ClearChemFSI

McILVAINE 4/9/2015 HOT TOPIC HOUR

DRY SORBENT INJECTION

ENABLING NEW OPERATIONAL EFFICIENCIES BY CONTROLLING EMISSIONS FROM COAL PLANTS EFFECTIVELY AND INEXPENSIVELY

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ClearChem Development, LLC

BACKGROUND

ClearChem is New Furnace Sorbent Injection Technology

- ✓ Decades-old attempts at furnace sorbent injection (FSI) showed poor results
- ✓ ClearChem is different – it solves past problems to release the full promise of FSI
  - o Sub-micron sized reagent particles are highly reactive and minimize deposits
  - o Computational Fluid Dynamic (CFD) modeling enhances sorbent furnace coverage
  - o Burner zone/fuel reagent application for longer reaction time & no sintering or pore pluggage
  - o High efficiency reagent utilization minimizes ESP/FF concerns

OPERATIONAL EFFICIENCIES ENABLED

- ClearChem and Dürr are working together to offer technology combinations, allowing maximum flexibility in a “One Stop Shop” for profitably meeting new plant APC requirements as well as for existing facilities
- Water recovery: ClearChem’s acid gas removal allows addition of lower cost condensing heat exchangers that improves plant heat rate while offsetting a power plant’s consumptive water use or selling water to third parties
- Allows increased plant efficiency (every ~40˚F lower flue gas temp. equals ~1% efficiency gain), plus gain 2% to 4% more by recovering the heat of vaporization of water (ie, a possible total heat rate, fuel use & CO2 reductions totaling 6% – 8%)

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CLEARCHEMFSI ATTRIBUTES:

- ✓ Effective scavenging of SO_3, SO_2, HCl & HF
- ✓ Minimizes tube deposits & ESP/FF impact
- ✓ Dry, fully reacted reagent provides minimal Ca increase and no sodium leaching in fly ash
- ✓ High surface area for some capture of oxidized mercury, but when combined with CCF and/or CHX more capture expected
- ✓ Allows lower exit gas temps with associated benefits
- ✓ <u>Only acid gas control technology that allows effective emissions control during plant startup and shut down</u>

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PROBLEM / OPPORTUNITY

- Coal-fired generation is a critical component of global energy supply and will be for a long time, but …
- Regulation threaten plant viability: NOx, SOx, Heavy Metals, Water, Particulates, CARBON
- Existing solutions (FGD, etc.) are piecemeal, disruptive, and prohibitively expensive
- Market participants are being forced toward 3 bad extremes:

1. Early retirement of profitable generating capacity;
2. Greatly reduced generation with minimal check on pollution;
3. Expensive FGD upgrades/additions.

SOLUTION

- ClearChem recently formed to develop, patent, and market an improved FSI process
- ClearChemFSI™ is FSI that works. ClearChem:
  - ✓ is an innovative, patented emission control process that involves injection of sub-micron sized particles of widely available, off the shelf reagents such as limestone (calcium carbonate) directly into a boiler/furnace
  - ✓ has wide operational range, can be effectively used as a “polishing” acid gas removal system combined with an FGD system, or as a stand alone system
  - ✓ is simplest and most capital-efficient mitigation of sulfur and other acid gas pollutants (up to 85%) from the combustion of carbon based fuels like coal, MSW (municipal solid waste), petroleum cokes, tires & residual oils, etc.
  - ✓ has a very small footprint, fast order, delivery & tie in (ie, in service in 3 to 6 months ARO)
  - ✓ ClearChem is ~10% of the combined CAPEX & OPEX cost of existing FGD systems

MARKETS

Domestic US:

- ✓ In excess of 1,400 coal-fired utility power plants (~38% of total US electricity production)
- ✓ Hundreds of smaller domestic industrial boilers, combustors and incinerators
- ✓ Utility & Industrial combined U.S. coal production in 2013 was just below **1 billion** short tons (984.8 Million short tons in 2013) – annual production trending down
- ✓ ClearChem is targeting ~4% (~10,500 Mega Watts (MW) of the ~270,000 MW US coal power plant market remaining after currently planned coal plant retirements

International:

- ✓ **7.687 Billion** short tons in 2012 supplying ~40% of international electricity generation – annual production trending up, with China and India using the most coal with an extremely urgent need for air pollution control, representing **~7X the US market**

COMPETITIVE COMPARISON – SO2 REMOVAL

Comparison of ClearChem Economics on SO2 Capture

	Scenario 1: *No existing SO2 control*	**Scenario 2:** *With existing SO2 scrubbers*
Key assumptions:		
Utility cost of capital	6%	6%
Unit size	300 MW	300 MW
Useful life/finance life	15 years	15 years
Capacity factor	40%	80%
SO2 output	35 lbs/MWh	35 lbs/MWh
CCFSI license fees	Max target	Max target
Added cost per kWh:		
Traditional Scrubber	$0.0216	$0.0035
Traditional DSI (Trona)	$0.0166	$0.0045
ClearChemFSI	***$0.0085***	***$0.0030***

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PARTNERS

Licensees:

Reagent Suppliers:

Strategic:

ClearChemFSI

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