A Method of Catalytic Neutralization of Exhaust Gases with Nitrogen Oxides

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ABSTRACT

In this article, the effectiveness of the nitrogen oxide exhaust gas purification process, the problems and solutions of the temperature dependence of the reaction are explained in detail. In this process, nitrogen oxides are reduced to nitrogen in the presence of reducing gas on the catalyst surface at high temperatures. In this case, the temperature of the catalytic process also depends on the type of gas regenerator used in the recovery process.

Keywords: catalyst, catalytic, exothermic, nitric acid, absorber, atmosphere, equivalent, stoichiometry.

Introduction

Catalysts based on platinum group metals (Pd, Ru, Pf, Rh) with high activity and cheap but less effective metals such as Ni, Cr, Ln, Zn, and V are used as catalysts for catalytic neutralization of nitrogen oxide waste gases. based catalysts are also used [1-4]. To increase the contact surface of the catalyst, these elements are embedded in porous hard and smooth materials. Such materials include Al_2O_3 ceramics, silica gel, etc.

The main part

In the catalytic process, methane- CH4, natural and coke gas, CO, and H_2 gases are used as the reducing gas. The effectiveness of the nitrogen oxide exhaust gas purification process depends primarily on the catalyst used and its activity [5-9]. When using a catalyst based on the platinum group, the residual amount of nitrogen oxides can be reduced to 0.005%. In this case, the temperature of the catalytic process also depends on the type of gas regenerator used in the recovery process. For example, when CH4 is used, the temperature of the catalytic process is 450-480 °C, C_3H_{10} 350 °C, H_2 and SO 250-200 °C [10-17].

The following in the cleaning process reactions occur:

1. $4\,NO + CH_4 \rightarrow 2\,N_2 + CO_2 + 2\,H_2O$
2. $2\,NO_2 + CH_4 \rightarrow N_2 + CO_2, + 2\,H_2O$
3. $2\,NO + 2CH_4 \rightarrow N_2 + 2CO_2$
4. $2\,NO_2 + 4CO \rightarrow N_2 + 4CO_2$
5. $2\,NO + 2H_2 \rightarrow N_2 + 2H_2O$
6. $2\,NO_2 + 4H_2 \rightarrow N_2 + 4H_2O$

In order for the reaction to take place, the gases must be mixed and heated to the initial temperature. Natural gas is usually used as a reductant for the catalytic neutralization of exhaust gases from nitrogen oxides in the industry because it is cheap and convenient. All reduction reactions are exothermic (with the release of heat), using which gas mixtures are heated due to this heat [18-21].

Temperature can increase to 700 °C due to the reaction. Therefore, the catalyst must be resistant to high temperatures. Now we will consider the technological scheme of the catalytic cleaning process carried out at high temperatures [22-25].

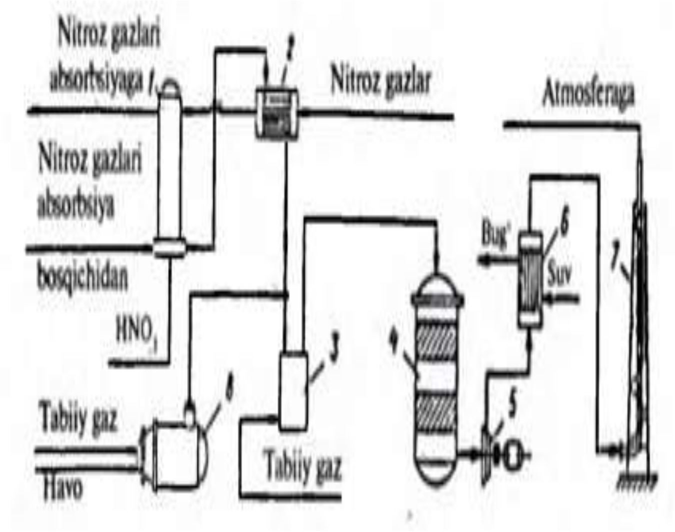

Fig. 1. Technological scheme of high-temperature non-selective catalytic treatment of exhaust gases with nitrogen oxides:
1-heater-separator; 2nd heat exchanger; 3-mixed indicator; 4th reactor, 5th recovery turbine; 6-heat recovery boiler; 7-chimney (chimney); 8-Burner

This is the technological scheme, the method of reducing nitrogen oxides formed in the production of nitric acid to nitrogen with the help of natural gas in the presence of a catalyst is presented based on the above-mentioned reaction. Here, nitrogen oxides (nitrous gases) leave the absorber at the stage of obtaining nitric acid, are heated in the 1st heater and 2nd heat exchanger, and are fed to the 3rd mixer.
The mixer is supplied with a return gas-natural gas and hot flue gases from the 8th burner (to raise the gas temperature). Then the gas mixture is sent to the 4th catalytic reactor. Here, with the presence of a catalyst, nitrogen oxides are reduced to elemental nitrogen.
Since the reduction reaction is exothermic, the temperature of the reactant gases is high. Therefore, these gases are passed through the 5th recuperation turbine and the 6th boiler-utilizer (hot water vapours are obtained) before being released into the atmosphere and are released into the atmosphere through the 7th chimney.
The advantage of this method is that the gases are well cleaned, the disadvantage is the high consumption of the gasifier and the formation of additional SO gas in the process.

The technology of catalytic selective purification of gases from nitrogen oxides. The reducing agent used in this method, ie ammonia - NH_3, reacts only with NOx gases, not with O2 contained in the gas being treated. Therefore, for the reduction reaction, the amount of NH_3 should be taken in an amount essentially equivalent to that of NOx. In order for the reaction to proceed completely, the amount of NH_3 is taken 10-30% more than stoichiometry. The following reactions take place in the process of selective purification:
$6NO + 4NH, \rightarrow 5N_2 + 6H_2O$
$6NO_2 + 8NH, \rightarrow 7N_2 + 12H_2O$
The presence of oxygen in the mixture does not interfere with the reaction.
$4NO + 4NH, + O_2 \rightarrow 4N_2 + 6H_2O$
The process takes place at 180-300 ℃. Due to the exothermic reaction, the temperature can rise by 10-20°C. If more ammonia is given in the process, it can be oxidized at the expense of atmospheric oxygen in the gas:
$4NH_3 + 3O_2 \rightarrow 5N_2 + 6H_2O$
Technological scheme of selective catalytic treatment of nitrogen oxide waste gases. Figure 2 shows:

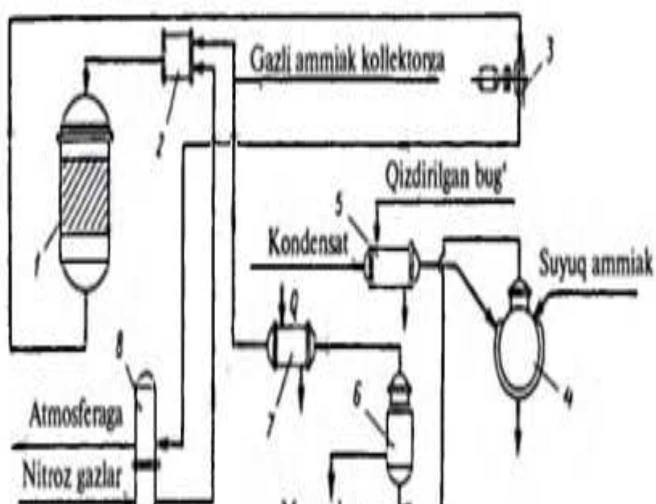

Fig. 2. Technological scheme of disposable selective catalytic neutralization of nitrogen oxides:
1st reactor; 2nd mixer; 3-recuperation turbine; 4-evaporator;
5,7,8- heaters; 6th filter.

In the technological scheme mentioned above, the nitrous gases formed during the absorption process in the production of nitric acid are mixed with ammonia gas in the mixer and then fed to the catalytic reactor. Here nitrogen oxides are reduced to elemental nitrogen in the presence of ammonia, a reducing gas. Then it passes through the recovery turbine and is released into the atmosphere. Currently, devices for catalytic neutralization of waste gases from nitrogen oxides have been installed at Chirchikkimyosanoat, Fergana "Azot" and Navoi "Azot" enterprises.

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