Washington University in St. Louis
School of Engineering & Applied Science

Energy, Environmental & Chemical Engineering

EECE Department Seminar

Friday, September 15, 2017

11:00am

Brauer Hall, Room 12

Ash aerosol partitioning and ash deposition mechanisms during coal and biomass combustion

ABSTRACT

Deposition of ash on heat transfer surfaces is a major factor in determining boiler performance. Deposits so formed consist of tightly bound "inside" deposits close to the heat transfer surface and loosely bound "outer" deposits that are easily dislodged. Here we describe research which focused on both *the composition* of inner and outer deposits, and also on *the rate of deposition* of the inner deposit layer. Presented are selected results from a wide ranging study concerned with mechanisms governing the formation of fouling deposits during air and oxy-combustion of various fuels in a 100 kW test rig. Additional results from oxy-combustion of biomass and biomass/coal mixtures (a process that can yield negative CO_2 emissions) are also presented. Not only are we concerned with impacts of conversion from air-firing to oxy-firing, but we also focus on establishing a relationship between the size segregated composition of the coal ash aerosol, and the spatially resolved composition of the deposit layer. Ultimately, we seek methods that predict rates of ash deposition under a wide range of fuels and conditions.

Data showed the composition of the inside layer, closest to the heat transfer surface, correlated with the composition of the sub-micron aerosol particles. Rates of deposition of the vertical deposits were also measured, and could be modelled by the transport process of thermophoresis. The effects of oxy-combustion are most pronounced in how they influence flame temperature. This affects both the *amounts*, and *composition* of the sub-micron sized ash fume, and the *composition* and *deposition rate* of the sticky inside layer of the deposits. Results presented here contrast ash aerosol and deposit characteristics for air combustion to those for oxy-combustion of PRB coal, an Illinois coal, 40/60 PRB Illinois PRB/Illinois Blend, a Utah Sufco coal, a biomass fuel of Rice Husks, and a Rice Husk/Utah Sufco Coal Blend. Conditions include air combustion and oxy-combustion with inlet O_2 concentrations of 27%, 50% and 70%. Additional experiments explored effects of the composition of recirculated flue gas that is often used to modulate peak flame temperatures in retrofit applications.

The importance of the sub-micron aerosol in determining rates of deposition of the inside layer was demonstrated by the surprisingly simple linear correlation between the deposition rate of the inside layer and the concentration of the sub-micron aerosol, regardless of its composition. This correlation held for *all four coals, for biomass (rice husks) and for biomass/coal mixtures*, under *all* the various *air- and oxy-firing* conditions for which data are available, This yielded a correlation coefficient was 0.79, and the result is surprising because it suggests the amount rather than the (variable) composition of the submicron aerosol is important. There was no correlation between deposition rates and total ash concentrations.

Jost O.L. Wendt, Professor

Chemical Engineering, University of Utah

Jost O.L. Wendt, Presidential Professor in the Chemical Engineering Department at the University of Utah. Previously he was Head of Chemical and Environmental Engineering at the University of Arizona Tucson. Jost obtained his Ph.D. and M.S. in Chemical Engineering from the Johns Hopkins University, and his B.Sc. from University of Glasgow, Scotland. He is past Chair (2009) of the Environmental Div. of AIChE, Fellow of the AIChE and has 40 years experience in theoretical and experimental combustion research. The author of over 120 peer reviewed papers and over 250 presentations, Jost is internationally recognized for his wide-ranging research on reduction of emissions from combustion processes. His research within academia, industry and EPA laboratories, has led to 'reburning' for NOx control, to mitigation of waste incinerator emissions through control of 'transient puffs' and 'rogue droplets', to the management of fine particle and toxic metal emissions using sorbents. He is active in oxy-coal combustion and mercury sequestration technologies. He is currently a PI of a collaborative NSF-NSFC research program between several Universities in China and the US.

For more information contact Kara Dix at kdix@wustl.edu