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THE RESEARCH OF BURNING TECHNOLOGY OF WATER COAL FUEL GOT FROM SHUBARKUL COAL

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Modern development of power system is characterized by the decrease of using expensive liquid fuel which is a valuable raw material for the oil refining industry and the increase of using solid fuels. Stocks of high-quality coal deposits are exhausted due to increase in a share of solid fuels. Besides, there is deterioration in a quality of solid fuels extracted by mining method. Transition to the development of powerful coal deposits mined by open way and the use of it as fuel for power plants and other fuel using devices are connected with certain difficulties. And mainly it is because of high cost and power consumption of preparation process for burning.

Keywords: fuel, coal, water coal fuel, nozzle, coal, installation, burning.

Introduction

Hydrocarbon fuel (WCF) is one of the most effective substitutes of coal, expensive liquid fuels and natural gas. Application of WCF is effective since it creates ecological purity, high culture in a boiler room and provides profitability by burning combustible [1].

Now there is a reconsideration of role and importance of coal in providing energy and economic security of the state. Thus, the increase of coal share in fuel balance is a stabilizing factor of protection of deep energy crises. However, environmental problems arising within the use of coal, demand development and implementation of new environmentally pure coal technologies. In this regard the use of coal in the form of suspension coal fuel is perspective (WCF). Implementation of WCF provides savings of energy and material resources and environment as well. In addition, the use of WCF is the most effective and environmentally pure method of utilization of thin coal slimes of mining- and recycling coal enterprises.

For use of water coal fuel (WCF) in an energy except WCF preparation, effective ways of its burning are obviously necessary also.

The very process of burning water coal fuel is not only a technical but a research interest as well. The feature of coal burning as a part of WCF is that burning happens in WCF drop, wherein, unlike coal dust burning, at burning of WCF there are at least two mechanisms:

• Classical burning on “drying-ignition-burning mechanism”;

• Decomposition of "coal + water" (C + H_2O) on synthesis gas (CO + H_2).

Today more than ten types of steam and hot water boilers on which WCF burning (DKVR, DE, KE, BKZ and others) is made are approved. In most cases a torch or vortex burning is used. Depending on brands of boilers and a specific situation at place, WCF burning is possible by replacement of nozzles on wear proof while working with WCF in standard oil-gas burners. In certain cases the change of aerodynamics of fuel burning that allows to use still not only WCF but also gas and/or fuel oil is required transferring them to the category of reserve fuel. Produced reconstructions allow burning WCF completely independently without flame stabilization by fuel oil or gas. However, in some cases it is more advisable to consider not only complete replacement of gas/fuel oil with WCF but partial as well. Preservation of 10 - 15% of fuel oil in fuel balance of a boiler can simplify its reconstruction that will allow reducing capital costs on transfer to WCF.

So far the technology of producing and use of WCF reached level of industrial application. However, a large amount of water, existence of mineral components in particles in size of 40-80 microns and rather low warmth of burning, that is, 12-17 MJ/kg demand certain conditions for reliable ignition, sustainable and efficient burning of WCF in fire chambers.

Suspension water coal fuel is a disperse system consisting of micronized coal of Shubarkul deposit (coal slime), water and reagent-softener.

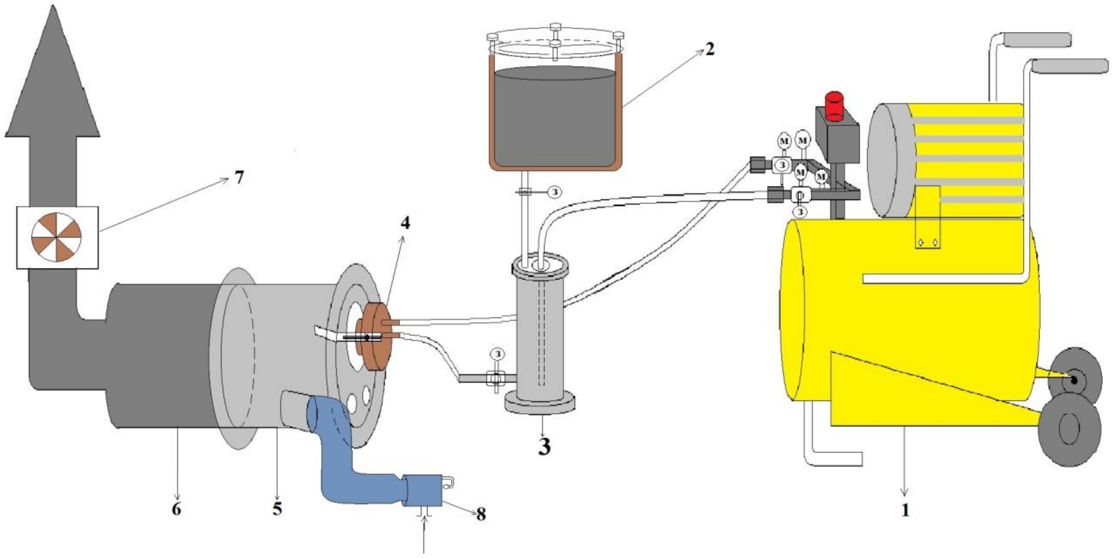
The vortex way of burning [2] provides maximum burning of coal particles using mechanisms of internal stabilization of burning that are characteristic for vortex fire chambers. Stabilization of burning in vortex fire chambers is provided because hot burning products are directed to the root of this torch and it provides reliable ignition at relatively low temperature. Besides, due to tangential input of blasting streams the vortex current and hashing of hot products combustion with coming streams that provides the highest burn up of fuel and combustion stability is organized.

Experimental conditions

The technology of WCF application is pure since wet grinding without dust allocation is used. Preparation, giving and burning of WCF technologically reminds and is similar to work on fuel oil but with less pollution. WCF is stored and transported in containers. For internal displacement pumps and pipelines are used [3].

In Hydrodynamics and Heat Exchange Laboratory fractions of Shubarkul coal deposits were ground by electrohydraulic method. Organic compounds and technology of dosed addition of found combinations in the mass of water coal fuel are selected. The process of formation of water coal suspensions spatial structure has been investigated, its rheological properties have been studied and it was established that stability of water coal suspensions got on the basis of concentrates is defined by physical and chemical properties of softeners. The use of softener allows create water coal suspensions with the spatial net-like structure not being exfoliated for a long time.

The experimental stand (figure 1) consisting of a compressor (1), a tank (3), nozzles (4), combustion chambers (6), a diesel fuel device (5) for ignition, manometer and blowing fan (7) is developed for experimental test of technology of WCF steady effective burning.



1- compressor, 2 – WCF storage tank, 3 – WCF tank, 4 – WCF nozzle, 5 – burner device, 6 – combustion chamber, 7 – blowing fan, 8 – ignition burner

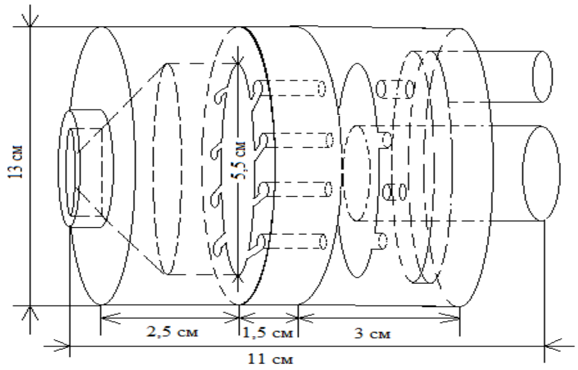
Fig.1. General view of installation for ensuring sustainable combustion of water coal fuel

The main unit providing steady burning of WCF is the nozzle developed in the laboratory.

Figure 2 shows the scheme and general view of nozzle for spraying water coal fuel.

a)

b)



c)

Fig.2. Photos (a, b) and scheme (c) are the nozzles for water coal fuel burning

The nozzle is made of steel, all parameters are shown on the scheme of figure 2. Simple nozzles, for example, in gas nozzles is one opening and in our case the nozzle is necessary for good injection when burning water coal fuel of 6 holes. The hole diameter is 2 mm.

Taking into account high erosivity of particles of water coal fuel firm phase, injector nozzles are made of wear-resistant material. The compressed air coming from the compressor with pressure to 0,6 MPa is applied as a spray.

There were sound effects of high-pitch tone characteristic for vibration burning while the nozzle was operating and it was like gas nozzles were operating. This effect was sustained in whirlwind fire at the base of the aerodynamic stabilizer of a nozzle.

The principle of operation of an experimental stand (Figure 1) is as follows: water coal fuel goes from tank for water coal fuel storage into tank. The air goes into the same tank from compressor which creates excessive pressure in tank volume promoting fuel pushing out into fuel line connected to the nozzle. Further water coal fuel is supplied into a nozzle under pressure. The air is supplied there also from compressor under pressure. Vortex airborne mixture is created with the help of the nozzle said above capable to ignite and burn steadily at certain temperature. The temperature in the combustion chamber was measured by a thermosteam and supply of WCF and air was measured by a manometer.

The aerodynamic structure of streams in a zone of active burning shows that investigated fuel burners really reproduces the whirlwind stretched on fire chamber depth with the formation of extensive recirculation zones near its longitudinal axis and side walls. A consequence of this process is a temperature distribution in the furnace volume.

The dispersion of water coal fuel by the compressed air is carried out as follows. In a nozzle when mixing WCF and spraying agent there is a crushing of WCF stream due to kinetic energy. Considering polydispersion of coal particles in WCF, at dispersion purely coal particles are formed from which at the expense of powers of hydrodynamic friction both the liquid film with the thinnest particles and water coal drops consisting of thin particles of coal and a liquid phase breaks. Figure 3 shows a trace of WCF dispersion from a nozzle.

Fig.3. Trace of nozzle dispersion

During tests it is established that there is an intensive crushing of drops in a stream and formation of small drops at vortex supply of air and fuel mixture.

Moving drops are affected by environment friction forces ($\Psi \rho V_r^2$) which tend to flatten out and shatter drops. On the contrary, forces of superficial tension ($2\sigma / r_k$) tend to give a spherical form to drops. When pressure of friction forces is more than pressure of superficial tension force there is crushing of drops. Drops of maximum size are obtained from the equality of these forces, i.e,

$$\Psi \rho V_r^2 = \frac{2\sigma}{r_k}, \qquad (1)$$

from

$$r_k = \frac{2\sigma}{\Psi \rho V_r^2}, \qquad (2)$$

where Ψ – coefficient of gas environment resistance;

ρ – density of gas environment;

V_r – relative speed of a drop toward gas environment;

σ – coefficient of superficial tension;

r_k – drop radius.

Formula (2) shows that diameter of WCF drops significantly depends on a superficial tension, density of the environment and relative speed of drop movement.

Results of experiment

We determine temperature of liquid fuel burning with the help of measuring device for determination of burning efficiency.

Figure 4 shows the schedule of dependence of temperature change of fuel burning for a time. As it can be seen from the diagram the initial flame temperature is 450^{0}C but it increased to 850-950^{0}C after opening the nozzle valve. The highest temperature of fuel burning reached 1050^{0}C.

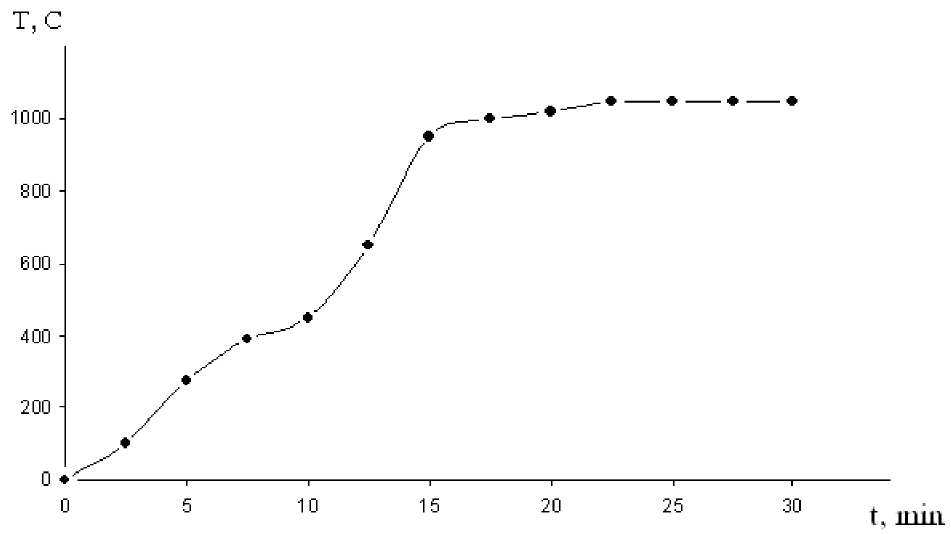


Fig.4. Schedule of dependence of temperature change of fuel burning for a time.

The active vortex aerodynamics created in the chamber by tangential giving of blowing is used for a deep burning of flying and ablation and suppresses emission of harmful substances due to active mix. Besides, due to vortex aerodynamics the time of fuel particles increases several times which also has a positive effect on the level of harmful emissions.

Conclusion

On the basis of done experiments it is possible to draw the following conclusions: the technology of water coal fuel burning got from slimes of Shubarkul coal is developed, the nozzle for spraying liquid fuel including aerodynamic processes when burning water coal fuel is made, the experimental stand is made, laboratory researches on burning water coal fuel on experienced installation are conducted, temperature dependence of WCF burning for a time is defined.

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