PROJECT ABSTRACT

Shell and Tube Heat Exchanger Demo

A student-fabricated shell-and-tube unit with brass tube bundle, hot and cold water circuits, and counter/parallel-flow valve switching.

Project type: Hardware

Availability: Built to order

Suitable branches: Mechanical

Technologies: Steel shell fabrication, Brass tube bundle, Immersion heater tank, Circulation pump, Dial thermometers, Valve piping arrangement, Flow measurement setup, LMTD experiment manual

Price: Request a quotation

Prepared by Projectech · projectech.in — for academic project reference.

1. Introduction / Background

The shell and tube heat exchanger is the workhorse of process-industry heat transfer, and the log-mean temperature difference (LMTD) method is the calculation every heat-transfer course demands. Yet students usually meet both only on paper: the exchanger as a cutaway diagram, the LMTD as an equation. Lab-scale exchangers are expensive and shared, so the experiment connecting the four thermometer readings to the LMTD number rarely happens hands-on.

This project fabricates a student-scale shell and tube unit: a horizontal steel shell housing a removable bundle of brass tubes, a hot-water circuit (tank with immersion heater and pump) through the tubes, a cold-water circuit through the shell, dial thermometers at all four ports, and a valve arrangement that switches between counter-flow and parallel-flow. The student brings the unit to steady state, logs temperatures and flow rates, and computes LMTD, heat-transfer rate and effectiveness from their own measurements — for both flow configurations, on the same hardware.

2. Problem Statement

Heat-exchanger theory hinges on measurements students never take: inlet and outlet temperatures of two streams, flow rates, and the steady-state discipline to wait for them. Without a working exchanger, LMTD and effectiveness remain algebraic exercises, and the famous counter-flow advantage is asserted rather than demonstrated.

An affordable, instrumented shell-and-tube demo with switchable flow configurations puts the complete experiment on the student's bench. The problem this project solves is the lack of a student-operable heat-exchanger rig for undergraduate heat-transfer laboratories.

3. Objectives

- Fabricate a single-pass shell and tube exchanger with steel shell and removable brass tube bundle (approximately 12 tubes).
- Build independent hot-water (tank, immersion heater, pump) and cold-water circuits with control valves.
- Fit dial thermometers at all four ports and provide timed-collection flow measurement.
- Arrange piping and valves for counter-flow and parallel-flow selection without re-plumbing.
- Establish a steady-state logging procedure with LMTD, heat-balance and effectiveness worksheets.
- Produce fabrication and piping drawings, a project report, presentation and viva preparation material.

4. Proposed Methodology

- Fabricate the horizontal mild-steel shell (approximately 500 mm long) with flanged ends and the tube bundle on tube sheets in brass.
- Make one channel head removable so the bundle construction is visible for the report photographs.
- Build the hot-water tank with immersion heater (approximately 1 kW) and circulation pump feeding the tube side.
- Pipe the cold-water circuit to the shell side from the mains with its own control valve.
- Fit the four 0–100 °C dial thermometers at the hot inlet/outlet and cold inlet/outlet.
- Arrange the counter/parallel valve manifold and the timed-collection flow measurement points.
- Validate with shakedown runs: leak checks, steady-state attainment, and repeatability of the temperature readings.
- Run the experiment programme: counter-flow steady-state set, parallel-flow set, and the comparative analysis.
- Document fabrication, theory, procedures and results format in the report.

5. System Architecture / Working

The unit has five functional assemblies. The **shell** is the horizontal steel cylinder carrying the cold-water shell-side flow. The **tube bundle** is the set of brass tubes on tube sheets carrying the hot water, with one removable channel head. The **hot-water circuit** is the tank, immersion heater and pump with its control valve. The **cold-water circuit** is the mains-fed shell-side line with its own valve. The **instrumentation** is the four dial thermometers plus the timed-collection flow points; the **valve manifold** selects counter-flow or parallel-flow.

In a run the heater is switched on, both circuits are started with the valves set for counter-flow, and the unit is left until all four thermometers read steady (unchanged over five minutes per the manual). The student logs the four temperatures and measures both flow rates by timed collection, then computes the LMTD, the heat lost by the hot stream, the heat gained by the cold stream, and the effectiveness — including the heat-balance check that reveals the uninsulated-shell losses. Switching the manifold to parallel-flow and repeating gives the direct configuration comparison: the student's own numbers show the counter-flow advantage.

6. Hardware / Software Requirements

- Horizontal mild-steel shell, approximately 500 mm, with flanged ends
- Brass tube bundle, approximately 12 tubes, on tube sheets; one removable channel head
- Hot-water tank with immersion heater (approximately 1 kW) and circulation pump
- Cold-water circuit piping with control valves
- Four dial thermometers, 0–100 °C, at the ports
- Counter/parallel-flow valve manifold
- Timed-collection flow measurement points (jug and stopwatch method)
- Dimensioned fabrication and piping drawings; experiment manual with worksheets (no software required)
- 230 V AC single-phase supply for heater and pump

7. Expected Outcomes

- A leak-free shell and tube demo unit reaching steady state in both flow configurations.
- Student-logged temperature and flow-rate datasets for counter-flow and parallel-flow runs.
- LMTD, heat-transfer rate, heat-balance check and effectiveness values computed by the student from their own data.
- A quantified counter-flow versus parallel-flow comparison from measurements on identical hardware.
- A complete project report with heat-exchanger theory, fabrication documentation, procedures and results format, plus presentation and viva kit.

8. Applications

- Undergraduate heat-transfer laboratory heat-exchanger experiments.
- Student determination of LMTD and effectiveness from measured data.
- Direct demonstration of the counter-flow advantage on one unit.
- Classroom discussion of heat balance and real-world heat losses.
- Mini-project platform for studying flow-rate effects on effectiveness.

9. Future Scope

- Insulated shell variant for quantifying heat-loss reduction.
- Digital temperature logging for automated steady-state detection.
- Baffle inserts for studying shell-side flow distribution.
- Finned-tube bundle as an interchangeable second configuration.
- Second unit in series for multi-pass staging studies.