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Design of experimental transsonic axial compressor

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1. Introduction

Axial compressors are a widely used today. This is principally due to their high efficiency and high compression in multi-stage arrangements. The requirement for a multi-stage arrangement to achieve a large pressure rise, making them complex and expensive relative to other designs (e.g., centrifugal compressors). Axial compressors are also sensitive to surging so it is necessary to operate these compressors under the correct operating conditions [2].

2. Blade profile

These are transsonic profiles for axial compressors designed by Jan Klesa [3] for a design Mach number of 0.8 (Fig. 1). The individual profiles are based on explicit geometric rules and are designed to have properties comparable to controlled diffusion airfoils (CDA). It is planned to use them for the design of a compressor for the secondary circuit of a gas-cooled nuclear reactor being developed under the KOBRA programme.

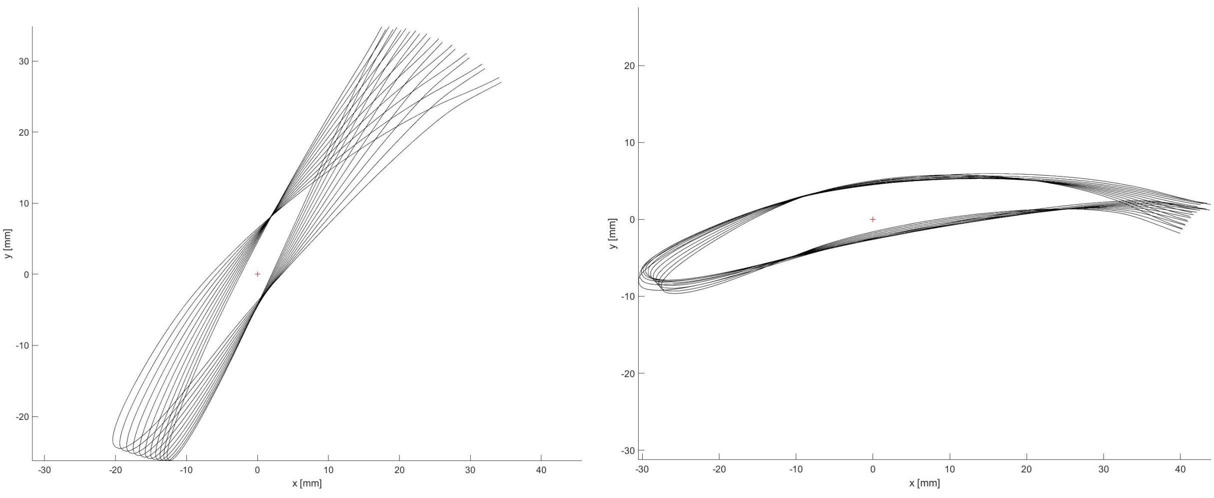

Fig. 1. Sections along the rotor blade height (*left*), sections along the stator blade height (*right*)

3. Structural compressor design

The experimental compressor will be designed as a single stage compressor and will be used to verify the characteristics of designed profiles. The compressor is driven by a 200 kW electric motor at 8000 rpm, and the rotor is supported by rolling ball bearing. The main design parameters are as follow: hub diameter 330 mm, shroud diameter 660 mm, mass flow 38.88 kg/s. The rotor blades is composed of sandwich design consisting of a carbon composite with a foam core. The flanges will be of pre-impregnated unidirectional carbon fabric, the cover of pre-impregnated plain weave fabric.

4. CFD calculation

A model of the flow path was created to enable the creation of the mesh. The mesh was made up of unstructured tetrahedra and only on the surface of the blades was the mesh refined and structured to capture the boundary layer processes, Fig. 2. The total number of elements of the mesh is 1 265 390.

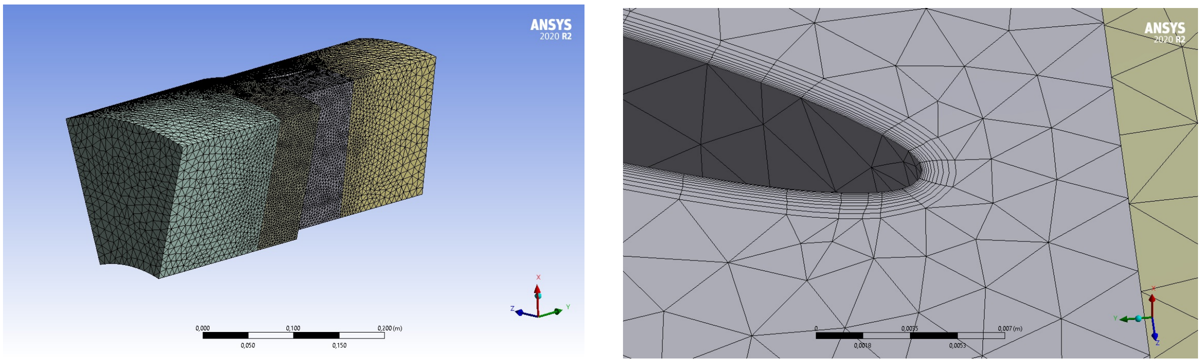

Fig. 2. View of the overall mesh (*left*), view of the detailed mesh on the stator leading edge (*right*)

For a single axial flow compressor the most commonly used the Mixing Plane Model [1]. The following parameters were used in the calculation: k-ω SST model, which is one of the most widely used models for simulating turbulent types of flow, ideal gas with Sutherland viscosity model as working gas. The inlet and outlet conditions correspond to the international standard atmosphere at 0 m altitude. A mixing plane were used to model the rotor-stator interface and the pressure-based solver for calculate a solution (Figs. 3 and 4).

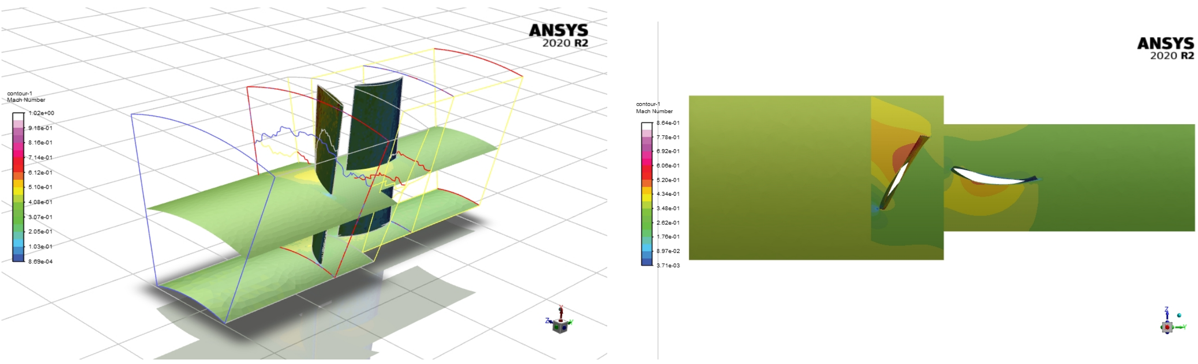

Fig. 3. Mach number distribution on the rotor blade, stator, hub and middle section (*left*), Mach number distribution on detailed middle section (*right*)

5. Conclusion

To explore the possibilities of use the new transsonic airfoil a single stage axial compressor was designed. A model of this compressor was computed using CFD solver and the flow do not exhibit undesirable phenomena such as pressure surges or flow separation at the blade surface.

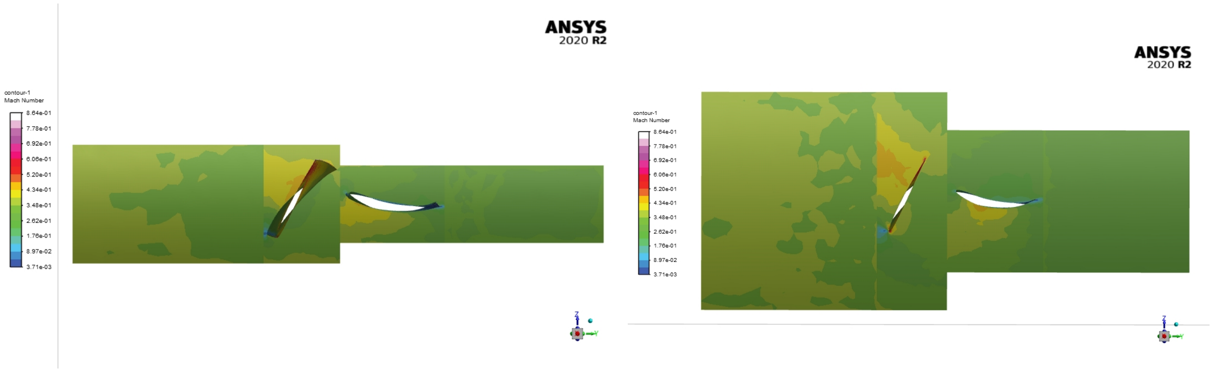

Fig. 4. Mach number distribution on detailed hub section (*left*), Mach number distribution on detailed shroud section (*right*)

Acknowledgement

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References

[1] ANSYS Inc., ANSYS Fluent tutorial guide, Release 17, 2016.
[2] Cumpsty, N. A., Compressor aerodynamics, Krieger, Malabar, 2004.
[3] Klesa, J., Aerodynamic design of transsonic compressor airfoil family, Proceedings of the 36th conference with international participation Computational Mechanics, Srní, University of West Bohemia, 2021.