

# Book Review

## **Recent Developments in Turbulence Management**

K.-S. Choi (ed.), Kluwer, Dordrecht, The Netherlands, 1991, 339 pp., \$99.00

This is the sixth book of the series Fluid Mechanics and its Applications. Appearing in this series thus far are two monographs and four meeting proceedings. The present volume belongs to the latter category and is a collection of 16 papers chosen from among 29 presented at the Fifth Annual European Meeting on Drag Reduction in Engineering Flows, held in London, November 15-16, 1990. According to the editor, written versions of the talks were requested only after the meeting, and were reviewed anonymously by reviewers whose names are listed at the end of the book. A final selection and acceptance process resulted in the present book.

Six papers are presented in the volume on different aspects of research on riblets, two on large-eddy breakup devices (LEBUs), two on surface roughness, four on compliant coatings, and two on dilute polymer solutions. (In the meeting itself, the corresponding numbers of papers were 9, 11, 3, 4, and 2, respectively.) The panel discussions that took place near the end of the conference were edited and appear in the last section of the book.

Turbulence management is a very broad subject, yet the meeting focus was fairly limited. Drag reduction, the main emphasis of the conference, is only one of several beneficial goals in managing a turbulent boundary-layer flow. For achieving that single goal, there are many more tools available than the four techniques discussed in the present volume. Moreover, management of free shear flows is not considered in any of the articles. The title of the volume is, therefore, a bit misleading.

The papers on riblet research in Sec. I cover the following topics: a wind-tunnel test with a 1:4.2-scale model of a commuter aircraft (prepared by J. G. TH. Van der Hoeven and D. W. Bechert); riblet effects on rates of convective heat transfer (by K.-S. Choi and S. Hamid); riblet performance in three-dimensional wall-bounded flows (by E. Coustols); numerical simulations of laminar and turbulent boundary layers with riblets (by L. Djenidi, L. C. Squire, and A. M. Savill); riblet effects on bursting events in the near-wall region of a turbulent boundary layer (by A. D. Schwarz-Van Manen, R. Hoogsteen, J. C. Stouthart, K. Krishna Prasad, and F. T. M. Nieuwstadt); and a water tank experiment with microgrooves (by F. T. M. Nieuwstadt, W. Wolthers, H. Leijdens, K. Krishna Prasad, and A. D. Schwarz-Van Manen).

The verdict on riblets appears to be that drag reduction is achievable even under field conditions, but the magnitude is a rather modest 2-3%. Heat transfer rates, on the other hand, seem to be substantially enhanced by the presence of the longitudinal grooves. This is particularly significant because the gain is not accompanied by the usual drag penalty.

Section II on LEBUs includes a theoretical and experimental study of the energy density spectra of the outer region of a manipulated turbulent boundary layer (by E. Augier, H. M. Atassi, E. Alcaraz, F. Ladhari, and R. Morel) and a brief review of the subject (by S. Tardu and G. Binder). The verdict on outer layer devices is not as promising as that on riblets. The former leads to net drag reduction at Reynolds numbers (based on the device's chord) characteristic of laboratory studies, but not at the much higher values typically found in practice.

The two articles comprising Sec. III are on the drag reduction of a *d*-type rough wall using thin ribs placed within the spanwise grooves (by H. Osaka and S. Mochizuki) and on the drag penalty associated with different roughness parameters typical of ship hulls (by R. L. Townsin). It is clear that although many practical surfaces are more or less hydraulically rough, smooth-wall research continues to dominate the available literature.

Compliant surfaces are treated in Sec. IV. A paper by P. W. Carpenter, A. D. Lucey, and A. E. Dixon provides an optimization scheme for selecting transition-delay coatings. A theoretical article by J. S. B. Gajjar discusses the nonlinear spatial/temporal evolution of traveling wave flutter modes commonly observed on compliant coatings when subjected to sufficient pressure fluctuations. Two papers from the former Soviet Union deal with "recipes" for modeling and choosing drag reducing coatings for turbulent flows (by B. N. Semenov) and an experimental verification of the same model (by V. M. Kulik, I. S. Poguda, and B. N. Semenov). Whereas there is now ample evidence that certain compliant surfaces are capable of substantial delay of laminar-turbulent transition, finding a coating that would lead to a reduction of the skin-friction drag in a turbulent boundary layer is still a very elusive task, despite frequent claims to the contrary.

Both papers in the polymer additives section are from the same laboratory that produced the last two articles in Sec. IV. The first paper in Sec. V, on perspectives of drag reduction in dilute polymer solutions, is by B. N. Semenov; and the second, on time-dependent Toms' effect, is by V. M. Kulik and B. N. Semenov. Polymers continue to offer the greatest potential for substantial drag reduction in turbulent liquid flows. Any remaining problems are mostly practical in nature, and might require more application-oriented research for finding appropriate solutions.

Finally, there were three panel discussion groups: applications of drag reducing devices, recent developments, and future research requirements. Their relatively brief canvass, at least in the edited version available in the present book, is perhaps a reflection of the limited scope

of the entire meeting. I did not find the comments made in this section particularly enlightening or visionary.

Limiting the number of presentations and/or papers is understandable when trying to keep the meeting and the book to a manageable size. But, curiously, 25% of the 16 articles in the book were written or cowritten by one particular researcher. It so happens that these same four papers are neither technically convincing nor well written. This raises questions regarding the rigorousness of the reviewing process employed.

No ground-breaking results are presented in the volume. Nevertheless, the papers are generally up-to-date

in their coverage. The level of detail and thoroughness varies. The articles are intended to provide the latest results rather than review a particular subject. As such, the book is geared toward specialists who already know the specific area of research. Although not quite on a par with journal papers, the articles, except for the four papers mentioned above, are reasonably well written.

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