Coal Combustion Inc.
Understanding the business of coal

One Day Coal Slag Class – by Rod Hatt

Introduction

Cover three areas

1. What coal properties influence slag formation
2. What milling and flame conditions promote slag formation
3. What can plant operations do to minimize slag formation

Coal Properties

1. **Heat content, calorific value (CV), Kcal/Kg, MJ/Kg, Btu/lb.**
    a. Low heat coals due to increases ash and moisture, increase coal flow through milling equipment. Generally milling effectiveness decreases with coal flow. Burner velocities increase with higher coal flow. Low CV coal increases slag formation due to larger particle sizing and increased velocity.
    b. High moisture coals need more drying capacity, higher temperature primary air (PA) and/or more PA flow. Both of these impacts increase gas volume and burner velocity.
    c. High ash coal due to "out of seam dilution, OSD" (rocks) should have increased mill rejects. Does plant handle increase reject material, or does it increase PA flow to put rocks through mill?
2. **Minerals in Coal**
    a. **Pyrite, FeS2** – This dense (S.G. ~5.0 g/CM3) mineral is the main source of low melting temperatures minerals in coal. This low melting behavior stays with the iron (Fe) until it reaches the fully oxidized or burn form of Fe2O3. The unburnt forms of pyrites can all promote slag formation. These are FeS2, FeS, Fe, FeO, Fe3O4. The sulfides promote water wall wastage, and the unburnt irons promote slag. The goal in many boiler designs with excess air set at 1.20 is to burn the iron in pyrite. Pyrite is removed by coal washing and pyrite rejection systems, or the use of low sulfur coal, but it is always there. We estimate the pyrite content of coal by reporting Fe2O3 in the ash. We suggest that this value be converted to loading values using the ash and CV.
    b. **Quartz, SiO2** – Quartz is the hardest mineral in coal and causes the most abrasion and erosion. It has a specific gravity of ~2.7 g/cm3. This make for the potential to wash quartz like rock out, or have them be rejected by the milling system. Quartz type rocks melt at high temperatures, but can add mass to slag by sticking in wet molten slags, later to be dissolved into the slag. Quartz can be large due to it's hardness.
    c. **Clays and Shales** – (Si_X, Al_Y, O_Z)+ Fe, Ca, Mg, K, Na, can be high and low melting compounds depending on specific types.
    d. **Organically** associated elements, CaO and Na2O and others elements can be bound to the coal organically. This is particularly true for low rank sub bituminous and lignite type coals.

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Plant Combustion Conditions that Impact Slag

1. **Coal (and mineral) Sizing** – Coal combustion is highly influenced by particle size. In pulverized coal flames it is a standard practice to maintain 70% minimum passing a 200 mesh (75 um) screen. This sizing can be changed to larger sizing to increase coal throughput. This is often done to process the necessary tons of coal when using low CV sub bituminous or lignite coals. This change is made based on the high reactivity of these type coals (think spontaneous combustion). For slag issues it is more important to look at the +50 mesh (300 um) material. Typical values can range from 0.0% to about 4%. My recommendations are 0.1% maximum remaining on the 50 mesh screen for minimum slag impact. The problem with many pulverizers, is that to obtain these levels of sizing on the 50 mesh screen, the percent passing the 200 mesh screen usually has to be over 70%, sometimes closer to 80% passing the 200 mesh screen.
2. **Burner Velocity** – Every coal burner in a boiler points at a water wall. High velocity and large mineral (pyrite) matter increases the chances of slag forming material to reach the wall. High coal flow and a constant primary air to fuel ratio (Pri A/F) means higher coal flow takes more primary air flow. Typically the design Pri A/F ratios for pulverizers is 1.6 to 1.8. Sometimes 2.0 for high moisture coals. Many operators use higher A/f than design. Both high A/F and low CV coal increase burner velocity. High air flow also tends to increase particle sizes.
3. **Excess Air** – Due to imperfect mixing of coal and air, to burn all the coal, pulverize coal boilers are designed to typically have 20% more air than coal (stoichiometric). Sometimes expressed as 1.20 excess air. Twenty percent excess air equates to 3.5% excess O2. Many boilers can operate with little slag issues running with as low as 3.0% excess O2 or 1.17 excess air. It is common practice, especially with sub bituminous and low rank coal firing to lower excess oxygen to levels of 2.2 or 2.4% average. These are slagging levels of excess O2, especially when individual O2 probes drop to less than 1.5%.
4. **High Load** – Continuous high load (particularly higher than MCR) for several days can slowly start slag formation due to high temperatures. This can occur with any coal. Unfortunately slag formation is expediential in nature. This is why operators say “we checked and found little slag, and then all of a sudden we had lots of slag.”
5. **Soot Blower and Wall Cleaning** – This equipment is important to have operational, and to use it effectively. Many smart computer soot blowing programs have difficulty seeing/detecting small deposits, which can grow fast. **Furnace observation** is important to finding and removing smaller more manageable deposits. Many operators have had to add doors and cameras to accomplish this, particularly on newer boiler designs.

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What to Do About Slag

1. Do not push unit beyond fan capacity. Maintain minimum O2 +2.5% AVG, 2.0% for any individual probe.
2. Look for CO values above 200 ppm in stack; try to reduce to below 50 ppm.
3. Use highest CV/Btu coal available.
4. Low ash and low sulfur coal helps.
5. Maintain +50 mesh pulverized coal below 0.1%, never over 2.5%.
6. Back off PA flow to less than **2.0** A/F, KLbs/KLbs, Ton/Ton, Kg/Kg…
7. Clean water walls to minimize reheater sprays, raise tilts, minimize FEGT.
8. Walk down boiler observing slag deposits, and take action.
9. Install cameras and observation ports to past areas of slagging.
10. Use rapid slag sheading load drops when needed.