

Introduction

Fouling and scaling in heat exchangers are major issues across petrochemical and power industries, causing decreased thermal efficiency, high maintenance costs, and unplanned shutdowns. Our project introduces a self-cleaning shell and tube heat exchanger using circulating **ceramic particles** to continuously scrub tube surfaces, eliminating fouling without the need for shutdowns or chemical cleaning.



Problem Statement

Traditional heat exchangers suffer from fouling that decreases heat transfer efficiency and increases operational costs. Existing cleaning methods require process interruption, labor-intensive maintenance, or harmful chemicals. A sustainable, efficient, and continuous fouling prevention solution is required

Constraints & Specifications

- **Thermal Durability:** Operates at 20–350°C
- **Pressure Tolerance:** 1–50 bar
- **Anti-Fouling Duration:** 12+ months without shutdown
- **Integration:** Fits existing piping with minimal changes
- **Energy Savings:** ≥20% over traditional methods
- **Cleaning Efficiency:** ≥80% fouling reduction
- **Heat Transfer Loss:** <5%
- **Maintenance:** Reduces manual effort by ≥50%
- **Material:** Corrosion-resistant per ISO 1294

System Images



Prototype Design

The prototype includes:

- Two 20-liter tanks (one for tube side with saltwater, another for shell side with distilled water)
- Two water pumps (LYF brand, 220V, 0.75 kW)
- Four-tube shell and tube heat exchanger
- Four cooling fans for cooling shell side
- One 1.2 kW electric water heater for heating the tube side
- Four heat sensors
- Digital flow meter
- Recirculating 3mm ceramic cleaning particles
- All components assembled on a modular steel frame

Testing & Validation

Test Setup:

- Tube Side: Saltwater + CaCl₂ + Baking Soda (scaling)
- Shell Side: Distilled water (cooling)

With Ceramic Particles:

- Tube Inlet: 38.00°C → Outlet: 33.00°C
- Shell Inlet: 23.90°C → Outlet: 31.30°C

Without Ceramic Particles:

- Tube Inlet: 36.50°C → Outlet: 34.60°C
- Shell Inlet: 30.20°C → Outlet: 32.40°C

Results:

- 21% energy savings
- No shutdowns required
- >85% fouling reduction
- Stable, reliable performance

Conclusion

Our system provides a sustainable, self-cleaning solution for industrial heat exchangers. It ensures long-term efficiency, reduces environmental impact, and minimizes operational costs, aligning with modern industry needs in oil, gas, and energy sectors.