Temperature Effect Analysis on Mutual Induction Based High Temperature Level Sensor Using COMSOL Multiphysics®

R. Rajalakshmi[1], S. Dutta[1], G. J. Gorade [1], B. S. V. G. Sharma[1]

[1]Bhabha Atomic Research Centre, Mumbai, India

Abstract

Liquid Metals are used as coolant in high temperature reactor applications. This liquid metal coolant process operating temperatures are around 1000 deg C and they are highly corrosive in nature. Any sensor used for liquid metal applications need to withstand such high temperatures and harsh environment. Hence development of non-contact type mutual inductance based level sensor was taken up for liquid metal level measurements in high temperature reactor applications. The proposed sensor works on the principle of variation of mutual inductance between two windings when they are in proximity of a conducting fluid (Liquid metal) due to change induced eddy current. Geometrical modeling and simulation studies were carried out using COMSOL Multiphysics® AC/DC module to study the feasibility of methodology, to design the optimum dimensions of the sensor and to study and obtain the optimum excitation frequency. Simulation studies were carried out to study the effect of temperature on the sensor output and to device a methodology for temperature compensation. This paper describes the details of modeling of this level sensor system configuration using the AC/DC module of COMSOL Multiphysics software. The governing equations and the modeling approach for 2D axisymmetric geometries are considered. Parameters like the magnetic flux density, Induced Voltage, Eddy current Density have been derived through this ACDC module interface. Further the temperature distribution along the Sensor due to high Temperature of Liquid Metal has been modeled through Heat Transfer Module.

The electrical conductivity of Liquid Metal varies with its Temperature. Thus the changes in the output due to variation in temperature were determined. Further Temperature Compensation Technique has been discussed. The Simulation results were verified with the experimental Results. Few simulation results are given below.

Reference

1.COMSOL Reference manual and AC/DC module user guide
2.Paris et al. 1976 Apr. 6, Probe for measuring the level of a liquid Metal.
3.Allen, B.C. (1972), Liquid Metals, S.Z. Beer, Dekker.

Figures used in the abstract

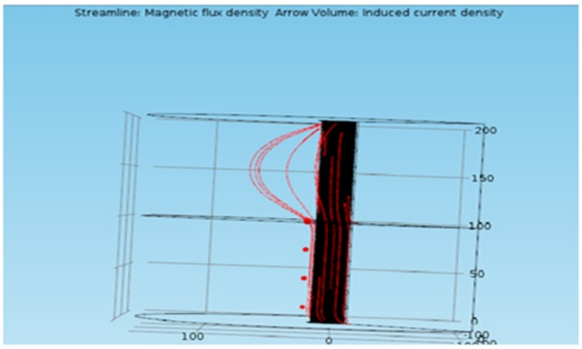

Figure 1: Variation of Magnetic Flux Density and Eddy current due to the presence of Liquid metal in the vicinity of the Sensor.

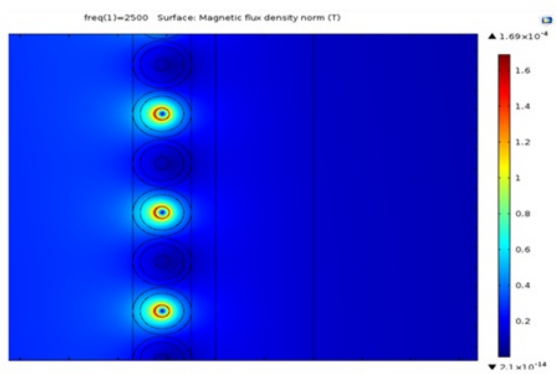

Figure 2: Distribution of the Magnetic Flux Density in the Windings of the Sensor.

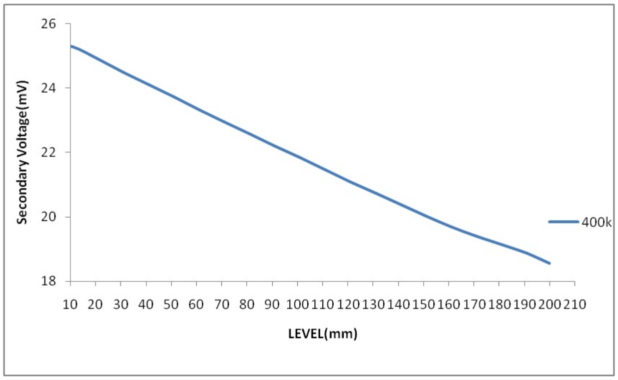

Figure 3: Simulation Result: Sensor characteristics at 360 °C of Molten Lead.

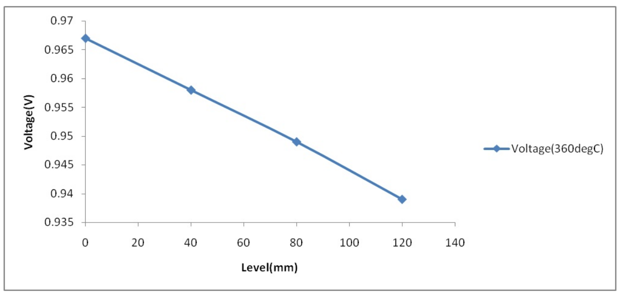

Figure 4: Experiment Result: Sensor characteristics at 360 °C of Molten Lead.