

Reinhold Environmental Ltd.



2009 NO_x-Combustion Round
Table & Expo Presentation

February 9 & 10, 2009, Cleveland, OH



Mixed SCR Catalyst Beds



REINHOLD ENVIRONMENTAL LTD.

2009 NO_x – Combustion PCUG Conference
Cleveland, Ohio
February 10, 2009



Argillon is now Johnson Matthey Catalysts



- Johnson Matthey acquired Argillon in February 2008
- British Company - Founded in 1817
- Traded on the London Stock Exchange
- Sales revenue of £7.5 billion (\$10+ billion)



Johnson Matthey Divisions



Johnson Matthey is a specialty chemicals company focused on its core skills in catalysts, precious metals, fine chemicals and process technology. It is organized into three global divisions:



**Precious
Metal Products**



**Fine Chemicals
and Catalysts**



**Environmental
Technologies**



Argillon + Johnson Matthey Product Lines



Argillon - Ceramic catalyst expertise

SCR catalyst

Extruded, homogenous, TiW honeycomb

Plate-type TiO₂ ceramic

Extruded, homogenous zeolite honeycomb

Small SCR systems

Johnson Matthey - Precision coating catalyst expertise

SCR catalyst for low dust

Oxidation Catalyst

Mercury Control:

 Precious metal catalyst for flue gas

 Pd sorbents for coal gasification (IGCC)

Ammonia Slip Catalyst for clean flue gas

Water-gas slip (WGS) catalyst

Small SCR systems





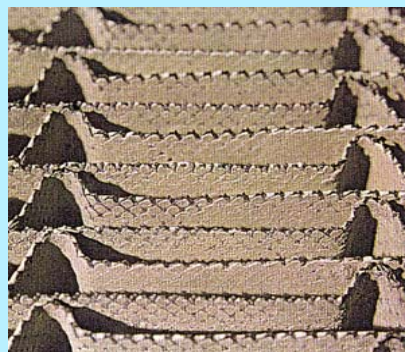
What is a mixed catalyst bed?

Often refers to an SCR reactor that contains a mix of plate, honeycomb or corrugated catalyst.

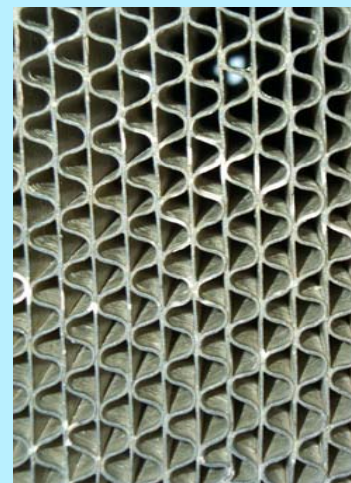
Can refer to an SCR reactor that contains catalyst that is not identical in every way: pitch, composition, wall thickness, regenerated, manufacturer



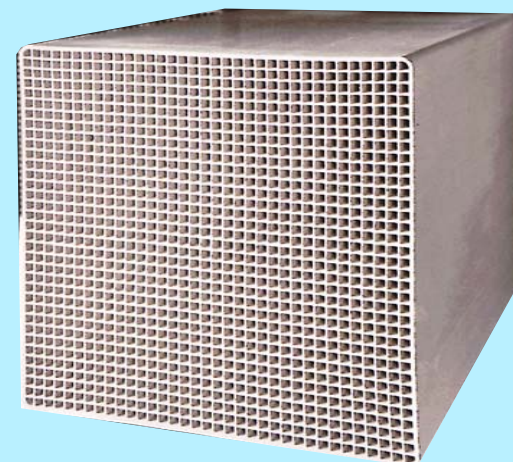
Catalyst types



Plate



Corrugated



Honeycomb



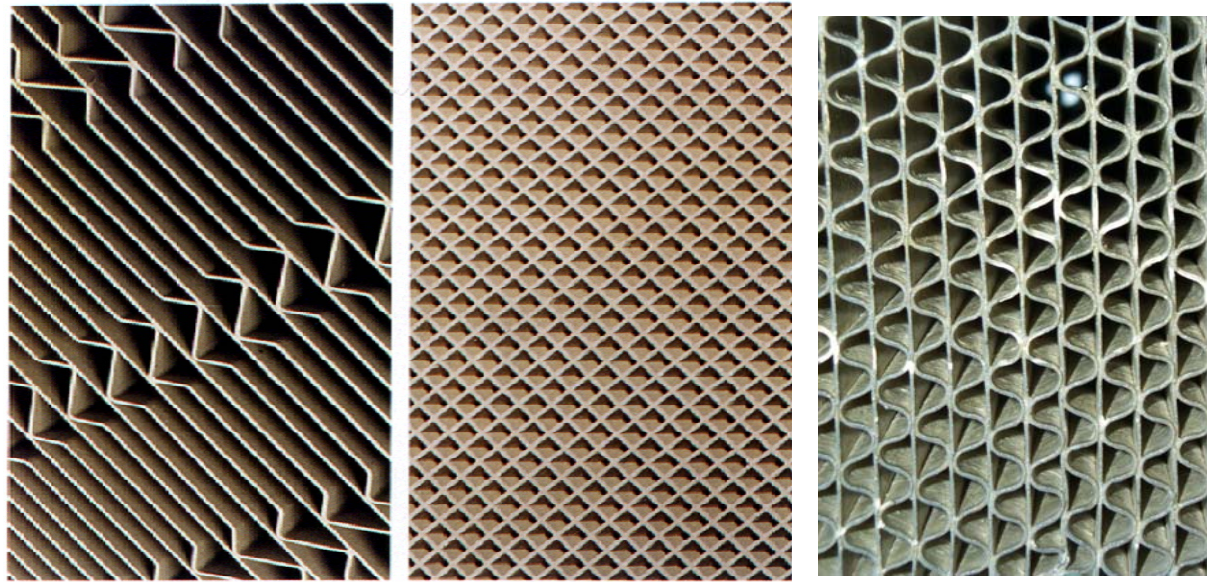
Catalyst types



Plate

Honeycomb

Corrugated



Why have a mixed catalyst bed?



Price, Problems or Improvements

Initial catalyst loading supplier's price or evaluated cost is not the lowest offered for the reload.

Initial loading had problems with deNOx performance, plugging, erosion

Enhanced product or feature, new to the market

Desire to enhance performance based on layer's position in the reactor

Delivery issues – limited selection due to short lead-time

Fuel change



Issues related to mixed catalyst beds



System guarantees:

Be prepared to provide sufficient information to other catalyst suppliers or regenerators about existing catalyst so they can evaluate whether to guarantee other's catalyst. Catalyst samples or test reports may be required.

OR

Layer guarantees:

Owner takes responsibility for performance of the System. Specify the layer requirements that will give the System performance needed.



System guarantees vs. layer guarantees



System guarantee

DeNOx % @ slip after X hours, ΔP for all layers, SO₂ conversion for all layers, usually field measured

Layer guarantee

Initial NO_x activity, EOL NO_x activity, ΔP for one layer, SO₂ conversion for one layer, lab measured



How is one layer specified?



Fleet or plant specific depending on environmental compliance goals

- Outage schedule → operating hours
- Fuel
 - Sulfur → tolerance to SO₃ & slip → SO₂ conv.
 - Ash loading → plugging → pitch
 - Ash properties → deactivation, erosion → pitch
 - Poisons → NO_x activity
- CMP → fleet standardization desired? Customizing for one unit may make it unsuitable for other units in the fleet later
- Other → mercury removal strategy



Catalytic potential required

At end of life:

$$P_{\text{req'd}} = \ln f(\eta_{\text{NOx}}, \alpha)$$

$\alpha = \text{NH}_3$ req'd for DeNOx incl. allowed slip

$$P_{\text{req'd}} = f(\text{NOx}_{\text{in}}, \text{NOx}_{\text{out}}, \text{slip})$$

Must have more P at beginning of life to account for deactivation, plugging, flow imbalances → experience

Can achieve $P_{\text{req'd}}$ with a number of catalyst designs.



Creating new problems



If your performance is good, be careful not to create new problems.

Most common – plugging where no plugging existed before → pitches for different catalyst types are not comparable. Screen opening size has been a problem.

Neglecting to specify a feature that you currently have and want to retain → wall thickness

Consider tools & seal design.



Bid evaluation strategy can affect outcome



Time period – 2 yrs, 5 yrs, 10 yrs?

Cost applied to alternative methods (i.e., SO₃ mitigation)

Price is king – lowest price offer due to budget, future considered less

Value applied to robustness

Decisions can result in different outcome



Catalytic potential – the great equalizer

If designs are received for a variety of volumes or activities, catalytic potential can be used to compare the designs.

Minimum catalytic potential required to achieve desired DeNO_x and NH₃ slip rates for given operating period

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

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

k_t = activity at time t (EOL)

V_{fg} = flue gas flow rate

AV = area velocity

A_{spec} = catalyst m²/m³



Catalytic potential – other considerations



Typical P values for a layer is 2-3.

Designs with the same potential may still have other features that should be considered, esp. SO_2 conversion and pressure drop.

Make sure to compare apples to apples.



- Catalyst activity, k
Catalyst formulation, V_2O_5
Flue gas characteristics: Temp, flow, H_2O , O_2 ,
 SO_2
Consider deactivation, $k_0 \rightarrow k_t$
Consider limits on SO_2 conversion
- Iterative process to determine AV
and k



Area Velocity

- Flue gas flow rate – according to plant conditions
- Volume: layer cross-section x catalyst height x layers installed
 - Cross-section limited by linear velocity, 4.5 – 6 m/s (14.5 – 20 ft/s)
 - Catalyst height typically 1200 – 1300 mm
 - Consider effect on pressure drop
- Specific Area, A_{spec}
 - Set by pitch
 - Pitch selected according to dust loading
 - Consider effect on pressure drop



Need help?



Catalyst manufacturers

Independent consultants

Regenerators & others

DIY - Commercial CMP Software Tool





Example Software

CAT MANAGER™

Andover Technology Partners

Microsoft Excel-based

Can model reactors with up to five layers of catalyst and two sublayers per layer

Estimate replacement times

Compare life-cycle cost of reprocessing vs replacement

Operating regime can be considered (seasonal, annual)

Estimate ammonia slip under varying conditions

Estimate cost of catalyst pressure drop

Estimate future cash flows

Modest price

Could be other commercially available programs with equal or better features.



Mixed beds can work successfully



Mixed beds can operate successfully.

Evaluate what features are important to your fleet or plant now and in the future.

Determine whether changes have been made to the plant's operation that would require changes to the initial loading specification.

Be careful not to create new problems.

Operating experience will help with future decisions.



Questions?



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