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Book review

"*Closure strategies for turbulent and transitional flows*", Brian Launder and Neil Sandham (Eds.), Cambridge University Press

This book is an outgrowth of a six-month Programme in Turbulence held at the Newton Institute in Cambridge in 1999, a programme resulting from an Initiative on Turbulence by the UK Royal Academy of Engineering, an admirable action. The Editors are Professors B.E. Launder of the University of Manchester Institute of Science and Technology and N.D. Sandham of the University of Southampton. Professor Launder has long been associated with second moment methods for the analysis of turbulent flows having published in 1972 with Hanjalic the pioneering paper on the subject.

The editors have facilitated a reviewer's task by providing an Introduction which completely sets forth the contents. We provide a brief summary thereof with comments deemed appropriate. The book consists of three parts. Part A involves ten chapters dealing with methods of analysis. The first six concern the usual methods of single point closure ranging from the commonly employed k–ε method and its variants to the second moment methods which largely differ from one another by the models of the pressure–velocity and pressure–rate-of-strain correlations and of the influence of walls on those correlations. Chapter 6 concerns turbulent flows involving heat transfer but under the limited circumstance of no coupling between the velocity and thermal fields. Thus the interesting cases of coupled fields are not dealt with. Chapters 7 and 8 concern direct numerical simulations (DNS) and large eddy simulations (LES); the former approach is important for providing under highly idealized and low Reynolds number situations details of turbulence impossible to obtain experimentally. LES which should be considered an approach intermediate between the Reynolds averaged Navier–Stokes (RANS) and DNS gives promise of providing an alternative to RANS for flows of applied interest and is currently the subject of intense development at many centers of turbulence research. The first part of the book concludes with Chapters 9 and 10. The former concerns multipoint closures and the latter an introduction to turbulent reacting flows with emphasis on the determination of mean density by means of univariate pdf's. The interesting and important influence of heat release on the turbulence is not discussed.

Part B of the volume concerns applications of single point closures and LES to a variety of turbulent flows, generally more complex and subject to greater errors than those treated in less advanced texts. Thus Chapter 11 relates to separated and impinging flows while Chapters 12 and 13 discuss the capabilities of LES. Of interest here is opposing views on the extent to which LES will replace RANS in industrial settings. Given the current reluctance to employ even second moment methods in such settings, this reviewer is inclined to be pessimistic about wide acceptance of LES but this prospect should not and certainly will not discourage its development. Horizontal

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shear flows involving coupling between velocity and thermal fields are the subject of Chapters 14 and 15. The observation is made here that in horizontal flows the coupling between the fields results in greatly altered transverse exchange in contrast with flows aligned with gravity, an interesting but upon reflection a not unexpected result. Chapters 16, 17 and 18 are concerned with bypass turbulence; the situation considered differs from that associated with our usual perspective of a laminar boundary layer with a quiescent external stream becoming unstable and going over into a turbulent boundary layer as a consequence of a variety of factors, surface roughness, surface curvature etc. Here the laminar boundary layer is exposed to a turbulent external stream as, for example, on turbine blades in rotating machinery and becomes turbulent as a result. The treatment of this phenomenon by various means including DNS/LES and special modelling is discussed in these chapters. Chapter 19 is concerned with the modeling of compressible flows and with the interesting phenomena connected with such flows, e.g., the alteration of turbulence in passing through a shock wave. In the analysis of high speed turbulence the benefits of utilizing Favre averaging are significant. Turbulent reacting flows are again considered in Chapter 20 with emphasis here on direct pdf methods for the composition variables. Calculations of this nature require Monte Carlo methods and thus capabilities significantly different from those called for in RANS. In the approach described in this chapter the associated velocity field is assumed to be given by RANS so that the uncertainties in the modeling of pressure–velocity and pressure–rate of strain effects in reacting flows where the pressure fluctuations are associated with the powerful effects of heat release arise. In more elaborate direct pdf methods in which the state variables and the velocity components are determined by a single pdf those same uncertainties arise.

Part C is concerned with the olympian matter of ''future directions'', topics currently outside of the mainstream of turbulence studies. Chapter 22 deals with the problem mentioned earlier, namely horizontal shear flows involving strong coupling between the velocity and thermal fields. Here an unsteady second moment calculation loosely related to a LES is found to capture the essential elements of the flow field. Chapter 23 also concerns the estimation of velocity pdf's from information on the higher moments. Separation bubbles at suitably low Reynolds numbers so as to be amenable to DNS are discussed in Chapter 24. Recent developments in LES and the issues to be addressed for this method to be reliable are treated in Chapter 25. Finally Chapter 26 concerns recent developments in two point closure.

This is a useful and valuable volume setting forth a variety of current, state-of-the art perspectives on the treatments of turbulence in engineering settings. The contributors are all leading research workers so that the topics discussed may be considered to be treated definitively. Finally, the book has been beautifully produced by Cambridge University Press.

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