Steady growth of demand for mineral fertilizers has been intensifying their production. At ammonium phosphate plants, production can be increased by raising the efficiency of the technological systems through increased heat carrier flow and/or concentration of the pulp to be granulated. The former intensification version is restrained by the presently operating absorption units and by the rate of entrainment of product granules of the required size, and is now practically abandoned. Pulp concentration is also restrained by pulp properties. For instance, ammophos pulp having moisture contents not exceeding 20–25% has a viscosity not permissible for pumping in industrial conditions, even though moisture contents of 10–11% are enough for getting the required granulometric composition.

Such a pulp is formed upon pressure ammoniation of extraction (wet-process) phosphoric acid (EPA) having $P_2O_5$ contents of more than 41–42%. At the moment of spraying directly into a drum granulator-dryer (DGD) or into an ammoniator-granulator (AG) [2], bypassing the intervening vessel, the pulp retains the fluidity and adhesiveness sufficient for granule formation. The reactors (reactor-DGD and reactor-AG) are compact, highly efficient, economic, and reliable, and are usable for processing various types of raw materials with a wide range of properties through a combination of chemical reaction and structure formation (aggregation).

However, at $P_2O_5$ contents of more than 47–48% in the EPA, heat evolution in ammoniation is so intense that, after throttling, the ammophos pulp has a moisture content that is not enough for formation of the required granulometric composition. Also, because of high excess pressure (above 300 kPa), the finely disperse ammophos pulp having moisture contents of 5–8% forms a large quantity of fine fraction (dust). In production of diammonium phosphate, because of its increased solubility, the reverse phenomenon (spontaneous agglomeration) is observed. In both cases, this makes it necessary to increase ammonia flow.

Alteration of the chemical composition of the pulp and its acidity helps improve granulation conditions even at lower moisture content. At the same time, not always does the chemical composition of the product correspond to the accepted standards, which leads to an increase in ammonia consumption and, accordingly, reduces profit from fertilizer sale.

There had been attempts to get standard products from unconcentrated EPA containing a variety of impurities by concentrating the acidic pulp through evaporation, followed by final ammoniation under pressure and granulation of the fusion cake formed in the DGD [3]. One of the demerits of this method is substantial dust formation due to high ammonia-
tion pressure. Also, for cooling of the fusion cake in summer, the specific heat carrier consumption is 1.2–1.8 times higher than for pulp drying, due to which heat carrier consumption rises.

Concentration of acidic pulps by evaporation is justified for weak acids that form viscous pulps. For more concentrated acids and less viscous pulps, two-stage ammoniation with partial expulsion of the moisture evaporated in the first stage, bypassing the granulator, is enough. For instance, in the industry, a scheme is used that includes ammoniation by gaseous ammonia with expulsion of the moisture to the atmosphere and final ammoniation by liquid ammonia with simultaneous spraying of the pulp into the DGD [4].

There is a method where the acid is neutralized by liquid and gaseous ammonia in a single apparatus (reactor), which allows more precise control of the moisture content and temperature of the pulp. Granulation is performed also in the DGD. Single-stage ammoniation is used for acids having $P_2O_5$ contents of 44–48%. In this case, although the entire evaporated moisture flows into the granulator, the moisture content of the heat carrier does not exceed the required equilibrium moisture content of the product.

The choice of the reactor design depends on the initial state of aggregation of ammonia and EPA concentration. Weak acids can be neutralized at atmospheric pressure, for which vessels having mixing devices and water jackets are used. Usually, several stages are used because the operation regime of serially connected sections approximates ideal expulsion. For example, in nitrophoska production, a cascade (series) of U-shaped single-casing reactors is used. Each of these consists of two vertical tubes, the lower parts of which are interconnected by an elbow. In each tube, there are cantilever shafts having two-tier propeller stirrers (mixers) rotating in such a way that the liquid moves downward through one tube and upward through another. Serial connection of such reactors allows gradual introduction of the reagents, which improves conditions for chemical reaction. But the need for servicing a multitude of mixing devices makes use of these reactors difficult.

Use of mechanical energy for mixing products of reaction with a solid phase is fully justified because the heat liberated is not enough. In a gas-liquid system, especially for fast reaction, use of mixing devices is not the best way to intensify the process. If the acid concentration is enough and the ammonia is in gaseous state, fast ammoniator-evaporator (FAE) is used. If the process is implemented in a confined space, a vapor-liquid emulsion forms in the reagents reaction zone. Because of the difference in densities, an ascensional (buoyancy) force develops and, as a result, the heat of chemical reaction is utilized not only for pulp heating and water evaporation, but also for development of active hydrodynamic conditions that facilitate restoration of mass exchange surface, i.e., intensification of the process. Repeated pulp circulation prevents vigorous boiling, hydraulic shocks, and loss of ammonia, and allows gradual ammoniation of the acid to high pH values.

Ammoniation of EPA containing less than 18% $P_2O_5$ without mechanical mixing is difficult because of inadequate heat evolution. At $P_2O_5$ contents higher than 40%, slow-moving pulps are formed. To pump and disperse them, the temperature and/or moisture content have to be raised, which is possible if ammoniation is effected under pressure. The higher the acid concentration, the higher the pressure that ensures pulp mobility.