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Headache-free Catalyst Replacement Strategies

Johnson Matthey Catalysts

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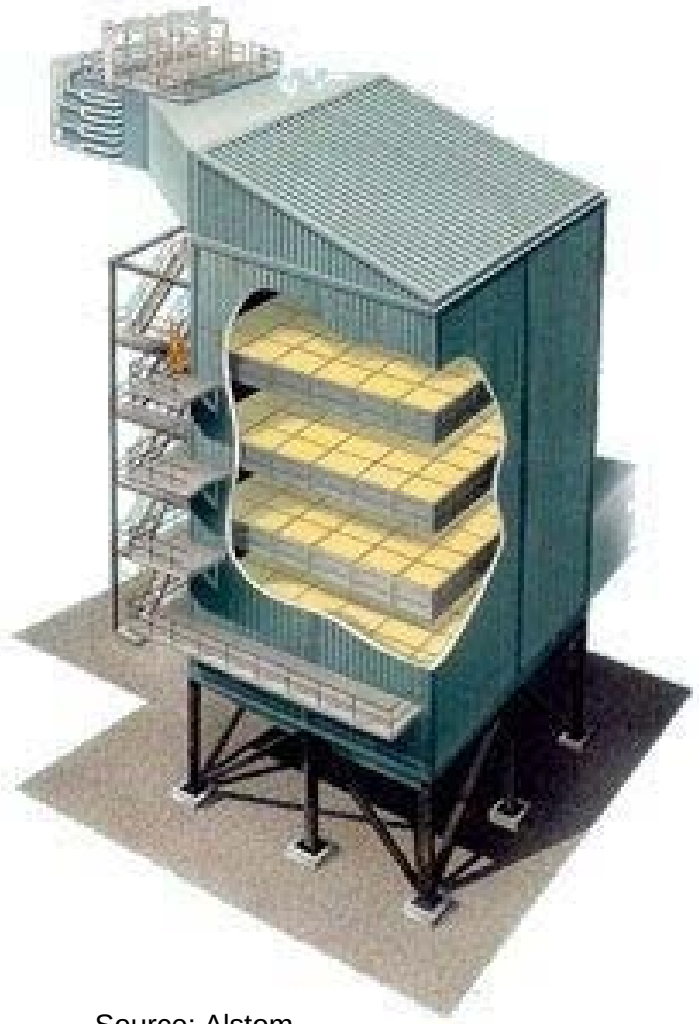
ENVIRONMENTAL CATALYSTS AND TECHNOLOGIES

Introduction/Objective

- The United States SCR Fleet in Coal Applications:
  - Over 350 individual SCR reactors
  - Over 950 individual catalyst layers filled currently
  - More stringent proposed regulations may increase the SCR fleet
- Unfortunately, high dust SCR catalyst has a limited lifetime
  - Requires periodic replacement
  - Plant Cost
- For SCR users, what process optimizes catalyst replacement certainty?



Source: Alstom

Overview

Message from catalyst supplier:
“help us help you!”

- Ensuring catalyst maintenance
- Economic impact of a non-conforming SCR
- Catalyst Design of New SCR vs. SCR Reload
- How to apply SCR system lessons learned to future SCR reloads
- Specification constraints and Performance Guarantees that can lead to headache-free catalyst replacements

Get the Most Life out of Existing Catalyst

- Don’t Let This Be You!
- SCR Catalyst is an asset
  - Use soot-blowers, sonic horns, maintain correct SCR environment
  - Learn from SCR operating experience
  - Follow catalyst operating manual
  - Poorly maintained catalyst loses it ability to be regenerated

Required Catalytic Potential for Specified NO_x Reduction Performance

- Potential: measure of catalyst's ability to reduce NO_x
- $P_{min} = f(NO_{x\ in}, NO_{x\ out}, NH_3\ slip)$ – theoretical value
- Add margin for . . .
  - Mal-distributions of NH_3-NO_x mixing and flow
  - Unavailable catalyst surface due to channel plugging
  - Catalyst material lost to fly ash erosion

Potential of Designed Catalyst

$$P = \frac{k}{AV}$$

k = NO_x activity, m/h

AV = area velocity, m/h

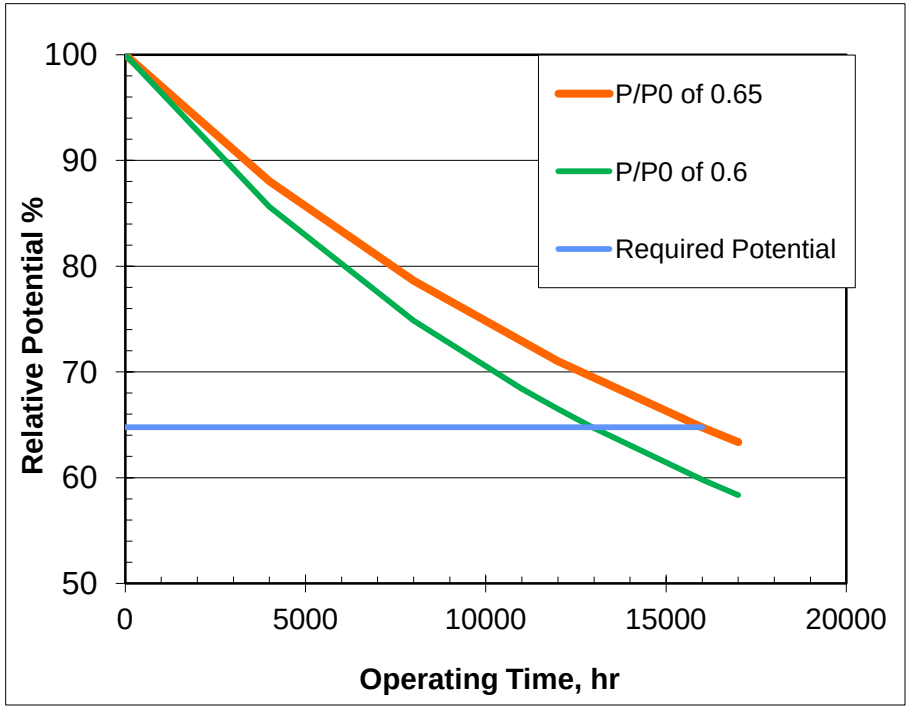
Sum for all installed catalyst layers.

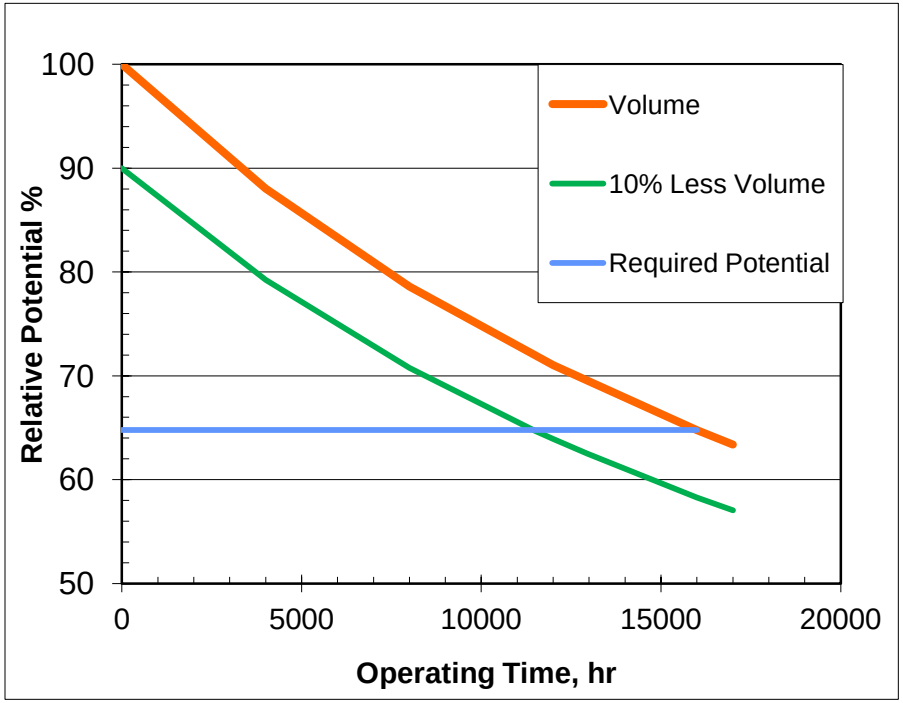
$$AV = \frac{V_{fg}}{Vol_{cat} * A_{spec}}$$

P_0 for 1 layer of 6.0 mm plate-type catalyst:

- AV = 14.0 m/h
- k_0 ~ 45 m/h
- P_0 = 45/14 = 3.2
- 2 fresh catalyst layers, P_0 = 6.4

Impact of Sizing Mistakes





Assuming a slower deactivation rate than required will cause the SCR to not make required lifetime.

Causes: Excessive plugging, catalyst poisoning

Not providing sufficient volume will cause the SCR to not make required lifetime.

Causes: Design Flow << Actual Flow, Design NOx << Actual Nox, flow distribution

Economic Impact of Non-Conforming SCR

- Proper SCR Performance is necessary for units to meet emission permit requirements, limit air heater plugging and fly ash contamination from excess ammonia slip
  - Therefore, non-conforming SCR can cause a unit derate, forced outage or increase planned outage time/expenses
- Obtaining and installing SCR catalyst can take a significant amount of time (days to weeks) and resources
  - ~$10-90/MW-hr of lost revenue
  - Catalyst Cost
  - Cost of removal and installation of catalyst modules
- Plant personnel can determine level of risk they want to take with SCR catalyst
  - Specification constraints based on existing experience/data can be utilized to minimize risk/ensure correct catalyst design

New SCR Design – Standard fare

- For the initial catalyst loading of a SCR, the catalyst supplier uses plant design information to obtain a suitable product
- Historic data for the fuel source must determine catalyst deactivation
  - No ability to utilize existing SCR performance

Application	Deactivation
Low dust configuration	Low
Bituminous firing	Medium
PRB firing	Medium-High
Lignite firing	High

Design Inputs

- DeNOx criteria - % of NOx to remove
- Operating period – 16,000/24,000 hr
- Flue gas flow conditions
  - Flow rate
  - Temperature
  - Pressure
  - Composition (NOx inlet, O2, H2O, SO2/SO3)
- Allowable NH_3 slip
- Catalyst geometry

Considerations

- Reactor configuration/space, flow distribution
- Coal type/specs, ash load
- Catalyst deactivation
- SO_2 to SO_3 oxidation
- Allowable pressure drop

Design Outputs

- Catalyst volume
- Catalyst activity
- SO_2 to SO_3 oxidation rate
- Pressure drop
- Design margin (safety factor)

Reload SCR Catalyst Design

- Complete ability to utilize existing SCR performance to more accurately design catalyst
  - General deactivation trends for the fuel type used can become reference, not an absolute
- A design advantage is gained only if SCR performance is known
  - Responsibility of SCR system owners

Design Inputs

- DeNOx criteria - % of NOx to remove
- Operating period – 16,000/24,000 hr
- Flue gas flow conditions
  - Flow rate
  - Temperature
  - Pressure
  - Composition (NOx inlet, O2, H2O, SO2/SO3)
- Allowable NH_3 slip
- Catalyst geometry/composition
- SCR Operating Data/Catalyst Deactivation

Considerations

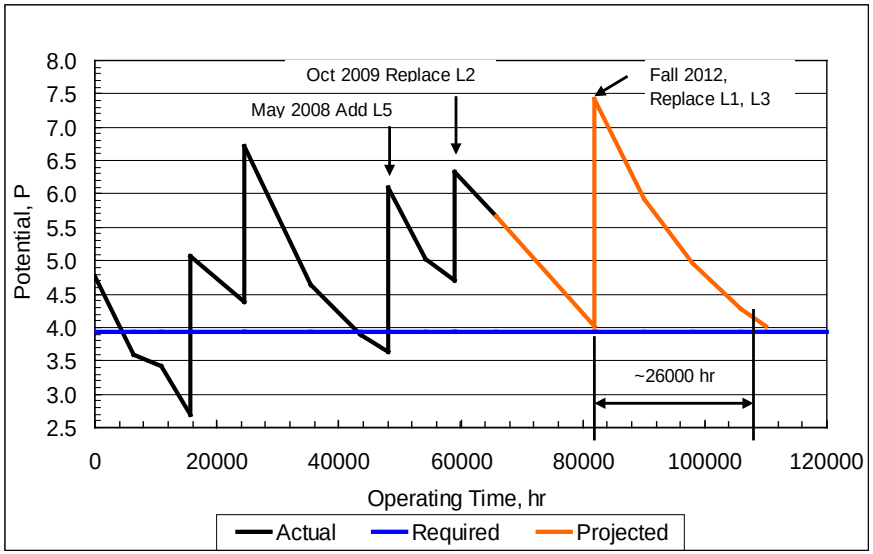
- Reactor configuration/space, flow distribution
- Coal type/specs, ash load
- Catalyst deactivation
- SO_2 to SO_3 oxidation
- Allowable pressure drop

Design Outputs

- Catalyst volume
- Catalyst activity
- SO_2 to SO_3 oxidation rate
- Pressure drop
- Design margin (safety factor)

Reload Opportunities

- Layer Replacement Bid Packages
  - Layer oriented
    - Request Initial Activity/Potential Guarantee (sometimes)
    - Request End of Life Activity/Potential Guarantee
    - Request layer SO_2 to SO_3 conversion Guarantee, pressure drop
  - Normally tied to predetermined catalyst management plan (CMP)
- Catalyst Management Planning is only useful if calibrated to actual operating data
- Factors that change CMP
  - Change in fuel or DeNOx target
  - Desire to meet planned outage schedule
  - Faster than designed deactivation



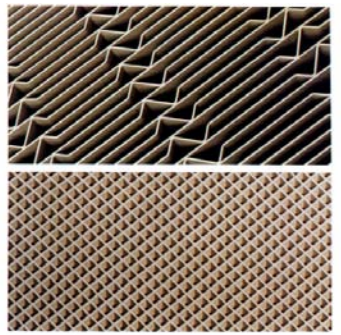
Catalyst Supplier aims to provide practical solutions that meet desired SCR performance

Requiring an initial potential guarantee can increase certainty

Reload Opportunities

- System oriented (Less common)
  - Request Guarantee on system deNOx ability for X operating hours
  - Catalyst supplier must know everything about operating SCR to provide system guarantee
    - If historic SCR operating information is not disclosed to all, this can disadvantage some suppliers
  - With accurate catalyst management planning, a layer oriented guarantee can provide similar objective

Useful Operating Information to maintain



- Existing Catalyst Geometry
  - Catalyst Type (Plate, Honeycomb, Corrugated)
  - Catalyst Pitch
  - Catalyst Element Height
- Existing Catalyst Performance
  - Initial Catalyst Activity
  - Tested catalyst activity at various operating times
  - SO_2 to SO_3 conversion
- Reactor inspection observations
  - Plugging
  - Excessive erosion
- Boiler Related Changes
  - Fuel Changes
  - Additives
  - Combustion modifications
  - Economizer modifications

Call Supplier to discuss what impact a plant change may have on catalyst performance

Acceptable testing strategies

- Available sample sizes
  - Full Bench
    - 150 mm by 150 mm by Full element Length
  - Semi Bench
    - 65 mm by 65 mm by 500 mm
  - Micro Scale
    - 25 mm by 25 mm by 200-400 mm
- All sample sizes can perform SO_2 to SO_3 conversion and NOx activity testing
- Performance Guarantee testing can be done by field testing or lab testing at design conditions
- Suppliers often will include catalyst activity testing during warranty period

Advantages of Maintenance of SCR Performance information

- Historic perspective on catalyst performance
  - Opportunity to revise catalyst management plan
- Provides SCR Owners information to better analyze the technical aspects of bid proposals
  - If catalyst does not perform adequately, both the catalyst supplier and the utility loses
- Opportunity to specify desired initial potential rather than activity
  - Potential levels playing field
- Allows utilities to determine which catalyst works best for their specific application

Incorporate Lessons Learned into Catalyst Specification

- Some SCR problems can not be fixed effectively by the catalyst design
  - Poor NOx/NH_3/Velocity distribution, Combustion problems, LPA, etc
- <u>Common Lessons Learned</u>
  - Reactor plugging
    - Increase Catalyst Pitch requirement (also ensure sonic horn/soot-blowing operation)
  - Difficulty predicting SCR performance as operating conditions change
    - Require, apply and understand performance correction curves
  - Performance deviating from Catalyst Management Plan
    - Recalibrate CMP
    - Require suppliers to provide an initial potential guarantee
  - Erosion
    - Look into catalyst products with higher abrasion resistance (also flow distribution)
  - SO_2 Conversion Problems (Opacity/Blue Plume)
    - Require suppliers to provide catalyst with lower SO_2 conversion
- Catalyst layers can differ in volume, pitch, type without negatively affecting SCR performance

Conclusion

- Let catalyst supplier work for you
- Get the most life out of your existing catalyst
- Maintaining existing SCR operating data can lead to most effective catalyst reload designs
- Incorporate lessons learned into reload bid packages

Thank You!

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