Pneumatic Classification Of The Granular Materials In The “Rhombic” Apparatus

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Abstract
This article deals with the classification of granular materials, the necessary apparatus for its fulfillment and its construction. Authors propose and describe the new model of apparatus for pneumatic classification which allows performing efficient classification of granular materials without contact devices. Experiments prove that the separation degree of the granular materials on coarse and fine fractions in this pneumatic classifier is very high.

INTRODUCTION

Granular materials separation processes become more and more important nowadays due to high demands which are put to raw materials and middling products and because of production increase. High demands are put to the dispersed materials which are raw materials or final products in chemical, mining, building and other industrial branches. Often the final products are in the form of powder, coarse-grained material or granules, quality of which depends much on their uniformity.

MATERIALS AND METHODS (THEORETICAL PART)

Classification (fractionating) is a process when mixed granular materials are separated into two or more segregated populations of granules thus main product can contain very small quantity of the materials from other classes. Fractionating of the granular materials is used for mineral fertilizers production [1] and for production of electrodes (when high dispersed particles must be removed from the raw material in the burning furnace) It is also used for cleaning and preparation of the seeds, which is an important agricultural technological process necessary before sowing.

High separation level in the dispersed materials classification process has big influence not only on the raw material unit consumption and its quality but also on the productivity and efficiency of other machines and apparatus in the technological scheme, and as a result it has influence on the technical and economical capacity of the production in general.

Main aims of the separation processes in different industrial branches are the following:
1) to get the dust-free products with minimal quantity of the fine grades;
2) to remove the coarse grades for getting the finely dispersed product;
3) to separate the material on some grades where each grade has different average size, and quantity of the fine and coarse grades in each product is limited;
4) to separate the polydisperse material into more than two grades each having the stated granulometric composition.

Pneumatic classification is based on the speed difference of the different fractions particles terminal velocity in the airstream. This method of classification is more improved than mechanical and hydraulic classifications and has some advantages. Using pneumatic classification method it is possible to separate the original material into all physical and mechanical characteristics of the fractions: size, form, surface roughness and density. Comparing with hydraulic classification method pneumatic method makes it possible to get the products dry and so the energy consumption when using the pneumatic method is much lower. These advantages of the pneumatic method make it widespread in different industrial branches.

The easiest pneumatic classifier is made in the form of a vertical chamber. Polydisperse material is delivered into its center body section. This classifier is not very popular because its productive capacity is low and fraction separation quality is not good enough. Later models were in the zigzag form, F. Kaiser apparatus [2], where thanks to gas flow turns there appear centrifugal forces and particles circulation process begins.

It is easier to produce the apparatus which are in the form of straight vertical chamber with rectangular section where there are lots of shelves at an angle to the flow through the opposite sides of the chamber. Quite good separation results one gets using the apparatus where in the vertical chamber there is created the fluidized layer on the specific grate or cascade perforated shelves. [3].

Barskiy M.D. [4] taken into consideration F. Kaiser research, proposed new principles of the efficient gravitational process classification and worked out their physical fundamental principles. Main point of these principles is that gas suspension motion is unsteady due to cascade of contact elements which are in the separation channel. Cascade pneumatic classification apparatus designs are actively developed; so in the new designs one uses full downward perforated shelves.

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To improve effective granular materials separation and to find new spheres for its usage one improves cascade pneumatic apparatus mostly by creating new contact elements. [5, 6]. But contact elements quantity causes local resistance when rising airstream moves and it influences on the apparatus energy consumption. The more shelves are in the apparatus the more intensive is the phase contact, but in this case hydraulic resistance increases and apparatus energy consumption increases too. So our aim is to design an apparatus which hydraulic resistance is minimal because there are no shelves contacts inside and as a result energy consumption is much lower.

**MATERIALS AND METHODS (EXPERIMENT)**

The laboratory stand of the pneumatic classifier was designed for research purposes. Many tests were completed to find out the best operating mode and to test the efficiency of granular materials separation.

![Figure 1](image1.png)

**Figure 1** «Rhombic» pneumatic classifier

The main purposes of the research were to find out the best way to classify granular materials correctly using the working space of the granulator, to find out more efficient ways and means to influence the granular material flow in such a way to provide additional material separation and so to reach much better separation efficiency and to work out such design of the classifier which enables to decrease hydraulic resistance and to reach high separation productivity and efficiency. For bringing to life these main purposes “rhombic” pneumatic classifier (Figure 2) was worked out and designed. It has rhombic body 1 form, two working parts - bottom part 2 - section for material rotating and separation where fine and coarse fractions are knocked out from the rotating layer and upper section -3 for fine fraction dispersion and drawing out from the apparatus, charging hopper 4, discharging devices 5 for coarse fraction and 6 - for fine fraction. Air supply is fulfilled through discharging device 5 for coarse fraction and air discharge - through discharging device 6 for fine fraction.

![Figure 2](image2.png)

**Figure 2** Pneumatic classifier operating principle.

Compressor (it is not shown in the Figure) inhaunts some air and forms air flow. Initial granular material is periodically delivered into the central body part of the rhombic classifier. This part of granular material is grasped with the air flow and delivered to the bottom section of the device. The special material layer is formed here; it is pressed with air flow from one side of the device to another one and so fine fraction is knocked out from the layer and is delivered into the upper section and coarse fraction - into the bottom section. Fine fraction grasped with the air flow is dispersed at rhombic closing angle in the upper section and is withdrawn from the device. Coarse fraction sheds into the bottom section and is withdrawn from the apparatus. Some part of the material which is not separated continues rotating. Further charging hopper supplies next part of the material and cyclic process takes place again. Periodical material supply into the rhombic apparatus body enables to create conditions for material layer (which is pressed from one to another apparatus sides) formation. Material layer is formed with gathered material particles which are not separated at once after getting into the device. Layer formation is artificially done since the first material part is supplied in triple quantity. This layer partially block air supply into the device and so, due to rapid rate increase, it gets rotary motion. When rotating the layer is pressed from one to another body side creating rapid flow speed up. It enables to achieve additional material separation in the bottom section of the device and to control material rotating process in the separation section which influences on the separation efficiency [7].

**RESULTS AND DISCUSSION**

Quartz sand was used as a test material. Test results are in the table 1 and in the diagram (Figure 3) Summing up the results in the table and diagram one can see that using this apparatus we get coarse fraction quantity about 96% and fine fraction quantity about 95%. Thus fine fractions quantity in the coarse grade and coarse fractions quantity in the fine grade is about 5%.
Table 1. Tests are made using binary mixture: coarse fraction \(-0.63+0.4\) mm and fine fraction \(-0.4+0.16\) mm

<table>
<thead>
<tr>
<th>Test sample</th>
<th>Weighed quantity, g</th>
<th>Fraction (-0.4+0.16) mm, g</th>
<th>Fraction (-0.63+0.4) mm, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original material</td>
<td>1129.2</td>
<td>574.9</td>
<td>554.3</td>
</tr>
<tr>
<td>%</td>
<td>50.91</td>
<td>49.09</td>
<td></td>
</tr>
<tr>
<td>Fine fraction</td>
<td>591.4</td>
<td>562.70</td>
<td>28.70</td>
</tr>
<tr>
<td>%</td>
<td>94.68</td>
<td>4.83</td>
<td></td>
</tr>
<tr>
<td>Coarse fraction</td>
<td>526.1</td>
<td>22.50</td>
<td>503.60</td>
</tr>
<tr>
<td>%</td>
<td>4.28</td>
<td>95.71</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3 Screen analysis curves of particles on fractions

Having done the research the following process peculiarities were noticed:

1) Continuous product loading has negative impact on the separation quality, so the periodic loading is preferred. Periodic product loading has positive impact on the separation process and when using this loading there is no rolling swirl in the separation section since this swirl prevents the gas flow from withdrawal of the fine fractions from the layer.

2) After having done the tests and having compared the results it was found out that using this apparatus design one can achieve effective classification without using the contact elements inside its housing. Since the flow does not swirl and it moves from wall to wall which causes additional resowing it has positive impact on the separation quality.

3) To get the best separation material quality it is important to provide the best opening and closing angles of the rhomb and necessary separating zone height.

4) When choose the best modes for controlling the flow speed main product which one gets contains no more than 5 % of other classes fractions.

5) So as a conclusion the test which are made prove that rhomb shaped apparatus have good potential in using them for grain materials separation.

CONCLUSION AND FUTURE DIRECTION OF RESEARCH

To summing up the above research results one can say that rhombic pneumatic classifier for granular materials separation is much more efficient than the analogs which are used in industries nowadays; it has easy technological design, has no hydraulic resistance and no moving parts, it is easy for maintenance. That’s why it has promising future for further development and usage in industries instead of less efficient analogs.

REFERENCES