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# PRODUCTION OF GRANULES WITH SPECIAL PROPERTIES IN SMALL-SIZED VORTEX DEVICES

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*Article is devoted to a feasibility study of the special properties of granules in a small-sized vortex device. A new way to create granules of porous structure was proposed. The experimental investigations of porous layer creation conditions on the surface of granules were conducted. The efficiency of the technological scheme and equipment in its structure were proved.*

*Keywords: porous structure, vortex streams, granules*

## INTRODUCTION

The most simple in manufacture and using of industrial explosive agent is porous ammonium nitrate (PAN). PAN is also a basic for production of other explosives.

The most common way of PAN production is based on mixing ammonium nitrate melt with porosity generation and gas generation impurities, followed by granulation. Gas generation and porosity generation impurities promote the formation of porous structure of PAN granules, which increases of absorbing and granule keeping ability. While the tower method of production has significant defects: cumbersome equipment, the significant costs of its service and repair, impossibility to create intensive hydrodynamic within the tower [1]. Creation of new PAN industries based on tower method requires considerable material and labor costs. Also Gas generation and porosity generation impurities that are part of PAN, reduce environmental PAN indicators.

Today for blasting is used standard ammonium nitrate, which was established for the needs of the agricultural sector. This nitrate is less expensive than PAN, but relatively less effective.

Currently, the leading overseas companies with produce nitrogen fertilizer granules and porous structure granules have mastered granular product release, which has increased quality indicators, and therefore granulated products produced in Ukraine may lose the market. For high quality products should be used new technological principles that create the structure of granules in the forming process, which can not provide the tower method of ammonium nitrate production [2, 3].

## AIMS OF THE STUDY

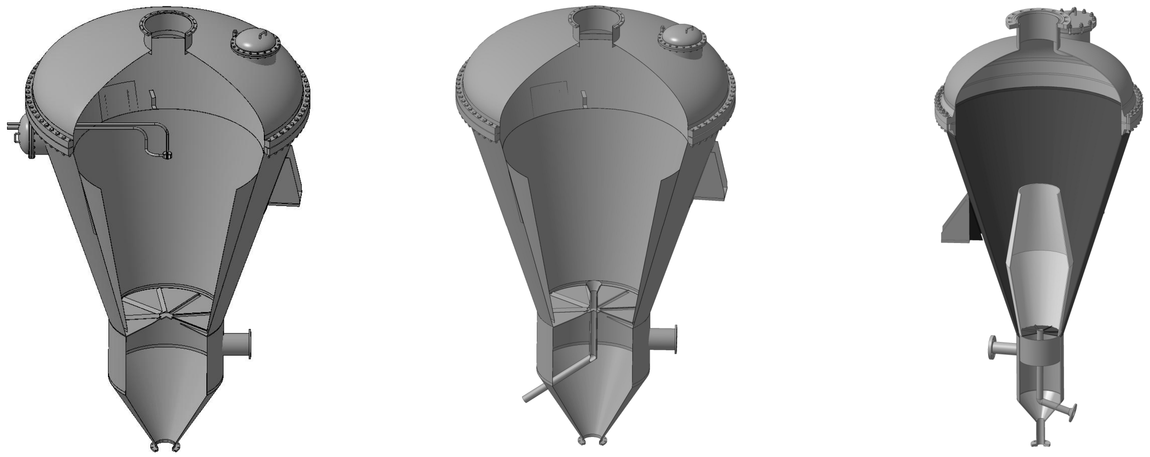
The purpose of the work is a feasibility study for the establishment in Ukraine of modern highly efficient and economical production of porous ammonium nitrate (PAN), which is currently absent. Development of new production will allow for mining and processing plants, quarries and other companies where conduct blasting operations with low-cost industrial explosives (PAN produced by Russia is used in 80% of industrial explosives). This issue becomes even more pressing due to the fact that the international community plans to shift production to lime ammonium nitrate, which is not explosive.

## RESEARCH METHOD

The formation of porous structure of PAN granules conducts on the granulation of ammonium nitrate stage. For porous surface layer getting there is applied a compact vortex type granulator with a variable height cross section of the working space (Figure 1).

The granulator work is based on new way, which was put to get granules of porous structure [4]. It was based on improving the flow dynamics of granules, which provides the increasing of monodispersion granules, which are grow in the vortex layer and uniformity of size distribution of the finished product. Thus, granules with causing solution are free from surface sealing layer, the conditions of freed moisture out on the surface of granules are created out, there is a porous structure of granules. The granules receive extra weight through the mud that settles on their surface.

The process of granulated ammonium nitrate getting in the vortex apparatus of combined type is endothermic and takes place during deposition on solids drops of solution with concurrent crystallization.



a) b) c)

**Figure 1. Constructions of small-sized vortex granulators: a) with dispersion of the melt; b) with previous moistening of granules and a simple internal case; c) with pre-moistening granules and composite internal case**

The porous structure of granules production by wetting granules with given quantity of moisture before entering the working volume into the balanced layer and the beginning of contact with high - temperature heat transfer medium provides simultaneity of drying process and porosity generation, to reduce the residence time in a fluidized layer of granules to the minimum necessary, and consequently, the strength of granules saving without destroying the internal crystal structure. The uniform layer of liquid material on the granules surface getting with its previous moistening allows to do the principle of uniformity the main point of which is during the implementation process of porosity generation there is a need to achieve uniform forces that arise in the interaction of damp granules and axisymmetrical eddy of heat transfer medium on each granule.

It is necessary to achieve minimum impact of hydrodynamic regime of the granulator working on initial core granules strength and enhance on the keeping granules ability regarding liquid fuels (for example, solar oil), as this indicator is the main quality characteristic of PAN [5-8].

The proposed method and compact granulator for its implementation to improve the effective of heat and mass transfer processes and porosity generation on the granules surface, the uniformity of their growth and increase the rate of granules formation with a uniform porous layer of dried liquid material in a range of sizes and masses, which provides the increasing of grain size material monodispersion and improve the quality of the final product.

A designed method to obtain layer of porous structure of any liquid material that becomes a prerequisite for bilateral and multi-grains in the volume of one device, on the granules surface.

## RESEARCH RESULTS

Experiment results define the beginning of monotonous decrease of strength granules with increasing the residence time in the apparatus of its starting value of 7-10 minutes in dependence on the characteristics of raw materials. Thus, there is a need to reduce the granule’s residence time in the work area of vortex granulator at least by a certain date. This is achieved by using the active turbulent vortex gas flow in granulators, which enables to increase the removing of moisture intensity from the granule and complete the process of porous surface layer creating to the core granules destruction. The creating of vortex fluidized bed with small intensity leads to the increasing time necessary for drying granules to given moisture; granules due to long-term collision between themselves and the walls of apparatus lose their strength or completely destroyed. The research results are shown in Figure 2 and Figure 3.

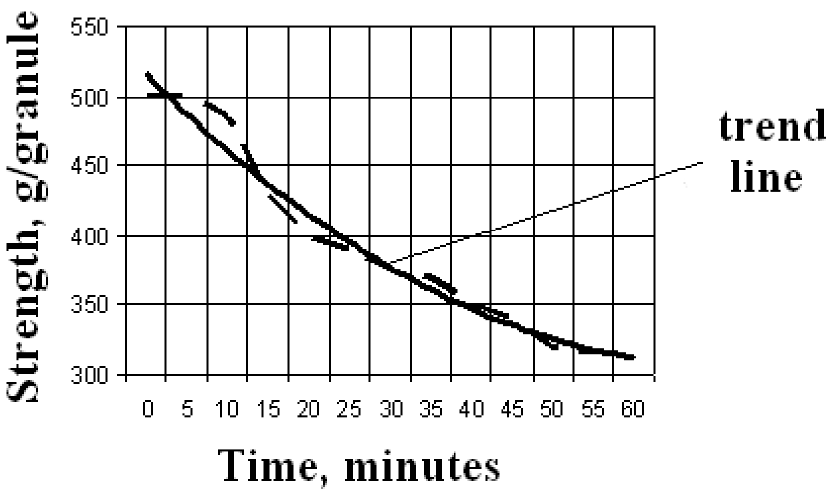



**Figure 2. The dependence of the granule’s strength and residence time in the vortex fluidized layer**

The experimental data (Figure 4) also demonstrate the increasing of the granule keeping ability with time, but the mechanism of this increase in time change. At the initial stage (10 minutes) the increasing of the granule keeping ability occurs through the creation of its porous surface layer and pore volume increase. Granule has an integral structure with a clearly expressed form (Figure 3, zone I). After a specified time the specific surface area of granules increases due to its destruction. There is cracks and chips on the surface of granules (Figure 4, zone II). When the residence time of granules in the vortex fluidized layer is 35-37 minutes there is monotonous decreasing of the granule keeping ability due to the total destruction of its core. The granule has incorrect form, significant cracks and chips (Figure 4, zone III).

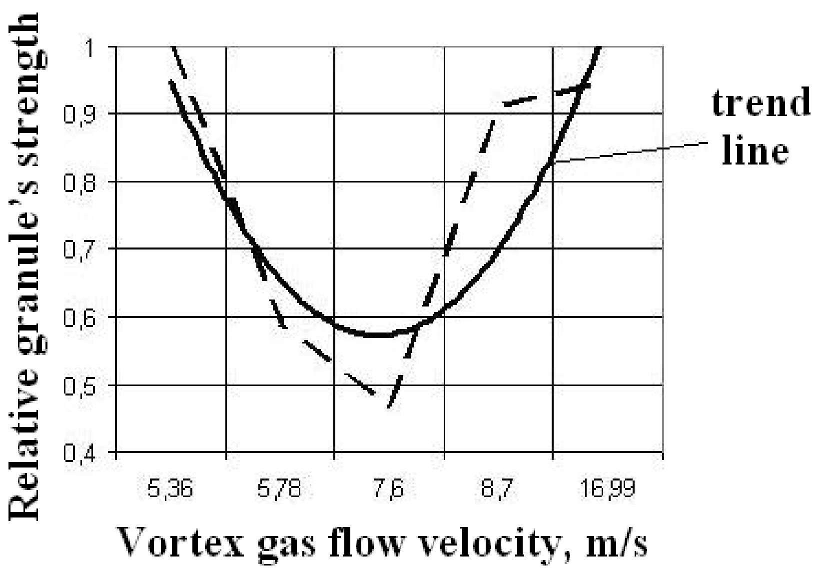



**Figure 3. The dependence of the relative granule's strength on the vortex gas flow velocity**

The analysis of PAN samples, which are received from domestic raw materials and Russian analogue (Figure 6-8) have showed the following.

All samples of porous surface layer have almost similar structure (the received samples in the vortex granulator with an identical strength and keeping ability are investigated) with the Russian analogue, which confirms the high quality of granules. (Figure 9). Analysis of elementary chemical composition of samples by atomic absorption method in graphite electrothermal and flame atomizers has showed the presence aluminum and manganese atoms in the Russian sample, which are part of gas generation and porosity generation impurities. The absence of these elements in received PAN by no-tower method while maintaining the basic parameters demonstrates the applicability of such technology in production.

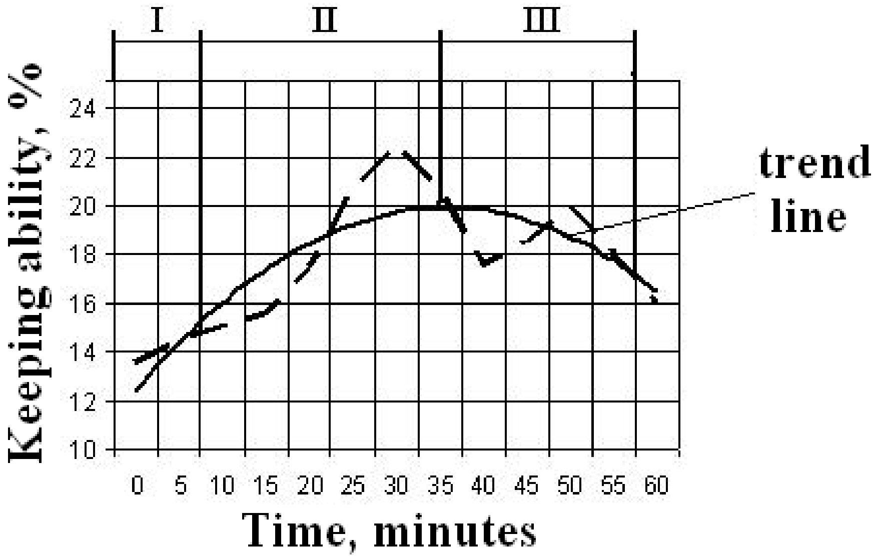



**Figure 4 – Dependence of the granule keeping ability from its residence time in the vortex fluidized bed**

**Figure 5 – The samples of granules (according to data of Figure 4): a) zone I; b) zone II; c) zone III**

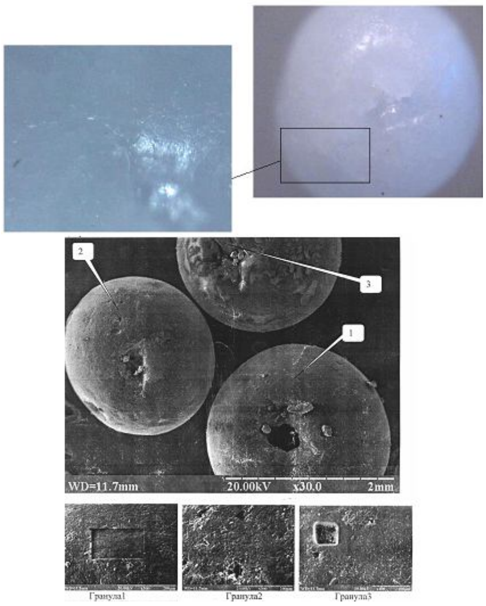



**Figure 6 – The analysis results of PAN, which received by no-tower method (as recycled granules of ammonium nitrate by "Exactly Nitrogen", Rivne production).**

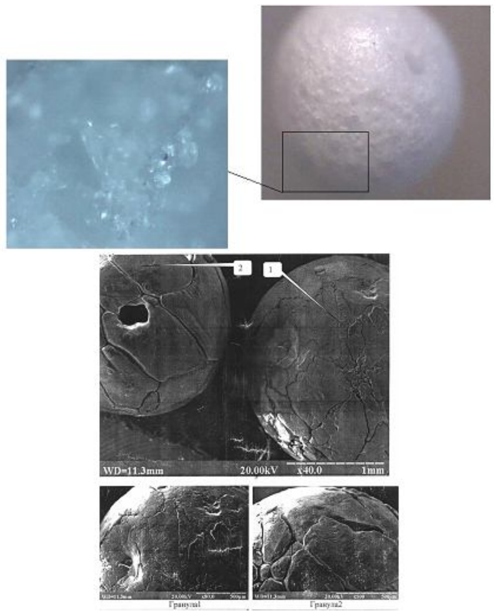



**Figure 7 - The analysis results of PAN, which received by no-tower method (as recycled granules of ammonium nitrate by "Dnipro Azot", Severodonetsk production).**

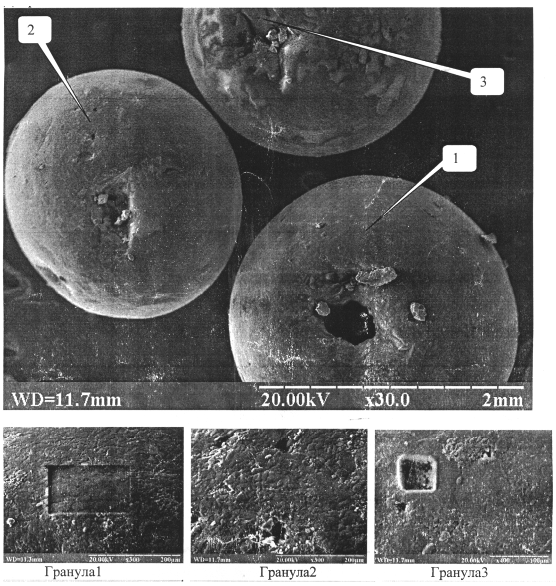



**Figure 8 - The analysis results of the Russian analogue PAN**

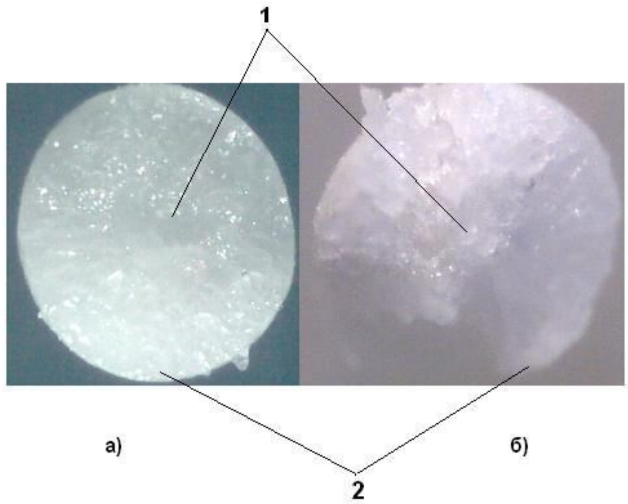



**Figure 9 - Section of granules which are obtained in the vortex granulator: a) according to Figure 6, b) according to Figure 7; 1 - the granule core, 2 - porous surface layer**

## CONCLUSIONS

During heat treatment nitrate granules are less strong than before heat treatment. Reducing the mechanical strength of granules is directly dependent on the number of cycles of heat treatment of which they were subjected. In addition, great importance is the presence these or other impurities in nitrate, most likely ammonium nitrate granules lose strength that contain no extraneous impurities [9].

The propose way of obtaining the structure of porous granules by heat treatment in combination with moistening granules allows, by varying temperature heating and cooling and cyclical wetting granules, receive the product with desired quality characteristics.

As a result, the comparative study of consumer properties of the product received by no-tower method with the Russian analogue is shown that the keeping ability of PAN on solar oil ranges from 9-17% at the strength of granules to 500 g/granule, and the keeping ability of Russian analogue - 6.8% at average strength of granules 300 g / granule. Experiment results are applied to the development of technological parameters of a porous structure of granules. The proposed technology of PAN (Figure 10), which based on studies, provides the keeping ability, strength and grain size of granules according to the regulations.

The resulting product due to comparatively low temperature of process in the vortex granulator (at 30-50 °C in comparison with the method of manufacturing tower) and no modification transformations provides the presence of air bubbles in granules core, which promote explosive properties of product with preserving mechanical strength and decreasing the number of heat treatment cycles.

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