

Article

Mathematical Description of the Aerodynamic Characteristics of Stationary Flows in a Vertical Conical Diffuser When Air Is Supplied through Various Tube Configurations

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Abstract: Conical diffusers of various configurations are used in many kinds of technical equipment and manufacturing processes. Therefore, it is a relevant objective to obtain reliable experimental and mathematical data on the aerodynamic characteristics of diffusers. This article presents experimental data on the aerodynamics of stationary flows in a vertical conical diffuser when air is supplied through tubes with various cross sections (circle, square, and triangle). Instantaneous values of air flow velocity are measured with a constant-temperature hot-wire anemometer. Data are obtained on the velocity fields and turbulence intensity along the height and the diameter of the diffuser's cylindrical part when air is supplied through tubes of various configurations. It is established that air supply through profiled tubes has a significant effect on the shape of the velocity field and turbulence intensity in a vertical conical diffuser. For example, higher values of turbulence intensity are typical of air supplied through profiled tubes (the differences reach 50%). A mathematical formulation (linear and exponential equations) of the change in the average speed and intensity of air flow turbulence along the height of the diffuser's cylindrical part for various initial conditions and supply tube configurations is presented. The obtained findings will make it possible to refine mathematical models and update algorithms for engineering the design of diffusers for various engineering processes and pieces of technical equipment.



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1. Introduction

In almost all branches of technology, equipment is used in which the main engineering process is associated with the movement of either liquid or gas. Examples of such equipment are heat exchangers, gas cleaning units, boilers, chemical equipment, industrial furnaces, various types of dryers, ventilation devices, and nozzle systems. Almost all these devices have a working chamber or supply channels with a conical diffuser [1]. The operation of these devices has shown that their calculated efficiency cannot be always achieved [2]. In many cases, this is due to the uneven supply of the working medium to the equipment's working area and, therefore, the flow's physical features in the diffuser and corresponding gas-dynamic losses [3,4]. All this testifies to the importance of studying the aerodynamics of process units with conical diffusers from the point of view of gas-dynamic improvement and finding ways to control flow characteristics. Moreover, it is necessary to obtain reliable experimental data on the features of gas flow dynamics and their mathematical formulation in order to improve engineering methods for calculating conical diffusers and to refine mathematical models [5,6].

Presented below is a brief review of classical (fundamental) research and updated knowledge of aerodynamic characteristics in a conical diffuser.

There are basic studies on the gas dynamics of flows in conical diffusers for various designs and at various initial levels of turbulence intensity. For example, A. Klein conducted

experiments and examined experimental data on the influence of inlet conditions on conical diffuser characteristics [7]. In particular, the article describes the effects of blocking the thickness of the inlet boundary layer for various forms of inlet flow, turbulence intensity, and Reynolds numbers. K. Jeyachandran and V. Ganesan studied the effect of various gas-dynamic conditions at the diffuser inlet with physical and mathematical modelling [8]. The paper presents an analysis of data on the velocity profiles, pulse power, shape factor, performance, and efficiency of the studied diffusers. P. A. C. Okwuobi and R. S. Azad experimentally studied the flow structure and turbulence characteristics in a conical diffuser with a fully developed inlet flow [9]. As a result, the basic physical laws were established, and recommendations for the design of conical diffusers were formulated [7–9].

There are modern studies of the gas-dynamic characteristics of gas flows in various diffuser configurations aimed at clarifying calculation methods, supplementing the knowledge base about the relevant physical mechanisms, and creating original mathematical models [10–13]. A. Ferrari proposed analytical dependencies that complement the Fanno models relating to viscous adiabatic flow in a pipe with a constant cross section and an inviscid adiabatic flow in a conical diffuser [10]. These new dependences expand the set of exact solutions of gas dynamics and improve the quality of mathematical models. J. Lee and co-authors investigated the features of turbulence and coherent structures in gas flow through a conical diffuser with various opening angles (2° , 4° , and 8°) based on numerical simulation [11]. The data obtained made it possible to refine the physical features of the gas dynamics of stationary flows in diffusers. X. Wu et al. discovered an internal layer in the gas flow through an asymmetric flat diffuser based on physical and mathematical modelling [12]. Other research will improve the engineering design methods for diffusers. Using numerical simulation, F. J. De Souza and co-authors investigated the gas dynamics of an air flow with various particles in a vertical conical diffuser [13]. It was found that even a small number of particles significantly affects the flow's shape in a diffuser; the flow can stick to the wall under certain conditions.

There is a large amount of applied research on the use of diffusers in various kinds of technical equipment. For example, diffusers are actively used in the organic Rankine cycle [14–18]. In this cycle, the key device is a turbo expander equipped with an outlet diffuser to increase pressure recovery and improve turbine efficiency. A. Zou et al. optimised the diffuser design for a specific turbine based on numerical simulation [14]. B. Dong et al. evaluated the influence of gas parameters at the diffuser inlet on its gas-dynamic characteristics (in particular, the velocity coefficient) with mathematical modelling [15]. C. S. From et al. studied the influence of flow turbulence intensity at the diffuser inlet on gas dynamics and its influence on the performance of a particular turbine [17]. J. A. Keep and co-authors studied the geometry of a combined (annular–radial) diffuser in relation to the gas-dynamic characteristics of flows and turbine efficiency in the Rankine cycle [18].

Diffuser channels are actively used and studied in many other technical applications. For example, it is relevant to optimise the shape and parameters of flows in a diffuser for a mixing chamber in ejectors [19,20], to fine-tune supersonic diffusers [21], to estimate parameters in diffusers for aircraft gas turbine engines [22], to introduce a diffuser into a reactor for ammonia oxidation [23], and to model and improve the aerodynamics of diffusers in a tubular reactor [24] or an industrial furnace [25].

Thus, the performed review showed that the study of gas-dynamic effects in a conical diffuser is an urgent task at present. This is due to the wide range of applications of diffusers in various technical applications such as: the Rankine cycle, gas and steam turbines, mixing chambers, ammonia oxidation reactors, syngas production plants, industrial furnaces, and others.

Based on an analysis of the data of other authors, the following conclusions can be drawn:

- Gas-dynamic improvement and the development of ways to control the gas dynamics of flows in a conical diffuser remain urgent tasks for fundamental and applied science;

- Recent research into the gas-dynamic characteristics of flows in conical diffusers is carried out mainly through numerical simulation;
- There is a lack of reliable experimental data (and their mathematical description) on the gas-dynamic characteristics of flows in a vertical conical diffuser for mathematical model verification.

Consequently, this research’s key objectives are as follows:

- To develop an experimental set-up for studying stationary flows in a vertical conical diffuser when air is supplied through tubes with various cross sections;
- To choose measuring instruments and research methods taking into account the physical features of the processes under research;
- To obtain data on the instantaneous values of the air flow velocity along the height and diameter of the diffuser’s cylindrical part for various initial conditions;
- To establish the evolution of the velocity fields along the height of the diffuser’s cylindrical part for various configurations of the supply tubes;
- To empirically determine the value of the drop in the average velocity along the height of the diffuser and provide a mathematical description of that process;
- To establish and mathematically describe the patterns of changes in the intensity of turbulence along the height of the conical diffuser under various initial conditions.

2. Description of the Experimental Measurement Facility

The aerodynamics of stationary flows in a vertical diffuser were studied using a laboratory set-up, the main elements of which are shown in Figure 1.

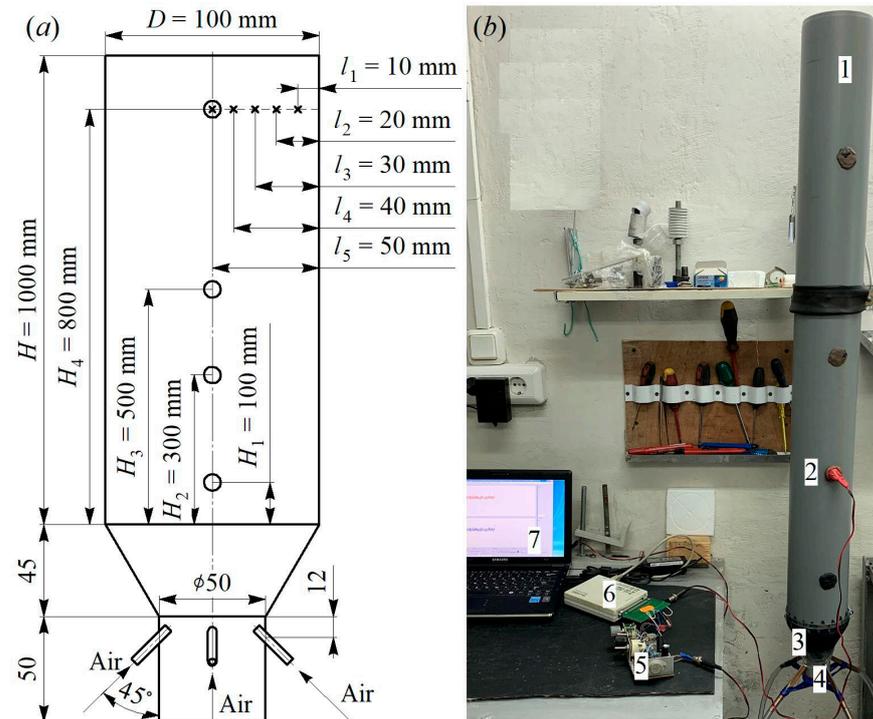


Figure 1. Size dimensions (a) and photograph (b) of the experimental set-up for studying the aerodynamic characteristics of flows in a vertical diffuser: 1—cylindrical part of the set-up; 2—hot-wire anemometer sensor; 3—diffuser; 4—base with supply tubes; 5—hot-wire anemometer for measuring instantaneous values of flow velocity; 6—analogue-to-digital converter; 7—laptop for collecting and processing experimental findings; $H, H_1 \dots H_4$ —height of the cylindrical part in the diffuser; $l_1 \dots l_4$ —linear dimension along the diameter of the cylindrical part of the diffuser.

The main purpose of the installation was to ensure the gas-dynamic characteristics of the air flow remained as similar as possible to real processes in such technical devices. The

conical diffuser consisted of three main elements: (1) a base with a diameter of 50 mm, in which four supply tubes were installed at an angle of 45° ; (2) a tapered section with a ratio of 1:2 (50 mm by 100 mm); and (3) a cylindrical section with a diameter of 100 mm and a height of 1000 mm. This configuration of the diffuser is used in installations for synthesis gas production. There were four control sections along the height of the diffuser at heights of 100 mm, 300 mm, 500 mm, and 800 mm. In each control section, measurements of the instantaneous values of the air flow velocity along the diameter of the cylindrical part at distances of 10 mm, 20 mm, 30 mm, 40 mm, and 50 mm (in the centre of the diffuser) were made. Measurements of instantaneous velocity values were carried out for 5–10 s for each location of the hot-wire anemometer sensor (primary data). Further processing was carried out in a specialized program (final data).

The working medium in the experiments was air with a temperature of $t = 20\text{--}22^\circ\text{C}$ and a barometric pressure of $p_o = 0.1013\text{ mPa}$. The typical measurement in this work was taken in the control section at a height of 100 mm and the centre of the cylindrical part of the diffuser (at a distance of 50 mm). During the experiments, the average air flow velocity in the typical section varied from 4 m/s to 8 m/s ($26,500 < Re < 53,500$). Therefore, the flow pattern in this study was developed and turbulent.

The automated measurement system consisted of a hot-wire anemometer with sensors, an analogue-to-digital converter, and a laptop with software. Measurements of the instantaneous values of the air flow velocity w_x with a hot-wire anemometer at a constant temperature were made. A nichrome filament with a diameter of $5\ \mu\text{m}$ and a length of 4 mm was used as the sensitive element of the hot-wire anemometer sensor. Five sensors with thread at distances of 10, 20, 30, 40, and 50 mm were made. The data from the hot-wire anemometer (output signal from 0 to 5 V) were received by an analogue-to-digital converter, and then they were transferred to a laptop for processing with custom-made software. The standard relative uncertainty of air flow measurement was 3.6%. The measuring system and the features of its functioning are described in more detail in articles [26,27].

The average flow velocity w at the measuring point was determined as the mathematical expectation of the function $w_x = f(\tau)$. One of the key aerodynamic characteristics of diffuser flows is the turbulence intensity TI. In this research, TI was calculated as the ratio of the root-mean-square pulsation velocity component to the average velocity of the flow under study [27].

The cross-sectional shape of pipelines has a significant effect on the structure of the flow in them [2,28,29]. Therefore, in this study, air entered the vertical diffuser through supply tubes with various cross-sectional shapes (Figure 2).

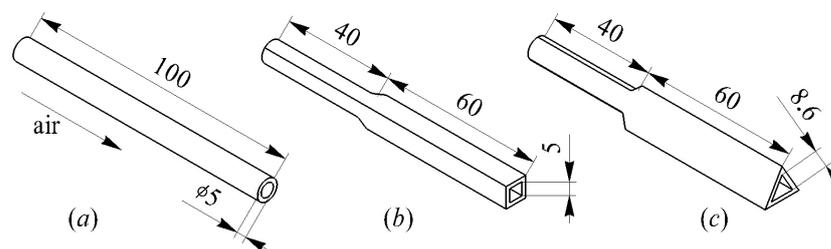


Figure 2. Plan view and key dimensions of the tubes for supplying air to the vertical diffuser: (a)—circular tube; (b)—tube with square cross section; (c)—tube with triangular cross section.

The size dimensions of the supply tubes' cross sections were determined based on the equality of the equivalent hydraulic diameters. Consequently, the round tubes had a diameter of $d = 5\text{ mm}$, the side of the square tubes was also 5 mm, and the side of the tubes with triangular cross sections was 8.6 mm.

3. Results and Analysis of Experimental Findings

Figure 3 shows the primary data as a function $w_x = f(\tau)$ for the sensor in the first section ($H_1 = 100\text{ mm}$) in the centre of the diffuser's cylindrical part ($l_5 = 50\text{ mm}$) when air

is supplied through various tube configurations. The data are selected so that the average speed in the first section is approximately the same for all the data presented and is about 4.5 m/s.

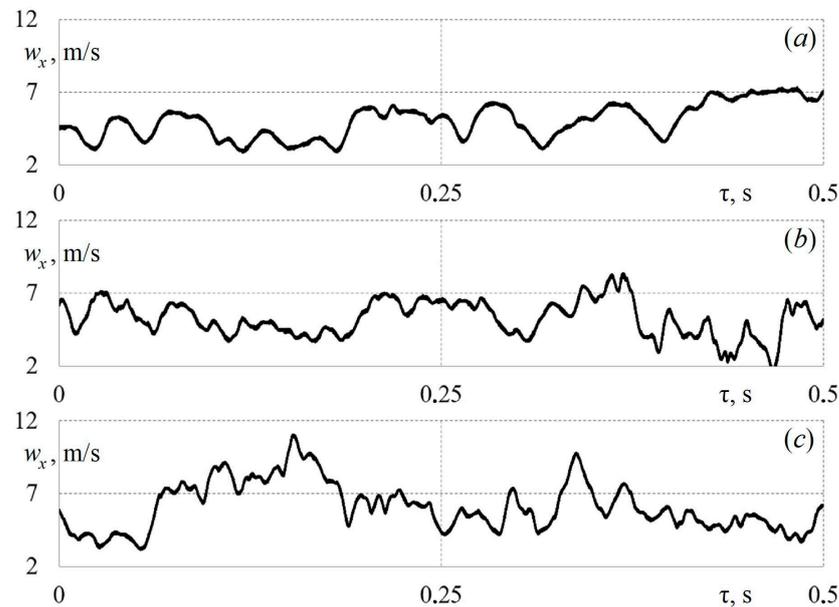


Figure 3. Dependences of local values of air flow velocity w_x on time τ in the first control section ($H_1 = 100$ mm) for a sensor in the centre of the installation ($l_5 = 50$ mm) for supply tube configurations: (a)—round tube (average parameters in cross section: $w_1 = 4.2$ m/s, TI = 0.231); (b)—square tube ($w_1 = 4.45$ m/s, TI = 0.18); (c)—triangular tube ($w_1 = 4.48$ m/s, TI = 0.285).

Figure 3 shows that the function $w_x = f(\tau)$ is white noise for all supply tube configurations. At the same time, visual observations show that the use of profiled tubes leads to the creation of small fluctuations in the $w_x = f(\tau)$ function. This can also be confirmed by the calculated data: TI for round tubes is 0.231 and 0.285 for triangular tubes (almost a 20% difference). This is due to the fact that stable and vortex structures are created in the corners of the profiled tubes, which turbulise the flow in the diffuser. Similar gas-dynamic effects were discovered in [28,29]. It is inappropriate to describe the presented dependencies mathematically, as those data are special cases.

Figure 4 also shows the primary data as the $w_x = f(\tau)$ function, but for the sensor in the third section ($H_3 = 300$ mm) in the centre of the diffuser's cylindrical part ($l_5 = 50$ mm) when air is supplied through tube configurations. Based on a comparison of the functions $w_x = f(\tau)$ in Figures 3 and 4, it is found that there is a significant decrease in small fluctuations in velocity upstream. This indicates a gradual relaxation of the flow along the height of the diffuser's cylindrical part.

Next, the data in each control section were averaged over the diffuser's height and diameter. As a result, the velocity fields in the diffuser's cylindrical part were obtained when air was supplied through tubes with various cross sections (Figures 5–7).

Figure 5 shows that there is a decrease in the average flow velocity along the height of the diffuser's cylindrical part (air supply through round tubes). A change in the velocity field's shape in the upward flow direction is also observed. Similar results in the case of air supply through profiled tubes were obtained (Figures 6 and 7). There is also a drop in velocity with the diffuser's height. When air is supplied through triangular tubes, the velocity fields are somewhat different from those in other configurations. This may be due to the influence of the vortex structures that are created at the corners of the triangular tubes.

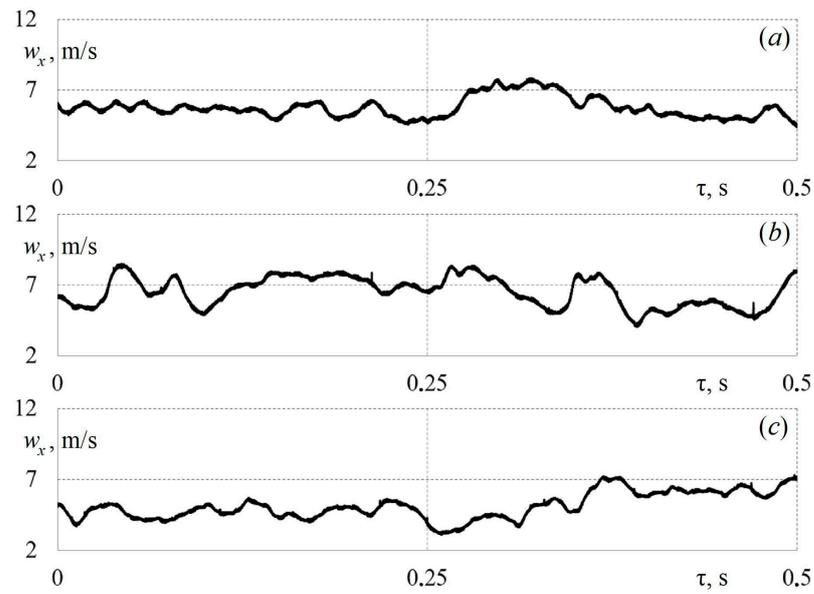


Figure 4. Dependences of local values of air flow velocity w_x on time τ in the third control section ($H_3 = 500$ mm) for a sensor in the centre of the set-up ($l_5 = 50$ mm) for various supply tube configurations: (a)—round tube (average parameters in the section: $w_3 = 4.81$ m/s, TI = 0.124); (b)—square tube ($w_3 = 4.85$ m/s, TI = 0.313); (c)—triangular tube ($w_3 = 4.79$ m/s, TI = 0.199).

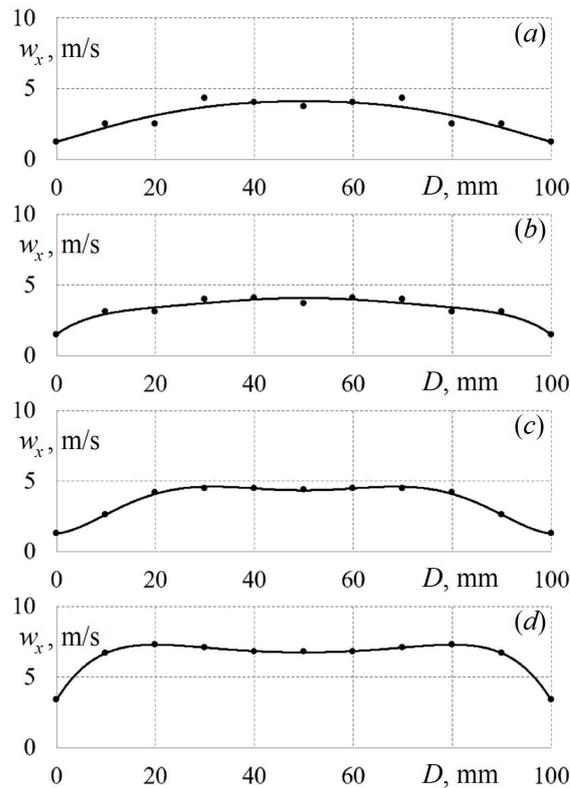


Figure 5. Change in local values of the flow velocity w_x along the cylinder diameter D when air is supplied to the diffuser through round tubes for the initial average flow velocity in the first section $w_1 \approx 6.31$ m/s along the set-up height: (a)— $H_4 = 800$ mm; (b)— $H_3 = 500$ mm; (c)— $H_2 = 300$ mm; (d)— $H_1 = 100$ mm.

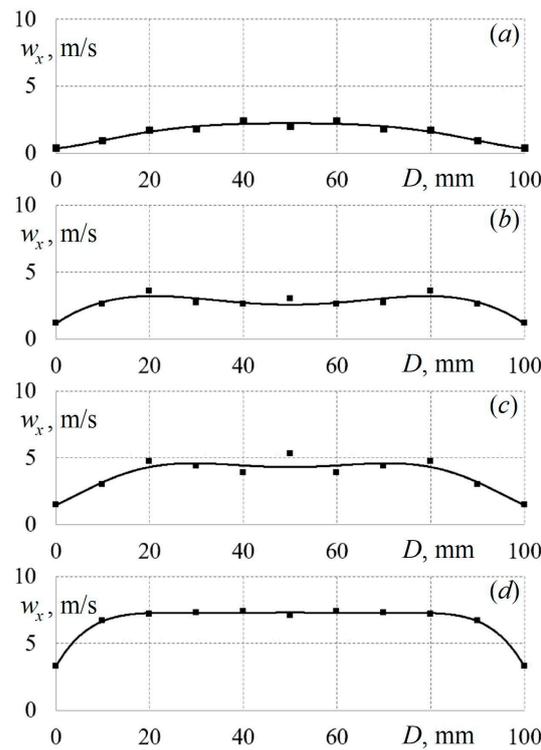


Figure 6. Change in local values of the flow velocity w_x along the cylinder diameter D when air is supplied to the diffuser through square tubes for the initial average flow velocity in the first section $w_1 \approx 6.45$ m/s along the set-up height: (a)— $H_4 = 800$ mm; (b)— $H_3 = 500$ mm; (c)— $H_2 = 300$ mm; (d)— $H_1 = 100$ mm.

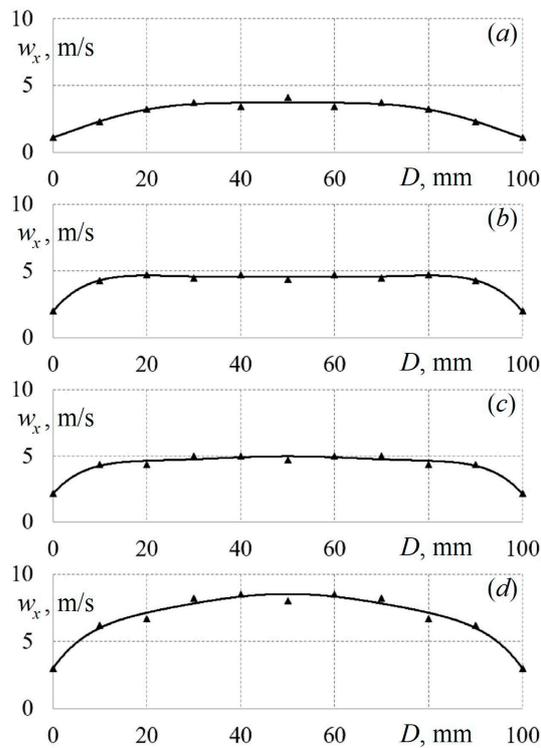


Figure 7. Change in local values of the flow velocity w_x along the cylinder diameter D when air is supplied to the diffuser through triangular tubes for the initial average flow velocity in the first section $w_1 \approx 6.65$ m/s along the set-up height: (a)— $H_4 = 800$ mm; (b)— $H_3 = 500$ mm; (c)— $H_2 = 300$ mm; (d)— $H_1 = 100$ mm.

The detected gas-dynamic effects are preserved for all initial air supply velocities under study and for all configurations of supply tubes. Accordingly, it can be assumed that there is a need for a mathematical formulation of the integral aerodynamic characteristics of flows for the studied configurations of a vertical conical diffuser. These data will make it possible to refine mathematical models and algorithms for the design of diffusers for various pieces of technical equipment.

The velocity fields are a clear illustration of the features of the gas dynamics of flows for different ways of supplying air to the diffuser. The analysis of the velocity field makes it possible to determine the gas-dynamic structure of the flow and draw a conclusion about the behaviour of the working medium in a potential technical device.

Figure 8 shows examples of changes in the turbulence intensity TI along the diameter of the diffuser's cylindrical part in the first section when air is supplied through tubes of various configurations.

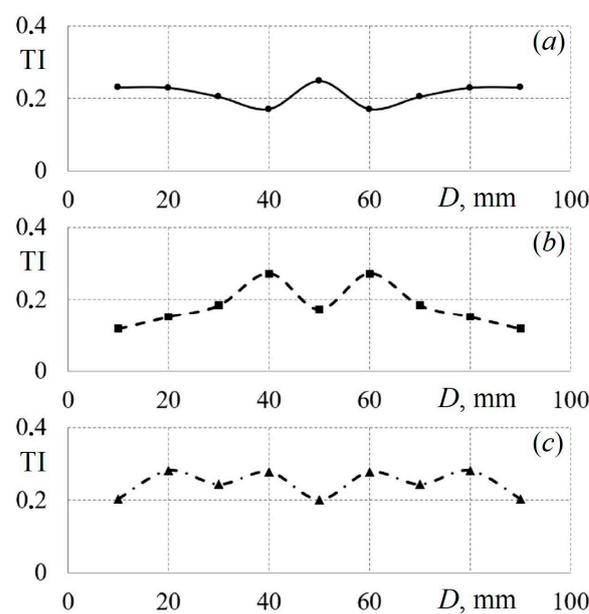


Figure 8. Change in turbulence intensity TI (in the first section $H_1 = 100$ mm) along the cylinder diameter D when air is supplied to the diffuser through tubes of various configurations: (a)—round tube ($w_1 \approx 6.65$ m/s, $TI_1 = 0.213$); (b)—square tube ($w_1 \approx 6.45$ m/s, $TI_1 = 0.180$); (c)—triangular tube ($w_1 \approx 6.65$ m/s, $TI_1 = 0.245$).

From Figure 8 and the entire array of data obtained, we can draw the following conclusions:

- No clear patterns in the change in TI along the diameter of the diffuser's cylindrical part were found;
- The influence of the tubes' cross-sectional shape on the function $TI = f(D)$ has not been established (according to the author, the changes are random);
- The amplitude of the fluctuations of turbulence intensity values relative to the average value is $\pm 35\%$;
- The mathematical formulation of the function $TI = f(D)$ for the cases under study is inappropriate until the physical laws are established.

Data on the turbulence intensity are important for practical applications, as the TI determines the efficiency of mixing of various media, the level of pulsation of the working medium in the flow, the duration of the working medium in the diffuser, and more.

Figure 9 shows the regularities of the drop in the average velocity in the control section along the height of the diffuser's cylindrical part when air is supplied through tubes with various cross sections for various initial flow rates.

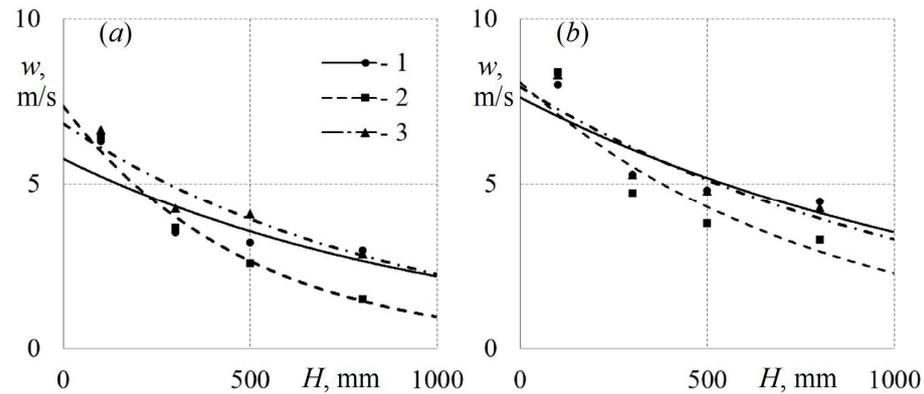


Figure 9. Dependences of the average air flow rate w along the installation height H when air is supplied through round (1), square (2), and triangular (3) tubes for the initial average flow rate in the first section: (a)— $w_1 \approx 6.5$ m/s; (b)— $w_1 \approx 8.25$ m/s.

The patterns of speed reduction in the upward flow direction are described with sufficient accuracy by the exponential dependence $w = a \cdot e^{-b \cdot H}$. At the same time, the shape of the tube cross section does not actually affect the intensity of the drop in the air flow velocity along the set-up’s height.

For example, the mathematical description of the change in the average air flow velocity along the height of the diffuser’s cylindrical part, when air is supplied through round tubes with an initial velocity $w_1 \approx 6.5$ m/s, is described by the following equation (approximation reliability 0.85):

$$w = 5.7e^{-0.0001 \cdot H}. \tag{1}$$

Similar relationships for air supply through square and triangular tubes are described by the following equation ($w_1 \approx 6.5$ m/s, approximation reliability 0.92):

$$w = 7.1e^{-0.00015 \cdot H}. \tag{2}$$

The mathematical description of the change in the average air flow rate along the height of the diffuser’s cylindrical part, when air is supplied through round and triangular tubes in the case of an increase in the initial flow rate to $w_1 \approx 8.25$ m/s, is described by the following equation (approximation reliability 0.83):

$$w = 7.7e^{-0.00085 \cdot H}. \tag{3}$$

Similar dependencies for air supply through square tubes are as follows ($w_1 \approx 8.25$ m/s, approximation reliability 0.86):

$$w = 8.0e^{-0.001 \cdot H}. \tag{4}$$

The proposed Equations (1)–(4) for describing the regularities of the average velocity drop in the control section along the height of the diffuser’s cylindrical part when air is supplied through tubes with various configurations are applicable for the indicated velocities and a set-up height of up to 1000 mm.

Figure 10 shows the dependences of the change in the turbulence intensity TI on the value of the average air flow velocity w in the control sections at distances of 100 mm and 800 mm. There is a decrease in TI with an increase in the initial air flow velocity, and this decrease in TI is well described by linear equations. At the same time, the intensity of turbulence has higher values when air is supplied through profiled tubes compared to round tubes. This is also explained by the turbulence of the flow due to the vortex structures typical of profiled channels.

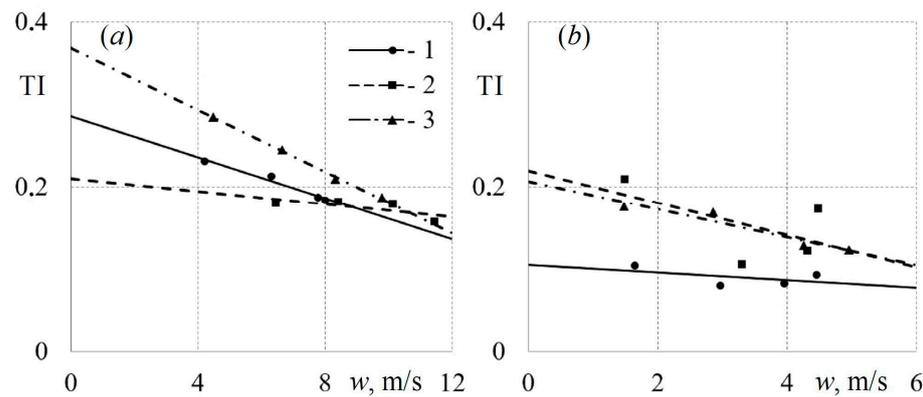


Figure 10. Dependences of the turbulence intensity TI on the average air flow velocity w when air is supplied through round (1), square (2), and triangular (3) tubes for various control sections: (a)—control section at the height of $H_1 = 100$ mm; (b)— $H_4 = 800$ mm.

The mathematical description of the function $TI = f(w)$ for the first section ($H_1 = 100$ mm) when air is supplied through round (5), square (6), and triangular (7) tubes has the following form (approximation reliability not less than 0.89):

$$TI = -0.125 \cdot w + 0.286. \tag{5}$$

$$TI = -0.0038 \cdot w + 0.21. \tag{6}$$

$$TI = -0.0188 \cdot w + 0.369. \tag{7}$$

The similar mathematical descriptions of the function $TI = f(w)$ for the fourth section ($H_4 = 800$ mm) when air is supplied through round (8), square (9), and triangular (10) tubes have the forms (approximation reliability not less than 0.92):

$$TI = -0.0047 \cdot w + 0.105. \tag{8}$$

$$TI = -0.0196 \cdot w + 0.219. \tag{9}$$

$$TI = -0.017 \cdot w + 0.207. \tag{10}$$

The proposed equations for describing the patterns of change in the intensity of turbulence from the average air flow velocity along the height of the diffuser’s cylindrical part are applicable for an initial velocity range from 1 to 12 m/s and a set-up height of up to 1000 mm.

The experimental data and proposed description equations can be used to verify mathematical models for modelling aerodynamic processes in a vertical conical diffuser.

Figure 11 shows the experimental dependences of the intensity of turbulence on the height of the diffuser’s cylindrical part for various initial flow velocities when air is supplied through tubes with various cross sections. The distribution of turbulence intensity along the height of the diffuser is important for the design of mixing chambers, industrial furnaces, and synthesis gas plants. Engineers need data on the level of pulsations in the installation to evaluate the efficiency and stability of operation.

Based on the analysis of the $TI = f(H)$ functions, the following conclusions can be drawn:

- The tubes’ cross-sectional shape has a significant effect on turbulence intensity along the height of the vertical diffuser’s cylindrical part;
- The dependency $TI = f(H)$ has a pronounced maximum in the region of $H = 300$ mm, which is typical of all initial average flow rates and all configurations of the supply tubes;

- The turbulence intensity has significantly higher values (up to 50%) when air is supplied through profiled tubes compared to round tubes, which is especially typical of a low initial w .

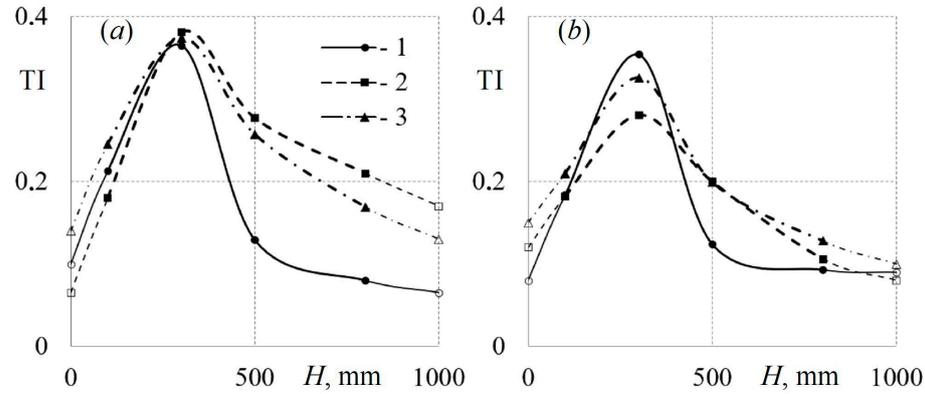


Figure 11. Dependences of the intensity of turbulence TI on the height of the diffuser H when air is supplied through round (1), square (2), and triangular (3) tubes for the initial average flow velocity in the first section: (a)— $w_1 \approx 6.5$ m/s; (b)— $w_1 \approx 8.25$ m/s.

For the convenience of the mathematical description of the experimental data, it is advisable to divide the $TI = f(H)$ function into two sections: (1) the first section for a height from 0 to 300 mm (section of the growth of turbulence intensity) and (2) the second section for $H = 300\text{--}1000$ mm (TI decline section). For the first section ($H = 0\text{--}300$ mm), the $TI = f(H)$ function for all tube configurations can be described by a linear equation with an approximation confidence of 0.94 (Figure 11a):

$$TI = 0.00085 \cdot H + 0.1. \tag{11}$$

Consequently, for the second section ($H = 300\text{--}1000$ mm), the $TI = f(H)$ function can be described by exponential equations for round (12), square (13), and triangular (14) tubes with an approximation confidence of 0.98 (Figure 11a):

$$TI = 0.254e^{-0.001 \cdot H}. \tag{12}$$

$$TI = 0.452e^{-0.0003 \cdot H}. \tag{13}$$

$$TI = 0.507e^{-0.001 \cdot H}. \tag{14}$$

The proposed equations for describing the patterns of changes in the intensity of turbulence along the height of the diffuser’s cylindrical part when air is supplied through tubes with various configurations are applicable for an initial velocity range from 1 to 12 m/s and a set-up height of up to 1000 mm.

It should be noted that all the above formulas are valid only for the studied configuration of the experimental set-up and the initial conditions of air flow. It is necessary to additionally clarify the regularities of changes in the physical characteristics of the flow in the case of a change in geometry or gas-dynamic parameters.

Thus, the aerodynamic characteristics of flows in a vertical conical diffuser can be approximated by relatively simple mathematical expressions that are convenient to use in engineering design.

4. Conclusions

Based on the conducted experimental studies, the following main conclusions can be drawn:

1. Experimental data on the instantaneous values of the stationary flow velocity along the height and diameter of the diffuser's cylindrical part for various initial conditions and when air is supplied through tubes with different configurations are obtained.
2. The velocity fields along the height of the diffuser's cylindrical part for various initial conditions when air is supplied through tubes with cross sections in the form of a circle, a square, and a triangle are determined. The evolution of the velocity fields in the upward flow direction is shown.
3. The flow's turbulence intensity TI along the height and diameter of the diffuser is calculated for various initial conditions and when air is supplied through tubes with various configurations.
4. A mathematical description (exponential equations) of the change in the average flow velocity along the height of the diffuser's cylindrical part for various initial conditions and configurations of the supply tubes is presented.
5. The regularities of changes in the intensity of turbulence along the height of the diffuser for various initial conditions and tube configurations are established.
6. The obtained data on the aerodynamic characteristics of flows in a conical diffuser can be useful for refining and verifying mathematical models and improving engineering calculations.
7. Further research could be conducted to obtain dimensionless equations for describing the aerodynamic characteristics of flows in vertical diffusers of various designs, as well as to refine mathematical models for modelling aerodynamics.

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Conflicts of Interest: The author declares no conflict of interest.

Nomenclature

w_x	local air flow velocity, m/s
w	average flow velocity, m/s
τ	time, s
p_o	barometric pressure, kPa
t	temperature, °C
(d)	diameter, mm
l	linear dimension, mm
H	height, mm
Re	Reynolds number
TI	turbulence intensity

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