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ERCOFTAC Series

Progress in Wall Turbulence: Understanding and Modeling

Proceedings of the WALLTURB International Workshop held in Lille, France, April 21–23, 2009

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Foreword

Over the years, the issue of turbulence has attracted the attention and skills of many researchers, maybe because of the complexity of turbulent flow and the challenge that its understanding represents for scientists. Between the von Karman analytical expression for turbulent boundary layers profiles and the analysis of the results of Direct Numerical Simulation (DNS), this understanding has considerably progressed. Among the different regions of the boundary layer, the wall region is particularly challenging because the dimensions are getting so small that it is difficult to investigate it experimentally.

Wallturb, a European Synergy for the Assessment of Wall turbulence, is the first European Commission funded collaborative project that addresses near wall turbulence. During more than 4 years, 16 European partners have collaborated on this topic.

The project generated considerable amount of new data, from both experiments and DNS computations. Improved measurement techniques (e.g. high resolution Particle Image Velocimetry), high density time resolved instrumentation and scaled up experiments gave researchers access to a level of detail never achieved before. A number of test cases were investigated, including the presence of adverse pressure gradients and separated flows. Thanks to the availability of large computing resources, DNS computations could be carried out at levels of Reynolds number never computed before. All the data generated was made available for researchers in the form of databases.

In parallel, other groups were working on the turbulence modelling aspects including Reynolds Average Navier–Stokes methods (RANS), Large Eddy Simulation (LES) as well as an innovative Low Order Dynamical Systems method (LODS). Comparison between experiments and computations highlighted strengths and weaknesses of the different approaches.

But what is the rational for a better understanding and for improved prediction methods if these are not used for practical applications? This is where the two industrial members of the consortium brought their needs and a challenging application: the prediction of the friction coefficient, which is directly dependent on the velocity profile at the wall, around the wing of an aircraft. Accurate prediction of the friction coefficient means accurate prediction of drag and thus of fuel consumption.

Wallturb has demonstrated that the (sometimes turbulent) mixing of academia, research centres and industry, and, the associated diversity of views and approaches, resulted in the creation of new knowledge and a realisation that the fertility of applied research is dependent on knowledge created by more upstream research. The project has clearly contributed to pushing the boundaries of understanding closer to the wall, at higher levels of Reynolds numbers and under conditions representative of aeronautical applications. This has lead to a better accuracy of the different prediction methods, ranging from those used in academia to those used in industry.

The final workshop was the occasion to share this new knowledge developed in the frame of European cooperation with other parts of the world, whose representatives acknowledged the high quality and innovativeness of the work performed. These proceedings of the final workshop attest to the quality of the work and advances that have been achieved during the project.

Brussels *Rémy Denos*

Preface

This book is gathering the contributions of most of the participants to the WALLTURB workshop on "Understanding and modelling of wall turbulence" held in Lille (France) on April 21st to 23rd 2009.

This workshop was organized by the WALLTURB consortium, as a final open workshop of the WALLTURB project, in order to present to the relevant scientific community the main results of the project and to stimulate scientific discussions around the subject of wall turbulence.

The workshop assembled 105 participants from all over the world, 7 invited lecturers and 46 contributions from which 27 where presented by the WALLTURB consortium as an output of the WALLTURB project.

This workshop was an opportunity to review the recent progress in theoretical, experimental and numerical approaches to wall turbulence. The problems of zero pressure gradient, adverse pressure gradient and separating turbulent boundary layers were addressed in detail with the three approaches, using most advanced tools in each of them.

This book is gathering papers from most of the contributors to the workshop. It is aimed as being a milestone in the research field, thanks to the high level of the invited speakers and the involvement of the contributors. It is also aimed at being a testimony of the achievement of the WALLTURB project.

Lille, Madrid, Melbourne

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