Approaches to development the system for control of quality and combustion of biofuels

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Abstract. **In this article the methods and facilities of the system of quality and combustion of various types of fuel are considered. The device for measuring the heat capacity and evaporation heat of moisture and organic liquids from inhomogeneous materials is considered, which is realized by the method of synchronous thermal analysis. The methods and facilities of control of burning process of fuel with using oxygen sensors are showed.**

Keywords — measurement system; evaporation heat; heat capacity; synchronous thermal analysis; fuel combustion; oxygen sensors

I. INTRODUCTION

To date, biomass is the fourth most important fuel in the world after coal, oil and natural gas. The energy potential of biomass is equivalent to 1.7 trillion cubic meters of natural gas, which is about 15% of the total consumption of all primary energy sources, including nuclear fuel [1].

It is known from open sources that the coverage of energy supply by burning biomass in developing countries is 48%. In the industrialized countries these parameters change: in the USA – 3,2%, in Denmark – 6%, in Austria – 12%, in Sweden – 18%. In general, the total amount of energy from biomass exceeds the total amount of nuclear energy by 4 times.

With the introduction of new market relations in the energy sector and the increase the selling prices for heat and electricity, the role of decentralized heat and power supply for autonomous industrial facilities, small settlements and farms is growing substantially. In this connection, the problem of creating a control system of quality and combustion of fuel for boilers working on biofuel becomes urgent.

II. FORMULATION OF THE PROBLEM

In the conditions of insufficiency of hydrocarbon fuel on the territory of Ukraine, the use of biomass as a renewable fuel resource is becoming increasingly important. As the main source of renewable fuel today are considered the waste of agricultural work, logging, woodworking and shoots of trees such as willow, poplar, alder, which grow rapidly on "energy plantations" [2].

For the most effective use of shoots of energy trees – as a basis or component of fuel briquettes – the wood must be crushed to a chip 2...5 mm and dried, because the calorific value of wood during dehydration from 50...60% to 10...20% increase by 2 times. For calculating the energy costs and the efficiency of the drying process of moist wood, we must know the thermophysical characteristics such as the evaporation heat and the heat capacity of moisture from biomass.

In the future, it's possible to close the operation of the boiler to the most rational modes with the help of an automatic control system of the combustion process, which is based on the using of oxygen sensors.

III. MAIN PART

For optimizing the process of drying the raw materials, it is necessary to consider the equation of the kinetics of drying, the parameters of which are the values of the known as criteria of Kosovich (Ko) and Rebinder (Rb). In terms of physical content, Ko and Rb are precisely the optimization criteria, and not similarity criteria [3], and the use of the corresponding values of these criteria for specific materials makes it possible to detail the problem of drying optimization in detail.

The Kosovich's criterion characterizes the relationship between the value of heat, which is expended on the process of evaporation of moisture Q_{evap}, and the heat that is expended on heating the material Q_{heat} for the entire drying process:

$$Ko = Q_{evap} / Q_{heat} = \frac{r \cdot \Delta W}{c \cdot \Delta T}, \quad (1)$$

где r is the specific evaporation heat of the liquid; ΔW is the change in the moisture content of the material during drying process; c is the specific heat of the material; ΔT is the temperature change of the material during drying process.

The Rebinder's criterion is the ratio of the heat that is consumed to heat the material, to the heat expended in evaporation of moisture over an infinitesimal time interval ($Rb = (Ko)^{-1}{}_{\Delta\tau \to 0}$):

$$Rb = \frac{c \cdot dT}{r \cdot dW}, \quad (2)$$

where dT is the change in the temperature of the material over an infinitesimal time interval; dW is the change in the moisture content of the material over an infinitesimal time interval.

Existing methods of measuring the specific heat of evaporation, both theoretical and experimental [4], do not satisfy modern needs in the accuracy and simplicity of obtaining the result. The evaporation of moisture or organic liquids in such materials can be accompanied by a considerable number of additional processes, among them the change in the concentration and the ratio of the components of organic liquids in the material, phase transitions of the second kind, crystallization and others.

For solving this problem, the Institute of Technical Thermophysics of the National Academy of Sciences of Ukraine has created a synchronous thermal analysis instrument for the experimental determination of heat capacity and evaporation heat of liquids from materials [5], which combines microcalorimetric and thermogravimetric methods of investigation (Fig. 1).

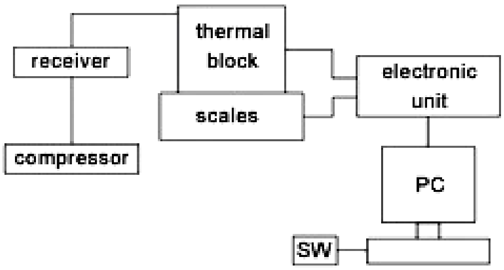

Fig.1. Schematic representation of differential evaporation microcalorimeter

For designing and using burners which operating on biofuels, a number of requirements are put forward, among which: compactness, convenience in use, long service life and relatively low cost. But one of the most important requirements is the need to ensure complete and reliable combustion of fuel with a minimum of excess air, i.e., burners should provide the formation of a stoichiometric air-fuel mixture. In Fig. 2 shows the factors affecting on the fuel combustion [6].

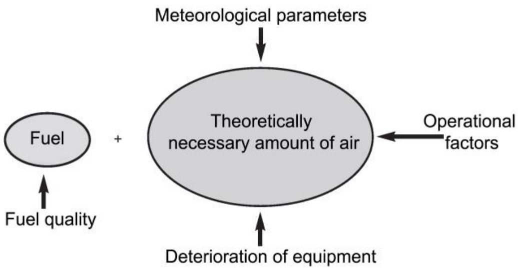

Fig.2. Factors of influence on the combustion process

The excess air factor (α) is used for determine the efficiency and profitability of fuel combustion, the value of which is determined according to the ratio:

$$\alpha = \frac{[O_2]}{[O_2]-[O_2]_{exh}}, \quad (3)$$

where $[O_2]$ is the concentration of oxygen in the air, %; $[O_2]_{exh}$ – is the concentration of oxygen in the products of fuel combustion,%.

Based on the developed methods, algorithms and software, a control unit has been created and is a part of the fuel combustion control system [7]. One of the features of the control unit is the possibility of using it as an independent gas analyzer (Fig. 3).

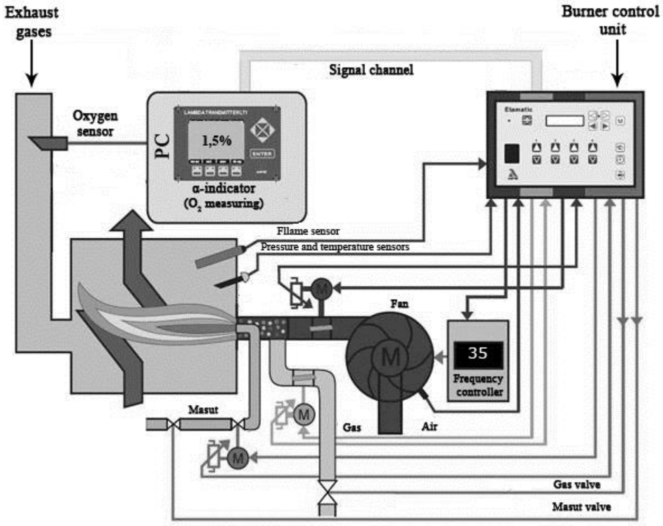

Fig. 3. The block diagram of the system of automatic control of the fuel combustion process in boilers

The obtained results show that the developed system provides the fuel combustion within the limits of acceptable concentrations of CO and NO in combustion products (<50 ppm) [8].

IV. Conclusions

The methods and hardware applications described in this article are the basis for creating the system for control of quality and combustion of fuels. This system will significantly increases the efficiency of fuel combustion by the thermal power objects.

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