Design and Simulation of MEMS Based Flow Sensor

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Introduction: Thermal Sensor is capable of measuring the velocity from 0 to 1 m/s with a resolution of 0.001m/s. The system works with intrusive type mechanism in which the fluid flows across the sensor and interacts with heating element and sensing unit. Temperature gradient measured across the inlet and outlet sensing units is a parameter to calculate the flow rate and velocity.

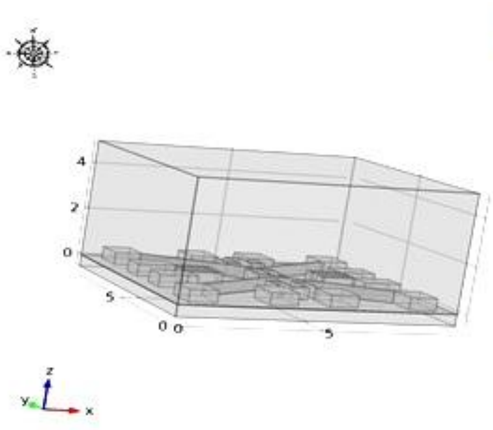

Figure 1. Thermal Sensor

Computational Methods: Conjugate Heat transfer module is used in the stationary mode of study. In the Simulation, the flow is along the 90º angle perpendicular to the heater to analyze both forward and reverse mode of operation.

$$\rho(u.\nabla)u = \nabla.\left[-\rho I + \mu(\nabla u + (\nabla u)^T) - \frac{2}{3}\mu(\nabla.u)I\right] + F$$

$$\nabla.(\rho u) = 0$$

$$\rho C_p u.\nabla T = \nabla.(k\nabla T) + Q + Q_{vh} + W_p$$

The Average velocity of inlet was set to 0.001 to 1m/s with no viscous stress and zero Pressure with suppressing backflow. The outlet domain was set to zero atm. The domain side walls and top wall were set to no slip and slip conditions respectively.

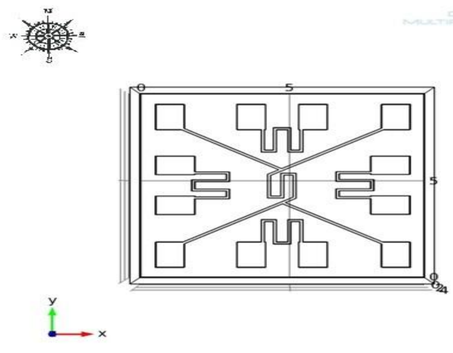

Figure 2. C.S View of Thermal Sensor

Results: The Forced Convection dissipates the heat from the heater to the downstream sensing elements by the means of Liquid Flow. Due to the heat dissipation, there is a temperature difference exists between the upstream and the downstream sensing elements.

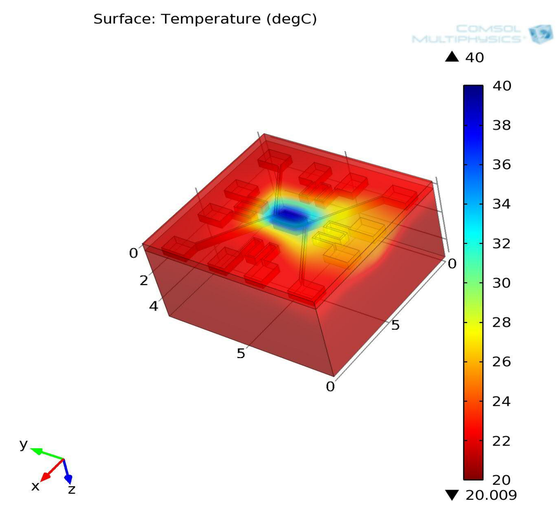

Figure 3. Flow Direction & Heat Dissipation

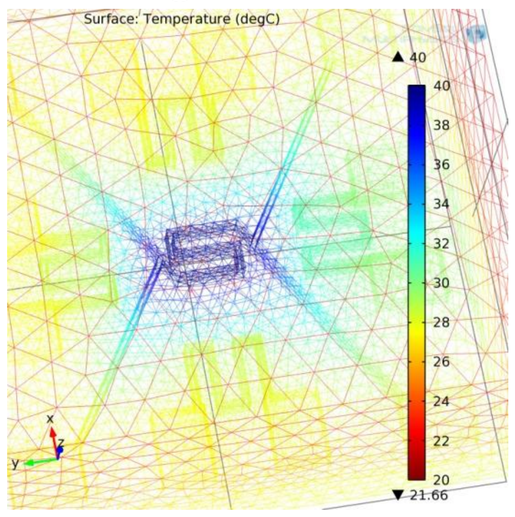

Figure 4. Wireframe View of Heat Dissipation

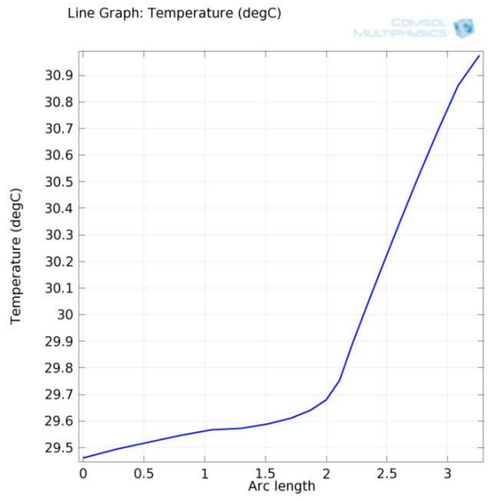

Figure 5. Model Graph

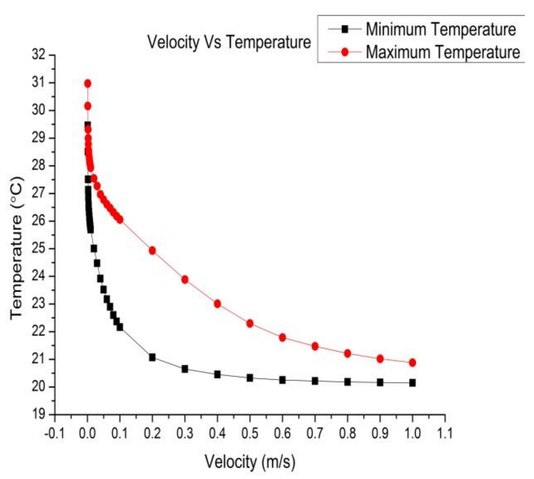

Figure 5. Title of the figure

Conclusions:Design of Thermal sensor for flow measurements is done using COMSOL multiphysics and analysis has been carried out for various flow ranges at 90º flow angle. The sensor is capable of measuring the velocity from 0m/s to 1m/s and has resolution of 0.001m/s with the exponential decay of temperature

References:

1. P. E. An, S. M. Smith, G. Grenon and A. J. Healey, Enhancement of the inertial navigation system for the Morpheus autonomous underwater vehicles, *IEEE J. Oceanic Eng.*, vol. 26, no. 4, pp. 548–560, Oct. 2001and other 13 Journals.