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CONVECTIVE HEAT TRANSFER IN AN EXPERIMENTAL INTERMEDIATE TURBINE DUCT

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ABSTRACT

In modern commercial jet engines, turbine interducts are used to guide the flow from the small-radius, high-pressure turbine (HPT) to the large-radius, low-pressure turbine. The trend towards lighter engines with smaller engine cores and higher by-pass ratios requires shorter turbine interducts with larger radial offsets and/or larger area ratios. This imposes higher demands on the flow calculation due to the larger pressure gradients present and the risk of flow separation. Current intermediate duct designs are conservative as experimental data on the flow in intermediate ducts has not been available until recently (the lack of experimental data was part of the motivations of the EC FP6 project AIDA) and if their design is to be optimized, the heat loads on them also need to be predicted accurately.

This paper presents and analyzes the results of detailed steady heat transfer measurements in a turbine interduct with nine unloaded vanes (see Figure 1). The measurements were performed in the Chalmers large-scale turbine facility as part of the aerothermal studies of the EC FP6 AITEB-2 project. The experiment was performed under realistic Reynolds number conditions (160k, based on the duct inlet height and axial inlet velocity) and at low speed (Mach number 0.07). The distribution of the heat transfer coefficient (HTC) for a sector covering 40° (an azimuthal period) has been obtained based on temperature measurements using infrared thermography with heating provided by a water bath.

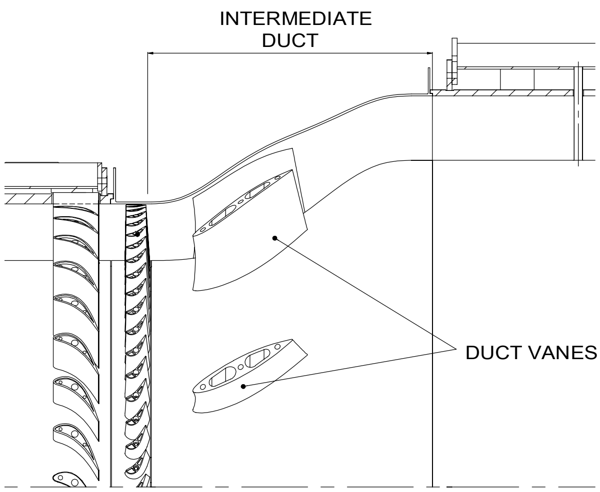

Figure 1. Intermediate turbine duct investigated.

The results (see Figure 2) show that while common correlations for the convective heat transfer on turbulent flat plate give a fairly good approximation of the levels found on the inner endwall[1], strong azimuthal variations of the heat transfer coefficient are present ("A" in Fig. 2, left) product of steady flow structures (e.g. wakes and vortical structures) originated on the HPT nozzle guide vanes ("B" in Fig. 2, right). Standard CFD practice often assumes azimuthally symmetric inlet flow (1D inlet boundary conditions produced by computations using mixing planes or by averaging measured inlet profiles) and cannot capture this effect. However, these variations, which were found to be as large as 20% *lower* should be taken into consideration for an optimized design as for instance, they might translate into large azimuthal temperature gradients and as a consequence, high thermal stresses.

In this paper, a description of the heat transfer coefficient distribution on the endwalls and vanes is given and an explanation of the features found is attempted based on the measurements of the flowfield made previously [shown in Arroyo 2008]. For example the vortex created by the interaction of the tip leakage flow with the vanes ("C" in Fig. 2, right) produces a region with high heat transfer ("D" in Fig. 2, left) as draws flow towards the endwall.

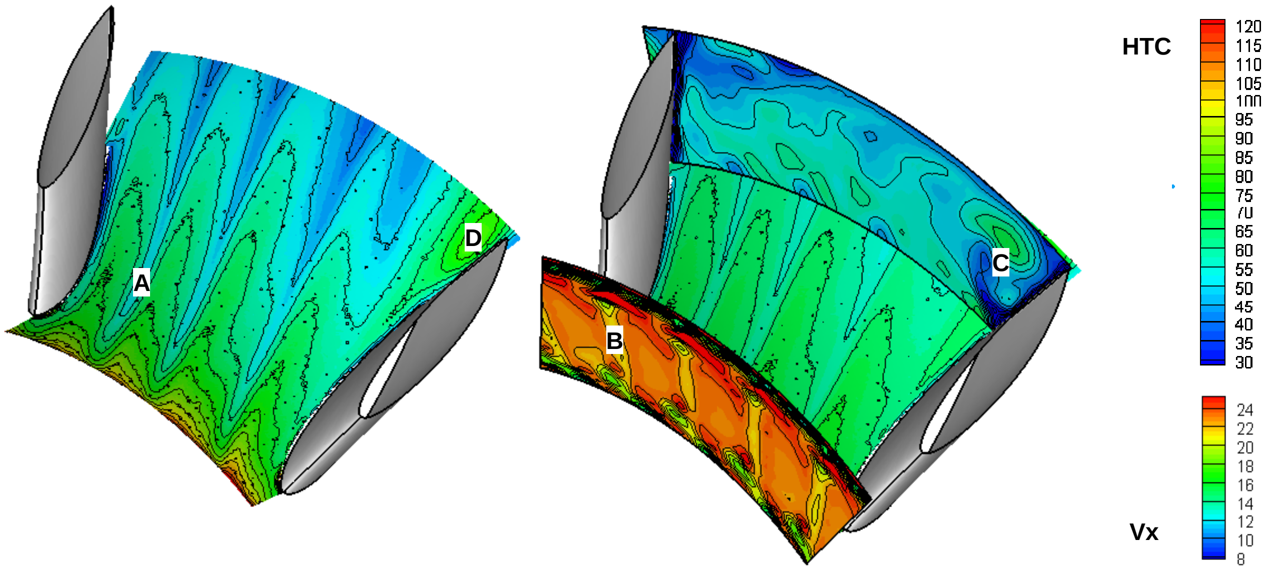

Figure 2. Heat transfer coefficient distribution on duct's hub (left), including axial velocity at two velocity measurement planes (right).

REFERENCES

Arroyo, C., Walin, F. and Johansson, G. [2008], Experimental and Numerical Investigation of an Aggressive Intermediate Turbine Duct – Part 2: Flowfield under Off-Design Inlet Conditions, *Proceedings of the 26th AIAA Applied Aerodynamics Conference, AIAA-2008-7056.*

COMMENT TO THE REVIEWER

At the submission of this abstract, the measurements of the heat transfer coefficient on both endwalls are finished. The results corresponding to the inner casing have been analyzed and currently the results

[1] Presently, only the results from the inner casing have been analyzed.

of the outer casing are being processed (the experiment is done in three separate steps: inner casing, outer casing and vanes). The measurements on the vanes will start soon and all results will be available well before July 1st.