New Plasma Arc Furnace for Brown Coal Combustion

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As it is well known coal is one of the main energy carriers by means of which electric and heat energy is produced in thermal power stations. The quality of the extracted coal decreases very rapidly. Therefore, the difficulties associated with its firing and complete combustion arise and thermo-chemical preparation of pulverized coal becomes necessary. Usually, other organic fuels (mazut – fuel oil or natural gas) are added to low quality coal for this purpose. The fraction of additional organic fuels varies within 35-40 % range. This decreases dramatically the economic efficiency of such systems. At the same time, emission of noxious substances in the environment increases. Because of all these, intense development of plasma combustion systems of pulverized coal takes place in whole world. In our paper we present development of new highly efficient plasma arc combustion system and first results of experiments on this system.

I. INTRODUCTION

A**t** heat power stations, in combustion of heavily ballasted coals that cannot burn by themselves, especially under conditions of minimum loads, it is necessary to provide a maximum intensification of the pulverized coal flame with fuel oil. In this case the share of fuel oil in total heat released in a boiler furnace may amount to 30 %. Combustion of coal with fuel oil in the above proportions leads to intensive high-temperature corrosion of screens, dramatic decrease in burnout of particles of a solid fuel (its unburned part is emitted together with ash and fume), chemical underburning, increase in the amount of pollutant emissions (compared with coal, fuel oil contains twice as much sulfur), and increase in the rate of accidents with steam superheaters. As a result, this causes reduction in the efficiency of boilers [1]. In order to improve the efficiency of coal combustion new plasma-fuel system for thermal power plants is developed. It is pulverized coal burner equipped with arc plasmatron. It provides fuel oil-free startup of pulverized coal fired boilers, flame stabilization, and as a consequence, the simultaneous decrease of unburned carbon and nitrogen oxides formation due to two-stage combustion [2]. Plasma-fuel systems procedure is based on

plasma thermo-chemical activation of coal for burning. It consists in arc plasma heating of air-fuel mixture up to the temperature of coal devolatilization and carbon residue partial gasification. By that from air-coal mixture hot combustible gas and highly-reacting coke residue is obtained. When mixed with secondary air at furnace it can be ignited and burn stably without use of fuel oil or natural gas traditionally used for boilers start up and low-rank coals flame stabilization [3]. The use of plasma-fuel systems at thermal power plants decreases the unburned carbon by 40-50%, nitrogen oxides by 50-60%, and carbon dioxide emissions can be reduced by 1-2%.

The idea behind a plasma-assisted pulverized coal burner (PAPCB) is to blow plasma torch into the pipe through which pulverized coal in air flows (Fig. 1) [4]. The procedure of plasma assisted start-up of a pulverized coal-fired boiler is similar to the procedure of start-up of a boiler using heavy oil. The essence of plasma assisted start-up procedure is that the plasma assisted pulverized coal burners with installed plasmatrons (Non-Transferred Plasma Torches) are fired first. The remaining pulverized coal burners are gradually started after reaching the required thermal parameters of the furnace and other elements of the boiler [4-7].

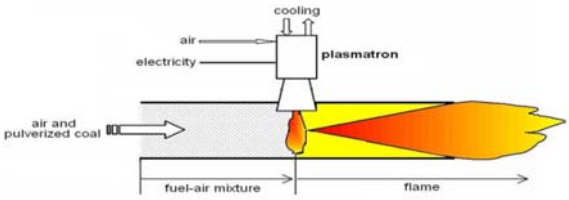

Fig. 1 Working principle of the PAPCB

II. EXPERIMENTAL SET-UP AND RESULTS

We developed the lab model of plasma arc burner and its power source (15kW). In our proposed system (as it shown of fig. 2) pulverized coal air mixture passes through the long plasma arc area that burns between to carbon electrodes directly in pulverized coal burner.

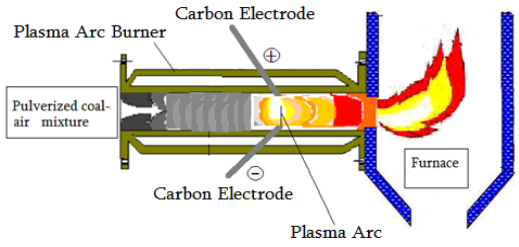

Fig. 2 General scheme of plasma arc burner system for pulverized coal combustion

Consumption of the carbon electrodes is low and does not need cooling system, but the main advantage of this method is that full power of long arc, especially its radiation, directly impacts on coal-air mixture that accelerates the process of thermo-chemical preparation of coal to burn.

To ensure the stability of the plasma arc in such difficult conditions, we have developed a power source which provides fixed current. During fluctuations in the arc resistance automatically compensated by the voltage change as well as regulation of plasma arc length over a wide range.

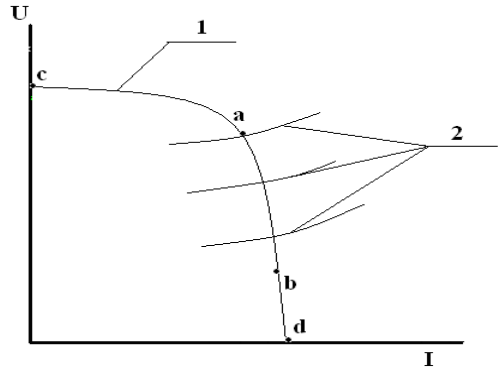

Fig.3 Volt-ampere characteristic of power supply

Volt-ampere characteristic of power supply is presented on Fig.3. The characteristic has practically rectangular form. The ***a-b*** part is the area of arc functioning, ***c*** is the idle voltage of power supply, ***d*** is the current wich corresponds to short-circuit.

Our combustion system, where a long plasma arc acts directly on a pulverized coal-air mixture, is technically simple compared to sistems using plasma torches, and has the ability to adjust the arc length as needed. This should allow significant improvement of pulverized coal combustion (especially low quality coal) and its economic efficiency.

Fig.4 Plasma arc burner laboratory mock-up

On Fig.4 laboratory mock-up of plasma arc burner constructed by us is presented. On the ***left side*** - combustion chamber with 0.7 m^3 volume constructed from flame resistant breaks. Plasma arc burner is in the ***central part***. Electric arc is lit between two carbon electrodes. The diameter of electrodes is 20 mm and they are installed in 100 mm diameter steel tube. Electrodes are either 1) slanted with 45 degree with respect to the steel tube axis, or 2) oriented in opposite direction to each other. The distance between the electrodes can be modified. Consumption of electrodes does not exceed 10 mm/hour. On the ***right side*** - arc power supply is placed.

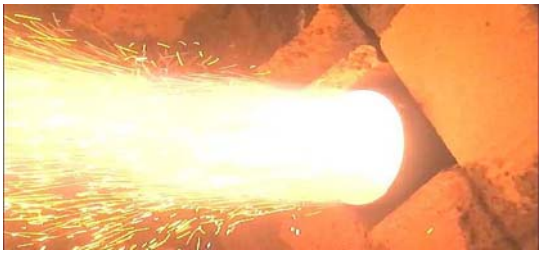

Fig. 5 Pulverized coal flame of plasma arc burner

Power supply delivers 15 kW and fixed arc current is of the order of 100 A.

The analysis of coal ash by Scanning Electron Microscope revealed presence of some quantity of heavy elements. Chemical and Spectroscopy analysis showed that as a result of combustion there is small amount of nitrogen oxides is exhaust area and their

quantity depends on combustion regime.

Preliminary experiments demonstrated the successful functioning of the system.

Acknowledgment

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