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COMPARATIVE EVALUATION OF THE EFFICIENCY OF THE RING-TYPE AND BUCKET INLET DEVICES FOR A POWER PLANT WITH A TURBOPROPFAN ENGINE

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The increase in losses in the inlet device leads to an increase in specific fuel consumption. When integrating the inlet device and the propeller or propfan, it is necessary to take into consideration their interaction to ensure the maximum efficiency of the power plant. The object of this study is a coaxial propfan with the channel of the inlet device. The results reported here are of practical value: a methodology for designing a bucket S-shaped channel of the inlet device of a power plant with a turboprop engine has been developed. The dependence of the coefficient of preservation of the total pressure of the inlet device on the height and speed of flight was obtained, which makes it possible to take into consideration the influence of the propfan of a turboprop engine. A comparison of the characteristics of the ring-type and bucket S-shaped channel of the inlet device of the power plant with the turboprop engine was carried out. Specifically, it was found that the change in flight conditions has a less significant effect on the change in the coefficient of preservation of the total pressureof the ring-typeinlet device than the bucket one. A comparative assessment of the obtained results of mathematical modeling of the flow in the bucket S-shaped channel of the inlet device, taking into account the influence of the propfan, with the results of flight tests of the ring-type inlet device of the prototype is given. The comparative evaluation shows that the use of a bucket inlet device, instead of a ring-type inlet device, makes it possible to increase the full pressure recovery factor by 5–7 %. Thus, there is reason to argue that replacing the ring-type with a bucket inlet device will minimize hydraulic losses at the inlet to the engine and reduce the uneven flow at the inlet. That, in turn, will improve engine efficiency

Keywords: bucket inlet device, ring-typeinlet device, propfan, turboprop engine, procedure

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1. Introduction

Turboprop and propfan engines with the ring-type and bucket shapes of the inlet device are known in the world; it is located directly behind the propeller and provides air supply to the engine compressor with minimal losses.

It should be noted that the specific fuel consumption of an aviation gas turbine engine (GTE) depends, among other things, on the loss of total air pressure in the inlet device. The pressure in the area behind the propeller varies along its diameter. Moreover, in the root of the propeller, due to perturbations introduced by the root part of the blades, the pressure is the lowest and can lead to a separation of the flow in front of the ring-type inlet device, as well as increase its hydraulic losses.

When using a ring-type inlet device, the air is supplied to the channel from the zone located directly behind the root edge of the blades. This is the main factor affecting the loss of air pressure in the air supply channel.

Reducing the loss of total pressure in the inlet device in front of the compressor is one of the urgent tasks because the increase in losses in the inlet device leads to an increase in the specific fuel consumption. In addition, the uneven flow at the inlet to the engine is the cause of the unstable operation of the compressor of aviation GTE.

For example, [1], under the mode of maximum flight duration of the power plant, a decrease in the coefficient of recovery of the full pressure in the inlet device by 1 % leads to an increase in the specific fuel consumption by 0.6 % and a decrease in engine thrust by 1.2 %.

That is why it is relevant to study measures to improve the efficiency of the subsonic inlet device of the power plant with a turboprop engine.

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2. Literature review and problem statement

When analyzing the operation of turboprop or propfan engines, it is important to take into consideration the effect of the propeller or propfan on the inlet device. This is because the aerodynamic trace of the propeller adversely affects the efficiency of the power plant. The reason for this effect is the uneven flow in front of the inlet device. In addition, the back pressure between the propeller blades and the inlet device affects the level of tension in the blade [2].

In [3], results of the preliminary design and optimization of the system including the air intake and engine nacelle are reported. The work was carried out as part of the process of integrating the turboprop engine on a small aircraft. The pre-design process is carried out using an interactive parametric approach to design. The parametric model of the aircraft is built using authentic PARADES software. However, to develop a technical project for integrating a real aircraft with a turboprop engine, it is necessary to carry out work to improve and optimize the inlet device.

In [4], it is shown that the use of an *S*-shaped inlet device makes it possible to increase the compactness of the power plant, reduce drag, and improve the visibility characteristics of the aircraft. However, the presence of curvature of the axial line of the *S*-shaped inlet device, which contributes to the formation of a pair of vortices that rotate in opposite directions, causes a longitudinal separation of the flow and reduces the coefficient of recovery of the total pressure. In the cited work, the inlet device is investigated by solving the Reynolds-averaged Navier-Stokes equations using the SST k-ω turbulence model. It is shown that the coefficient of recovery of the full pressure at the outlet of the inlet device changes periodically. The effect of the propeller on the flow in the *S*-shaped inlet device causes circular and longitudinal unevenness. Circular unevenness mainly affects the secondary flow in the *S*-shaped inlet device, and longitudinal unevenness contributes to the longitudinal separation of the flow in the *S*-shaped inlet device and then affects the coefficient of recovery of the total pressure. The coefficient of recovery of full pressure at the outlet of an *S*-shaped inlet device with an air propeller is 1–2.5 % higher than that of an *S*-shaped inlet device without an air propeller. The coefficient of the unevenness of the total pressure at the outlet of the *S*-shaped inlet device with an air propeller is 1–12 % higher than that of an *S*-shaped inlet device without an air propeller. However, the authors considered only the operating modes of the engine at an altitude of 6000 m.

In [5], an attempt was made to improve the flow field in the *S*-shaped inlet device of the turboprop engine through the use of vortex generators. However, the use of vortex generators greatly complicates the design of the inlet device. However, under some operating modes, they can significantly increase the level of uneven flow at the inlet, which will lead to a deterioration in engine operation.

The methodology of multicriterial optimization of the inlet device, which is part of the intake system of the turboprop engine, is considered in work [6]. The proposed methodology combines and expands existing methods to effectively optimize real engineering tasks. The purpose of optimization was to reduce the loss of total pressure and reduce the uneven flow at the inlet to the engine.

The study reported in [7] focused on improving the process of optimizing the aerodynamic shape of the small aircraft engine intake system. Optimization using a multicriterial model is carried out to reduce the loss of full pressure along the motor path and increase the uniformity of the flow in the plane at the inlet to the compressor. The Latin Hypercube Design method is used to sample the design space. The cited paper describes the application of the above procedure to the design process of the inlet device of the turboprop engine. The kriging-based optimization workflow is used to reduce full pressure losses and improve flow uniformity in the channel of the motor inlet device. However, the Latin Hypercube Design method has some limitations.

In [8], the influence of inlet conditions on the non-stationary aerodynamics of complex inlet devices by the method of a full-scale experiment was evaluated. That factor plays an important role in assessing the actual operation of the inlet device. The study evaluated the effect of incoming vortices of different strengths and placements. The authors showed that the presence of an inlet vortex affects the secondary flows of the inlet device and strengthens the vortex that was rotating in the same direction as the inlet vortex. That disrupted the characteristic flow mode of the *S*-shaped channel of the inlet device and shifted the turbulence zone. The results reported in the cited work show that the vortex practically does not affect the turbulence of angular instability. However, when the vortex was sucked in on the underside of the inlet device, flow instability decreased by 25 % compared to other positions of the captured vortex, and a decrease in instability was observed in all frequency ranges. The main conclusion that can be drawn from the results is that it is necessary to take into consideration the nature of the nonstationarity of the inlet flow since it significantly affects the characteristics of the flow in the inlet device.

In [9], the focus is on numerical modeling of compressed flow in diffusion *S*-shaped channels. It is shown that there are secondary currents when the boundary layer is detached. It is proven that the *S*-shaped channel creates a curvature of the streamline and an unfavorable pressure gradient. During the research, two geometries of *S*-shaped channels were considered. One was used in an experimental study in the early 1990s, and the other is a reference configuration to evaluate the accuracy of the results. Mathematical modeling was carried out using the software for calculating the hydrodynamics of the flow ANSYS-FLUENT. The solution of the Navier-Stokes equations, averaged by Reynolds, was carried out on a structured grid using several turbulence models. The results of the calculations record the flow field and pressure recovery with acceptable accuracy compared to the experimental data. A turbulence model that gives the best results was determined.

In [10], the results of the study of the mechanism of formation of vortices during flow in the *S*-shaped inlet device of the engine are reported.

Practical studies of the influence of the shape of the inlet device on its effectiveness are described in [11]. The authors investigate the characteristics of the ring-type and bucket inlet device. It is shown that the bucket inlet device has a smaller loss of total pressure. However, the cited work does not provide methods for designing the geometric shape of the ring-type and bucket inlet device.

Our literary reviewreveals that studies on improving the aerodynamics of the inlet devices of turboprop engines are performed by the method of numerical modeling of the flow. The main purpose of improving the inlet devices of turboprop engines is to optimize the shape of the inlet device and reduce the loss of total pressure at the inlet to the engine while ensuring a decrease in uneven flow. Toderive more accurate values in assessing the loss of total pressure and uneven flow, the joint work of the propeller and inlet device is considered. However, the issue of assessing the impact of a coaxial propfan on the operation of the inlet device and its characteristics has not previously been considered.

When integrating the inlet device and the coaxial propfan, it is necessary to take into consideration the conditions of their interaction to ensure the maximum value of the recovery coefficient of the total pressure of the inlet device. Such a task requires the improvement of the research procedure, the use of modern models, and the improvement of analysis methods and modeling procedures.

3. The aim and objectives of the study

This study aims to evaluate the effectiveness of the ring-type and bucket inlet devices of the power plant with a turboprop engine with a coaxial propfan. This will make it possible to reduce the loss of total pressure in the inlet device.

To accomplish the aim, the following tasks have been set:

– to devise a procedure for designing a bucket S-shaped channel of the inlet device of the power plant with a turboprop engine;

– to calculate the coefficient of recovery of the total pressure of the inlet device depending on the height and speed of flight of the power plant with a turboprop engine, taking into consideration the influence of the coaxial propfan.

4. The study materials and methods

The object of this study is a coaxial propfan with a bucket *S*-shaped channel of the inlet device (Fig. 1), consisting of two modules.

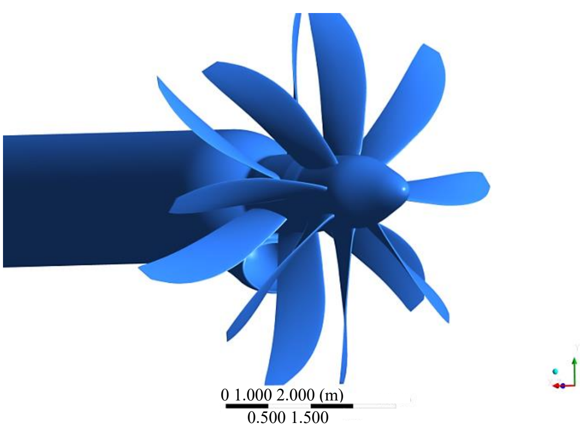

Fig. 1. Model of a coaxial propfan with a bucket *S*-shaped channel of the inlet device

The first module is a coaxial propfan with two rows of propellers: the front row consists of eight blades – z_f=8, and the rear row of six blades – z_b=6. The front and rear rows rotate at a frequency of n_f=n_b=850 rpm (Fig. 2), which corresponds to the cruising mode of flight.

The second module is a bucket *S*-shaped inlet device of an aircraft power plant with a turboprop engine.

To solve the problem of flow modeling in a bucket *S*-shaped inlet device of an aircraft power plant with a coaxial propfan, the ANSYS CFX software package was used, which makes it possible toapply various standard mathematical models and tools in modeling turbulent flow.

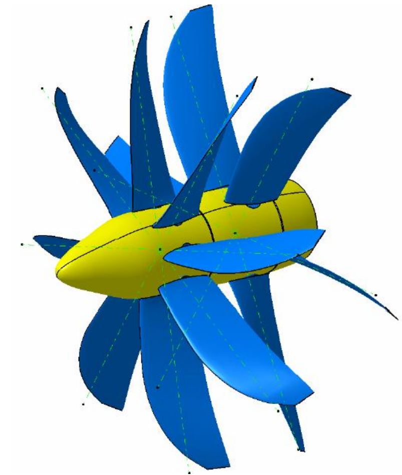

Fig. 2. Coaxial propfan model

The parameters and characteristics of the coaxial propfan used in the model are similar to the prototype SV-27 and are used on a power plant with a turboprop engine of the D-27 type [12]. The diameter of the propeller blades is 4.5 m.

Initial data for modeling.

We accept the following initial data for mathematical modeling:

– for the flight altitude H=3976 m with the Mach number M=0.394;

– for the flight altitude H=9067 m with the Mach number M=0.615;

– cruising mode of operation of the engine, determined by the angles of installation of the blades of the front and rear rows of the propfan.

To conduct a numerical study of the flow of the blade crowns, different types of estimation grids are used; the most common are structured and hybrid, and each of these types has advantages and disadvantages [13]. The methods of generating a structured and hybrid finite-element grid are used in this work. The grid model of the inlet device is constructed by the method of a structured grid, and the model of the propfan is constructed by the hybrid grid method.

The grid model consists of 4 domains:

– the first row of the propfan – a hexahedral mesh of 10 million 456 thousand 368 elements;

– the second row of the propfan – a hexahedral mesh of 7 million 982 thousand 442 elements;

– external environment – a hexahedral grid of 1 million 841 thousand 930 elements;

– an inlet device – mainly hexahedral grid, part at the inlet – tetrahedral – of only 811 thousand 794 elements.

The total number of finite-element grids of the model is 21 million 092 thousand 534 elements.

The simulation was carried out by solving the Navier-Stokes equations using the Florian Menter SST Transitional No. 4 Gamma Theta two-layer turbulence model since it is the most versatile and was developed on the basis of basic proven models of k-ε and k-ω. Justification of the turbulent viscosity model for the study of the characteristics of the coaxial propfan and the inlet device of the turboprop engine is presented in [14].

5. The results of studying the effectiveness of the ring-type and bucket inlet devices of the power plant

5.1. Procedure for designing a bucket S-shaped channel of the inlet device of the power plant with a turboprop engine

The length L and the relative area of the inlet device – $\bar{F}_{inlet}$ (the ratio of the inlet area to the inlet device F_{in} to the inlet area of the inlet device F_{AIP}) are taken from the prototype in [15]:

$$\bar{F}_{inlet} = \frac{F_{in}}{F_{AIP}} = 0.53. \quad (1)$$

When profiling an *S*-shaped inlet device, the channel is divided into two parts: inlet and outlet.

The length of the inlet and outlet parts of the *S*-shaped inlet device is $L/2 = X_{mid\,\max}$.

The inlet part of the *S*-shaped inlet device has the shape of an ellipse. The inlet area of the investigated *S*-shaped inlet device is equal to the inlet area of the outletring-type device of the prototype.

The outletshape of the inlet part of the *S*-shaped inlet device is equal to the average inlet and outlet area of the prototype ring-typeinlet device:

$$F_{mid} = \frac{F_{in} + F_{AIP}}{2}. \quad (2)$$

We assume that the larger radius of the ellipse of the inlet part of the *S*-shaped inlet device b_{in} is equal to the sleeve radius of the inlet part of the ring-typeinlet device of the prototype $b_{in} = r_{h\,in}$. Then the smaller radius of the ellipse of the inlet part of the *S*-shaped inlet device is equal to:

$$a_{in} = \frac{F_{in}}{\pi \cdot b_{in}}. \quad (3)$$

To profile the inlet part of the *S*-shaped inlet device, we take the radius of formation of the middle line of the channel of the inlet part $R_{in} = 1.51 \cdot a_{in}$ (Fig. 3).

The following ratio is used:

$$\varphi_{\max} = \arcsin\left(\frac{X_{mid\,\max}}{R_{in}}\right) = \arcsin\left(\frac{L/2}{R_{in}}\right), \quad (4)$$

to determine half of the maximum angle of bending of the channel $\varphi_{\max} = 90.0°$.

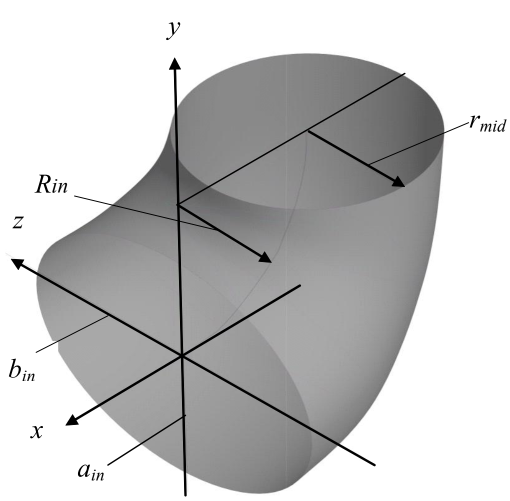

Fig. 3. Profiling diagram of the inlet part of the *S*-shaped inlet device

The coordinates of the middle line of the inlet part of the channel are determined from the ratios:

$$x_{midf} = R_{in} \cdot \sin\varphi; \; y_{midf} = R_{in} \cdot (1 - \cos\varphi), \quad (5)$$

when changing the angle in increments of $\Delta\varphi$ in the range of angles $0 \le \varphi \le \varphi_{\max}$.

The value of the radii of the ellipse, in each cross-section of the inlet part of the channel when changing the angle φ with the step $\Delta\varphi$ in the range $0 \le \varphi \le \varphi_{\max}$, is determined from the dependences [15]:

$$a_{if} = a_{in} \cdot \begin{pmatrix} 1 + 3 \cdot \left(\frac{r_{mid}}{a_{in}} - 1\right) \cdot \left(\frac{\varphi}{\varphi_{\max}}\right)^2 - \\ -2 \cdot \left(\frac{r_{mid}}{a_{in}} - 1\right) \cdot \left(\frac{\varphi}{\varphi_{\max}}\right)^3 \end{pmatrix}, \quad (6)$$

$$b_{if} = b_1 \cdot \begin{pmatrix} 1 + 3 \cdot \left(\frac{r_{mid}}{b_{in}} - 1\right) \cdot \left(\frac{\varphi}{\varphi_{\max}}\right)^2 - \\ -2 \cdot \left(\frac{r_{mid}}{b_{in}} - 1\right) \cdot \left(\frac{\varphi}{\varphi_{\max}}\right)^3 \end{pmatrix}.$$

The outlet part of the *S*-shaped inlet device starts from the outlet of the inlet part, goes around the bushing of the drive shaft of the propfan and ends with a ring-type channel before the flow enters the engine compressor.

To profile the outlet part of the *S*-shaped inlet device, we take the radius to form the middle line of the channel $R_{AIP} = r_{mid}$.

To profile the outlet part of the *S*-shaped inlet device, we take the radius for forming the middle line of the channel R_{AIP} equal to the average radius of the inlet device:

$$r_{mid} = \frac{r_{in} + r_{AIP}}{2}. \quad (7)$$

The coordinates of the middle line of the outlet part of the *S*-shaped inlet device are determined from the ratios:

$$x_{mid\,b} = R_{AIP} \cdot \sin\varphi; \; y_{mid\,b} = R_{AIP} \cdot (1 - \cos\varphi), \quad (8)$$

when changing the angle of bending of the channel in increments of $\Delta\varphi$ in the range of $0 \le \varphi \le \varphi_{\max}$.

The value of the areas of the circle, in each cross-section of the channel F'_{ib} when changing the angle φ in increments $\Delta\varphi$ in the range $0 \le \varphi \le \varphi_{\max}$, is determined using the ratios:

$$F'_{ib} = F_{mid} \cdot \begin{pmatrix} 1 + 3 \cdot \left(\frac{F_{AIP}}{F_{mid}} - 1\right) \cdot \left(\frac{\varphi}{\varphi_{\max}}\right)^2 - \\ -2 \cdot \left(\frac{F_{AIP}}{F_{mid}} - 1\right) \cdot \left(\frac{\varphi}{\varphi_{\max}}\right)^3 \end{pmatrix}. \quad (9)$$

We determine the area occupied by the sleeve in each section F_{hi}.

Then the channel area of the outlet part of the *S*-shaped inlet device is equal to:

$$F_{ib} = F'_{ib} + F_{hi}, \quad (10)$$

and the outer radius of the circle, in each cross-section of the outlet part of the channel, is determined by the cross-sectional area:

$$r_{ib} = \sqrt{\frac{F_{ib}}{\pi}}. \qquad (11)$$

Thus, we devised a procedure for designing a bucket inlet device for a power plant with a turboprop engine. According to the obtained procedure, a model of a bucket *S*-shaped inlet device was built, which is shown in Fig. 4.

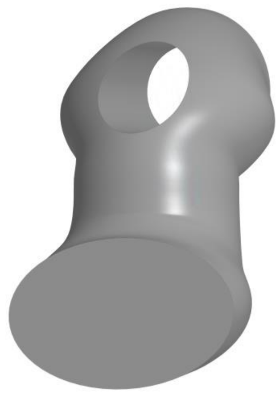

Fig. 4. Bucket *S*-shaped channel model of the inlet device

Using the model of a coaxial propfan and an *S*-shaped inlet device, we build a model of the object of our study.

5. 2. Calculation of the coefficient of recovery of the total pressure of the inlet device of the power plant with a turboprop engine

To take into consideration the conditions of interaction between the inlet device and coaxial propfan to ensure maximum efficiency of the power plant during operation, a coaxial propfan and inlet device are combined in one estimation model. This made it possible to calculate the coefficient of preservation of the total pressure, taking into consideration the influence of a coaxial propfan.

For each variant of the mathematical modeling of the joint operation of the coaxial propfan and the bucket inlet device of the power plant with a turboprop engine, the following flow parameters were determined: the total pressure at the inlet to the inlet device – p^*_{in}, the total pressure at the outlet of the inlet device – p^*_{AIP}.

The coefficient of preservation of the total pressure of the inlet device was defined as the ratio of the total pressure at the outlet to the total pressure at the inlet:

$$\sigma = \frac{p^*_{AIP}}{p^*_{in}}. \qquad (12)$$

Our results of calculating the coefficient of preservation of the total pressure of the inlet device are shown on the histogram (Fig. 5).

Simulation of the flow in the coaxial propfan with the inlet device was carried out for two modes of operation: flight altitude, H=9076 m; Mach number at the inlet, M=0.593; and flight altitude, H=3967 m; Mach number at the inlet, M=0.394.

When modeling under the operating mode at a flight altitude *of* H=3967 m, the temperature was set to 0 °C, atmospheric pressure 61830,930 Pa, and air density 0.78872 kg/m^3.

When modeling under the operating mode at a flight altitude of H=9076 m, the air temperature was set to –40 °C, atmospheric pressure 30439,842 Pa, and air density 0.44243 kg/m^3.

Our results of flow modeling in a coaxial propfan with a bucket inlet device were compared with flight test data on a similar coaxial propfan only with a ring-type inlet device [15]. At the same time, the airflow rate through the inlet device was the same for identical operating modes. This made it possible to evaluate the effectiveness of the bucket and ring-typeinlet devices.

According to earlier studies reported in [14], the accuracy of calculating the flow parameters during the flow of the coaxial propfan and the ring-type inlet device was checked. Verification of the methodology for calculating the coefficient of recovery of total pressure in the ring-type inlet device was carried out by comparing flight test data and mathematical modeling of the flow in a similar ring-type inlet device. When comparing the values of the full pressure recovery coefficient in the ring-type inlet device obtained during flight tests and the numerical experiment, the calculation error was less than 1 %. In these studies, the model of the coaxial propfan remained unchanged while the model of the inlet device was changed. When modeling the flow, the same topology of the estimation grid, the model of turbulent viscosity Florian Menter SST Transitional No. 4 Gamma Theta was used, as in [14]. This allowsus to assume that the results of calculating the coefficient of recovery of the total pressure of the bucket inlet device obtained in the current work are adequate.

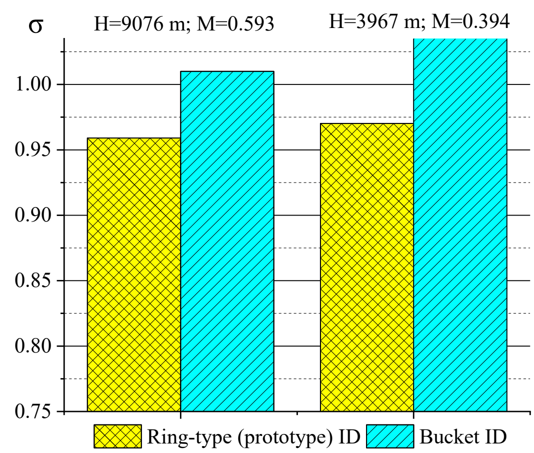

Fig. 5. Values of full pressure recovery coefficients for ring-type and bucket inlet devices

The histogram shows the values of the coefficient of reduction of the total pressure of the bucket inlet device (ID) and the inlet device of the ring type (prototype) [15] at H=9076 m, M=0.593, and H=3967 m, M=0.394.

6. Discussion of results of the effectiveness of the ring-type and bucket inlet devices of the power plant

This paperreportsa procedure devised for designing a bucket inlet device for the power plant with a turboprop engine. Unlike the procedure described in [16], a feature of our proposed methodology is that when designing the *S*-shaped channel of the inlet device of the aviation turboprop engine, it sinlet part was considered, which has the shape of an ellipse in the cross-section – formula (3), (6). The reported procedure has practical value; it is intended for engineers and scientists who are engaged in the development and research of bucket-type inlet devices.

The main criterion for evaluating the effectiveness of the ring-type and bucket inlet devices of the power plant with a turboprop engine is the coefficient of recovery of the total pressure in the inlet device. This coefficient characterizes the loss of total pressure when air is supplied to the engine. The greater the coefficient of recovery of the total pressure of the inlet device, the higher, with a given flight mode, the degree of pressure increase in the inlet device. That is why the magnitude of the coefficient of recovery of total pressure has a significant impact on the specific fuel consumption and specific power of the engine.

It can be seen from the histogram (Fig. 5) that the use of a bucket inlet device with an *S*-shaped channel instead of a ring-type inlet device can reduce hydraulic losses in the bucket inlet device with an *S*-shaped channel and provide an increase in the coefficient of recovery of full pressure by 5.3 % for the flight altitude H=9076 m and the Mach number M=0.593. When flying at an altitude of H=3967 m and the Mach number M=0.394, the full pressure recovery factor when using a bucket inlet device with an *S*-shaped channel increases by 6.8 %.

In addition, the results of our study show (Fig. 5) that when the flight conditions change from H=3967 m and M=0.394 to H=9076 m and M=0.593, the coefficient of preservation of the total pressure of the ring-type inlet device changes less significantly than the bucket one – from 0.9702 to 0.9591 (by 1.2 %).

It should be noted that for a bucket inlet device with an *S*-shaped channel (Fig. 5), the same change in flight conditions leads to a greater change in the coefficient of preservation of the total pressure, from 1.036 to 1.01 (by 2.6 %).

According to the considerations in [11], there are several reasons for the increase in the coefficient of recovery of total pressure in the bucket inlet device that exceeds unity. This is the so-called effect of supercharging the propfan, inducing flow vorticity, distortion of streamlines, and draining of the boundary layer from the fairing sleeve.

We have calculated coefficients of loss of total pressure at the inlet to the turboprop engine. A feature of the results of this calculation is that the influence of a coaxial propfan on the flow parameters at the inlet to the inlet device is taken into consideration (usually a single-row propeller is investigated).

Thus, it can be stated that the issue of assessing the influence of a coaxial propeller on the operation of the inlet device and its characteristics has been considered. When integrating the inlet device and coaxial propfan, the conditions of their interaction are taken into consideration to ensure the maximum value of the recovery coefficient of the total pressure of the inlet device.

The limitation of this study is that the considered model does not take into account the non-stationarity of the flow that exists in the real inlet device. However, this takes into consideration the uneven flow, which is modeled in the stream behind a coaxial propfan.

The disadvantage of this work is the lack of analysis of the uneven flow at the inlet to the turboprop engine.

The direction of further research is likely to assess the effect of curvature and narrowing of the *S*-shaped channel of the inlet device, taking into consideration the influence of the propfan of the engine turboprop engine and the effect of changing the mode of operation of the propfan on the operation of the inlet device. It is also planned to investigate the non-uniformity at the inlet of a turbofan engine with an *S*-shaped channel of the inlet device.

7. Conclusions

1. A methodology for designing a bucket inlet device for a power plant with a turboprop engine has been developed. A distinctive feature of the procedure is that the inlet area of the *S*-shaped inlet device is in the form of an ellipse. The area of the inlet of the investigated *S*-shaped inlet device is equal to the area of the inlet of the outlet ring-type device of the prototype. The developed procedure makes it possible to build a bucket inlet device for the power plant with a turboprop engine, providing equivalence of airflow, compared with the ring-type inlet device.

The geometric feature of the resulting bucket inlet device minimizes the loss of full pressure during storage of the required airflow at the inlet to the engine. Thus, when integrating the inlet device and coaxial propfan, the conditions of their interaction are taken into consideration to ensure the maximum value of the recovery coefficient of the total pressure of the inlet device.

The methodology reported here is of practical value; it is intended for engineers and scientists involved in the development and research of inlet devices of bucket type.

2. The calculation of the coefficients of recovery of the full pressure for the bucket inlet device was carried out. The dependence of the coefficient of preservation of the total pressure of the inlet device on the height and speed of flight was established, taking into consideration the influence of the propfan in a turboprop engine. It was found that the change in flight conditions has a less significant effect on the change in the coefficient of preservation of the total pressure of the ring-type device than the bucket inlet device. A comparison of the characteristics of the ring-type and bucket inlet devices of the power plant, taking into account the effect of the propfan in a turboprop engine, found that the bucket inlet device is more efficient. The use of a bucket inlet device, instead of a ring-type inlet device, makes it possible to increase the recovery factor of full pressure by 5–7 %.

Thus, replacing the ring-type inlet device with a bucket will minimize the loss of full pressure at the inlet to the compressor, and reduce unevenness at the inlet to the engine. This, in turn, will improve engine efficiency.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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