Fouling & Corrosion in Feed Gas Compressor

- Economics
- Locations & Mechanisms
- Causes
- Monitoring
- Control Method
- Case Study
FGC Fouling - Economical Impact

Polymer deposits on compressor internals which increases frictional losses and alters flow pattern

Results In

- Loss of compressor efficiency
- Pressure drop increase in after coolers
- Potential for unbalancing rotor & seal damage

Impact

- Initially increasing speed compensates efficiency loss
- Later it limits plant capacity
- Energy consumption increases all the time
- Increase in suction pressure reduces furnace yields
- Increase in maintenance efforts & cost
Fouling Location

Compressor Internals
Fouling Location

Compressor Labyrinth Seals
Fouling Location

Compressor Discharge Lines
Fouling Location

Compressor After Cooler
Corrosion & Erosion Location

Compressor Corrosion & Erosion
Fouling Mechanism

Chemical Mechanism
- Free Radical Polymerization
- Diels-Alder Condensation

Physical Entrainment
- Wash Oil Impurities
- Caustic Carryover – Inorganic Salts
- Corrosion By-Products
- Carryover from inter-stage KO Drums
Fouling Reasons

High Temperature
- Design inadequacies or operation above design capacity
- Lower MW due to increased severity - $C_p/C_v \uparrow$
- After cooler underperformance/fouling
- Higher CW supply temperature

Concentration of Precursors
- Dienes and other precursors increases with cracking severity
- Recycles from downstream units may contain various reactants
- Contaminants in Fresh Feed, Wash Oil, Chemicals etc.

Presence of Promoters & Catalysts
- Ingress of oxygen or peroxides and other spurious compounds via. >> Feedstock, Recycles, BFW, CW leaks, Chemicals etc.
- By products of Corrosion
Its essential to accurately measure the extent of fouling in running compressor by continuous monitoring

- Helps in initiating corrective actions at right time & location
- Calculation of Polytropic Efficiency
  - Accurate measurement of stage pressure & temperature
  - Stream Compositions
    - Furnace effluent composition from Furnace Models
    - Compressor inlet composition from Simulation Models
  - Water Injection
    - Stage temperature changes due to water injection
    - Simulation Model is essential for efficiency calculations as per injection rates

*Any inaccuracies in above makes it difficult or nearly impossible to monitor the extent of fouling in compressor*
Fouling Monitoring

- Performance comparison
  - Impact of deviation in operating conditions like feed volume, cracked gas MW, speed etc. needs to be accounted
  - Comparison plots for Design Vs. Actual Compressor performance
  - Monitoring of deviation in design and actual efficiency

*Simulation model is used for accurate data generation & comparison*

- Vibration analysis, thrust bearing temperatures, torque meters
  - Not a direct unambiguous measurement of fouling
  - Needs to be coupled with other monitoring parameters

- Analysis of casing drain for polymer content

- Pressure drop survey across compressor casings
  - Indicates precise location of fouling in compressor internals
• Fouling in after coolers
  – Flow corrected pressure drop across exchanger
  – Trending of fouling factors
    » Exchanger model accurately predicts fouling for given conditions
    » Helps in monitoring the rate of fouling in exchanger

*Use of exchanger model is essential for accurate estimation of fouling factors for given operating conditions*

• Specific power consumption of compressor
• Water Injection
  – Optimum injections rates
• pH and Iron content in inter-stage KO drums for monitoring & controlling corrosion
Identifying the mechanism & exact reasons for fouling is key for its control & cost effective mitigation.
Case Study

Ethylene Plant located in USA – Propane Feed

- 5 stage FGC machine
- Severe fouling on shell side of after coolers
- After-cooler $\Delta P$ increased to 40 - 42 psi
- Resulted in Plant feed limitation
- Repetitive shutdown to clean the FGC after-coolers
- Severe fouling & Corrosion in compressor internals
- Drop in polytropic efficiency
Case Study

Action points to reduce compressor fouling & corrosion

• Contaminants in Furnace Feed
  – Formation of Aliphatic organic acids in furnace effluent
  – Close monitoring of BFW quality
  – FGC knockout drum pH maintained at 7 (neutral)

• Impact of neutralizer amine
  – Salt formation due to reaction with acid components
  – Ionic Simulation Model developed
    » Predicts the pH, dew point & salt deposition temperature
    » Appropriate selection of neutralizer amine
    » Determination of require quantity of amine for given conditions
  – Amine injection shifted to compressor outlet

• Wash Oil Injection

• Water Injection
  – Use of de-aerated water & optimum rates
Case Study

Design modifications to improve after cooler performance

• Replacement of tube bundle within existing shell
  – Original after-cooler tube bundle geometry:
    >> External fin type tubes
      → Prone to accumulation of fouling material
      → Replaced with plain tubes
    >> Rotated square pitch arrangement
      → Increase in cleaning lane
      → Easier mechanical cleaning
    >> Baffle arrangement modifications

• Positive Impact
  – Reduction in after cooler pressure drop
  – Minimal rise in pressure drop
Case Study

After cooler ΔP has reduced significantly and fouling is being controlled well.
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