

MARSULEX

ENVIRONMENTAL TECHNOLOGIES



Beneficial Byproducts of Coal Combustion and Gasification -
Ammonium Sulfate Crop Fertilizer from FGD

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Mcllvaine “Hot Topics” – April 28, 2011

AS-FGD offers significant advantages over traditional flue gas scrubbing

- Economics are significantly enhanced with high sulfur fuels
- Reduces/eliminates solid and liquid waste costs & liabilities
- Valuable AS fertilizer provides a **significant** revenue stream (capital cost payback)
- Potential to outsource the fertilizer processing operation & marketing – relieving the owner of gypsum system capital cost, O&M and disposal liabilities
- Ammonia is a highly reactive reagent and is not subject to potential dissolution issues (as with limestone) offering reliable, high efficiency SO₂ scrubbing levels
- No CO₂ gas is released in the AS-FGD unlike conventional limestone FGD (where ~ 0.7 ton CO₂ is released per ton of SO₂ absorbed.)

AMMONIUM SULFATE -FGD Development History

- ◆ **1985-87** General Electric Environmental Services, Inc. (GEESI) developed Benchscale Ammonia Scrubbing (AS-FGD) Technology – first patent awarded
- ◆ **1992-93** 10 MW Pilot Demonstrated at Dakota Gasification Company (DGC)
- ◆ **1994** Contract signed with DGC for Full-Scale Plant; 2nd patent awarded
- ◆ **1996-97** Startup and Successful Demonstration at DGC
- ◆ **1998** GEESI Acquired by Marsulex, forming MET
- ◆ **2006** AS-FGD installation in operation at Syncrude in Alberta, Canada
- ◆ **2009** Two AS-FGD systems in China operational on (4) coal boilers for Sinopec
- ◆ **2010** Another Sinopec AS-FGD system installed on coal fired boilers
- ◆ **Today** AS-FGD under construction on 5 coal fired boilers in Poland

The AS-FGD process has been commercially proven at full-scale for over a decade.

AS-FGD Commercial Installations

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ZAP | Poland
(under construction)



SINOPEC | China



DGC | United States

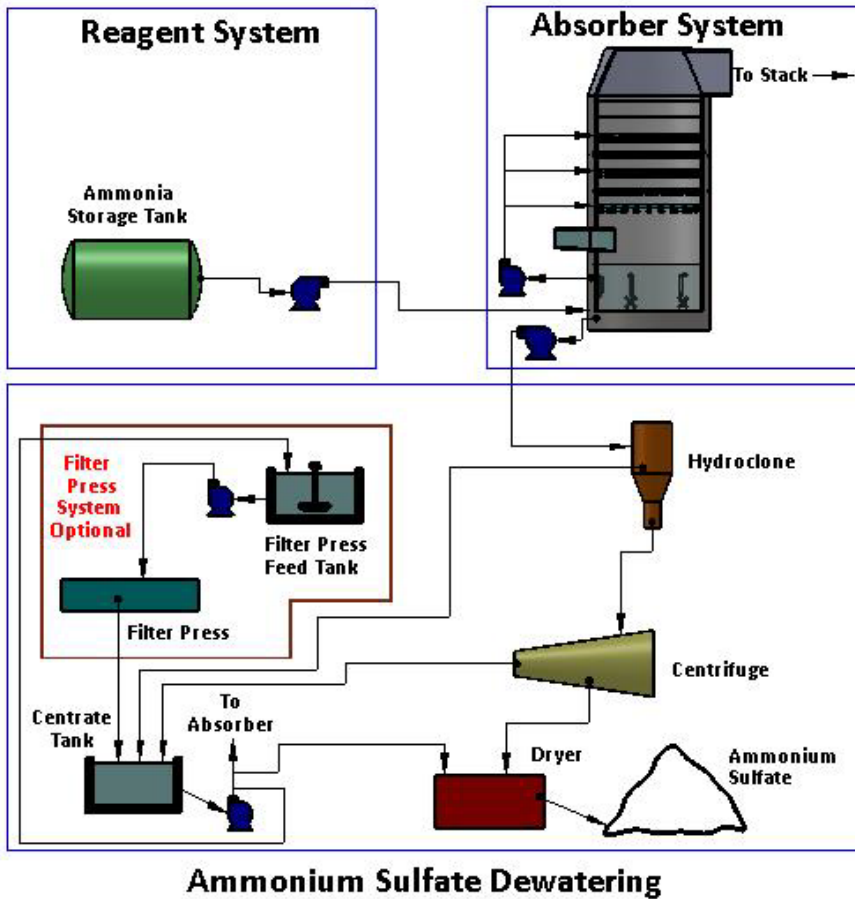


Syncrude | Canada

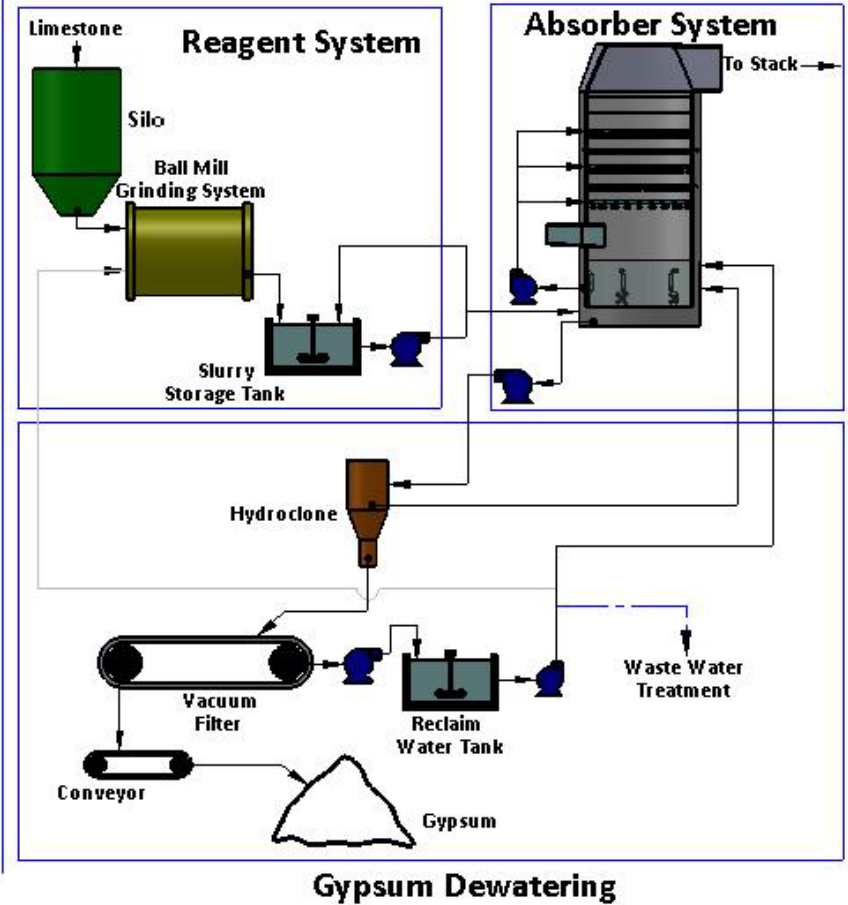
AS-FGD vs. Limestone Process Comparison

Same familiar & proven absorber tower features – using a different reagent

Ammonium Sulfate Process



Limestone/Gypsum Process



Ammonium Sulfate FGD

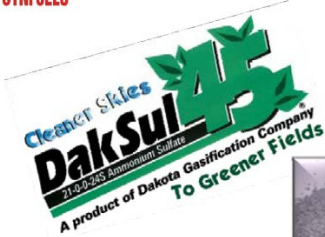
Commercial Grade AS produced in the U.S., Canada and China



DAKOTA GASIFICATION COMPANY
A BASIN ELECTRIC SUBSIDIARY

Ammonium Sulfate

(21-0-0-24S)



Product Quality Characteristics

Purity - 99+%

- ◆ Nitrogen - 21.0 - 21.1%
- ◆ Sulfur - 24.0 - 24.2%
- ◆ Water Insoluble Matter - < 0.1%
- ◆ Color - White to Beige
- ◆ Heavy Metals - < 10 ppm

Exceeds Fertilizer Specifications

Residual Moisture

- ◆ Multiple Drying Steps
- ◆ Less Than 1.0 wt% Moisture
- ◆ Coated with Anti-caking Agent

Excellent Storage & Handling Characteristics

Particle Size

- ◆ 1.0 mm - 3.5 mm
- ◆ 240 - 275 SGN
- ◆ Uniformity Index - 45 - 50

Ideal for Bulk Blending & Direct Application

Hardness

- ◆ Demonstrated Compaction Technology
- ◆ Expertise in Product Hardening Technology
- ◆ 1 - 3% Attrition in Industry Test

Can be Handled and Transported With Minimal Dust Problems

Process Chemistry



- **For every part (mass unit) of SO₂ removed:**
 - ~ **One-half part** Ammonia is consumed
 - ~ **Two parts** of Ammonium Sulfate is produced
- **One part** of Ammonia generates about **four parts** of Ammonium Sulfate fertilizer

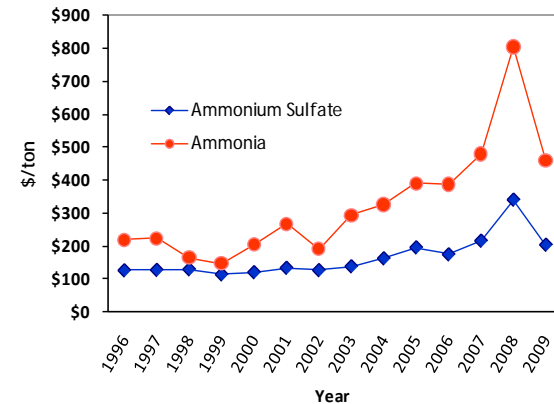
**- Ammonium Sulfate Production – Rule of Thumb -
100 tons/year, per % Sulfur in fuel, per MW (@ 100%
load factor)**

Fertilizer Revenue Ballpark Figures

A 600 MW Unit's Ammonium Sulfate Production =
60,000 tons/year per % Percent Fuel Sulfur
(@100% Load Factor)

Assume NH_3 and AS market pricing results in a positive differential of \$100/ton average of AS produced:

- ☐ = \$12MM/year for 2% sulfur fuel
- ☐ = \$24MM/year for 4% sulfur fuel



Site-specific factors such as actual source/cost NH_3 , market price of AS, unit load factor, fuel costs, transportation, etc., need to be factored.

Summary of the Ammonium Sulfate FGD Process

- Commercially proven in full scale for over a decade
- AS-FGD system provides high on-line operating reliability
- Site specific economics include:
 - offset operating costs
 - potentially lower fuel costs
 - potentially lower capital and operating costs
- Small or no liquid purge stream to wastewater treatment plant
- Production of high value fertilizer byproduct instead of low value gypsum or sulfite waste sludge
- Additional information available at www.met-apc under the “library” section
- *Who are the right customers for this technology?*