European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)

International Conference on Renewable Energies and Power Quality (ICREPQ'11)
Las Palmas de Gran Canaria (Spain), 13th to 15th April, 2010

Meat and Bone Meal as a Renewable Energy Source in Cement Kilns: Investigation of Optimum Feeding Rate

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Abstract. Meat and Bone Meal (MBM) is a CO_2 neutral fuel, and hence is a good candidate for substituing fossil fuels like pulverized coal in rotary kiln burners used in cement kiln systems. MBM is used in several cement plants, but the optimum substitution rate has apparently not yet been fully investigated. The present study aims to find the maximum possible replacement of coal by MBM, without negatively affecting the product quality, emissions and overall operation of the process. A full-scale experiment was carried out in the rotary kiln burner of a cement plant by varying the MBM substitution rate from 0 to 7 t/hr. Clinker quality, emissions and other relevant operational data from the experiment were analysed. Additionally, coal and MBM were compared by laboratory experiments. The results revealed that MBM could safely replace more than 40% of the coal energy without giving negative effects. The limiting factor is the free lime content of the clinker. Possible explanations to the free lime increase are given. If 40% of the coal in the rotary kiln burner was replaced by MBM on a long-term basis, the total annual CO_2 emissions of the plant could be reduced by 10%.

Key words

Meat and bone meal, Alternative fuel, Carbon dioxide, Rotary kiln, Free lime

1. Introduction

The cement production process is highly energy-intensive and generates a world average CO_2 emission of 0.81 kg per kg cement produced [1]. The calcination of carbonates in the raw materials accounts for roughly 60% of the CO_2 emitted, while the remaining carbon dioxide results from combustion of fuels in the kiln system [2]. Although coal, petroleum coke and other fossil fuels traditionally have been burnt in cement kilns, many cement plants have turned to energy-rich alternative fuels due to economical and environmental benefits. The replacement of coal by carbon dioxide neutral fuels will reduce net carbon dioxide emissions to the atmosphere, while letting the manufacturer gain economic advantages by reducing fuel costs and possibly earning CO_2 allowances under an Emissions Trading scheme [3].

In modern precalciner cement kilns typically 60 % of the fuel energy is supplied in the precalciner, whereas the remaining 40 % is supplied via the rotary kiln burner. The operating temperature in the calciner is around 900 °C as the decarbonation of calcium carbonate occurs at this temperature. In contrast, the flame temperature in the rotary kiln burner typically should be around 2000 °C to ensure sufficient formation of melt in the solid materials being processed. Traditionally, solid alternative fuels are fed to the calciner rather than to the kiln burner, partly because of the lower temperature, partly because gravitation-facilitated feeding can be implemented in the calciner. This also allows for feeding of lumpy fuels. However, in the kiln main burner, solid fuels have to be ground into a fine meal and then fed pneumatically into the rotary kiln. There are examples of plants replacing as much as 90 % of the coal energy in the calciner by solid waste fuels [4], [5], provided the feeding and processing of the alternative fuels are done properly [2]. When the replacement potential in the calciner is fully utilized, one may turn to the kiln burner to increase the overall fossil energy replacement ratio even more.

The range of alternative fuels is very wide. Meat and bone meal - MBM (also called animal meal) is used in several cement kilns, in particular in Western Europe. The fuel is prepared by post-treating (grinding and sterilizing) the waste materials associated with slaughtering operations. Since it contains only biogenic materials it can be categorised as 100% biomass fuel which gives no net carbon dioxide emissions during the combustion process.