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Identification of Gas Flow Regimes in Adiabatic Microtubes by means of Wall Temperature Measurements

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Abstract

There exists the laminar flow, transitional flow, turbulent flow and choked flow regimes in a microtube gas flow. Development of a non-invasive identification method of the flow regimes within a microdevice is expected. This paper demonstrated how the internal gas flow regimes can be identified by measuring the distribution of the external wall temperature of the microchannel along the flow direction. A series of experiments were conducted by using nitrogen as working fluid through a stainless steel micro-tube with an inner diameter of 523 µm and a fused silica micro-tube having a diameter of 320 µm. The experiments were performed by fixing the back pressure at the exit of the microchannel at the atmospheric value and by varying the inlet pressure in order to modify the gas flow regime. In order to measure the external wall temperature along the microtube, two or three bare type-K thermocouples with a diameter of 50 µm were attached to the micro-tube external surface by using a high conductivity epoxy. In the case of the microtube having a diameter of 523 µm, local pressures were measured at three local pressure ports along the microtube. The pressure ports were placed on the opposite side of the tube wall where three thermocouples were attached (Fig. 1). The microtube external wall was thermally insulated with foamed polystyrene to prevent heat gain or loss from the surrounding. The experimental results show that the wall temperature decreases in the laminar flow regime, increases in the transitional flow regime, decreases in the turbulent flow regime and it stays nearly constants in the choked flow regime. The behavior of the average Fanning friction factor and the local Mach number can be explained by identifying the flow regime. It is clarified that the microtube external wall temperature is a reliable indicator of the flow regime..

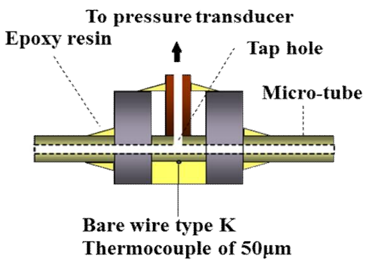

Fig. 1 Details of pressure tap holder

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