Engineering of centrifugal dust-collectors based on parallel comparing tests applying computer modelling

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Abstract. Currently researchers are giving serious consideration to studying questions, related to issues of atmosphere protection, in particular, studying of new construction of gas-cleaning SPM cyclonic devices effectivity. Engineering new devices is impossible without applying mathematical model methods, computer modeling and making physical models of studying processes due nature tests.

1. Introduction
The main problem in development and improvement of inertial gas filters is absence of the dispersion phase structuring model in aggregates, and as well absence of parallel comparing tests of newly developed dust-collector and certain prevalent aggregates, conducted in equal conditions with the same type of dust. Besides, questions related to exploitation of the dust-collector in term of concrete processing are not in consideration, such that signatures of recommended for the technology aggregate are much worse against signatures, achieved in laboratory conditions. The Cathedra of «Life Safety and Environmental Protection», Don State Technical University, is making R&D on studying aerodynamic characteristics and effectivity of cyclonic equipment with different shapes [1, 2]. Currently the is no uniform requirement for choosing optimal shape of cyclones, however in construction of the most modern cyclones there is a distinct emerging tendency of the cone part evolution. There is a wide range of relations between the cyclone geometrical shape and its effectivity, which is emerging through sophisticated aerodynamic of streams, appearing in this equipment.

One of the proposing technical decisions is previously patented cyclonic equipment, completed as inverse cone without cylindrical part [3]. For solving problems related centrifugal dust-collectors construction improvement it is necessary to develop an experimental installation suitable for making parallel comparing tests of cyclonic equipment with different shapes.

2. Equipment description.
One of the proposing technical decisions is original experimental equipment (application №2014136881 invention RF), allowing parallel and effective exploring of aerodynamic processes and processes of dust precipitation inside centrifugal equipment with various construction (fig.1). The installation is processing in the following way:

Dust-and-air mixture tangentially invades into cyclone through inlet pipe. Due to helically-formed enter, stream crimpling and moving downward spiral line along wallsides of the equipment. As a result of crimple moving, by the action of centrifugal forces dust particles discharging from stream; due
to existence of electrically conductive layer on transparent material of the cyclone and upper camera of dust-controller it doesn’t precipitate on wallsides, but lands in dust-collector.

**Figure 1.** 1-upper cyclonic cone; 2-inlet pipe; 3-exhaust pipe; 4-lower cyclonic cone; 5-cone bases; 6-dust-collector; 7-pipe; 8-upper dust-collector camera; 9-lower dust-collector camera; 10-pneumatic cylinder; 11-semicolonrical hatches; 12-rotary joint; 13-axis, comparing to which the half-rounded slots are rolling; 14-forcing element; 15-control module; 16-feeding source; 17-video camera; 18-ground path; 19-lugs; 20-pneumatic cylinder’s bases; 21-withdrawable pneumatic cylinder’s stocks; 22-carbon grains.

Construction of the dust-collector provides carriage of conditions for controlling value in prescribed limits. Before entering lower camera of dust-collector, dust, moving rotary, lands on a surface, for example, on baffles in upper camera. Dust grounds onto semicircular hatches, forming uniform layer. Video camera of the equipment fixes achievement of the allowed height of dust layer in upper camera of dust-collector and sends signal to control module, which in its turn gives command to actuate pneumatic cylinder, opening semicircular hatches. Dust disposes into the lower camera of dust-controller and semicircular hatches recover to normal position after some break, allowing the assigned value of dust-collector and effective air cleaning.

The particles discharge into dust-collector, and cleaned gas proceeds into exhaust pipe.

Realization of case and upper camera of the dust-controller of transparent material with application of electrically conductive layer prevents balling of powdery and allows visualizing aerodynamic processes inside the aggregate through using for example carbon grains. By variation of stream-giving speed and immersion depth of exhaust pipe it’s possible to explore the dust-landing process and aerodynamic characteristics of stream for detecting its optimal properties.

Experimental installation (fig.2) is realized in the way to allow exploring cyclonic equipment with various shapes. It is attained due quick-disconnecting fixation in area of inlet and in area of convention of lower cyclonic cone to dust-collector bunker. There is a possibility to regulate the heights of connection between inlet pipe and air-duct, conveying dusted gas into cyclonic equipment.
3. Experimental studies are realizing in isothermic terms (at the environmental temperature). Air consumption is in wide range of about 500...2000 m³/hr, dust concentration is about 3.4...50 g/ m³. Through experimental action on working units of the installation the next main parameters are measuring: inlet consumption and inlet (exhaust) air speed; cyclone hydraulic resistance; depression in cyclone areas; depression in bunker; blower-made pressure; duration of collecting process; amount of uploaded dust in the feed unit; amount of dust, left in feed unit; amount of collected dust in the cyclone; measuring pressures in the inlet and exhaust of the cyclone.

Some number of tests was realized on exploring cyclone equipment to determinate influence of the cyclone shape and its construction on the dust-landing processes effectivity. Examples [1,2] demonstrate, that cyclones with inverse cone (CIC) have higher dust-collecting effectivity, than cylindrical aggregates. Optimal construction parameters CIC (immersion depth of exhaust pipe and correlation between cyclone working unit and bunker), improving dust-collecting intensity, were estimated.

Established, that dust-collector construction with inverse cone and regulating geometrical parameters allows effective leading of air-stream cleaning process in term of low hydraulic resistance against traditional smooth-wall cyclones. Demonstrated, that using cone cross section and availability to regulate immersion depth of exhaust pipe into the cyclone corpus encourages cyclone hydraulic resistance reduction against smooth-wall cyclones.

4. Computer modeling is a necessary instrument for modern technical objects engineering. Recently many developers and researchers pay special attention to attract commercial packages of application programs for modeling processes, passing in cyclone aggregates. Computer models in programs SolidWorks [4,5] and ANSYS were made for more detailed studying of the processes inside cyclone aggregates. Computational simulation software ANSYS is a universal program system of final element analysis, disposing much more wider modeling possibilities against SolidWorks. Considering specificity and difficulty of solving problems, ANSYS in line with standard $k-\varepsilon$ - turbulence model, considering rotating flows inside the aggregate, it is possible to use $k-\omega$ - model to describe processes in near-wall areas. The fundamental equations, describing processes inside cyclone equipment, are: equation of continuity (mass conservation), impulse and energy transfer (heat) [5]. Also it is required to set entry and frontier terms. Range of goals, which were already solved due using computer models introduces profiling of sustainable trapezium-shaped construction of inlet pipe CIC etc.
5. Conclusion.

Ways of improving the centrifugal dust-collectors construction are proposed. The experimental installation, allowing to make parallel comparing tests of cyclonic equipment with various shapes is created. Received experimental data about aerodynamic processes in cyclones and dust-collecting processes allows to realize identification of mathematic models and to improve computer models of studying processes.

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