Optimization and Computational Fluid Dynamics
Preface

The idea of this book was born during the “Conference on Modelling Fluid Flow” held in Budapest at the beginning of September 2006. During this occasion, we had decided to propose and thus hold a workshop entitled “Coupling CFD with Optimisation”, based on our rapidly increasing experience with this highly interesting topic. We were nevertheless surprised to see the resonating enthusiasm displayed throughout the workshop by the conference participants.

From the discussions with all the speakers present at this workshop as well as the survey of the scope of the available books and review articles on this subject, it became easier to understand this great interest. While there is a wealth of new research projects that deal with the coupling of Computational Fluid Dynamics (CFD) and modern Optimization techniques, it is however difficult to find reference publications on this topic. There are indeed a few, excellent books available (see also the Introduction), but they are mostly restricted to aerodynamics, since this has been the first field of CFD for which optimization has become a tool of major importance. Moreover, the connection between CFD and Evolutionary Algorithms, often required when considering more complex systems of equations and physical models, has not been documented extensively.

Therefore we decided, together with the support of almost all workshop participants and a few internationally renowned newcomers, to gather and recount our experience concerning Optimization based on evaluations obtained through Computational Fluid Dynamics (a procedure abbreviated in this book as CFD-O), in order to prepare a book covering most of the relevant aspects and issues. Thanks to the hard work and constant support of all contributors, it has been finally possible to release this publication almost exactly one year after the workshop in Budapest. We hope that the interested readers will find here appropriate answers to the main questions: “What is indeed CFD-O? What simulation is today possible using CFD-O? How can I rely on CFD-O for my own applications and which approach should I choose?”
Our first research project on CFD-O was connected with the Ph.D. supervision of Mr. R. Baron at the École Centrale in Paris. He is the creator of our Optimization library (Opal) and must be thanked here for the quality of his work and for his unsurpassed motivation. The authors would furthermore like to thank Ms. Imelda Pasley for her thorough corrections of the manuscript. The quality of many graphical illustrations has been greatly enhanced by Mr. Imre Ferencsin.

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Acronyms

AGA Approximated Genetic Algorithms
AHM Adaptive Hybrid Method
ANN Artificial Neural Network
BFGS Broyden, Fletcher, Goldfarb and Shanno
CC Cross-Corrugated
CFD Computational Fluid Dynamics
DNS Direct Numerical Simulation
DOE Design of Experiment
DOF Degrees Of Freedom
EA Evolutionary Algorithm
ES Evolution Strategies
FEA Finite Element Analysis
FOPD Fiber Orientation Probability Distribution
GA Genetic Algorithm
HOCS Headbox Optimization Control Simulator
LES Large-Eddy Simulation
LSD Low Solidity Diffuser
MD Machine Direction
MDO Multi-disciplinary Design Optimization
MG Multigrid
MOEA Multi-objective Evolutionary Algorithm
MOGA Multi-objective Genetic Algorithm
NSGA Nondominated Sorting Genetic Algorithm
NURBS Non-Uniform Rational Basic Splines
OF Objective Function
PDE Partial Differential Equation
POF Pareto Optimal Frontier
RANS Reynolds-Averaged Navier Stokes
RBF Radial Basis Function
RSM Reynolds-Stress Model
SA Simulated Annealing
VEGA Vector Evaluation Genetic Algorithm