BURNERS, COMBUSTION AND HEAT TRANSFER

(656) - (*) - EFFECTS OF NATURAL ILMENITE FOR OXYGEN CARRIER AIDED COMBUSTION ON THE PERFORMANCE OF SMALL- TO MID-SCALE BIOMASS BUBBLING FLUIDIZED BED BOILERS

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The application of oxygen carrier (OC) materials has its origin in chemical looping processes (CLC). In a dual-reactor system, the OC transports oxygen from an air to a fuel reactor. The local separation of both processes enables oxyfuel combustion in the fuel reactor, which simplifies the sequestration of CO_2. The OC thereby acts as oxygen transport agent. Following this concept, researchers started to implement the oxygen carrier aided combustion (OCAC) in conventional circulation fluidized bed (CFB) boilers. The OC replaces the conventional bed material partly or completely and acts as local and temporal oxygen buffer within the fluidized bed. Thus, the OC balances imperfect mixing and inhomogeneous oxygen or solid fuel distribution within the bed.

The Chair of Energy Process Engineering focuses on small- to mid-scale bubbling fluidized bed (BFB) combustion of solid biomass fuels. Inhomogeneous solid fuels and fuel feeding – especially for such small-scale systems – result in local and temporal oxygen deficits. Usually, the addition of excess air mitigates incomplete combustion. However, this has a negative impact on the overall boiler efficiency. The application of ilmenite as an alternative bed material addresses various challenges during the thermochemical conversion of solid biomass. It is supposed to support the in-bed fuel conversion and consequently improve the boiler efficiency. Compared to CFB's, BFB's are characterized by a low bed expansion and high particle loads. Moreover, larger particle diameters of bed materials in BFB's reduce the active surface of applied OC materials. Therefore, a detailed study of the behavior of ilmenite in BFB is necessary.

The proposed contribution presents the process design and experimental validation of OCAC in BFB's. Thereby, we focus on the effects on the plant performance indicators, namely emissions, in-bed heat release and overall efficiency. First, the goal of experiments in a 7 kW_{th} lab-scale BFB reactor was to develop a model describing the oxygen buffering effect of ilmenite in a BFB during OCAC. Thus, the oxygen distribution along the reactor height was in the focus of first experiments with in-bed methane combustion. The comparison with data obtained from experiments with conventional silica sand shows, that ilmenite enhances the in-bed CO_2 yield by 55%. The provided oxygen mass even increases at lower excess air ratios.

The verification of the beneficial effect of ilmenite serves as basis for the application in a 45 kW_{th} BFB with biomass in field test environment. The results during long-term operation (>500h) with 50wt% ilmenite verify the reduction of CO emissions and the increased boiler efficiency due to reduced air-to-fuel ratios. Simultaneously, the in-bed heat release increases, which enhances the heat supply for e.g. steam generation applied with an in-bed heat exchanger. The presentation will discuss these performance optimizations and provides an outlook on the upscale options for industrial scale and several use cases. Moreover, the long-term experiments allow comprehensive conclusions on the interaction of biomass ash with ilmenite and silica particles, especially for problematic elements like potassium. Ilmenite significantly reduces ash melting and layer formation on the particle surfaces and reduces agglomeration issues.

Palavras-chave : oxygen carrier, bubbling fluidized bed, biomass combustion, biomass ash