

Yu. A. KVASHA, N. V. PETRUSHENKO

## ON THE AERODYNAMIC IMPROVEMENT OF AIRCRAFT GAS-TURBINE ENGINE AIR INTAKES

*Institute of Technical Mechanics  
of the National Academy of Sciences of Ukraine and the State Space Agency of Ukraine  
15 Leshko-Popel St., Dnipro 49005, Ukraine; e-mail: yukv@i.ua; bolotova\_nataly@yahoo.com*

This work is devoted to the development of approaches to the aerodynamic improvement of aircraft gas-turbine engine inlet devices. Air intakes, which are the main components thereof, must provide a sufficiently uniform flow at the compressor inlet. The goal of the work is to computationally assess the effect of the shape of the air intake duct midline on nonuniformity in the distribution of the flow parameters over the outlet cross-section.

As the basic tool, a numerical simulation of 3D turbulent gas flows on the basis of the complete averaged Navier–Stokes equations and a two-parameter turbulence model was used. For one of the air intake configurations for an aircraft turboprop engine, the effect of the shape of the air intake duct midline on nonuniformity in the flow parameter distribution over the outlet cross-section was assessed. A numerical simulation of a 3D turbulent flow in the air intake duct showed a significant effect of midline shape variation on the coefficient of nonuniformity of the Mach number and pressure distribution over the outlet cross-section even in the case of fixed coordinates of two chosen points of the line at the duct inlet and outlet and a fixed direction of the line at those points. This makes it possible to reduce the coefficient of nonuniformity by choosing an appropriate midline shape. On the whole, this work shows that the shape of the air intake duct midline is an important factor, accounting for which allows one to reduce nonuniformity in the flow parameter distribution at the duct inlet without going beyond the design constraints on the air intake dimensions and flow inlet and outlet angles. The reliability of the results is provided by the consideration of a real-life air intake design and the use of the authors' repeatedly verified method of numerical simulation. The results may be used in the aerodynamic improvement of aircraft gas-turbine engine inlet devices,

**Keywords:** *air intake, duct midline, nonuniformity in flow parameter distribution, coefficient of nonuniformity, numerical simulation.*

1. Shmyrev V. F. Features of the design of a turbofan air intake lip. Open Information and Computer Integrated Technologies. 2019. No. 86. Pp. 25-36. (in Russian).
2. Sevinç Koray. Aerodynamic design optimization of a bellmouth shaped air intake for jet engine testing purposes and its experiment based validation. Journal of Physics: Conference Series. May 2021. 11 pp. <https://doi.org/10.1088/1742-6596/1909/1/012028>
3. Gogoi A., Angadi M. B., Mall A., Singh S. V., Goud K. S. Design and CFD analysis of air intake for combat aircraft. Proc. of Symposium on Applied Aerodynamics and Design of Aerospace Vehicle (SAROD 2011). (Bangalore, November 16-18, 2011). Bangalore (India), 2011. 8 pp.
4. Vyshnevskiy O. A., Davydov O. S. Dimension optimization of the simulation of hyperbolic-elliptic contours of gas-turbine air intakes. Information Processing Systems. 2013. No.113. Pp. 52-56. (in Ukrainian).
5. Prasath M. S., Shiva Shankare Gowda A. S., Senthilkumar S. CFD Study of air intake diffuser. The International Journal of Engineering and Science (IJES). 2014. V. 3. Pp. 53-59.
6. Kvasha Yu. A. Calculation of a 3D turbulent flow in the blade channels of supersonic compressor stages. Teh. Meh. 1999. No. 1. Pp. 9-13. (in Russian).
7. Patankar S. Numerical Heat Transfer and Fluid Flow. Moscow: Energoizdat, 1984. 152 pp. (in Russian).
8. Hah C. Calculation of three-dimensional viscous flows in turbomachinery with an implicit relaxation method. J. of Propulsion and Power. 1987. No. 5. Pp. 415-422. <https://doi.org/10.2514/3.23006>
9. Kvasha Yu. A., Dyachkin A. A. Calculation of a 3D turbulent flow in asymmetric channels. Teh. Meh. 2000. No.1. Pp. 72-76. (in Russian).

10. Kvasha Yu. A., Zinevych N. A. Aerodynamic optimization of the shape of supersonic compressor stage guide blades. *Teh. Meh.* 2017. No. 4. Pp. 18-25. (in Russian).  
<https://doi.org/10.15407/itm2017.04.018>

Received on November 22, 2024,  
in final form on December 5, 2024