BLSpray: Understanding the Effect of Black Liquor Properties and Splash Plate Nozzle Configuration on Spray Characteristics

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ABSTRACT

Black liquor spraying is an important parameter for proper combustion in a chemical recovery boiler. Understanding the spray distribution and droplet size of a particular operation allows the operator to optimise combustion. An ideal spray minimises carryover while maintaining a char bed shape that maximises chemical reduction.

Measuring spray distribution and droplet mean diameter in-situ is very difficult. As a consequence, work began in September 2000 to develop a computer code (BLSpray) that can accurately predict black liquor spray flow characteristics. The three main uses of the code will be as follows: develop an improved nozzle based on understanding the effect changes in nozzle configuration and black liquor properties have on spray characteristics; given the operating parameters of a boiler, predict the black liquor droplet size, or conversely, determine the optimum nozzle selection for the specific operation; provide input for CFD modelling. The present code has been validated against laboratory results.

This paper will describe the status of the code. It will also describe the results obtained by varying black liquor properties and nozzle configuration. Liquor properties considered include viscosity, surface tension and density. Nozzle configurations considered include velocity, sideskirts, different plate shapes and different bore shapes.

INTRODUCTION

Black liquor droplet size is an important parameter for proper combustion in a chemical recovery boiler, especially as units are pushed to higher and higher firing rates. Droplets that are too large do not have sufficient time to dry and partially pyrolyse before reaching the char bed, causing bed instability and possibly a black out. Droplets that are too fine are entrained with the flue gas. This carryover can deposit on the upper furnace tubes, potentially plugging the flue gas passage.

Drop size and flow distribution is also important in maximising reduction efficiency. Droplets that are large enough to reach the bed partially pyrolysed provide carbon to the char bed, and maintain sodium sulphide (Na_2S) in a reduced form. For droplets that are too small, Na_2S is oxidised to sodium sulphate (Na_2SO_4), thus decreasing the amount of sulphur leaving with the smelt in a reduced form.

A well-distributed liquor spray also increases reduction efficiency. Liquor spray is optimised when the nozzle provides an even, horizontal pattern with uniform droplets. This type of distribution promotes even coverage of droplets over the plan area of the lower furnace. This maximises the surface area available for pyrolysis, combustion, and reduction, which take place in the active top layer of the bed. It is for this reason that a splash plate design is considered optimum. It is designed to provide the spray pattern described above, and has the ability to provide spray coverage close to 180°, without spraying back on the walls.

Droplet mass mean diameter (MMD) is difficult to measure in-situ. Therefore, although the generally accepted optimum droplet mass mean diameter is approximately 3 mm [1], this has not been validated by extensive field testing. A computer code that could accurately predict black liquor spray droplet size and flow distribution based on specified operating conditions and nozzle configuration would be invaluable.