The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

IMPLICIT LES OF THE TRANSONIC FLOW OVER A HIGH-PRESSURE TURBINE CASCADE USING DG SUBCELL SHOCK CAPTURING

Bjoern F. Klose[1], Christian Morsbach[2] and Edmund Kügeler[2]

[1] Institute of Test and Simulation for Gas Turbines, German Aerospace Center (DLR), Am Technologiezentrum 5, 86159 Augsburg, Germany
[2] Institute of Propulsion Technology, German Aerospace Center (DLR), Linder Höhe, Cologne 51147, Germany

Key Words: *Shock-capturing, discontinuous Galerkin, transonic turbine.*

Scale-resolving simulations are an integral part in the validation of lower-cost computational fluid dynamics (CFD) methods and, with increasing computational resources, are also becoming an attractive tool for the design process in modern-day turbomachinery. Because such flows are typically at high Reynolds numbers, possibly transonic, and strongly affected by the incoming turbulence levels, agreement of experimental and numerical results can be challenging [1]. Among the numerical methods used for these high-fidelity large-eddy simulations (LES), high-order spectral methods, and in particular the discontinuous Galerkin spectral element method (DGSEM), have become popular, as they feature reduced dispersion and dissipation errors over lower-order schemes [2]. Spurious polynomial oscillations can, however, occur at shock fronts and result in unphysical solutions. The development of shock capturing methods tailored for the DGSEM framework is an active area of research and Hennemann *et al.* [3] only recently developed a novel subcell shock capturing approach for the split-form DG method.

We present results from implicit LES of the transonic high-pressure turbine cascade VKI-LS89 under transonic operating conditions using a high-order accurate discontinuous Galerkin spectral element method. The subcell shock capturing method by Hennemann *et al.* [3] is tested and results from simulations with laminar and turbulent inflow conditions are validated against numerical and experimental results from literature. The transonic VKI-LS89 high-pressure turbine cascade is a well-suited test case for the performance of numerical tools given the plethora of numerical references available in literature and the subcell-shock-capturing method is shown to perform well by effectively reducing spurious oscillations across the shock front and acoustic waves while leaving the rest of the solution domain unaffected.

REFERENCES

[1] D. Dupuy, L. Gicquel, N. Odier, F. Duchaine and T. Arts, Analysis of the effect of intermittency in a high-pressure turbine blade. *Physics of Fluids*, Vol. **32**, 2020

[2] M. Kronbichler and P.-O. Persson, Efficient High-Order Discretizations for Computational Fluid Dynamics. *CISM International Centre for Mechanical Sciences*, Vol. **602**, Springer, 2021

[3] S. Hennemann, A. M. Rueda-Ramírez, F. J. Hindenlang and G. J. Gassner, A provably entropy stable subcell shock capturing approach for high order split form DG for the compressible Euler equations. *Journal of Computational Physics*, Vol. **426**, 2021.