FABRICATION OF HOT-WIRE PROBES AND ELECTRONICS FOR CONSTANT TEMPERATURE ANEMOMETERS

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***Abstract*— The purpose of this paper is to discuss the construction of constant temperature hot wire anemometers. Different options are analyzed for the fabrication of sensors and electronics. A practical and simple method is developed to manufacture the probe and associated electronics. The fabricated sensor has a diameter of 2 µm and approximately 500 µm in length. The associated electronics are designed to keep the sensor working at a constant temperature and allow the indirect measurement of speed. The design is simple, inexpensive and highly flexible regarding its use and modifications. The dynamic tests performed and the comparison with a commercial model shows a satisfactory performance. The unit built also includes an option for testing with a square wave, which is generated internally, and a comparator mode to measure the resistance of the sensor.**

***Keywords*— Anemometer circuit, hot-film sensor, sensor fabrication.**

I. INTRODUCTION

Despite the development of optical techniques, for fluid flow measurements, such as Laser Doppler Anemometry and Particle Image Velocimetry, constant temperature hot-wire anemometry remains a basic tool for measuring velocity fluctuations in turbulent flows. The principle of this technique is the variation of heat transfer from a thin metal wire to a flow of liquid or gas with flow velocity. The most widely used strategy is to adopt a wire whose resistance varies with temperature. This resistance is kept constant by means of a feedback system and the power required to achieve this is measured. A general review of the subject was published by Fingerson (1994), Goldstein (1996) and Tavoularis (2005).

Hot-wire anemometers consist of two systems: the hot-wire probe and the feedback and measurement electronics. The wire is very fragile and is often broken. For practical use of this technique, the ability to build or at least repair the probes is a need.

The present work describes a low cost and simple construction technique for both the sensor and associated electronics using equipment generally available in laboratories. The probe was assembled using a Wollaston-type wire, which is a very fine platinum wire in a silver jacket, following the method of Westphal *et al.* (1988) and Ligrani *et al.* (1989). This makes the wire easier to manipulate and solder but requires the posterior removal of the silver by chemical etching.

Electronics were built following the design of Itsweire and Helland (1983) but including modifications to avoid the use of components not readily available, like variable inductors and delay lines.

Frequency response was measured as suggested by Freymuth (1977) and Fingerson (1994). Measurements of a turbulent flow field were performed simultaneously with the present electronics and a commercial unit (TSI1051). The two measurements were equivalent for frequencies up to approximately 50 kHz.

II. PROBE CONSTRUCTION

Hot-wire probes are built with a thin wire of 0.5 to 20 µm diameter supported by two relatively sharp prongs. There are several ways to adhere the wires to these prongs. The principal techniques make use of conductive glue, spot welding, or soft soldering. Spot welding is the fastest method for relatively thick platinum alloy or pure tungsten wires. A primitive way to do this is by discharging a capacitor via a copper tip pressed on the wire to be welded to the prong. A more sophisticated device for spot welding is presented by Walker and Moss (1998). It should be noted that spot welding is easier to perform on stainless steel prongs. When using a Wollaston wire the other two methods are typically applied. The use of glue avoids the residual stresses that arise in the welding or soldering processes and thus allows the construction of sensors with thinner wires, but the process is slow and cumbersome.

In the present case the sensors were built using Wollaston wire attached to the tips using soft solder. The wire that was used has a platinum core with a purity of 99.9% and 2 µm in diameter, according to data provided by the manufacturer -Goodfellow Cambridge Limited, Huntingdon, England. An alternative provider is Sigmund Cohn Corp., Mount Vernon, NY, USA. The wire has a silver jacket, with an overall diameter of 37 µm. The reason that motivated such choice was the availability of the wire in a small diameter, although the use of platinum wire diameters of 5 µm or larger is perhaps better suited for most applications. The first step in the procedure was to solder the wire on two sharp prongs of copper wire. Then a portion of the silver coating is removed, leaving a small section of platinum wire (approximately 500 µm long) exposed.