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## **СИСТЕМИ РОЗРОБЛЕННЯ ТА ПОСТАВЛЕННЯ ПРОДУКЦІЇ НА ВИРОБНИЦТВО**

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## **OPTIMIZATION MODELING AND DEVELOPMENT OF SEPARATION, HEAT AND MASS TRANSFER EQUIPMENT OF THE UNIT FOR PRODUCTION OF LIQUID NITROGEN FERTILIZERS**

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According to the Report of the European Commission Joint Research Centre announced in 2015 raise of prices on nitrogen fertilizers is one of the biggest challenges which increase the food problem worldwide. The main reason for this is high energy consumption of the production process of solid nitrogen fertilizers. While production of liquid nitrogen fertilizers is 30-40% cheaper than manufacturing of complex concentrated water soluble fertilizers. In the agriculture of the United States about 50% of all nitrogen fertilizers are used in liquid form. One of such fertilizer types is ammonia water with ammonia concentration which is 25% min. But using of this liquid nitrogen fertilizer is economically efficient at a short distance from the production plant and manufacturing of liquid nitrogen fertilizers with high nitrogen content is a significant challenge for the chemical industry of Ukraine and the EU.

To solve this problem, scientists of the department processes and equipment of chemical and petroleum-refineries from Sumy State University (SSU) have developed new methods and advanced technology for liquid nitrogen fertilizer (LNF) manufacturing, which is implemented in the mobile research and industrial unit with the capability 30 t/h. It has block and modular component system of the main and auxiliary technological equipment that enables to transport an industrial unit to the necessary installation area, thereby reducing the cost of fertilizer transportation (the customer - "Agroservis LTD", Ukraine).

To solve practical problems of calculation, design, analysis, simulation, optimization and synthesis of chemical technology processes (CTP) and technological equipment one used advanced computer systems of mathematical and engineering calculations (CAD / CAE-system). The main purpose of chemical-engineering processes modeling was composing and solving equations of heat and material balance to calculate the material and energy flows, identifying the main energy costs for performing the technological process, calculating and developing of the separation, heat and mass transfer equipment. Based on the computer models selected by numerical modeling one determined basic mode parameters of main and auxiliary equipment of the device, physical and chemical properties of raw materials, finished products, related materials and intermediate products.

One can increase the content of main target components (MPC) in the obtained liquid nitrogen fertilizers, which remain stable even under normal conditions ( $T = 20^{\circ} = 293 \text{ K}$ ,  $P = 1,013 \cdot 10^5 \text{ Pa}$ ) by replacing the process of obtaining saturated water ammonia solution using the method of physical absorption on the

processes of neutralizing of acid solutions (nitrogen or phosphate) with ammonia water or ammonia gas, interaction of salts with ammonia in the water solution with the formation of stable amino complexes that already represent a rare type of complex liquid fertilizers. That is why a technological unit for producing of complex liquid fertilizers is provided in several different modes that will enable to manufacture certain products (ammonia water solution and liquid nitrogen-phosphorus fertilizers) for agricultural purposes, depending on customer requirements.

Summary results and analysis of the computer simulation of the technological process for obtaining ammonia water are the following. Necessary overpressure of the environment which must be maintained in the absorption columns should be at least 0.2 MPa. It enables to get the finished product with ammonia concentration 25% wt. min (20% wt. for nitrogen) and thus to achieve a high degree of ammonia absorption at the absorption stage.

When following the technological parameters of calculation, ammonia absorption degree is more than 99%, which enables to exploit the technological equipment with minimal ammonia recycling, which is not absorbed in the packed absorber. Increased consumption of liquefied ammonia at the input of a unit enables to raise ammonia concentration in the finished product up to 32-34% wt., but it will greatly reduce the efficiency of ammonia absorption and will lead to the compulsory recycling of unabsorbed gas when one starts the device, which requires additional equipment and energy costs. In addition, ammonia vapor pressure over the finished product will be much higher than atmospheric pressure at 20°C, which makes the product unstable under normal storage conditions.

It is recommended to maintain positive pressure in a shell and tube chemical reactor-mixer which should be higher than 0.2 MPa and it would allow withdrawal of unabsorbed gaseous ammonia to the absorption section without additional equipment only under the influence of excessive pressure. Getting the liquid nitrogen fertilizer is possible using the raw material - nitric acid with a concentration 56% wt. instead of 65% wt., but it will lead to the reduction of the active ingredient (nitrogen) in the finished product, but it enables to apply the obtained fertilizer at some lower ambient temperatures. Increased consumption of the ammonia supplied to the reactor, cause no raise of the nitrogen content in the finished product, but only increase ammonia content in the reaction mass in the gas phase. Then this gaseous ammonia will be separated from liquid and it must be supplied to the absorption section. Such operation aspect of the reaction section enables to manufacture simultaneously two types of the finished product- ammonia water and ammonium nitrate within one technological unit.

The developed new industrial unit for LNF production solves the problem of using the liquid fertilizers regardless of the place of their production and it allows farmers to save costs on fertilizing the soil. Having developed a technological maintenance requirement card of the unit working modes one can produce liquid nitrogen-phosphorus fertilizers of different composition depending on the needs of the agricultural crops or soil that must be fertilized.