Radcliffe Brown

EET3120: Sensors and Instruments

Prof. Vladetescu

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**Summary: A flexible Flow Sensor System and Its Characteristics for Fluid Mechanics Measurement**

At the State Key Laboratory of Precision Measurement Technology and Instruments of the Tsinghua University in Beijing, China, a flexible flow sensor system was developed. The developers wrote an article detailing the physical concept behind the sensor, material used, fabrication process and calibration process. They further tested variables of the system such as dynamic response and angular response. Also discussed in the article are uses of the sensor and its economic value.

The type of fluid sensor illustrated in the article is a thermal flow hot film sensor sensor. It uses convective heat transfer between an electrically heated resistive material and the flow of the fluid. The velocity of the fluid flow cools the resistive element and changes to the resistance is detected by the system to measure the fluid flow. Fluid flow sensors historically have been silicon based since 1974 but the designers in this article challenged themselves to creating a flow sensor that is sturdier, more reliable, more cost effective and easy to fabricate.

Polymide is used as the foundation of the sensor due to its lower conductivity, rigidity and higher flexibility over silicon. It is also standard for use in printed circuit boards (PCB) so it's familiar to work with. Nickel (Ni) is used as the main thermal element because of its high temperature coefficient resistance. Unfortunately, due to its unsatisfactory oxidation resistance, Platinum (Pt) is used to protect the nickel. Finally, Chromium (Cr) is used to bond the nickel to the PCB. Magnetron Sputtering technology is used to put everything together and then the sensor is post treated to make the sensor more stable, durable and increase its longevity.

The Thermal anemometry system consists of the thermal sensor (with thermal resistive properties) connected to a Wheatstone bridge then connected to a servo amplifier, conditioning circuit (with the output also feedback to the Wheatstone bridge), an output amplifier and an output indicator. The thermal sensor uses convective thermal transfer between a resistive element powered to maintain a constant temperature and the fluid flow. When the fluid flows along the resistive element, it cools and changes the resistance. The Wheatstone bridge monitors the change in the sensor and uses the difference to determine an output signal. The output signal is amplified and conditioned with the output fed back to the Wheatstone bridge to allow the sensor to adjust to maintain constant temperature. The signal is also amplified once more before being sent to the output indicator for reading.

The Wheatstone bridge also has a potentiometer for Calibration purposes. This is used to calibrate the overheat ratio as it has a direct relationship with the sensitivity and power consumption of the sensor. Further tests are ran to determine the dynamic response as voltage increases and the time response as flow velocity increases. The final test ran was in regard to the angular response of the sensor as the angle of the fluid flow changes between a range of -90 to +90 degrees.

The sensor is operational at low power and the system can be used for applications that require portability, durability, and compactness. It lasts as long as 10 hours on a standard battery power supply. downsides of the sensor is the lower response time compared to conventional hot film sensors and is limited to use at low frequency. It is noted that the sensitivity, flow rate range and frequency response can be enhanced by increasing the overheat ratio but that comes at the cost of power efficiency. Due to its ease of manufacture and low cost, the sensor can be used to situations where they are unlikely to last.

**Reference**

Liu, Peng, Rong Zhu, and Ruiyi Que. “A Flexible Flow Sensor System and Its Characteristics for Fluid Mechanics Measurements.” *Sensors* 9.12 (2009): 9533–9543. *CrossRef*. Web.