AccuraCy Improvement of the transient heater foil technique for heat transfer tests: Preliminary Results

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Abstract

A modification and improvement of the transient heater foil method is presented using a single impingement cooling setup. The existing method using a constant heat flux at the surface to run the experiment is modified and a linearly increasing heat flux is applied, which improves the accuracy of the measurements especially in low heat transfer regions. This new procedure is in good agreement with the baseline method (heater foil with step heating) and the literature, and the accuracy of the results is improved compared to the baseline.

introduction

Nowadays impingement channels are widely used to cool gas turbine blades and vanes in regions of high thermal load. Advanced manufacturing processes such as soluble core investment casting or additive manufacturing offer the possibility of integrating complex cooling solutions like narrow impingement channels [1] in a double wall geometry [2], which can achieve very high heat transfer rates.

The impingement cooling channels usually consist of several adjacent cooling jets which are arranged in a radial direction in the turbine airfoil. This arrangement of the individual jets causes a crossflow which reduces the heat transfer performance of the downstream jets. Therefore, one of the keys for further development of impingement channel design is on reducing the crossflow. This problem can be tackled by arranging two or more channels in a cascading scheme, where fluid from the first channel can be reused in the following channel by means of an intermediate plenum chamber, thus resetting the crossflow.

RESULTS and DISCUSSION

Gaffuri et al**.** [**3]** presented a model setup for the experimental investigation of the thermal performance of these cascade channels using the transient liquid crystal heater foil technique which overcomes the drawbacks of the well-known transient liquid crystal heater mesh method for this setup. The special feature of this method is that the change in driving temperature is achieved by a thin conductive foil applied to the wall and through which an electric current is passed. The resulting temperature evolution of the surface is determined by observing the color change of a thermochromic liquid crystal coating. The convective heat transfer can therefore be determined by means of the one dimensional heat conduction equation and a semi-infinite assumption. However, this method also poses challenges, such as the increased measurement inaccuracies in the low heat transfer areas, the precise determination of the applied heat flux and the associated resistance dependence.

In this paper, improvements to the heater foil technique are presented. A metallic foil made of a low temperature coefficient of resistance is used. Additionally, instead of a temperature step like in the classical heater mesh and heater foil method, here a linear increase of the heat flux is used, which improves the measurement accuracy in the low heat transfer regions. The improved method is tested on a single impingement setup, with variations of jet to plate distance and Reynolds number. Results are compared to the baseline method (heater foil with step heating) and data from the literature **[4]** for similar configurations.

Results show excellent agreement with literature data **(Figure 1)** and the baseline method, while accuracy is increased, especially in the wall jet region, thanks to the linearly varying heat flux which results in a more regular wall temperature evolution.

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| **Figure 1. Radial Nusselt number distribution on a plate placed at a distance of 6 jet diameters from the jet exit at Re=30000, and comparison to Goldstein and Franchett [4**]. |

References

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