

FUEL TREATMENT OPTIONS FOR SLAG CONTROL

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OPERATING CONDITIONS

Most coal-fired (and other solid fuel), boilers periodically experience operating conditions that result in problematic slagging and fouling. Frequent excessive slag conditions are not uncommon with units burning PRB and other Western coals. Many of these boilers experience ash fouling and/or slagging severe enough to cause frequent systematic load sheds. In severe circumstances, units must come off-line for complete cleaning.

Slagging and fouling challenges have been on the rise in conjunction with power plants changing fuels to compliance coals to reduce SO₂ emissions. While this change in coal selection has reduced sulfur emissions, increased problems with slagging and/or fouling have become common.

EFFECTS OF CHANGES IN FUELS

As a result of different burning characteristics and lower ash softening temperature of western sub-bituminous coals, particularly those of the Powder River Basin (PRB), furnaces may foul on the lower water-walls. This will, in turn, cause higher furnace exit gas temperatures and fouling in the convection and platen sections. Convective sections designed for fuels with high ash softening temperature will encounter problems.

As these deposits grow during normal operations, the slag restricts gas flow through portions of the pendants and causes “channeling”, resulting in gas velocities five to seven times higher than designed. This situation then leads to increased fan vibration/RPMs, erosion of non-fouled tube surfaces, lower than expected runs between cleanings, capacity problems, and/or production limitations.

PRB and other Western coals frequently contain low melting point sticky ash compounds that travel through the furnace in a gaseous or molten state, and quickly freeze/harden after contacting cooler tube surfaces. Some deposits even remain in a semi-molten, plastic state. This results in tenacious and difficult to remove ash deposits. As these deposits grow, they can cause the following problems:

- Loss of heat transfer as indicated by falling superheated steam temperatures and increasing stack temperatures
- Increased fuel usage to maintain steam temperatures
- Restricted air flows leading to increasing draft losses, higher gas velocities, tube erosion, and eventual tube failure
- Formation of large, heavy clinkers that fall and can damage boiler furnace floor tubes

These problems frequently lead to unscheduled boiler outages for cleanings and increased tube replacement due to erosion and occasionally under-deposit corrosion.

In cases where slag and fouling challenges are deemed out of control, power producers are inclined to consider alternative coals (less slag prone varieties). Unfortunately, these fuels are almost certain to be more expensive, and in many cases, *much more* expensive. For example, fuel combinations such as 85% PRB coal and 15% Eastern bituminous coal might be considered. In

addition to the higher cost, blending challenges also arise. Consistent fuel blending is difficult to manage. As a result, the very problems the blending was intended to remove occur anyway.

Regardless of the coal blend, the resulting untreated coal ash tends to cause fouling and slagging of a unit's reheat, finishing vertical superheat and wall pendant sections. These deposits will then cause flow restrictions and efficiency losses. These problems are often only marginally controlled by increased soot blowing, systematic thermal shocking and shotgun deslagging.

Ultimately, this can lead to a premature outage being taken, to allow manual cleaning of the affected heat transfer surfaces. With a particularly poor blend of coals, a maximum unit run may be as short as a week before diminished thermal efficiency favors a shut-down over continuing operation.

FUEL TREATMENT OPTIONS: MAGNESIUM HYDROXIDE OR VERMICULITE

Fuel Tech offers options in fuel-treatment chemistry. For most applications suffering problematic slag and fouling issues, magnesium hydroxide chemistry has been found to be most cost effective because of its flexibility in dealing with the multiple slag/fouling related issues that occur in large Utility boilers. In the rare instances where problems are restricted to the pendants near the furnace exit, well engineered targeted injection of vermiculite could prove more cost effective as long as fuel quality is not changing over time and operating practices for the unit are consistent through out the run. Magnesium Hydroxide treatment has an advantage in recovering should an interruption in treatment occur.

Magnesium Hydroxide Targeted-In-Furnace Injection (TIFI)

Fuel Tech recommends a specific stabilized magnesium hydroxide slurry where the magnesium hydroxide particles have a very large surface area per unit volume ratio (approximately 530,000 sq.ft./cu.ft). This high surface area / volume ratio allows for minimal treatment dosages (normally 1-2 pounds of MgOH slurry per ton of coal burned) while its stability in a concentrated slurry eliminates many of the handling and feeding problems inherent in the use of vermiculite.

Magnesium hydroxide works by modifying (weakening) the crystalline structure of ash deposits in the boiler. When properly conditioned, slag and fouling deposits are easily removed through normal soot blowing practices. Slag control is achieved even though ash fusion temperatures are unaffected.

More Than Chemistry

The right chemistry is not enough. *Delivery* of the right chemistry to the *right locations is equally critical*. Fuel Tech's Targeted In-Furnace Injection (TIFI) program utilizes advanced Computational Fluid Dynamic modeling, combined with virtual reality visualization techniques to ensure that the chosen chemical reaches the specific problem areas for a given unit. Each TIFI application begins with the construction of a highly detailed CFD model, which is then placed in a virtual reality environment. In effect, a "pre-trial demonstration" is run in virtual reality *before the actual on-site Trial ever* occurs. This approach significantly increases the speed with which the problematic slagging and fouling issues are corrected. Many Fuel Tech Customers report tangible results within the first week of a TIFI Trial demonstration.

Specifics on CFD Modeling & Virtual Reality Visualization

Process Design Modeling involves simulating the operation of a particular furnace in a high performance computer and then testing various “what if” problem and solution scenarios at various power settings. A great deal of detail goes into running this modeling process.

All size and design dimensions, fuel and heat rates, fuel chemistry, details of air usage and boiler geometry are programmed into the model.

The data set output from this model is complex and difficult to visualize. Recent advances with virtual reality visualization techniques, coupled with fluid dynamics modeling, have yielded new insights into how complex dynamic systems like coal burning utility boilers and other furnaces, behave in real time.

Targeted In-Furnace Injection (TIFI)

TIFI technology involves using fluid dynamics modeling and a virtual reality engine. Together, these create a running simulated duplicate of a given furnace with injection overlays and dosage maps to determine specific chemical concentrations throughout the boiler. This process ensures optimal coverage of the targeted zones for a specific application.

The most common application of TIFI technology utilizes magnesium hydroxide slurry that is diluted with water and then atomized with air. This mixture is sprayed into the furnace at computer-determined locations (i.e. specific injection ports), that allow for complete coverage of the problem area(s).

With Targeted In-Furnace Injection, the limitations inherent in adding the slag control agent directly to the fuel are overcome. The whole issue of being close to the burners and subject to limitations of the fuel and air mixing is removed. Instead, the injection takes place in conjunction with what is happening to the burn zone, taking advantage of fluid dynamics in that zone and avoiding pitfalls identified during modeling.

Results achieved through TIFI are often dramatic. Injectors are located where they will maximize chemical effectiveness, while minimizing feed requirements. This methodology is effective on radiant section water-wall slagging, convection pass fouling, plugging of platens and cold end corrosion control associated with high sulfur fuels.

Vermiculite - Non-Targeted In-Furnace Injection

Vermiculite is a naturally occurring sheet silicate mineral, usually formed by the hydrothermal alteration of mica minerals such as biotite and phlogopite. Vermiculite ranges in size from microscopic particles of clay mineral to lustrous brown sheets up to half a meter in size although they are usually in the range of 1mm to 1cm diameter. Most vermiculites when heated quickly to above about 230°C will lose their interlayer water and this results in the flakes exfoliating to form concertina shaped particles.

Vermiculite as a Fuel Treatment Additive

Vermiculite can be used to control slag and fouling problems in coal fired boilers. Although there are no detailed and extensive studies available on vermiculite and its efficacy to control slag, it is believed that through expansion or exfoliation, vermiculite controls slag by providing a brittle

cleave plane for slag to adhere onto. Deposits are then be more easily removed by proper soot blowing.

Unlike magnesium based slurries, vermiculite by itself is ineffective in complexing with vanadium in fuels such as oil to prevent low melt point vanadium compounds. Vermiculite is also ineffective for controlling acid from H₂SO₄. The use of vermiculite is extremely temperature sensitive. It is critical to feed it at a point where temperature has minimal variation. Temperatures outside a specific zone will prevent product expansion (too cool), or promote premature expansion (too hot). In those cases, the vermiculite will not be available at the required application point. In units with highly variable temperatures, vermiculite is not able to provide consistent slag and fouling relief. As vermiculite is less forgiving to temperature swings, Mg(OH)₂ is more commonly recommended for Utility boilers.

SUMMARY

	<u>MAGNESIUM HYDROXIDE</u>	<u>VERMICULITE</u>
ADVANTAGES	<ul style="list-style-type: none"> • Can be targeted to specific areas of the boiler using Fuel Tech's patented TIFI program • Neutralizes SO₃ • Can clean up existing ash deposits in many cases • Easy to control dosage • Fed as a slurry 	<ul style="list-style-type: none"> • When boiler design and operation is ideal for simple injection strategy (i.e., into overfire air) boiler penetrations can be avoided. • No dilution water requirements
DISADVANTAGES	<p>All Mg(OH)₂ are not alike. Selection of the wrong type negates the advantages listed above.</p>	<ul style="list-style-type: none"> • Cannot remove existing deposits • Difficult to feed (dry) • Difficult to control dosage • Does not neutralize SO₃

CONCLUSION

FUEL TECH has the capability to reduce or eliminate fireside slagging, fouling, corrosion and erosion problems. Utilizing both bench-top and computer laboratory facilities, and drawing upon years of fireside experience, FUEL TECH will design a custom-fit program to address the unique needs and goals of our Customers: *The right chemistry, fed consistently and precisely to the specific locations most problematic for your boiler.* The bottom line result is more megawatts produced annually at a lower overall cost of plant operation.