

## Research Article

# Low-Temperature Combustion Technology

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Any coal-fired boiler is always designed on a certain kind of coal. In the EU and Russia in the old coal mines can be mined coal with a high content of moisture and ash. In order to use coal with different characteristics in the same steam generator, it is necessary to create a new coal combustion technology.

## 1. Introduction

There is an urgent need in the growing efficiency of coal boilers. The boilers functioning for few years have a lot of problems. One of them is impossibility of using solid fuel with another chemical composition [1, 2]. During coal dust combustion, melted ash particles influence on the local slagging occurring in the furnace. By reason of slagging, steam generation decreases. In order to avoid negative consequences, decrease in coal feed is necessary. It allows decrease of the main risk of boiler stopping, but in this case also quantity of outlet steam reduces. Low efficiency of the boiler is the main reason to create a new combustion technology which does not depend on fuel chemical composition and herewith does not reduce quantity of outlet steam.

## 2. Methods

The schemes of furnace and low-speed burner which are investigated are shown in Figure 1(a) [3–6]. The burners are arranged on the frontal wall [3–6]. The methods of research, experience of combustion are described in detail [3–9]. The characteristics of fuel are presented in [10].

## 3. Inventions and Experimental Research

**3.1. Low-Speed Burner.** The short length  $l_f \approx 0.5$  m of the initial area of the flame is a main disadvantage of low-

speed burner (LSB) (Figures 1(a), 1(b) and 2). In this case opportunity of boiler stopping is real by reason of unburnt carbon melt. An impact on burning process here is impossible [3–6].

**3.2. High-Speed Burner.** At the beginning we developed a high-speed burner (HSB), which is shown in Figure 1(b). It is an intermediate option. These burners were tested. The experiments had shown good results. The separate inlet of air and coal-air mixture is recommended for accident-free operation of boiler. Although length of the initial flame area  $l_f$  is approximately 1.5 meters, this technology still does not allow control the behavior of flame [3–6].

**3.3. Multifunctional Burner.** In Figure 1(c) is shown the multifunctional burner (MB) [11–14]. Its feature is an ability to create a low-temperature combustion technology (LTCT) of any kind of fuel. The burner is equipped with air channels, channel supply fuel-air mixture, and the gas supply nozzles. MB created specifically for the combustion of lignite with a high degree of moisture and with a high degree of ash. The technology is based on a forced-air diffusion system. The oxidizer is fluently supplied into the furnace. This technology allows you to control the initial flame area and helps to reduce the temperature in the furnace of the steam generator. Therefore, control of the flame improves. Most importantly LTCT increases the efficiency of coal boilers.

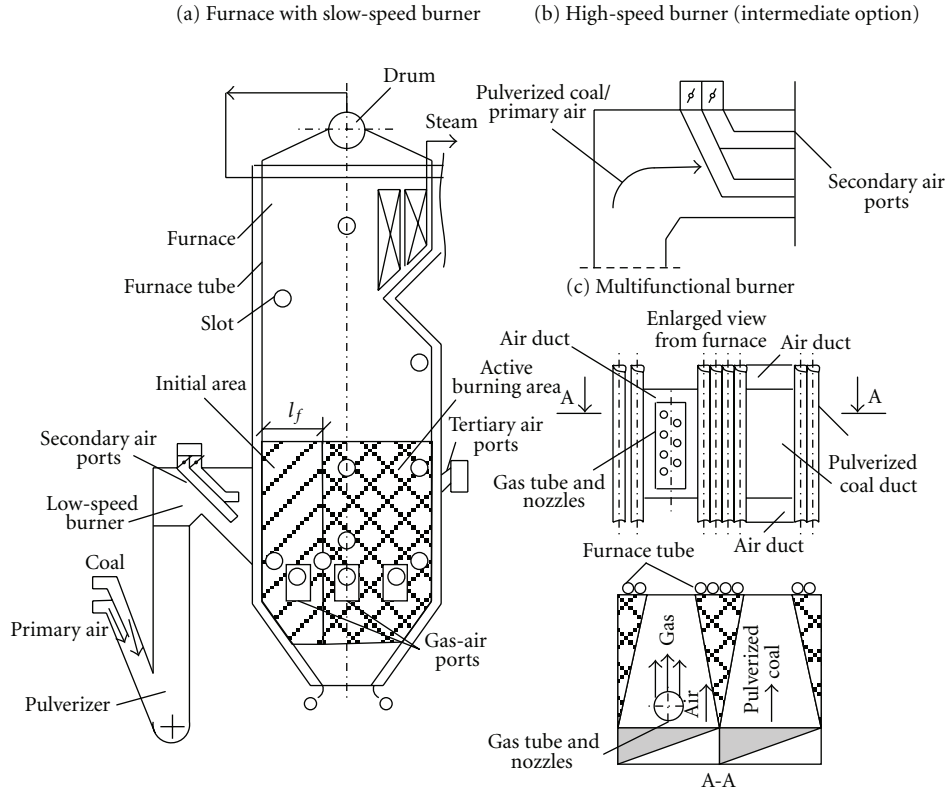


FIGURE 1: Coal-fired steam boiler (BKZ-210-140F) with different types of burners.

**3.4. Burning.** The homogeneous burning of coal-air mixture is realized according to curve 1 (Figure 2). In Figure 2 are presented the main characteristics of the flame [15, 16].

(a) The degree of fuel burnup is calculated using

$$a = 1 - L_4 - L_5, \quad (1)$$

where  $L_4$  is the heat loss due to formation of CO and  $L_5$  is the heat loss due to unburnt carbon in ash.

(b) The relative value of the consumption of the oxidant is calculated using

$$\overline{O_2} = 1 - \left( \frac{O_2}{21} \right), \quad (2)$$

where  $O_2$  is the oxygen content of the make-up air, %.

(c) The relative value of the formation of triatomic gases is calculated using

$$\overline{RO_x} = \frac{RO_x}{RO_x^{\max}}, \quad (3)$$

where  $RO_x$  and  $RO_x^{\max}$  are the current value of the triatomic gases concentration and its maximum value, %.

(d) gas temperature  $T, K$ .

The amount of combustion products increases along the trajectory of the flame [1, 2]. In this case the radiative heat flux, enthalpy, and temperature are increased. Furthermore, increase in heat flux is proportional to flow rate of oxidizer and fuel. The maximum values of thermal parameters are displaced to the boundary of the initial area (length  $l_f$  in Figures 1 and 2) [15, 16]. Comparing curves 1, 2, and 3 in Figure 2 shows that the degree of fuel burnup depends on the length of the initial flame area. If oxidizer fluent enters into the furnace according to curve 3 (MB) in Figure 2, temperature is decreased at the initial section then the combustion process is delayed in time. Carbon particles burn out better. The area of active burning is shifted to the center of the combustion chamber, and the slag does not have time to form. In comparison with other technologies for coal-fired boiler, temperature drops several tens of Kelvins. This technology can be named LTCT [15, 16].

**3.5. Environmental Aspects.** One of the important results is the reduction of the nitrogen oxides emissions. Experience shows in case of controlling of burning (in case of using MB) quantity of emissions harmful to the environment is reduced [8, 9, 15, 16].

## 4. Conclusion

In conclusion, MB is recommended for coal-firing boilers with frontal burner arrangement. In practice, MB creates

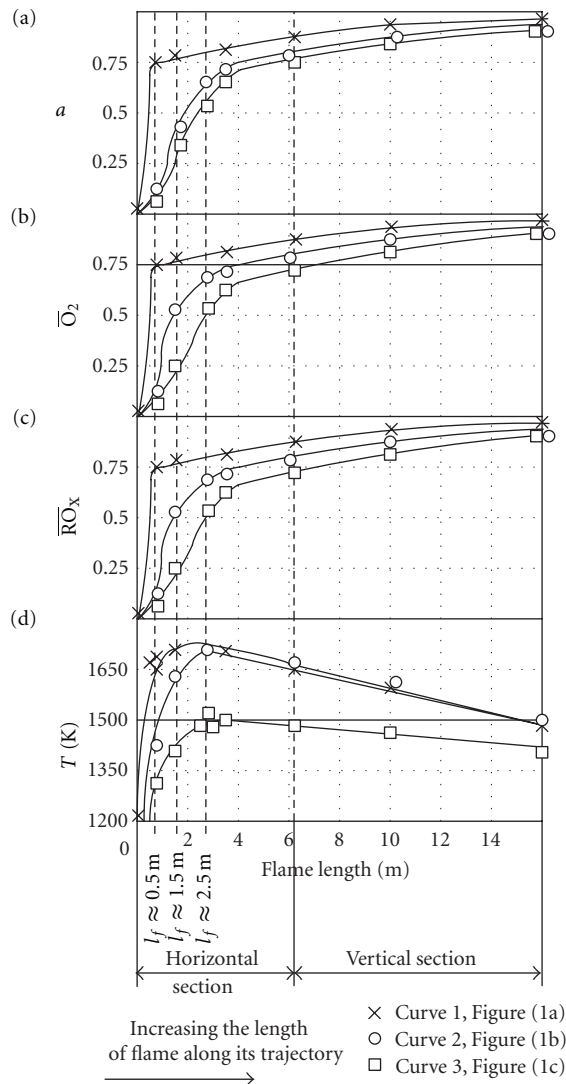


FIGURE 2: Change in the main flame characteristics along the flame length.

a new low-temperature combustion technology and allows controlling the length of initial flame area. This length  $l_f$  can be increased to 2.5 m. By reason of MB design feature, it is possible to avoid slagging occurring in the furnace, increase the life-time burner, and reduce the concentration of the nitrogen oxides in the exhaust gases [15, 16]. Furthermore MB and LTCT which are used on steam boilers in Russia can be recommended for any others coal-fired boilers in the EU.

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