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BOOK REVIEW

Hot-Wire Anemometry: Principles and Signal Analysis

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Abstract

Hot-wire anemometry (HWA) is one of the basic measuring techniques used by research scientists and engineers working in fluid mechanics. It is applicable to a wide variety of flows from studies of atmospheric phenomena to investigations of supersonic flows. HWA is an indirect measuring technique based on the heat transfer from a sensing element and for this reason is very sensitive to ambient variations in the temperature. The use of HWA is therefore not usually recommended for the measurement of mean flow properties. However, owing to the fast response and good spatial resolution of the technique, it is irreplaceable for investigations of rapidly varying flows and especially turbulence. Different modes of operation of the hot-wires permit measurements of velocity, temperature and concentration at a modest price and effort which makes the technique attractive and profitable in many situations. In spite of tremendous developments of other measuring techniques over the past two decades, particularly optical techniques such as laser-Doppler anemometry (LDA) or particle image velocimetry (PIV), HWA retains a number of distinct advantages which ensure its present and future use. Hans Bruun has written a comprehensive book which provides a state-of-the-art survey on developments and use of HWA. In many details the book complements the classical monographs of Corrsin (1963), Melnik and Weske (1967) and the more recent contributions to the subject from Perry (1982) and Lomas (1986).

The author approaches the subject in an easy to read, straightforward manner, starting with the basic principles of HWA. He avoids putting much effort into describing the electronic arrangements or compensation networks, concentrating on the heat transfer considerations and the time/space resolution capabilities of HWA for turbulence measurements. The author proceeds with a general introduction to the velocity measurements. The material is informative and introduces topics such as the response equations used for HWA signal interpretation and methods for data acquisition, processing and presentation. Separate chapters are devoted to one-, two- and three-component velocity measurements. The author continues at considerable length with all necessary information about HWA for conducting measurements, including probe design and manufacture, aerodynamic effects of prongs and probe support, calibration techniques and signal interpretation. The emphasis is placed on methods which have been successfully used in turbulence

research in the past.

Temperature effects and measurements of the temperature fluctuations are presented in chapter 7. A good account is given of the methods for correcting hot-wire readings for drift in the ambient fluid temperature. The text also covers the resistance-wire method for measurements of the instantaneous temperature fluctuations. The author dedicates a separate chapter to hot-wire techniques used for investigating reverse flows and near-wall flows. The pulsed and flying hot-wire techniques as well as the split film probes are discussed in detail. A brief account is also given of other interesting attempts to extend the applicability of HWA to flows of high turbulence intensity. This chapter ends with an extensive analysis of near-wall hot-wire measurements and the determination of the wall shear stress.

The author summarizes in a separate chapter successful extensions of the HWA technique beyond conventional applications. The material covered includes the determination of the void-fraction and turbulence properties in two-phase flows, evaluation of concentration fluctuations in gas mixtures and turbulence measurements in compressible flows.

Vorticity measurements are discussed in chapter 10. These are of special importance to turbulence modelling since the vorticity is directly related to the turbulent dissipation rate. Modelling of the transport equation for this quantity seems to be the weakest link in the existing turbulence models used for engineering applications (CFD). This is good discussion of instantaneous velocity gradient measurements in turbulent flows and a good description of basic and more recent complex hot-wire configurations used for the vorticity measurements.

The last two chapters deal with conditional sampling and time series analysis of turbulence fluctuations. There is plenty of interesting material related to processing and averaging signals measured in periodic flows, intermittency measurements and identification of coherent structures in turbulent flows. The closing chapter provides a useful survey of conventional statistical analysis of random signals in amplitude and phase domains. The list of the references at the end provides a complete overview of virtually all important studies related to HWA published to date.

This is an excellent book written in a clear and readable style suitable for students, research scientists and engineers. The text is well supported by mathematical analysis and, whenever necessary, with adequate illustrations and diagrams. I highly recommend the book to everyone working in the field of experimental fluid mechanics. It should be obligatory reading for students involved in turbulence measurements.

J Jovanovic

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