Design of NO_x Treatment System for Coal Power Plant

Quick Facts

- Coal as its main fuels is burned to generate electricity
- Air Pollution : Nitrogen oxides, which harm air quality
- Selective Catalytic Reduction (SCR) reduces NO_x emissions

Objectives

- To study occurence and theories rerated to NO_x
- To study the NO_x treatment process by SCR
- To design SCR for NO_x treatment

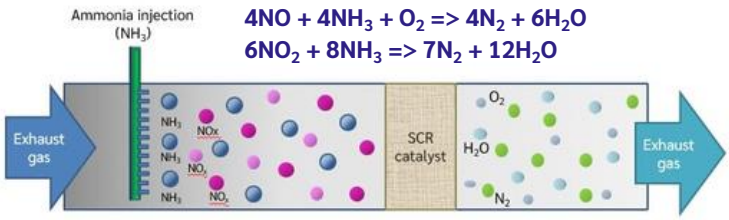
Nowadays, natural resources are essential for energy production, leading to the establishment of numerous thermal power plants. In Thailand, thermal power plants primarily rely on natural gas and coal as fuel sources. **This study focuses on coal as the main fuel.** Several coal-fired power plants operate in the country, including Mae Moh, BLPC, and Krabi power plants. However, coal power plants raise significant environmental concerns due to the emission of various pollutants, particularly CO, CO_2, SO_2, Dust, and NO_x. **This study specifically focuses on NO_x emissions**.

- Secondary pollution
- Acid rain
- Soil contaminate
- Damage to the human
- Chronic lung disease

- Announcement of Ministry of Natural Resources and Environment **$NO_x \leq 200$ ppm**
- Announcement of Department of Industrial Works
  - **Power plant used coal as a fuel 200 ppm**

What is Selective Catalytic Reduction (SCR)?

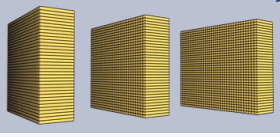
- SCR system effectively treats NO_x.
- It injects ammonia into the flue gas upstream of the catalyst, where NO_x reacts with NH_3 and O_2 to produce N_2 and H_2O.



$4NO + 4NH_3 + O_2 \Rightarrow 4N_2 + 6H_2O$
$6NO_2 + 8NH_3 \Rightarrow 7N_2 + 12H_2O$

Catalyst

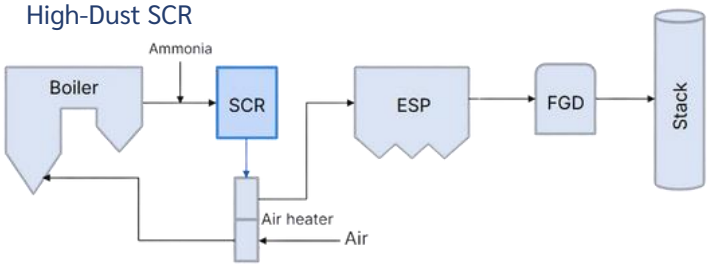
- The catalyst accelerates the reaction between NO_x and NH_3, efficient reduction of NO_x to N_2 and H_2O.
- **Vanadium pentoxide (V_2O_5)** is the most commonly used catalyst due to its high efficiency in reducing NO_x.
- The structure of the catalyst is Honey Chrome.



Honey Chrome SCR Catalyst

SCR Configuration

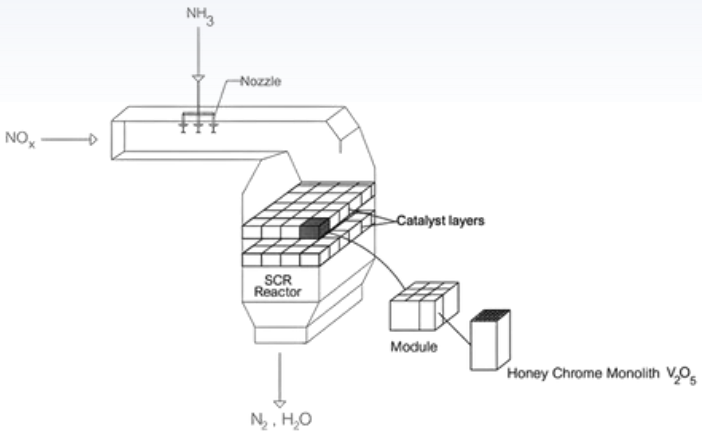
High-Dust SCR



High-Dust SCR is a NO_x reduction system installed before the electrostatic precipitator (ESP), utilizing a catalyst to effectively reduce NO_x emissions in flue gas. This system is widely favored due to its cost-effectiveness and simple structure.

- **Cost-effective and easy to install** : Does not require a gas-cleaning system before entering the SCR
- **Operates at an optimal temperature** : The installation position ensures that the flue gas temperature remains
- **Low energy consumption**

With these advantages, High-Dust SCR is an ideal choice for power plants and industries seeking an efficient and cost-effective NO_x reduction solution.



Ammonium Hydroxide (NH_4OH)

An aqueous solution of ammonia (NH_3) dissolved in water. It is commonly used in various industrial applications, including SCR systems for NO_x reduction.

Advantages

- Safer to handle
- Easier to transport and store

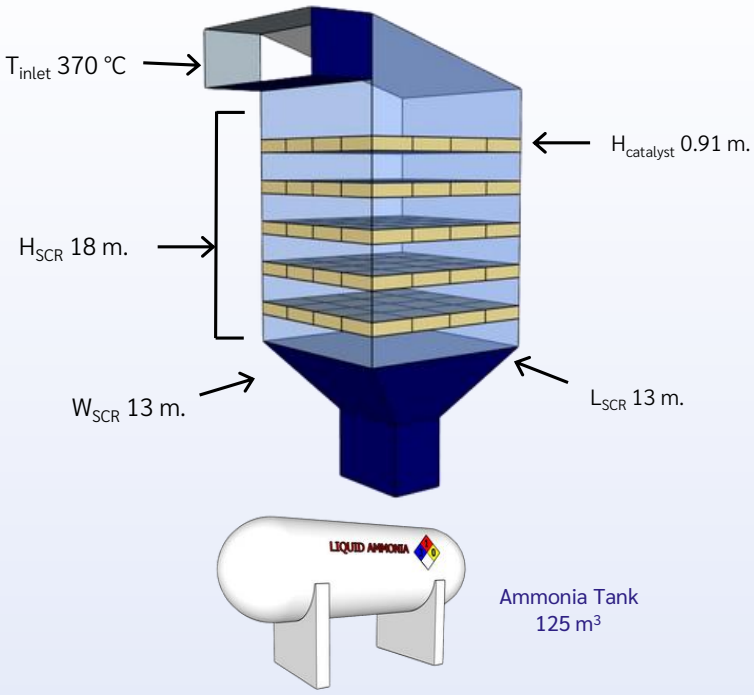
Disadvantage

- Lower ammonia concentration
- Requires more energy for evaporation

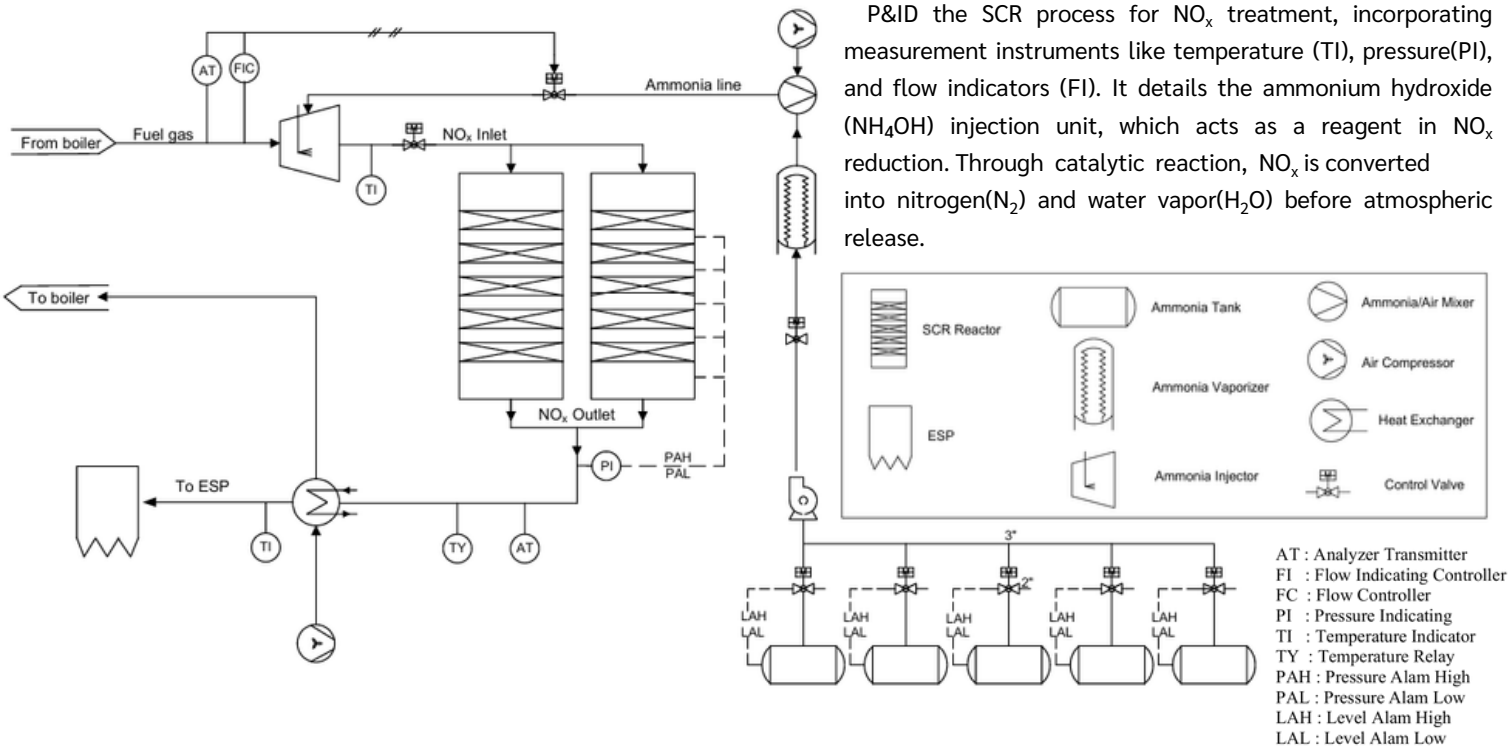
Ammoniam hydroxide Design Equations

Design Equations		
$V_{catalyst}$	$Vol_{catalys}=2.81\times Q_B\times \eta_{adj}\times slip_{adj}\times NO_{xadj}\times S_{adj}\times \frac{T_{adj}}{N_{SCR}}$	
$A_{catalyst}$	$A_{catalyst}=\frac{q_{fluegas}}{\left(\frac{16\ ft}{sec}\right)\times\left(\frac{60\ sec}{min}\right)}$	
A_{SCR}	$A_{SCR}=1.15\times A_{catalyst}$	
V_{SCR}	$\forall_{SCR}=A_{SCR}\times L$	
$V_{ammonia\ tank}$	$\forall_{tank}=q_{sol}\times t_{storge}\times 24$	
Design Parameter	**Value**	**Unit**
m_{fuel}	10,000	ton/day
NOx_{inlet}	0.11	g/MJ
$q_{flue\ gas}$	708.78	m^3/s
q_{flue}	0.88	g/MJ
Q_B	1611.50	MW
Efficiency	90%	
NOx_{outlet}	0.01	g/MJ

Designed SCR



Piping and Instrumentation Diagram



P&ID the SCR process for NO_x treatment, incorporating measurement instruments like temperature (TI), pressure(PI), and flow indicators (FI). It details the ammonium hydroxide (NH_4OH) injection unit, which acts as a reagent in NO_x reduction. Through catalytic reaction, NO_x is converted into nitrogen(N_2) and water vapor(H_2O) before atmospheric release.

Conclusions

- The SCR system is designed to reduce NO_x levels to 138.5 ppm. with 90% efficiency. A high-dust SCR configuration is used, with dimensions of **18 m. in height, 13 m. in width, and 13 m. in length**, featuring **5 catalyst layers,** each with a **height of 0.91 m.**
- The system utilizes **ammonia hydroxide (aqueous ammonia)** for NO_x reduction, with a consumption rate of 543 m^3 every 14 days, stored in **5 tank, each with a capacity of 125 m^3**

Cost Estimation	
Ammonia tank Tank	6,182,115 ฿ (30 years)
Ammonium Hydroxide	656,075.52 ฿ (14 days)
Catalyst	2,530,792.80 ฿ (2-5 years)
Sonic Soot Blower	336,900 ฿ (10 years)

Ref.

- TLT CONSULTANTS COMPANY LIMITED. 2021. **EHIA of Mae Moh Replacement Power Plant Project Units 8-9 of the Electricity Generating Authority of Thailand(EGAT)**. Available form: https://eia.onep.go.th/eia/detail?id=10439
- U.S. Environmental Protection Agency. 2019. **Chapter 2 Selective Catalytic Reduction**. Available form: https://www.epa.gov/sites/default/files/2017-12/documents/scrcostmanualchapter7thedition_2016revisions2017.pdf

3D SCR

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