Part 1

AIR POOL PROTECTION FROM EMISSIONS OF THE POWER INDUSTRY

1.1. Reducing nitrogen oxides emissions

1.1.2. Technological methods to reduce nitrogen oxide formation in the boilers during combustion of different types of organic fuel

1.1.2.1. Regime and commissioning activities to reduce nitrogen oxide emissions

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The main advantages of this group of the activities if their simplicity and lack of need in carrying out reconstruction of the furnace-burner units. These activities can be implemented by the operational staff of TPP or alignment organization on oil-gas boilers and to a lesser extent – on coal-fired boilers.

Complex of the regime activities is illustrated in Fig. 1.2? which shows the change in the concentrations of NOx and CO as a function of excess air (more precisely, the oxygen concentration of O_2 in the combustion products of the combustion chamber).

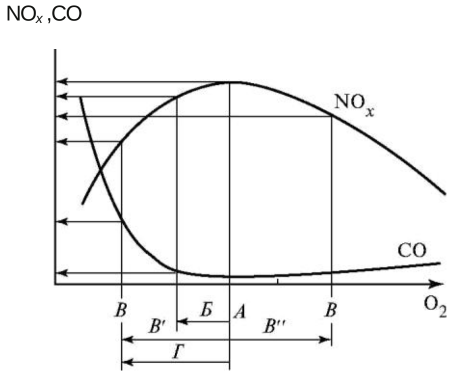

Fig. 1.2. curves of reduce NO_x formation under different regime activities:
А — initial mode; *Б* — regulation of excess air in the burner; *В′*, *В″* — nonstoichiometric combustionсжигание; *Г* — simplified two-stage combustion

1.1.2.1.1. Low Excess Air - LEA

One of the most common and easily implemented regime of measures aimed at reducing nitrogen oxide emissions i the reduction Low Excess Air in the furnace. As a result, reducing the oxygen content in the flame if suppressed formation of thermal and fuel NO_x, and therefore this event can be applied during combustion of all types of the fossil fuel.

Effect of excess air on nitrogen oxides formation is described by an extreme dependence with a maximum for the oil-gas boilers α_{max} = 1,3...1,5 and for the coal-fired boilers α_{max} = 1,3...1,5 (Fig. 1.2, mode A). Besides the maximum concentration of NO_x in the flue gases corresponds to the value of excess air ratio, at which reached the most complete fuel combustion in these conditions.

It should be emphasized that the formation of nitrogen oxides affect only the air that is fed into a active combustion zone with fuel. Change in value of suction in the combustion chamber of cold air, which is not involved in the ignition and fuel combustion, virtually no effect on the nitrogen oxides formation and therefore at the same excess air ration at the exit from combustion chamber $\alpha_т''$ and burners $\alpha_{гор}$ because of the different suction $\Delta\alpha_т$ can significantly differ. This in turn lead to different outputs of NO_x.

Fuel combustion with low excess air can be widely used in boilers that operate with high excess air ration in the burners, close to the values of α_{max} (Fig. 1.3) [5]. It does not require any additional capital and operating costs, and all the coasts of implementation of this method are reduced to the cost of regime and commissioning activities of the boilers. However, the reduction of excess air is possible only so long until it leads to rapid growth of products of incomplete combustion.

Reduction of α below a certain critical value $\alpha_{кр}$ leads to a heavy increase in chemical underburning (incomplete combustion) and increase of the concentration of carbon monoxide CO, hydrogen H_2, soot and polycyclic aromatic hydrocarbons, in particular, benz(a)pyrene. In addition, there is an increase in ash content of burnable, increasing the intensity of the slagging of heating surfaces and high temperature corrosion of screens, so the operating excess air taken slightly above the critical values during the transition to work with low excess air:

$$\alpha_{раб} = \alpha_{кр} + 0,02...0,04.$$

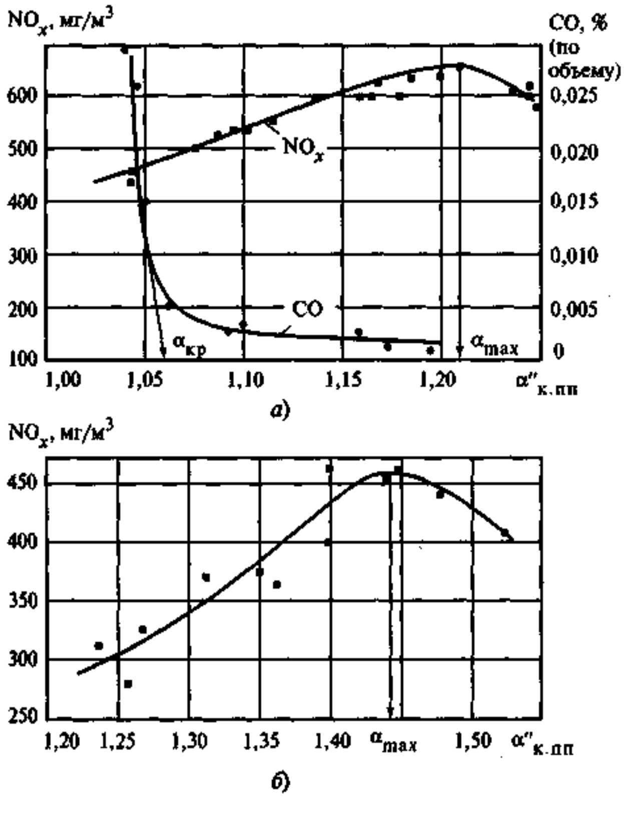

Fig. 1.3. Effect of excess air on nitrogen oxides formation:
а — oil-gas boilers; *б* — coal-fired boilers

Fuel combustion with extremely low excess air requires some preparatory work.

This is due to the fact that $\alpha_{кр}$ depends on the suction of cold air into the furnace, the uniformity of fuel and air distribution for the burners, the temperature of the hot air, types of the burners and some other factors, so before the introduction of this event is producing seal the chamber, calibration of the instruments and the removal distortions in the fuel-tracts.

The latter allows you to optimize combustion and reduce the output of CO and polycyclic aromatic hydrocarbons. The maximum value of NO_x concentration remained unchanged, but the whole plot of $NO_x(\alpha)$ is shifted to lower excess air (Fig. 1.4). After that shall be regime and commissioning tests, during which the determined values of the critical $\alpha_{кр}$ and operating $\alpha_{раб}$ excess air at various loads and developed the operational regulations. It is believed that excess air can be reduced to the level that does not cause increased concentration of CO in the flue gases in excess of 0,02 % by volume, i.e. 200 ppm [5]. The specific value of $\alpha_{раб}$, which corresponding to this level of CO, depends on the perfection of the burner and the uniformity of the distribution of fuel and of the air between burners.

Numerous experiments on the boilers of various types have confirmed that the reduction of excess air is uniquely reduces the output of NO_x. This event helps to reduce nitrogen oxide emissions in the atmosphere at 15…30 % depending on the characteristics of the boiler and the combustion process (Table 1.4). Variable efficiency to reduce NO_x emissions at different pots for the following reasons. Firstly, the reduction of excess air differently affects on the thermal and fuel NO_x formation, whose shares in the total NO_x emissions are determined by the temperature of the furnace process and the nitrogen content in the fuel. Secondly, reducing the number of the fed onto the chamber of organized air is provided in some cases only a decrease in volume of secondary air, in others – while reducing the volume of the primary and secondary air.

Table 1.4. R**educing nitrogen oxide emissions in the transition to low excess air [3, 5]**

Type of the boiler, TPP	Fuel	Excess air		Reduced output of NO_x, %
BKZ-420-140, Karagandinskaya TPP-3	Ekibastuzsky coal	1,3	1,2	25
TPP-312, Ladyzhenskaya SDPP	Donetsk coal of type GSSh	1,3	1,1	33
PK-41, Karmanovskaya SDPP	Gas	1,09	1,02	34
TGM-84, Ufimskaya TPP-4	Oil	1,09	1,04	25
TGMP-204, Zaporozskaya SDPP	Oil	1,1	1,0	43

In addition, the combustion with lower excess air increases boilers efficiency by reducing the temperature and flow rate of flue gases and reduces the low-temperature sulfuric corrosion. Due to the fact that the costs of air and flue gases are less, power consumption to drive of the exhaust fans and blower fan is somewhat reduced.

Limit of the applicability of the technological activities determined by the appearance in the flue gas of the incomplete combustion (CO, H_2, polycyclic aromatic hydrocarbons), an increase in the content of combustibles in fly ash, increasing the intensity of the slagging of the heating surfaces and high temperature corrosion of screens. For most domestic boilers limiting factor in the excess air burners is 1,1…1,15 during solid fuel combustion and 1,0…1,03 during natural gas and oil combustion.

It should be noted that the work at lower excess air imposes higher demands on the state of the boiler unit and the work of measuring and control devices, as well as training of operating personnel and technological discipline.