AIR PROTECTION FROM POWER INDUSTRY EMISSIONS

1.5. Technologies of organic fuel combustion at TPPs with the lowered level of harmful emissions into atmosphere

1.5.1. Combustion of solid fuel in fluidized bed boilers

1.5.1.2. Combustion of solid fuel in circulating fluidized bed boilers

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Recently foreign power supply companies prefer boilers with the circulating fluidized bed (CFB).

FB and CFB technologies have the same operational principle. Air is blown into the furnace, where a bed, formed by ash, fuel and limestone, fluidized by the air, is generated. Fluidization causes a turbulent mixture, raising the fuel combustion efficiency and intensifying the limestone and sulfur dioxide binding, formed at oxidation of fuel sulfur. Inside the bubble bed, velocity of air and flue gases from the furnace is low (less than 2 m/s) and the bed borders can be visually observed.

The turbulence is enough for the satisfactory combustion of a high-reaction fuel, but not for the lean coal. The circulating fluidized bed velocity is about 5 m/s, and the bed material is taken into the upper part of the furnace. To return the material into the furnace, a separator is installed, and material, collected and removed from the bed, is returned into the bottom part of the furnace. This way the circulation loop of solid particles is created and this loop gave a name to the technology (Fig.1.59).

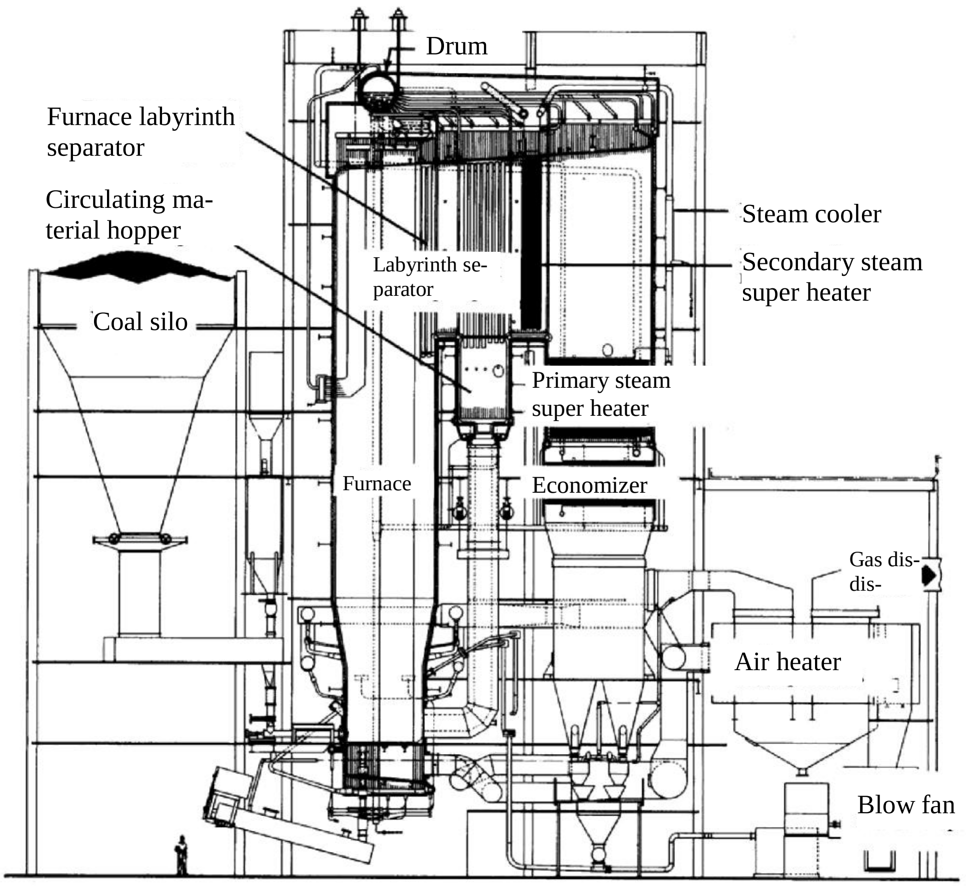

Fig.1.59. A boiler with the circulating fluidized bed and in-furnace separator

CFB-boilers have a greater extent of fuel combustion (approximately 99% in comparison with 90…95% in case of stationary fluidized bed boilers). They can operate at a lower excess air factor (1,10…1,15 instead of 1,20…1,25). Fuel supply systems at CFB-boilers are rather simple. The boilers are less demanding for the flue quality and are better adapted for the staged combustion, necessary for nitrogen oxide emission reduction. Such furnaces allow binding more than 90% of sulfur at the mole Ca/S relation of 2,0, whereas it is necessary to supply more limestone (Ca/S =3) into the stationary fluidized bed furnaces to bind 80…90% of sulfur.

The analysis of technical and economic benefits of CFB technology application shows that the most essential technical advantages of CFB-boilers are:

- provision of strict standards for NO_x and SO_2 emissions without costly and large-size installations for DeSOx and DeNOx;
- possible combustion of different types of fuel in the same furnace unit;
- stable operation at low loads without oil lighting;
- fast start-up from the hot condition (after 8-hour-downtime);
- no slagging and minimal pollution of the heating surfaces;
- possible location of new CFB-boilers inside the existing boiler sections of the operating power plants.

For hard coal and high-sulfur brown coal the same level of SO_2 emissions for CFB-boilers could be achieved only in case of wet desulfurization application and a level of NO_x emissions could be reached at application of technological measurements in combination with purification of flue gases from NO_x.

Till now a rich experience in designing and operating of CFB-boilers has been accumulated in foreign countries. Constructive solutions have been considerably improved, steel intensity has been reduced, economical efficiency and reliability have been increased, and the regulation range has been expanded. In CFB-boilers different specific types of fuel were successfully burned, such as pet coke with minimum volatile content, coal beneficiation wastes, rock refuse and slag with an ash content to 70%, high-moisture flows and biological sludge with the moisture to 70%. In all the cases NO_x emissions of less than 300 mg/m^3 were provided, an efficiency of sulfur binding was more than 90% and unburnt carbon losses and incomplete burning losses made less than 4%. By that, in the same furnace at the moderate decrease in economical efficiency it was possible to combust the design fuel as well as the ones, quite different from the design fuel, including biomass. The issues relating to use of ash from CFB-boilers are not completely worked out. Due to a low-temperature burning and limestone addition, the ash is less suitable as the constructive material component.

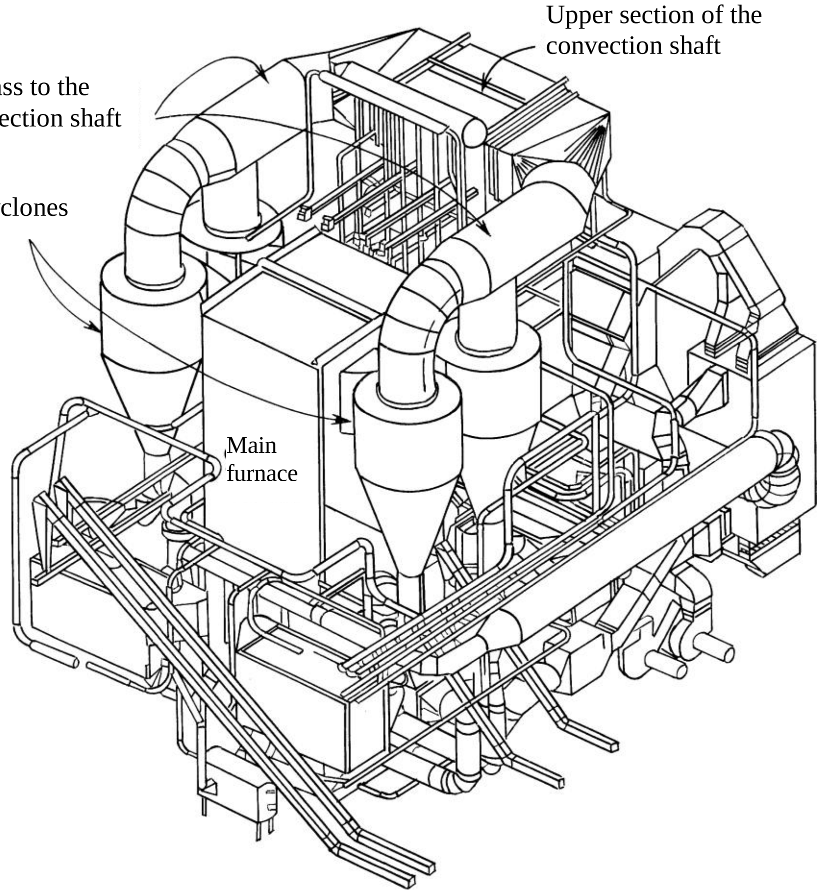

Fig. 1.60. CFB-boiler of the power unit of 250 MW (France). The boiler is equipped with four cyclones with the installation of external heat exchanger in bottom part of each one

In foreign countries there are different modifications of CFB technology applied. CFB-boilers with "hot" cyclones (Fig.1.60) and ash heat exchangers provide the lowest level of pollutants, the minimum carbon content in the bed, and the best conditions of the steam temperature (load) regulation, their ash and slag wastes are easy to apply for construction purposes. CFB-boilers with cooling or non-lined separators (Fig.1.59) can be faster started-up from the cool condition; they possess the best dynamic characteristics, the highest operating availability and require less operating costs. Capital investments in boiler construction with the modern CFB technology modifications are lower, than in boilers with traditional technologies of "hot" cyclones application.

In industrially developed countries (USA, German, Japan) CFB-boilers of different types are under construction and successful operation. By that, advantages of this or that technology are not obvious, considering all the constructive, operation aspects and local conditions.

In RF staff of VTI, design bureaus and designers of manufactures fulfilled the opportunity and reasonability analysis of CFB technology application for replacement of a great number of coal-fired boilers with a steam capacity of 160-230 t/h. These boilers depleted their resource and need replacement, but stricter ecological requirements don't allow just to install the similar pulverized coal combustion boilers replacing the old ones. The conducted work showed that in case of CFB-boilers, prospect standards for pollutant emissions into atmosphere are provided by construction and performance activities to improve a combustion process inside the furnace. By this, for a number of fuel types a limestone addition is insignificant or makes a zero. Additional investments and spaces are not required for installation of nitrogen DeNOx and DeSOx plants.

Comparing the sizes of CFB-boilers and BKZ-210, BKZ-220, PK-14, TP-230 coal-fired boilers testify that in CFB-boilers the combustion section and the volume are less at the increased height. Mainly, increase in the boiler height is connected with a necessity of air distribution grill installation at the point of 5,5…6,0 (by 2…3 m higher than the bottom point of the boiler throat) for a possible location under the grill of a primary air chamber and units for removal and cooling of bottom ash. Besides, a certain volume of the narrowed lined bottom part of CFB-boiler is required for arrangement of a turbulent bed and staged air supply. For low-reaction fuel an increase in height is necessary in order to reduce the unburnt carbon in single-span particles. Analysis of the mentioned-above data shows that CFB-boilers with the channel-shaped separators and multicyclones are installed within the existing sections of the replaced coal-fired boilers. In process of combustion of the most fuel types, an increase in a height of the building is not required.