UTILIZATION OF LOW VOLATILE COAL IN STEAM PLANTS

Coal Combustion, Inc.
Understanding the Business of Coal

Rod Hatt
rod_hatt@coalcombustion.com

Office 859-873-0188
Fax 859-873-0252

114 S Main St
Versailles, KY 40383

INTRODUCTION

In recent years many utilities have begun utilizing low volatile bituminous coals to reduce their production costs and/or improve emissions. This is a result of the low volatile mines increasing production and the subsequent effort to expand and diversify markets for low volatile coal. The technology of burning low volatile coal in steam plants has advanced considerably in the last four to six years. This paper will describe the experience of utilities using low volatile coal in pulverized coal and cyclone type boilers, in addition to the concerns that current users have overcome.

LOW VOLATILE COAL CHARACTERISTICS

Low volatile bituminous coal is higher ranked than high volatile or subbituminous coals. The longer formation time and the extra pressure exerted on the coal layers causes the coal to lose inherent oxygen and hydrogen. This results in lower volatile matter as a percentage of total weight and a higher percentage of carbon on a moisture, ash-free (MAF) basis. Low volatile coals tend to have high hardgrove grindability indices (HGI) in the 90-105 range. High grindability coals provide the advantage of lowering net unit heat rates due to lower auxiliary power consumption of hammer mills and/or pulverizers in addition to adding capacity. However, the high grind coals have a potential to cause handling problems due to a higher percentage of fines. Typically these coals have 70-90% less than 1/4 inch. Fugitive dust emissions may also be a concern due to these sizing characteristics. Both of these concerns are influenced by the amount of surface moisture present. There is a difference in handling characteristics between cleaned and raw coals. The washed products exhibit better handling characteristics due to the removal of clays which tend to act as binders when the coal becomes wet. The fine sized nature of these coals also limit the penetration depth of rain, so the whole pile is not affected.

High quality low volatile coals have been primarily used in the metallurgical market. This is due to low ash and sulfur in addition to its coking characteristics; namely fluidity properties and high yield due to the high carbon content. However, as productivity of these mines has increased more of this fuel has become available for the steam market. Table I illustrates typical characteristics of both a steam and metallurgical quality low volatile coal.

EXPERIENCE WITH BURNING LOW VOLATILE COAL

There is considerable experience with utilities burning low volatile coals. Several plants located near the low-volatile coal fields in northern West Virginia and Maryland were designed for and continue to operate on low vol coal. One plant in New England originally designed for coal, was converted to oil, back to high vol, and has now been converted to low volatile coal (1). This plant has Babcock and Wilcox front wall fired PC boilers, with EL type mills. During the conversion to low volatile coal, concerns about handling, pulverizer performance, flame stability and emissions were addressed. Concerns about chute pluggage and fugitive dust did not materialize even though the coal was 87% less than 1/4 inch and over five inches of rain fell during the two week test.

The pulverizers experienced a 25 percent reduction in power requirements due to the high (100) HGI resulting in a net heat rate improvement and the use of only three (vs. four) mills for full load operation. Observed flame stability was equivalent to that of the high volatile coal. This is due to the use of the laboratory flame stability tests to prequalify test coals (2).

One of the laboratory evaluations involves the calculation of the calorific value of the volatile matter. The following is a method for determining the higher heating value (HHV) of the volatiles on a per-pound-of-coal basis.

1. Prepare coal samples per ASTM method D2013.
2. Determine the dry Btu content of the coal (HHV_{coal}) as per ASTM method D2015. The required thermochemical corrections should be applied. Utilize ASTM methods D3173 and D3177 (or D4239) for determining and calculating the moisture and sulfur contents of the coal.
3. Determine the volatile matter content (VM%) of the coal sample using ASTM method D3175.
4. Retain the char button obtained from step 3. Obtain enough char (by repeating the heating step in step 3) so as to determine its; 1) total sulfur content and 2) Btu content using the above cited ASTM method in duplicate, if necessary.
5. Grind all the char to minus 60 mesh with a mortar and pestle or a small mill.
6. Determine the total calorific value (HHV_{char}) of the dry char by ASTM method D2015. The required thermochemical corrections should be applied. In some cases, a 50/50 blend of the char and benzoic acid (used as a standard for calibrating the calorimeter (may have to be used to ensure complete combustion of the char during the test.
7. Calculate the HHV of the volatiles per pound of coal using the following equation:

$$HHV_{vol/lb\ coal} = HHV_{coal} - [(1 - VM\%/100) \times HHV_{char}]$$

Upon calculation of the HHV of the volatiles per pound of coal, a recommended minimum of 3636 Btu/lb (dry basis) is necessary to maintain stable flame characteristics. This number has been taken from previously published studies on the correlation between the HHV of the volatile matter and flame stability in a pulverized fired furnace.

Another utility utilizing low volatile coal in a pc wet bottom boiler primarily for the low sulfur and low fusion characteristics of the Pocahontas #3 seam has also had success in handling and flame stability.

Since low volatile coals usually have high grindability indices, the particle sizing at the mill outlet will decrease without changing classifier settings. This smaller particle size (typically 80-85% through a 200 mesh screen) tends to promote char burn-out. Another stabilization technique is to increase the pulverizer outlet temperature. This does not create an explosion hazard due to the low reactivity of the coal. Pulverizer capacity is not adversely affected by the increased outlet temperature due the offset provided by the high hardgrove grindability index. In fact, pulverizer capacity is usually increased when utilizing a high grindability, low volatile coal.

Both of these utilities and others using low volatile coal have found that chutes lined with high molecular weight polypropylene or stainless steel have improved the handling. Vibrators that are used intermittently have been utilized more, and have had better success than air cannons or continuous vibrators. The fugitive dust blown from piles has been controlled with periodic wetting using an elevated sprinkler system.

Concerns with regards to furnace explosions when utilizing low volatile coals have been addressed as long as the HHV of the volatiles in the coal is above the 3650° cutoff required to maintain flame stability. Furnace startups utilize gas or oil as a support fuel so this isn't a problem with low volatile coals. Minimum load operation may require some gas or oil flame support (i.e. ignitors) as a safety measure. This is dependent on the furnace firing arrangement and furnace size. Also, many furnaces have flame scanners in place that are quite useful as a safety measure in the prevention of furnace explosions when utilizing both low and high volatile coals.

There has also been considerable experience utilizing a high quality, low volatile Pocahontas #3 seam coal in cyclone furnaces. The B&W steam (3) book recommends fuels with 18% to 45% volatile matter as being suitable for cyclone furnace boilers. The hot intense flame created in cyclones combined with the high turbulence negates the concern over low volatile content in the coal. Tests performed at full load, minimum load and during unit start-up have proven that a high quality, low fusion, low volatile coal is a viable alternative to high and low sulfur high volatile coals in cyclone furnaces.

COAL BLENDING

A high quality low volatile coal such as the coal illustrated in Table I, can be used as a blending fuel for two major reasons. First, it can be used as a means of blending to meet SO_2 requirements when mixed with high sulfur coal. It is an ideal blending fuel due to its high Btu content and low ash. These qualities allow for a comparatively lower percentage of coal needed to blend down to a desired SO_2 limit. Also, the lower ash will simultaneously decrease the particulate inlet loading to the particulate collection device. There are, in some cases, more handling concerns when the low vol coal is blended with raw high sulfur coal.

This type of coal has been used as a blender with high volatile subbituminous coals to produce the characteristics of a high volatile bituminous coal at blend ratios of as little as twenty percent. The twenty percent blend yields enough of an increase in total Btu content to allow full load capability that was previously either unattainable or borderline due to Btu input capabilities. This low volatile high quality coal is currently being successfully used as an octane boost with Powder River Basin coals at several midwestern utilities.

CONCLUSION

To summarize, low volatile coals can be burned with only minor revisions to operating parameters on most furnaces designed to utilize high volatile bituminous coals. High quality, low volatile coals provide for increases in boiler efficiency and pulverizer capacity. The two stipulations necessary for a successful test burn are; 1) determine the chemical characteristics in addition to the HHV of the volatile content, fusion temperatures, Btu content and ash content, 2) develop a safety assurance program prior to beginning the test burn. A safety program could include (but would not be limited to) oil and/or gas flame support, furnace T.V. cameras, flame scanners and a unit specific revised operating procedure detailing the important differences in firing with a low volatile coal.

REFERENCES

1. Afonso, R.F. and Molino, N. M. "Compliance Coal and Low Volatile Coal Testing at New England Power, EPRI Conference on Effects of Coal Quality on Power Plant, St. Louis, MO, September 1990.

2. Rohrer, W. M. et al, Compliance Strategy and Coal Performance of a Low Volatile Coal in Homer City Unit 3, American Power Conference Proceedings 1987.

3. The Babcock and Wilcox Company, "Steam, Its Generation and Use" 38th Ed. 1975.

TABLE I LOW VOLATILE COAL CHARATERISTICS

SEAM STATE	UPPER FREEPORT WEST VIRGINIA	POCAHONTAS #3 VIRGINIA
Moisture	7.0	5.0
Ash	10.0	5.0
Volatile	18.0	18.0
Fixed Carbon	65.0	72.0
Sulfur	1.6	0.8
Btu/lb.	13,000	14,100
Grindability (HGI)	100	100
Fusion	2700°F	2300°F
T-250	2680°F	2400°F