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Improvement of the Designs of Hot Water Boilers of Small Dimensions

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Abstract: *The article discusses the issues of improving the energy efficiency of hot water boilers of small dimensions. The calculation method of the boiler, the calculation of the economizer and gas-water heaters are given. A water heating boiler with small dimensions is being investigated, equipped with: a fuel loading hopper that ensures the duration of gorenje; a grate combustion chamber; an economizer convective heat exchange beam system; a system for ash removal and convective beam purification; a system for natural air inflow and exhaust gas removal.*

Keywords: *Heat exchange equations, heat balance equation, calculation of economizer and gas-water heaters, fuel loading hopper, grate combustion chamber, economizer convective heat exchange beam system, ash removal and convective beam purification system; natural air inflow and exhaust gas removal system.*

Introduction.

Due to the fact that there are places with limited natural gas supply in our region, heating of residential and public premises is difficult in the cold season. For a comfortable stay in them, this universal boiler was developed. Due to the fact that the early designs were not very efficient and large-sized, with low efficiency and high consumption of fuel raw materials, requiring multiple loading and cleaning during the day, making operation and maintenance of early produced boilers inconvenient, the task arose to design a boiler running on various types of fuel, having high efficiency, large fuel loading capacity, which would reduce the loading time and increase the running time of a single download.

The calculation of the economizer and gas-water heaters

With the constructive calculation of the economizer, the enthalpy of gases and water at the inlet is known.

$$Q_{econ} = \left(Q_{estim}\eta_k + Q_{\Phi} + Q_{out.contr}\right) \cdot \frac{100}{100-q_4} - \left(Q_f + Q_b + Q_{sup} + Q_{\text{int.sup}} + Q_{\text{exc}}\right)$$

kJ/kg (kJ/m^3) (1)

where is the amount of heat absorbed per 1 kg (1 m^3) of fuel:

Q_f – in the furnace; Q_{estim} – estimated heat output of the boiler;

Q_b, Q_{sup}, Q_{econ} – boiler beams and festoons, superheater (except radiation), industrial superheaters and economizer; Q it is substituted without taking into account the heat received in the furnace;

$Q_{\text{int.sup}}$ – intermediate superheater;

Q_{exc} – excess air. $Q_{exc} = \beta_{exc}(I_{exc.air} - I'_{air\ heater})B_p$, kW. (2)

β_{exc} – the ratio of the amount of excess (given "to the side") air to the theoretically necessary.

$I_{exc.air}$ – the enthalpy of excess air.

$Q_{out.contr}$ – the heat introduced into the furnace by air when it is heated outside the boiler – steam from waste, waste heat, etc.

Q_{noz} – heat introduced into the furnace by steam blast (nozzle steam),

η_k – The efficiency of the boiler when calculating the working fuel in the case of its drying by exhaust gases in a closed cycle.

The heat introduced into the furnace by air when it is heated outside the boiler – steam from waste, waste heat, etc.

$Q_{out.contr} = (\beta' - \beta_{exc})(I'_{air\ heater} - I_{cold\ air})$, kJ/kg (kJ/m^3) (3)

where: β' - the ratio of the amount of air at the entrance to the air tract to the theoretically necessary.

$I'_{air\ heater}$ - enthalpy of combustion products in the air heater, air heater

$I_{cold\ air}$ – enthalpy of cold air.

Heat introduced into the furnace by steam blast (nozzle steam),

$Q_{noz} = G_{noz}(i_{noz} - 2400)$, kJ/kg (4)

where: G_{noz}, i_{noz} – consumption of steam enthalpy for blowing or spraying fuel kg/kg and kJ/kg.

Universal boiler with fuel loading hopper

For heating small buildings located in places where there is no centralized gas supply or there are interruptions in gas supply, this boiler was designed (Fig. 1)

This universal boiler allows you to heat a room of large areas, has a self-cleaning system. In the absence of natural gas in the system, there is a bunker for filling combustible materials (coal, firewood, combustible garbage), which allows you to increase the operating time of the boiler with a single load. During operation, the boiler showed its positive qualities:

- ✓ small dimensions;
- ✓ large heating area;
- ✓ high EFFICIENCY;
- ✓ easy to maintain;
- ✓ long-term combustion;
- ✓ economically low consumption of materials in the manufacture of the boiler;
- ✓ ability to work at low gas pressure;
- ✓ does not require monitoring devices;
- ✓ does not require a forced exhaust system of burnt gases and blowing;
- ✓ does not require the use of electrical energy.

- ✓ it is possible to operate the boiler on liquid, gaseous, solid and combined fuels.

The principle of operation:

Hot water boiler with economizer system. This boiler has 5 systems (see Fig.1.):

1. A fuel loading hopper that ensures the duration of combustion;
2. Grate combustion chamber;
3. Economizer convective heat transfer beam system;
4. Ash removal and convective beam cleaning system;
5. The system of natural air inflow and exhaust gas discharge.

As an experimental model, a boiler of this design with a capacity of 45 kW was manufactured and tested. With overall dimensions of 200x200x600 mm. the following parameters were obtained: power - 45 kW; water capacity - 16 liters; volume of the loading hopper - 20 liters.

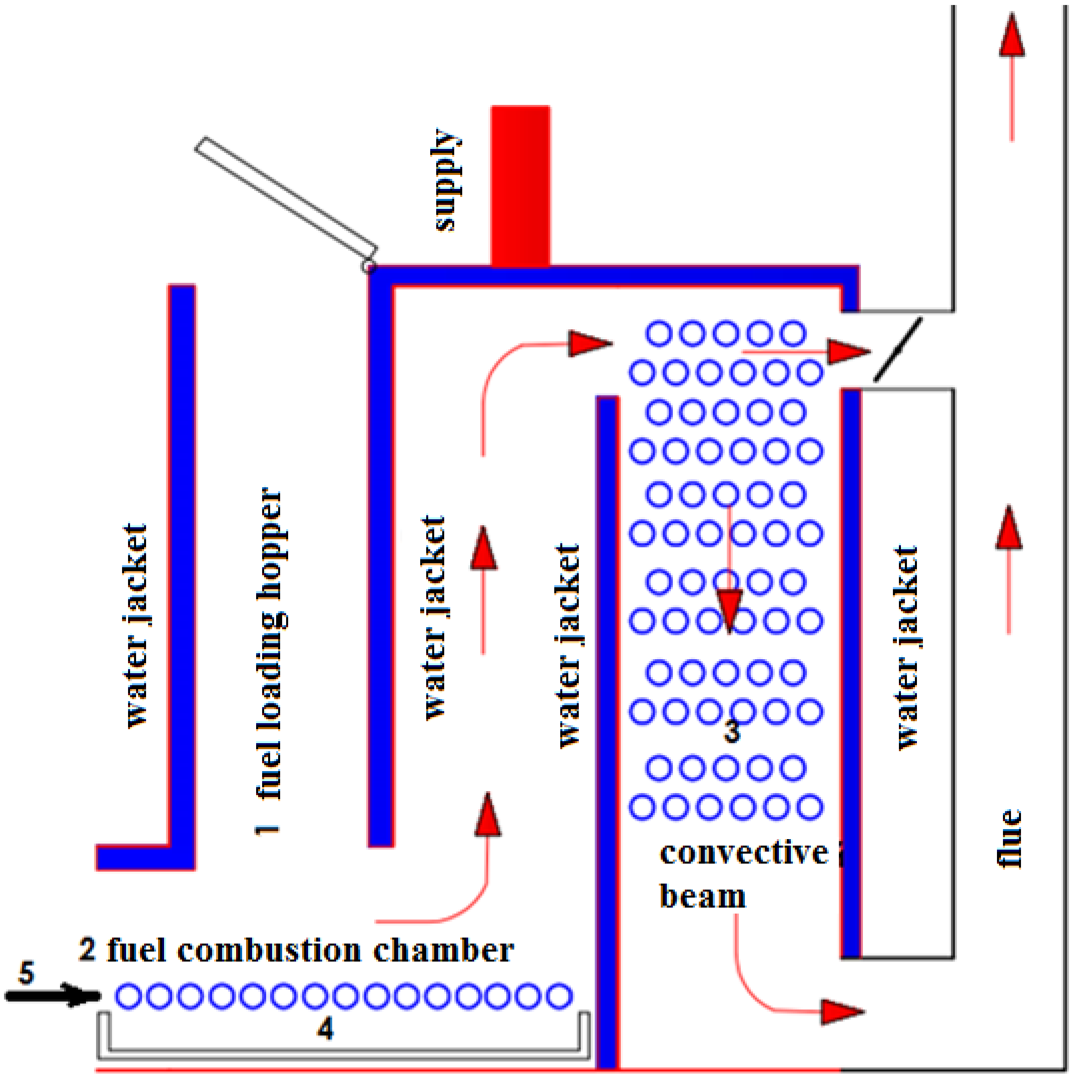

Figure 1. Diagram of the boiler device with an economizer.

Results and Discussion

When using coal as fuel, the boiler showed a daily consumption of 7 kg., while the area of the heated premises was 50 m^2, the heat loss of the house was 150 w/m^2, the estimated air temperature outside: - 2^oC, indoors 25^oC. At the same time, the boiler was installed outdoors and it had no insulation. The total volume of water in the heating system was 150 liters. The total power of the radiators did not exceed 5 kW. The average temperature of the heating devices was about 75^oC. Boilers of this design were installed in other facilities with much larger areas of heated rooms. In these cases, the boilers also showed high efficiency.

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