

SHAPE OPTIMISATION OF TURBOMACHINERY COMPONENTS

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Keywords: *Computational Fluid Dynamics, Shape Optimisation, Rotating Impeller, Turbomachinery Design*

Low-order models are the first choice to find the initial design of turbomachinery components screening many configurations. The final optimisation of the three-dimensional geometry is crucial for the best performance. Because of the ability to accurately predict the performance of turbomachinery, fluid dynamic simulations became a powerful tool [1]. However, parameter studies for shape optimisation relying on fluid dynamic simulations are computationally expensive and might fail to reveal the optimal geometry. Gradient-based optimisation approaches allow a significant reduction of simulations and hence, determine the optimum efficiency. The adjoint method finds the optimisation gradient by calculating the derivatives of the state variables with respect to the design objective without the need for finite differences [2]. Thus, the adjoint optimisation is especially efficient for problems with many degrees of freedom and few design objectives, e.g. increasing efficiency. The application of the adjoint method for shape optimisation is demonstrated on the example of a centrifugal compressor impeller. The shape of the rotor blades is optimised, and the impact of different objection functions, i.e. reducing the required moment or increasing the achieved pressure ratio, and optimisation constraints, i.e. retaining the operating point or keeping an area ratio, is analysed. The results demonstrate that the compressor performance can be significantly improved using the adjoint method. However, the challenge is to obtain not only an optimised shape for operating points but also for the entire operating map. The final shapes are compared, obtained with approaches averaging the optimised shapes for operating points.

REFERENCES

- [1] E. Sundström, B. Semlitsch, and M. Mihaescu, Similarities and differences concerning flow characteristics in centrifugal compressors of different size., *Proceedings of the 5th International Conference on Jets, Wakes and Separated Flows (ICJWSF2015)* , pp. 457–464, 2016.
- [2] A. Jameson, *Aerodynamic shape optimization using the adjoint method*. Lectures at the Von Karman Institute , Brussels, 2003