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USING HYDRODYNAMIC CAVITATION IN NICTRIC ACID PRODUCTON

Introduction. Modern production of nitric acid has not been significant changes since the start of the first plant in 1917 by the Andreev method. The manufacture of nitric acid is based on the catalytic oxidation of synthetic ammonia using platinum-rhodium catalyst. The reaction product of ammonia oxidation (very high-speed catalytic process) – nitrogen monoxide NO is further oxidized to nitrogen dioxide NO_2 (it should be noted, that this activationless process occurs spontaneously). The resulting nitrous gases (a mixture of nitrogen oxides NO_x) then undergoes the water absorption stage. This production can be represented as chemical reactions [Eq. (1-3)]:

$$4NH_3 + 5O_2\ (cat. - Pt) \rightarrow 4NO + 6H_2O \quad (1)$$

$$2NO + O_2 \rightarrow 2NO_2 \quad (2)$$

$$2NO_2 + H_2O \rightarrow HNO_3 + HNO_2 \quad (3)$$

After detailed analysis of this production method, we proposed two ways of it modernization. One is based on the intensification of absorption stage [1], the second method is more radical, which runs without ammonia and allow to oxidize molecular nitrogen [2]. But both methods require the generation of highly reactive substances - radicals, in particular hydroperoxide (•OOH) and hydroxyl (•OH). So first it need to determine which way they will be receive. For this, we examined all possible ways to generate •OH radicals [3]. From this review we concluded: "the most appropriate way to obtaining hydroxyl radicals in production is dynamic cavitation". The most appropriate raw material for this method is hydrogen peroxide solution (but not water itself). The scheme of generation radicals from hydrogen peroxide under dynamic cavitation given in [Eq. (4-5)]:

$$H_2O_2 \rightarrow 2\ \bullet OH \quad (4)$$

$$H_2O_2 + \bullet OH \rightarrow H_2O + \bullet OOH \quad (5)$$

Intensification of nitric acid formation. To solve the problems which are characteristic for the formation of nitric acid is necessary to activate production processes through effective optimization absorption phase of nitrogen oxides NO_x. The formation of nitrite acid (Eq. 3), which subsequently decomposes to water and oxides by the scheme: $2HNO_2 \rightarrow H_2O + NO + NO_2$, occurs only in the gas phase. Next NO must pass further oxidation to NO_2. The absorption stage where hydrolysis of NO_2 occurs through the surface mechanism, the proposed intensification process of interaction nitrogen oxides with radicals, independently of the phase, as shown in [Eq. (6-7)]:

$$NO + \bullet OOH + M \rightarrow HNO_3 + M^* \quad (6)$$

$$NO_2 + \bullet OH + M \rightarrow HNO_3 + M^* \quad (7)$$

The received experimental data indicate the possibility of absorption and radical process take place in the same reactor simultaneously (max. value of the conversion ≈ 20%) [1].

Direct oxidation N_2 in HNO_3. This technology will allow to refuse from oxidation of ammonia which synthesis requires large amounts of natural gas. The proposed method is based on the combined oxidation process N_2 by products of nitric acid thermal decomposition (Karavayev effect) and decomposition products of HOOH (Nagiev effect) with the possibility of recycling the primary number of HNO_3. Raw materials are atmosphere air and hydrogen peroxide solution. Combined method Karavayev-Nagiev, represented as simplified Eq. 8 [2]:

$$4HNO_3 + O_2 + N_2 + 3H_2O_2 + hc/\lambda\ (\lambda = 662\ нм) \rightarrow 6HNO_3 + 2H_2O \rightarrow 6HNO_3 \quad (8)$$

In this paper were presented two new methods for nitric acid production with using dynamic cavitation. Both technological solutions have high rates of increase in the finished products (20 and 50 % respectively).

References

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