THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

89-JPGC/FACT-2

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Improving Coal Quality Solves Problems for Power Plants

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ABSTRACT

The quality of coal utilized at a steam generation facility can impact the cost, performance and life expectancy of the boiler and associated equipment. Many areas of the steam plant can be affected by coal quality. Affected areas include coal handling equipment, all boiler equipment, pollution control devices and the ash disposal equipment. This paper documents how specific coal quality improvements solved operating problems for several plants. I will detail one industrial and two utility plant experiences, specifically referencing their particular problem areas, what properties of the coal influenced each plant and the resultant coal quality solution.

A determination as to the cost effectiveness of improving fuel quality must be made for each situation. It may be useful to use computerized coal quality impact models for initial screening or to estimate capacity limitations or maintenance cost. (1,2,3) Well documented test burns can also be used to quantify the behavior of different coal qualities on plant operation.

CASE 1. STOKER-FIRED INDUSTRIAL STEAM PLANT

The steam plant at this site was a refurbished electric utility plant with several Detroit Rotograte stoker-fired boilers. The plant's design fuel was unknown. The coal being fired was of local origin and partially washed with the characteristics shown in Table 1.

The plant was experiencing coal handling problems due to coal plugging the chutes and bins. Slagging of the screen tubes and grates caused capacity restrictions due to the slagging and low heating value of the fuel.

The handling problems were due to excess surface moisture, fine coal and clay minerals not removed during the cleaning process. These factors, coupled with the old handling system, caused frequent bunkering delays and capacity limitations due to coal feeder pluggages. A sized, fully washed stoker coal could eliminate these problems. The coal size was controlled by double screening to remove oversized and fine coal. Screen sizes were 1-1/4 and 1/4 inches. The resultant coal had a maximum of 10% less than 1/4 inch. In addition to minimizing the fines, the handling was improved by using a fully washed coal. The coal was washed using heavy media cyclones and discarding the minus 100 mesh material. Using this technology, clay binding type materials are removed.

The slagging problems were also brought under control by using higher quality coal. Analysis of this coal is also shown in Table 1. Again, the problem was caused by several factors. These were the slagging potential, or fusion temperature of the ash, and the ash loading. Although the "as received" sulfur content of the coals was similar, there was a difference in the amount of pyritic sulfur on a dry coal basis (1.7% vs. 1.0%). The mineral pyrite (chemically iron disulfide (FeS_2)) provides iron in the ash. Iron is an effective fluxing agent for the ash in the reducing atmosphere found on the grate. This explains the lower fusion temperatures found in the partially washed coal. In addition to the lower fusion temperatures, the partially washed coal has 50% more ash when expressed in pounds of ash per million Btu. This calculation is simple to perform and is more representative of what the boiler experiences in terms of ash loading.

Presented at the Joint ASME/IEEE Power Generation Conference
Dallas, Texas—October 22-26, 1989

Table I

Analysis of previously burned, partially washed coal and fully washed coal presently used in Case 1 steam plant.

As Received Basis	Partially Washed	Fully Washed
Moisture	18-22	7.0
Ash	9.0	7.3
Sulfur	2.6	2.6
Btu/lb	10,400	12,700
Size	2x0 CROM	1 1/4 x 1/4
Fines	15-20% < 1/4"	10-15% < 1/4"
Fusion Temperature	2000°	2250°

By solving the handling and slagging problems on this unit, the fuel related capacity restrictions were eliminated. This raised the availability of both the steam plant and the associated processing equipment. The availability and efficiency increases, due both to coal quality and more consistent boiler operation, offset the higher price of the fully washed coal.

CASE 2: PULVERIZED COAL FIRED UTILITY PLANT

This utility plant was originally designed for Illinois Basin coal and was converted to low sulfur fuel in the late 1970's. During the 1970's and most of the 1980's, the plant burned a variety of western fuels. Problems were incurred such as spontaneous combustion, lack of wall slag (high fusion coal), fouling due to calcium sulfate (4) and opacity excursions due to high fly ash resistivity. A switch to Central Appalachian coal occurred briefly, along with problems associated with grindability and coal reactivity. The cost of western Powder River Basin (PRB) coal dropped significantly a couple of years ago due to increased coal supply and competition between railroads transporting the coal. The quality of this PRB coal is shown in Table II along with an eastern bituminous and a blend of the two.

The utility decided to use the PRB coal at this station because of the low delivered cost. Unfortunately, the low heating value caused unit load restrictions. Additionally, western coal with high ash calcium levels had caused fouling problems in the past. The spontaneous combustion problems had been solved using coal pile compaction techniques and the high fly ash resistivity was lowered using sulfur trioxide (SO_3) flue gas conditioning.

The plant has a coal handling system which allows them to accurately blend coals from the coal yard. A steadily increasing blend of the western PRB coal with Central Appalachian eastern coal was tested. The present blend is approximately 75% western with 25% eastern fuel. The small amount of eastern coal, although more expensive, is used to increase the heating value to maintain full load and to reduce the fouling potential of the western coal.

Another nearby utility is also taking advantage of a similar blending program using a high quality metallurgical coal as an "octane booster" for the Powder River Basin coal in cyclone units.

Table II

Analysis of Western, Eastern and Blend Coals for Case 2.

	Western	Eastern	75/25 Western/Eastern
Moisture	20.0	8.0	17.0
Ash	6.0	8.0	6.5
Sulfur	0.4	0.7	0.5
Btu/lb	8,800	12,500	9,725

CASE 3. CYCLONE-FIRED UTILITY BOILER

There were many Babcock and Wilcox cyclone-fired boilers built in the midwest designed to burn local high sulfur coals. The high sulfur coals have low ash fusion or, more appropriately, low viscosity slags. As the laws changed concerning sulfur emissions, the owners of the Case 3 unit knew they would be forced to utilize low sulfur coal. No significant boiler changes were made, however, a hot-side electrostatic precipitator (ESP) was installed to limit the high resistivity effects of low sulfur coals on cold-side ESP's.

The availability of low sulfur/low fusion coal is limited in the U.S. This is due to the pyrite-iron relationship described earlier. As the sulfur content of most midwestern and eastern coals decrease, so does the pyrite and the iron in the ash. Hence, most eastern low sulfur coals are high fusion with corresponding high slag viscosities. The western coals are an exception to this rule because they have higher levels of calcium and magnesium in the ash. This calcium and magnesium acts as a flux similar to the iron in eastern coals. This enables the western low sulfur fuels to perform satisfactorily in cyclone-fired units.

The Case 3 unit has a hot-side ESP installed to accommodate the high resistivity of the low sulfur coals. Theoretically, at higher temperatures (600-800°F) the resistivity of fly ash is not controlled by sulfur content or surface conductivity, but by volume conductivity. (5) If the fly ash consists of a glassy matrix, then small ions such as sodium and lithium can migrate through the particle causing it to be conductive. This theory works on eastern type coals where the fly ash is a silica based glassy matrix. Unfortunately, the higher calcium levels in the western coals that form the low viscosity slags, do not form glassy type fly ash. As a result, the Case 3 unit had excessive particulate emissions due, in part, to high fly ash resistivity.

The fuel that seemed to fit this unit's particular needs would be a low sulfur, low fusion coal with eastern type ash. There is an extremely high quality metallurgical coal that met this criteria. The analyses of this coal and the typical western coal is shown in Table III. The low fusion requirement was met by washing the coal so thoroughly that the iron level was increased by removing a large portion of the silica based clays and shales that were diluting it.

There were some concerns in utilizing the high quality fuel. It is ranked as a low volatile bituminous and is less reactive compared to the high sulfur bituminous or western sub-bituminous coals. This lower reactivity is offset by the high combustion temperature and turbulence associated with cyclones. With the low ash levels there was a concern about obtaining a sufficient slag coating in the cyclones. This was not the case due to the iron content in the slag. The final concern was handling. Low volatile coals generally have high Hardgrove Grindability Indices (HGI). This particular coal has an HGI of 100. The high HGI tends to allow the coal to break down in particle size. Small sized coal, when wet, can plug chutes and, when dry, can produce fugitive dust. It is the small size that allows the coal company to wash the extraneous ash out to produce such high quality coal. If the coal fines are thermally dried, the pluggages can be reduced or eliminated.

Table III

Analysis of Western and High Quality Eastern Coals Used in Case 3.

	Western	High Quality
Moisture	12.0	5.0
Ash	6.0	5.0
Volatile	33.0	18.0
Sulfur	0.6	0.8
Btu/lb	11,000	14,200
Carbon	60.0	82.0
Hydrogen	5.3	4.1
Silica	32.0	41.0
Alumina	13.0	27.0
Iron	7.0	14.0
Calcium	22.0	7.0
B/A	0.8	0.35
T-250	2180	2450
Resistivity @ 700°F	8.2 E+09	2.6 E+08
HGI	50	100

The results of using the high quality coal over the long term were quantified. Several advantages were noticed. The hot-side ESP's performed well and particulate emission tests were passed. This was due to lower resistivity a result of the glassy type ash and lower ash loading to the precipitator. The boiler efficiency and corresponding heat rate improved two to three percent due to lower moisture in the flue gas. This is a combined effect of lower moisture and lower hydrogen in the coal.

In some cases, the use of higher quality coal can not be justified due to cost or other external reasons. The Case 3 unit does not regularly use the higher quality coal. Instead it uses the western coal due to overall company cost savings.

CONCLUSIONS

In conclusion, the use of higher quality coal can solve many operational, equipment limitation, maintenance and availability problems. The cost must be justified and evaluations performed to quantify the cost saving. This paper outlines several specific examples in an effort to promote the use of coal quality impact models, test burns and coal cleaning technology.

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