# Ph.D. Seminar Talk 1

## a) TITLE OF THE SEMINAR:

Topology optimization of single-phase natural circulation loops

**Speaker:**
Mr K.O.V.B. Rama Reddy (ME17D202)
**Biography of the Speaker:**

Ph.D . Research Scholar for Dept of Mechanical Engineering, IIT Madras.

## b) DATE AND TIME OF SEMINAR TALK:

28-4-2025 (Monday), 4:00 pm
Google Meet joining info
Video call link: https://meet.google.com/naw-xdhp-arb

**Affiliation of the Speaker:**

## c) GUIDE NAME:

Prof. Sourav Rakshit

## d) DC/GTC MEMBER NAMES

Chairperson: Prof. Krishna Kannan,
Prof. Chakravarthy Balaji, ME
Prof. Sundararajan Natarajan, ME
Prof. Sarith P Sathian, AM&BE

## e) ABSTRACT

This work presents topology optimization-based designs of the heater section of a single-phase rectangular Vertical Heater and Vertical Cooler (VHVC) Natural Circulation Loop (NCL) for enhanced flow rate. A 2-D steady state, laminar incompressible flow is assumed where Navier-Stokes equation is coupled with convection-diffusion equation incorporating Boussinesq approximation. The Grashof numbers considered in this work spans a wide range from $10^3$ to $10^8$. The key challenges highlighted include the difficulties associated with solving velocity-based objectives through density-based topology optimization, especially for natural convection problems. Use of standard interpolation methods such as Rational Approximation of Material properties (RAMP) generate porous outputs for better flow rates and heavy projection schemes are not much successful due to a wide transition zone of intermediate densities leading to sub-optimal results. This work proposes a promising solution to find better designs for enhanced flow rates in NCL by interpolation of the buoyancy force term, which is reported for the first time in literature. The new method of buoyancy interpolation has been tested with two different schemes for material interpolation: RAMP and sigmoid. Numerical experimentation showed that with careful calibration, interpolation of buoyancy force with a sigmoid function in sync with projection scheme enhances the chances of the optimization algorithm to find better optimal output. The significance of buoyancy interpolation in density-based topology optimization of natural convection-based cooling systems such as the NCL at high Grash of numbers are clearly evident from this work.