Energy generation from wood waste

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Abstract. The reconstruction of the heating system of the administrative and amenity building of “Tekhnologii Retsiklinga” LLC is proposed by replacing the heat energy of electric boiler with the heat energy produced by a wood waste boiler.

1. Introduction
In many regions of the Russian Federation, biofuel boilers successfully operate, although their percentage is very low (1-2%) and there are no plans concerning the complete transition to renewable energy sources in the country. However, even several biofuel boiler houses can serve as examples for enterprises, both in their own region and in the whole country for the efficient use of biomass [1]. If we compare our country, for example, with Finland, in Finland wood chips are preferable to fuel oil and coal in the vast majority of regions of the country, and in Russia, even in areas rich in forests, expensive coal and oil products are imported.

The idea of using wood waste as fuel has already been realized in numerous designs of pellet boilers. But pellets are quite expensive to manufacture, at least $ 7-8 per tonne, so today chip boilers are becoming more relevant. In this case, fuel costs are reduced by approximately 40-50%. In addition, the use of wood chips in boiler rooms allows the problem of wood waste utilization to be solved.

Chip fuel is environmentally friendly fuel. Its ash content is less than 3%. In the process of burning this fuel, the release of carbon dioxide into the atmosphere is equal to the amount absorbed by the plant during its growth. The low cost of wood chip makes it a worthy alternative to pellets and briquettes. But wood chip as a heat source is attractive only in areas located close to guaranteed sources of its formation. Transportation of wood chip over long distances is unprofitable due to its small specific gravity, compared with pellets and pressed fuel briquettes.

Thus, wood chip are affordable, inexpensive and energy-intensive raw materials suitable for heat and electricity. The calorific value of 100 kg of dry wood chip is equivalent to the combustion of about 40 kg of coal or 50 kg of dry peat.

2. Schematic diagram of a boiler of KTU series
Currently, a significant amount of wood waste delivered by “EVRAZ ZSMK” JSC to the territory of the slag processing workshop of “Tekhnologii Retsiklinga” LLC is received for further processing (1400 tonnes). In addition, in “EVRAZ ZSMK” JSC there are approximately 500 m³ of branches and cut trees, as well as foundry models – about 1500 tonnes. Every year, the municipal enterprise of the city collects branches and cuts of trees in an amount of more than 5000 m³.

An electric boiler is used to heat the administrative and amenity building. The main disadvantage of such heating system is the high tariffs for electricity. For example, during the heating season from...
September 2017 to April 2018, 742000 kW were spent on heating the administrative and amenity building, which is 2 619 260 rubles.

In order to reduce heating costs, it was proposed to reconstruct the heating system of the administrative and amenity building by replacing the heat of an electric boiler with the heat energy of a wood waste boiler. For the normal operation of the boiler and the prospect for expansion of the company, as well as for the possible prospects of introduction of heat generation into the market, it was decided to purchase a boiler unit KTU-750 manufactured by “Teploresurs” LLC. Figure 1 shows a schematic diagram of KTU-750 boiler.

The design feature of the furnace is an arch vault allowing highly moist fuel up to 55% to be burnt and it is made with one furnace front, which provides maintenance of the grate and loading of lump fuel (cuttings, firewood, etc.). The design of the boiler KTU-750 provides a window for the mechanized supply of bulk fuel (sawdust, wood chips, bark, peat, etc.). A special design of the furnace is the inclined and horizontal grate, in combination with an air distribution device, it is possible to use both bulk and lump fuel as fuel without additional boiler modernization.

For ease of operation, two cleanouts are provided – on both sides of the furnace, and a viewing window for visual inspection. The heat-insulated furnace cover increases the efficiency by reducing heat loss through the furnace walls.

The blower fan, which is supplied with the boiler, provides air supply to the undergrate space, afterburning of fuel, and the air flow, in turn, being heated when the walls of the furnace are cooled, passes through the grate and the fuel layer gets involved in the main combustion.

The heat exchanger with smoke tubes. The heat carrier (water) is pumped into the heat exchanger, flue gases wash the inner walls of the pipes where the heat exchange takes place.

A safety group is installed on the heat exchanger of KTU-750 boiler, which includes two safety valves, a pressure gauge and a ball valve.

Safety valves are used to release excess steam (water) from the boiler when the pressure in it is higher than the calculated one. The manometer serves to control the pressure in the heat exchanger. The ball valve is designed to bleed the vapor-air mixture from the heat exchanger. At the heat exchanger branches, glasses are provided for direct and return water temperature sensors. A fitting with a ball valve mounted on it is embedded in the heat exchanger to remove water when the boiler stops.

The heat exchanger of the boiler is equipped with a cleanout, which provides access to the heat exchange surfaces of the smoke pipes at the time of the work on cleaning the heat exchanger from ash deposits. The heat exchanger is thermally insulated from the environment, which eliminates the loss of heat energy and increases the efficiency of the boiler. From the operational hopper-dispenser using the fuel supply mechanism – 6 (screw conveyor or hydraulic pusher), the fuel enters the burner of the boiler – 4. The fuel is burned on the inclined grate – 5, on which loose (sawdust, shavings, wood chips, peat, crop waste) and lump wood is burnt.

In the process of burning in the combustion chamber, the fuel goes through three stages (three combustion cycles):

![Figure 1. The basic scheme of boiler KTU-750: 1 – heat exchanger; 2 – cleanout of the heat exchanger; 3 – furnace door; 4 – burner; 5 – grate; 6 – fuel supply mechanism.](image-url)
Stage 1 – drying of the fuel. In boiler houses installed at wood processing enterprises, in most cases, wood chips and sawdust with high humidity obtained after sawing up fresh trunks are used as fuel for boilers. In plywood factories, wood is pre-steamed in process water pools before treatment, in this case the fuel has high humidity. At the first stage of the fuel movement in the boiler furnace, sawdust and wood chips from the fuel tray are squeezed directly into the furnace, where they are distributed along the width of the furnace front, on the inclined grates. Moisture evaporation occurs because of the heating effect of the red-hot furnace lining and the radiant energy of combustion reflected from the vault screen of the furnace.

Stage 2 – primary oxidation and release of CO. Layered combustion occurs at relatively low temperatures of 700-750 °C on the inclined and horizontal grates with forced separate blowing.

Stage 3 – CO afterburning in the flare of the boiler furnace. Afterburning takes place directly in the boiler furnace, in the air supply zone (oxidation activator) at a temperature of 900-950 °C, which is most optimal for the carbon oxidation reaction to occur. Air intake is made from the air gap between the lining and the outer lining of the boiler. This helps to reduce heat losses and increase efficiency. At each combustion stroke in proportion to the fuel supply, a dosed supply of oxidizer (atmospheric air) by several fans (blow and afterburning) is organized. After the residual carbon is completely burned, the ash falls through the grate to the ash pan, from where it is manually (or mechanically, depending on the design) removed through the cleaning hatch directly in the mode of operation of the boiler.

A heat exchanger is a special construction for transferring heat energy from a heated coolant to a colder one. In the design of boilers of KTU series, a heat exchanger of a gas-tube type is used. It is a “barrel” with smoke pipes passing through it, piercing it from the front of the boiler to the back with a 180 ° rotation of gases according to the two-way scheme. Flue gases passing through the pipes heat the coolant circulating inside the heat exchanger and washing the outer walls of the pipes. The rate of passage of flue gases is determined by the level of vacuum in the combustion chamber and is regulated by a smoke exhauster.

The optimum speed of movement of the heat agent in the heat exchanger is automatically regulated and is provided by the pumping station. A heat-insulating lining is used at the inlet of the heat exchanger to protect the jacket from high-temperature gases.

Flue gas anti-explosion valves and safety group valves for heat carrier – hot water are used. The coolant is supplied through the inlet, and the outlet through the output collector. The collectors are equipped with coolant temperature sensors. Information from the sensors is fed to the control panel, allowing the fuel supply to the furnace to be adjusted, thereby keeping the specified coolant parameters. The heat exchanger housing is lined with a sheet profile.

The fire pipe design of the heat exchanger minimizes the need for chemical water treatment (CWP) and allows the heat exchanger to be serviced directly in the operation mode of the boiler. Fuel can be supplied either automatically or manually. High-moisture wood waste, milled peat (relative humidity up to 55%) without preliminary drying, dry wood waste can serve as fuel for boilers of this series.

This boiler equipment has a total length of 5.6 m, a width of 1.4 m, a height of 3.750 m. The equipment will be installed exactly in the middle of the building, where the distance from the walls of the building will be 2.3 m for the comfortable operation of this equipment according to SNiPII-35-76.

The building has two openings:
- the first opening – two meters high and one meter wide for the passage of personnel;
- the second opening is three meters wide and four meters high for unloading wood chips by road transport.

3. The main stages of the technological process for the production of wood chips
The main stages of the technological process for the production of wood chips at “Tekhnologii Retsiklinga” LLC are:
- waste sorting, preparation of wood raw materials for processing;
- pre-processing, preparation of wood at the site, delivery to the receiving hopper of the production line;
• production of wood chips, storage of finished products and loading into the boiler.

The raw materials for the production of wood chips are wood waste delivered by “EVRAZ ZSMK” JSC to the territory of the slag processing workshop of “Tekhnologii Retsiklinga” LLC. Considering the peculiarities of the incoming raw materials and the fact that the raw materials for production are waste with a humidity of at least 20%, high-temperature dryers are not required for their drying, therefore, the problem of safe removal of moisture can be solved in another way. For example, by “kinetic” removal of water from the surface of wood particles during their fine grinding. The heating medium necessary for this, in which atmospheric air acts, occurs directly in the mill body as a result of the temperature separation of the air flow similar to the Ranque-Hilsch Effect.

This technology is implemented in SCARABEY small-sized automated lines, which are equipped with combined mills and heaters of the S.A.M.P. 2012 model. This equipment was specially designed for the production of wood chips from raw materials with humidity up to 30% in automatic mode, without the use of fire-hazardous “fire” drying methods. The SCARABEY line most fully meets the requirements of small industries.

For pre-processing and grinding of secondary waste wood of oversized dimensions, a twin-shaft shredder PPM 1 and a chip mill are used. The main purpose of the shredder is the grinding and crushing the bulky waste – wooden pallets, logs, lumber waste. The chip mill crushes large wood chips and other wood wastes (branches, knots, sawmill waste) to produce chips of smaller fractions that can be used as fuel for a boiler room. Figure 2 shows a diagram of the production of wood chips from wood waste.

4. Conclusion

The competitiveness of wood chips in comparison with other alternative solid fuels underlines the success of wood chips in the biofuel market and its stable growth rate. When implementing this measure, the expected annual profit of the enterprise will be 917008 rubles, the payback period of the project is 3.16 years.

References

[1] Golovkov S I, Koperin I F and Naydenov V I 1987 Energy Use of Wood Waste (Moscow: Lesnaya Promyshlennost) p 224