# Heat Exchanger Design and Optimization

Panta, Maya (School: Woodrow Wilson High School)

The Shell and Tube Heat Exchanger is widely used in high-pressure industrial applications such as petrochemical processing and offshore oil rigs. This study examines the thermal performance of an HT33 Shell and Tube Heat Exchanger Unit (Armfield, Inc.) with a 20,000 $mm^2$ heat transfer surface area, 144 mm heat transfer length, and 44.45 mm shell diameter housing seven smaller tubes (6.35 mm each) with six semicircular baffles. A countercurrent flow configuration was used, with cold water circulating through the shell while hot water flowed in the opposite direction at controlled velocities. The primary objective is to analyze how varying hot fluid velocities impact heat exchanger effectiveness. Experimental testing and computational modeling using ANSYS Fluent's finite volume method (FVM) were conducted. Results showed that increasing hot fluid velocities improved heat transfer effectiveness by 7%. However, overall effectiveness remained low (0.22) due to pressure stabilization issues, fouling, insulation inefficiencies, and structural constraints. CFD simulations predicted an effectiveness of 0.28, revealing a 27% discrepancy between experimental and simulated results. To enhance heat transfer, two design modifications were proposed. The first incorporated 15 radially placed straight fins, increasing the heat transfer surface area by 250% and potentially improving effectiveness to 0.50. The second introduced U-shaped tubes embedded with similar fins, further expanding the surface area by 300%, potentially achieving even greater effectiveness. Ongoing ANSYS Fluent and MATLAB simulations aim to validate these designs for industrial applications, optimizing heat exchanger performance and efficiency.

**Awards Won:**