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STEAM BOILERS, POWER-GENERATING FUEL, BURNERS, AND BOILER AUXILIARY EQUIPMENT

An Annular-Furnace Boiler for the 660-MW Power Unit for Ultrasupercritical Parameters Intended for Firing Brown Slagging Coals

F. A. Serant[a], I. Yu. Belorutskii[a], Yu. A. Ershov[b], V. V. Gordeev[b, †], O. I. Stavskaya[a], and T. V. Katsel[a]

[a] *ZiO KOTES, ul. Kropotkina 96/1, Novosibirsk, 630049 Russia*

[b] *Podolsk Machinery Construction Works, ul. Mashinostroitelei 23, Podolsk, Moscow oblast, 142115 Russia*

Abstract—We present the main technical solutions adopted in designing annular-furnace boilers intended for operation on brown coals of the prospective Maikubensk open-cast mine in Kazakhstan as part of 660-MW power units for ultrasupercritical steam conditions. Results from 3D modeling of combustion processes are presented, which clearly show the advantages furnaces of this kind have over a traditional furnace in burning heavily slagging brown coals. The layout of the main and boiler auxiliary equipment in the existing boiler cell of the 500-MW power unit at the Ekibastuz GRES-1 district power station is shown. Appropriate attention is paid to matters concerned with decreasing harmful emissions.

Keywords: annular-furnace boiler, pulverized-coal burner, brown coal, ultrasupercritical steam conditions

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Along with the first-rate Ekibastiz coal field in Kazakhstan, which has been developed for a long period of time, large deposits of Maikubensk brown coals are also available in the same Pavlodar region. According to the data of Karagandagiproshakht i K, the balance deposits of these coals amount to 2.1 billion t. Planned mining of Maikubensk coals has been conducted since 1987. In 2011, 7.5 million t of these coals was produced, and it is planned to bring their annual production to 15.64 million t per year by 2020. Maikubensk coals are currently supplied and fired as substituting off-design fuel at many industrial enterprises in Kazakhstan, Russia, and Ukraine. For further development of such a large coal field be advisable, large permanent consumers of its coal must be available.

The Maikubensk open-cast mine offers coals categorized in the following groups of supply for being fired at power stations in pulverized form: with ash content $A^d = 13$, 22, and 28% with the working content of moisture $W^r \approx 18\%$. Maikubensk coal has high reactivity: with an average yield of volatiles equal to 41–42.9%, its heating value is 18840–19000 kJ/kg [1]. The heating value of volatiles with an ash content of 13–28% is around 7950 kJ/kg. This coal is related to Group 3 of explosion hazard (characterized by the explosibility criterion K_{st}, the value of which is in the range 1.5–3.5), as the majority of brown coals. Geographically, the Maikubensk open-cast mine is located not very far from the Ekibastuz mine, but the coals produced in them differ significantly from each other (Tables 1–3). Thus, in contrast to slagging and explosion-hazardous Maikubensk brown coal, Ekibastuz brown coal is related to Grade SS and Group 1 of explosion hazard; this coal is less readily ignited and is almost nonslagging. Thus, the slagging that occurred during the experimental combustion of Maikubensk coals in the highly heat-intensive furnaces of the P-57 boilers operating in the composition of the 500-MW power units at the Ekibastuz GRES-1 district power station did not allow these power units to be loaded to more than 70% of their nominal output.

In order to secure reliable and efficient operation of the boiler on Maikubensk coals, its furnace must be set to operate with moderate thermal intensities in its section to ensure a low temperature level of gases in the flame core and in the furnace top part.

On request of the Ekibastuz GRES-1 Directorate, specialists of ZiO-KOTES, working jointly with specialists of the Podolsk Machinery Construction Works, elaborated the profile of an annular-furnace boiler tailored for firing Maikubensk slagging coals as applied to a 660-MW power unit for ultrasupercritical steam conditions.

The technical solutions for the boiler were elaborated taking into consideration the experience gained from operation of the E-820 annular-furnace boiler installed at the Novoirkutsk cogeneration station in the city of Irkutsk. This boiler, designed for a steam output of 820 t/h, is installed in the existing cell for a boiler with a steam output of 500 t/h and has successfully been operating for already 12 years [2]. The boiler

† Deceased.