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REVIEW

Turbulence Modelling for CFD. By D. C. WILCOX. DCW Industries Inc., 1993. 460pp. $75.

This volume aims at giving the postgraduate student or professional engineer with interests and some experience in aeronautical computational fluid dynamics (CFD) the essentials of the origins, form and performance of engineering turbulence models. While the author is especially known, through his journal papers, for the advocacy of a particular turbulence model, a diversity of strategies is covered in this volume. It is true that his prejudices start to show when conclusions are drawn, but the virtues of finding the characteristic turbulent time scale by using an equation for ω (the reciprocal of the time scale) rather than the usual equation for ϵ (the energy dissipation rate) are real enough provided one confines attention to simple boundary layers as, to the disappointment of the reviewer, this volume largely does.

Besides the text, a disc is provided for the user to test different models on some half-dozen cases covering boundary layers and free shear flows. Mr Kazuhiko Suga at UMIST kindly tried out the software for me and reported no operational difficulties.

The book is organized in eight chapters. The first two of these are brief, one concerned with scene setting, the other with obtaining the Reynolds equations and, curiously, the stress transport equations. I say 'curiously' because, while explaining the global behaviour of turbulent shear flows in different circumstances through the varied forms of the stress-generation tensor *does* provide a good route to introduce the subject, the text entirely eschews this opportunity. Instead, after two pages of algebra, the chapter ends with the comment: 'This exercise illustrates the closure problem of turbulence'. In fact, it also helps explain the approach taken for the rest of the book: a series of recipes for satisfactorily cooking the CFD cake in different flows.

Chapter 3 is concerned with algebraic models. The fact that this represents the earliest type of closure is strangely echoed in the style adopted. The treatment could almost have come out of Schlichting's *Boundary Layer Theory* with a 1960s style of derivation of the mixing-length hypothesis and a focusing on similarity solutions for simple free shear flows.

Chapter 4, running to nearly one hundred pages, provides the core of the book. It starts with one-equation treatments then moves on to focus on the k-ϵ and k-ω two-equation models with a passing mention of other schemes, too.

Chapter 5 is a welcome and unusual addition, especially important for aeronautical engineers, concerned as it is with compressibility effects. There are in fact several distinct effects to be accounted for: genuine compressibility effects on *turbulence structure*, changes in turbulence passing through a shockwave, viscous-layer effects associated with intense density gradients, and separated flow induced by shockwaves. Only the first two are intrinsically compressible flow phenomena; the latter two arise in an incompressible flow given a similar mean velocity field. This distinction is not well drawn in the text but, arguably, to disregard such matters may be helpful within the overall recipe-book treatment adopted.

Chapter 7 provides a brief exposure to some of the many numerical problems associated with solving the modelled transport equations. It is especially concerned with scalar equations (k and ω, say) and with their solution in a boundary layer context rather than separated flows. Thus, the not inconsiderable problems arising in the use of stress transport closures in separated flows are not even approached.

The provision of stress transport models (rather than their numerical treatment) is in fact the main subject of Chapter 6 entitled *Beyond the Boussinesq Approximation.* For me it was the least successful of the chapters as manifestly so much more could have been done. Indeed, one disadvantage of writing a practical textbook on a fast-moving subject is that it is hard to avoid sounding out of touch from the moment of publication. To me the principal omissions in the present text are: Shima's simple low-Reynolds-number stress transport model that has been attracting considerable use in difficult two- and three-dimensional flows (Shima 1993); any meaningful account of 'new' developments in stress transport modelling, using nonlinear pressure–strain models – a trend stimulated by the venerable old paper by Lumley (1978); an up-to-date presentation of nonlinear viscosity models which, for many difficult flows, can give as good accuracy as a stress transport model for virtually the price of a linear eddy viscosity model (Craft *et al.* 1993); and any mention of the work by Schiestel or others on multi-scale modelling where *two* scale equations are solved rather than one (a practice that is eminently sensible in complex flows where one may, in any event, be solving six transport equations for the stress components).

Some of these matters *are* examined more closely in Schiestel's own recent textbook, Schiestel (1993); but that volume, besides being inconsiderately written in French, presumes a competency and interest in mathematical analysis that is not found in most English-speaking CFD practitioners. For those, Wilcox's text provides a helpful acquaintanceship with some of the more popular engineering turbulence models, after which those wanting either to go further, or simply to expose themselves to a *different* set of prejudices, will at least be equipped to plunge into the journal literature themselves.

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