Chapter 11
Wall-layer models for LES of separated flows

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Abstract In order to extend large-eddy simulation (LES) to practical engineering and aeronautical applications, wall-layer models are required. In the present study recent developments in this field are presented. A new version of the two-layer model (TLM) is proposed and tested in a separated flow. The TLM methodology is based on a zonal approach, in which the computational domain is divided in an outer-flow region, where the filtered Navier-Stokes equation are solved and an inner-layer, near the solid walls. In this layer a simplified set of equations is solved and the effect of all turbulent structures is modeled. A limit of the TLM formulation, as used so far, is that an algebraic turbulence model is used to parameterize the effect of turbulence in the inner-layer. Although, the results in equilibrium flows were very satisfactory, some loss of accuracy is expected in separated flows. To account for the more complex physics in this type of flows a more advanced turbulence model, namely the Spalart-Allmaras model [*Rech. Aérospatiale* **1**, 5–21, (1994)] is introduced. The results obtained for the backward-facing-step flow agree well with the reference data.

11.1 Introduction

Despite the impressive advances of Computational Fluid Dynamics in the past thirty years, turbulence remains a challenging problem. The most common numerical approach to deal with turbulent flows is to devise a model able to take into account the overall effect of turbulence on the mean flow quantities. This is the basic assumption behind the Reynolds-Averaged Navier-Stokes (RANS) approach. The RANS equations are derived from the Navier Stokes equations by using a time-average or ensemble-average operator. This procedure introduces additional unknowns that have to be modeled in order to close the system of equations. The empiricism and the assumptions that underlie the construction of such models are a major obstacle in the establishment of the RANS approach as a reliable predictive tool. This is directly linked to the fact that in the RANS methodology one attempts to calculate a turbulent flow field without actually resolving the turbulent eddies, but using a model which is linked to the mean flow only.

A different approach, which does not suffer from the above drawbacks since all scales of motion are resolved, is the Direct Numerical Simulation