PANS vs. LES for computations of fluid flow and conjugate heat transfer in a matrix of surface mounted cubes

Branislav Basara†

* AVL list GmbH
Hans List Platz 1, 8020 Graz, Austria
branislav.basara@avl.com

ABSTRACT

The paper compares the performance of the variable-resolution Partially-Averaged Navier-Stokes (PANS) method (Girimaji [1]) with that of the Large Eddy Simulation (LES) method for simulations of the flow in a matrix of surface-mounted cubes including the heat transfer as well. The PANS method belongs to so called bridging or seamless methods. This approach, which adjusts seamlessly from the Reynolds-Averaged Navier-Stokes (RANS) to the Direct Numerical Solution (DNS) of the Navier-Stokes equation, is gaining popularity in the Computational Fluid Dynamics, especially for simulations of complex flows. There are three main variants of the PANS model which are derived up to now, one based on the k-ε, the second is based on the k-ω formulation and the last one is based on the ζ-f model (Basara et al. [2]). The ζ-f PANS is used in the present work. In adopted approach, the filter width is controlled by specifying only one control parameter: an unresolved-to-total ratio of turbulent kinetic energy. In the practice, this parameter is defined by using the grid spacing and calculated integral length scale of turbulence. When the grid size is smaller, then more of the turbulent kinetic energy can be resolved and the model covers only an unresolved part. The same modelling principles are applied on energy equation and on the wall heat transfer. The very recent work of Basara [3] presented a well-established algorithm for the employment of the PANS and compared results with those obtained with the Reynolds-Averaged Navier-Stokes approach. The same test case was used as in this paper. The results are largely improved by using the PANS. However, in order to make a proper assessment of this relatively new approach, it is necessary to perform LES calculations as well and this is presented here. The variant of Large Eddy Simulation (LES) model known as the Coherent Structure model (Kobayashi [4]) is used for the current comparisons.

Measurements, which were explained in detail by Meinders and Hanjalic [5], were used as a reference point to the present calculations. At the measurements section, the flow is declared to be fully developed and only one cube in this region was heated. This means that the case can be set up with periodic boundaries for all equations except for the energy equation. A special focus of this work is to analyse the resolution parameter in the field and the unresolved part of the turbulent kinetic energy in order to assess where different modelling approaches should have advantages and if this is confirmed by present results.

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