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Research of Woodchip Automation System Modernization Boiler Using O_2 Concentration Optimization Options in the Flue Gas

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Abstract: *This topic is the research woodchip boiler automation system modernization feasibility study, through the optimization of the concentration of O_2 in the flue gas. Goal is to reserach and identify existing furnace automation control systems in one company, and the development of automation control systems improvement model to one chip furnace .*
Keywords: *Automation control systems, gas detectors, sensor systems and applications*

I. Introduction

One of the most actual problems of society in the 21st century, energy-related - its operation as over time, increasing technological development, the society is increasing its commitment to the comfort, which in turn increases the demand for energy. Sustainable development of society based on the idea that the growth of energy consumption is to ensure that present needs are met without compromising the needs of future generations. Ensuring a sustainable society is the use of thermal energy to maximize the use of renewable natural energy resources. Thus, indicating that environmental protection and good economic results are not conflicting economic growth and social quality of life should not degrade the environment. Sustainable development of society is characterized by three interrelated dimensions: the ecological state of the environment, economic and social dimension.

To date, most of the Autonomous oven is still powered by fossil fuels: oil, gas or coal. Fuel is fed from a furnace to a low pressure burner where it is ignited. The oven immediately able to operate at full capacity only after a query can stop the operation immediately. However, to ensure complete combustion of fossil fuels for furnaces require a large amount of oxygen and traction, thus increases, but decreases with increasing heat absorption process, thereby causing the heated chimney.

In addition to oxygen consumption in the furnace can increase the formation of nitrogen oxides in the flue gas, which has a negative impact on the environment. It is characterized by the fact that natural resources (oil, gas, coal) almost never recover naturally. The European Union has identified the requirements for all fossil fuel boilers meet performance standards higher than 90% [[4]].

Since the use of fossil fuels to provide a temporary quality of life and degrades the environment, studies show that it is necessary to get away from fossil fuels and move fuel from biomass [[4]].

Thus, a sustainable society is important for research in the field of renewable and clean energy sources, and also uses the heat dissipation. Significant biomass resource is wood. Time timber resource recovery is about 40 years. Wood used directly as fuel wood waste, which is not further used in the industry: the branch of tree bark chips, wood and other green wood. Wood chip furnace is widely used. Wood, depending on the size and capacity can be used for residential heating and industrial needs used industrial furnaces:

- Hot flue gases for the dryer drum drying, high-quality wood,
- Thermal heating of industrial premises,
- Creation of steam and thermal power as a by-product, still more heat, which can be used in the local heating of the housing [[2]].

These ovens are usually automated. However, the automation system does not always provide complete combustion of the material, which creates more ash, is therefore necessary to increase the fuel consumption of resources. Thus, the decision to study the problem associated with the automatic control system, the new control algorithm development is to increase furnace efficiency.

II. Problem formulation

The Oven chips are diverse, the differences depend on the fuel provided for the degree of humidity and the quality of the material. Oven chips classified according to material quality, which can burn in furnaces. Classification can be seen in *Fig 1*.

Co-current oven is designed for dry combustion of fuel, such as pellets, straw, etc. Such systems oven reduces NO_x unburned gas into the atmosphere, burning it completely, combustion waste gas containing relatively high ash emissions. To free environment, there should be a separate filter system the ash collection.

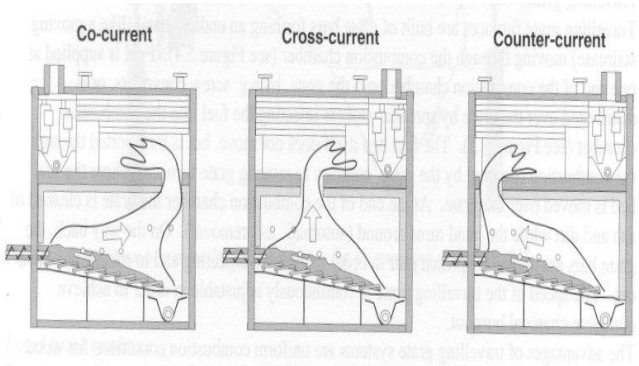


FIGURE1. Oven chips classification types.

Counter-current woodchip furnace type is the most low-quality combustion of fuel, such as: wet bark, wood chips or sawdust. Thermal convection as a result, the hot flue gas is dried in an oven incoming materials. In this system, the flue gas evenly mixed with secondary air supply, thus ensuring efficient waste gas combustion and reducing emissions.

Cross-current oven it is combined in such a way that it can burn both dry and relatively wet material, the above-mentioned furnaces. However, the lack of oven is a relatively large amount of ash in the flue gas, which may come into flue systems therefore provide powerful filter system [[14]].

Oven chips are a completely automated. Wood moisture may be from 15% to 50%, and can burn wood chips with a higher degree of humidity, but a large part of the energy is consumed in drying the material. Boiler sizes are divided into three groups:

- 10-20kW small thermal power;
- medium 50kW of thermal energy;
- a large pot to 100 MW of thermal energy [[4]].

Oven theoretical capacity for air volume calculation is given by an equation (1):

$$Q = m \cdot C \cdot \Delta T \qquad (1)$$

Where:

Q - amount of heat (kJ) 1kW=3600kJ;

C- specific heat (kJ/kg·C);

ΔT - the temperature difference between the outgoing and incoming temperature of the oven .

Oven ingested material thermal capacity is calculated by an equation (2):

$$Q_{silt.piev.} = m \cdot \rho \cdot C, \qquad (2)$$

Where:

Q - heat input capacity of the timber (MWh);

ρ - bulk density kg/m^3 ;

C- calorific value MWh/t

Woodchip furnaces may have different constructive solutions, but the operating principle remains the same to them. Furnace operating principal flowchart view *Fig 2*. After the picture you can see that the furnace consists of:

- Material supply which delivers fuel to the furnace for incineration. There are a number of ways, such as material feeding the furnace with snails, conveyors, material supply with hydraulic mechanism;
- Primary air supply, the air is fed to the incineration of the material. Performances may be based on a number of air supply fans, but in any case the primary air ensures the material drying, combustion and gas formation;
- Secondary air supply, fed oxygen gas mixture in the furnace;
- Basically at issue one constructive solution with moving floors. Constructive solution can be seen *Fig 2*;
- Ash left over from the combustion process, in principle, all ovens are the same ash discharge operating principles;
- The hot flue gas, which is used as heat media are used for all furnaces.

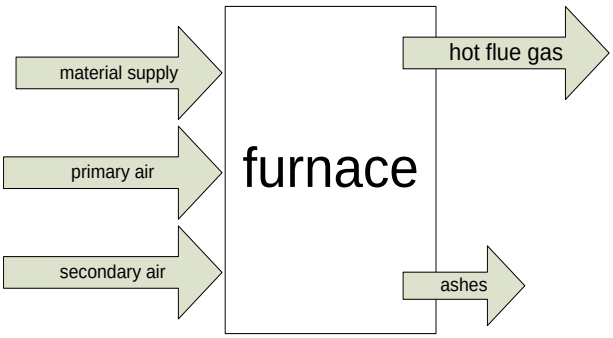


FIGURE 2 . Furnace operation block diagram.

III. Automatic control systems.

Automation control systems designed to improve overall efficiency, reduce operating costs and improve process control initially, the PLC is designed to replace relay logic systems and were programmed ladder logic, this program system is strongly reminiscent of the relay circuit. Applications examples can be seen in *Fig 3.* Such programming languages created to electronics engineers are able to easily understand the functioning of the program and to develop it in order not to specifically attract programmers.

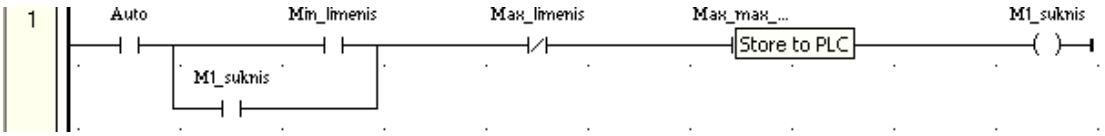


FIGURE 3. Ladder logic program example.

Woodchip furnace is a multi-complex system in which each system provides specific actions implemented. Furnace control system:

- the material supply system;
- moving floor system, which is divided into four zones and moving the burning material in an oven;
- divided into four zones of the primary air supply system;
- divided into three zones of the secondary air supply system;
- ash transport system.

Oven operating block diagram is shown in *Fig 4*. The primary air ensures the material in the furnace combustion

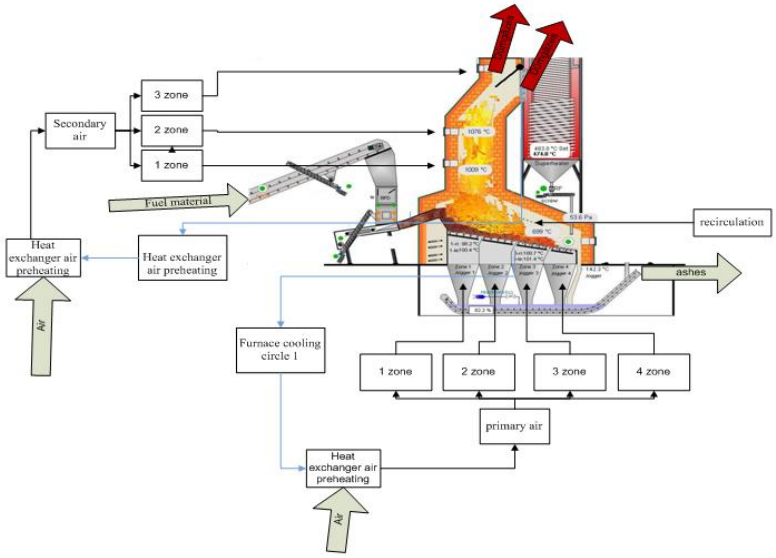


FIGURE4. Woodchip boiler automation systems

There is process that produces the flue gas, which is then burned by providing secondary air. Recirculation furnace aim is to process that produces the flue gas, which is then burned by providing secondary air. Recirculation furnace aim is to prevent the furnace too high temperatures leading to the furnace may be damaged. Furnace cooling circuits is cooled furnace important nodes that cannot be mechanically withstand high temperatures. Similarly, furnace cooling circuits increases the primary and secondary air inflow

temperature, thus speeding up the drying process of the material gas ignition processes. Woodchip furnace is very widely applicable. Stoves can be used as a multi-storey home heating and up to a small village Woodchip furnace is very widely applicable.

IV. Algorithm drum dryers for woodchip furnace automation system model management

Furnace automation control system is determined by both depression (underpressure) and the oxygen concentration in the flue gas sensor. Depression value specified algorithm is a manufacturer recommended approximate size, because it depends on the oven depreciation and material quality.

Below is the automatic furnace control algorithm by steps:

Step1. There shall be regulated material feed rate (determined in step 2 and 3).

Step 2. If the oxygen concentration is greater than 3% of the material is accelerated feeding rate of the furnace floor speed, the primary air supply amount is increased to 10% and the secondary air supply is reduced. After all sizes increasing move to step 4.

Step 3. If the oxygen concentration is less than 3% of the material is then slowed feeding speed in the oven and floor speed, the primary air supply is reduced and secondary air supply amount is increased to 50%. After all sizes increasing move to step 4.

Step 4. Adjusts HIDROLIK engine speed (down 2 and step 3).

Step 5. A change in the primary air feeding volume. 10% change steps 2 and 3, and 7 and 8 step variable amount up to 90% limit.

Step 6. Secondary air feeding amount is changed in step 2 and 3.

Step 7. If the furnace current depression is less than 300 Pa, the primary air supply is reduced and after parameter change switch to step 1;

if not less, then move on to the next step.

Step 8. If the furnace current depression is greater than 300 Pa, the primary air supply is being scaled up, and move on to the first step; if does not - go to the next step.

Step 9. If the oven existing depression equal to 300 Pa, then, without changing anything, move on to the first step.

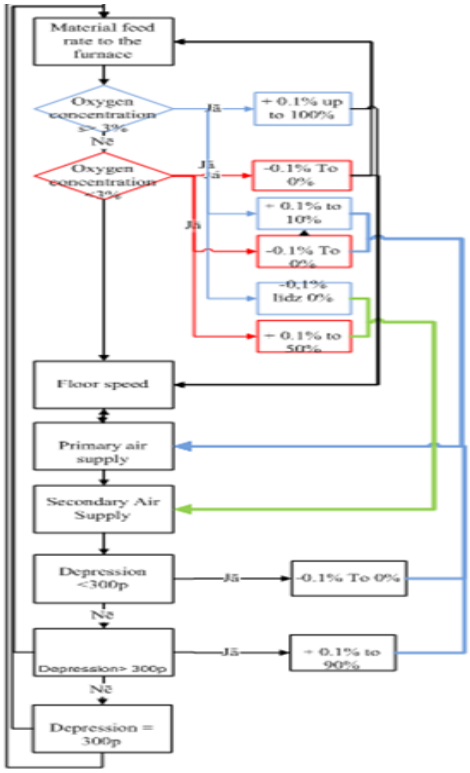
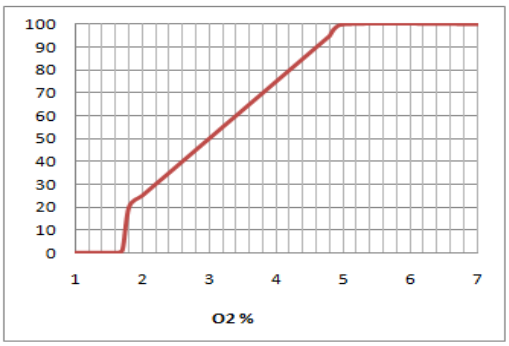


FIGURE 5. The developed algorithm block diagram dryers for woodchip furnace automation system model management.

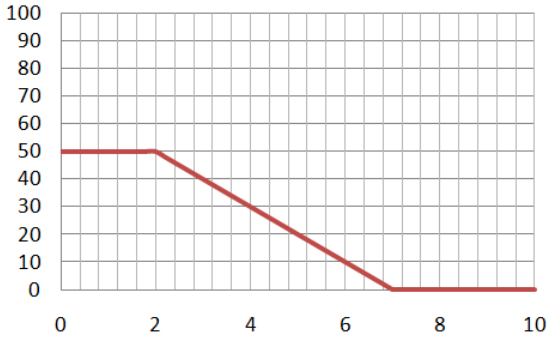
Articles of combustible feed the furnace is controlled by the percentage of oxygen concentration in the flue gas, that is, the percentage increase in oxygen concentration in the flue gas, the fuel for the furnace is injected more frequently. This visual representation of the process, see Fig. 6.

If the oxygen concentration in the flue gas falls below 2%, for security reasons, to avoid the formation of explosive gas oven, exponentially it reduces the material supply.



OY axis Material handling and floor speed (%);
OX axis O_2 concentration (%);
Curve creates a material feed rate and the floor movement's dependence on oxygen concentration.

FIGURE 6. Oxygen concentration on the primary air supply amount.



OY axes secondary air supply volume (%);%
OX axis O_2 concentration (%);
Curve creates a secondary air volume control the oxygen concentration in the flue gas.

FIGURE 7. Secondary Air dependence on oxygen concentration

V. Conclusion

Analysing the scientific findings on woodchip furnaces and their applications, concluded that the woodchip furnaces are used in the timber industry, which is due to more efficient use of wood as twigs wood chips, bark and wood chips is surplus it when not in use should be discarded.

- Woodchip furnace high efficiency and simple operation principle because they are used for diverse purposes;
- Significant differences in the use of furnaces, in particular, are used in a rotating drum drying particle drying, used cogeneration plant for steam production, which cut turbine;
- Furnaces, which are used in drum drying are simplified operation principle of respect as the furnace operation algorithms based on one variable;
- Oven, which is used in combined heat and power station is controlled by the oxygen concentrations in the flue gas, and by comparison with other stoves concluded that the thus obtained more energy from the burning material;
- When driving the drum drying ovens used in the oxygen concentration in the flue gas sensor, it would save the fuel.

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