Extending furnace run length and coil life through decoke procedure & optimization

by

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EMET 2014 Conference

October 21st, 2014

Presentation Outline

- Introduction
- Need For Decoke Modification
- Basis for Decoke Modification
- Methodology Adopted
- Case Study – Ethylene Plant
- Conclusion
- Q&A

Introduction

Coke deposition in furnace coils is inherent to the process

- Ethylene is produced by thermal cracking of hydrocarbons (Ethane/Propane/Naphtha etc.) in radiant coils of furnace section
- Furnace effluents from radiant coils are immediately quenched in transfer line exchangers (PTLE*, STLE, TTLE etc.) to arrest the chain reaction avoiding secondary reaction
- During normal operation, coke slowly deposits in the radiant coils and transfer line exchanger tubes

* Primary Transfer Line Exchanger (PTLE), Secondary Transfer Line Exchanger (STLE), Tertiary Transfer Line Exchanger, etc.

Effect of Coke Deposition

Coke deposition limits production

- Reduced heat transfer to the process fluid resulting high TMT (tube metal temperature) ➔ shut down to prevent tube failure
- Increased pressure drop, and eventually plugged coils in extreme case.
- High PTLE outlet temperature exceeding design limit of downstream piping ➔ shut down to protect piping
- Reduction in furnace run-length and feed throughput in furnaces as ability to reach required temperatures in process fluid cannot be achieved safely

Furnace Operating Parameters

To get desired yield from the cracking furnaces, operating parameters are continuously measured and monitored

- Feed rate and composition → determines appropriate operational settings
- Coil pressure ratio(CPR) → one variable determining need for decoking
- Coil outlet temperature(COT) → one variable determining need for decoking
- Hydrocarbon to Dilution steam ratio(HC/DS) → helps optimize throughput and cracking severity
- Transfer line exchangers outlet temperature and pressure → one variable determining need for decoking

Decoke Operation

Furnace operation is typically terminated and decoking done when specific criteria is reached

Furnace Run-length terminating criteria:

- CPR reached to 0.9
- Maximum TMT of any coil reached to the design limit of coil metallurgy (1050 ºC)
- Maximum TLE outlet temperature limit of D/S piping

Need for Decoke Modification

Decoking procedures differ; getting it wrong is expensive

Generally manufacturing takes between 16 to 32 hours depending on the decoking procedure

•Rigorous decoking (high air and steam flows and COT) to burn the coke inside radiant coils and TLE exchangers – Upside is the speed of 16 hours but the downside is potential coil damage

•Mild decoking (low air and steam flows and COT) for extended period – Upside is less metallurgical damage but downside is the increased time of nearly 32 hours resulting in increased production loss and energy usage

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Basis for Decoke Modification

A holistic and scientific approach should be used to develop a specific decoke procedure for every Ethylene plant based on furnace type, feed, severity and TLE fouling

Operational and decoking parameters to trend include:

- Coking rate in Radiant coil
- Rate of rise in TLE outlet temperature
- Fouling rate in TLE
- TMT of individual Radiant coils associated with respective TLE
- COT of individual Radiant coil
- Excess CO_2 during decoke steps
- Gas velocity during decoke steps
- Dilution steam to Air ratio during decoke operation
- Physical observation status of radiant coils during Furnace cracking and decoke operation

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Methodology Adopted

Ingenero combines best of breed technology into a single software tool for Ethylene producers for this purpose and other optimization

Sample Software Combined and/or results utilized:

Furnace Side / Hot Side

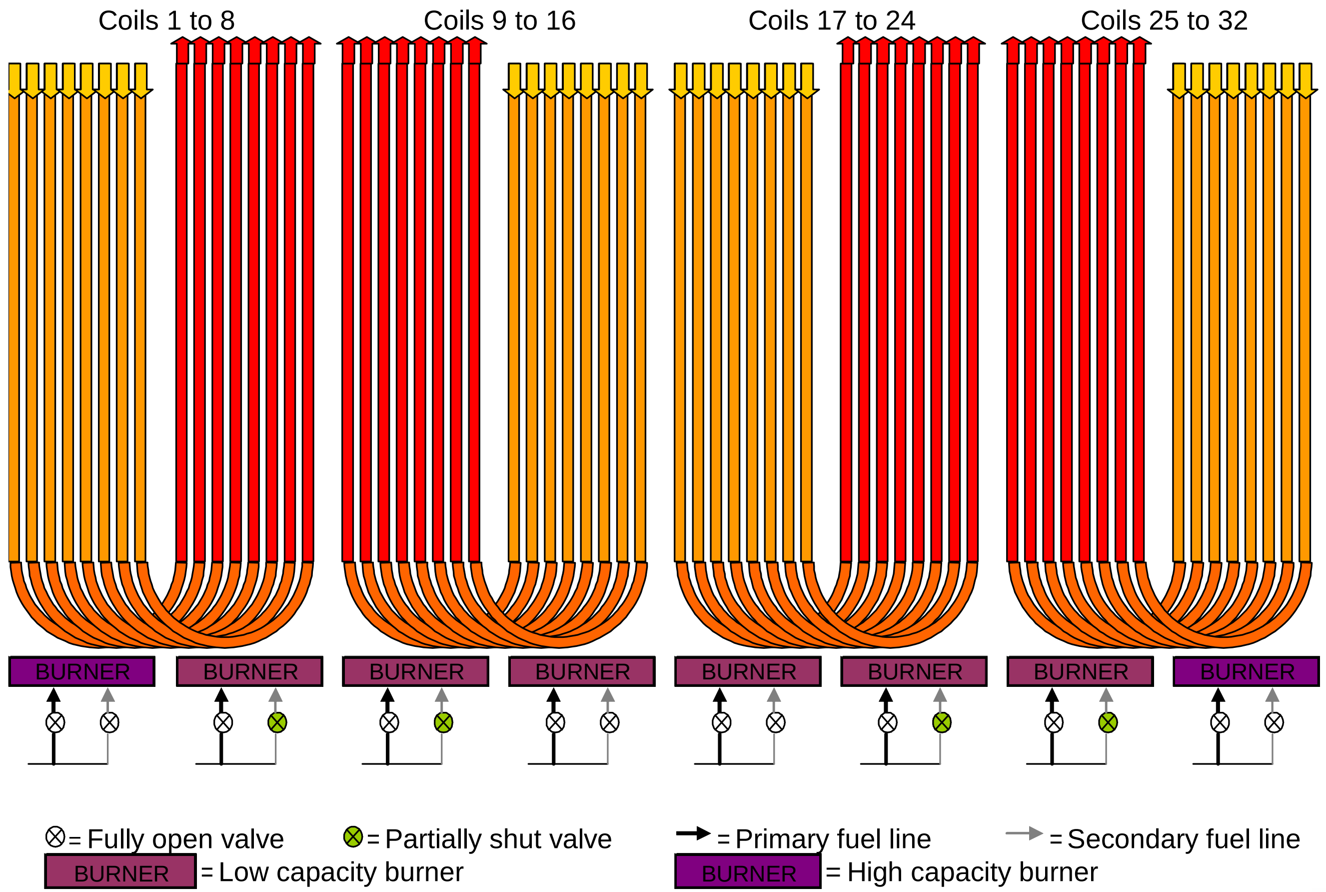
- Convection section modeling (e.g. FRNC 5)
- CFD
- Fire Box Modeling (geometry / heat flux models)
- Yield models
- ANN
- LP Model

Recovery / Cold Side

- Steady State Simulation
- Pinch
- FN Pro 2

Burner Adjustment for Controlling TMT

Fire box (geometry / heat flux) models allows individual burner management



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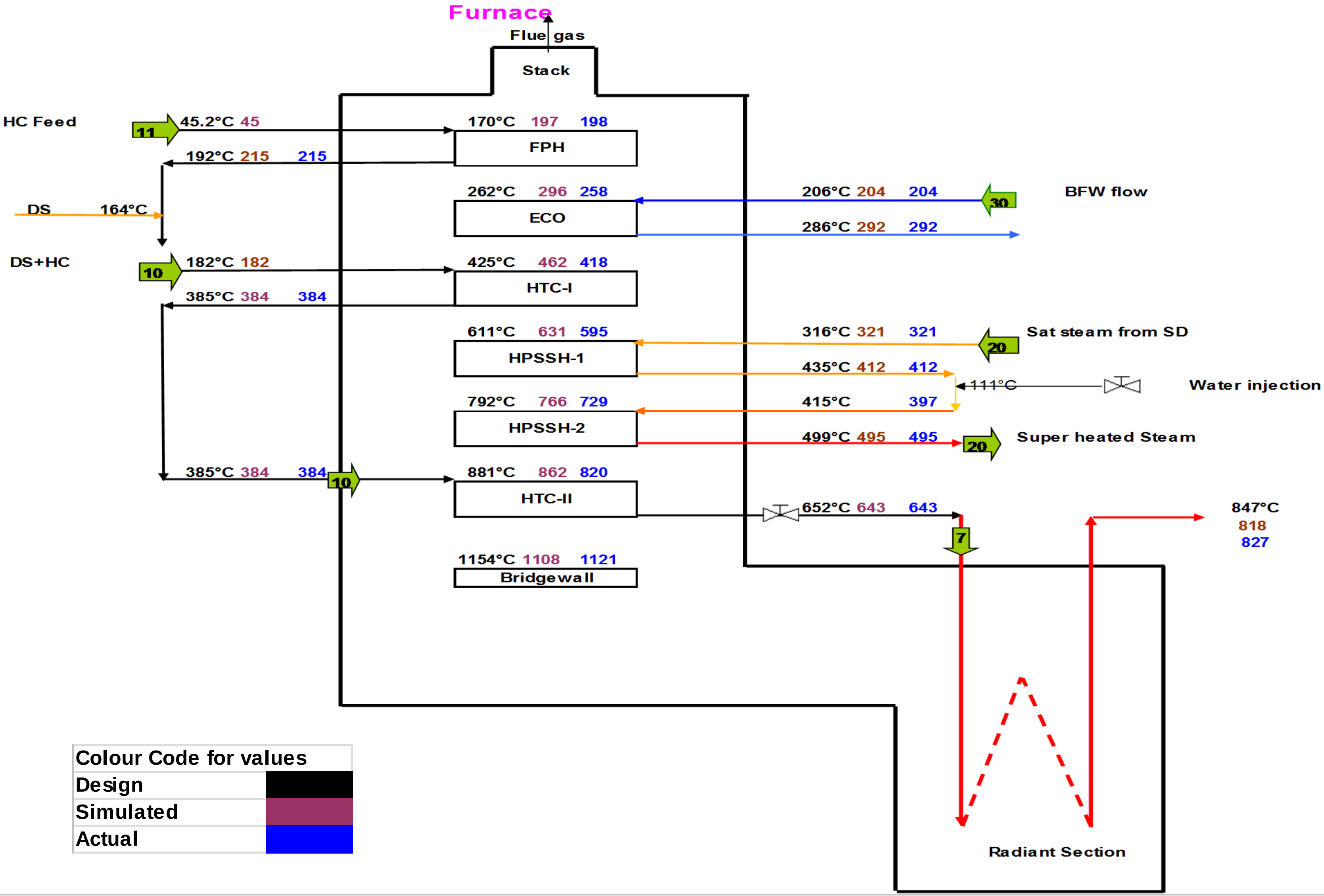
FRNC to Monitor Convection Section



Colour Code for values	
Design	
Simulated	
Actual	

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Methodology Adopted

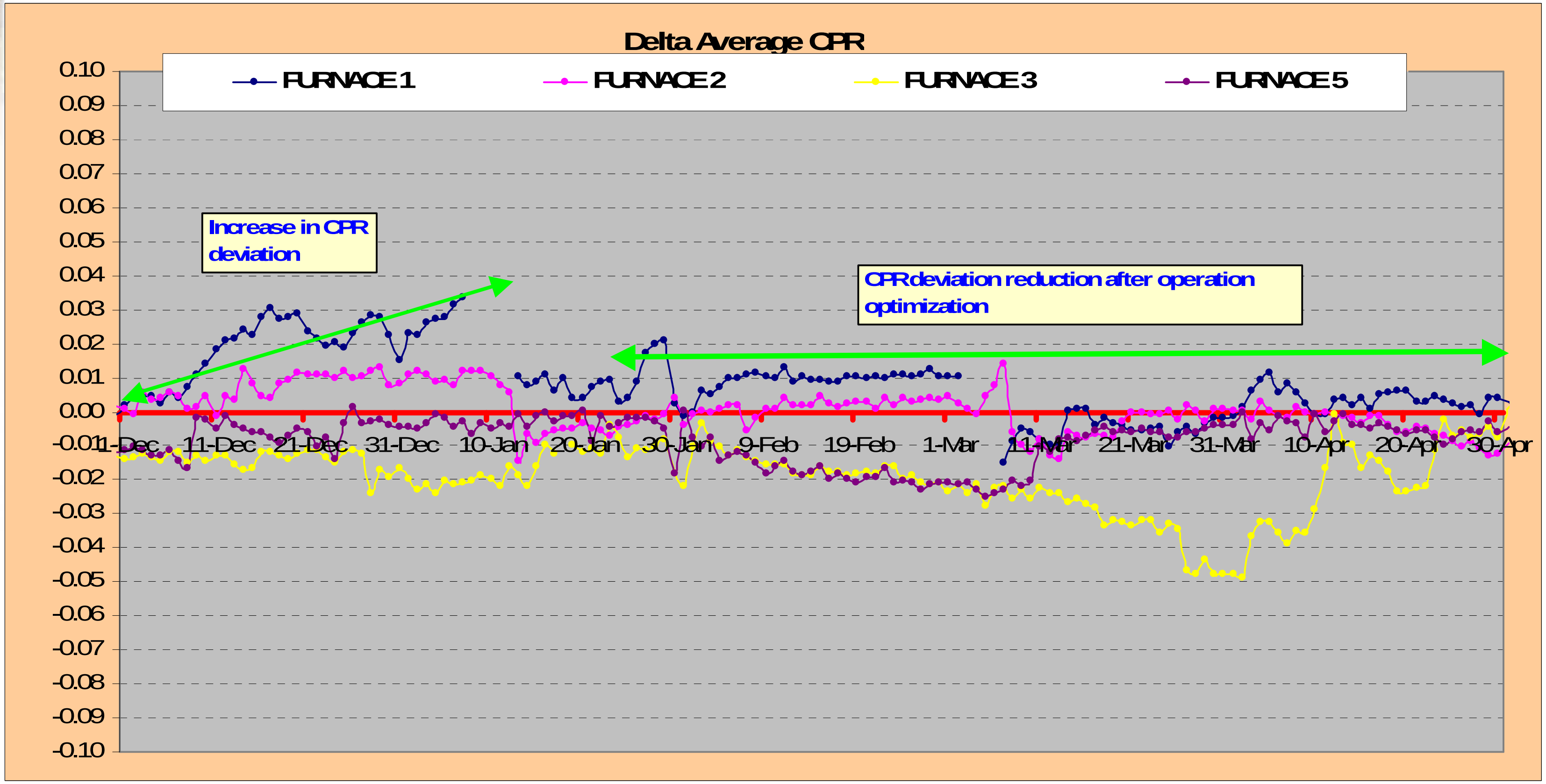
Specifically for decoking optimization those key operational and decoking parameters are analyzed

- Deviations of individual coil CPR, TMT and TLE outlet temperatures are tracked and trended for individual furnaces for daily review and analysis
- Analysis of furnace parameters, Feed trims, COT trims and Burner management provides daily guidance to control CPR and TMT of coils as well as TLE outlet temperatures
- Fouling trends of individual radiant coil and TLE in the furnace from HTRI/ HTFS software is incorporated into the daily output
- With historical analysis and predictive modeling, the appropriate decoke steps and modifications in decoke procedure are achieved

Case Study

Software allows deviation of furnace radiant coils CPR to be controlled through management of burner and other furnace operating parameters to minimize coking

CPR deviation trends of Furnaces



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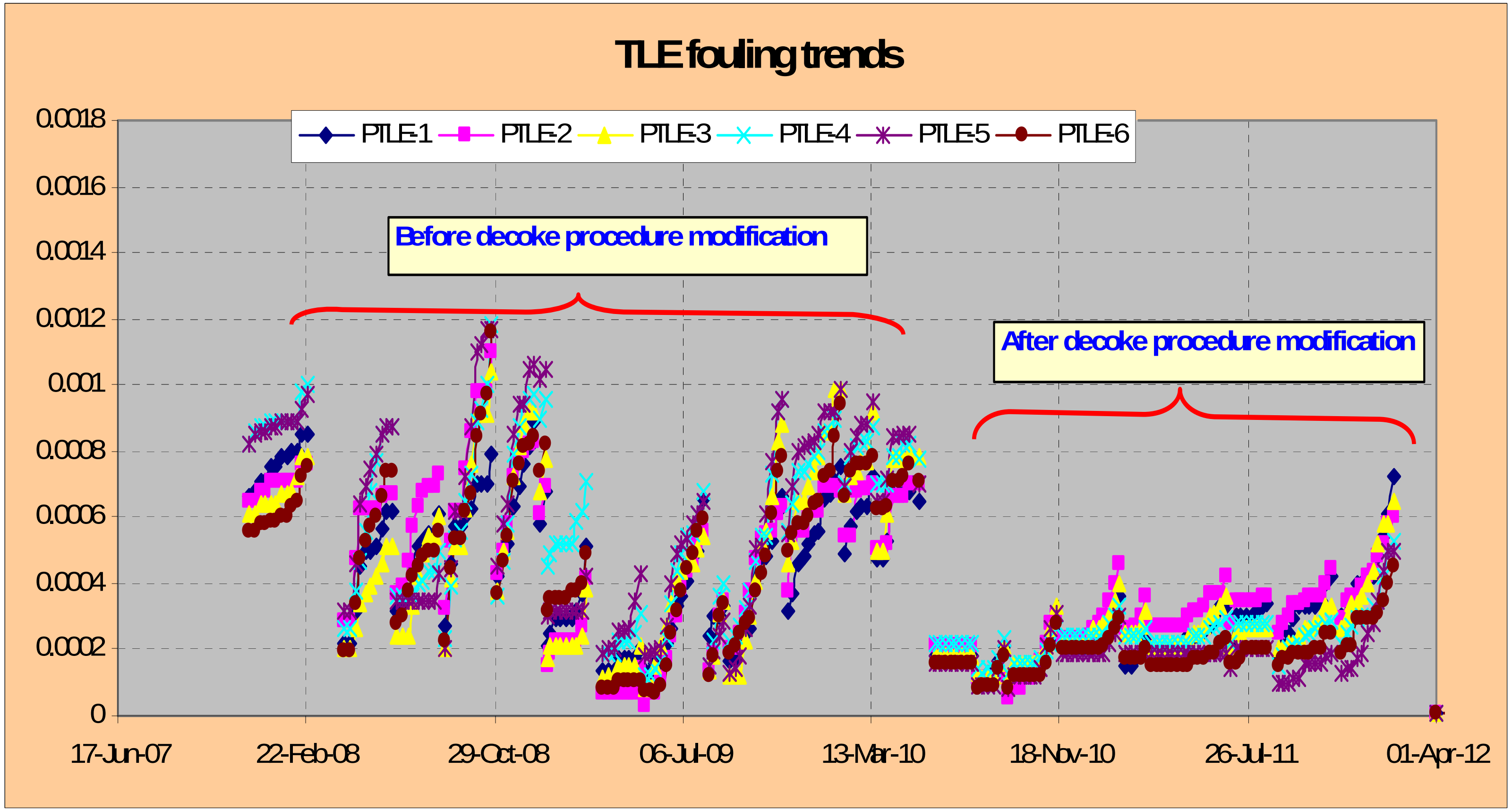
Case Study

TLE fouling is reduced by modifying Decoke procedure

TLE fouling trends before and after Decoke procedure modifications



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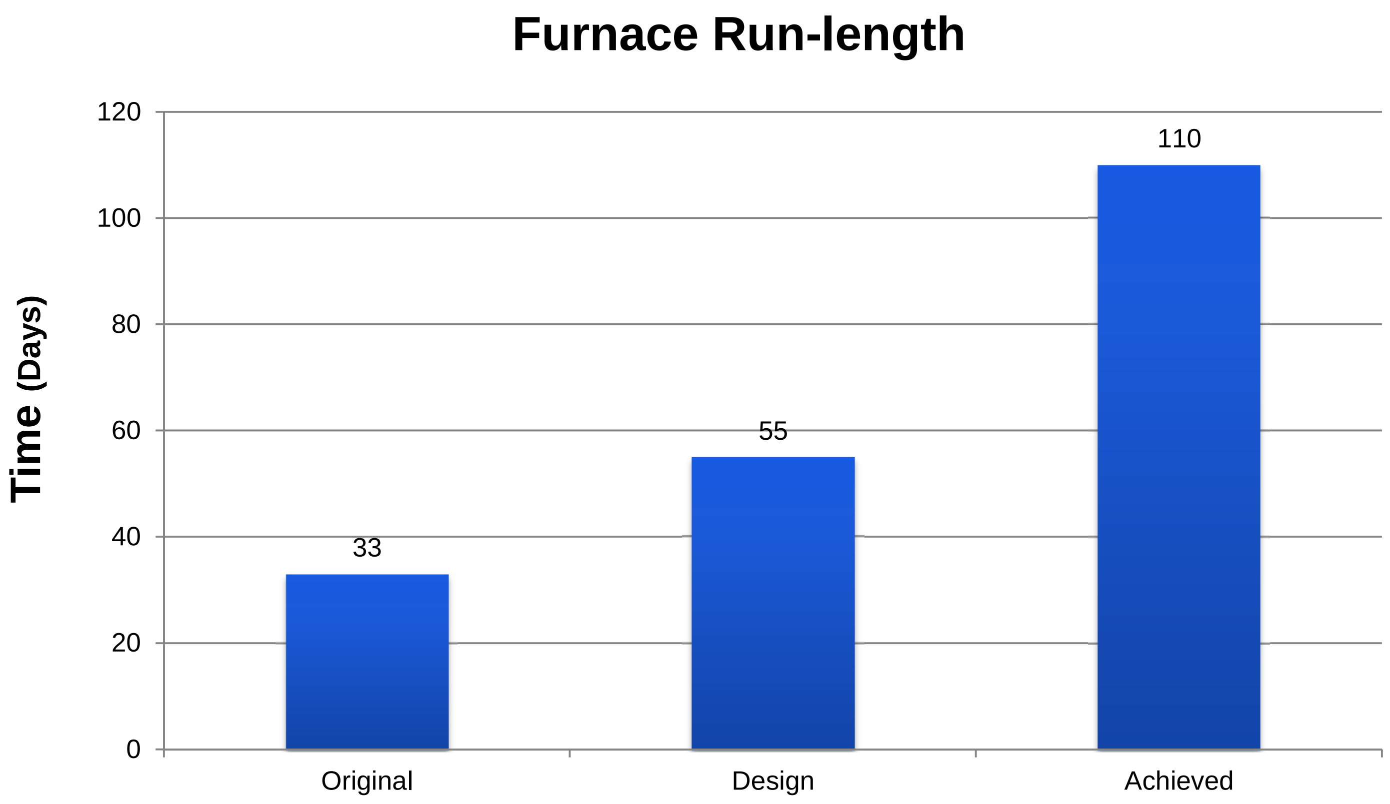
Case Study: Improve Furnace Run-length

Run length met design quickly and then was greatly exceeded



Impact on Plant Performance

- Yield improved about 3% from 76.6% by Decoke procedure modification & optimization

Year	2004	2005	2006	2007	2008	2009	2010	2011
Net Ethylene Made (Tons)	386,000	437,000	565,709	531,996	500,466	577,772	538,069	551,112
Feed Processed (Tons) excl. CH_4	504,000	548,000	702,226	670,034	621,904	722,327	680,342	696,515
% Yield	76.6%	79.7%	80.6%	79.4%	80.5%	80.0%	79.1%	79.1%
% Yield Improvement	-	3.1%	4.0%	2.8%	3.9%	3.4%	2.5%	2.5%
Improvement due to Yield (Tons)	-	16,988	27,893	18,835	24,167	24,562	17,013	17,670

✓ ***Reduction in no of Decoke cycle***

✓ ***Increase in furnace yield with increased feed rate***

✓ ***Delimiting PTLE max design o/l temperature by Decoke procedure modification***

Conclusion

Applying a systematic and careful analysis of decoking process and variables associated with coking can have dramatic effects

Example Client:

- Furnace run length improvement **(33 days to 105 days)**
- Delimited TLE maximum outlet temperature
- 3 Furnace decoke operations were avoided during the year.
- Equivalent to extra Ethylene production 1055 tons
- Other intangible benefits - Increased Furnace Coil life/ reliability due to reduction in decoke cycle
- Energy saving due to reduced decoke cycle
- Prediction and planning for mechanical cleaning of TLE

Ingenero Profile And Contact Coordinates

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Ingenero – Team Member’s Profile

Vinod Mishra

- **Assistant General Manager – Process Technology**
- **Leads Ethylene plant support teams implementing and supporting technology and training for major Ethylene Producers**
- **Over 24 yrs work experience in Ethylene and Petrochemical Plant Operations and Technical Services for Reliance**
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Questions