Proceedings of the Canadian Society for Mechanical Engineering International Congress 2022
CSME Congress 2022
June 5-8, 2022, Edmonton, AB, Canada

Buoyancy Driven Convection in a Horizontal Cylinder

Kyle Teather, Isaac Clapp, Kamran Siddiqui
Department of Mechanical and Materials Engineering, Western University, London, Canada

ABSTRACT

Buoyancy-driven convection is an essential consideration when analyzing heat transfer within fluid-filled horizontal cylinders heated uniformly through the walls. An example of this situation would be an underground tank filled with fluid for energy storage purposes. When fluid is exchanged within the tank, the internal temperature will experience a sudden change, after which heat is exchanged with the surrounding soil through the walls of the container. Natural convection in this geometry has not been well investigated. The experimental studies that have been conducted on this topic have been limited to temperature measurements, and numerical studies have used simplified models to approximate the heat transfer. Hence, there is a need for a detailed characterization of the flow fields in a horizontal cylinder heated uniformly through the walls to better determine the heat transfer tendencies of that geometry.

A previous study was conducted by the authors in a quasi-2D geometry, in which a thin circular cavity was heated uniformly through the circumferential walls. While the qualitative results show a mainly two-dimensional flow, three-dimensional effects were introduced by the close proximities of the front and back wall, restricting the characterization of the realistic velocity fields.

The present study addressed this issue by constructing a new setup. This setup is comprised of an acrylic tube filled with water, with a much larger ratio of axial length to diameter than the previous study to reduce the effects of the front and back walls. The water in the tube is seeded with near-neutrally buoyant hollow glass spheres and submerged into a tank filled with water that is maintained at a preset temperature, providing the isothermal conditions around the submerged pipe. Particle image velocimetry (PIV), a non-invasive optical technique with high spatial resolution, is used to capture the flow field within the pipe once quasi-steady-state conditions are achieved. Velocity fields are captured along a mid-horizontal (longitudinal) plane and multiple pipe cross-sectional planes. Different isothermal surrounding conditions are considered. Detailed results will be presented and discussed at the conference.