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Proceedings of the Combustion Institute 36 (2017) 3341–3350

Proceedings of the Combustion Institute

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# Ash deposition propensity of coals/blends combustion in boilers: a modeling analysis based on multi-slagging routes

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Received 2 December 2015; accepted 9 June 2016
Available online 21 June 2016

**Abstract**

A method that is based on the initial slagging routes and the sintered/slagging route has been developed and used for predicting the ash deposition propensities of coal combustion in utility boilers supported by the data collected from power stations. Two types of initial slagging routes are considered, namely (i) pyrite-induced initial slagging on the furnace wall, and (ii) fouling caused by the alkaline/alkali components condensation in the convection section. In addition, the sintered/slagging route is considered by the liquids temperature, which represents the melting potential of the main ash composition and is calculated using the chemical equilibrium methods. The partial least square regression (PLSR) technique, coupled with a cross validation method, is employed to obtain the correlation for the ash deposition indice. The method has been successfully applied to coals/blends combustion in boilers, ranging from low rank coals to bituminous coal. The results obtained show that the developed indice yields a higher success rate in classifying the overall slagging/fouling potential in boilers than some of the typical slagging indices. In addition, only using the $SiO_2/Al_2O_3$ ratio to predict the melting behaviors and slagging potential is inaccurate since the effect of the $SiO_2/Al_2O_3$ ratio is dictated by both the original ash composition and the way in which the $SiO_2/Al_2O_3$ ratio is changed. Finally, the influence of the acid components ($SiO_2$ and $Al_2O_3$) on the ash deposition prediction is investigated for guiding the mineral additives. It is noticed that the predicted ash deposition potentials of the three easy slagging coals investigated decrease more rapidly by adding $Al_2O_3$ than by adding $SiO_2$.


*Keywords:* Ash deposition indice; Thermodynamic modeling; Partial least square regression; Boilers; $SiO_2/Al_2O_3$ ratio

## 1. Introduction

Considerable progress has been made in the last decades in understanding the ash deposition

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http://dx.doi.org/10.1016/j.proci.2016.06.060

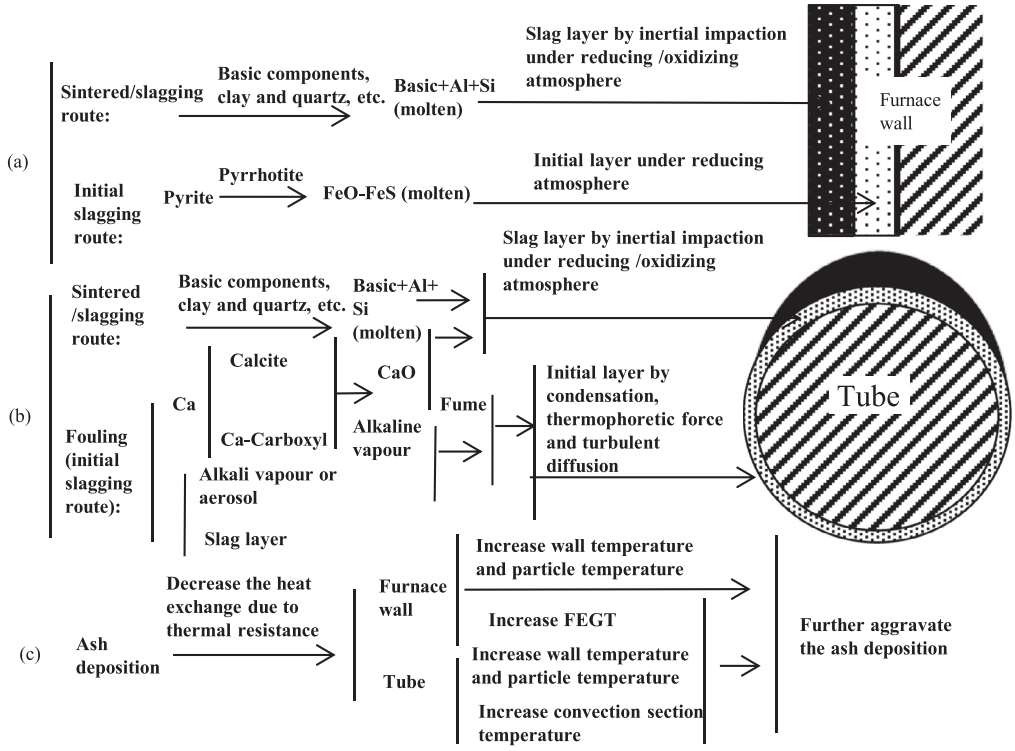


Fig. 1. Schematic of the ash deposition routes in boilers (modified from [1,7,8]).

mechanisms of various coals. For example, Eastern US coals (such as Illinois and Appalachian coals) have higher concentrations of Fe components than Western US coals [1], and the initial slagging caused by the pyrite is one of the main issues related to slagging problems [1–3]. For low rank Western US coals (such as Wyoming and Montana coals) which have higher concentrations of alkaline/alkali components than Eastern US coals, fouling in the convection section is a serious problem [4–6]. Figure 1 shows the main ash deposition mechanisms for US coals in utility boilers [1,7,8]. Generally, it is regarded that ash deposition can be mainly dictated by three different routes: (i) Pyrite-induced initial slagging route generates from the pyrite particles due to its large density and low melting temperature under reducing atmosphere on the furnace wall [3,8,9]; (ii) Fouling-induced initial slagging route generates from the condensation of alkali vapors and thermophoretic deposition of aerosol/fume particles on the superheaters or economizers; (iii) The sintered/slagging route is triggered by the molten matrix generated from the major basic components reacting with clay and quartz, etc., and the reducing atmosphere can promote this process when a high Fe concentration is present in the coal [1,7]. Furthermore, severe slagging in the furnace chamber could increase the furnace exit gas temperature (FEGT) and hence this may further aggravate the ash deposition in the convection section. Therefore, the severe ash deposition in boilers could be triggered by the three different routes and a successful ash deposition indice should be capable of predicting the deposition formation from these three formation routes.

Although there exist several publications on developing a slagging indice for coal combustion, most of these methods were developed either based on slagging observations in entrained flow reactors or by only considering the sintered/slagging route [10–15]. Gibb [12] developed a slagging indice based on the computer controlled scanning electron microscopy (CCSEM) based mineral composition in the coal. This indice was developed based on the assumption that the degree of assimilation of iron and calcium into the aluminosilicate glass determines the ash deposition characteristics of the coal. This assumption neglects the influence of the initial slagging routes caused either by pyrite or by condensation. McLennan et al. [11] developed an iron-based slagging indice based on the included and excluded iron related minerals composition in the coal. However, this indice only considers the effect of iron related minerals on the slagging behavior. Also, both of these two CCSEM slagging indices are yet to be validated