Part 1

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

1.5.1.1. Combustion of solid fuel in atmospheric fluidized bed boilers

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with atmospheric fluidized bed

By position fluidized bed (FB) furnaces are between the fuel-bed-firing furnaces and pulverized combustion furnaces. Together with the fuel-bed-firing furnaces they, first of all, can burn crushed coal and have a lattice, through which air is supplied to the bed. At increase in the air velocity, blown through the bed, the moment comes when the aerodynamic force, acting each particle of fuel, overcomes friction forces between the particles. A further growth of air flow leads to fluidization of particles of the fuel, it seems as if the bed is boiling (therefore, it is called "fluidized bed"), its height and pore volume increase.

A minimal velocity, at which fluidization begins, is called as the first critical velocity W_1^{cr}. The second critical velocity W_2^{cr} is the one, at which the aerodynamic force is equal to a gravity of fuel particles and their intensive removal from the bed starts. Both the parameters are rigidly defined only for the monodispersed material with a constant density, and the burnt fuel, as it is well-known, contains of particles of different size.

It should be mentioned that in FB furnaces an amount of combustible material usually makes a small part of the bed mass, inert material or fuel ash (at combustion of coal with a high ash content) is its base.

An intensive mixing of solid particles under fluidizing air impact, flowing through the bed of grainy material, provides a more intensive heat and mass exchange in the bed. Heating surfaces, immersed into FC, allow keeping the temperature at such a level that it does not result in slagging of the bed and the heating surfaces themselves.

Summarizing the advantages of a method of solid fuel combustion in FB, the following aspects can be marked:

- providing of the high heat-transfer factor in FB;
- long residence time in FB allows burning coal with the increased ash content and production wastes;
- it becomes possible to create a more compact furnace unit without a dust-preparation system, that reduces the specific capital costs for boiler-house construction as well as repair costs;
- limestone addition into the bed binds the fuel sulfur with the ash residue, that decreases sulfur dioxide emissions discharged into atmosphere together with flue gases;
- low temperatures of the bed (800…950^{0}C) provide zero of thermal nitrogen oxides, that reduces NO_x emissions into atmosphere.

Recently the interest in FB furnaces is not falling down: a necessity of its application is connected with worsening of the coal quality, which is to be included into the fuel balance. In some cases a combustion technology in FB allows using wastes from coal producers, landfilling of which pollutes the environment.

In the system of RAO "UES of Russia" the largest boiler, equipped with a furnace with traditional FB, is the EP_r-420-140FB boiler with capacity of 420 t/h. This boiler was designed by NPO CKTI, VTI, PO "Sibenergomash", SKB VTI and VNIPIenergoprom (Fig. 1.58). The boiler has standard parameters of drum coal-fired boilers of similar steam capacity (13,4 MPa, 560^{0}C), but metal mass under-pressure is 1,5 and the total metal mass is 2 times less compared to the coal-fired boiler E-420-140. The boiler furnace has four independent FB sections, which are placed in pairs one above the other. One of four sections serves for afterburning of fly ash, collected in a cyclone. It's the boiler with the forced circulation; its evaporating system and a steam superheater are located in FB. Steam-generating heating surfaces of the combustion chamber above FB, are made of membrane tubes, hung up at the boiler body. This provides an ability of vertical heat extension. In the transitional flue duct there are placed hot cyclones for separation of fly ash, returned into FB for afterburning.

In the boiler tail section there is an economizer and an air heater. Boiler load can be regulated in a range of 70…100 %. By switching off different sections, a minimum load of 30 % of the nominal capacity, can be reached.

For air supply into the furnace there are two pressure fans installed. A velocity of combustion products, passing through FB, is accepted of 2,5 m/s (max. 3,5 m/s). The lattice is formed by a system of caps, which are welded into the flanges of horizontal part of membrane screen that forms a chamber for air distribution.

The boiler has been designed for burning lignite from Kansko-Achinsky basin, mineral part of which contains calcium. According to the intention of the project designers, this must reduce sulfurous anhydride emissions into atmosphere after installation of EP_r-420-140FB boiler at Barnaulskaya CHPP-3.

In accordance with a target complex program on mastering of BKZ-420-140FB boiler from 1996 to 1999, Barnaulskaya CHPP-3 and JSC "Altaienergo" conducted a complex of commissioning activities of main and auxiliary equipment with participation of all the interested organizations. In process of supply of the raw coal (0…25 mm) and bed filler into two lower sections of the boiler, ignition modes, boiler start-up and shutdown to hot reserve have been mastered, steam parameters, close to the project ones, have been obtained (p = 11 MPa, t = 450°C). Steam was supplied to the remote net water heaters, and heat was transported to the Barnaul heating system.

In the prospect JSC "Altaienergo" will use the received data: exclude hydraulic slag conveying from five operating boilers to ash disposals of food plain of the river Ob and these way will improve the ecological situation in Barnaul. Besides, slag and products of slag processing are assumed to be used in road construction as well as in construction industry.

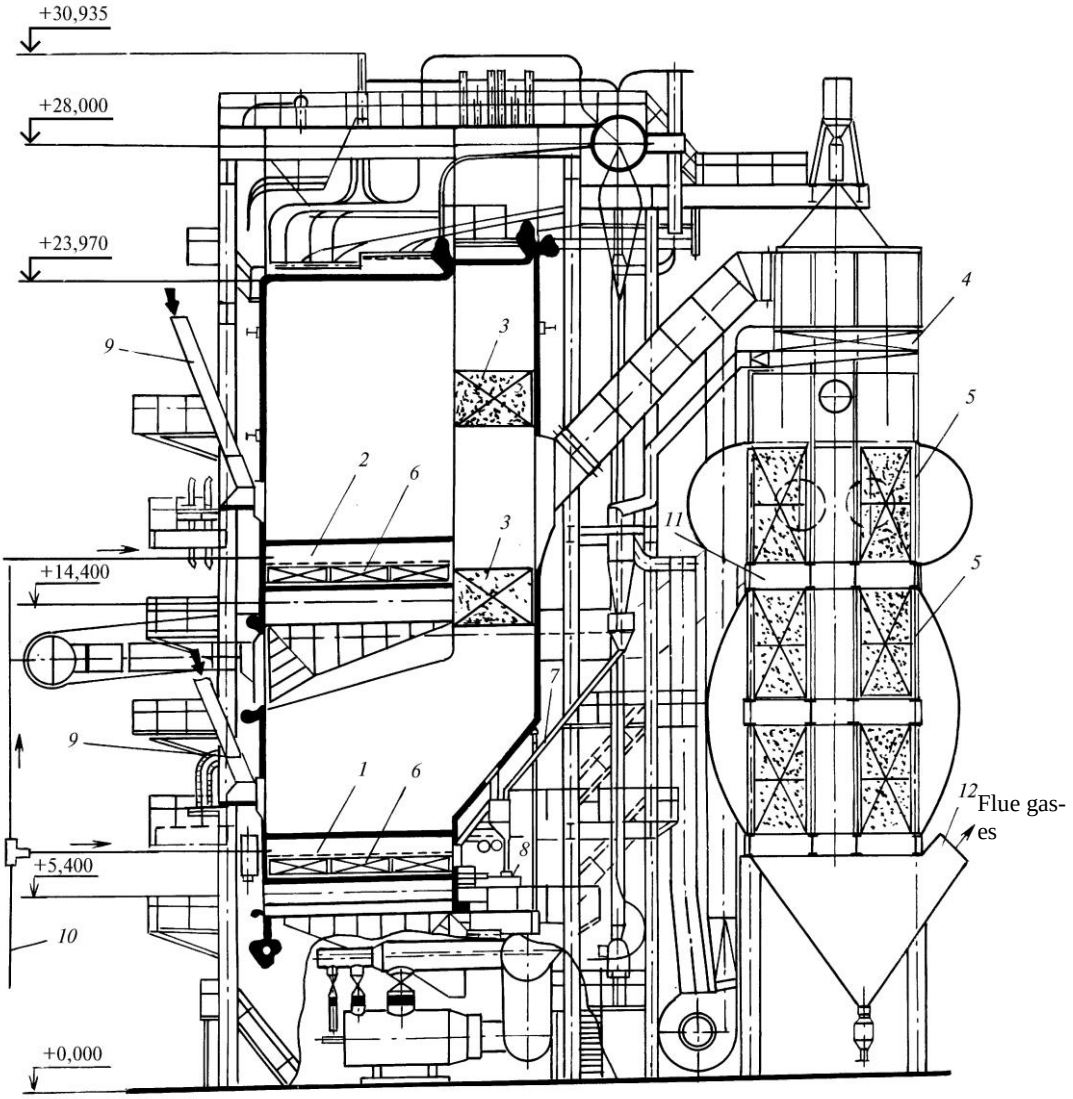

Fig. 1.58. BKZ boiler of EP_r-420-140FB type with steam capacity of 420 t/h with a stationary fluidized bed:
1 — lower section with FB; *2* — upper section with FB; *3* — economizer; *4* — ash collector; *5* — air-heater; *6* — evaporating and steam superheating tube packages, dipped into FB; *7* — pneumatic conveying return line; *8* — pneumatic conveying line with divisors of the fine fractions of fuel (0…1 mm); *9* — chute of the crushed fuel supply (1…25 mm); *10* — pneumatic conveying line of the bed filler supply; *11* — gas selection for coal drying; *12* — flue duct to ESP