

ADVANTAGES AND DISADVANTAGES OF NITRIC ACID PRODUCTION AT ATMOSPHERIC PRESSURE

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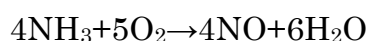
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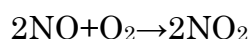
ABSTRACT

Nitric acid (HNO₃) production is widely used in industry and is primarily carried out through the Ostwald process. This process is of significant importance in the production of nitrogen-based fertilizers, explosives, and other chemical products. The Ostwald process is the main method for producing nitric acid and consists of the following stages:

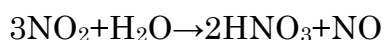
In the first stage, ammonia (NH₃) is catalytically oxidized with oxygen from the air. Catalysts such as platinum or ruthenium are used for this process. The reaction takes place at a temperature of 750-900°C and under high pressure (4-10 atm). As a result of the reaction, nitrogen oxide (NO) is formed.



In the second stage, the produced NO gas reacts with oxygen in the air, resulting in the formation of nitrogen dioxide (NO₂):



In the next stage, nitrogen dioxide absorbs in water, forming nitric acid:



During this process, the produced nitrogen oxide (NO) is oxidized again and reintroduced into the process. The technological processes and equipment used for nitric acid production consist of the following main elements:

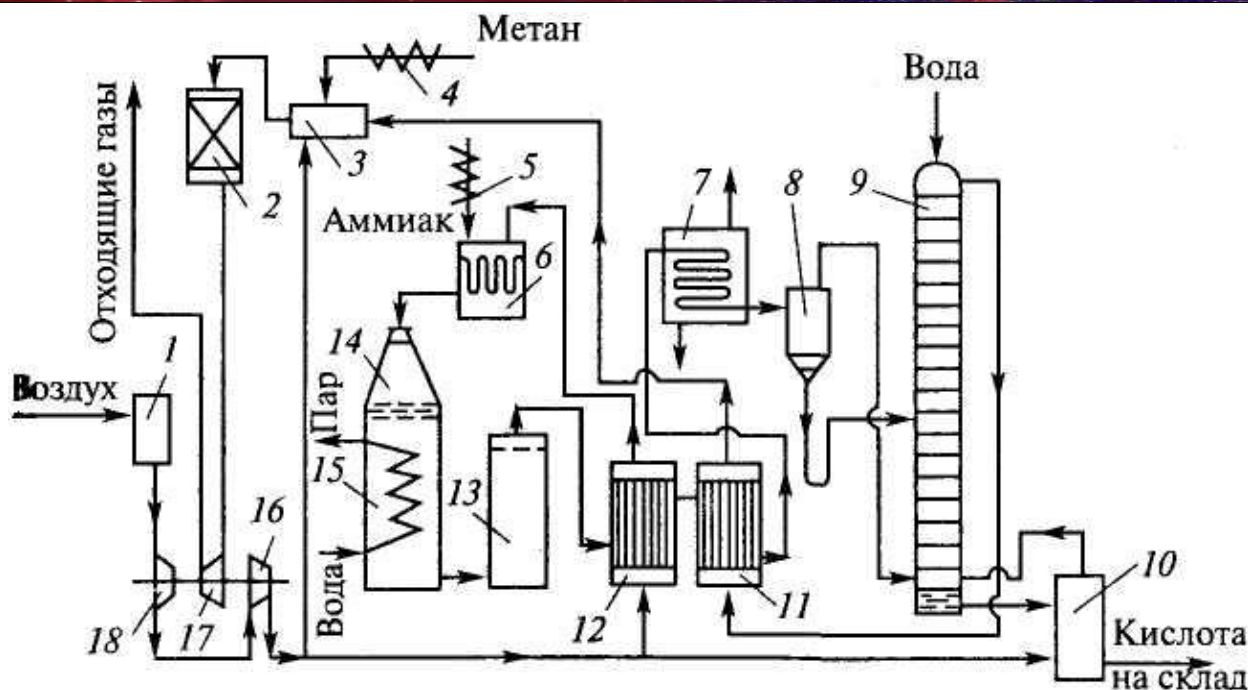
Reactor (oxidation column): Used for the catalytic oxidation of ammonia and air.

Absorber (absorption column): Used in the process of absorbing nitrogen oxides with water to produce nitric acid.

Catalysts: Platinum-based catalysts are used to increase the reaction rate.

Compressors: Used to maintain high pressure in the process.

The main problem in nitric acid production is the emission of NO_x (nitrogen oxides). These gases contribute to atmospheric pollution, making it important to capture them with specialized purification systems. Additionally, due to the process being conducted at high temperatures and pressures, safety measures are necessary. The traditional Ostwald process operates under high pressure; however, the atmospheric pressure production technology focuses on reducing energy consumption and maintenance costs. In this technology, catalysts and reactors are optimized to be effective even at low pressures.



Picture 1. Technological scheme for obtaining nitric acid at atmospheric pressure.

(Air, Exhaust gases, Methane, Ammonia, Steam, Water, Acid storage)

Nitric acid obtained at atmospheric pressure typically has a concentration of 50-60%. To increase its concentration to a higher level, the acid is distilled or concentrated through dehydration. The oxidation of ammonia occurs at high temperatures during the passage of the ammonia and air mixture through a catalyst. Nitrogen oxidation takes place in condensation columns, where nitrogen oxide combines with oxygen to form NO_2 . To synthesize the acid, NO_2 reacts with water, resulting in nitric acid production. Advantages and Complexities: The production of nitric acid at atmospheric pressure does not require very high pressure, which reduces energy consumption. However, because the acid concentration is lower, additional distillation or other methods are required to increase the concentration. In your article on nitric acid production technology, you can expand on these stages with technical details, such as heat exchange, properties of catalysts, or methods for optimizing the process. The distillation process is a method of separating the different components of a mixture based on their boiling points. This process is often used for purifying compounds or increasing their concentration, specifically applied to enhance the concentration of nitric acid as well.

Distillation generally consists of the following stages:

1. Heating:

The mixture is heated in a distillation flask or column. During the heating process, one or more components of the mixture reach their boiling point and evaporate. For example, in a mixture of nitric acid and water, water has a lower boiling point, so it evaporates first, resulting in an increased concentration of residual nitric acid.

2. Evaporation:

The component that reaches its boiling point (e.g., water) evaporates and transitions to a gas state. The evaporation rate of each component depends on its boiling point and its chemical interactions with other components in the mixture. In the distillation related to nitric acid, the dehydration process of nitric acid occurs at high temperatures.

3. **Condensation:**

The gaseous components rise to the top of the distillation column and are condensed through cooling. Condensation occurs in condensers or special pipes, where vapors are converted back into liquid. For example, water in vapor form turns into liquid upon cooling and condenses. This liquid is then collected as condensate.

4. **Fraction Separation:**

If multiple components are present in the mixture during distillation, each component is separated according to its boiling point and collected in different fractions. The boiling point of each fraction depends on the purity of the components.

5. **Residue Collection:**

Components with higher boiling points remain as residue in the mixture during the distillation process. In increasing the concentration of nitric acid, water with a lower boiling point is separated, resulting in a higher concentration of nitric acid.

Distillation of Nitric Acid:

The distillation process is used to increase the concentration of nitric acid during its production. Typically, a mixture of nitric acid and water has a concentration of 50-60%. In distillation, water with a lower boiling point is separated, allowing the concentration of nitric acid to rise to 95% or higher. The equipment used in the distillation process includes distillation columns, steam generators, and condensers. These tools are employed to enhance the efficiency of the process. To improve the efficiency of the distillation process, the following factors and technological innovations can be considered:

They can help increase process efficiency, reduce energy consumption, and improve product quality.

Multiple-effect distillation:

Explanation: Connecting several distillation columns in series allows for energy savings by using the vapor produced in the first stage in the subsequent stages.

Advantages: Significantly reduces energy consumption and minimizes waste. Multiple-effect systems optimize steam production.

Improvement of heat exchange systems:

Explanation: Heat exchangers play a significant role in the distillation process. By using multi-layer or improved heat exchange equipment in vapor discharge areas, the efficiency of the process can be increased.

Advantages: Reduces the amount of heat used in the process and allows for the recycling of waste heat.

Heat integration:

Explanation: Heat recovery systems can be applied to reuse the heat generated after steam is released. In this case, the outgoing heat is repurposed as an energy supply for other parts of the distillation system.

Advantages: Reduces overall energy consumption in production.

Vacuum distillation:

Explanation: Conducting the distillation process under low pressure (in a vacuum) lowers the boiling points of the components.

Advantages: Distilling at lower temperatures reduces heat consumption and is suitable for heat-sensitive substances.

Optimization of column design:

Explanation: Improving the internal design of the distillation column (e.g., trays or packings) can enhance mass transfer efficiency.

Advantages: Improves mass and heat transfer conditions and accelerates the process.

Optimized control systems:

Explanation: Implementing automated control systems allows for real-time monitoring and control of each stage of the process.

Advantages: Ensures optimal consumption of fuel and other resources, and provides continuous quality monitoring.

Application of energy-saving technologies:

Explanation: To improve energy efficiency, heat pumps or steam compressors can be used.

Advantages: Such technologies help save energy and make the distillation process economically efficient.

Adaptation of the distillation column to raw materials:

Explanation: Each distillation system should be tailored to the substance being processed. For example, using materials resistant to high temperatures and pressures.

Advantages: Enhances product quality and extends the operational lifespan of the equipment.

Implementation of membrane technologies:

Explanation: In some cases, membrane separation technologies can be applied as an alternative or supplement to distillation.

Advantages: These technologies allow for efficient separation of components with low energy consumption.

References

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