Fouling Inhibition on Heat Exchanger Copper Surfaces

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SMART ENERGY & THERMAL TRANSPORT LAB

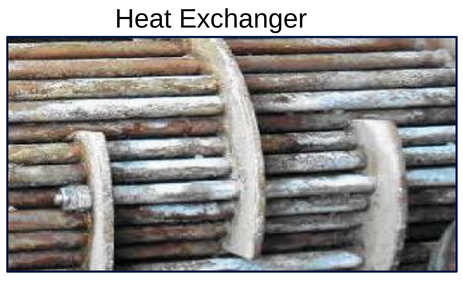
Motivation

What is Scaling?

Precipitation of minerals from water or other liquids on heat exchanger surface

1. Reduces Heat Transfer Efficiency.
2. Increases maintenance cost.
3. Decreases Equipment Lifespan

Heat Exchanger



- Addressing fouling improves reliability and reduces greenhouse gas emissions.
- Minimizes the need for harmful cleaning chemicals.
- Ensures compliance with strict regulatory standards.
- Supports economic competitiveness for industries.
- Advances sustainable solutions through innovative anti-fouling materials and technologies.

Scale formation on Heat Exchanger

Introduction

The primary goal of this project is to mitigate the scaling on copper surfaces in heat exchangers through the application of hydrophobic coatings.

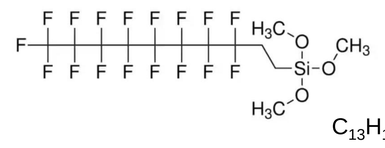
1.Accelerate the formation of scale under controlled laboratory conditions using various salt solutions at different concentrations.

2.Measure and analyze the extent of scaling on untreated surfaces.

3.Apply hydrophobic coatings to the copper surfaces and reassess the scaling behavior to determine the effectiveness of these coatings in reducing scale formation.

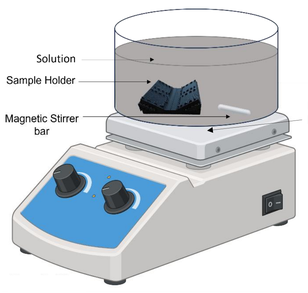
This experiment compares bare and HTMS-coated copper and aluminum tubes and plates under identical conditions, with performance readings recorded.

1H,1H,2H,2H-Perfluorodecyltrimethoxysilane



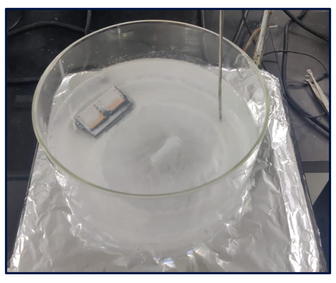
$C_{13}H_{13}F_{17}O_3Si$

Experimental Setup



Conditions maintained

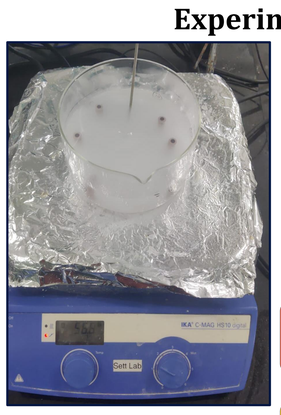
Temperature: 70 ^{0}C
PH = 8-9
Volume of Solution = 1.5l
No. of copper samples : 2



Experiment 1: Different concentration of CaSO4 and CaCO3

Experiment 2: Different concentration of mixed solution. (**Mixture of Calcium carbonate, Calcium sulphate, Magnesium chloride hexahydrate, Magnesium sulphate)*

- Experiments 1 and 2 aimed to identify the optimal salt concentration for clear scaling visibility. The water was evaporated completely, leaving salts on the surface.
- Subsequently, the samples were placed in an oven for 15–20 mins to ensure complete evaporation of any remaining moisture.
- The scale weight was calculated by subtracting the initial weight from the final weight.



Temperature = 70^{0}C
PH = 8-9
Volume of solution = 0.5 l

Experiment 3: Different concentration of mixed solution (Cu & Al Tubes)

Bare Cu

HTMS coated Cu

Bare Al

HTMS coated Al

Cleaning Procedure

Sonication with Acetone (10 mins)

Sonication with water (10 mins)

Dip in HCL then wash with water

HTMS Coating Procedure

0.1 ml HTMS+ 0.9ml Toluene

Keep it in oven

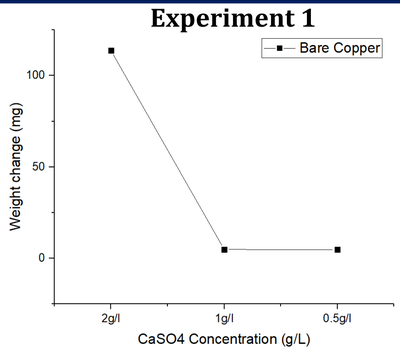
Conditions maintained

Temp T= 80^{0}C
Time=3 hrs

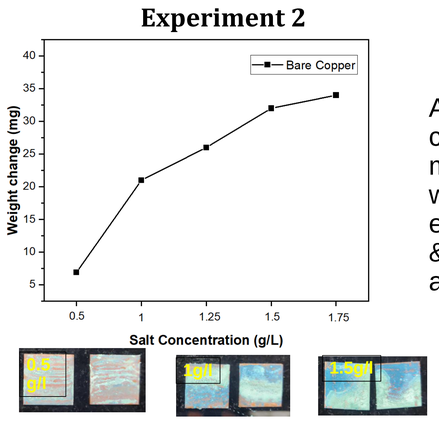
The Cleaning procedure for aluminium involves sonication with acetone and water, excluding the use of HCL washing.

Results & Discussion

Experiment 1

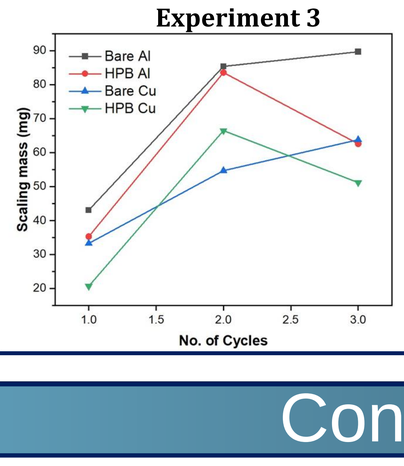


Experiment 2

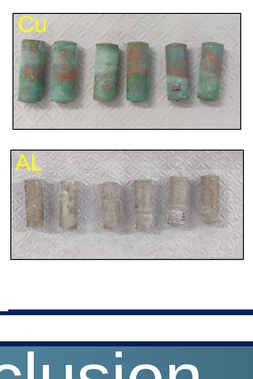


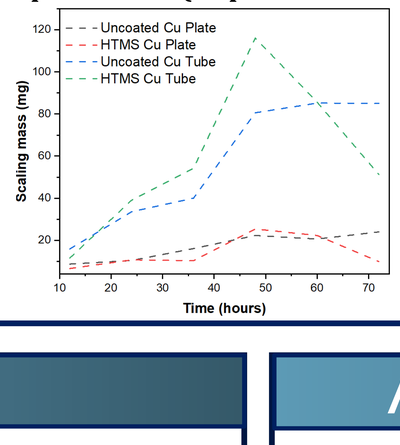
A 1 g/L mixed salt concentration produced the most consistent scaling and was chosen for further experiments.. Experiment 3 & 4 were conducted for 3hrs and 70 hrs. respectively.

Experiment 3



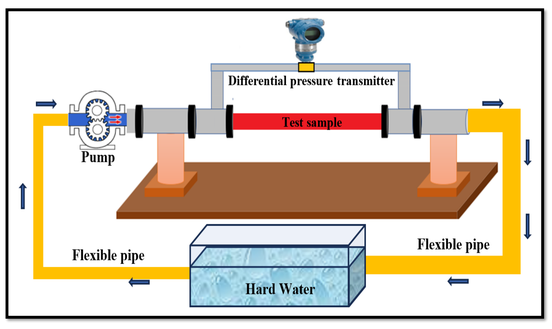
Experiment 4: (Cu plates & Cu tubes)

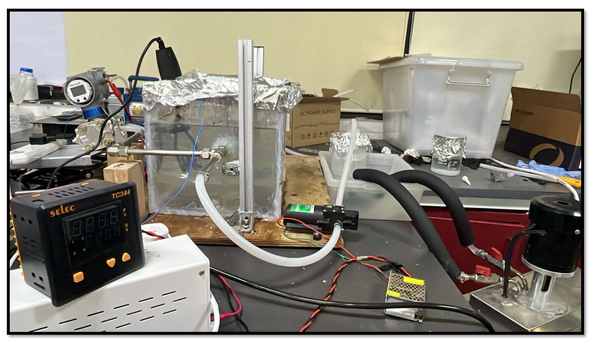




This experiment was conducted to check the durability

Future Work





- In our future work, we are focusing on developing a dynamic fouling setup to study the deposition and impact of fouling on copper (Cu) tubes.
- The system includes a flow loop where a working fluid (salt solution) , circulates through the copper tube. A pump controls flow rate, a chiller regulates temperature, and thermocouples and a pressure transmitter monitor T & P change.
- The experiment starts with a clean copper tube, followed by the induction of fouling to study its effects on heat transfer efficiency and pressure drop.
- Periodic evaluations measure the thickness and composition of fouling.

Conclusion

HTMS coatings were used to create hydrophobic surfaces, reducing fouling by repelling liquids and preventing particle adhesion. This improves heat transfer efficiency, minimizes pressure drops, and reduces cleaning and maintenance costs.

In the static fouling experiment, we observed that

1. Initially, scaling is similar on both uncoated and HTMS-coated Cu plates. Over time, scaling increases significantly on the uncoated plate but decreases on the HTMS-coated plate.

2. Initially, scaling on both uncoated and HTMS-coated Cu tubes is similar. Later, scaling increases more rapidly on the HTMS-coated tube but eventually decreases sharply.

Acknowledgement

We would like to thank Prof. Soumyadip Sir for giving us the opportunity to work on this project. We would also like to N. Rahul for guiding us throughout the project and to Abhayraj for his assistance with the cyclic experiment.

Contribution

Sakshi Katkur: Supervision, Conceptualization, Methodology, Validation, Investigation.
Yug Verma: Data Collection, Investigation, visualization.
Yashvi Kothiya: Data Collection, Investigation, visualization.
Purva Shah: Data collection, Investigation

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