INTRODUCTION

- Transfer of cryogenic fluids from the storage Dewar to the end applications is a daily occurrence in laboratories/industries.
- Vacuum or Super-insulated transfer lines are efficiently used for the above applications.
- Most of the time two-phase flow occurs during the transfer process.
- It is very important to measure void fraction (liquid hold up).

MOTIVATION

- Many techniques are available to measure the void fraction.
- Implementation of these techniques to cryogenic fluid flow is sometimes difficult and expensive.
- An attempt has been made to develop simple capacitance sensors for measuring the void fraction for LN2 flow.

SELECTION OF TUBE MATERIAL FOR CAPACITANCE SENSOR

- Glass tube deformation is minimum among other insulating tube materials. Handling and making end connections for glass tubes is quite difficult.
- Deformation of Bakelite material is next to glass and is considered for the capacitance sensor development.

MEASUREMENT OF DIELECTRIC CONSTANT OF BAKELITE

- It is very important to measure the dielectric constant of tube material for capacitance simulation.
- The capacitance C, is defined as,
  \[ C = \epsilon_0 \epsilon_r \frac{A}{d} \]  
  \[ \text{Where } \epsilon_r = \text{permittivity of free space } = 8.84 \times 10^{-12} \text{ F/m}, \epsilon_r = \text{relative permittivity}, A = \text{Area of electrode in m}^2 \text{ and } d = \text{distance between the electrodes in m}. \]
- Equation 1 can be written as,
  \[ \frac{C}{A} = \epsilon_0 \epsilon_r \left( \frac{C}{A} \right) = \epsilon_0 \epsilon_r \frac{1}{d} \]
  \[ \epsilon_r = \frac{C}{A} \frac{1}{d} \]  
  \[ \text{Substitute equation 3 in equation 4, we get } C = \epsilon_0 \epsilon_r \left( \frac{C}{A} \right) = \epsilon_0 \epsilon_r \frac{1}{d} \]
- \[ C \text{ and } C_0 \text{ can be found by simple experimental setup shown in Fig 4.} \]
- Measured dielectric constant of Bakelite is 2.06 at 77 K.

CONCLUSIONS

- An attempt has been made to develop simple capacitance sensors for measuring the void fraction for LN2 flow.
- Thermo-structural analysis has been done for different insulating materials.
- Bakelite has been selected as the insulating materials.
- Experimental setups have been developed to measure the dielectric constant and the capacitance of the developed sensors at 77 K.
- Capacitance simulation has been done with the developed sensors with ANSYS Maxwell software and the results are in good agreement with the experimental results.
- The developed capacitance sensors are calibrated with standard sensor.
- These simple sensors will be very useful for void-fraction measurement of LN2 flow.

REFERENCES

- Jiang Chen, Yuchen Wang, Wei Zhang, Limin Qiu and Xiaobin Zhang, Capacitance-based fast holdup measurement of cryogenic two-phase flow in a nearly-horizontal tube, Cryogenics 84/2017, pp 69-75.
- Lam Qha Lin and Tong Boon Tang, Design of concave capacitance sensor for void fraction measurement in gas-liquid flow, ICTEE, Yogyakarta, Indonesia, 2016.