

## NOISE REDUCTION IN THE DUCT FAN

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The source of aerodynamic noise in a duct fan is non-stationary processes in the duct [1], occurring during the flow of the blade crowns. The predominant role in the noise spectrum belongs to intensive discrete components, manifested at frequencies, in general, directly proportional to the product of the angular speed of rotation of the impeller on the number of blades in it. Discrete components in the interaction of blade crowns are caused by periodic perturbations caused by inhomogeneity of the potential flow, aerodynamic traces behind the blades or other obstacles in the channel, for example, support struts. Generation and propagation of discrete components in the channel fan obey the laws of acoustics of circular waveguides, which have a selective ability with respect to the passage of sound waves. In this case, the character of waveguide propagation and noise emission level for discrete components depends on the circular speed of the fan, the ratio of the number of blades of movable and fixed crowns, the shape and geometric dimensions of the flowing annular channel, as well as the wave resistance of its walls. The favorable number of blades can be calculated depending on the circular speed of the fan and the axial flow velocity.

Suppose the number of blades is chosen correctly. In that case, other known methods of reducing discrete noise components, such as blade tilting, installation of blades with variable pitch, increasing the axial clearance and others, do not have a significant effect. From the standpoint of acoustics and aerodynamics, at a favorable number of blades, it is recommended to apply the value of relative axial clearance in the range of 0.3-0.4 of the chord size of the wheel blade.

An effective way to achieve low noise levels is to use fans with the lowest possible flow velocities of the impeller blades. These fans have a large pressure coefficient value and a small relative hub diameter.

Another source of noise is the fan motor support legs in the duct. The interaction of the inhomogeneous flow behind the support legs with the impeller behind them results in an additional increase in noise. However, when

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they are also located behind the fan, the influence of the struts is also significant. In this case, they are streamlined by an unevenly swirled flow, which causes flow breakaway from the struts. In addition to the fact that this breakaway flow itself leads to increased noise levels, it also leads to increased pressure pulsations on the wheel blades and increased noise generated by the wheel. Support stands behind the impeller in its form should be performed as the blades of the straightening apparatus, to arrange them not radially or evenly. It is necessary to ensure their inclination to the side opposite to the slope of the inlet edge of the impeller blades, and stands behind the wheel – to the side opposite to the hill of the outlet edge of their blades, with the angle between the directions of the support stand and the edge of the blade should be 10-15 degrees.

Especially for noise reduction in the design of duct fans, including multistage fans, such additional elements as rod imitators and paired blades are added. Rod imitators are designed for fans with non-rotating blades. The imitators are plates or rods fixed to the casing inside the fan or the fan hub. The use of rod simulators for noise reduction is based on creating additional aerodynamic footprints similar to those of the blades. When flowing with the flow, each blade of the wheel is affected alternately by the blade traces and the simulators, which, in terms of discrete component generation, is equivalent to doubling the number of blades. The arrangement of the simulators should ensure equal angular spacing between the traces. The simulators introduce pressure losses of the order of 1.5%, commensurate with the losses in the fan guide apparatus. The reduction in fan efficiency with the use of simulators can also reach 1.5%. To reduce aerodynamic losses, the simulators are installed outside the inter-blade channel of the propulsor and are as close as possible to the impeller. The dimensions of the simulators are determined on the basis of data on the flow of rods and blade grids of profiles or experimentally.

It is known [2] that the amplitudes of generated sound waves from flow inhomogeneities are determined mainly by the magnitude of the maximum velocity deficit in the wake. Therefore, the transverse dimensions of the simulators can be found from the conditions of equal degree of flow inhomogeneity in the trace with the fan blades at the same radius of curvature. Using simulators allows for a reduction of the level of the first discrete component by 5-9 dB, depending on the mode of operation of the fan, while the broadband noise is practically unchanged.

To reduce the noise of fans with rotary blades, twin blades are used, each consisting of two blades connected by bridges at the hub and casing. The blades are connected so that they form a grid with equal pitch. Each paired blade is rotatable about a common axis passing through the crosspieces. When paired blades replace blades, their number in the fan becomes twice as large, ensuring

a minimum level of discrete noise component. Unlike imitators, the paired blades can be used both in the guide and straightening apparatuses of the fan, while reducing the noise from the interaction of the apparatus with the impellers located upstream and downstream.

In the process of designing a fan with paired blades it is necessary to adhere to the following acoustic requirements, which will ensure the minimum value of aerodynamic losses:

- the geometry of blades should be recalculated according to the known dependencies for twice the number of blades while maintaining the lattice density;
- the axes of blade profile alignment are located radially at an equal angular distance from each other;
- the rotation axis of a twin blade is radially located and positioned in such a way as to ensure minimum radial clearances between the blades and the casing;
- the lintels of the twin blades should have a bend on cylindrical surfaces coaxial to the fan axis.

The use of paired blades allows reducing the sound power level in the octave band of 125 Hz for the first discrete noise component by about 9 dB, while the broadband noise and aerodynamic characteristics remain practically unchanged.

If the above recommendations are followed, axial fans with improved acoustic characteristics can be created. The use of such fans as propulsors will make it possible to create noiseless aircraft practically without affecting their aerodynamic characteristics.

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