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BOOK REVIEWS

P. BRADSHAW. **An Introduction to Turbulence and its Measurement.** Pergamon Press, Oxford (1971). pp. 218. £2.50.

EVERYBODY admits that turbulence is a statistical phenomenon but there is still only a limited number of studies which treat the turbulence problem statistically. It is true that only recent developments in electronics and digital computers have made possible a really statistical approach to the turbulence problem, both from the analytical and the experimental aspects. At present, however, in all but the simplest flows, prediction procedures are forced to introduce parameters of the fluctuating motion and designers are obliged to be concerned with fluctuating loads on the structure in their calculations. A graduate student or an experimentalist, for whom the book is intended, who has been assigned a turbulence project should therefore be aware from the very beginning that he is dealing with a statistical phenomenon which could be treated statistically. The introduction of the statistical concept in a book intended for beginners to turbulence research makes this book highly valuable. It is the right book at the right time.

The first part of the book is concerned with the basic physics of turbulence and the definition of the quantities to be measured; the second part deals with measurement techniques and signal analysis. The chapter on the Physics of Turbulence is based on the analysis of the Navier–Stokes equations and the "vortex stretching" model of turbulence. The chapter on Measurable Quantities is mostly concerned with turbulence parameters compatible with the "vortex stretching" concept. The statistical analysis is mainly based on the power spectra and correlations, the probability density distribution analysis being somewhat neglected. The intention to make the book self-contained rather than to recommend a separate book on statistics should, however, be highly appreciated. It is rightly pointed out that books on statistics tend to concentrate on Gaussian theory while, unfortunately, one of the basic characteristics of turbulence is the departure from the Gaussian distribution. A chapter on the Examples of Turbulent Flows, which follows, includes flows ranging in complexity from grid-turbulence to separated flows. A reader might possibly expect to find in it more measurements of the statistical quantities defined in the preceding chapter, instead of the mainly mean flow results presented. This would be more consistent with the intention to introduce the statistical concept in the book. However, the author points out that he is unwilling to present results without a critical analysis, and the absence of the results on the fluctuating motion parameters could then reflect the state of the art in experimental turbulence research. Also, the reader is referred to original papers on various flows where the missing data can be found.

The second part of the book is concerned with measurement techniques and, what is very important, the analysis of fluctuating signals. Velocity measurement methods are dealt with in great detail. There is also a chapter on temperature fluctuation measurements, while pressure fluctuation measurements—and only those on the walls—are treated on slightly more than one page, although some methods of in-stream pressure fluctuation measurements already exist.

Regarding velocity fluctuation measurement methods in general, it could be remarked with regret that the very low velocity range, which is important in natural convection and viscous sublayer studies, is not treated in the book. Of all the velocity measurement techniques the hot-wire anemometry, quite naturally, receives most of the author's attention due to its suitability for statistical measurements and its stage of development. It has to be pointed out, however, that almost all other velocity fluctuation measurement methods are either discussed briefly or the reader is referred to the original papers. This includes the methods which have received attention quite recently, such as Doppler-shift or Pulsed-wire Anemometry. The hot-wire technique, as applied to the moderate and high velocity range, is dealt with in great detail, and all the important problems of its application, together with much useful advice, are mentioned. Problems associated with the measurement of very low velocities, such as: calibration, high non-linearity of the signal, "wall effect", etc., are, however, left out. It is regretable, also, that the influence of high intensity fluctuations on the signal is interpreted conventionally rather than on a statistical basis. Of the temperature fluctuation measurement methods, only resistance thermometry is treated in some detail. This is, of course, the best available method as it leads to the possibility of simultaneous velocity and temperature measurements.

A chapter on the Analysis of Fluctuating Signals gives additional value to this very useful book. Here again, the author is consistent in making the book self-contained rather than to recommend separate readings on signal analysis. Of course, analogue techniques are given the most attention, as these techniques are more likely to be used by beginners in turbulence research. However, the importance of digital recording and analysis for advanced statistical analysis is fully recognized, and a short introduction to digital methods is provided.

Z. ZARIĆ

Boris Kidrič Institute, Beograd.