RESEARCH OF METHODS FOR DETERMINING THE AERODYNAMIC RESISTANCE OF CYCLONE HEATERS

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The resistance of the cyclone-vortex device is an important characteristic, since this value is characterized by the blowing machine that feeds the working fluid into the vortex device, the flow rate of the working fluid, kinematic and other flow parameters. The resistance of the cyclone-vortex device is characterized by the resistance coefficient $\xi = \frac{2\Delta P}{\rho W^2}$, where W is the average flow rate at one point or another of the vortex furnace, and ρ-the flux density in the same place, ΔP - the difference between the pressure at the entrance to the cyclone-vortex furnace and at the exit from it. There are different methods for determining the drag coefficient. In [1], the resistance of the vortex chamber is estimated by the reduced coefficient of resistance:

$$\xi_{прив} = \frac{2\Delta P_{полн}}{\rho W_{прив}^2}$$

where $\Delta P_{полн}$ -measured total pressure drop in the furnace

$W_{прив} = \frac{Q}{F_ц}$ reduced air velocity related to the total cross-section of the cyclone furnace.

This approach is possible when the drag coefficient is calculated based on experiments. In theoretical terms, such a definition of the drag coefficient has no substantiation, since in the flow of an ideal fluid, the difference in total pressures in accordance with the Bernoulli equation is zero and, therefore $\xi = 0$, and hence $\Delta P_{полн} = 0$.

In addition, it remains unclear whether the total pressure at the outlet from the vortex chamber will be equal to atmospheric or to the pressure in the furnace. A picture of the air flow in the cyclone chamber is obtained: its central part is limited by the radius (the zone of "quasi-solid rotation"), where the rotation obeys the law $\frac{W_U}{r} = \omega = const$, and the peripheral part, where the rotation in its end sections can be described by the equation $W_U \cdot r = \frac{\Gamma}{2\pi} = const$, which is an expression of the law of constant circulation. Revealed the existence of a surface characterized by a zero value of excess static pressure. This surface coincides with the surface of quasi-rigid rotation. It is noted that it would be erroneous to consider the movement in a cyclone exclusively as a plane rotation, since in some areas the axial movement velocities become quite comparable with the rotational ones.

Tests have shown that the aerodynamic characteristics of the cyclone chamber are determined only by its dimensionless characteristics, and the experimental data obtained can be extended to fireboxes geometrically similar to the investigated one.

In [2], a method for calculating the drag coefficient of a cyclone is proposed, based on separate accounting for the aerodynamic drag of the air distribution and the cyclone chamber itself: $\Delta P_{ц} = \Delta P_{в} + \Delta P_{к.с.}$ where $\Delta P_{в} = \xi_{в} \frac{\rho \cdot W_{вых}^2}{2}$ - air distribution resistance equal to the pressure difference between the secondary air duct and the cyclone chamber. $\Delta P_{к.с} = \xi_{к.с.} \frac{\rho_Г W_Г^2}{2}$ - resistance of the actual combustion chamber; $\xi_{в}$ - the coefficient of resistance of the air distribution system, including the secondary air distribution box, nozzles with regulating bodies, guide vanes with channels, etc. $\xi_{к.с.}$ is the coefficient of resistance of the combustion chamber, related to the average flow rate of the combustion products, calculated from the total area of the cyclone inlet throat. The value $\xi_{в}$ it is recommended to define by blowing the model with data transfer to the field or blowing out the nature itself.

The most famous work on the study of the aerodynamic resistance of cyclone furnaces is [3], which provides an empirical dependence for determining the Euler criterion:

$$E_U = \frac{\left(\frac{77}{n_c} + 88\right) \cdot \left(1{,}28 - 0{,}28\overline{\Delta}\right) \cdot \left[66{,}7 + 2{,}67 \cdot \left(\frac{h}{в}\right)^{1{,}63}\right]}{\overline{L}^{0{,}273} \cdot \psi^{1{,}43} \cdot \left(1 + \overline{d}\right)^2} \cdot \left(\frac{1{,}9}{\sqrt[3]{\frac{T_Г}{T_{вх}}}} - 0{,}9\right)$$

As in [4], the empirical dependence obtained in this work for determining the Euler criterion is based on the flow rate in the vortex chamber, since the average flow rate is determined not by the flow area but by the area corresponding to the cyclone diameter. The applicability of this dependence is limited by the conditions of the experiment. Calculations have shown that at a heating degree of 10 or more, the Euler criterion according to dependence [2] acquires a negative value. The resistance coefficient for furnaces with constriction has negative values. This result can be explained by the definition of the Euler criterion in [3] from the difference in total inlet-outlet pressures. Therefore, one should not neglect the output speed when determining the resistance coefficient of cyclone-vortex furnaces.

A number of studies belong to EN Saburov, SV Karpov [5]. Here the authors propose to determine the resistance coefficient also by the difference in total input-output pressures, divided by the velocity head of the entrance to the vortex chamber. In [152], the results of a study on the change in the drag coefficient of cyclone chambers with a change in the Reynolds number are presented. For smooth-walled chambers, on the basis of experimental data, an empirical dependence of the form was obtained:

$$\xi = 145{,}6 f_{вх}^{1{,}531} \cdot d_{вых}^{-1{,}646} \cdot e^{-1{,}352} \cdot Re_{вх}^{n}$$

Graphic dependencies presented in the work $\xi = f(Re_{вх})$ indicate an increase in the drag coefficient with an increase in the Reynolds number for smooth-walled chambers and its decrease for rough chambers. The same chambers, differing only in the magnitude of the constriction at the same Reynolds numbers, have different values of the resistance coefficients, which raises doubts about the legality of determining the Reynolds number from the velocity at the inlet and the diameter of the cyclone furnace.

The most characteristic works based on the laws of hydrodynamics are the works of M.A. Goldshtik. In [6], an objective physical model of the flow in a vortex furnace with the presence of an internal central vortex is considered. The flow in the vortex chamber is conventionally divided along the radius of the chamber into 3 zones. For zone 2, the total pressure in the section is determined and then the resistance coefficient is determined.

It should be noted that the obtained dependences refer to an ideal fluid. In reality, the flow is characterized by viscosity, therefore, to calculate cyclone-vortex furnaces in real conditions, dependencies should be obtained taking into account the reality of the process.

The quantity $\Psi_{пр}$ proportional to the ratio of the total moment of momentum to the moment of momentum at the entrance to the cyclone. The dependency is obtained here

$$\xi_{вх} = f\left(\Psi_{пр}, \frac{d_n}{Д_ц}\right); \; \xi_{вх} = A\Psi_{пр}^{n}\left(\frac{d_n}{Д_ц}\right)$$

Using the energy equation written in the form of the Bernouli equation, the equation of conservation of angular momentum and the equation of conservation of mass (continuity), the author of [7] managed to obtain an analytical expression for calculating the drag coefficient of a single-chamber cyclone furnace in an isothermal flow in the following form:

$$\xi = \left[\frac{\frac{R_0}{R_\Pi}}{\varphi_0 \frac{R_\Pi}{R_Ц} \left(1 - \frac{\Sigma f}{\pi R_0 R_\Pi} \cdot \frac{1}{4 tg \alpha_1} \cdot \frac{1}{\varepsilon} \right) \cos \alpha_1} \right]^2,$$

where φ_0 - coefficient of speed loss in inlet pipes; ε - coefficient of reduction of the initial moment of the amount of motion.

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FEATURES OF THE USE OF ALTERNATIVE ENERGY SOURCES IN UKRAINE

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This topic is extremely relevant. Thanks to alternative energy sources, businesses are becoming more competitive. This is due to reduced emissions and using of traditional fuels and rejection of toxic materials.

Alternative energy, enlarge on the use of unbounded energy sources, can go a ‘key’, which will discover the door to freedom in two sectors: fuel and gas. The Law of Ukraine "On Alternative Energy Sources" sets out the basic principles of state policy in the field of alternative energy sources, public administration in this area, stimulating the production and consumption of energy produced from alternative sources, sets "green" tariffs for all types of energy and state guarantees for entities that use alternative sources for production [1].