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EFFECT OF AIR DISTRIBUTION ON SOLID FUEL BED COMBUSTION

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ABSTRACT

One important aspect of refuse mass-burn combustion control is the manipulation of combustion air. Proper air manipulation is key to the achievement of good combustion efficiency and reduction of pollutant emissions. Experiments, using a small fix-grate laboratory furnace with cylindrical combustion chamber, were performed to investigate the influence of undergrate/sidewall air distribution on the combustion of beds of wood cubes. Wood cubes were used as a convenient laboratory surrogate of solid refuse. Specifically, for different bed configurations (e.g. bed height, bed voidage and bed fuel size, etc.), burning rates and combustion temperatures at different bed locations were measured under various air supply and distribution conditions.

One of the significant results of the experimental investigation is that combustion, with air injected from side walls and no undergrate air, provide the most efficient combustion. On the other hand, combustion with undergrate air achieves higher combustion rates but with higher CO emissions.

A simple one-dimensional model was constructed to derive correlations of combustion rate as functions of flue gas temperature and oxygen concentration. Despite the fact that the model is one dimensional and many detailed chemical and physical processes of combustion are not considered, comparisons of the model predictions and the experimental results indicate that the model is appropriate for quantitative evaluation of bed burning rates.

INTRODUCTION

Combustion of solid fuels on a fixed or moving grate is common to many combustion facilities ranging from coal burning combustors to solid waste incineration furnaces. In the combustion processes, air is introduced to the furnace from beneath the grate as well as from the over-bed region to achieve good combustion efficiency. The distribution of undergrate and overfire air is known to play an important role in the combustion control of organic emissions from municipal waste combustors(Kilgroe, et al., 1990). Manipulation of the undergrate air allows control of the combustion processes and burning rates. The overfire air, injected at high velocity through nozzles on furnace walls, can effect complete combustion by entrainment and by promoting turbulent mixing of off-gases and entrained solids from the fuel bed.

Good mixing is essential for efficient combustion and it is achieved by introducing the proper amounts of air at the proper locations. Practical design and operation guidelines, mostly based on decades of experiences in coal and wood burning, for combustion air control are generally dependent upon the furnace design and fuel characteristics. Due to the complexity of furnace geometry, variation in fuel properties, and associated thermal and chemical processes, theoretical analysis of solid fuel bed combustion are limited only to simplified situations. Recently, with advances in computational fluid dynamics, two-dimensional furnace flow and thermal analysis have been attempted by researchers to aid the design of combustion air nozzles(Ravichandran and Gouldin, 1992, and Bette, M, et al., 1994). Despite all these, fundamental understanding of the mechanisms of solid fuel bed combustion is still insufficient for establishing general guidelines of broad applicability on combustion air distribution design and control.

With the aim of gaining more fundamental knowledge of effects of air supply and distribution on solid fuel bed combustion processes, laboratory experiments were conducted to provide data as the basis for analyzing the physical and chemical processes of solid fuel bed combustion and