Aerodynamical Probation Of Semi-Industrial Production Plant For Centrifugal Dust Collectors' Efficiency Research

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Abstract. In previous studies, experiments were carried out on the small-size models of cyclonic units, but now there completed the semi-industrial pilot plant «Cyclone», which would allow comparative testing of real samples of different shaped centrifugal dust-collectors and compare their efficiency. This original research plant is patented by authors. The aim of the study is to improve efficiency of exhaust gases collecting process, by creating improved designs of centrifugal dust collectors, providing for the possibility of regulation constructive parameters depending on the properties and characteristics of air-fuel field. The objectives of the study include identifying and studying the cyclonic apparatus association constructive parameters with their aerodynamic characteristics and dust-collecting efficiency. The article is very relevant, especially for future practical application of its results in dust removal technology.

1. Introduction

In recent years the «Life Safety and Environment» department of Don State Technical University conducts researching works of aerodynamic characteristics and dust-collecting efficiency of different shaped cyclonic units.

If in previous studies experiments were carried out on the small-size models of cyclonic units [1-6], then now there completed the semi-industrial pilot plant «Cyclone», which would allow comparative testing of real samples of different shaped centrifugal dust-collectors and compare their efficiency. This original research plant is patented by authors in 2014-2015. [7, 8].

The aim of the study is to improve efficiency of exhaust gases collecting process, by creating improved designs of centrifugal dust collectors, providing for the possibility of regulation constructive parameters depending on the properties and characteristics of air-fuel field.

The objectives of the study include identifying and studying the cyclonic apparatus association constructive parameters with their aerodynamic characteristics and dust-collecting efficiency.

There why the article is very relevant, especially for future practical application of its results in dust removal technology.

Statement of research objectives and requirements for aerodynamic experiment

To achieve the goals and objectives there were formulated requirements for the experiment:

- to achieve tightness of completed semi-industrial experimental plant (first experimental studies of the plant must be carried out without hoppers);

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- tests are carried out in accordance with the requirements of GOST 12.3.018-79 Safety security standards system, ventilation systems, aerodynamic testing methods;
- to identify characteristics of pressure changing, air velocity and its flow rate at different points in the cross sections of inlet and outlet pipes of cyclonic plant for different defined performance of exhaust blower;
- to obtain experimentally full, static and dynamic pressures at different points in the cross sections of inlet and outlet pipes of cyclonic plant for different defined performance of exhaust blower;
- to compare the calculated and experimentally determined coefficients of hydraulic resistance at the inlet and outlet of investigated cylindrical cyclone CN-15-300.
- to determine the flow regime at the plant (to calculate the Reynolds number).

Experimental plant (Fig. 1) is constructed in such way, that it could be possible to provide research of removable cyclone devices of various shapes. This is achieved by quick release at the area of inlet and outlet pipes and transition of lower cyclone cone into dust-collecting hopper. There is also the possibility of regulation of inlet pipe connecting highs with ductwork, feeding dusty gas into the cyclone plant.

Figure 1 – Experimental plant «Cyclone»: 1 – inlet pipe, 2 – outlet pipe, 3 – Cyclone CN-15-300 (through quick release clamps can be easily replaced to COK), 4 – hopper, 5 – round blower

2. Aerodynamical tests of the semi-industrial plant

With the aim to study aerodynamical characteristics of cyclonic apparatus precision differential micromanometers Testo 521-1 with a set of pressure Pitot tubes and impeller pocket anemometer Testo 410-2 were used.

For founding relations between aerodynamical characteristics and shape of testing cyclonic apparatus at the plant the next research was carried out.

To measure pressure and velocity of air flow in ductwork (channels) there must be chosen sectors with location of dimensional sections at distances for at least six hydraulic diameters D_h, m behind the place for the flow disturbance (taps, dampers, apertures etc.) and at least two hydraulic diameters before it. Coordinates of pressure dimension points and velocity (Fig. 2), as well as number of points are determined by the shape and size of dimensional circular section in line with GOST 12.3.018-79.

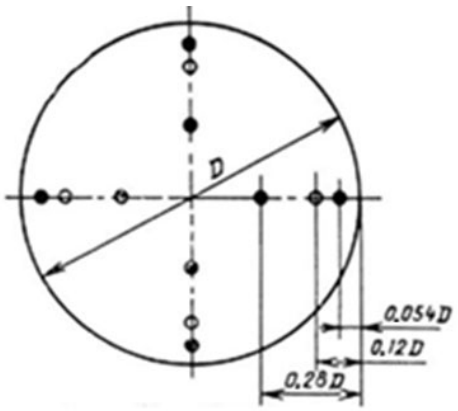

Figure 2 – Scheme of placing of pressure dimension points and velocity in cylindrical section ductwork

In our case the pipe diameter is 200 mm, consequently, dimension points will be placed at a distance of 0.12D from wall of pipe.

There were made some perforation at the inlet and outlet pipes of the experimental plant with D_{OTB} = 20 mm. In this perforation Pitot pipes were fixed with silicone plugs, connected to two differential micromanometers Testo 521-1. Next wasrunning up radial fan, mounted on the outlet connection. After 15 minutes working in the inlet and outlet of the plant were carried out measurements of full, static and dynamic pressure, rate and velocity of air flow. For objectivity of the study measurements were conducted 60 times.

3. Results and Discussion

Experimental results were analyzed and are presented in graphs (Fig. 3-8).

As seen from the graphs (Fig. 3), velocity of air flow in the outlet pipe for different performance of blower in any dimensional point greatly exceeds velocity of air flow in the inlet pipe (in 1.73…2 times). This is due to the blower VC 1446 (working on the hood) is placed structurally closer to the outlet pipe of cyclonic apparatus.

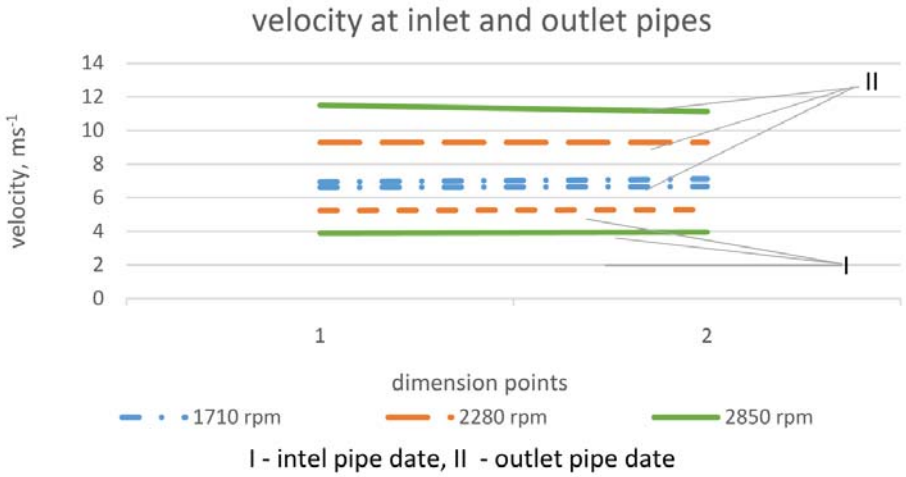

Figure 3 – Air flow velocity at inlet and outlet pipes dimension points of the experimental plant for different performance of blower

At the Fig. 4 presented relations of obtained experimentally airflow costs at the inlet and outlet respectively. These experiments made it possible to establish, that air cups in the direction of

movement are absent and the plant has integrity. Costs value at the inlet and outlet pipes by dimension points and for different performance of blower practically have no differ. Wherein experiments were specially conducted without hoppers with cap on the cyclone CN-15 – 300.

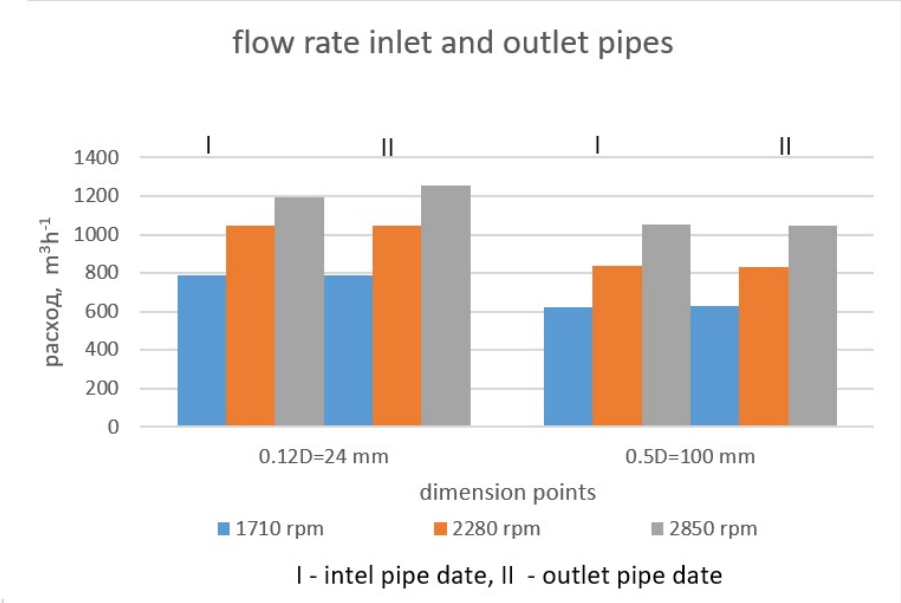

Figure 4 – Inlet and outlet air flow rate for the plant for different performance of blower.

At the Fig. 5 presented the results of measurement of full air flow pressures at the inlet and outlet pipes of the plant for different performance of blower.

The changing characteristics of full pressures shows, that in the outlet pipe of the cyclone vacuum forming goes on. This phenomenon is explained through vortex flow not only in the cyclone body, but also at the plant outlet, wherein pressure is distributed on the periphery of the vortex.

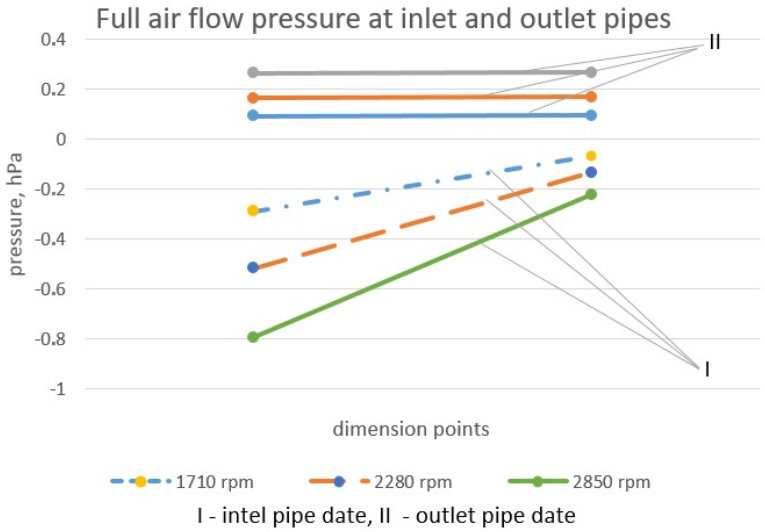

Figure 5 – Full air flow pressure at inlet and outlet pipes of cyclone CN-15- for different performance of blower

Basing on the experimental values of full pressures at the inlet and outlet of cyclone, and also measured velocities the hydraulic resistance coefficients of cyclone apparatus CN-15-300 were calculated. They are presented at Fig. 6. As cyclone CN-15-300 was produced under production conditions, it was important to determine KGF at the inlet of present apparatus and compare it with KGF of standard cyclone CN-15-300. Average value KGF at the inlet pipe is 4.12. For standard cyclone CN-15 KGF=4.30.

The Reynolds numbers have also been calculated according to the available experimental data. Reynolds number at the outlet pipe nearly 2 times more, than at the inlet pipe (7000) and it is up to 15000. The values of Reynolds numbers allow us to conclude, that in the experimental plant there occurs the turbulent movement of air.

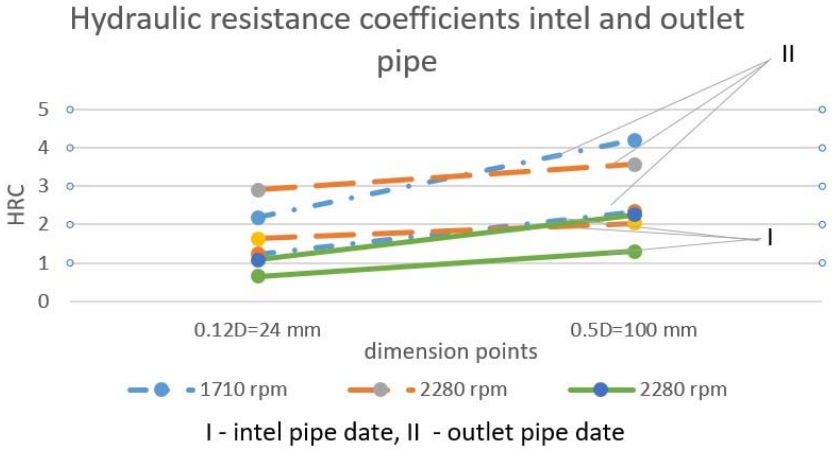

Figure 6 – Hydraulic resistance coefficients at the outlet of cyclone CN-15-300 for different performance of blower

4. Conclusion

The impermeability of completed semi-industrial experimental plant is reached, which allows to use it further in compare tests with different dust collectors.

The character of pressure change, air flow velocity and its rate at different points in the cross sections of inlet and outlet pipes of cyclonic plant for different defined performance of exhaust blower is identified.

Experimentally full, static and dynamic pressures at different points in the cross sections of inlet and outlet pipes of cyclonic plant for different defined performance of exhaust blower are obtained.

Coefficients of hydraulic resistance at the inlet and outlet of investigated cylindrical cyclone CN-15-300, which are consistent to data, given in the literary sources [9], [10] are found.

Turbulent air flows in the plant is obtained.

In future we suppose to conduct more detailed experimental studies, including cyclone apparatus dust collecting efficiency.

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