Numerical simulation of cooling gas injection using adaptive multiscale techniques

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Abstract

The interaction of a jet of cooling gas injected through single boreholes or slots with a supersonic flow field plays an essential role in the design of innovative cooling systems. In order to appropriately resolve the physically relevant effects an efficient and reliable solver is needed. For this purpose, a fully adaptive and parallel multiresolution finite volume scheme is used. Here grid adaptation is based on a multiscale decomposition of the discrete flow data in terms of cell averages at hand. The resulting multiscale data are compressed by means of hard thresholding. From the remaining data a locally refined grid is constructed.

For validation purposes, first a simplified two-dimensional configuration mimicking the gas injection through a slot of infinite length in a plate is investigated. These numerical results are thoroughly validated by van Driest's self-similar solution for laminar boundary layers and computations performed with non-adaptive codes. In the following, three-dimensional simulations of slots of finite length are carried out and compared with experimental data. The influence of varying rate of cooling gas, injection angle etc. on the cooling efficiency is investigated.

Keywords: Finite Volume Method, Film cooling, Cooling gas injection, Multiscale techniques, Grid adaptation

1. Introduction

In combustion chambers of rocket engines the walls are exposed to very high temperatures. In order to avoid material damage one has to resort to well-designed thermal protection system. Another application area for such systems are supersonic reentry processes. One widely-used cooling concept for problems of this type is *radiation cooling* in combination with materials with very low thermal conductivity. One disadvantage of such passive techniques is that they

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