UMEÅ UNIVERSITET

Refractory Corrosion in Biomass Gasification

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Akademisk avhandling

som med vederbörligt tillstånd av Rektor vid Umeå universitet för avläggande av filosofie doktorsexamen framläggs till offentligt försvar i hörsal N360, naturvetarhuset,
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Fakultetsopponent: professor Ragnhild Aune
Norges teknisk-naturvitenskaplige universitet, institutt for materialteknologi.

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Abstract
To stop the net emission of CO2 to the atmosphere, we need to reduce our dependency of fossil fuels. Although a switch to a bio-based feedstock hardly can replace the total amount of fossils used today, utilization of biomass does still have a role in a future in combination with other techniques. Valuable chemicals today derived from fossils can also be produced from biomass with similar or new technology. One such technique is the entrained flow gasification where biomass is converted into synthesis gas. This gas can then be used as a building stone to produce a wide range of chemicals.

Slagging and corrosion problems are challenges presented by the ash forming elements in biomass during thermochemical energy conversion. The high temperature in the entrained flow process together with ash forming elements is creating a harsh environment for construction materials in the reactor. Severe corrosion and high wear rates of the lining material is a hurdle that has to be overcome to make the process more efficient.

The objective of this work is to investigate the nature of the destructive interaction between ash forming elements and refractory materials to provide new knowledge necessary for optimal refractory choice in entrained flow gasification of woody biomass. This has been done by studying materials exposed to slags in both controlled laboratory environments and pilot scale trials. Morphology, elemental composition and distribution of refractories and slag were investigated with scanning electron microscopy and energy dispersive X-ray spectroscopy. Crystalline phases were investigated with X-ray diffraction, and thermodynamic equilibrium calculations were done in efforts to explain and make predictions of the interaction between slag and refractory.

Observations of slag infiltration and formation of new phases in porous materials indicate severe deterioration. The presence of Si in the materials is limiting intrusion by increasing the viscosity of infiltrated slag. This is however only a temporary delay of severe wear considering the large amount of slag that is expected to pass the refractory surface. Zircon (or zirconium) (element or mineral?) based material show promising properties when modeled with thermodynamic equilibrium, but disassembling of sintered material and dissociation of individual grains was seen after exposure to a Si- and Ca-rich slag. Fused cast materials have a minimal slag contact where the only interaction is on the immediate hot face. Dissolution was however observed when exposed to a silicate-based slag, as was the formation of NaAlO2 after contact with black liquor..

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