TEAM F044

Integrated Smart Water Quality Monitoring and Reinjection System for Minimizing Scale Formation in Oil Wells

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PETE
ISE 3 CHE

Background

Water injection is essential to maintain reservoir pressure in oilfields. However, changes in temperature, pressure, and water chemistry can cause scale to form inside flowlines. Over time, this accumulation affects oil production, making effective monitoring vital.

Problem Statement

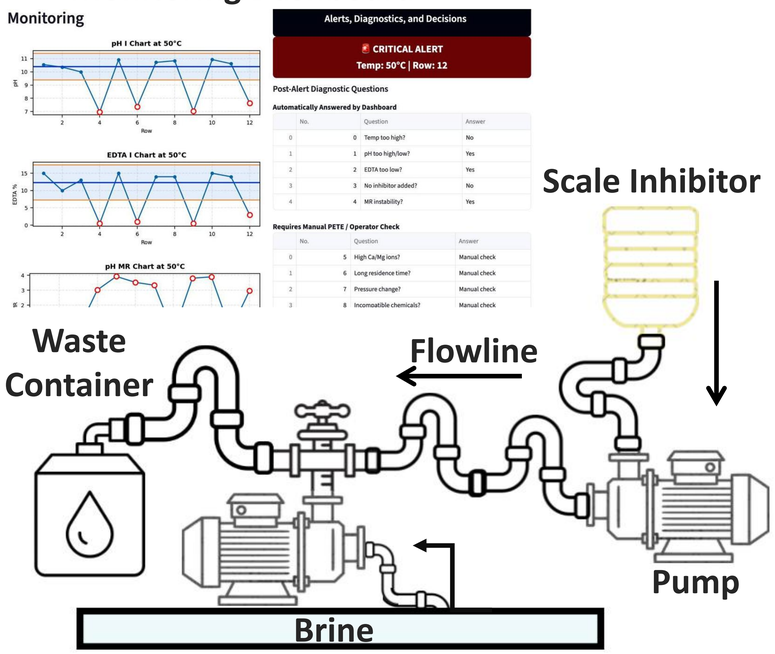
Scale formation in oilfield injection systems causes flow restriction, pressure buildup, and production losses. Existing monitoring approaches are reactive, leading to delayed detection and high operational costs.

Objective

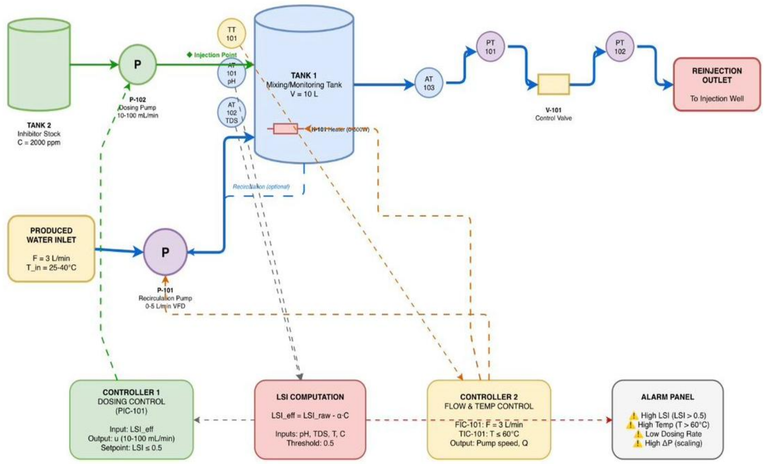
To implement a cost-effective, data-driven system that enables real-time monitoring and optimized inhibitor injection to mitigate scale in oilfield flowlines.

Prototype Design

Monitoring Dashboard



Process Flow Diagram



Constraints

- System withstands **high** salinity
- **Safe** lab-simulated experiments
- Inhibitor: $10 \leq Q \leq 100$ mL/min
- PI gains: $\mathbf{K_p}$ **(20–80),** $\mathbf{K_i}$ **(0.2–1.5)**

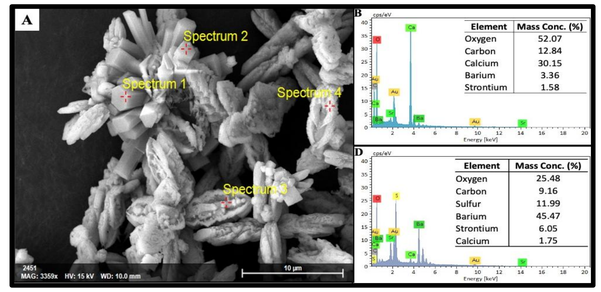
Specifications

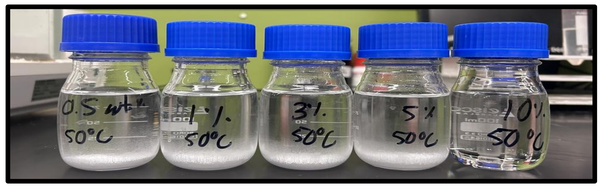
- Scale formation within **≤ 24 hr**
- EDTA - **0.5, 1, 3, 5, 10 wt.%**
- SPC to detect data anomalies
- Inhibitor dosage accuracy **= ±5%**
- **pH accuracy = ±0.1**
- TDS accuracy within **±10%**

Conclusion

A data-driven monitoring system based on lab data, uses SPC to enable scale detection and optimized inhibitor dosing, resulting in effective scale treatment.

Testing & Validation





- SEM and EDX show that $\mathbf{CaCO_3}$ and $\mathbf{BaSO_4}$ exist at high concentrations
- **EDTA** successfully dissolved scale

Optimization Framework

Objective Function

$$\min F(d) = \sum_{t=1}^{N} \left(c_1 d_t + c_2 P_t + c_3 (d_t - d_{t-1})^2 \right)$$

Operational Guarantees (Key Constraints)

$10 \leq d_t \leq 100$	Inhibitor dosage bounds (mL/min)
$P_t \leq P_{\max}$	Scale risk threshold constraint
$\lvert d_t - d_{t-1} \rvert \leq \Delta_{\max}$	Dosage stability / smoothness constraint

Ensures optimal, safe, and stable inhibitor dosing under operational constraints.

50°C Results		80°C Results	
Total Samples	116	Total Samples	84
True Positive (TP)	51	True Positive (TP)	35
True Negative (TN)	65	True Negative (TN)	49
False Positive (FP)	0	False Positive (FP)	0
False Negative (FN)	0	False Negative (FN)	0
Accuracy	100.0%	Accuracy	100.0%
Precision	100.0%	Precision	100.0%
Recall	100.0%	Recall	100.0%
False Alarm Rate	0.0%	False Alarm Rate	0.0%
Miss Rate	0.0%	Miss Rate	0.0%
Accuracy Target Check	Meets ≥85% target	Accuracy Target Check	Meets ≥85% target