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ON THE AERODYNAMIC OPTIMIZATION OF IMPELLERS OF SUPERSONIC COMPRESSOR STAGES

The study deals with the pressing problem of diminution in the computer time for an aerodynamic optimization of blade rims of axial compressors when a numerical simulation of the flow based on the full averaged Navier-Stokes equations is used for calculating the end function. The work goal is to verify the serviceability of the authors' saving procedure of the aerodynamic optimization of impellers of the supersonic compressor stages. The procedure uses reasonably crude computational grids in a numerical simulation of a 3D turbulent air flow in impellers. However, these grids would be selected in order to save the sensitivity of the computational results to variations in the geometric parameters of a blade rim. Criteria of quality are formulated as air flow-averaging values of the power characteristics of an impeller. Finding the optimal geometric parameters of blades uses the points of the uniformly distributed sequences in space of parameters. The Rotor-37 impeller of a supersonic compressor stage has been selected for computations for verifying the serviceability of the procedure. Using the mentioned high-loaded impeller as an example, it is shown that in comparison with the prototype the improved combinations of the variable geometric parameters of impeller blades can be selected by employing a moderate number of the points of the uniformly distributed sequences. The validity of this conclusion is supported by the following calculation of the power characteristics of the reference impeller and optimized one using a detailed computational grid. The results obtained can be employed for the aerodynamic optimization of the geometric parameters of blade rims of compressor stages.

Keywords: *aerodynamic optimization, impeller of compressor stage, numerical simulation, uniformly distributed sequence.*

1. *Chang Luo* Multiobjective optimization approach to multidisciplinary design of a three-dimensional transonic compressor blade / *Chang Luo, Liming Song, Jun Li, Zhenping Feng* // Proc. of ASME TURBO EXPO 2009. – Orlando, Florida (USA), 2009. – 10 p.
2. *Rongye Zheng* Blade geometry optimization for axial flow compressor / *Rongye Zheng, Jianhua Xiang, Jinju Sun* // Proc. of ASME TURBO EXPO 2010. – Glasgow (UK), 2010. – 12 p.
3. *Chaolei Zhang* Aerodynamic shape design optimization for turbomachinery cascade based on discrete adjoint method / *Chaolei Zhang, Zhenping Feng* // Proc. of ASME TURBO EXPO 2011. – Vancouver, British Columbia (Canada), 2011. – 10 p.
4. *Jinguang Yang* Multi-row inverse method based on the adjoint optimization / *Jinguang Yang, Xiuquan Huang, Hu Wu* // Proc. of ASME TURBO EXPO 2011. – Vancouver, British Columbia (Canada), 2011. – 11 p.
5. *Hong Wu* Optimization of highly loaded fan rotor based on throughflow model / *Hong Wu, Qiushi Li, Sheng Zhou* // Proc. of ASME TURBO EXPO 2007. – Montreal (Canada), 2007. – 11 p.
6. Framework for multidisciplinary optimization of turbomachinery / *M. G. Turner, K. Park, K. Siddappaji, S. Dey, D. P. Gutzwiller, A. Merchant, D. Bruna* // Proc. of ASME TURBO EXPO 2010. – Glasgow (UK), 2010. – 9 p.
7. *Mengistu T.* Aerodynamic shape optimization of turbine blades using a design-parameter-based shape representation / *T. Mengistu, W. Ghaly, T. Mansour* // Proc. of ASME TURBO EXPO 2007. – Montreal (Canada), 2007. – 10 p.
8. *Xu C.* A turbine airfoil aerodynamic design process / *C. Xu, R. S. Amano* // Proc. of ASME TURBO EXPO 2001. – New Orleans, Louisiana (USA), 2001. – 10 p.
9. *Ashihara K.* Turbomachinery blade design using 3-D inverse design method, CFD and optimization algorithm / *K. Ashihara, A. Goto* // Proc. of ASME TURBO EXPO 2001. – New Orleans, Louisiana (USA), 2001. – 9 p.
10. *Demeulenaere A.* Application of multipoint optimization to the design of turbomachinery blades / *A. Demeulenaere, A. Lligout, C. Hirsch* // Proc. of ASME TURBO EXPO 2004. – Vienna (Austria), 2004. – 8 p.
11. *Cravero C.* A Navier-Stokes based strategy for the aerodynamic optimization of a turbine cascade using a genetic algorithm / *C. Cravero, A. Satta* // Proc. of ASME TURBO EXPO 2001. – New Orleans, Louisiana (USA), 2001. – 8 p.
12. *Shahpar S.* Application of the FAITH linear design system to a compressor blade / *S. Shahpar, D. Radford* // Proc. of XIV Int. Symp. on Airbreathing Engines. – Florence (Italy), 1999. – 12 p.
13. *Chan-Sol Ahn* Aerodynamic design optimization of an axial flow compressor rotor / *Chan-Sol Ahn, Kwang-Yong Kim* // Proc. of ASME TURBO EXPO 2002. –Amsterdam (The Netherlands), 2002. – 7 p.
14. *Sivashanmugam V. K.* Aero-structural optimization of an axial turbine stage in three-dimensional flow / *V. K. Sivashanmugam, M. Arabnia, W. Ghaly* // Proc. of ASME TURBO EXPO 2010. – Glasgow (UK), 2010. – 14 p.
15. *Burguburu S.* Numerical optimization for turbomachinery blades aerodynamic design using a gradient method coupled with a Navier-Stokes solver / *S. Burguburu, C. Toussaint, G. Leroy* // Proc. of XV Int. Symp. on Air Breathing Engines. – Bangalore (India), 2001. – 7 p.

16. *Sanz J. M.* A neural network aero design system for advanced turbo-engines / *J. M. Sanz* // Proc. of XIV Int. Symp. on Airbreathing Engines. – Florence (Italy), 1999. – 7 p.
17. *Xiang X.* Optimum initial design of centrifugal compressor stage with genetic algorithm / *X. Xiang, X. L. Zhao* // Proc. of XV Int. Symp. on Air Breathing Engines. – Bangalore (India), 2001. – 6 p.
18. *Oksuz O.* Turbine cascade optimization using an Euler coupled genetic algorithm / *O. Oksuz, I. S. Akmandor* // Proc. of XV Int. Symp. on Air Breathing Engines. – Bangalore (India), 2001. – 9 p.
19. Design and Overall Performance of Four Highly Loaded, High-Speed Inlet Stages for an Advanced High-Pressure-Ratio Core Compressor: NASA Technical Paper 1337. – 1978. – 132 p.
20. *Kvasha Yu. A.* Computations of 3D turbulent flow through vane channels of supersonic compressor stages *(in Russian) / Yu. A. Kvasha* // Tekhnicheskaya Mekhanika. – 1999. – No 1. – P. 9 – 13.
21. *Abramovich G. N.* Applied Gas Dynamics *(in Russian) / G. N. Abramovich.* – Moscow : Nauka, 1969. – 824 p.
22. *Krayko A. A.* Development of efficient direct methods for problems of construction of optimal aerodynamic forms *(in Russian) / A. A. Krayko* // Proceedings of the 9th International School-Seminar on Models and Methods of Aerodynamics. – Moscow : MTsNMO, 2009. – P. 109 – 110.
23. *Kvasha Yu. A.* Rational selection of computational grid in aerodynamic optimization of configuration of vane channels of compressor stages based on numerical simulation of turbulent flows *(in Russian) / Yu. A. Kvasha, S. V. Melashich, Ye. Yu. Yampol* // Tekhnicheskaya Mekhanika. – 2009. – No 4. – P. 57 – 67.
24. *Kvasha Yu. A.* On the selection of computational grids in numerical simulation of 3D turbulent flows through impellers of supersonic compressors stages *(in Russian) / Yu. A. Kvasha, N. A. Zinevich* // Tekhnicheskaya Mekhanika. – 2013. – No 3. – P. 34 – 41.
25. *Sobol I. M.* Selection of Optimal Parameters for Multi-Criteria Problems *(in Russian) / I. M. Sobol, R. B. Statnikov.* – Moscow: Nauka, 1981. – 110 p.
26. *Melashich S. V.* Validation of efficient applications of stochastic methods for problems of aerodynamic optimization of configurations compressor rims of gas-turbine engines *(in Russian) / S. V. Melashich* // Tekhnicheskaya Mekhanika. – 2015. – No 3. – P. 39 – 45.