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

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WTERT Waste-to-Energy Research & Technology Council
Advancing Sustainable Waste Management

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.

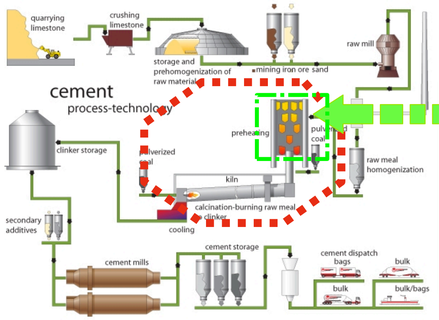
Research Goal: Compare HHV of Plant 1 samples, Plant 2 data (Mexico) and environmental impact of EF with other fuels currently in use to understand to what extent fossil fuels in cement production can be substituted by EF.

Cement Production Process

What is Engireed 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 (99Mt in 2005)
- 13.6 MMt of coal needed if only fuel (average HHV of coal)
- Cement plants contribute to 5% of global CO_2 emissions



Schematic of the cement production process. Energy-intensive steps are outlined.

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

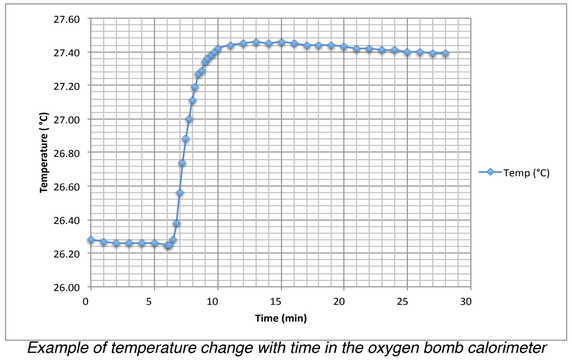
- 1 ton of cement requires 4 MMBtu(±200 kg of coal)
- Primary fuel fed to rotary kiln (>=40%) ; secondary fuel fed to preheater (<=60%)
- Secondary fuels diversity much more flexible than primary
- Shift from natural gas and petroleum to coal and pet coke resulted in a further increase in CO2 emissions: 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

EF samples tested (L: fluff, R: pellet)

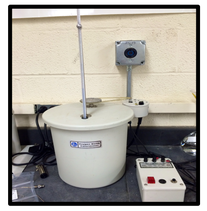
The EF can be kept as a fluff material or pelletized. The effect of packing on heating value is looked into. Pellets are easily handled, transported and conveyable.

Mass of samples burnt ± 0.7000 grams
Temperature rise ± 1.4 C
Effect of sulfur content on HHV: < 0.005%
Effect of unrealistic pure O_2 atmosphere: <1%



Example of temperature change with time in the oxygen bomb calorimeter

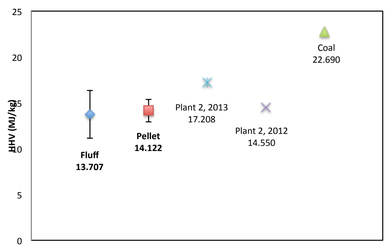
$$t = t_c - t_a - r_1(b-a) - r_2(c-b) \qquad HHV(cal/g) = \frac{tW - e_1 - e_2 - e_3}{m}$$



Oxygen Bomb Calorimeter

Tadlar Bag for Gas Sampling

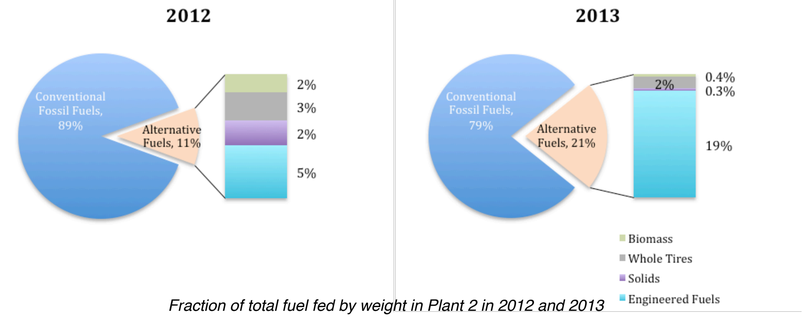
Results & Discussion



Average HHVs determined for Plant 1 samples and obtained from Plant 2 versus average HHV of coal produced in the US

	Fluff Samples	Pellet Samples
HHV	13.7 ± 2.6 MJ/kg	14.1 ± 1.2 MJ/kg
Variability	1 to 32 %	1 to 34 %

- Compared to the average HHV of EF for 2012 and 2013 reported by Plant 1, the HHV 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.
- Unpredictability of 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.



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 reduced fossil fuel use and improve waste management in the US.

HHV data obtained from Plant 2

- The HHV of EF makes it 6th out of the 7 fuels used as energy sources in this plant.

- The results obtained from calorimetric tests in the lab on samples from Plant 1 validate the data given by Plant 2.

- Secondary fuels provide up to 60% of total energy required during cement production. By looking at fuels with ± similar HHV, EF could theroretically replace residual carbon fuels which represented 13% of feed in 2012 and 7% in 2013.

Although a thorough investigation on emissions data has still to be done, a first general look confirms that all emsisons related to EF are below standard requirements for carbon dioxide, nitrous and sulfur oxides, particulate matter, heavy metals and dioxins.

Future Goals

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

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