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Analysis of the intakes existing schemes for power plants and parameters that determine their efficiency

The work presents an analysis of the work process of intakes for power plants, and also existing schemes of intakes for power plants and parameters that determine their efficiency are analyzed

The intakes of the power plants are designed to take air from the atmosphere, supply air to the engine and partially convert the kinetic energy of oncoming flow into the potential energy of compressed air with minimal losses of total pressure [1].

Thus, the intakes perform two main functions. Firstly, they provide the required speed field at the entrance to the engine. Secondly, the energy of the high-speed flow is converted into pressure.

In order to ensure the maximum possible power and the minimum possible specific fuel consumption, the implementation of these functions of the intake should be carried out with minimal losses.

The value of the total pressure recovery coefficient has a significant effect on the main parameters of the engine (specific fuel consumption and thrust) and is therefore one of the main criteria for the efficiency of the intake.

In order to reduce losses in the process of air compression, the area of the passage sections of the intake is chosen in such a way that the calculated speed of the flow at the entrance to the engine is provided in the rated flight mode.

In the duct of the intake, when the cross-sectional area changes, it is possible to slow down or accelerate the flow.

That is why, in power plants of aircrafts for subsonic flight speeds we use the intakes that differ mainly in the shape of the internal duct (Fig. 1) [1].

The change in pressure - p, temperature - T, and velocity - c for each duct shape of the intake (Fig. 1) shows how it is necessary to profile the duct of the intake to ensure the required flow rate and flow uniformity at the entrance to the engine in the rated mode.

The internal duct of the subsonic intake, operating in the range of Mach numbers from 0 to 0.7...0.95, expands, the subsonic flow moving through the duct slows down and the air pressure increases. The increase in pressure depends on the degree of expansion of the diffuser duct.

The inlet edges of subsonic diffusers are rounded to obtain a smooth flow to prevent flow disruption at the inlet.

Flight speed and engine operating mode have a significant influence on the nature of the flow at the entrance to the subsonic diffuser.

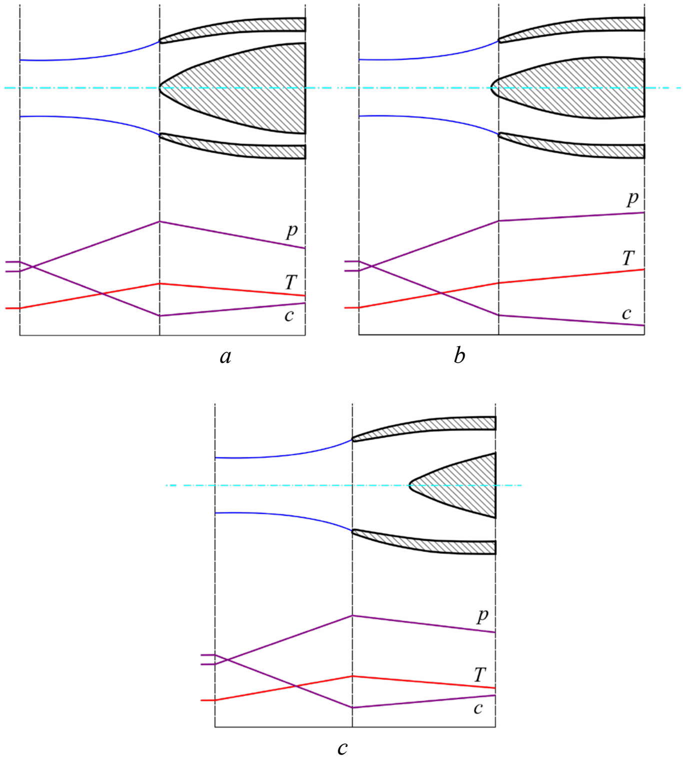

Fig. 1. Schemes of a subsonic intake ducts:
a – a convergent duct; *b* – a divergent duct; *c* – a duct that initially divergent and then convergent

Depending on the flight speed at the entrance to the intake, three characteristic modes of airflow before the entrance are possible. When the engine is running in place, when $V_n = 0$, the flow in front of the intake accelerates from the zero velocity of the undisturbed flow to the velocity at the input V_{in}, which then is decelerated in the duct of the intake. At speeds $V_n = V_{in}$, the airflow enters the intake without changing its shape, the flow is slowed down in the duct of the intake. At the speed $V_n > V_{in}$ (Fig. 1.2, c), the transformation of the flow's kinetic energy into potential energy begins even before entering the diffuser and ends in its duct. The best mode of operation of a subsonic intake is one in which $V_{in} \approx 0.5 \cdot V_n$ [1].

Under these conditions, a braking flow is formed before the entrance, in which up to 75% of the degree of pressure increase is realized.

By braking the flow to the entrance to the intake, the hydraulic losses in the diffuser are reduced, since the air passes through its duct at lower speeds, which is especially important with long and curved inlet ducts, which is characteristic of bucket and frontal intakes.

Significant retardation of the flow in front of the intakes leads to large angles of air inflow to the edge of the nozzle, an increase in the flow speed on the outer surface of the intake, and can cause either flow disruption or the formation of local supersonic zones. Both of these phenomena lead to a significant increase in external resistance.

The results of previous studies of the joint operation of a coaxial propeller fan and an intake [2-7] show that the improvement of the characteristics of an annular intake operating on a coaxial propeller fan is possible due to the rational choice of geometric parameters (the shape of the fan, the size of the power racks, the shape of the flow part and the maximum approximation of the propeller to the nozzle) of the intake; the intake operating on a coaxial propeller fan is possible due to the choice of a rational form of the bucket intake and the removal of the boundary layer before the entrance to it.

Conclusions

The paper presents an analysis of the work process of intakes of power plants, analyzed existing schemes of intakes of power plants and parameters that determine their efficiency.

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