Viscosity Predictions of the Slag Composition of Gasified Coal, Utilizing FactSage Equilibrium Modelling

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Abstract

Agglomeration of ash particles provides the desired porosity of the ash bed for adequate agent (steam and oxygen) flow and distribution, whereas excessive slagging inside the gasifier can cause channel burning, pressure drop problems or unstable operation, resulting in cut backs on gasifier load, which implies a direct loss in gas production. The ash flow temperature (AFT) is one property that specifically gives more information on the suitability of a coal source for combustion or gasification purposes. However, normal AFT analyses give an average flow property and do not indicate exactly at what temperature the first melt/slag is occurring or what the properties of the slag is at a specific temperature. Operating experience indicates that even when the gasifiers are operated at temperatures above the flow temperature as given by AFT analysis, a low percentage of slag is formed.

In this study the focus will be on the application of viscosity determinations together with FactSage modelling. Conventional AFT analyses take the bulk chemical composition of the mineral phase into account, and does not differentiate between the composition in the slag-liquid phase and the composition of the crystalline phase. It is therefore important to describe the viscosity of not only the completely molten phase, but also the partly crystallised slag and liquid portion. The combination of viscosity predictions together with FactSage modelling will result in viscosity predictions of the actual liquid component, rather than just an average or pseudo viscosity prediction of the total mineral system at a specific temperature.

Based on the fact that the Urbain model assumes the composition as 100% liquid or molten, which is not the case for example during fixed bed gasification where the mineral structure is of a heterogeneous nature with partial melting and crystalline material, viscosity predictions of the slag or molten portion can be more accurately determined by using the FactSage results. The viscosities, as determined from specific slag compositions at specific temperatures between 1000°C and 1250°C, differ from the average viscosity prediction and is highly likely to be a more accurate prediction of the slag viscosity than just based on the average mineral composition. The viscosity of the actual slag composition also remains fairly constant up to temperatures >1200°C. This can also be related back to the initial deformation temperature onset of the coal, where the slag properties are cumulative enough for the onset of deformation to start. The specific decrease of the viscosity at the temperature between 1200°C and 1250°C correlates with the slag formation trend as obtained with FactSage modelling.

During the gasification process the viscosity of the slag portion decreases to ±3.5cp, which is on the border between a weak deposit and strong deposit. With increasing temperature above 1250°C, for this specific coal source the viscosity moved into the strong deposit region. After the gasification zone, the viscosity increased again as the material crystallised in the combustion process. For a specific coal source, the viscosity of the slag portion can thus be calculated. The major source of glass is derived from included minerals in carbon rich particles. It is clear that a focus on the modification of the unclassified/amorphous phase, to increase the viscosity (decrease slag formation or have a higher concentration of crystalline phases) at a certain temperature, is important.

An AFT analyses only supplies information on the temperature where a mass of material, enough to deform the structure of the cone, starts to slag and does not give information on the properties of the

slag below that point. The use of viscosity predictions together with FactSage modelling supplies a better understanding of slag and ash properties at specific temperatures.