TURBINE ROTOR HEAT TRANSFER MEASUREMENTS USING DOUBLE-LAYERED THIN FILM GAUGES

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Nowadays, temperatures as high as 1800 K are commonly encountered in civil aero engines, in the case of military engines the temperaratures go above 2000 K. Of course, no known metal can withstand such high temperatures without melting (the most advanced single crystal blade would not stand more than 1200 K)

The design of an efficient cooling system is not an easy task. The designer must limit the temperature levels in the metal (far from the melting point) to avoid creep and limit high temperature gradients leading to thermal fatigue. The external convective heat transfer around a blade, conduction heat transfer in the blade itself and the internal convective heat transfer due to the coolant flow inside the blade must be taken into account in the design stage.

The goal of this project is to investigate the convective steady and unsteady heat transfer around the rotor blade of a transonic turbine stage. Measurements have been carried out at the compression tube facility CT3 using a new technique: double layer substrate thin film gauges.

These gauges (Figure1) consist of nickel temperature detectors deposited on a polyamide sheet. Wrapped around a turbine blade, they are used to measure the wall temperature evolution during a blowdown test.

Calibration of the thermal properties of the substrates is carried out using a hot air jet and an optimization algorithm. The impact of the calibrated parameters on the heat flux determination is investigated by means of a sensitivity analysis. Spurious effects due to strain in the gauges caused by the high centrifugal forces have been detected in the initial temperature distribution of the profile before the blowdown.

Both time-averaged and time-resolved Nusselt number distributions have been obtained for the rotor blade showing good agreement with the single layer technique. The instantaneous heat transfer rate at the leading edge region where the vane trailing edge shock impinges directly is 30% higher than that of the time-averaged value at the same location.

The improved signal to noise ratio that the double layer gauge presents with respect to the single layer one leads to higher correlation coefficients and lower levels of RMS.

Therefore, the potential capabilities of this technique to capture the highly unsteady phenomena present in gas turbine stages have been demonstrated.

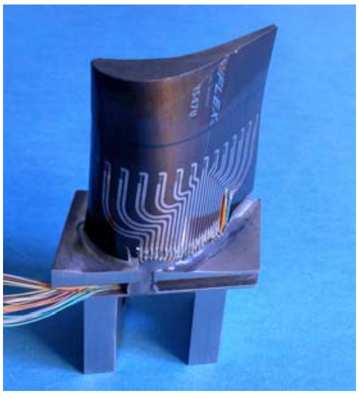

Figure 1: Turbine rotor blade instrumented with double layer thin film gauges