Furnaces with vortex burning for burning of wood waste and coal

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Abstract. The paper presents use of wood waste as fuel in industrial thermal power plants. The paper proposes methods of disposal of low calorific fuels produced from waste. The results of physical experiments and numerical simulations showed possible effective application of wood waste as fuel in industrial thermal power plants. The presented boilers are of superior environmental performance as they are equipped with fuel circulation system. The boilers make rational use of wood waste and lower coal consumption in small and medium-sized thermal power plants. New technology is tested in an operating facility.

1 Introduction

Nowadays, the development industrial power plants requires the significant environmental and economic advantages boilers. The major economic criterion for boiler plants is fuel consumption.

One way to improve the economic efficiency boiler plants - the use of alternative fuels, i.e. wood waste and agricultural waste. Combined burning of low-grade coals and solid biomass fuel would help in addressing the problem of improve the economic efficiency boiler plants. One of the important solid biomass in Siberia is wood waste.

Combined burning of low-grade coal and wood waste in medium power boilers is a very difficult task. The point is that fine particles of wood fuels hard to keep to furnace of boiler. It is quite possible that is formed ash sediment in furnace and convective zone [1]. As a result of this, arise repeated fires in the gas flue of the boiler.

Combined burning of low-grade coal (such as brown coal) and humid wood waste have a number of drawbacks. That prevents from full taking advantage of the energy of a fuel [2, 3].

Fig. 1. Tanner's fuel triangle

2 Methods

Based on the experience gained, in identifying the limit of the burning was used triangle (Fig.1) [3]. Limit values: combustible material for more than 25%; humidity less than 50%; ash less than 60%. As you can see in the figure 1, autogenous combustion zone is shaded and data of alternative fuels is entered in the triangle field [9]. One can see in a figure 1 that wood waste, peat can be reclaimed of direct combustion, while humid wood waste and lignin shall be prepared to burning (f.e. processed into briquettes). Wood waste is low-ash and high-humid fuel (humidity sometimes reaches 60-70%).

Scientists from the Polzunov Altai State Technical University together with "BARNAULENERGOMASH" LTD engineers have explored of alternative fuels characteristics and examined the burning processes. The

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experiments were performed with a view to identifying the fuel dynamic properties in the fuel laboratory of ASTU (Fig.2). These data need for studying the drying, pyrolysis and burning processes.

τ_0 – time to particle warm-up, τ_c – time to particle drying, $\tau_{b.l.}$ – time to volatiles release, $\tau_{b.c.}$ – time to coke particle burning, τ_r – time particle burn-up, $\tau_r = \tau_c + \tau_{b.l.} + \tau_{b.c.}$.

Fig. 2. The dynamic of thermal decomposition of fuel.

During the experiment incinerated particles of wood waste weight from 0,5 to 2,5 g at a temperature no lower than 500°C but no higher than 900°C. [1, 4]. During the examination of the thermal decomposition wood waste was plotted the mass loss as a function of time stay in high temperature zone (Fig.2). The dependences of the yield of volatiles on the decomposition temperature are established, the temperature of the maximum yield of volatiles is determined. The yield of volatiles for wood waste in integral (on left) and differential (on right) form shown in the figure 3.

Fig. 3. The yield of volatiles for wood waste in integral (on left) and differential (on right) form.

The combustion process at an early stage differed from process coke burning because of high yield of volatiles. The yield of volatiles and pyrolysis process is a series of parallel and sequential reactions (Fig.3).

Based on the experimental and estimated results designed boilers with multiple fuel circulation in the furnace. (Fig.5). The proposed furnace boiler profile allows to hold low-density particle by the principle of inertial separation (Fig. 4, 5) [6]. The figure 4 are presented 3D model (on left) and pilot plant in the fuel laboratory of ASTU (on right). Inertial separation accepted since gravity separation wood waste is ineffective [7].

Fig. 4. 3D model of a pilot plant (on left) and pilot plant in the fuel laboratory of ASTU (on right).

Retention of fuel particles in the furnace until they burn deep by means of multiple fuel circulation in the furnace (Fig.5). The aerodynamic configuration was simulated in software complex CFD.

3 Results and Discussion

The figure 6 are presented 3D-model boiler "KBМ-2,5ДВО" for burning wood waste. The figure 7 are presented system a pipeline for boiler with furnace device "ТНФГ", which is designed Scientists from the Polzunov Altai State Technical University together with "BARNAULENERGOMASH" LTD engineers.

Fig. 5. Aerodynamic situation in the boiler furnace.

Fig. 6. 3D-model boiler «KBМ-2,5ДВО».

The method for combusting wood waste: shredded wood waste served in furnace, where we have the combined flare-layer burning (Fig. 8). Heavy particles run through inclined and horizontal fire-grate, and small particles burn in a whirlwind.

Fig. 7. System a pipeline for boiler.

The system multiple fuel circulation include precipitator of ash, smoke extraction and system nozzles. The boilers with system multiple fuel circulation almost complete burnout occurs fuels.

1 - vortex formation in the boiler furnace; 2 - convection pipes (1 stroke); 3 – convection pipes (2 stroke); 4 – precipitator of ash; 5 – smoke extraction; 6 - chimney.

Fig. 8. Boiler «KBМ-2,5ДВО» for burning wood waste.

The figure 9 are presented 3D-model boiler «E-6,5-14ИД». This is a steam boiler with a steam capacity of 6.5 tons of steam per hour. The boiler is installed on a furnace-device that allows you to burn wet wood waste.

Fig. 9. 3D-model boiler «E-6,5-14ИД» with furnace-device that allows you to burn wet wood waste.

The boiler furnace is covered with bricks, for burning wood waste with a humidity of more than 50%.

Fig. 10. Boiler plants for burning wood waste with high humidity.

This technology (Fig.10) provides complete combustion of fuel, and consequently increases the efficiency of the steam boiler [13]. Combination of layer combustion (Fig.11) and vortex combustion allows for sustainable burning of wood waste.

Fig. 11. Furnace-device for burning wood waste with high humidity.

The multiple fuel circulation system has been installed to increase the efficiency of fuel combustion and reduce the amount of unburned fuel. The multiple fuel circulation is carried out through the selection of combustion products from the precipitator of ash. (fig. 10, 12).

1 – precipitator of ash; 2 – smoke extraction; 3 – An inlet valve; 4 – system nozzles.

Fig. 12. The multiple fuel circulation system.

The multiple fuel circulation system allows you to increase the efficiency of the boiler, reduce fuel consumption and improve the ecology of the boiler (Fig.12).

4 Conclusions

The paper presents use of wood waste as fuel in industrial thermal power plants. The paper proposes methods disposal of low calorific fuels, producing from waste. The results of physical experiments and numerical simulations showed that possible effective application of wood waste as fuel in industrial thermal power plants. The presented boilers are of superior environmental performance as it is equipped with fuel circulation system. The boilers make rational use of wood waste and lower coal consumption in small and medium-sized thermal power plants.

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