Increase of coal use efficiency at heat-and-power engineering units by coal mechanical activation and microgrinding

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The presented below are the experimental results for combustion of the mechanically activated microgrinded coals of 30-40 mcm at the thermal test benches of 1 and 5 MW. Efficiency of the technology of mechanically activated coal microgrinding in the large-scale heat-and-power engineering and small generators is being proved in this paper in the context of improvement of cooperation between the countries of the Asia-Pacific Region.

Key words: **microgrinded coal, mechanical activation, heat-and-power engineering units, efficiency.**

1. INTRODUCTION

Russia has been developing international cooperation both in Europe and in Asia. Good prospects for such cooperation exist in the Asia-Pacific Region (APR) including Siberia and Far East. Owners of the coal business are trying to squeeze out maximum from the current state of the market and increased demand in the power station coal in this region.

At the oil deficit and high prices the number of new coal power-generation projects increases in the APR countries. In 2010 new power units are planned for commissioning in China - 35 GW (coal consumption 132 mln. tones), India - 17 GW (coal consumption 80 mln. tones), and other Asian countries - 8 GW (coal consumption 34 mln. tones) [1].

However, use of raw coals and their combustion are inefficient (low efficiencies of the existing boiler equipment, increased losses, and high harmful emissions in the atmosphere) and their application area is rather limited.

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Extended use of the energy efficient coals in the heat-and-power engineering units for the account of efficient coals combustion may be achieved at the increase of their chemical reactivity at mechanically activated microgrinding up to 10–40 mcm with the use of different mills (vibrocentrifugal, planetary, and disintegration types). Among the areas of such use are replacement of gas and fuel oil in the units of large-scale heat-and-power engineering and small generators, and involvement of low-reaction coals in fuel balances. Besides, application of mechanically activated microgrinded coals at thermal preparation of fuel results in additional suppression of furnace nitrogen and decreases emissions of NOx.

In domestic heat-and-power engineering the main technology for coals combustion is coal dust torch, at that, there are problems of necessary stabilization of torch burning at the use of low-reaction coals, and besides, the ignition of coal-dust boilers is often realized with the use of available high-reaction hydrocarbon fuel - gas / mazut. In the eastern part of the country gas supply is short and price of mazut is much higher than the one of the coal. Therefore, change of physical and chemical properties of coals becomes rather topical in terms of their approximation to hydrocarbon fuel. It should be noted that this issue is relevant to the development of new technologies of coal processing as well, including gasification being the principal stage of processing at the development of steam and gas units.

Results of mechanically activated microgrinded coals combustion obtained at the experimental units of Kutateladze Institute of Thermophysics SB RAS have shown that the proposed energy efficient technology provides new useful qualities of coals – increase of their reaction capacity. At that, coal-dust torch becomes

similar to liquid fuel for the account of the change of physical and chemical properties of the coals (in dimensions, calorific intensity and burnout intensity) that allows its replacement.

2. EXPERIMETNAL STUDIES OF MECHANICALLY ACTIVATED MICROGRINDED COALS COMBUSTION WITH MINIMAL HARMFUL EMISSIONS

Over the last years Kutateladze Institute of Thermophysics SB RAS has carried out intense and broad investigation of mechanically activated microgrinded coals in the units of the large-scale power engineering and small generators at specially developed test-benches of 1 MW and 5 MW.

Since main mechanism of nitric oxide formation at coals combustion is bound with fuel nitrogen, then to decrease nitric oxides emission in the process of coal dust torch ignition, fast heating of coal particles with minimum air surplus at this stage was realized.

2.1. Main structural components of the test-bench.

The burner with the changeable structure is connected with the muffle subdivided furnace extension though the flange. The furnace extension has windows for visual monitoring of the torch and for thermocouple setting and the outlets for the introduction of the probe of optical-absorption gas analyzer. Exhausts of combustion products go to the chamber from concrete rings and then to the vortical scrubber-refrigerant, and then to air-exhauster and to the exhaust.

The system of dust preparation consists of the external crusher from where the ground fractions to 10 mm are supplied to the tank for the ground coal and then by the “Noriya” conveyor is supplied to the receiving tank, and further on by the feeder of vibration type to the disintegrating mill. The obtained coal dust suspension is supplied with the primary air to the combustion chamber. It is inflamed with the use of special gas device - the ignition control system - or plasmatron. Cooling of the combustion products and ash catch occur in the scrubber. Besides, primary cooling of exhaust gases by water injection to the chamber prior to the cyclone is provided. Supply of primary and secondary air is realized by the blow fans. Along with the secondary air mechanically activated microgrinded coal-dust can be supplied for “re-burning” in the coal and dust afterburning chamber. It is also possible to use the option of dry catch by cyclones with dilution of combustion products with cold air before smoke exhaust.

The control system for burning products structure consists of the measuring block including the gas analyzer and the block of sample preparation, the block for the interface with the PC, probe for sample selection, filter and line for sample transportation. Sample transportation line includes gas commutator providing analysis of the samples taken from different spatial points of measurements. The system serves to carry out continuous measurement of the combustion gas concentration, data store using the PC system of data collection and processing, and to determine the effect of coal mechanical activation method at microgrinding on the activation energy at inflammation and combustion of coals.

3. EFICIENCY OF MECHANICALLY ACTIVATED MICROGRINDED COALS COMBUSITON

Approximation of reaction properties of mechanically activated microgrinded coals to gas and mazut properties opens wide opportunities for fuel replacement in gas and mazut boilers by mechanically activated coals, [2], [3]. At coal mechanical activation decomposition of individual chemical bonds occurs with formation of free radicals speeding up further processes in chemical reactions. At that, organic component of the fuel being a high-molecular compound becomes deformed. At macromolecule deformation the molecular chain structure, interatomic and intermolecular distances change with the weakening of intra- and intermolecular bonds and respective increase of free substance energy. At deformation of electronic shells energy barrier of reactions decreases. At coal dispersion

structural changes occur along with the decrease of the pack density, the share of the layered carbon, etc. These processes approximate combustion of the coal-dust fuel of fine grinding to combustion of gas-mazut fuel.

Besides, coal mechanical activation serves to decrease nitrogen oxides formation at dust and coal combustion. Rate of natural nitrogen separation is normally identified as the rate of volatile emission, i.e. time of coal particles heating. So, to decrease the amount of NOx the prospective is grinding of particles that serves to reduce time of volatile emission and NO_X formed at that in the area of inflammation and dust and coal combustion onset.

To determine specific features of the coal grinding methods influence on its kinetic characteristics the series of studies were carried out to investigate changes of physical and chemical properties of brown coals of B-2 grade mechanically dispersed in the mills with increased calorific intensity (planetary, vibromill and disintegrator); the coals were from Kansko-Achinsk deposit and had the following characteristics, % A^p -20.4; V^{dat}= 46.5; W^p – 34.2.

It is shown that at intense mechanical activation of coal substance in dispersing apparatuses with rather high energy influence along with the decrease of the particles' dimensions and specific surface their activation occurs; it includes partial mechanical destruction of relatively high-molecular components of organic mass of coal that results in significant change of its physical and chemical properties, including the increase of reaction capacity.

Fig. 1 shows the results of measurement of brown coal particles' dimensions after grinding employing two types of mills: vibrocentrifugal (VCM) and disintegrating mill.

It is apparent that the average size of their particles is practically the same and equals ~ 40-42 mcm, i.e. the reaction surface in both cases is practically the same and it can be assumed that the rates of inflammation and burning of the coal-dust torch at such coal combustion shall be the same.

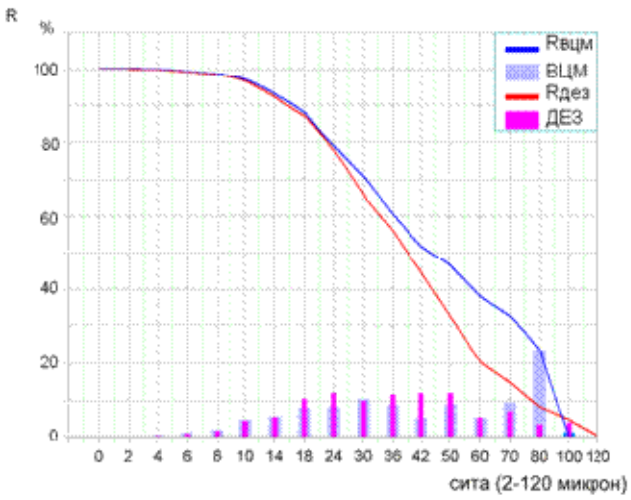

Fig. 1. Spectrum of the particles of brown coal of B-2 grade after grinding employing two types of mills: vibrocentrifugal (VCM) and disintegrating mill (DIS).

However, the experiments have revealed that the combustion rates after grinding in the different types of mill are significantly different. This is proved by great difference in the activation energy at inflammation and combustion of coal after grinding. Torches in the furnace volume of the extended test-bench at the use of vibrocentrifugal mill and at the use of vibrocentrifugal and disintegrating mills are significantly different (Fig. 2, 3). The experiments show that at mechanical activation in the disintegrating mill activation energy decreases (to 2-3 times); the coal and dust torch becomes similar to the gas/mazut one (in terms of dimensions, calorific intensity and burnout intensity) for the account of the changed physical and chemical properties of coal.

Fig.2. The torch in the furnace volume of the heat-and-power test-bench at brown coal combustion in the vibrocentrifugal mill.

Fig.3. Coal and dust torch burning at mechanically activated microgrinded coal in the disintegrating mill.

The innovation product – mechanically activated microgrinded coal – can be used as follows.

- For re-equipment of coal chain-grate boilers for ultra fine coal combustion;
- For replacement of the used liquid fuel (mazut, diesel) and gas in the gas and mazut boilers in small power generators;
- For replacement of the used mazut and gas at ignition and stabilization of the coal and dust torch combustion in the coal and dust boilers of large-scale power engineering and small generators;
- For direct use in gas-turbine units without the stage of gasification.

Implementation of technology comes up to re-equipment of the boiler or boiler house using liquid fuel (mazut, diesel) and gas with new production units for their replacement – devices for ultra-thin coal grinding and additional equipment for coal storage, supply and combustion as well as the systems of ash-catch and disposal.

The principal production unit is the unit of ultra thin grinding. For ultra thin coal grinding (30 – 40 mcm) the most preferable are disintegrating mills with the lesser dynamic loads. They serve to regulate the shock-abrasive treatment mode and develop the necessary degree of thinness and structural modification of mineral substances. The productivity range is from 100 kg/hour to 5 tones/hour, power inputs - 25 – 40 kWh/t. However, selection of the mill type would depend on specific technical and economic conditions.

Technological solutions for additional equipment are standard; as applied to specific solutions only their modification will be needed. There are design organizations and plants manufacturing mills and additional equipment.

The calculations of commercial effectiveness show that the projects where mechanically activated microgrinded coals are applied in a number of boilers of the Eastern Siberia and Yakutia instead of liquid fuel are characterized by short backpay periods – from several months to 2-3 years, and in the large-scale power engineering for the replacement of mazut ignition and illumination in coal and dust boilers – about 2-5 years (Fig. 4, 5).

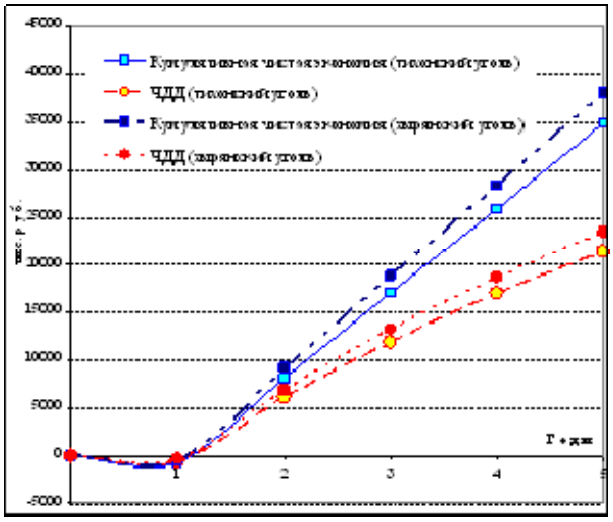

Fig. 4. Financial profile of the project "Replacement of liquid fuel in the boilers of Sakha-Yakutia"

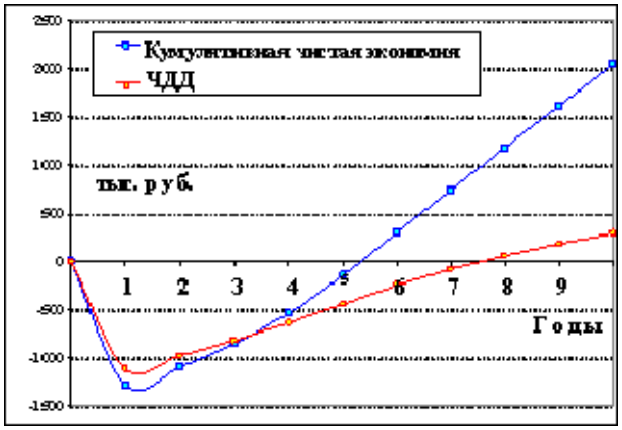

Fig.5. Financial profile of the project of coal microgrinding system development at the boiler BKZ-420 of Ust-Ilimsk cogeneration plant of "Irkustkenergo" JSC

4. COOPERATON WITH THE CONTRIES OF ASIA-PACIFIC REGION (APR) IN POWER ENGINEERING

In the near future dynamics of the world consumption of the power-generating coal will directly depend on the economic situation in APR countries. Inexpensive Asian goods with relatively high quality have found their market among the demanding consumers and at the conditions of economic crisis have proved their competitiveness. Therefore, Asian consumers for whom supply of energy resources is the Achille's heel will go on experiencing considerable need in power-generating coals. Even China, one of the main world coal powers, in 2009 first time in history became a net-importer and exported 10 tons of power-generating coal from Russia. At the conditions of relatively high rates of economic growth in APR countries lack of power can be faster and the least expensively filled by construction of coal electric power stations on the coast.

Increase of the export of Russian power-generating coals to APR countries can be achieved for the account of the increased supplies from Siberia and Far East (Kuznetsk, Tugnuisk, Elginsk, Ural and other coals) [4,5].

Along with the interest of Russia in the development of power supply systems in the Asia Pacific Region at present the emphasis is being made at the strengthened industrial cooperation and collaboration in technology transfer. There are intentions to develop joint projects with China, Japan, and South Korea with the view of active cooperation in the development of both raw material industries of Siberia ad Far East and new technological trends. Besides, the forum of Asia Pacific Economic Commonwealth (APEC) has broadened the area for academic research. Participation of Russia in the Forum can be realized both by the construction of new energy configuration of APR and in the development and promotion of new technological developments. There are long-term APEC programs: the Program "Environmentally Sound Energy Infrastructure Initiative" studying practical experience of the region in the transfer of the so called "pure" technologies of solid fuel combustion with the lesser waste, implementation of new and renewable energy sources as well as the Program "21st Century New and Renewable Energy" targeting to reduce the barriers of new technologies implementation in power engineering.

The proposed technology on increasing efficiency of the wide range of coals used in the region for the account of coals mechanical activation and microgrinding can be also considered as a proposal for cooperation with Asia Pacific countries along with the proposals being developed on export of coals.

5. REFERENCES

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