In the cutting area, a trailer with a power plant (15) is placed on the loading platform, fuel chips are loaded into container (11), gas generators (10) are started and engine (8) is started up on the generator gas. Initially, the engine 8 can be run on another fuel, for example, on compressed or liquefied gas. Associated with the engine, the generator (17) begins to generate a constant current and charge the battery uninterruptible power supply (16). The heated air after the cooling unit (9) and some of the combustion products can be sent to a container with chips (11) for drying. After the power plant reaches its nominal mode of operation, cable (20) supplies power to the DC motor (14), the load of which is hydrostation (7). The self-propelled chassis starts moving along the technological corridor, while cable (20) is unwound from drum (18). To bypass trees and reduce friction during unwinding cable used guide rollers (figure 2). The manipulator (2) with the working body (3) cuts and fells trees, performs pruning and bucking. Low quality stem wood and branches are fed to the chipper (4), the chips received by the pneumatic conveyor (5) are sent to the body (12). After filling the body (12), the self-propelled chassis (1) returns to the power plant for unloading chips and filling the container with fuel.

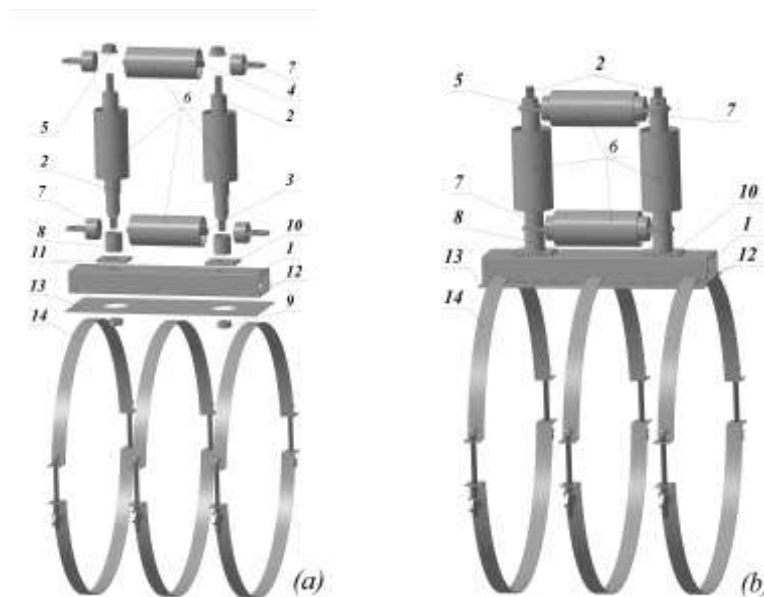


Figure 2. Model of the roller for cable rolling along the cutting area a) partially disassembled; b) assembled: 1 - profile; 2 - axes perpendicular to the profile; 3 - axis at the base; 4 - far axis; 5 - clamping nuts; 6 - rollers; 7 - eye nuts; 8 - thrust bushings; 9 - tightening nuts; 10 - plates; 11 - locking grooves; 12 - holes; 13 - sheet metal; 14 – clamps.

4. Conclusion

The use of an autonomous power supply system for harvesting wood resources based on wood fuel can save up to 870 liters of motor fuel from non-renewable resources per 1,000 cubic meters of harvested wood. The advantages of the proposed device are: reduction of the mass of the technological machine and the use of generator gas from low-quality wood instead of traditional motor fuel. Reducing the mass of equipment mounted on a self-propelled chassis is ensured by replacing the internal combustion engine with an electric motor and the absence of fuel tanks, water cooling systems, batteries and exhaust systems. The consequence of reducing the weight of the machine is to reduce the harmful effects on the fertile soil layer and high permeability.

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