Contribution ID: **132** Type: **Poster presentation (105min)**

Pressure-drop reduction and heat-transfer deterioration of slush nitrogen in square pipe flow

Thursday 10 July 2014 10:30 (2h 15m)

Cryogenic slush fluids such as slush hydrogen and slush nitrogen are solid-liquid two-phase fluids containing solid particles in a liquid. There are high expectations as a functional thermal fluid for use of slush fluids in various applications. The presenter has proposed and has been developing a high-efficiency hydrogen energy system which uses slush hydrogen as a means of long-distance transportation and storage of hydrogen, and as a refrigerant for superconducting electrical power transmission and SMES using MgB2.
Experimental tests were performed using slush nitrogen to obtain the pressure drop and heat transfer coefficient flowing in a horizontal square pipe with a heated length of 800 mm and a side length of 12 mm. The primary objective was to investigate phenomena of the pressure-drop reduction and heat-transfer deterioration according to changes in velocity, solid fraction and heat flux. The flow pattern and behavior of solid particles were also observed using a high-speed video camera and the PIV method.
From experimental results, the pressure drop reduction emerged clearly at flow velocity of over 2.5 m/s and the reduction was up to 12% regardless of heated or non-heated condition. On the other hand, the heat transfer coefficient deteriorated in all the velocity range and the deterioration was up to 20% at the heat flux of 20 kW/m2.
In the comparison between measured and numerical (SLUSH-3D) results of flow pattern and solid particles' behavior, the mechanism involved in pressure-drop reduction and heat-transfer deterioration peculiar to a square pipe was obtained.

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Session Classification: Thu-Mo-Posters Session 3.3

Track Classification: C-06: Heat transfer and thermo-physical properties of solids and fluids