Ash Deposition Rates for a Suite of Biomass Fuels and Fuel Blends

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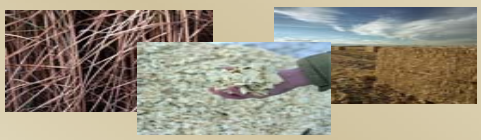


Biomass is a CO_2 neutral renewable fuel that offers an alternative to using fossil fuels for energy production.

Drawbacks to biomass fuels include a high corrosion potential and varying ash content. This creates potential problems for boiler operators.

A suite of six biomass fuels incorporating a wide range of organic and inorganic components was used to investigate blending effects on deposition rate.

Straw

Sawdust | Sugar Beat Pulp | Shea Nut Shells | Sunflower Shells

Grain Screenings

Five Physical Ash Deposition Processes

$$\frac{dm}{dt} = I\ G + E + T + C + R$$

$$\dot{m}_d = \frac{\dot{m}_f X_a}{A_r} A_p\ \eta\ G$$

- Inertial impaction (I)
- Eddy impaction (E)
- Thermophoresis (T)
- Condensation (C)
- Chemical Reaction (R)

m_d= mass deposition rate

m_f = mass flow rate of the fuel

X_a = mass fraction of ash in the fuel

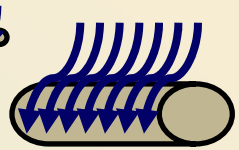
A_p= probe projected area

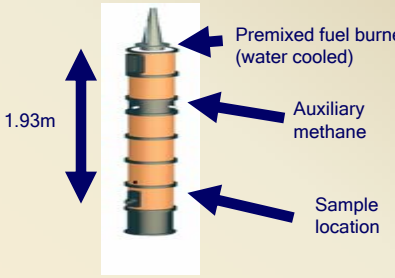
h = the impaction efficiency

A_r = reactor cross section (cm^2)

$$Stk = \frac{\rho_p d_p^2 V_p}{9\ \mu_g d_c}$$

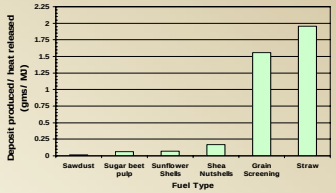
$$\eta(Stk) \cong \left[1 + b(Stk - a)^{-1} - c(Stk - a)^{-2} + d(Stk - a)^{-3}\right]^{-1}$$



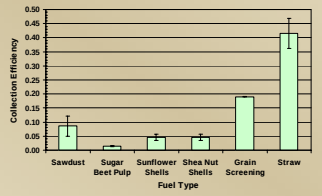


The Multifuel Flow Reactor (MFR) is a down-fired laminar-flow reactor allowing for ash deposition modeling in a controlled environment.

Deposition rates for pure fuels vary by two orders of magnitude (~130) between minimum and maximum ash producing fuels.



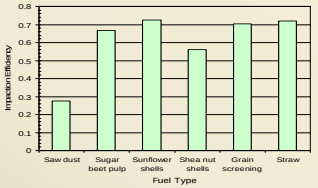
Normalization over ash content of fuel, fuel feed rate and projected area for deposition reduces the variation by an order of magnitude (~28).

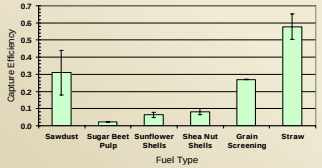


Collection efficiency

$$c = \frac{m_d}{m_f X_a A_p / A_r} = \eta \cdot G$$

$G_{max}/G_{min} \sim 25$

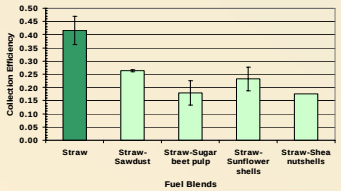


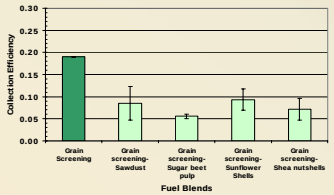


An order of magnitude variation in capture efficiencies indicates the role of fuel interactions and ash chemistry in deposition process.

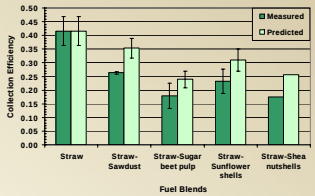
Straw and grain screenings differ from the other fuels because of ash composition and ductility.

Ash deposition rates for the respective fuel blends are lower than that of pure straw and pure grain screenings by factor of 2.0.

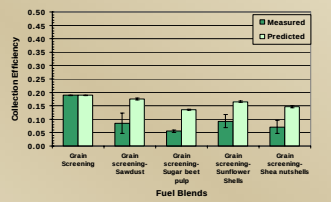




The deposition model used overpredicts the deposition rates for all blends, since the capture efficiencies of the blends are weighted averages of pure fuel capture efficiencies.



The differences in the predicted and measured data are large compared to the uncertainty limits.



Conclusions: Ash deposition rate is a function of ash content, capture efficiency, and, in instances of small particle size, and mechanisms other than impaction. Mixing fuels results in lower capture efficiencies thus lowering the amount of deposited ash. The simple deposition model can accurately predict ash deposition rates to within 20% of actual amounts with exceptions of few over predictions.

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