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CHT ANALYSIS OF THE TIP SEAL OF THE COUNTER ROTATING LP TURBINE

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Much emphasis in aviation is put on reducing pollutant emissions and fuel consumption. It is mainly associated with an increase of the turbine cycle efficiency, e.g. by minimizing the internal leakages. Research and development of the seal design are therefore very important. The most common seals in the steam and gas turbines are labyrinth seals, mainly because of their simplicity, low cost, reliability, material selection flexibility, lack of pressure limitations and tolerance to thermal variations. They are often combined with honeycomb structure

The honeycomb seal withstands high temperatures and high rotational speeds, while allowing limited rubbing of the stator fins at the rotor without the danger of seal failure. Therefore, a significantly tighter seal clearance, which represents a leakage-reducing factor, can be realized (Li et al., 2007).

The most common tool in analyzing the flow phenomena in complex geometrical configuration of the labyrinth seal are simulation methods based on CFD.

The object of the study was the tip seal with the honeycomb land of the low pressure turbine of a counter rotating aircraft engine. The seal configuration was previously optimized, what is described in (Wróblewski et al., 2010). It consists of two fins and stepped honeycomb land above the fins (Fig. 1).

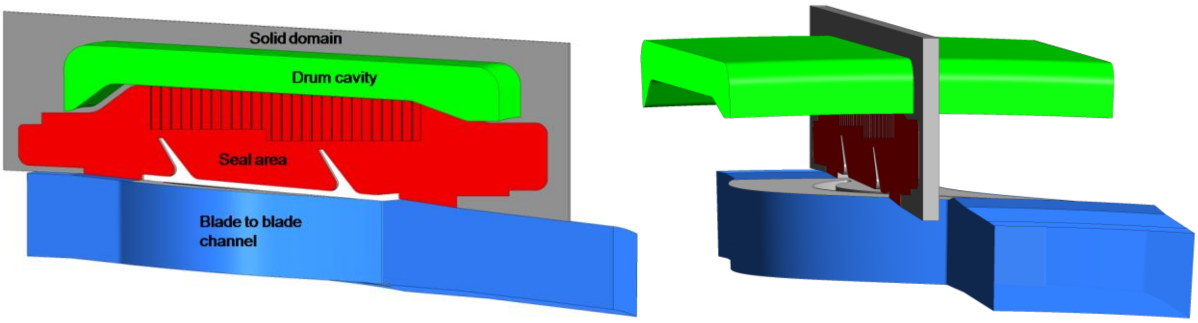

Fig. 1 Sketch of the analyzed geometry

The aim of the study was to examine the phenomena connected with leakage flow through the tip seal and CHT analysis of the whole tip area of the blade including: seal area, rotating cavity above the seal, the tip part of the blade to blade channel and solid domain (Fig. 1).

The CFD analyses were performed using the commercial software ANSYS-CFX. The area of the interest is complex and large in relation to scales of phenomena that occur, therefore very important role played definition of the calculation domain and the mesh generation. The calculation domain consisted of four periodic parts with individual pitch for each of them, which were connected with the use of appropriate interfaces. Individual pitch is important because of the reduction of the whole calculation domain. The mesh for the blade to blade channel was generated as fully structural. For the remaining parts the extruded hexa-dominant mesh was generated.

Calculations were performed using the Shear Stress Transport turbulence model with the Kato-Launder production limiter and the curvature correction. The ideal gas properties were assumed. Molecular viscosity and conductivity were specified as a function of static temperature according to Sutherland's formula. The specific heat at constant pressure was also specified as a function of temperature

The CHT analyses were performed for two cases characterized by a different thermal conductivity of the metal. At the outer surface of the solid domain a forced convection is assumed with bulk temperature T=288K.

For fluid flow such parameters were taken into account like: velocity (e.g. Fig. 1), static and total pressure, static entropy and turbulence kinetic energy, which allowed to recognize flow structures, losses and mixing. The streamline plot shows complex flow structure with many vortices, which depends mainly on the seal geometry.

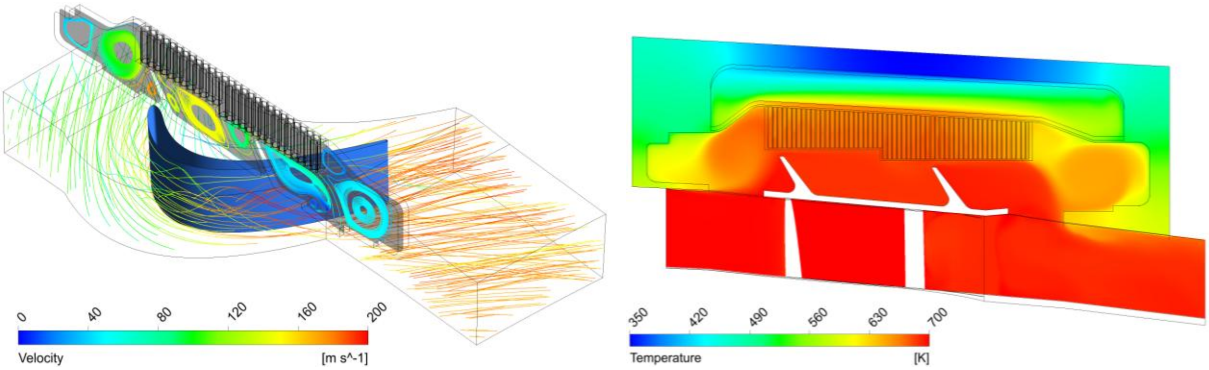

Fig. 2 Streamlines plot and temperature distribution for analyzed area

In CHT analyses the flow structures for the cavity and the heat transfer conditions were obtained. Also the temperature distribution in the whole domain was considered (Fig. 2). A relatively weak forced convection in the cavity was detected, caused by the higher temperature of the inner surface of the cavity, lower of the outer surface and relatively small radial size of the cavity. The difference of the thermal conductivity changed the temperature distribution in the solid, cavity and near the honeycomb.

References

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