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**HOME WORK**

*A FLEXIBLE FLOW SENSOR SYSTEM AND ITS CHARACTERISTICS FOR FLUID MECHANICS MEAUREMENTS.*

In this paper we learn the a novel about micro machined hot-film flow sensor system, by using film depositing process and incorporating a standard printed circuit techniques. It is divided into different categories such as:

1. Introduction

The silicon-based flow sensor was first demonstrated in 1974 and since then many application-oriented flow sensors have been developed based on various sensing principles, such as thermal anemometry, Doppler frequency shift, and indirect inference from pressure differences. Among these sensors, thermal flow sensors possess merits of simple structure and easy use, and thus offer practical solutions for various fluidics applications. “Hot-wire and hot-film anemometers utilize a thermal element that serves as both a Joule heater and a temperature sensor. Under a constant bias power and zero flow rate, the temperature of the thermal element reaches a steady-state value. If an external fluid flow is presented around the thermal element, the thermal element experiences forced convective cooling. Accordingly, the temperature of the thermal element provides the means to gauging the cooling rate and the flow velocity.”

The advantages of these sensors include simple structure, low-cost, and flexibility, thus being easy to attach on object surfaces, integrating good mechanical characteristics and sensing capability with electric circuits. The steady and dynamic characteristics of the sensors and sensor system are systematically tested and the application prospects are analyzed.

2. Sensor Design and Fabrication

The working principle of thermal flow sensors relies on the detection of the convective heat transfer between an electrically heated resistive sensing element (hot-wire or hot-film) and fluidic flow. The hot-wire or hot-film experiences cooling due to heat transfer given that the sensor is heated to a higher temperature than that of the surroundings. Heat transfer depends on the flow velocity.

The flow field information around the surface of an object could be divided into two components, that is, the normal pressure exerted on the surface and the shear stress along the surface. Both of the components are useful for inferring the flow parameters, such as flow velocity. We measure the flow velocity that is correlative with both the normal pressure and the shear stress by using hot-film flow sensors, which will be described in the following section. In our measuring mode, sensors are located in or near a flow environment and experience heat loss when subjected to fluid flow. Flow sensing is accomplished by monitoring the resistance change with temperature

Conventional hot-wire/hot-film sensors adopt tungsten, platinum, or metal alloys as the sensing element. Tungsten has a high-melting point and is difficult to deposit. Platinum (Pt) does not have as high a temperature coefficient of resistance (TCR) value as nickel (Ni), but the oxidation resistance behavior of Ni is not satisfactory, while Pt has good antioxidation properties. Considering both sensitivity and stability, the thermal elements of our hot-film sensors are made of composite materials. Ni is used as the main thermal element material, Pt as a cover layer and chromium (Cr) as a bonding layer between Ni and the substrate PI for enhancing the adhesion of the sensing element.

3. Sensor Characteristics

A hot-film/hot-wire sensor can be operated either inconstant voltage (CV), constant current (CC) and constant temperature (CT) modes. In CV mode, the heating voltage is held constant, for which the circuit is easy to be realize but the sensitivity is low. In CC mode, the heating current, or power, is held constant and the sensitivity and the response are low. Conversely, in CT mode, the sensor temperature is held constant by feedback circuitry and the increase in heating power required for maintaining constant temperature is measured in response to flow. Feedback provides automatically adjusting electronic compensation for the thermal inertia of the filament as its operating point varies. The major advantage of CT mode is that the frequency response is quicker and the sensitivity is higher than that of other modes. In this paper, we use the CT mode to operate the hot-film sensors for flow measurements.

4. Conclusions

We present a novel hot-film flow sensor with a flexible substrate. The sensor is fabricated directly on a flexible printed circuit board, which is economical and easy to integrate with a signal processing circuit. As a result, hot-film anemometry sensors can be potentially produced with low cost and high fabrication efficiency. Fluid mechanics measurements can also be further realized by using large arrays of these sensors. The sensor system has the advantages of good mechanical characteristics and sensing capability, simple structure, low-cost, and flexibility, thus being easy to attach on object surfaces.