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Process Level Investigation of the Flue Gas Latent Heat Recovery Using a Condensing Heat Exchanger in a Biomass-Fired Boiler

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Extended Abstract

Biomass-fired boilers offer an alternative to the use of fossil fuels. The relatively high moisture content in biomass fuels results in the flue gas containing a large amount of water vapour following the combustion process within the boiler. Unused latent heat in the water vapour decreases the overall boiler efficiency. One way to recover some of the lost latent heat is to condense the moisture out of the flue gas stream.

The condensation process is a complex combined heat and mass transfer process, in which the flue gas can be considered a mixture of water vapour and non-condensable (NC) gases. The presence of NC gases has proven to inhibit the condensation heat and mass transfer rate [1]. Furthermore, the mass transfer results in a decrease in the water vapour content which causes a corresponding reduction in the partial pressure and saturation temperature of the flue gas. This can result in large variations in the water vapour volume, heat transfer coefficient, and specific heat capacity of the flue gas along the flow path [2].

Many researchers have used variations of the Colburn-Hougen method [3] to model the flue gas condensation process for different applications. Rączka and Wójs [4] conducted a study comparing a modified Colburn-Hougen model and the VDI algorithm [5]. This was used to model a flue gas condensing heat exchanger within a 900 MWe coal-fired boiler. They considered the VDI algorithm to be the preferred method as it accounts more accurately for mass transfer.

In this research, a steady-state, one-dimensional thermofluid process model of a flue gas condensing heat exchanger is developed using the VDI algorithm. It is integrated within an existing whole-boiler process model firing sugarcane bagasse, developed by Rousseau et al. [6] for an operating John Thompson boiler with a maximum continuous rating of 29 kg/s of steam at 3 MPa and 400°C.

This is used to evaluate the impact of the heat exchanger on important boiler process parameters, including the flue gas latent heat recovery and overall improvement in boiler efficiency. Perspectives on the technical feasibility and design decisions for prototype development of the flue gas condensing heat exchanger are provided.

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