

High order scheme for compressible turbulent flows

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One of the most important challenge in Computational Fluid Dynamics (CFD) is the simulation of turbulent flow. When high Reynolds turbulent flows are combined with complex and large size geometry, computers are no longer enough powerful to deal with Direct Numerical Simulation (DNS), that is to say with the resolution of all the scales of turbulence motion [3]. Thus, at a fixed scale such as computations can be performed, one have to model the unresolved scales of the turbulence. Although there is an important variety of such models, all of them include intrinsically the turbulent viscosity as a parameter or a variable. Numerical schemes always induce an artificial dissipation that it is crucial to control, such as to be always lower to the viscosity obtained by subscale modeling of the turbulence. High order numerical approximations provide a framework where the constraint on the numerical dissipation can be achieved. Finite elements is suitable for the design of high order scheme with compact stencil that is efficient for parallel computing strategies by domain decomposition and messages passing.

The main weakness of the classical finite element method (Galerkin) is its lack of stability for advection dominated flows. We consider in this work a compressible Navier-Stokes equations combined with the one equation Spalart Allmaras turbulence model. Therefore, the numerical stability is achieved thanks to the Streamline Upwind Petrov-Galerkin (SUPG) formulation [1]. Within the framework of SUPG method, artificial viscosity is anisotropic and the principal component is aligned with streamlines. The aim is to put sufficient viscosity to get rid of instability and unphysical oscillations without damaging the accuracy of the method. The amount of artificial viscosity is controlled by a stabilization tensor τ . Besides SUPG method is also used in combination with a shock-parameter term which supplied additional stability near shock fronts [2].

We will propose some validations over 2D unstructured grids using MPI for messages passing. Navier-Stokes equations combined with the one equation Spalart Allmaras turbulence model are solved thanks to two different methods, with our SUPG scheme and with a finite volume scheme. The comparison should allow us to exhibit improvements supplied by our finite element method. Numerical results for turbulent flow over a flat plate around a RAE2822 airfoil are presented. Comparisons with litterature results are provided in both case, and the C_p curve for the RAE2822 will be compared to experimental data.

Références

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