LESSONS LEARNED FROM THE ERCOFTAC SIG15 COMPUTATIONAL WORKSHOPS: FLOW IN A 3D DIFFUSER AS AN EXAMPLE

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ABSTRACT

The use of Computational Fluid Dynamics (CFD) in solving fluid flow problems and those of related disciplines such as heat and mass transfer has significantly intensified over the last decades. Rapid advances in computer technology have greatly stimulated the development and application of these methods as a design or predictive aid for complex flows of industrial and environmental importance. Accordingly, CFD is playing an important role in design, development and optimization in engineering practice. At the same time, concerns regarding the fidelity and reliability of these simulations for turbulent flows have increased. To address these concerns, intensive verification and systematic validation of the CFD technology have been carried out by computing configurations of both fundamental importance and industrial relevance. The role of the European Research Community on Flow, Turbulence and Combustion (ERCOFTAC) Special Interest Group for Turbulence Modeling (SIG15) is closely connected to this issue. The task has been accomplished for years in the form of a series of relevant computational workshops. Fourteen such workshops had been organized in the past: Lyon (1991), Manchester (1993), Lisbon (1994), Karlsruhe (1995), Chatou (1996), Delft (1997), Manchester (1998), Helsinki (1999), Darmstadt (2001), Poitiers (2002), Gothenburg (2005), Berlin (2006), Graz (2008), and Rome (2009), see www.ercoftac.org. In this way, a large database of simulation results supplemented with reliable reference data from experiments, Direct Numerical Simulation (DNS) and highly-resolved Large-Eddy Simulation (LES) has been assembled. The SIG15 workshops promote the discussion and allow for conclusions about the predictive performance of a variety of turbulence models in the Reynolds-Averaged Navier-Stokes (RANS), LES and hybrid LES/RANS frameworks for a broad range of well-documented flow configurations. That represents a treasure trove for scientists and users from the academic field and from industry interested in CFD and turbulence modeling.

The activity of the SIG15 computational workshops will be exemplarily presented on the basis of the last workshop held at 'La Sapienza' University in Rome on September 18th, 2009. The flow configuration studied at this workshop was an incompressible fully-developed duct flow expanding into an asymmetric diffuser with two deflecting walls. The experimental and DNS reference data were provided by Cherry et al. (2008, 2009) and Ohlsson et al. (2009), respectively. The flow is characterized by complex three-dimensional flow separation induced by an adverse pressure gradient. All state-of-the-art turbulence modeling strategies were scrutinized and compared in detail including RANS models of various sophistication levels, LES and hybrid LES/RANS methods. Various degrees of success for different classes of models were observed and will be discussed in the presentation.