Preheat train monitoring allows better management of fouling

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Heat Transfer Research Inc. (HTRI)
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Corporate overview

• A for-profit corporation established in 1962
• HTRI products in use at more than 1400 corporate sites worldwide
• Staff in eleven (11) countries around the globe
• Sales representatives in eight (8) countries
Corporate Headquarters (Navasota, TX)
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Office and Conference Center
Research & Technology Center

Wholly owned facility built in 2006
Research & Technology Center
HTRI Products and Services

• Research and technical publications

• Software
  – HTRI thermal design software (Exchanger Suite) – industry standard for heat exchangers
  – SmartPM – Crude preheat train monitoring and prediction
  – Exchanger Optimizer – optimizes operating and capital costs
  – EdgeView – Heat exchanger troubleshooting
HTRI Products and Services

• Technical support
• Training
• Proprietary Contracts
  – Custom testing services
  – Fouling services including testing
  – Computation Fluid Dynamics simulations
  – Consulting services
Crude Oil Fouling Task Force (COFTF)

- Subset of HTRI members (~25 persons)
- Responsibilities:
  - Help ensure research is **industrially relevant**
  - Reviews research plans and data
  - Provide field data and experiences
  - Provides guidance
  - Donates oil
- Meets 5-6 times per year
Goals of Fouling Program

1. **Collect** world-class data

2. **Translate** rig data to the field

3. **Predict** fouling

   \[
   \frac{dR_f}{dt} = \frac{m}{\lambda_d \cdot \rho_d} \left( \frac{C_b}{1 + \frac{1}{k_m \cdot k_f \cdot C_s}} \right)
   \]

4. **Mitigate** Fouling

   ![Diagram of fouling mitigation process]
Predicting fouling – research perspective

• Understanding **fundamentals**
• Developing more accurate **fouling models**
• Developing methods to **translate fouling rig data to field**
• Linking crude **chemistry** with fouling model parameters

Research deliverables are implemented in software to improve field predictions
Predicting fouling – field perspective

• Development of accurate system models
• Obtaining historical field data
• Reconciling historical data to assess $R_f$
• Regression of fouling models to historical data
• Simulating the system to project future performance
• Identification of most economic cleaning strategies

Good predictions rely on good monitoring
What is involved in PHT monitoring and prediction? (How HTRI SmartPM Works)

**Input data**
- Exchanger geometry
- P&ID Diagram for PHT
- Stream properties
- Monitoring data
- Cost data (energy, shell cleaning costs ...)
- Operating strategies
- Constraints

**Process**
- Construct network model
- Data reconciliation
- Fouling analysis
- Predictions

**Output data**
- Reconciled data
- Historical network performance
- Fouling model parameters
- Network thermo-hydraulics
- Cleaning schedules
- Retrofit/revamp assessment
- Reports
Construct Network Model

Exchanger geometry
Process Flow Diagram
Stream properties
Monitoring data

Data Reconciliation

Reconciled data

Historical network performance
Review/Study/Analyze Reconciled Data

- View up to 37 heat exchanger parameters
- For example, for any exchanger see flow rate, crude slate and fouling
Fouling Prediction
Benefits of monitoring & prediction

Monitoring
- Assess current status of fouling
- Assess chronic fouling behavior
- Identify acute fouling events
- Compare fouling of different crude slates
- Assess performance after cleaning

Prediction
- Forecast performance
- Determine which exchangers to clean with most economic benefit
- Determine when to clean
- Avoid production limitations

What’s happening and why?  What’s the most economical response?
Monitor fouling helps monitor crude quality

• Assess acute fouling events
  Examples:  
  • Desalter upset
  • Change in crude (incompatibility)
  • Significant change in operation (flow decreased by half)

• Assess chronic fouling

• Compare fouling of different crude slates

Is it the crude or the operation?
Case 1: Identification of acute fouling
Identification of a bad oil

Crude identified that cause acute fouling problems

Refinery stopped using that crude because monitoring provided clean data associating the crude with the problem
Case 2: Grangemouth - Change in Chronic Fouling
Different crudes have different fouling tendencies

Overall ranking
(low to high fouling propensity)

1. San Joaquin Valley (SJV) [Known low fouler]
2. Low-sulfur (LSC)
3. Loreto (LRT)
4. Maya
5. Refinery Blend #1 (RB1)
6. Refinery Blend #2 (RB2)
7. Arab Medium (ARM) [Known high fouler]
8. Grangemouth (GRM)

Grangemouth Refinery Data

Surface temperature $\approx$ constant

Flow $\approx$ constant

???
Grangemouth Blend

• North Sea and West African predominantly
• Crude has a high chronic fouling rate
• Uncharacteristic to have a period with steady-state Rf
• Behaviour not explained by operation; must be a change in the fluid
• No information on daily crude slate
• Possible explanation for this sort of behaviour
  – Significant change in blend
  – Antifoulant addition

Better monitoring of crude/additives would have allowed valuable insights to be made
Summary

• HTRI is world leader in heat transfer research and prediction
• HTRI is now building a bridge between fouling experiments and refinery fouling management
• PHT data is already being collected
• Proper monitoring allows visualization of performance
• Good monitoring practices allow observation of fouling trends
• Fouling trends are affected by crude quality