Part IV
Cross-Sectional Projects

An essential prerequisite for an efficient overall integral model for the simulation of combustion chambers is, on the one hand, the efficiency of sub-models, and on the other hand, the development and efficient integration of numerical methods. The contributions dealing with this topic constitute the content of this part. Adequate optimization algorithms are developed that allow for reaching the proximity of the technical optimum with a relatively small number of complex simulations.

Chapter 10 presents a gradient-based optimization strategy which is employed involving a parallel multigrid solver for the flow and sensitivity equations.

In Chap. 11, another approach for the optimization of turbulent flows is followed by incorporating multilevel optimization algorithms. With this kind of algorithms, different levels describing a problem can be efficiently used for the optimization. Typical examples are discretization levels or models of different physical fidelity. Especially a discrete adjoint approach is applied here. The numerical results that show the efficiency of the adjoint mode and the optimization algorithms include shape optimization and boundary control examples for the Navier–Stokes Equations (NSE), Large Eddy Simulation (LES) and Reynolds Averaged Navier–Stokes (RANS) Equations.

Since LES was recognized as an attractive approach for combustor simulation due to its demonstrated superiority over classical RANS, quality of LES results has to be addressed. In Chap. 12, quality assessment studies for LES that have been carried out in simple configurations are extended to complex geometries following a dynamic quality control technique. Thereby an efficient computation of the adjunct flow equations is necessary along with efficient methods of model reduction such as Proper Orthogonal Decomposition (POD) and Centroidal Voronoi Tessellations (CVT).

The last chapter in this part demonstrates the feasibility of the overall integral model for the simulation of complex combustion chambers.