The Finite Volume Methods for Navier-Stokes Equations

Milovan Perić

CoMeT Continuum Mechanics Technologies GmbH,

Geschwister-Vömel-Weg 3,91052 Erlangen, Germany

E-mail: milovan@continuummechanicstechnologies.de

Lecture 1:

Finite-Volume approach to flow Simulation: Advantages and drawbacks compared to alternative methods

Finite-volume methods are widely used to compute laminar and turbulent, incompressible and compressible flows. They are employed in almost all mayor commercial general-purpose CFD-codes used by industry. They have many features which make them popular with engineers, especially the inherent conservativeness and the physical meaning of most terms that need to be approximated, as well as the mathematical simplicity. However, finite-volume methods also have some drawbacks – the major one being that the complexity drastically increases if the order is higher than second. This lecture will outline engineering approach to finite-volume methods and their main features.

Lecture 2:

Computation of incompressible flows: Fractional-step methods

A large family of fractional-step methods for solving the Navier-Stokes equations exists; they are mostly used to compute transient flows. This lecture is devoted to the description of the generic approach and will also outline the possibilities to develop new versions of the algorithm which better deal with the non-linearity of the Navier-Stokes equations.

Lecture 3:

Computation of incompressible flows: SIMPLE and related algorithms

Pressure-correction methods of SIMPLE-type are most widely used in general-purpose CFD-codes, since they can efficiently deal with both steady and unsteady, incompressible and compressible flows. Although there are many versions in literature under different names, they are all based on the same idea and are actually very similar to fractional-step methods. Special attention will be given to under-relaxation techniques and the choice of under-relaxation parameters to minimize the computing effort.

Lecture 4:

Computation of flows with moving boundaries: The importance of the space-conservation law

Many flows of engineering interest involve moving boundaries. This lecture deals with methods that allow treatment of tangential and normal displacement of solid walls and the role that the space-conservation law plays. It will be shown in particular how the space-conservation law can be accounted for without computing grid velocities, and how small wall displacements can be taken into account without moving the grid.