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Hydrodynamics of A Barbage Exhaust Apparatus for Wet Purification of Dust Gases

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Abstract
The article presents the design and principle of operation of a bubbling vortex apparatus, which provides vortex contact of a liquid with a dusty gas, cleaning by a wet method. Theoretical studies have been carried out and a formula has been derived for calculating the total pressure loss in the working chamber of the apparatus depending on the flow rate of dust gases in the working chamber of the apparatus and the resistance coefficients of the formed local and contact elements. As a result of calculating the total pressure loss using the recommended formula, it is possible to determine the efficiency of gas and dust cleaning and the optimal hydrodynamic parameters of the contact elements of the apparatus.

Keywords: dust gas, swirling flow, contact element, liquid screen, drag coefficient, pressure, drop eliminator, nozzle.

Introduction

Recently, the amount of pollutants released into the atmosphere in Uzbekistan is increasing due to the fact that the dust and gas cleaning equipment in industrial enterprises was installed 10-15 years ago, and they are outdated both physically and mentally.

Metallurgical, energy, oil and gas and mining industries, factories specializing in the production of construction materials, and harmful substances emitted from motor vehicles are the main sources of atmospheric gas pollution. These problems are not only problems of Uzbekistan, but of the whole world [6].

The efficiency of existing dust-gas capture equipment in industrial enterprises is only 86 percent. In the process of environmental protection, the requirements to ensure the creation and installation of devices with an efficiency of not less than 99.5 percent at stationary sources of atmospheric air pollution are defined [1,2,3,6]. Based on the above-mentioned problems and the requirements for dust and gas cleaning devices, we are conducting scientific research on the creation of new constructions of wet dust and gas cleaning devices. Below are the theoretical studies conducted in recent years on the apparatus for cleaning dust and gases by wet method.

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Research Object:

The apparatus under investigation is a bubble stacking apparatus, and Figure 1 shows an overview and calculation scheme. The structural structure and the principle of operation of the device are also presented below.

The structure of the device is as follows:

Working chamber pipe 1, which directs the dusty gas, is installed parallel to the working chamber pipe, liquid conveying pipe 2, barrier forming a liquid return screen 3, liquid spreading nozzle 4, contact element (zavikhritel) directing the flow of gas and liquid in a lumped motion 5, cyclone of the working chamber It consists of a connecting flange 6, a slurry discharge pipe 7, a cyclone-like device 8 that catches liquid drops in the purified gas, and connecting flanges 9 and 10.

The principle of operation of the device:

The dusty gas is transferred to the apparatus, through the input pipe 1 to the working chamber of the apparatus. At the same time, the liquid is pumped through the liquid transfer pipe 2, which is installed parallel to the pipe of the working chamber. During the movement of the liquid transmission pipe 2, it comes to the nozzle 4, and the jet from the nozzle hole hits the obstacle 3 perpendicular to the transmission pipe at a high speed, and as a result of the collision with the obstacle, the liquid jet forms a screen and spreads over the entire cross-sectional surface of the gas introduction pipe 1. The dusty gas flow passes through the liquid screen formed in barrier 3.

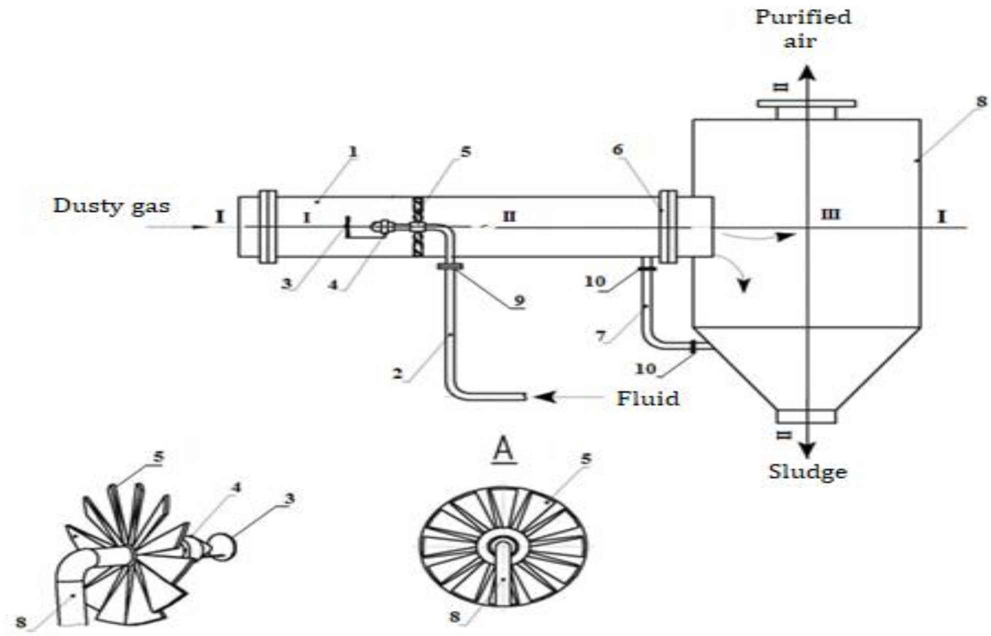

Figure 1. Apparatus overview and calculation scheme.

During this passage, the dust contained in the gas begins to contact the liquid screen, and due to the speed of the transmitted gas flow, the gas follows the liquid screen and forms a liquid flow and hits the contact element that creates a twisted flow. As a result, it passes through the

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blades of the contact element at an angle, and at the expense of the angle, the contact of the liquid flow with the dust is formed again. Due to the angle of the blades of the contact element, the flow of liquid and dusty gas is driven into a lumpy motion, it hits the walls of the working chamber pipe 1, and under the influence of the speed of the flow of dusty gas and liquid, it spreads along the wall of the working chamber and forms a liquid film. As a result of this, the remaining dust in the gas is caught in the liquid film and forms a slurry, which passes through the pipe 10 to the cyclonic device that catches the drops. Due to the speed of the purified gas, it also carries away liquid droplets with its flow. To solve this problem, a cyclonic device 8 is attached to the last part of the working chamber by means of a flange 10. Drops of liquid coming out, mixed with the purified gas coming out of the working chamber, hit the walls of the device by reducing its speed due to the size of the cross-sectional surface of the cyclonic device, and the drops form a liquid film on the walls of the device during this impact and flow down and join the slurry due to its weight. Cyclonic Drops of liquid coming out, mixed with the purified gas coming out of the working chamber, hit the walls of the device by reducing its speed due to the size of the cross-sectional surface of the cyclonic device, and the drops form a liquid film on the walls of the device during this impact and flow down and join the slurry due to its weight. Cyclonic Drops of liquid coming out, mixed with the purified gas coming out of the working chamber, hit the walls of the device by reducing its speed due to the size of the cross-sectional surface of the cyclonic device, and the drops form a liquid film on the walls of the device during this impact and flow down and join the slurry due to its weight. Cyclonic In the drip catcher, the purified gas and sludge are separated.The pipe of the cylindrical working chamber is installed obliquely to the cyclone, taking into account the slurry flow.In the design of the device, attention is paid to the following: the efficiency of cleaning the dust gases of the device depends on the resistance coefficients of the contact element 5, which directs the gas flow, and depends on the angle of inclination of the blades of the contact element, which ensures the movement, and is determined through experiments. The thickness of the liquid film in the working chamber and the spread along the length of the cleaning chamber wall are determined depending on the resistance coefficient of the contact element, local resistance coefficients, and surface tensions and viscosities of the selected liquids. The sizes of the holes of the nozzle that disperse the liquid are also selected depending on the resistance coefficients of the hole. Optimum values of cleaning efficiency at small values of liquid consumption are taken into account.In addition, this device can be installed directly on dust gas lines without separate installation. This in turn reduces additional costs.

The Results Obtained:

Using the scheme of calculating the apparatus, we consider the pressures generated in sections II and II-II and the total pressure lost in the apparatus through them. For this, we use Bernoulli's equation. Pressures on sections are affected by P_1 and P_2 in section II, and P_3 in section II-II. In Uhol, the total pressure can be written as follows, Pa;

$$\Delta P_{gen} = P_1 + P_2 + P_3 \tag{1}$$

where: ΔP is the total pressure loss in the device, Pa; P_1 is the pressure lost due to the friction of dusty gas in the inlet pipe to the device, it is determined according to the following equation [3,4,5], Pa;

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$$P_1 = \xi_1 \frac{\rho_{mix} \omega_{mix}^{\ 2}}{2} \quad (2)$$

in this; ω_{mix} - the speed of the dust gas flow in the pipe of introduction to the device m/s; ξ_1 - is the resistance coefficient formed by the friction of the dust gas flow with the hardware pipe, which is determined according to the following equation [3];

$$\xi_1 = \lambda_1 \cdot \frac{l_1}{d_1} \quad (3)$$

in this; l_1 – pipe length, m; d_1 – pipe diameter, m; λ - Darcy's coefficient, it is determined that it depends on many scientists in expressing the law of change with empirical equations.
The coefficient of friction λ depends on the flow regimes of the dusty gas in the pipe, and for the laminar regime, when Re ≤ 2320, it is determined as follows.

$$\lambda = \frac{64}{\mathrm{Re}} \quad (4)$$

The flow mode is defined as follows when 2320<Re<4000.

$$\lambda = 0,0025 R_e^{0,333} \quad (5)$$

For smooth pipes, when 4000<Re<10000, it is defined as follows.

$$\lambda = \frac{0,3164}{R^{0,25}} \quad (6)$$

A.D. Altshul friction coefficient in computational work in all types of turbulent flow λ proposed the following empirical formula based on experiments for a wide field of [3,4,5];

$$\lambda = 0.11(\varepsilon + \frac{68}{\mathrm{Re}})^{0.25} \quad (7)$$

If we put equation (2) instead of λ – resistance coefficient in equation (3), then the equation will look like this, Pa;

$$P_1 = \lambda_1 \cdot \frac{l_1}{d} \cdot \frac{\rho_{mix} \cdot \omega_{mix}^{\ 2}}{2} \quad (8)$$

P_2– is the hydraulic resistance in the contact element of the device, which is determined according to the following equation, Pa;

$$P_2 = \left(\xi_{\text{water}} + \xi_z\right) \frac{\rho_{mix} \cdot \omega^2_{\ mix}}{2} \quad (9)$$

where: ξ_{water} - is the resistance coefficient formed when the liquid-dust gas flow hits the liquid screen, which can be determined only by experiment; ξ_3 -is the coefficient of resistance formed when dusty gas and liquid flow collides with a vortex forming a twisted lumpy flow, which is also determined through experiments; ω_{mix} - gas velocity during the passage of dusty gas and liquid flow through the contact element, m/s;
ρ_{mix} - is the density of the dust and gas mixture, which is determined according to the following equation [4], kg/m^3;

$$\rho_{mix} = \rho_g + \left(\rho_{\text{dust}} \cdot \gamma\right) \quad (10)$$

where: ρ_{dust} - is dust density, kg/m^3; ρ_g - gas density, kg/m^3; g - the amount of dust in the gas, %.

P_3-pressure loss in the droplet arrester that mixes with the purge air. Pa. It is defined as follows[4,5];

$$P_3 = \lambda_2 \cdot \frac{l_2}{d_1} \cdot \rho \cdot \frac{\omega^2}{2} \quad (11)$$

where λ_3 - is the coefficient of friction with the wall of the gas cleaned from drops from the cyclonic device, l_2 - is the length of the gas moving droplet catching device, m; d_1-diameter of the droplet catching device, m; ρ-refined gas density, kg/m^3; ω - velocity of the purified gas moving in the triple device, m/s.

If we put formulas (8), (9) and (11) into equation (1), then the formula for calculating the total pressure loss in the apparatus is as followsappears [10; 59-62-b], Pa;

$$\Delta P = \lambda_1 \cdot \frac{l_1 \cdot \rho_{mix} \cdot \omega_{mix}^{\ 2}}{2d} + \left(\xi_{\text{water}} + \xi_z\right) \cdot \frac{\rho_{mix} \cdot \omega_{mix}^2}{2} + \lambda_2 \frac{l_2 \cdot \rho \cdot \omega^2}{2d_1} \quad (12)$$

As a result of theoretical studies, the formula (12) was developed to calculate the total lost pressure in the proposed apparatus. Using this formula, it is possible to calculate the total lost pressure depending on the hydrodynamic parameters of the apparatus.

Conclusion

In the article, the constructional structure and principle of operation of the bubbling agglomeration device, which ensures the agglomeration contact of the liquid with the dust gas, is given in the article. As a result of theoretical studies, a formula for calculating the total lost pressure in the apparatus working chamber was derived, depending on the dust gas flow rates in the apparatus working chamber and the resistance coefficients of the resulting local and contact elements. As a result of the conducted theoretical studies, as a result of the calculation of the total pressure lost by the recommended formula, it was possible to determine the efficiency of dust gas cleaning and the optimal hydrodynamic parameters of the contact elements of the apparatus.

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