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Sommario

This PhD research project and the findings of its intensive experimental analysis regard various internal leading edge cooling systems designed both for aircraft engines and heavy duty gas turbines. In the last decades, research in the area of such power systems has mainly focused on the improvement of the overall efficiency and power output, making sure the strict legislative requirements which regulate pollutant emissions (particularly NOx) are observed. These aspects are related to turbine inlet temperatures (TIT) which, in recent years, have reached values far above the acceptable material temperatures of the components directly exposed to hot gases. One of the most thermally loaded regions is represented by the leading edge of the turbine blades in which more complex cooling schemes are required to keep the metal temperature at levels consistent with the design life. The present work regards an experimental survey on different scaled up leading edge cooling schemes aimed at measuring the heat transfer coefficient (HTC) inside the leading edge cavity of high pressure gas turbine blades. Several experimental models were designed in order to meet the requirements of the industrial partners, in fact a modular approach has been used to test four different external leading edge profiles with different internal impingement geometries. The

complete leading edge cooling scheme has been replicated which is, in particular, composed of ”cold bridge” systems with different jet arrangements (number of jets, shape, jet-to-jet pitches) and coolant extraction from the cavity, with different extraction hole arrays, in order to underline the influence of the coolant extraction on the internal heat transfer distribution. Detailed two-dimensional heat transfer coefficient maps have been obtained by means of a transient technique, using a TLC (Thermo-chromic Liquid Crystals) thermography in a narrow band formulation. The experiments have been performed in an engine similitude in terms of impingement jet Reynolds number, which is the main driving parameter in these internal cooling systems. The study has been carried out within the European Research Project ERICKA (Engine Representative Internal Cooling and Knowledge Applications), part of the European Union Framework Programme 7, whose overall objective is to provide a means for improving the existing turbine blade cooling technology, thus reducing the turbine blade cooling mass-flow. In this scientific framework, the University of Florence is involved in Work Package 2 which focuses on the stationary experiments in leading edge impingement cooling systems, together with its industrial partners AVIO and ALSTOM Switzerland.

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