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

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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 SO$_2$ scrubbing levels
- No CO$_2$ gas is released in the AS-FGD **unlike** conventional limestone FGD (where ~ 0.7 ton CO$_2$ is released per ton of SO$_2$ 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; 2<sup>nd</sup> 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

- 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**
- **Reagent System**: Ammonia Storage Tank
- **Absorber System**: Absorber Tower, Filter Press, Centrate Tank, Ammonium Sulfate Dewatering

**Limestone/Gypsum Process**
- **Reagent System**: Limestone Silo, Ball Mill Grinding System, Slurry Storage Tank
- **Absorber System**: Absorber Tower, Hydroclone, Ammonium Sulfate, Gypsum Dewatering
- **Waste Water Treatment**: Reclaim Water Tank, Gypsum
Ammonium Sulfate FGD

Commercial Grade AS produced in the U.S., Canada and China
Proprietary Ammonium Sulfate FGD

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

**Particle Size**
- 1.0 mm - 3.5 mm
- 240 - 275 SGN
- Uniformity Index - 45 - 50

Ideal for Bulk Blending & Direct Application

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

Excellent Storage & Handling Characteristics

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

Can be Handled and Transported With Minimal Dust Problems
Proprietary Ammonium Sulfate FGD

Process Chemistry

\[
\text{SO}_2 + 2\text{NH}_3 + \text{H}_2\text{O} \rightarrow (\text{NH}_4)_2\text{SO}_3 \quad (1)
\]
\[
(\text{NH}_4)_2\text{SO}_3 + \frac{1}{2} \text{O}_2 \rightarrow (\text{NH}_4)_2\text{SO}_4 \quad (2)
\]

- For every part (mass unit) of \(\text{SO}_2\) 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)
A 600 MW Unit’s Ammonium Sulfate Production = 60,000 tons/year per % Percent Fuel Sulfur (@100% Load Factor)

Assume NH₃ 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 NH₃, 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?