AIR PROTECTION FROM POWER INDUSTRY EMISSIONS

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

1.5.5. Efficient reduction of nitrogen oxide emissions in the boiler furnaces by means of aerodynamic optimization of the staged fuel combustion

1.5.5.3. An efficiency of high location of double-sided and strongly inclined nozzles of secondary blast at boilers with bottom burners

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At oil- and gas-fired boilers with bottom eddy burners a problem relating to reliable operation of furnace screens at oil combustion, has been worked out. At the same time a problem on ensuring a reliable operation of metal of screens and convective superheater packages at gas combustion, became sharper. In addition, specific emissions of nitrogen oxides are several times higher than the standard values at oil combustion and, especially, at natural gas combustion. Based on the model calculations and aerodynamic research, the staff of Boiler Plants and Ecology in Power Engineering Department of the Moscow Power Engineering Institute - MPEI (TU) has developed a technology of the staged gas and oil combustion for boilers with bottom burners. Since 1990, 12 boilers with bottom burners were reconstructed. A feature of the technology is a high double-sided location of the secondary air nozzles, greatly inclined downwards. By that, a share of secondary air is 0,25 ... 0,4, and the efflux rate of blast jets is in the range of 40 ... 50 m/s.

In 1992-1997 six coal-fired small-capacity boilers of Kaliningradskaya SDPP, formerly transferred to oil burning with application of two bottom vortex burners, have been reconstructed under the project of OJSC "CKB Energoremont" with installation in the corners of a middle part of the furnace of four angled downward and tangentially directed nozzles of secondary blast. Efflux rate of the blast jets was adopted to be 45 ... 50 m/s at the secondary air share of about 25%.

Results of tests, conducted at the reconstructed boilers, showed that reduction of NO_x concentration in flue gases made 25 ... 45% in the range of initial concentrations of 190 ... 225 mg/m^3 (at these boilers gas recirculating systems are not applied). Excess air after the steam superheater at almost all the boilers was unchanged. Reliability of oil ignition, especially, in the firelighters modes, was improved.

The greatest DeNOx effect was achieved at the reconstructed in 1990 TP-80 boiler under the project of the OJSC "Mosenergoproekt" at CHPP-16 of the OJSC "Mosenergo". This boiler was previously equipped with four three-flow bottom burners, set in a row. At the boiler slightly inclined bottom was carried out and double-height screen was eliminated, i.e., in fact, it was turned into TP-87 boiler. The boiler operation before reconstruction was characterized by a high NO_x concentration in flue gases (650 and 1000 mg/m^3, accordingly, when burning gas and oil; in the last case, with recirculation of gases, fed into the peripheral channels of burners). In case of gas combustion, separate coils of screens and convective superheater packages had the permitted metal temperature levels, and the total injection volume was 35 ... 40 m/h.

Boiler reconstruction was followed after a large amount of modeling studies on combustion aerodynamics at the isothermal stand. As a result, a layout diagram of installation of eight secondary air nozzles [14], shown in Fig. 1.75, was designed. Its feature is double-sided high location of nozzles, greatly inclined downward, orientation of nozzle axes under the scheme of the opposite-biased jets (OBJ) in the projection on the horizontal surface and a high velocity of secondary air jets. At gas combustion, this gas velocity makes 45 ... 50 m/s at the secondary air share of about 37%. A working draft of the boiler reconstruction was made by OJSC "Mosenergoproekt".

Tests, conducted at the reconstructed boiler, showed its high integrated efficiency. Due to the locking effect of blast jets on the flame and recycling of tail parts of the flame into fresh blast jets and combustion jets, the heat load of the steam superheater reduces, and a temperature of the tube metal was below the acceptable standards. NO_x concentration in flue gases of the boiler was 100 and 180 mg/m^3, accordingly, at combustion of gas and fuel, i.e. decreased by 85 and 82%. The excess air after the steam superheater remained about the same - 1.1.

In connection with these positive results at CHPP-16 two TP-87 boilers were reconstructed (in 1992 and 1993), and one TP-26 boiler was retrofitted in 2006. The project of the last boiler reconstruction was fulfilled by OJSC "CKB Energoremont".

TP-80 boiler of CHPP-12 of the OJSC "Mosenergo" was equipped with six bottom gas-oil burners (in each compartment, three in the row, axis of which is parallel to the double-height screen). In 1999, the boiler was reconstructed under the project of OJSC "Mosenergoproekt." Installation was implemented in the corners of each compartment of four tangentially directed and angled down secondary air nozzles (Fig. 1.76). As model aerodynamic research showed, due to the dynamic pressure of high-speed jets of blast jets (at the secondary air share of 40% and its velocity of about 50 m/s) in the axial zones of semi-furnaces the flame is blocked, but its afterburning is carried out in a spiral vortex flow near the furnace screens. After the boiler reconstruction at gas combustion, the reliable operation of steam superheater metal was improved, the excess air in the mode section remained unchanged, while NO_x concentration in flue gases reduced to 100 mg/m^3 at a small degree of loading of the gas recirculation exhauster (RGE). It should be noted that the discussed layout diagram of the secondary blast nozzles seemed to be high-effective at TP-87 boiler, reconstructed in 1993 at CHPP-11 of OJSC "Mosenergo". This boiler is equipped with six plate-flame burners, placed at the mark of 9,15 m of front and back walls of the furnace. Eight blasting nozzles were installed at the mark of 19,02 m at the same walls.

Prior to the installation of nozzles, specific emissions of nitrogen oxides at gas combustion made 160 ... 285 mg/m^3 in the load range of 250 ... 420 t/h. By that, a scheme of injecting recycling gases into burners to raise a temperature of the superheated steam up to a nominal one, was applied. After installing the nozzles, specific NO_x emissions under comparable conditions were in the range of 26 ... 50 mg/m^3. Excess air in the mode section (after the second stage of water economizer) has not changed, remaining about 1.12. The secondary blast share was 31% of the amount of the arranged air, and velocity of the blast jets at a load of 420 t/h made 50 m/s [15].

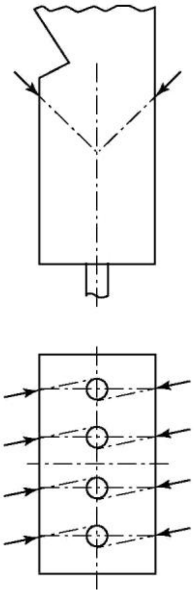

Fig. 1.75. Layout diagram of the secondary blast nozzles at TP-87 boiler

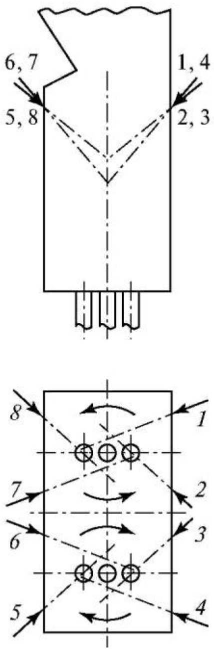

Fig. 1.76. Layout diagram of the secondary blast nozzles at TP-80 boiler