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TRANSITION LOCATION EFFECT ON SHOCK WAVE BOUNDARY LAYER INTERACTION

ORGANIZER: PIOTR DOERFFER

Application of EARSM turbulence model to shock boundary layer interaction with laminar to turbulent transition

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ABSTRACT

The aim of the project on *Transition location effect on shock wave boundary layer interaction* (TFAST for short) is to improve our understanding of phenomena related to unsteady shock wave boundary layer interaction in the presence of a laminar to turbulent transition. In order to do so, both experimental and numerical investigations were conducted in close collaboration. A series of basic configurations were defined at the start of the project.
The present paper aims at describing the progress done so far on CFD aspects for two different configurations. The first one corresponds to a low pressure compressor cascade at an inlet Mach number of 1.22 and Reynolds number of 1.38 10^6. The second configuration corresponds to a high pressure turbine cascade at an exit Mach number of 1.05. Both experiment are performed by DLR (in Köln and Göttingen, respectively) based on Rolls-Royce geometrical blade inputs.

One of the biggest present challenges for CFD is to accurately represent turbulence in a complex industrial configuration. Despite their known limitations for certain flow conditions, Linear Eddy-Viscosity Models (LEVM) are widely used by industry. More advanced turbulence models are often much more demanding in term of computational resources. However, a good compromise between accuracy and efficiency can be achieved by using Explicit Algebraic Reynolds-Stress (EARSM) turbulence models. Indeed such models have proved to accurately represent secondary flows with strong adverse pressure gradient [1].

In order to investigate the capabilities of such a model to represent shock-wave boundary layer interaction in a laminar-to-turbulent boundary layer, it is here proposed to combine the

EARSM turbulence model of [2] with a transition model based on the work of [3]. This new method has been first validated against classical test cases, such as flat plate with favorable and adverse pressure gradients. Furthermore, it has been applied to the two cascades of the TFAST project and compared to standard LEVM approaches. For the compressor cascade, it appears that shock boundary layer interaction strongly depends on the three-dimensional flow structure inside the blade passage which is affected by the turbulence closure scheme used (see figure 1). For the turbine test case, the flow is more two-dimensional and less affected by the turbulence closure scheme.

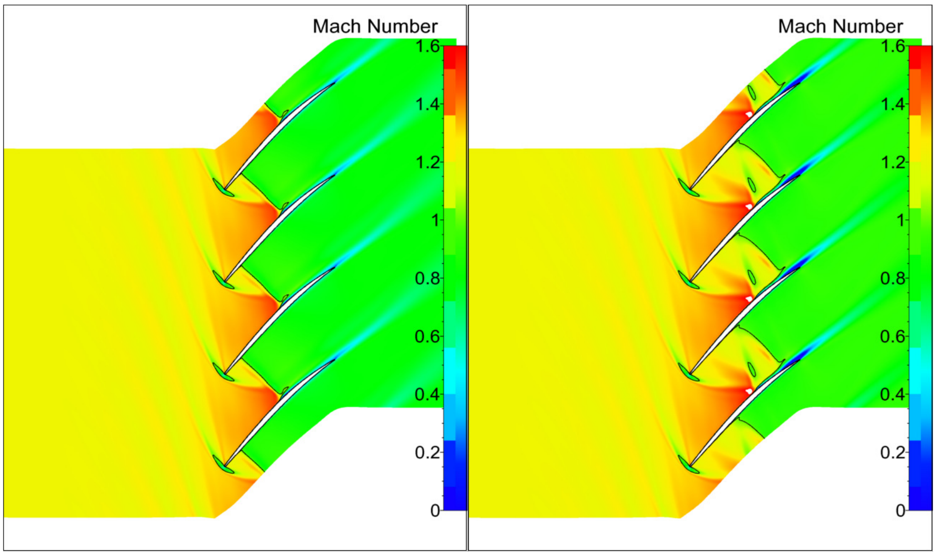

Figure 1. Mach number distribution at mid-span for the compressor cascade configuration with transition model together with EARSM (left panel) and SST (right panel) turbulence models.

[1] O.Z. Mehdizadeh, L. Temmerman, B. Tartinville, and Ch. Hirsch, "Application of EARSM turbulence model to internal flows", GT2012-68886, ASME Turbo Expo 2012, Copenhagen, Denmark, 2012

[2] F.R. Menter, A.V. Garbaruk, and Y. Egorov, "Explicit algebraic Reynolds stress models for anisotropic wall-bounded flows", EUCASS – 3rd European Conference for Aero-Space Sciences, July 6-9th 2009, Versailles, 2009

[3] R.B. Langtry, "A Correlation-Based Transition Model using Local Variables for Unstructured Parallelized CFD codes", PhD thesis, Stuttgart University, May 2006