

DIRECT INJECTION TECHNOLOGY

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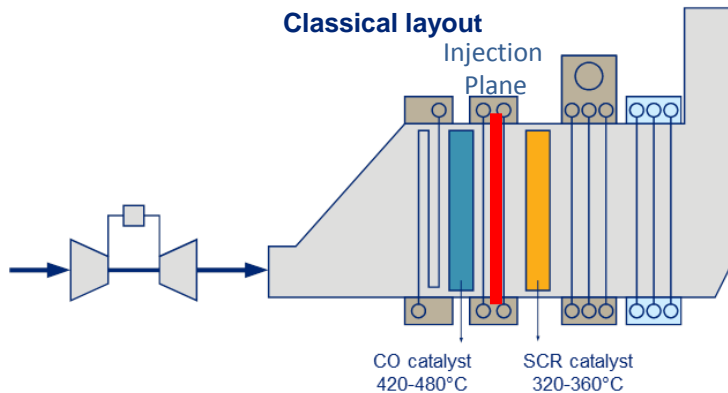
LP AMINA | Energy and Environmental

DIRECT INJECTION SIMPLIFIES THE AMMONIA INJECTION PROCESS FOR A MORE COST-EFFECTIVE SOLUTION WITH BETTER AMMONIA DISTRIBUTION

TRADITIONAL VERSUS DIRECT INJECTION

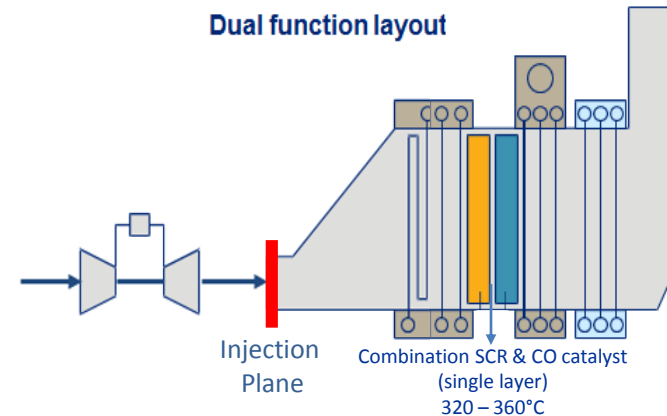
TRADITIONAL

Classical layout



DIRECT INJECTION

Dual function layout



Costly and complex AFCU skid

- Unreliable hot gas fans

Costly and complex AIG

- Hard to tune
- Typically $\text{NH}_3:\text{NO}_x$ of 10% RMS or higher

Two layers of catalyst (CO, SCR)

- Higher pressure drop
- Higher HC oxidation

Overall longer HRSG, footprint (new builds only)

Simple and reliable AFCU skid

- Metering pumps

Eliminates AIG

- Simple to tune
- Achieves $\text{NH}_3:\text{NO}_x$ of 5% RMS

Single layer of catalyst (CO + SCR)

- Lower pressure drop (~\$50,000 fuel savings annually per 1 iwcd saved for F-class CTG)
- Lower SO_2 oxidation
- Easier installation & replacement

Smaller, more compact HRSG, footprint (new builds only)

DIRECT INJECTION ELIMINATES MANY OF THE MORE COSTLY COMPONENTS OF THE CO/SCR EMISSION CONTROL SYSTEM

TRADITIONAL VERSUS DIRECT INJECTION COMPARISON

TRADITIONAL

AMMONIA FLOW CONTROL UNIT

- 2 x 100% hot flue gas recirculation fans (high HP)
- Structured column (\$\$) or air-atomized (parasitic load) vaporizer
- Electric or gas heater for fast start (high O&M cost)
- Large-bore piping

AMMONIA INJECTION GRID

- Complex piping with thousands of small holes
- Large empty duct required downstream of AIG for mixing

DUAL CATALYST LAYERS

- Requires separate layers for CO, SCR (increased pressure drop)
- Traditional frame design (costly)

DIRECT INJECTION

AMMONIA FLOW CONTROL UNIT

- 2 x 100% metering pumps (low HP)
- No vaporizer, heater required (lower O&M cost)
- ½" to 1" stainless piping = reduced footprint & cost
- Can include small compressor station for atomizing air

AMMONIA INJECTION SYSTEM

- 6-18 injectors installed in the HRSG inlet duct
- Dual-fluid atomizing nozzles with insulated aerodynamic sheaths
- Much simpler to tune and troubleshoot

SINGLE CATALYST LAYER

- If CO reduction is required, dual-function CO/SCR catalyst is used
- Self-supporting design eliminates cost of traditional frame

LP AMINA HAS INSTALLED AND PROVEN DIRECT INJECTION ON A COMMERCIAL SCALE IN CHINA

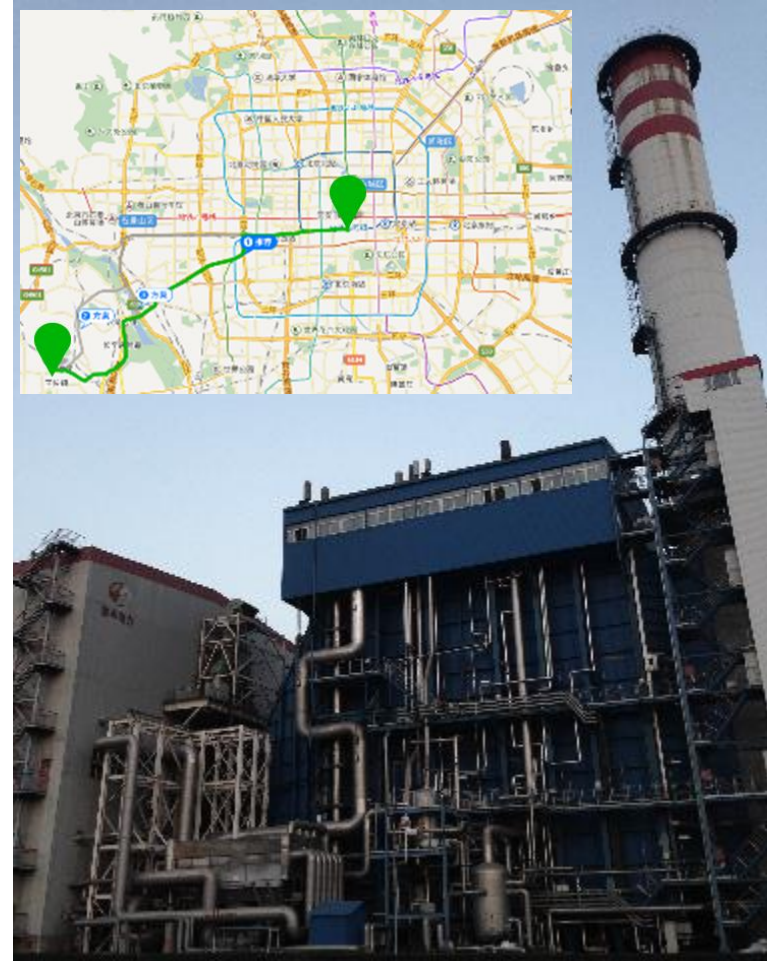
BEIJING ENERGY JINGFENG (京能京丰电厂) PROJECT OVERVIEW

- 1 x 1 x 1 single-shaft combined cycle power plant
- Located in southwest Beijing (~30 km from city center)
- Built by Mitsubishi in the late 90's ("old plant" in China)
- MHI 701F with MHI three-pressure HRSG downstream (~400 MW rated, unfired NG fuel, with a gas flow rate of ~5,300,000 lbm/hr).

No cavity for a traditional SCR!

LP Amina was able to offer **Direct Injection** using 20% aqueous ammonia as a cost-effective alternative.

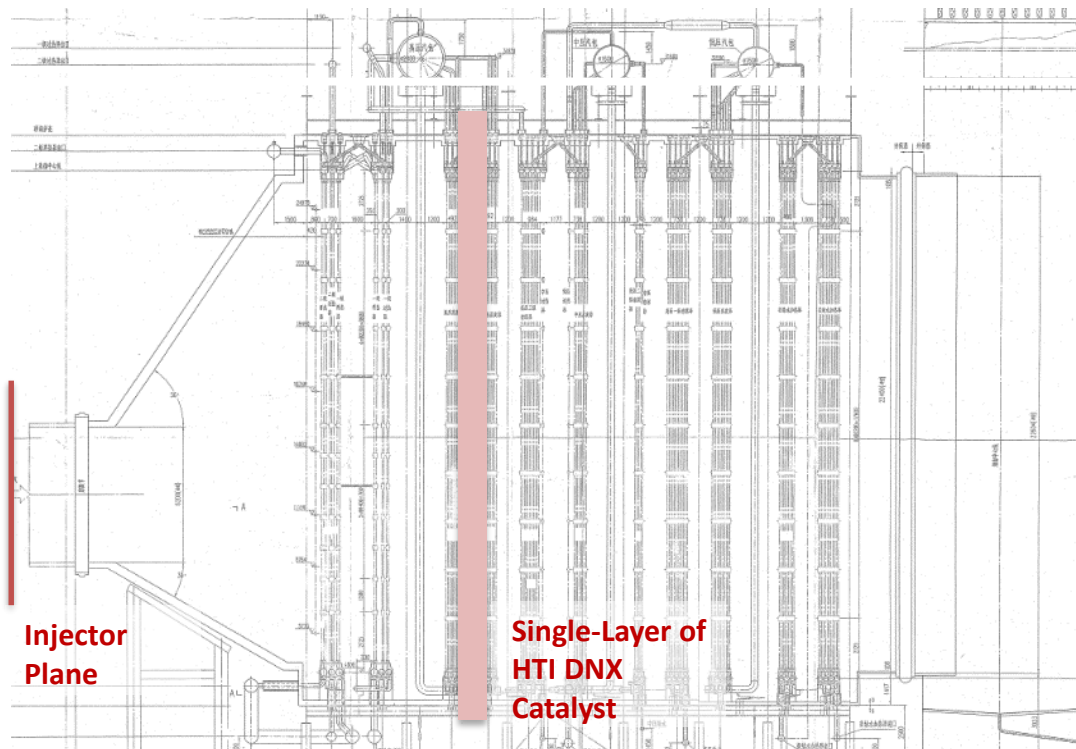
Direct Injection system has been operational since 2013



LP AMINA PROVIDED FULL SCOPE (EPC) FOR THE JINGFENG PROJECT

JINGFENG SCOPE & ELEVATION GA

- Complete system design
- Cold flow physical model
- CFD modeling
- DCS programming
- Ammonia tanks & pumps
- SCR reactor & support steel
- All instrumentation
- Detailed control philosophy
- Installation labor
- Commissioning
- Operator training
- Performance test



Installed **single catalyst layer** (~22" [560 mm] frame depth) between HP EVAP sections (~35" [914 mm] clear distance)

RESULTS WERE BETTER THAN EXPECTED WITH MALDISTRIBUTION ~5% RMS

RESULTS FROM OCTOBER 2013 TUNING

	PERFORMANCE GUARANTEES	PERFORMANCE RESULTS
NO _x Reduction	80% reduction Initial 34 ppm (15% O ₂) Target 6.8 ppm	82% reduction Actual 5.9 ppm
Ammonia Slip	≤ 3.5 ppm	≤ 0.9 ppm
Pressure Drop	≤ 1.6 iwcd	≤ 1.0 iwcd
NH ₃ : NO _x Maldistribution	± 10% RMS	± 5% RMS

Direction Injection system has been operational for over 20,000 hours!



FIND OUT HOW WE CAN HELP YOU!

Please contact Matthew Zedler to learn more.

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THANK YOU