Turbine Stator Well Cooling - Flexible Parameterisation, Automated Meshing and Optimisation

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Long Abstract

Introduction

Over the last decades the significance of internal cooling air systems has gained more and more importance in the field of modern gas turbine engines. An improvement of the overall efficiency, and thus a reduction in engine specific fuel consumption (SFC), is achieved by an increase of gas temperature in the main gas path. These exhaust gas temperatures - coming from the combustion chamber - exceed the thermal material limit of the engine components, both within and adjacent to the main gas path. To prevent damage and to protect these components from overheating, internal cooling systems are designed. The required cooling air is bled from the compressor and introduced to the exposed cavities, which are formed by stationary and rotating walls. In order to maximise the overall cycle performance it is desirable to reduce the amount of cooling air to a minimum, while still ensuring the optimum component life. There are mainly two reasons in favour of a reduction of the cooling air: first, the higher the amount of cooling air is, the worse is the engine thermodynamic cycle performance. Second, the higher the amount of cooling air re-entering the main gas path at a later stage, the lower is the stage efficiency [1, 2].
Experiments as well as numerical simulations have shown that with the use of a deflector plate, the cooling flow is fed more directly into the disc boundary layer, allowing more effective use of less cooling air, leading to an improved engine efficiency.
As a follow up study of the work carried out during the MAGPI (Main Annulus Gas Path Interaction) project, another programme funded by the European Commission has been set up, called AMEDEO (Aerospace Multidisciplinary Enabling Design Optimisation). Within AMEDEO (project number 316394), framework 7 specifically aims towards heat transfer prediction methods and cooling optimisation in turbine stator wells (TSW).

1. Methods

This paper concentrates on a flexible design parameterisation of a turbine stator well geometry with an included stationary deflector plate as it is depicted in Fig. 1. The main focus of the work lies in the implementation of the geometry in an automatic meshing system with respect of finally executing an automated design optimisation. Special attention and effort is turned to the flexibility of the parameterisation method in order to reduce design variables to a minimum on the one hand but increasing the design space flexibility & generality on the other hand. The parameterisation makes use of a series of curves connected to each other by special rules. Each curve can be defined by a cubic B-spline which is generated from defined control points. This allows a deformation of the shape locally as well as the movement of complete structures due to thermo-mechanical engine movements. The current method provides an efficient and inexpensive means for identifying the optimum position and

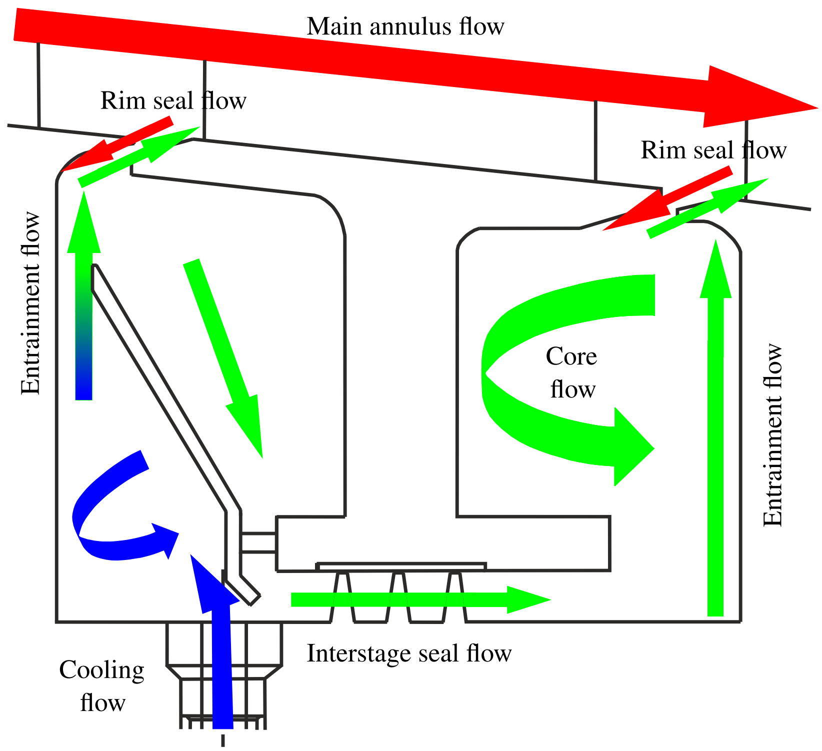

Figure 1. Stator well flow structure with stationary deflector plate

orientation of the deflector plate inside the cavity. For a successful optimisation it is essential to have an automated and efficient meshing system. The geometry created is fed into the in-house meshing code PADRAM, which then creates a 3D hybrid mesh for the purpose of carrying out RANS simulations. In a last step an automated optimisation using the multipoint approximation method (MAM) is used with the objective of increasing the overall cooling effectiveness of discs inside the cavity.

References

[1] J. Illingworth, N. Hills, and C. J. Barnes. 3D Fluid-Solid Heat Transfer Coupling of an Aero-Engine Preswirl System. *ASME Turbo Expo GT2005-68939*.

[2] D. Amirante and N. Hills. A Coupled Approach for Aerothermal Mechanical Modelling for Turbomachinery. *1st International Conference on Computational Methods for Thermal Problems*.