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WAYS TO USE WASTE-FREE TECHNOLOGY IN THE PRODUCTION OF SODA PRODUCTS

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ANNOTATION

The ammonia method of soda production generates a large amount of liquid and smoky gaseous waste. Disinfection of these wastes is an urgent task in the chemical industry. The article recommends using a membrane separator device to extract limestone and separate the burner from exhaust gases to extract carbon dioxide, as well as using sodium hydroxide instead of lime milk to extract ammonia. Such a solution prevents the release of gaseous waste into the environment, and instead of liquid waste, a solution of sodium chloride is obtained, which is reused in production. In addition, the consumption of water, sodium chloride, electricity and fuel is significantly reduced, and the profitability of production increases.

Keywords: soda ash, ammonia method, distilled liquid, exhaust gases, membrane technology, membrane separation.

Today, the most common method of producing soda ash in the chemical industry is the dissolution method or the ammonia method. The ammonia method is based on the following reaction [1]:

$$NaCl + NH_3 + CO_2 + H_2O \leftrightarrows NaHCO_3 + NH_4Cl$$

Since carbon dioxide is poorly soluble in water in the absence of ammonia, sodium chloride salt solution is first ammoniated in the absorption compartment with partial absorption of CO_2, while ammonia passes into the bound form $(NH_4)_2CO_3$, NH_4HCO_3, NH_4Cl, NH_4COONH_2, NH_4OH). Since ammonia is constantly processed in production, its regeneration is carried out by thermal decomposition of salts (at a temperature of 70-100°C). However, ammonium chloride does not decompose at certain temperatures, and in traditional production it is disposed of with lime milk $Ca(OH)_2$. At the same stage, the main waste products are formed– $CaCl_2$ solution or distilled liquid:

$$2NH_4Cl + Ca(OH)_2 = 2NH_3 + 2H_2O + CaCl_2$$

About 9-10 m^3 of distilled liquid (suspension) containing about 100 g/l $CaCl_2$, 50 g/l NaCl, $Ca(OH)_2$ and $CaCO_3$ is formed per one ton of the resulting soda [2]. Solids are released from this stream, and the liquid phase is ejected as a liquid stream. This waste stream mainly contains calcium and sodium chlorides[3]. Dumping of these wastes into reservoirs leads to their excessive mineralization and solidification, which harms the environment.

Due to the constant tightening of environmental safety requirements and the irrational use of material resources, this problem is becoming more and more urgent in the world. Methods of recycling these wastes are being developed, but due to their large amount, they continue to drain into nearby reservoirs or accumulate in mud reservoirs (sedimentary ponds or «white seas»). The authors of this article have developed a technical and economic analysis of waste-free production of soda ash by the ammonia method.

For production, carbon dioxide is proposed to be obtained partly from soda ash, which is formed in furnaces during production as a fuel combustion product, or partly from exhaust gases that can be obtained from nearby industries (instead of traditional extraction and burning of limestone). This significantly reduces carbon dioxide emissions into the environment. An additional advantage of this technology is the reduction of emissions into the atmosphere. Carbon dioxide can be isolated using membrane separation methods.

The difference between the proposed technology and the traditional scheme of replacing a limestone incinerator with a membrane one: the exhaust gases are condensed, then cooled and transferred to a membrane separator unit, purification from which is about 40%. The $CO_2$is directed into the absorption columns against the carbonation section. Membranes with high selectivity of CO_2/N_2 gas separation are presented on the chemical industry market today [4].

Traditional methods of absorption separation of $CO_2$are not used due to its low concentration in exhaust gases and large gas flows, since CO_2 removal devices must be large-scale and energy-intensive.

The use of membrane separation to remove carbon dioxide from exhaust gases leads to the formation of a by–product - technical nitrogen (97%). It can be used for fire extinguishing systems, cleaning pipes, testing them and refuelling cars.

Since in this technological scheme there is no need to prepare lime milk $Ca(OH)_2$ for mining, burning limestone and, accordingly, decomposition of ammonium chloride, it is recommended to replace calcium hydroxide with sodium hydroxide NaOH:

$$NH_4Cl + NaOH = NaCl + H_2O + NH_3$$

Thanks to this technical solution, instead of a large amount of liquid waste discharged into sedimentary wastewater, the reaction product is a sodium chloride solution that can be regenerated during full production. At the same time, the consumption (consumption) of water and the purchase of sodium chloride are significantly saved. Due to the absence of a limestone-burning workshop, the consumption of electricity and fuel is significantly reduced.

A preliminary technical and economic analysis of the proposed technology showed that the enterprise, built based on the proposed technology, will fully recoup the costs incurred within 4.6 years.

Thus, due to the use of this technology, the amount of both liquid and gaseous waste is reduced at the enterprise, which allows saving about 450 m^3 of carbon dioxide and 12 m^3 of distilled liquid per year for each ton of soda produced using traditional technology. Since there is no need for limestone mining and sodium chloride consumption, such production can be located far from large natural deposits, next to factories that consume soda ash.

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