'Engineered Fuels' as Partial Substitutes for Fossil Fuels in Cement Production

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Motivation

Energy recovery from non-recyclable waste that is otherwise landfilled, namely engineered fuel (EF), and partial substitution of fossil fuels in cement production plants. Process Concept: Perform calorimetric tests and carbon analysis on EF samples sent from Plant 1 (US) using Oxygen Bomb Calorimeter and renewable carbon testing.

Research Goal: Compare HHV of Plant 1 samples, Plant 2 data (Mexico) and environmental impact of EF with other fuels currently in use to understand to what extent fossil fuels in cement production can be substituted by EF.

Cement Production Process

What is Engineered Fuel?
EF is defined as residual waste from MRFs (Material Recovery Facilities) that has been processed and pelletized to be transportable to plants where it is used as a source of energy in fueling different industrial processes.

Importance of the cement industry in the World and the US
• World cement makers claim a revenue of $250 billion yearly  
• 78 MMt of cement produced in the US in 2013 (99MM in 2005)  
• 13.6 MMt of coal needed if only fuel (average HHV of coal)  
• Cement plants contribute to 5% of global CO2 emissions

Secondary Fuels
Multiple fuels through an array of injection methods:  
• Conventional Liquid fuels  
• Conventional Gas fuels  
• Pulverized fuels (coal, pet coke)  
• Solids (Engineered Fuel)

Energy requirements for cement production process
• 1 ton of cement requires 4.4 MMJ/g (±20% of coal)  
• Primary fuel fed to rotary kiln (640–740°C): secondary fuel fed to preheater (<60%)  
• Secondary fuels diversity much more flexible than primary  
• Shift from natural gas and petroleum to coal and pet coke resulted in a further increase in CO2 emissions: coal generates 1.8x more than NG, 1.2x more than oils  
• If HHV of EF = HHV of coal, in theory total substitution is possible

Calorimetric Test

The EF can be kept as a fluff material or pelletized. The effect of packing on heating value is looked into. Pellets are easily handled, transported and conveyable.

Mass of samples burned ± 0.7000 grams
Temperature rise ± 1.4 C
Effect of sulfur content on HHV: < 0.005%  
Effect of unrealistic pure O2 atmosphere: < 1%

Results & Discussion

• Compared to the average HHV of EF for 2012 and 2013 reported by Plant 1, the EF obtained for Plant 1 was 7% with Fluff and 10% with Pellet.

• High Heating Values determined experimentally showed up to 34% variability for sub-samples of the same sample sent by Plant 1 for testing.

• Uncertainties in energy content of EF is therefore a major limitation regarding the extent to which it can substitute fossil fuels which HHV is stable across regions and over different periods.

2012

2013

Fraction of total fuel fed by weight in Plant 2 in 2012 and 2013.

The use of EF increased from 5% to 19% of total fuel use within one year. This increase is paralleled by a decrease in conventional fossil fuels from 89% to 79%.

Keeping this trend can reduce fossil fuel use and improve waste management in the US.

Future Goals

• Analyze combustion gases for biogenic vs. non biogenic carbon content  
• Process emissions data given by Plants 1 and 2 concerned with other fossil fuels related emission  
• Provide a full recommendation regarding the extent to which EF can substitute fossil fuels in the plants  
• Consider other industries that could make use of EF, i.e.: steel production

Acknowledgements

Dr. Nickolas Themelis & Earth Engineering Center Team  
Dr. Marco Castaldi & Combustion Catalysis Laboratory Research Team  
CEMEX Balcones/Teva  
Beta Analytic Inc.