SCR and Advanced Ammonia Slip Catalyst

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June 11, 2015
SCR System Configuration & Ammonia Injection

Engines

Turbines / Boilers
SCR uses NH$_3$ as the reductant to remove NOx from lean exhaust

Relevant chemical reactions:

- $4 \text{NH}_3 + 4 \text{NO} + \text{O}_2 \rightarrow 4 \text{N}_2 + 6 \text{H}_2\text{O}$
  - standard SCR reaction (fast)
- $4 \text{NH}_3 + 2 \text{NO}_2 + 2 \text{NO} \rightarrow 4 \text{N}_2 + 6 \text{H}_2\text{O}$
  - fast SCR (very fast)
- $4 \text{NH}_3 + 5 \text{O}_2 \rightarrow 4 \text{NOx} + 6 \text{H}_2\text{O}$
  - undesired reaction (above 425$^\circ$C)
- $4 \text{NH}_3 + 4 \text{NO} + 3 \text{O}_2 \rightarrow 4 \text{N}_2\text{O} + 6 \text{H}_2\text{O}$
  - undesired reaction (GHG)

Note: there are other reaction pathways but these reactions dominate in lean exhaust
Relationship between NOx conversion, NH₃ slip, ammonia NOx ratio (ANR)

At ANR 0.8 max NOx conversion is 80% (1:1 stoichiometry) and because there is insufficient NH₃ NH₃ slip is low

At ANR 1.0 the max NOx conversion achieved here is higher, but with higher NH₃ slip

At ANR 1.2 excess NH₃ enables even higher NOx conversion, but with much higher NH₃ slip

Increase NH₃ → increase NOx conversion but increase NH₃ slip
Advanced ammonia slip catalyst (ASC) technology significantly improves overall SCR performance

Even the optimal catalyst cannot achieve maximum NOx conversion with non-uniform NH$_3$ distribution

Non-uniform NH$_3$ distribution can be a result of:
- Flue gas mal distribution
- Control system / Injection system
  - Location of sample ports, CEMS system, AIG Configuration or tuning
- Fluctuating load or inlet NOx values
  - NH$_3$ Injection won’t match NOx

Non-uniform NH$_3$ distribution can result in localized ANRs:
- ANR $<$ 1 results in incomplete NOx conversion
- ANR $>$ 1 results in NH$_3$ slip

Ammonia Slip Catalyst (ASC) can compensate for non-uniform NH$_3$ distribution
ASC allows operation at higher ANR boosting NOx conversion with low NH$_3$ slip
Advanced dual-function ASC is very selective to N₂
(selectivity = fraction of specific product)

Advanced dual-function ASC:
• 50 ppm NH₃ + 50 ppm HC fed to ASC
• Very active for NH₃ conversion
• NH₃ exiting ASC is very low
• Formation of NOx, N₂O is very low
• Highly selective to N₂

Previous generation ASC:
• 20 ppm NH₃ fed to reactor
• Very active for NH₃ conversion
• N₂O formed at low T, NOx formed at high T
• Not selective to N₂

NH₃ → NOx above 425°C
Additional benefits of adding ASC to SCR catalyst system

- Allows operation at higher ANR increasing NOx conversion at low NH$_3$ slip
- ASC improves HC conversion
- Incomplete combustion of HC over V-SCR results in formation of CO
- ASC provides CO conversion
- In some applications, use of ASC can eliminate the need for an oxidation catalyst

Engine data: equal volumes SCR and SCR+ASC
Thank You