Technical Publication

ATRITA Pulverizer System Upgrade for PRB Coal Conversion

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ATRITA PULVERIZER SYSTEM UPGRADE FOR PRB COAL CONVERSION

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ABSTRACT

Driven by fuel availability, economics or emission compliance considerations, the amount of PRB coal fired in the U.S. power plants has been increasing considerably over the past decade. However, in most cases, it is a challenge for the power plants to convert to PRB coal if the existing boiler and fuel handling system were originally designed to fire higher quality bituminous coal. Not only will firing PRB coal increase slagging and fouling in the boiler, it will also require an increase in mill system capacity and primary air flow and / or temperature to enable proper drying since PRB coal typically has high moisture content and relatively low HHV.

This paper presents an upgrade implemented on the Atrita pulverizer system at James River Power Plant of City Utilities of Springfield to accommodate a desire to fire 100% PRB coal. Discussion will focus on mill system design considerations exclusively for PRB coal application, operational results of the upgraded mill system and the latest mill design improvement for better coal fineness, improved emissions and lower fly ash unburned carbon.

INTRODUCTION

The interest by utilities to convert from bituminous to sub bituminous coal firing has increased significantly in recent years because of environmental and economic advantages. Not only does this impact the boiler design and operation, it has a significant impact on fuel burning systems especially the coal pulverizer. This paper discusses the engineering analysis and actual implementation of a coal pulverizer upgrade at City Utilities of Springfield, James River Power Station in order to burn 100% PRB coal.

The original project goal was to be able to burn 100% PRB coal, instead of the current PRB / Bituminous coal blend, while maintaining full load capability. This goal was driven by both economic and environmental considerations. Alternatives for modifying the existing milling system were evaluated, but none allowed for full load operation on 100% PRB coal. Therefore, the decision to replace the existing mills was made.

At the time of the original project inception, James River Power Station had no method for selling of flyash. Therefore, fineness requirements on the new milling system where only driven by efficiency considerations, not potential flyash sales. After startup of the Atrita mill retrofit, a new system which provided the ability for flyash sales was commissioned. At that time, an effort was made to improve flyash quality on all units at James River Power Station. Riley Power, a Babcockpower Inc., Company, was then contacted for any methods to improve coal fineness to the point at which the flyash was able to be sold, instead of landfilled. During this effort, the DynaRing™ Classifier modifications to the 558S mills commenced.

Atrita Pulverizer Design

The Atrita mill is an attrition type, high speed and compact designed pulverizer. For over 70 years, the Atrita mill has been used for coal firing boilers to pulverize a wide range of fuels including eastern and mid-western bituminous coals, sub-bituminous coals, lignite and delayed coke. There are over 1000 Atrita pulverizers currently in operation at utility and industrial boilers in the US. As shown in Figure 1, the Atrita mill can be divided into three (3) sections: crusher dryer, pulverizing and fan section. Both single and duplex Atrita pulverizers can be supplied.

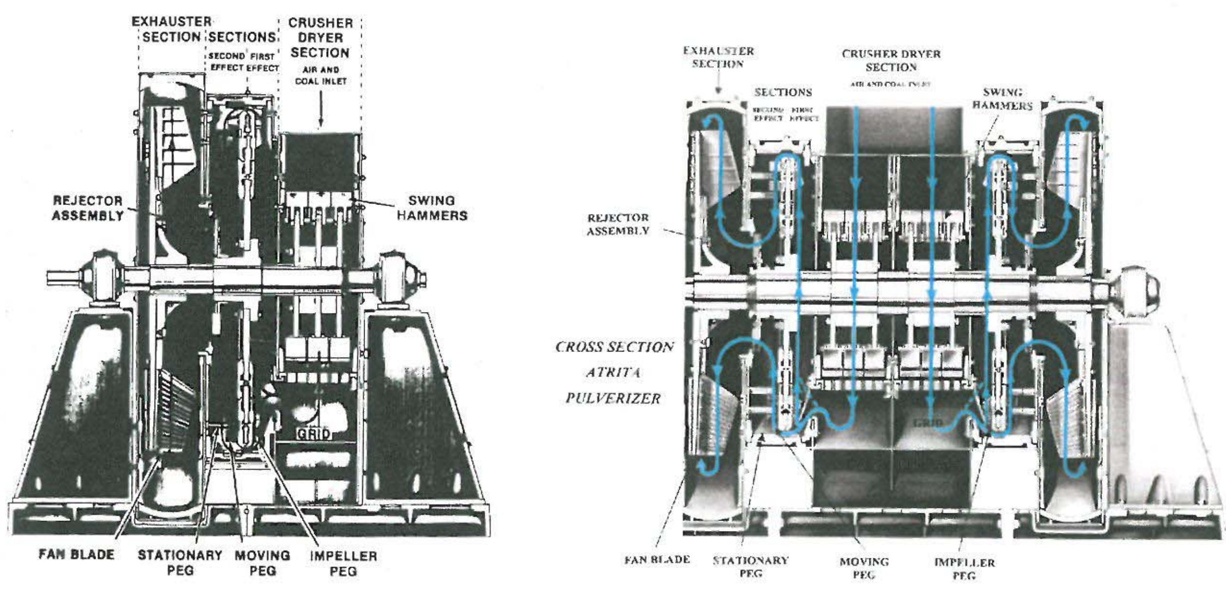

Figure 1. RPI Atrita Pulverizer Design.

Raw coal is fed from a feeder, mixed with hot primary air, and introduced into the crusher-dryer section. In the crusher dryer section, swing hammers impact the raw coal on breaker plates, adjustable crusher blocks and grids reducing the raw coal to a nominal 1/4" size. The crusher-dryer also acts as a flash dryer, through which the effect of surface moisture on capacity, power consumption, and fineness is minimized. The resultant decrease temperature in primary air lowers the risk of a fire in the mill. The pulverizing section is a two-staged chamber that further reduces coal size by attrition (impact of coal on coal, and coal on moving and stationary parts). There is no metal-to-metal contact of pulverizing elements. Conventionally, a rejector located between the pulverizing and fan sections controls pulverized coal fineness. V-shaped rejector arms at high rotating speed generate a centrifugal field to retain coarse particles in the pulverizing zone for further size reduction, while the qualified fine particles are extracted into the fan section through mill throat and discharged from the mill to the burners. An integral fan wheel with adjustable fan blades, mounted on the mill shaft in the fan section acts as primary air fan to transport the pulverized coal from the mill through the coal pipes to the burners.

Fuel System Evaluation

CUS James River Unit 4 is a single-drum boiler type designed and installed by Riley Power Inc., (RPI) in the 1960's. The maximum continuous rating (MCR) of the boiler is 450,000-pph-steam flow at 1525 psi and 1005 F. A peak capacity of 495,000 pph steam flow is limited to 4 hours continuous operation. The boiler was originally designed to burn 100% bituminous coal, 100% natural gas, or any combination of bituminous coal and natural gas. The furnace was later converted to balanced draft operation from its original pressurized design. The fuel firing system was upgraded in 1996 with six (6) low NO_x CCV Riley Power Burners installed in two rows of three each in a common windbox on the furnace front wall. The original pulverizer system consisted of three (3) Atrita 550S mills and three (3) 18" RPI drum-type coal feeders.

When converting to PRB coal, the required mill coal flow rate for full load increased by 33% due to the relatively low heating value of PRB coal. In addition, the high moisture content in PRB coal resulted in a mill grinding capacity reduction by 17%. Both lower heating value and higher moisture content required the mill system grinding capacity to increase by nearly 50% when firing PRB coal. Therefore, three (3) Atrita 556S mills were proposed to replace the existing Atrita 550S mills for the PRB coal conversion requirement.

The fuel characteristics of PRB coal and original mill system design coal are listed as follows.

Fuel	Moist, %	V.M., %	F.C., %	Ash, %	HHV, Btu/lb	HGI	Coal Type
PRB coal	27.16	32.06	36.31	4.47	8822	51	Sub Bit
Original Design Coal	7.26	33.76	46.16	12.82	11743	50	Bit

A comprehensive engineering study for increasing mill system drying and grinding capacity for the fuel firing system was conducted to determine the necessary modifications. The study included mill system testing to evaluate the capability of the other equipment associated with the Atrita milling system.

The study found that the existing mill system has insufficient PA temperature for coal drying when firing PRB coal. This deficiency results in the need for additional primary airflow or higher A/C ratio in the milling process. Compared with other types of mills, an A/C ratio is the more important operating parameter for Atrita mills. Although it will decrease the PA temperature requirement, the higher A/C ratio or PA flow will reduce residence time of coal and dilute the coal particle concentration and subsequent attrition process within the grinding zone in the mill, which will deteriorate coal fineness since the Atrita mill is an attrition type mill. Diluting the particle concentration will result in less particle-to-particle interaction and less size reduction due to dilution. For A/C ratios from 1.35 to 1.60, the expected moisture to be evaporated will be between 10% and 14%, depending on the available PA temperature, as shown in Figure 2. A PA temperature of 600°F or higher is desired to achieve optimum mill performance for PRB coal. The existing air heaters, at James River Power Plant, however, were unable to provide hot air with sufficiently high temperature for the desired drying requirement when firing PRB coal.

The study also indicated that the existing coal pipe, PA duct and burner nozzle were undersized following installation of the larger capacity Atrita 556S mills due to increased coal and PA flow. It was therefore recommended to upgrade the existing 12" diameter coal pipe (riffles to burners) and 18" diameter coal pipe (between mill outlets and riffles) to 14" and 20" diameter pipes, respectively. The burner nozzle size should increase from 14" to 15" diameter. If the desired PA temperatures are not economically feasible, the PA temperature should be increased by replacing the tempering air damper with a new damper designed for near zero leakage in the closed position. In addition, the installation of more efficient air heater baskets should be considered when refurnishing the air heater.

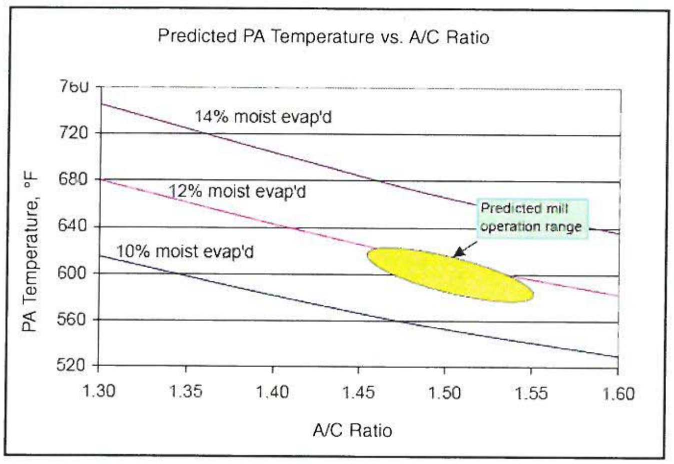

Figure 2. Predicted PA Temperature for Various A/C Ratios and Coal Moisture Content.

Due to budget constraints, CUS was unable to completely upgrade the milling system as RPI had proposed. All modifications were implemented except for enlarging the coal piping or increasing PA temperature. Therefore, RPI's scope of supply was limited to the following equipment:

* Three (3) No. 556S Atrita mills complete with crusher-dryer, pulverizing and fan sections in one combined shop-assembled package. Each mill was complete with a tramp iron chute, shaft coupling and bearing lubrication and cooling system

* Three (3) coal/air inlet ducts

* Three (3) coal discharge transition sections

* Three (3) coal pipe spool sections

* The design of new mill foundations

The milling system upgrades were performed over a 6-week outage duration while commissioning lasted about 2 weeks. Figure 3 shows the equipment furnished except for the larger coal piping.

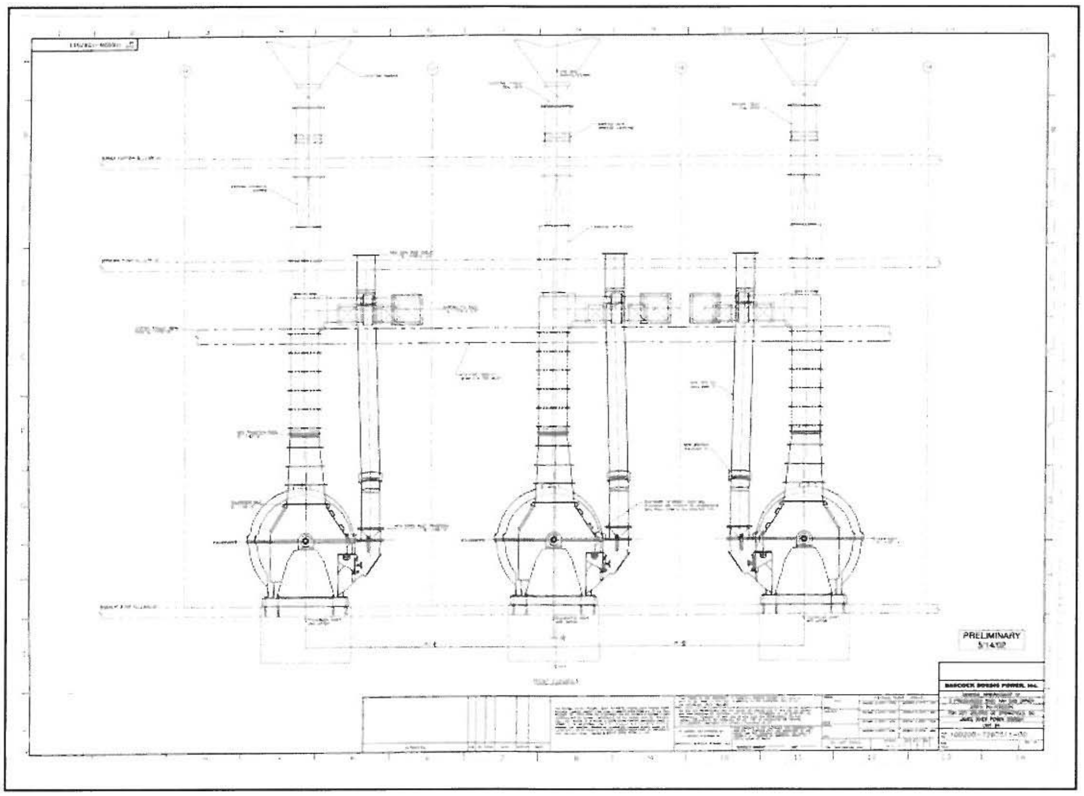

Figure 3. Atrita Mill System Upgrades Installed for CUS James River Power Station.

Other recommended mill system equipment upgrades were implanted by CUS.

A new mill primary airflow and A/C ratio characterization was developed based on reusing the existing coal piping and having limited PA temperature available. This is shown in Figure 4.

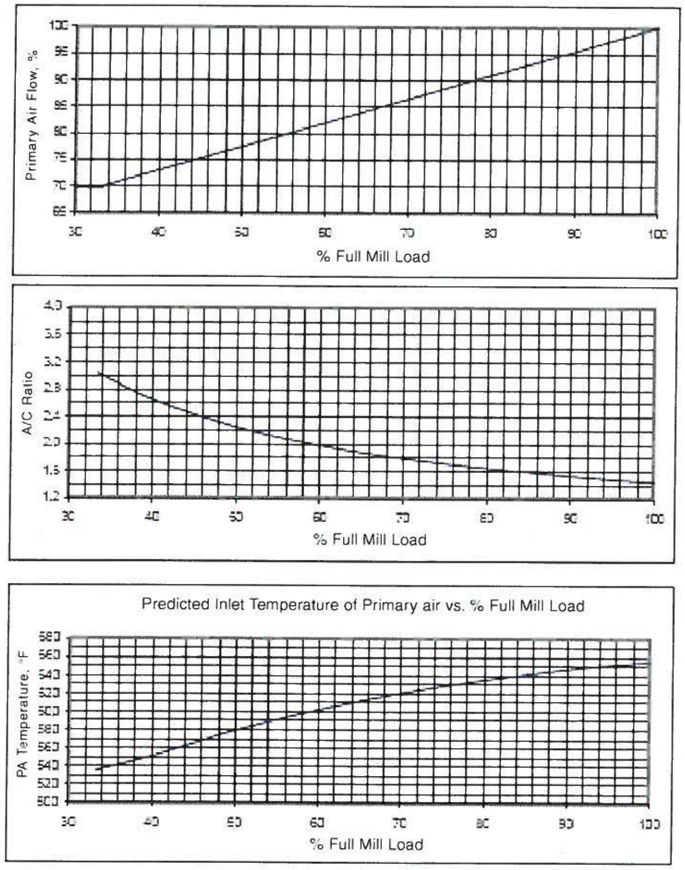

Figure 4. PA Flow, A/C Ratio and PA Temperature Characterization Requirement for James River Power Station.

Initial Post Retrofit Results

Post retrofit testing was then conducted without the benefit of larger coal piping and with the PA temperature limited to 560°F. Coal fineness results from full load testing produced 97%+ passing 50 mesh which was equal to that predicted but the % passing 200 mesh was <65% or lower that predicted. In order to increase this level of fineness an additional row of grinding clips and pegs was added to the Atrita, which further upgraded the design from 556S to 558S.

This upgrade improved the % passing 50 mesh an additional 1% but improvement on 200 mesh was not evident. Furthermore, two (2) of the three (3) Atritas were also retrofitted with a new classifier recently developed by RPI for better performance. A description of the new DynaRing Classifier (DRC) and final post retrofit results follows.

DynaRing™ Classifier and Final Post Retrofit Results

To further improve coal fineness on the Atrita pulverizer, RPI developed a dynamic classifier to replace the original rejecter arms. This new classifier is referred to as the DynaRing™ Classifier and is shown in Figure 5. (Reference 1)

Figure 5. DynaRing™ Classifier.

The original rejector arm assembly was installed on the Atrita between the grinding section and fan section to control pulverized coal fineness. The rejector arm assembly is comprised of an axially adjustable hub, V-shaped arms with attached guards, and a stationary rejector ring. In the grinding process, the V-shaped rejector arms, rotating with the pulverizer rotor, function as a classifier to retain coarse coal particles in the grinding zone for additional pulverization, while finer coal particles, transported by primary air, pass through the rejector arms into the fan section. It was essential to set a tight clearance between the side surfaces of the rejector ring and the side end of the rejector arms to achieve design performance for coal fineness control. However, this tight clearance requirement had been difficult to obtain or maintain due to material wear and dimensional variation. This resulted in less than desirable classification in the pulverizing process by failure to prevent coarse particles from "leaking" through the gap between the rejector arms and rejector ring.

With the DynaRing™ classifier design, this tight seal requirement is no longer required since a labyrinth seal is established with an aerodynamic seal feature to prevent coarse coal particles from "leaking" through the seal gap. In this new seal design, a solid continuous ring made from segments is added in between the rejector ring and rejector arms. The rejector arms connected to the main shaft rotate this added "dynamic ring". Thus, the end surfaces of the dynamic ring and rejector ring form a continuous seal gap between the rotating and stationary parts.

In addition, the rejector arms of the DynaRing™ classifier are redesigned to improve classification capability by enhancing the centrifugal field in the grinding section.

The 558S Atrita mill at James River Power Station was retrofitted with the new DynaRing™ Classifier. Post retrofit results showed a significant improvement in coal fineness for both % passing 50 and 200 mesh sieve sizes. Figure 6 shows the improvement in coal fineness comparing the original 550S Atrita with older style rejector arm classifier to the newer 558S Atrita with new DynaRing™ Classifier. The impact of such an improvement in coal fineness is that the correction factor used for pulverizer capacity evaluation is greatly minimized for Atrita mills equipped with DynaRing™ Classifiers. This is demonstrated in Figure 7.

At the James River Power Station, only two (2) of three (3) Atritas have been retrofitted with the DRC. The improved fineness has reduced flyash LOI from >5% to <1%, as shown in Figure 8. The third mill is planned to be retrofitted with a DynaRing classifier during the scheduled outage in Spring 2007. This will provide continued flyash quality improvement.

The DynaRing™ Classifiers also allowed for operation at higher A/C ratios, while maintaining the desired coal fineness. This allowed for improved mill system operation with wet coals. Prior to the DynaRing classifiers, coal fineness greatly deteriorated during periods of wet coal operation. With the DynaRing classifiers, and the higher A/C ratio, the milling system is able to run wet coal, while still maintaining acceptable fineness results.

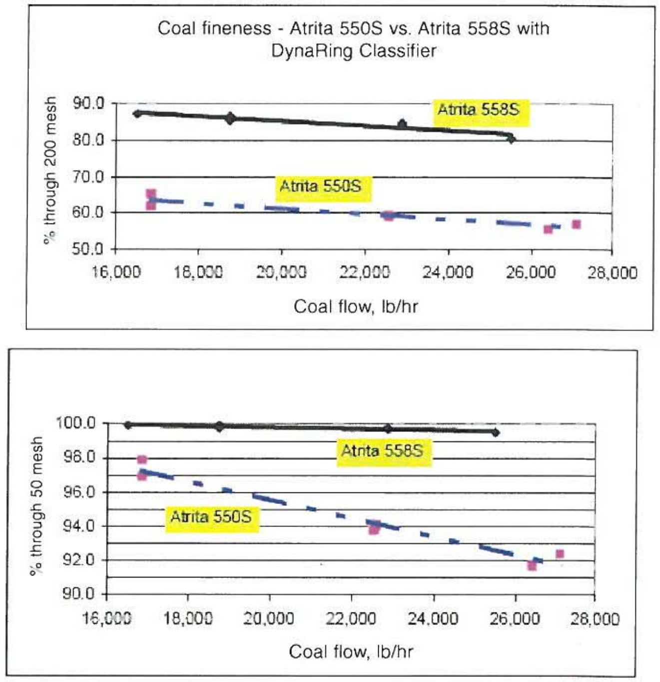

Figure 6. Coal Fineness Results Comparing Original Atrita 550 S with New Atrita 558 S Equipped with DRC at James River Power Station.

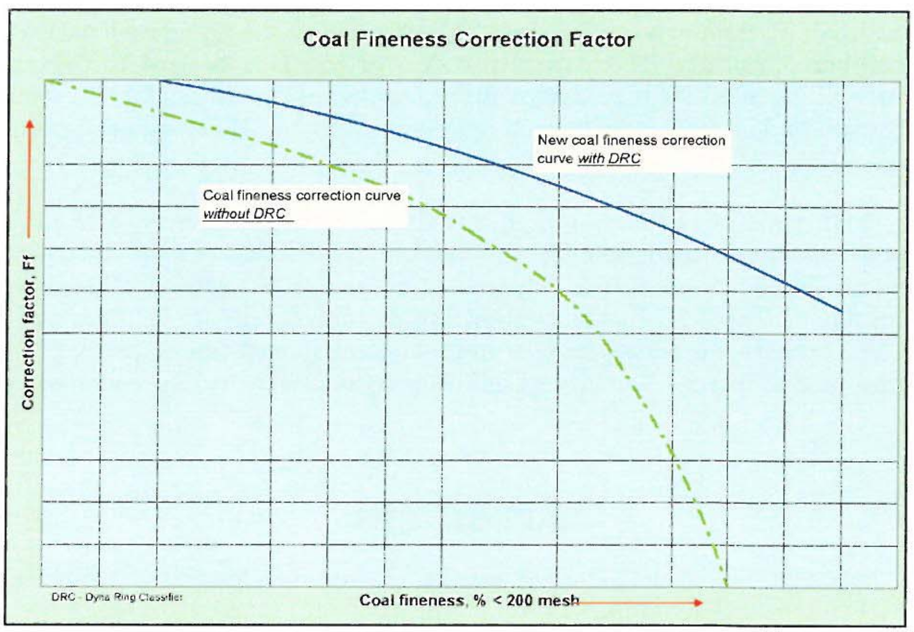

Figure 7. Impact of DynaRing™ Classifier on Atrita Mill Capacity Correction Factor.

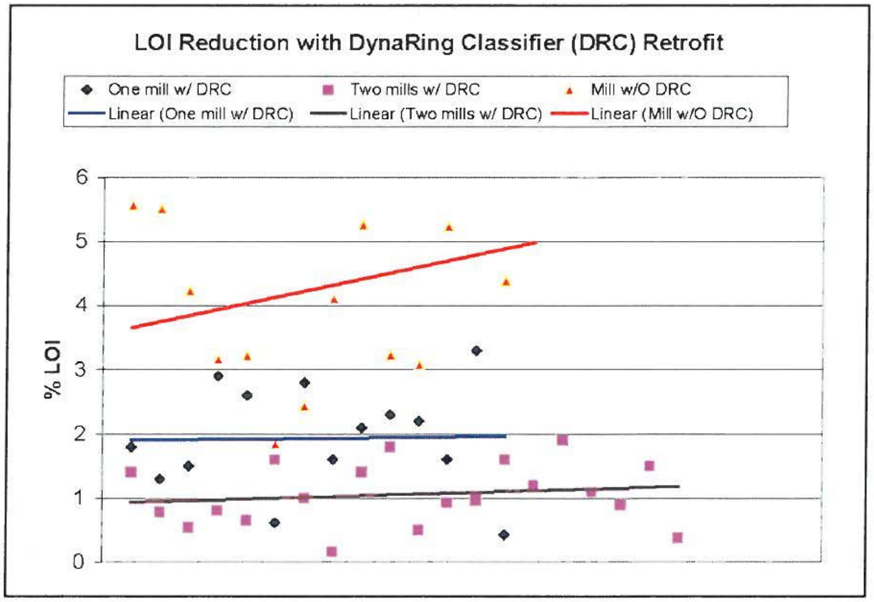

Figure 8. The Impact of the DynaRing™ Classifier on Flyash LOI.

SUMMARY

PRB coal conversions can have a significant impact on pulverizer system capacity. Coal flow capacity requirements can increase up to 50% because of reduced heating value and higher moisture content than typically experienced with higher quality bituminous coal. In addition, other mill system equipment such as coal pipe size, PA ductwork size and coal feeder capacity may also be affected when converting to PRB coal. Particularly, mill system drying capacity should be reviewed when analyzing a PRB coal conversion. Typically, PA temperature of over 600°F is desired to prevent insufficient drying during the milling process. Insufficient drying will cause additional mill capacity reduction due to poor dispersion and/or agglomeration. In some cases, poor mill drying performance will result in mill pluggage.

When processing high moisture PRB coal, higher A/C ratio is typically needed to provide sufficient drying performance. However, the higher A/C ratio and higher PA flow can also adversely impact coal fineness performance from an Atrita mill. The recent development of the DRC has provided a good solution to this problem. The DRC has been shown to provide excellent coal fineness even with the high A/C ratio. The operational benefit of this improvement in coal fineness has been lower flyash UBC, and the continued ability for a utility to sell their flyash following the conversion to PRB coal.

REFERENCES

1. Lin, Q., Penterson, C., "Coal Pulverizer Design Upgrades to Meet the Demands of Low NO_x Burners", Presented at Combined Power Plant Air Pollutant Control Mega Symposium, Washington, DC, 200