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Keynote presentation:

The behavior of ash species in suspension fired biomass boilers

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The behavior of ash species in suspension fired biomass boilers

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Abstract

While fluid bed and grate fired boilers initially was the choice of boilers used for power production from both wood and herbaceous biomass, in recent years suspension fired boilers have been increasingly used for biomass based power production. In Denmark several large pulverized fuel boilers have been converted from coal to biomass combustion in the last 15 years. This have included co-firing of coal and straw, up to 100% firing of wood or straw and the use of coal ash as an additive to remedy problems with wood firing. In parallel to the commercialization of the pulverized biomass firing technology a long range of research studies have been conducted, to improve our understanding of the influence and behavior of biomass ash species in suspension fired boilers. The fuel ash plays a key role with respect to optimal boiler operation and influences phenomena's as boiler chamber deposit formation, corrosion of steam coils, deactivation of SCR catalysts and utilization of residual products. A broad range of research tools as probe measurements on power plants, entrain flow reactor studies and deposit modelling have been used to gain an improved understanding of ash transformation and ash deposit formation in suspension fired boilers. The presentation provides an overview of the knowledge obtained with respect to ash species behavior in suspension fired biomass boilers.

A mechanistic understanding of the fly ash formation process in biomass fired PF boilers is obtained today. A high fraction of alkali salt species are released to the gas phase during the initial fuel combustion process. The salt species are present in gas phase in the boil chamber and upon cooling in the convective pass aerosols are formed. Recent studies indicates that a large fraction of the residual condensed phase ash fragments to generate ash particles typically in the size range of 50 to 200 μm on biomass suspension fired power plant boilers. A fragmentation rate of fuel particles of 3 have been used to describe both the residual ash formation process in laboratory entrained flow reactors and in full scale boilers.

A range of advanced deposit probe measurements have been conducted on biomass power plants. The measurements have provided insight into the relations between the chemical composition of fuel ash, fly ash and deposits. Furthermore the measurements have provided quantitative data on deposit formation rates as a function of fuel composition, and local surface and flue gas temperature. The processes of deposit removal by both natural shedding and soot blower induced deposit shedding have also been studied by the probe measurements. In most cases deposits are removed by de-bonding, where the deposits break up near the interface to the steam tube metal surface. Especially an increased tube temperature makes it more demanding to remove the ash deposit.

Modelling of the deposit formation process have been developed by combining sub-models of the ash formation process, the condensation of ash species on tube surfaces, ash particle deposition, heat transfer in the deposit and deposit sintering. The model mainly provides information on how changes in fuel ash composition and local conditions influences deposit formation rate and deposit chemistry. Comparison of the modeling results with laboratory and full scale data shows that further development of both the particle adherence model and the alkali condensation model is wanted.

The speciation of potassium from the biomass in the boiler chamber as salts or alumina silicates and other species with high melting temperatures strongly influence the operation of both the boiler and flue gas cleaning equipment. Different additive types can be used to reduce the alkali salt content in the boiler chamber. The additive often works by reaction with the salts thereby binding the alkali metal to high melting temperature species and release the chlorine to the gas phase as HCl. Presently coal fly ash with a high content of Si and Al is used as an additive on wood fired plants to reduce the problems with alkali salt de-activation of SCR catalysts. While the fundamental chemistry of the additives are well known detailed reaction models of the interaction of salts and additive particles are presently not available.