Optimization of Waste Fuels in Cement Production Plant

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***Abstract* - Rotary kilns are widely used for the production of cement clinker, which is a very energy intensive process. In the subsequent sintering process in the rotary kiln, the material is heated up to temperatures above 1700 K to ensure the formation of the calcium silicate- and calcium aluminate-phases, which are essential for the mechanical strength of the final product (cement). To provide the energy required for the clinker phase transition, different types of fossil and alternative fuels like biomass, rubber MSW etc are commonly fired through the main burner. Thus, there is a need to find out the applicability of alternative fuel in India cement plant. The objective of the present paper is:**
To gain improved methodical and technical facts on the combustion of Municipal Solid Waste as alternative fuels in the cement rotary kiln.

***Index Terms* - Municipal Solid Waste, alternative fuels, Cement rotary kiln. FEA etc.**

I.INTRODUCTION

“Sustainable development and operation” have become the guiding philosophy for all industrial activities, including production of cement. By this philosophy, development should be eco-friendly and should conserve non-renewable natural resources to the extent possible.

From both these angles, it is necessary not only for the cement industry but for all industries consuming fossil fuels to start looking for alternatives that will replace fossil fuels progressively.

The carbon in fossil fuels contributes to ~0.29 kg of CO_2/kg clinker at the prevailing level of fuel efficiency. Fuel costs keep increasing year after year, influencing the costs of production of cement. Therefore, from this angle also substitutes or alternatives which have commercially usable heat value, which produce a lesser quantum of greenhouse gas (GHG) and which are cheaper are proposals worth considering.

1.1 Sources and Types of Alternative Fuels

The selection of fuel for the cement production is an important parameter for the cement plant, especially since the fuel often makes up a significant cost of the plant operation. Before a fuel is selected it is important to consider the following three parameters:

- Costs, e.g. fuel purchase, availability, fuel handling, maintenance.
- Product quality, e.g. impacted by unburnt particles in the clinker
- Environmental impact, e.g. CO_2, CO, and NOX emissions

The alternative fuels essentially come from biomass residues of both biogenic and non-biogenic processes. Broadly speaking, the biomass from the biogenic processes refer to the non-fossilized and biodegradable organic materials originating from plants, animals, and microorganisms and include agricultural residues, organic fractions of industrial and municipal waste, and gases and liquids recovered from the decomposition of non-fossilized and biodegradable organic substance.

The non-biogenic waste materials, originating from manufacturing and other industrial processes but not from actions of living organisms, may not necessarily be biodegradable but they contain organic compounds that provide heat and energy on combustion. The renewable biofuels derived in the form of ethanol and diesel from naturally oil-rich edible and non-edible plants form another potential source of alternative fuels [3].

1.2 Biomass Residues

The woodchips and pellets, particularly originating from the construction and demolition waste, are extensively available in India. Rice husk is available in large volume in some of the Asian countries. The cement plants in India are reportedly meeting > 15% of their total thermal need with the help of rice husk.

Coffee husk, sunflower shell, oil palm husk, sugar cane stalk and bagasse, groundnut shell, bamboo dust, etc. are examples of other biomass residues that are used in different countries. It is important to note that the availability of biomass residues is seasonal and region-specific. Hence, the experience of its use is essentially local. Drying is an important process requirement for using biomass, as the freshly cut wood has a low heating value due to high moisture content. The drying process can be either natural or forced with the help of waste heat from the cement plants.

II-LITERATURE REVIEW

C. Pieper (2020) presents CFD simulation of a commercial scale revolving klin for concrete clinker creation. The fuel for the klin fire is a blend of pulverized coal and a Refuse Derived Fuel (RDF). Propelled models were created to fittingly portray the warm change attributes and optimal design of non-round RDF particles. The models depend on point-by-point fuel parameters investigations (e.g. flight and ignition attributes, physical and substance fuel properties) of major RDF divisions, similar to plastic foils, 3D plastic particles, paper and cardboard and materials. The procedures in the clinker inside the kiln are estimated utilizing a basic one-dimensional model that figures heat and mass transfer with the gas stage and the subsequent synthetic mineralogical responses in the solid bed. Calculation results of the one-dimensional model were compared to measurements obtained from a semi-industrial laboratory rotary kiln. Fayza S. Hashem (2019) et. al. expects to believe the chance of utilizing Rubber waste (RW) and plastic waste (PW) as resources of denied inferred fuel in the cement plant. The investigation is isolated into two sections. The initial segment is to contemplate the effectiveness of Rubber Waste and Plastic Waste as fuel sources just as the qualities of their ashes. Though in the second part the impacts of RW and PW particle residue on the properties and hydration qualities of Portland concrete clinker were contemplated.

III-RESEARCH METHODOLOGY

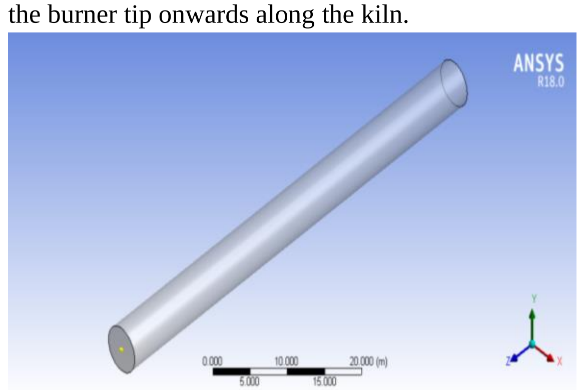
Computational fluid dynamics (CFD) modelling allows detailed simulation, and it is an effective and advanced tool to predict and understand the combustion characteristics inside a cement rotary kiln. Coal combustion inside cement rotary kilns has been investigated by many researchers.

The commercial CFD software ANSYS FLUENT, version 18.0, was used for modelling and simulating the combustion process inside the cement rotary kiln. Steady state three dimensional simulations were carried out. Process parameters and kiln and burner dimensions were taken from a full-scale cement plant in central India that produces approximately 3400 tons of clinker per day.

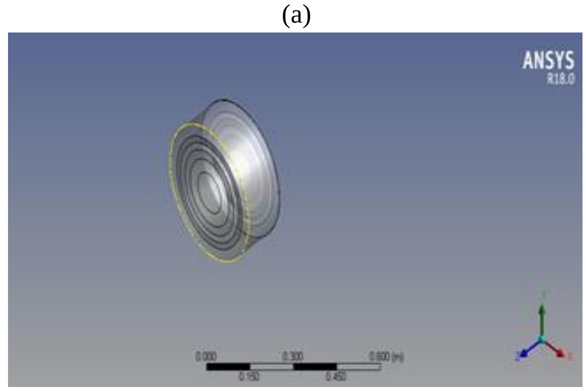
Coal is used as a reference fuel, and Municipal Solid Waste is selected as the waste-derived fuel as mentioned before. The effect of gravity is also included. Because the main focus was on the primary burner, the solid charge inside the kiln and the clinker reactions are not considered. The kiln rotation is also neglected. A detailed validation was unfortunately not possible because adequate industrial data could not be obtained due to the difficult environment inside the kiln and at the kiln gas outlet.

Geometry and Grid Generation

A three-dimensional 63m kiln was created in Ansys Design Modeler. Although the real kiln is 68m long, the system for the modelling work is defined only from the burner tip onwards along the kiln.

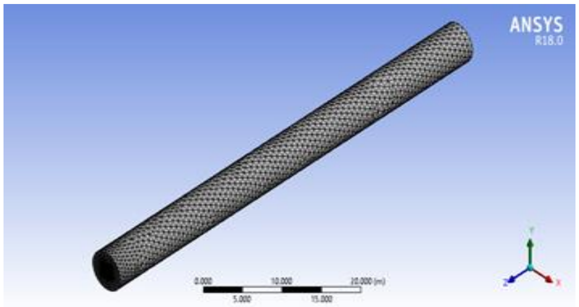


(a)

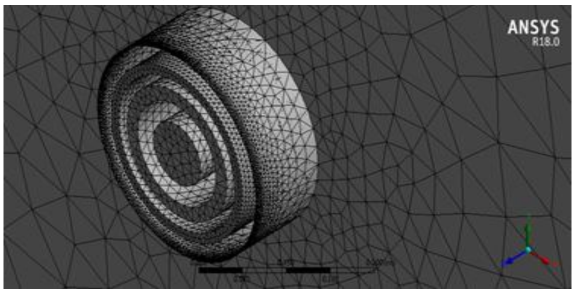


(b)

Figure 3.1 (a) Rotary Cement Kiln, (b) Burner Geometry



(a) Meshed Cement Kiln



(b) Meshed Burner

Figure 3.2 Meshed Model of Cement Kiln and Burner

IV-RESULT ANALYSIS

CFD Results for Fuel Combustion in Cement Kiln Burner

For the analysis of Cement kiln, the fuel composition considered as 68% of coal and 32% of MSW. The kiln temperature, CO_2, moisture and Oxides of nitrogen generation, has been observed while varying the jet air inlet temperature and particle size of the fuel.

Effect of Jet Air Temperature

The jet air temperature at inlet has been varied from 308K to 348 K with the difference of 20K. Figure shows the Kiln temperature variation contours with respect to jet air inlet temperature while having the particle size 3mm.

For the analysis point of view the section near the fuel burner has been considered for showing in the contour as the length of kiln is much more than the kiln diameter.

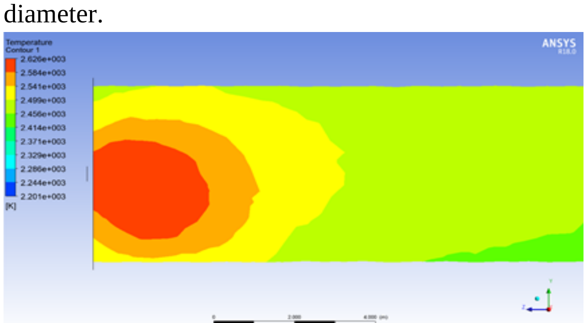


Figure 4.1 The kiln Temperature Profile at Jet Air Temperature 308K and Particle Size 3mm

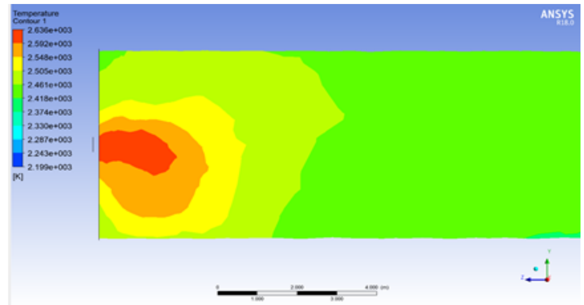


Figure 4.2 The kiln Temperature Profile at Jet Air Temperature 328K and Particle Size 3mm

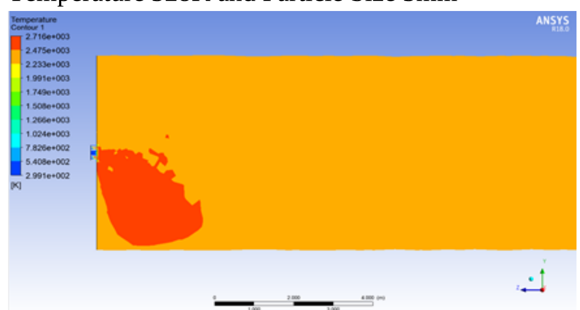


Figure 4.3 The kiln Temperature Profile at Jet Air Temperature 348K and Particle Size 3mm

V-CONCLUSION

To provide the energy required for the clinker phase transition, different types of fossil and alternative fuels are commonly fired through the main burner. In this work, CFD simulations of a cement rotary kiln, which include advanced models for RDF combustion and a 3D-model for modelling the clinker bed, are presented. The Municipal solid wastes is used as alternative fuel in combination with coal.

Initially a detailed calculation has been made to estimate the amount of fuel and heat required for calcination need to be calculated. The optimum value found the combination of 68% coal and 32% MSW.

The following calculation have been made after the CFD study:

1. It has been observed that as the jet air temperature increases the kiln temperature also increases. The increment follows the polynomial curve of second order.
2. It has been observed that the fuel particle sizes influence the drying and devolatilization inside

the kiln during the combustion process within a very short time.

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