Uniform Heat Transfer In Fired Heaters

FURNACE IMPROVEMENTS SERVICES INC.

- Increased Capacity
- Longer Run Lengths
- Higher Efficiency
- Lower NOx Emissions

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TRAINING SERVICES

Ashutosh Garg
Fired Heater Expert, Furnace Improvements Services Inc.

- He brings to this course more than 40 years of experience in design, engineering, and troubleshooting of fired heaters and combustion systems for the refining and petrochemical industries.
- He graduated from the Indian Institute of Technology, Kanpur, India, in chemical engineering in 1974. He worked for six years at KTI India and eight years at EIL, New Delhi, in the heater group. He joined KTI Corporation, San Dimas, California, in May 1990 and moved to KTI Houston in 1992.
- He has published several papers on fired heaters and burners. He is a registered professional engineer and a member of AIChE, ASME, API subcommittee of heat transfer heaters.
WHO SHOULD ATTEND?

- Project Engineers
- Process Engineers
- Technical Service Engineers
- Maintenance Engineers
- Reliability Engineers
- Operation Engineers

FOLLOWING COMPANIES HAVE SENT THEIR ENGINEERS TO OUR SCHOOLS:

- ABB Lummus
- Lion Oil Company
- Occidental Chemical Corporation
- Sasol
- Devon Energy
- Chevron Chemicals
- Exxon Refining
- Westlake Chemicals
- Huntsman Petrochemicals
- Marathon Inc.

- Air Products & Chemicals
- Sabic
- Coastal Refining
- BP
- AKzo Nobel
- Flint Hills Resources
- Valero Refining
- Equistar Petrochemicals
- LyondellBasell
- Mitchell Gas Services

PARTICIPANT’S FEEDBACK

“The course helped improve my understanding of heaters, how they operate and how to improve furnaces.”
– James Jones, Coker Unit, Lyondell-CITGO

“All course material has been found to be valuable, reinforcing past experience.”
– Attila Marcus, Flour Daniel, S. Africa

“Overall content was very good and there were many ideas to optimize our unit furnaces.”
– A. Arias, BASF

“I wish I had this course a year ago; Discussion on levels of Burner NOx capabilities, information on vendor products, pitfalls to avoid and suggestions for revamps are the most valuable topics in the course.”
– Andy Holman, Phillips66

OUR COMPANY

Furnace Improvements Services (FIS) est. 1996 in Sugar Land, TX.

Mission: to improve performance and provide uniform heat transfer in fired heaters.

For over 20 years now, FIS has provided engineering services to improve the performance and efficiency of various fired heaters and boilers as well as help reduce refinery NOx emissions. FIS has performed over 400 projects for clients like Citgo, Valero, Phillips 66, Alon, Frontier, and Total.

We have a vision to be the ultimate technology provider for fired heaters and boilers.
OUR EXPERTISE

FIS can revamp all types of refinery fired heaters including Crude, Vacuum, Catalytic Reformer, Hot Oil, Coker Heaters, and CO boilers.

FIS provides complete turn-key services for the design, engineering, and supply of new fired heaters to end users. Our designs are the most economical, efficient, and reliable. Furnace Improvements has several patented technologies for improving the performance of fired heaters. These patented technologies are aimed at improving performance of existing fired heaters.

<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>APPLICATION</th>
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<tbody>
<tr>
<td>Split Flow Technology</td>
<td>Increases capacity with limited process side pressure drop</td>
</tr>
<tr>
<td>Flue Gas Injection</td>
<td>Reduces coking &amp; tube metal temperatures</td>
</tr>
<tr>
<td>Inclined Firing System</td>
<td>Reduces flame impingement and high tube metal temperatures</td>
</tr>
<tr>
<td>Spider Gas Tip</td>
<td>Shorter flame gas burners</td>
</tr>
<tr>
<td>Stack Damper</td>
<td>Provides Smooth Control of Heater Draft</td>
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INCLINED FIRING SYSTEM

One of the most common issues faced by operators and owners is high tube metal temperature in fired heaters. Most tube failures in fired heaters occur due to high tube metal temperatures (TMTs).

‘Furnace Improvements developed the patented Inclined Firing System (IFS) to eliminate flame impingement on heater tubes.’

Burners are installed at an angle 5° – 7° away from the tubes with this burner arrangement; a heater will have the following advantages:

- Lower Tube Metal Temperature
- Longer Tube Life
- Increased Heater Run Lengths
- Uniform Heat Transfer
- Lower Coking Rates
INCLINED FIRING IN A CATALYTIC REFORMER

In the Inclined firing case, temperature contours clearly show the reduction in the flue gas temperature around the radiant tubes.

INTERHEATER -2
INTERHEATER -1
CHARGE HEATER

INCLINED FIRING IN A DOWN FIRED STEAM REFORMER

Base Case

High flue gas temperature going towards the tubes

Inclined Firing Case

High flue gas temperature going away from the tubes

In the Inclined firing case, temperature contours clearly show the reduction in the flue gas temperature around the radiant tubes.
Inclined Firing in a Double Fired Coker Heater

- **Vertical Up Firing**
- **Inclined Firing**

Inclined Firing in Horizontal Tube Cabin Heater with End Wall Firing

- **Existing Case**
- **7° Inclined Firing Case**

High temperature region is in the centre of the heater, flue gas temperature near the radiant tubes is reduced.
**SOME PROJECTS WHERE WE USED INCLINED FIRING SYSTEM (IFS)**

<table>
<thead>
<tr>
<th>REFINERY</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alon USA LP</td>
<td>Reboiler Heaters H-102 &amp; H-205</td>
</tr>
<tr>
<td>Citgo</td>
<td>Twin Cell Crude Heater 11-H-01</td>
</tr>
<tr>
<td>CountryMark LLP</td>
<td>DHT Charge Heater 210-H-100</td>
</tr>
<tr>
<td>Gladieux Processing</td>
<td>Hot Oil Heater</td>
</tr>
<tr>
<td>Valero</td>
<td>Crude Heater (in progress)</td>
</tr>
</tbody>
</table>

*Patent # US 7,484,478 B2

**SPLIT FLOW TECHNOLOGY**

Split Flow aims to improve the utilization of thermal energy for process heating. This objective is achieved by splitting the process fluid into two parallel streams:

1. **Main Stream**
2. **Split Stream**
SPLIT FLOW TECHNOLOGY

Main Stream
The fluid in the first stream is heated predominantly by the convective and radiant heat transfer mechanism.

Split Stream
The fluid in the second stream is heated predominantly by the convective heat transfer mechanism.

The streams are then combined at the heater outlet. The Catalytic Reformer technology has been very successful for capacity increase of fired heaters particularly in heaters. Increases the capacity of a heater by 15% to 30%.

Other Advantages of the Split Flow Technology include:
- High heater efficiency
- Low process pressure drop
- Low firebox temperature
- Low radiant heat fluxes
- Low TMTs
- Low installation costs

SOME PROJECTS WHERE WE USED SPLIT FLOW TECHNOLOGY

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<tr>
<th>REFINERY</th>
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<tr>
<td>Alon USA LP</td>
<td>H2 Heater</td>
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</tr>
<tr>
<td>Citgo</td>
<td>Catalytic Reformer</td>
</tr>
<tr>
<td>ConocoPhillips</td>
<td>Reformer Catalytic Heater</td>
</tr>
<tr>
<td>Gladieux Processing</td>
<td>Hot Oil Heater</td>
</tr>
<tr>
<td>Valero</td>
<td>Catalytic Reformers</td>
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CFD MODELING

At Furnace Improvements, we utilize CFD modeling to analyze problems and evaluate possible solutions. This tool enables us to study the existing design and operating conditions of heaters and determine recommendations for solving any operational issues. CFD gives a competitive edge over other analyses due to its visual presentation of the observed conditions and proposed modification.

The following are a few areas where FIS has used this tool effectively:

- Study air flow distribution across all burners in a heater.
- Design of ammonia injection grid & mixing devices to enhance mixing of flue gas & diluted ammonia stream.
- Combustion (burner & heater design)
- Tube Failures
- Heat transfer studies

Temperature contours (°F) Base Case
**VELOCITY CONTOURS**

Velocity magnitude

Existing

Proposed
DEVIATION IN MASS FLOW

![Bar chart showing RMS deviation in mass flow for each burner.](image)

**Burner No.**

RMS Deviation in Mass Flow, %

- Existing
- Proposed

<table>
<thead>
<tr>
<th>Burner No.</th>
<th>RMS Deviation in Mass Flow, %</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>-15</td>
</tr>
<tr>
<td>2</td>
<td>-20</td>
</tr>
<tr>
<td>3</td>
<td>-5</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
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<tr>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>8</td>
<td>20</td>
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<tr>
<td>9</td>
<td>-10</td>
</tr>
<tr>
<td>10</td>
<td>-5</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
</tr>
</tbody>
</table>

**FIS 3-D MODELING**

- **a** - Model of Inclined Firing Technology applied to an 8 burner system
- **b** - Model of a Verticle Cylindrical Heater with a common stack
- **c** - Model of a Naphtha Splitter Reboiler Heater
- **d** - Model of a Compressed Air Heater
REVAMPED HEATERS

Revamping fired heaters is a practical and effective way to improve heater performance. This strategy focuses on working with existing components, and as a result, capital investment and downtime are minimized.

NEW HEATERS

New hot oil heater at Phillips 66 Wood River; FIS was responsible for the design, engineering, procurement, and fabrication services on this project.