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Low speed calibration of hot-wire anemometers

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Abstract

A device for calibration of hot-wire anemometers at low velocities is described. The calibration technique is based on moving hot-wire probes in stagnant air. The device is relatively small, highly mobile and consists of a horizontal swing arm rotated by a DC motor. The motor speed can be adjusted to obtain the desired velocity range. Calibration procedures and data acquisition techniques used in this calibration are described. Results of calibration are discussed and the calibration constants are determined and compared with previous studies.

Keywords: Calibration; Hot-wire anemometer; Low speed

1. Introduction

Hot wire anemometers have provided one of the most important sources for data in turbulent flow investigations. In recent years, increasing interests in micro-machined jets for propulsion of miniature Micro Airborne Platforms (MAPs), microchip cooling devices and micro pumps have highlighted the need for low velocity calibration of hot-wire anemometers to characterize the flow field as well as aerodynamic coefficients of micro-devices. In the past, an accurate calibration of hot-wire anemometer at low velocity (0–1 m/s) has been a major problem. Typically, hot-wire probes have been calibrated using a wind tunnel or calibration nozzle. The velocity is evaluated from the pressure difference using pitot-static tube in the wind tunnel or the pressure drop across the calibration nozzle. However, when the velocity becomes smaller than about 2 m/s, the pressure drop in airflow becomes so small that it is difficult to obtain accurate velocity measurements using these methods [1]. Several methods for calibration of hot-wire anemometers at low velocities have been proposed and investigated. The most popular method is based on a gravitationally driven mechanism [2–6]. Another method of calibrating hot-wire anemometers at low velocities is by utilizing fully developed laminar pipe flow [1,7,8]. Lee and Budwig [7] used a shedding-frequency method in which the reference velocity is obtained from a continuous Strouhal–Reynolds number relationship. Tsanis [9] and Chua et al. [10] mounted hot-wire probes on a traversing mechanism that is driven by a servo motor and travels at constant speed.

One issue that arises when calibrating hot-wire anemometers is the correlation between the velocity, U, and the voltage across the hot wire, E. The most commonly used relationship is the modified King's Law

$$E^2 = A + BU^n \tag{1}$$

where A, B and n are constants. The exponent n is found to be strongly dependent on the velocity regime and varies from 0.4 to 1.3 [6,10]. Few studies have been reported on calibration of hot-wire anemometers at low velocities and therefore additional independent calibrations at low velocities are required. This paper describes a device for calibration of hot-wire anemometers at low velocities. The method is based on moving hot-wire probe in stagnant air. Results of the calibration are presented and constants of the modified King's Law are determined and compared with previous studies.

2. Calibration setup and procedure

2.1. Calibration device

A device for calibration of hot-wire anemometers at low velocities is shown in Fig. 1. The calibration method is based

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