MATEC Web of Conferences **72**, 01122 (2016) DOI: 10.1051/matecconf/20167201122
HMTTSC-2016

ESTIMATES OF TWO-PHASE FLOW PARAMETERS IN THE CYCLONE CHAMBER

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Abstract. It providesanalysis of methods for assessing circumferential speeds distribution of pressure in the cyclone chamber. It is shown that for cylindrical chambers of less than two diameters and the inlet section of at least 0.1 square cross section the maximum peripheral speed and rate distributions circumferential speeds along the current line is not changed. Analysis of the distribution shows that the concentration of small particles that are typical for gas dedusting systems have a significant impact on the distribution of pressure, vacuum and on the axis of the absolute value decreases toward dust of output section unlike the swirl chambers fuel combustion.

1 Introduction

The cyclone chamber with solid particles are widely used in various fields of engineering and technology for the intensification of physical-chemical processes. The critical parameter defining intensity the warmly-mass-exchange of processes and the separation of effects in the swirl chamber is level rotary components of speed of gas and speed of particles The existing methods based on sounding of fields of speeds are [1] labor-consuming and demand introduction of the adjusting coefficients for elimination of influence of a probe on the high-speed field of a flow. Furthermore, they are not suitable for studying swirling two-phase flow. Experience the definition of speeds dust swirling flows cylindrical probe showed unsatisfactory reproducibility of the measurement due to clogging of the probe channels [2]. Therefore, the preferred are more reliable methods that do not require adjustments and are suitable for estimating the parameters of dust swirling flows [3]. The basic geometrical relationships influencing the efficiency and flow resistance of the cyclone chamber, the relationship to the inlet area of the planned area of the cyclone, the ratio of the inlet area to the area gas outlet pipe, the area ratio dust of output holes to the total surface of the chamber.

On the characteristics of flow in cyclones with different geometries can get an idea if we use the data [4, 5], where there are fields of distribution of flow rates in the volume of the cylindrical and conical cyclones. The available numerous pilot studies of distribution of fields of speeds allow to draw a conclusion that in a counter flow cyclone there is an averaging of the moments of speeds and at the relations of the areas of an entrance and an exit less unit distribution on height of radial gradients of the moments of speeds changes

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slightly. Moreover, the maximum radius of base peripheral speed and the maximum speed of zero radius adjustment for the cylindrical cyclone same [1, 5]. In [1] shows the results of the study chamber length affect the pressure loss of circulation and distribution. Moreover, significant changes in the length of the chamber is not observed, whereas the total level of circumferential speeds within the chamber and the pressure on the wall decreases. This indicates that in the chamber are averaged over the length of the radially circumferential speed distributions due maximum radial and turbulent transfer pulses and angular momentum. The pressure on the wall relative to the pressure input is determined not only vortex design features, but also the relative size of the outlet chamber and a relative length that accounts for the effect of injection indirectly effects in the central area, which extends up to the input splines [4]. Effect of generating turbulence in the forced vortex spreads all over, but the R1/R2<0,2 flow deceleration rotation slightly in the free vortex and circumferential speeds distribution of a free vortex in a potential close to [1].

2 The calculated ratio

The rotational component is determined from the ratio $V^2 = R/\rho \cdot dp/dR$, where ρ – density of the gas, R– the current range, V – circumferential speed of the gas. One of the parameters defining the whirling stream is the intensity of the rotational motion $\Delta p_0 = p\left(R_2\right) - p\left(0\right) = \rho\int_0^1 \left(V^2 / \bar{r}\right) d\bar{r}$, where $\bar{r}$=R/R2, R2– camera radius [1].

Radial pressure drop in a particular section is determined from the equation of motion in the radial direction.

$$V = V_\Delta\left(\frac{R_2}{r}\right) \text{ при } R_2 > r >; V = V_\Delta \frac{r}{r_m}\left(\frac{R_2}{r_m}\right)^n \text{ at } r < r_m \tag{1}$$

$$\Delta P = \int_0^{R_2} \rho\frac{V^2}{r}dr = \int_0^{r_m} \rho\frac{V^2}{r}dr + \int_{r_m}^{R_1} \rho\frac{V^2}{r}dr + \int_{R_1}^{R_2} \rho\frac{V^2}{r}dr \tag{2}$$

here r_m– the maximum radius of the circumferential speed $V = \upsilon_m$ in particular section, R_1– the radius of the exhaust pipe, V_Δ– circumferential speed at a distance $0{,}03R_2$ from the wall of the outer cylinder of radius R_2. These equations allow to calculate the value of the exponent, the radius rm according to the differential pressure on the wall of the exhaust pipe and the axis of the periphery and axis. At the top of the cyclone pressure on the surface of the radius r_m unknown, it must be determined.

$$\overline{\Delta P}_{0-m} = \frac{\Delta P_{0\text{-m}}}{\rho\frac{V_\Delta^2}{2}} = \left(\frac{R_2}{r_m}\right)^{2n}; \qquad \overline{\Delta P}_{1-2} = \frac{\Delta P_{1\text{-}2}}{\rho\frac{V_\Delta^2}{2}} = \frac{1}{n}\left[\left(\frac{R_2}{R_1}\right)^{2n} - 1\right], \tag{3}$$

$$\overline{\Delta P}_{0-m} + \overline{\Delta P}_{m-1} = \left(\frac{R_2}{r_m}\right)^{2n} + \frac{1}{n}\left[\left(\frac{R_2}{r_m}\right)^{2n} - \left(\frac{R_2}{R_1}\right)^{2n}\right] = \overline{\Delta P}_{0-m}\left(1 + \frac{1}{n}\right) -$$

$$-\frac{1}{n}\left(\overline{\Delta P}_{1-2} \cdot n + 1\right) = \Delta\bar{P}_{0-2} - \Delta\bar{P}_{1-2}$$

from whence

$$\overline{\Delta P}_{0-m} = \frac{n\overline{\Delta P}_{0-2} + 1}{1 + n} \tag{4}$$

In these formulas ΔP_{0-m}, ΔP_{1-2}– pressure differentials between the axis and a surface with a radius r_m, and between the radius surface R_1 and the outer wall of the upper part of the cyclone, respectively. Using the first relation (3) is determined by the position of the radius r_m:

$$\frac{R_2}{r_m} = \left(\overline{\Delta P}_{0-m}\right)^{\frac{1}{2n}} \tag{5}$$

In the second equation (3) is numerically define n (table 1). At n>1 relative pressure differences indicated in the table, for $\overline{R}_1$>0.4 impossible.

Table 1. Values *n*.

$\overline{R}_1$	$\overline{\Delta P}_{1-2}$			
	1	3	6	9
0.3	–0.9	0.18	0.7	0.93
0.4	–0.45	0.5	>1	>1
0.6	–0.1	1	>1	>1

3 Experimental setup and measurement

Figure 1 shows the pressure measurement circuit in a cylindrical cyclone 1. Consumption was measured using a pitot tube. For the measurement of small pressure differences used micromanometer. Pressure measured using an axis movable tube outer diameter of 3 mm with drilled holes, which could be isolated. The selection pressure on the periphery of the cyclone was conducted through nozzles communicating with the holes in the cabinet. The diameter of body 100 mm in diameter clean air outlet - 34 mm, pressure in the range of selection of the cyclone cover the surface of the exhaust pipe r_{pr}=20 mm (figure 1), reflector diameter at the bottom of the cylindrical cyclone – 43 mm. F_{in}= 22x50 mm^2, H=200 mm. Distance calculation conducted from dust outlet sections.

Used micropowder M40. The dispenser represented vibrovoronki with different sizes of output sections. The powder is loose material having a particle size of 40 microns, has good flowability.The air flow rate determined by the formula

$$G_{в} = \rho Q;\ Q = kF_{in}\upsilon_d;\ \upsilon_d = 10\sqrt{\frac{2\Delta p_d g}{\rho}} \approx 40.4\sqrt{\Delta p_d} \tag{6}$$

here ρ – density ρ≈1.2(g/dm^3), Fin – entrance area (dm^3), Δp_d – dynamic pressure (kgs/m^2), $\upsilon_д$ – speed is determined dm/s, $G_в$ – mass flow determined in g / s, k– Nikuradze correction.

Consumption was determined expiration time, in minutes from funnel vibro mass of material in grams $Gm = \frac{M}{60t}\left(\frac{g}{s}\right)$, the concentration of the material is determined by the formula $C = \frac{G_m}{G_v}1000\left(\frac{\text{g material}}{kg \text{ air}}\right)$.

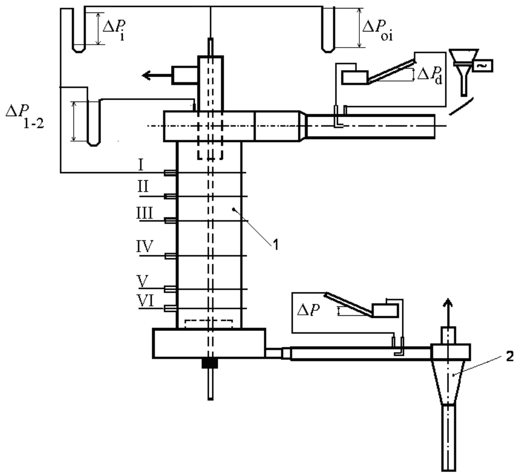

Fig. 1. Diagram of the measured pressure in the cyclone.

In order to reduce pressure fluctuations held retraction some of the air with the dust in the cyclone bypass 2. The influence of drainage on the pressure distribution.Number of exhaust air from the receiver was determined in a similar manner. The relative amount of exhaust air from the receiver determined by the formula $\overline{G}_{отв} = \frac{G_{отв}}{G_{в}} 100\ \%$.

Figure 2 shows the values of the pressure in the cylindrical cyclone. For clarity tags spaced in height, although they all belong to the same section.

Value △p

№	$G_в = 28 \div 29$ (г/с)					
	$\bar{G} = 5\%$		$\bar{G} = 18\%$		$\bar{G} = 7.5\%$	
	C=0	C=6.2	C=0	C=6.2	C=0	C=13
	●	■	▲	○	□	+
I 299	170	155	175	167	170	145
II 259	160	145	170	151	160	135
III 219	150	140	170	160	155	130
IV 159	140	125	160	137	145	121
V 104	140	130	160	137	145	124
VI . 74	132	120	150	140	140	126

Value p_0

№	$G_в = 28 \div 29$ (г/с)					
	$\bar{G} = 5\%$		$\bar{G} = 18\%$		$\bar{G} = 7.5\%$	
	C=0	C=6.2	C=0	C=6.2	C=0	C=13
	●	■	▲	○	□	+
I 299	250	240	250	247	250	240
II 259	235	220	245	235	231	230
III 219	230	220	237	227	231	220
IV 159	226	220	230	220	221	220
V 104	220	210	230	217	215	215
VI 74	210	206	226	220	210	210

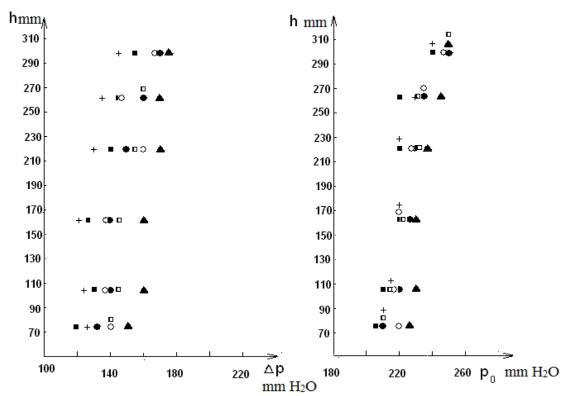

Fig. 2. The pressure distribution in the cylindrical cyclone.

Analysis of the distribution shows that the concentration of small particles that are typical for gas dedusting systems have a significant impact on the distribution of pressure, vacuum and on the axis of the absolute value decreases towards the output section of the dust, unlike vortex chambers, studied in [1]. The gradients of pressure in the axial direction of the dust-laden flow and dusty identical.

Similar distribution in the axial direction of the pressure drop. Considerable importance is the value of the exhaust air in the bypass dust precipitator. With the increase in the relative values - of exhaust dust at the bottom of the thin air on the axis increases, thinning gradients and radial gradients in the axial direction the pressure decreases. Obviously, the value of the relative velocity at the wall is dependent on the concentration of particles.

Consequently, the speed change ratio α is determined on the wall of the particle concentration.

4 Calculated values

Using (2) and (3) the following expressions can be obtained, for example, to section IV

$$\left\{\left(\frac{R_2}{r_m}\right)^{2n^{IV}} + \frac{1}{n^{IV}}\left[\left(\frac{R_2}{r_m}\right)^{2n^{IV}} - 1\right]\right\}\frac{V_{\Delta IV}^2}{2}\rho = \Delta P_{0-2}^{IV} \quad (7)$$

$$V_{\Delta IV} = V_{\Delta I}\left(\frac{R_2}{r_m}\right)^{n^I}\left(\frac{R_2}{r_m}\right)^{-n^{IV}} \quad (8)$$

The calculation of the basic values of the radii and circumferential speeds produced by the formulas (1)–(5) at $R_2/R_1 = 2.94$; $F_{in}=1.1\cdot10^{-3}$ m^2; V_{in} =15.1 m/s; ΔP_{1-2} =400 Pa; ΔP_{0-2} = 1700 Pa; for the upper part of the cyclone (section I) α= 0.88; $V_{\Delta I}$=13.2 m/s. From the second formula of (3) the method of iterations we obtain for the cross section I–I value $n^I \approx$ 0.5; value $\overline{\Delta P}_{0-2} = \dfrac{1700}{1.2\dfrac{(15.1\cdot 0.88)^2}{2}} = 16.3$; of the formula (4) we obtain $\overline{\Delta P}_{0-m} = \dfrac{n\overline{\Delta P}_{0-2}+1}{1+n} = \dfrac{0.5\cdot16.3+1}{1+0.5} = 6.1$; of the formula (5) we obtain R_2/r_m=6.1. Throughout this ratio is constant height. From (8) we obtain:

$$V_{\Delta IV} = V_{\Delta I}\left(\frac{R_2}{r_m}\right)^{n^m}\left(\frac{R_2}{r_m}\right)^{-n^{IV}} = 13.2\cdot 6.1^{0.5}\left(\frac{R_2}{r_m}\right)^{-n^{IV}} = 32.6\left(\frac{R_2}{r_m}\right)^{-n^{IV}}$$

,substituting into (7) yields:

$$\left\{(6.1)^{2n^{IV}} + \frac{1}{n^{IV}}\left[6.1^{2n^{IV}} - 1\right]\right\}(6.1)^{-2n^{IV}}\cdot 637.7\cdot 1.2 = 1400;$$

$$\left\{1 + \frac{1}{n^{IV}}\left[1-(6.1)^{-n^{IV}}\right]\right\} = 2.19.$$

Solving this relation, we obtain $n^{IV}\approx 0.75$.

5 Conclusion

Analysis of the distribution shows that the concentration of small particles that are typical for gas dedusting systems have a significant impact on the distribution of pressure and vacuum on the axis of the absolute value decreases towards the output section of the dust, unlike vortex chambers fuel combustion. Similar distribution in the axial direction of the pressure drop. These relations and the calculations correspond to the experimental data given in [5, 6].

DOI: 10.1051/matecconf/20167201122

Acknowledgments

The work was held within the research state assignment "Science" 13.1339.2014/K (Code of Federal Target Scientific and Technical Program 2.1410.2014).

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