NUMERICAL INVESTIGATION OF SQUEALER BLADE TIP LEAKAGE FLOWS IN HIGH PRESSURE TURBINES

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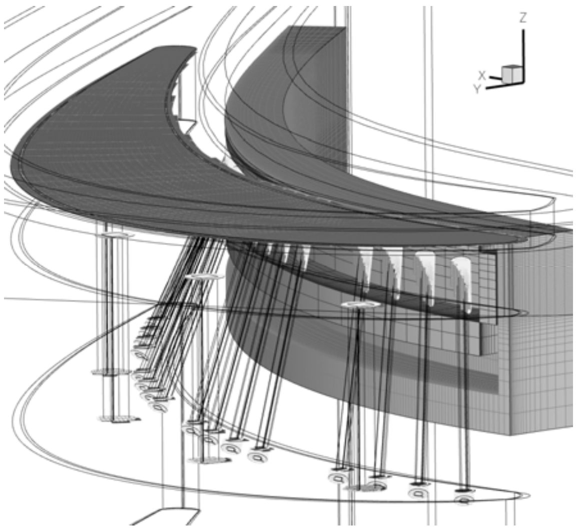
In a high pressure gas-turbine stage, the leakage flow in the gap between the tip of the unshrouded rotor and the casing is a source of significant losses. Adequately designed tip geometries – including the use of squealers, partial squealers, etc. – are supposed to minimize the mass flow through the tip-gap and thus the losses in this region. On the other hand, the high inlet temperature, which exceeds the melting point of the blade material in modern high pressure turbines, can cause a serious damage, especially in the tip region of the rotor blade, where cooling is complicated. A numerical investigation of such a configuration can help understanding the features of the flow-field and aid the future design of blade tip geometries.

The numerical campaign is a part of a EU project (AITEB-2) at the von Kármán Institute, dedicated to the thorough investigation of tip leakage flows. The current PhD study focuses on the industrial approach to the aero-thermal investigation of the tip-leakage flow phenomena. The finite volume solver elsA (developed at ONERA, France) will be invoked for the computation; it is a new and powerful tool in industrial CFD, developed to be used for the simulation of compressible flows. The software provides a flexible user interface applying the Python scripting language.

The numerical investigation is being conducted on four different blade tip geometries; with full, only suction side, partial suction and pressure side squealer, and the full configuration in worn condition. The model also includes sixteen pressure side cooling holes and four dust holes, and a plenum, which distributes the coolant between the holes. A crucial point of the modeling is the application of overlapping grids and masking. These techniques simplify the connection of large (external) and small (internal) scale flows in the domain. The validation of the aero-thermal simulations is performed against the pressure, heat transfer measurements and flow-visualizations provided by Tomaš Hofer.

The work so far focused on the modeling of the three different blade tip designs, their validation, and –since elsA was a new tool at VKI - the development of a “best-practice-experience” using the code. The future work will be devoted to the modeling of the fourth geometry, as well as to the further improvement of the heat transfer simulations quality.



(a)

(b)

Figure 1: Structured, overlapping grid with masking for TG1 (a), and numerical and experimental flow visualization on the blade tip and suction side of TG2 (b)