N E W S
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
**SERIES OF GEOLOGY AND TECHNICAL SCIENCES**
ISSN 2224-5278
Volume 1, Number 427 (2018), 144 – 149

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# DIRECTIONS OF STUDYING THE PROCESS OXIDES FORMATION OF THE PYROLYSIS OF EKIBASTUS COAL DUST

**Abstract.** In this article, installations and fire settings for the pyrolysis of coal dust and burning of pyrolysis products with a phase shift of the air supply have been developed and performed. Experiments on the determination of nitrogen oxides in inert and aerial environment have been carried out and the methodic of procedure has been described. The results of the experiment showed that in an inert medium nitrogen oxides are not formed, but in the air medium are suppressed up to three times during the pyrolysis of the Ekibastuz coal dust. Programs have been developed and the calculation of the processes of nitrogen oxides formation during burning of Ekibastuz coal of high concentration on an ECM, taking into account the oxygen concentration, temperature and time, have been carried out. The fire-technical method of suppressing the formation of nitrogen oxides by pyrolysis of fuel with a phase shift of the air supply is proposed in the work, which allows to reduce emissions of nitrogen oxides to the level of modern requirements. Proposed ecological and economic advantages of the method comparing with existing ones.

**Key words:** nitric oxide, gasification, formation of air, suppression, incineration.

Gasification of solid fuels is used when the target product is a combustible gas. To this end, the fuel is oxidized in such a way as to fully convert its chemical energy into the chemical energy of the gas (i.e. its heat of combustion, which is determined mainly by the presence of CO and H2) [1].

As it is stated [2], the term "synthesis gas" (I.e. gas for chemical synthesis) can be applied only in the second case, therefore the term "generator gas" is proposed as a general name, which will be used further in this paper. In some cases, partial gasification is carried out when, in addition to gas, the desired product is also a solid residue, which in addition to high value can have properties that allow it to be used for chemical production [3].

To study the effect of the shift of combustion processes (SCP) on the formation of nitric oxide, a vertical tubular furnace with electric heating was used (figure 1).

A stainless steel tube with a diameter of 10 mm was installed in the furnace to supply air from below (7). In the fault plane (3) located on the furnace, a system of transverse built-in pipes was suppressed, for supplying argon, air and a gas mixture.

A stream of argon (8), heated in an additional electric furnace (6), was fed into the fault plane. The air was fed into the flow of the gas mixture from the tube by a cross stream. The gas mixture was fed into the by moving in a stainless tube along the axis of the vertical combustion chamber. Dust from Ekibastuz coal (4) was also fed from the feeder through the top of the fault plane.

The time of meeting coal dust heated by argon in a fault plane with air was regulated, taking into account the flow rate of the gas mixture.

By the transverse flow of these streams, the instantaneous mixing of coal dust with a stream of argon and the flow of the gas mixture with air was ensured. Such a mixture of streams created a time delay for the fuel and oxidant to meet.

The ratio of air consumption and the amount of argon in the mixture was regulated by the concentration of oxygen.

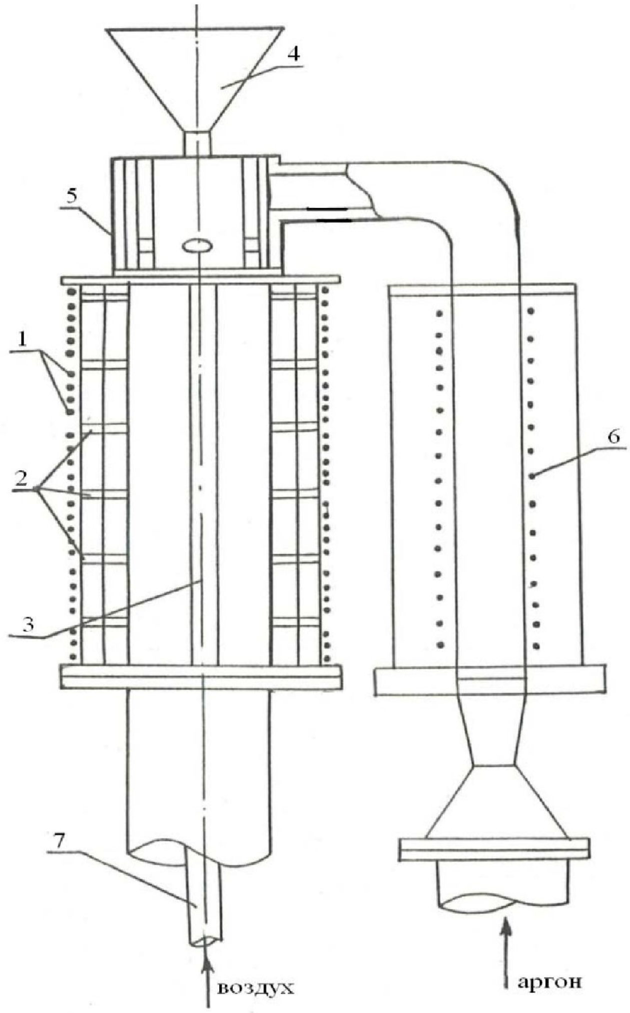


Figure 1 – Scheme of the pilot factory

The adopted experimental procedure, taking into account the furnace size, composition and consumption of the mixture elements, allowed the time for the shift of combustion processes, determination of oxygen concentration ($O_2$) and furnace temperature.

The experiments were carried out with the dust of Ekibastuz coal of $R$ = 18%. The dust consumption in all the experiments was kept constant and composed 0.042 $\frac{g}{s}$. excess air coefficient $\alpha$ = 1,2. The temperature in the furnace varied from 0 to 700 $^0$C. The oxygen concentration in the furnace was 11%. It was determined using a chromatograph LXM-8MD. Determination of the concentration of nitric oxide was carried out with the help of the "Evdiometer-1" device. The method of running gas analysis is described in [4, 5].

The primary data of the experiments on the effect of SCP time on the formation of nitric oxide: $O_2 = 11\%; \tau = 0; 0.05; 0.1\,s; NO = 220; 160; 83\,\frac{mg}{nm^3}$ at the temperature in the furnace 50 $^0$C and $NO = 146; 113; 98\,\frac{mg}{nm^3}$ at the temperature in the furnace 700 $^0$C. These values are significantly lower than the concentration of nitrogen oxides ($340-670\frac{mg}{nm^3}$) obtained in the gasification of the same coal dust in the air, in the temperature range of 500–900 $^0$C. The experimental data are in correspond with the experimental data of the All-Russian Thermal Engineering institute and Kazakh Scientific Research

Institute of Power Engineering on suppressing the formation of nitrogen oxides by preliminary heating of the fuel ($\tau = 0$), as well as with the results of calculating the thermal decomposition of the Ekibastuz coal dust, recombination of atomic nitrogen into nitrogen molecules, and the kinetics of fuel nitric oxide formation.

It is shown that nitrogen oxides are not formed in the inert medium, despite the 11.8% oxygen content of in the Ekibastuz coal.

In the literature, the results of research and an attempt to use the decomposition of nitric oxide by carbon, carbon monoxide, and also hydrogen to reduce emissions of nitrogen oxides with flue gases are known.

We conducted experiments to determine the effect of coal dust on the reduction of nitrogen oxide emissions when it is fed into the combustion zone through flue gases. For these experiments, the experimental setup was slightly modified. The flue gases formed in the additional furnace were fed into a vertical furnace into the dust stream of Ekibastuz coal. The dust consumption was $0.133\frac{g}{s}$ approximately equal to the concentration of coal dust in a real combustion furnace ($6.84\frac{g}{nm^3}$). Sampling was carried out at a distance 0.5m from the place where coal dust insertion, which corresponds to the time of arrival 0.29 – 0.3s.

When natural dust is fed into the flue gases, an increase of NO in the content is observed. This can be explained by the interaction of gasification products of coal particles with flue gas oxygen, leading to the additional formation of nitric oxide. Experiments were also conducted with the addition of coke dust into the flue gases obtained by preheating natural coal dust at a temperature 900 $^0$C.

With the supply of coke dust, the content of nitric oxide in the flue gases decreased from $670-820\frac{mg}{nm^3}$ to $400-460\frac{mg}{nm^3}$.

From this experimental data on the suppression of the formation of nitric oxide by the shift of furnace processes and the reduction of nitric oxide by coke of coal dust to molecular nitrogen, it can be seen that the two independent methods of reducing toxic nitrogen oxide emissions are considered to have good performance potential and can be used in the organization of environmentally friendly burning processes.

**Results of analysis and recommendations.** The amount of nitrogen released during high-temperature coking depends on the degree of carburization. For coals with a high degree of carburization, the highest temperature is required for the onset of a maximum of nitrogen evolution.

At higher temperatures, the concentration of nitrogen-containing components in volatiles is higher than at low temperatures.

Blair, examining 20 grades of coals and two grades of semi-coke, obtained an empirical expression for determining the mass fraction of the lost nitrogen of fuel as a function of temperature [6]:

$$\psi_N = \frac{0{,}4861\cdot 0.01V^P + 3545\cdot \exp\left(-\frac{85700}{RT}\right)}{1+3545\cdot \exp\left(-\frac{85700}{RT}\right)}$$

Here $R \approx 8{,}3\frac{Дж}{моль\cdot K}$ - the gas constant; $V^p$ – Volatile yield on the working mass,%.

From the above analysis it can be seen that two tendencies can be traced in the construction of mathematical models of calculation. It seems preferable to use simplified schemes - from the equations of total kinetics by introducing refinements into these schemes.

In figure 2, the calculated results are compared with the experimental data [6]. Their coordination is generally satisfactory. Some higher calculated values of nitric oxide formation than in the experimental data are explained by the kinetic nature of the chemical reactions considered in the mathematical model. In fact, this rate of chemical reactions is somewhat slower because of unaccounted factors related to the nature of the organization and the diffusion of the processes of mixture formation. Comparison of the

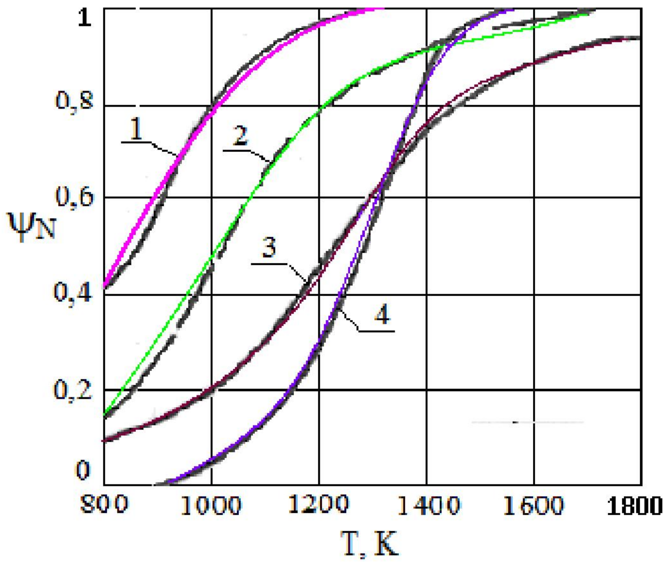


Figure 2 – The degree of gasification of fuel nitrogen depending on the temperature for Ekibastuz coal (calculated and experimental), 1, 2 – T.V. Vilensky, 3 – Pershing, Wendt, 4 – VI. Babiy.

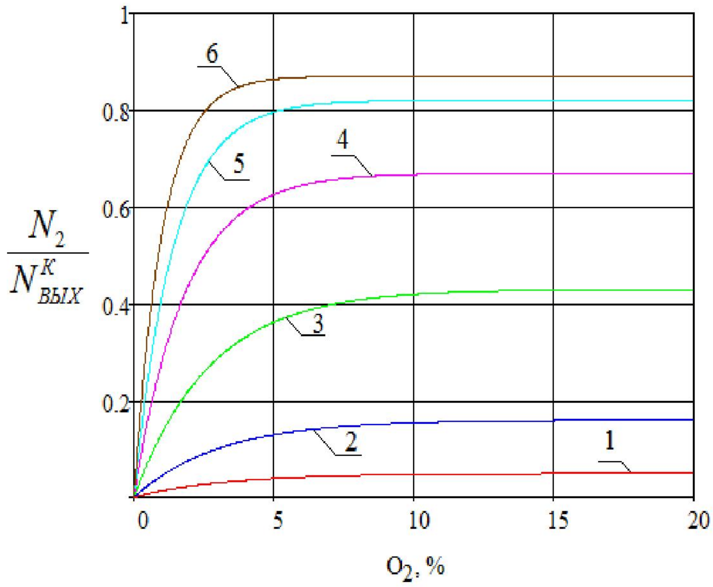


Figure 3 – Recombination of N in $N_2$ at different curves $O_2$.
1 – T = 800 K; 2 – T = 1000 K; 3 – T = 1200 K; 4 – T = 1400 K; 5 – T = 1600 K; 6 – T = 1800 K

curves 4,5 and 6 (see figure 3), referring to the same temperature 1200 K, but to different values of the oxygen concentration (3 and 14%) and the coefficient γ(0,67; 0,82; 0,88) taking into account [6] the proportion of nitrogen of the fuel passing into the gas phase. The main calculated curves 1, 2, 3 in Figure 2 have a value γ = 0,26 that occupies an intermediate position between the values of 0,2 and 0.3 indicated in [6] for stone and brown coals, respectively.

**Conclusion:**

1. The installations and fire settings for the pyrolysis of coal dust and burning of pyrolysis products with a phase shift of the air supply have been developed and performed.

2. Experiments were carried out to determine nitrogen oxides in an inert and air medium using a pyrolytic attachment and describe the experimental procedure using chromatographs LXM-8MD, KhPM-4 and Eudio-meter-1.