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MULTIPLE HOT-WIRE PROBE MEASUREMENTS OF TURBULENT VELOCITY AND VORTICITY VECTOR FIELDS

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The book provides specific information that covers vacant space in voluminous literature related to hot-wire anemometry. It is focused to the theory and practical aspects of the application of multiple hot-wire anemometer probes, specified for measurements of turbulent velocity and vorticity vector fields, as well as for measurements of dissipation tensor of turbulent kinetic energy. The importance of such experiments is based on their crucial role in understanding the mechanism of generating, developing and decay of the turbulent flows and further advancement of the mathematical models of turbulence.

The manuscript is organized in eight chapters, with list of 268 references that include a majority of relevant publications related to development of this sophisticated measurement method. The book is illustrated with 131 figures. The content is so divided that it corresponds to suggested logical structure made: "Introduction", "Turbulence and its measurement", "Constant temperature hot-wire anemometers: General principles and signal analysis", "Measurements of turbulent velocity fields by multiple hot-wire probes", "Measurements of turbulent vorticity fields by multiple hot-wire probes", "Operational properties of the vorticity-type and hot-wire probes for velocity measurements", "Generalized numeric procedure", "Conclusions".

"Introduction" includes a short review of the manuscript and motives for its writing. The importance of up-to-date contributions in development of anemometer probes with multiple sensors, as well as the place of some own authors contributions in this area are also indicated.

"Turbulence and its measurement" and "Constant temperature hot-wire anemometers: General principles and signal analysis" provide fundamental information that is useful especially for the beginners, since it enables to comprehend the complex theory presented in further chapters, related to modern exotic and rare measurements that utilize the multiple hot-wire probes.

Extremely complex nature of turbulent flows is clearly described in the second chapter, indicating its stochastics and coherent structure. Accurate definitions of its basic specific properties enable the beginners to completely understand subtle differences between the turbulent and other flows and importance of turbulence research from the theoretical and practical engineering point of view. Detailed comparison review of the two most important methods specified for turbulence parameters measurement, hot-wire anemometry and Laser-Doppler anemometry is also presented here. The conditions and

fields of application for which each of these methods is superior are listed, showing that these two methods are not only direct competitors, but also complements: each of them have provided important results in understanding the complex nature of turbulence in the flows in which the specific method is superior.

The basic theoretical principles of hot-wire anemometer, primarily related the foundations of hot-wire anemometry in its standard and classic applications (i.e. related to the probes possessing one or two sensors), are also explained here. The sensor cooling mechanism (i.e. relations between the voltage drop along hot-wire and the instantaneous fluid velocity vector, basic electronic schemes and principles of primary signal interpretation procedures are presented. Simultaneously, all limitations of measurements, based on application of simple probes possessing one or two hot wires, are indicated, providing the arguments for writing the further text. Presented information is very useful from the practical point of view, because it can be used as some kind of "instruction manual" for application of standard commercial hot-wire anemometers, a necessary step in reaching more complex measurement techniques based on the multiple hot-wire probes.

The fourth chapter, entitled "Measurements of turbulent velocity fields by multiple hot-wire probes", entrances the central area of the book, related to the theory and practice of using the multiple sensor probes specified for measurement of instantaneous turbulent velocity vector components, their higher-order moments and gradients. The four-wire probe is chosen for the central theme, because it represents the basic element of all later discussed hot-wire probes. The design and manufacturing of the four-wire probes are explained in detail, as well as the theoretical foundations of their application, including the influence of probe configurations and their dimensions on the measurement accuracy. Although these probes provide the possibility of streamwise vorticity measurement, this chapter is primarily focused to velocity field measurements. The problem of estimating the uniqueness range of hot-wires response equations and methods for its enlarging are discussed in detail. The design and performances of own probe configuration with eight wires, based on two quadruple probes are explained also. In this chapter, researchers who wish to design their own probes for specific purposes can find a detailed guide and recommendations, which will make easier the probe manufacturing and optimization of their dimensions and configuration.

The next three chapters, the central part of the monograph, present primarily own original studies and experience in designing, testing and using the multiple hot-wire probes. The chapter "Measurements of turbulent vorticity fields by multiple hot-wire probes" reviews up-dated information on the theory and practice of designing, manufacturing and using the vorticity probes with nine and twelve sensors. The latest results of comparison testing the nine-wire and twelve-sensor probes are presented, showing clear advantages of the latter: larger uniqueness range and higher measurement accuracy. The importance of knowing and accurate measurement of the components of vorticity vector and turbulent kinetic energy dissipation for better recognizing the nature of turbulence is explained in detail. Here is also analyzed the temporal and spatial measuring resolution in the whole range of scales of turbulent vortex structures, simultaneously discussing the optimal number of sensors and the probe configuration and dimensions.

The sixth chapter "Operational properties of the vorticity-type and hot-wire probes for velocity measurements", presents a unique detailed analysis of measuring accuracy and

possible enhancing of the operational properties of multiple sensor probes. The influence of neglecting the components of fluid velocity vector and their gradients over hot-wire probe sensing volume on the measurement accuracy of turbulent velocity field in is discussed in detail. Possible ways for estimating the optimal probe parameters and optimal time and frequency of acquiring hot-wire anemometer output voltages are also presented. On the base of own comparison results of measuring turbulent velocity field mean statistical parameters by different probe configurations, authors showed the necessity of using the twelve-wire probes in three-dimensional flows of higher turbulence level.

In the voluminous chapter, entitled "Generalized numeric procedure", physical and mathematical background of calibration and signal interpretation algorithms for the probes with two, four and twelve hot-wires are presented. Detailed information, provided here, represents a unique useful guide for the researchers who intend to make an own code for calibration constants evaluation and hot-wire probes signals interpretation.

"Conclusions" are a short review of the most important conclusions, showing that presented results of authors in the area of hot-wire anemometry represent the logical continuation of extensive investigations of many researches worldwide during many years, showing their belonging to the world scientific trends and community.

Altogether, this monograph represents a valuable and unique scientific contribution, originally imagined and even more originally written. It differs in many elements from the rich available world literature in this area. As such, the book is an important courageous contribution that will be accepted with interest among scientific community. The special usefulness of the monograph is in its practical applicability for future workers in the complex area of turbulence structure investigation.

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