Harvesting "Low Lying Fruit": Enhancing Pulverizer & Unit Performance

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Abstract

In an industry altered by deregulation and competition, it is increasingly more important to manage equipment availability, reliability and efficiencies while capital and maintenance budgets are evaporating. This includes managing slagging and waterwall corrosion within coal fired furnaces and getting the greatest benefits from auxiliary power requirements. This was a recent task on a Riley Power designed turbo furnace that was outfitted with three double ended ball tube mills. Each end of a mill supplies either a front or rear wall set of burners. Limited primary air fan static head has limited the ability to utilize external centrifugal mill classifiers and has produced relatively coarse coal particles. Changes to the setup of the classifiers and burner line orifices, used for flow balancing, have helped to improve coal fineness, reduce furnace slagging and corrosion potentials and improve combustion efficiencies without any additional loading on the primary air fans.

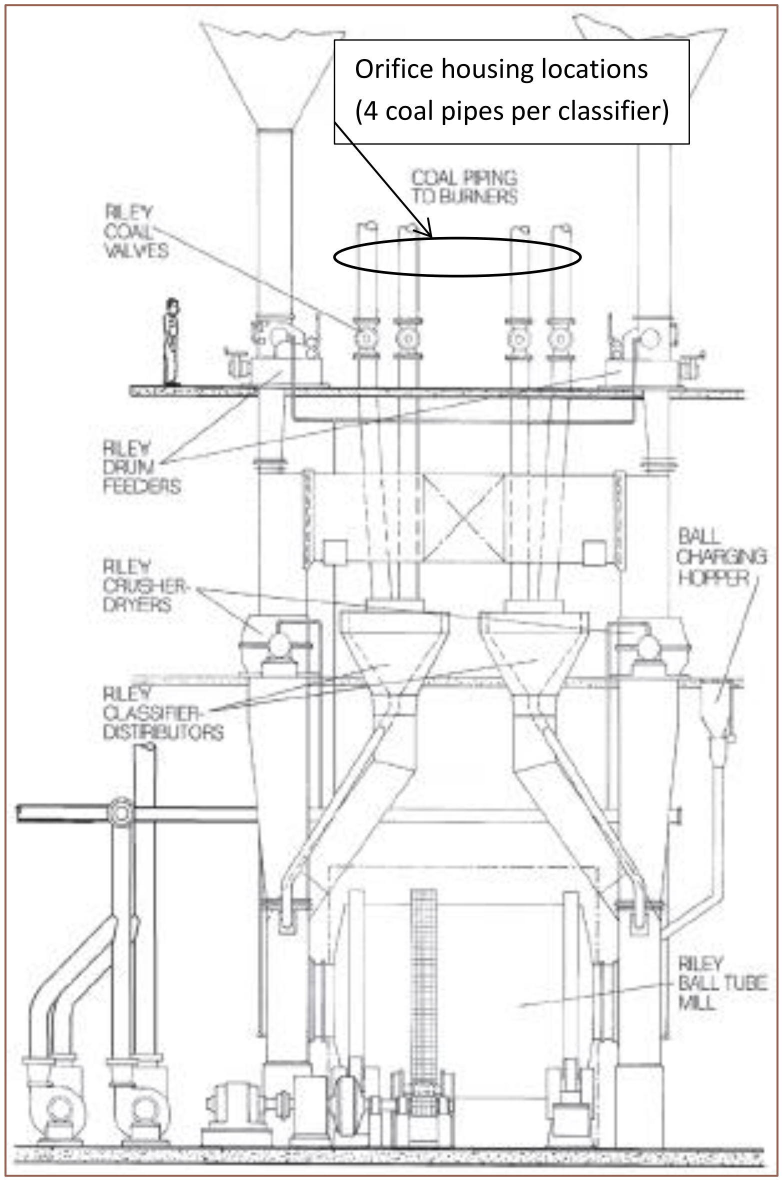

Figure 1: Typical mill layout. (Riley Power)

Overview

The power plant involved has two coal fired units. Both are Riley Power designed turbo furnaces, each fed by three double-ended ball tube mills, 13’ diameter x 16’ long barrels. The unit output is nominally 540 MWg each. The units burn bituminous coals from the Illinois Basin and utilize combustion staging for in-furnace NOx control.

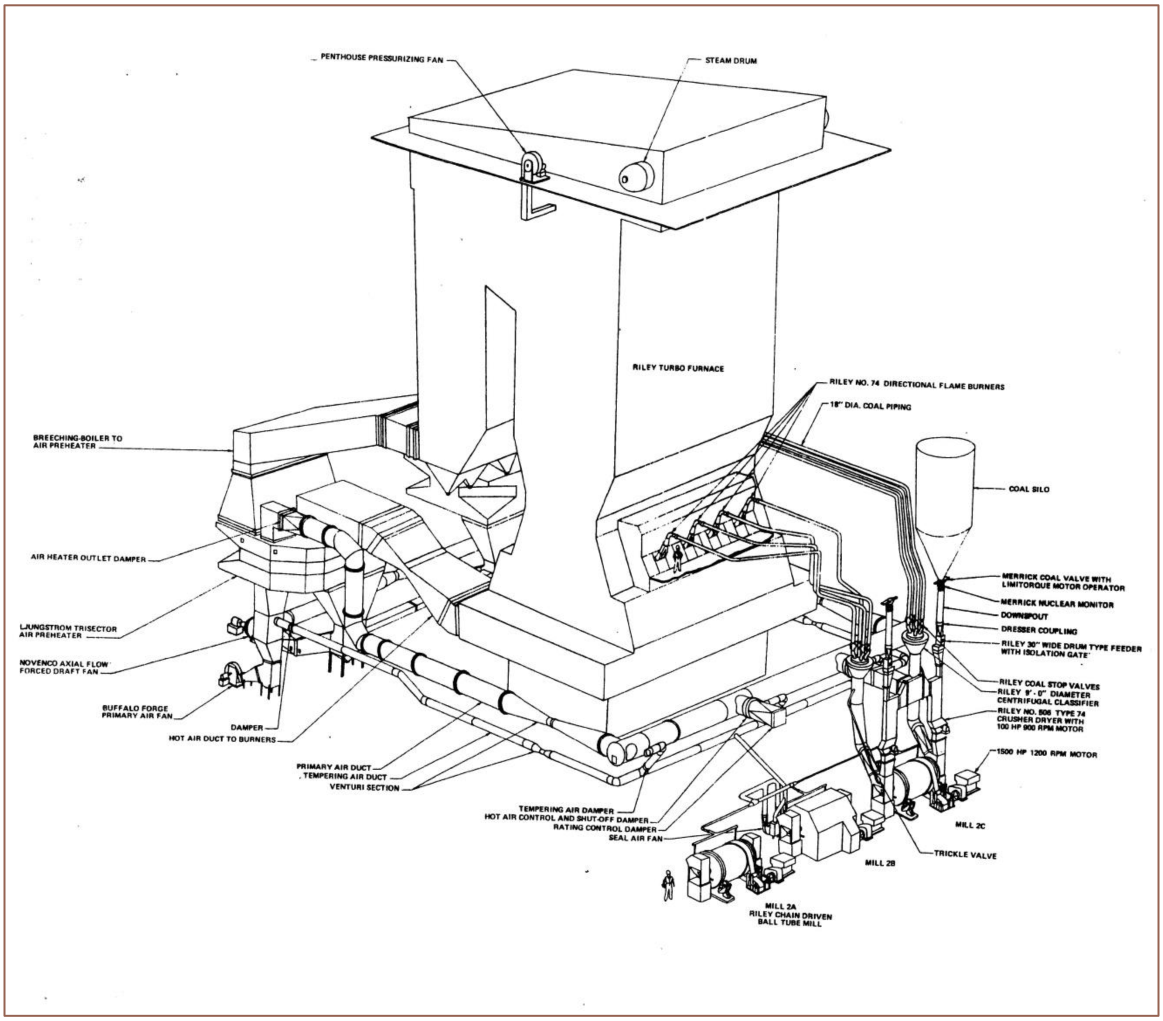

Figure 2: Unit layout. (Riley Power)

The two units have experienced waterwall corrosion associated with localized reducing atmospheres and periodically severe slagging in the pendant secondary superheater outlet platens.

Each of the ball-tube mills supply a total of eight burners, four on the front wall and four on the rear wall. As indicated in Figure 2, the mills are oriented along the front of each steam generator. Therefore, the front wall burner pipes generally have shorter lengths, fewer elbows and lower pneumatic transport losses. Orifice housings had been previously installed on each of the coal pipes, just downstream of the isolation coal valves. Fixed diameter orifices are installed in each of these housings with the intent of balancing the flows between all eight burners.

Originally, Riley incorporated their Model 70 centrifugal classifier with the units and mills. Because of primary air fan limitations, the classifier vanes on the classifiers were left in the most fully open position, producing coarser coal sizing. In an attempt to reduce pneumatic loses and gain fineness improvements, Riley supplied new larger Model 80 classifiers, reference Figure 3.

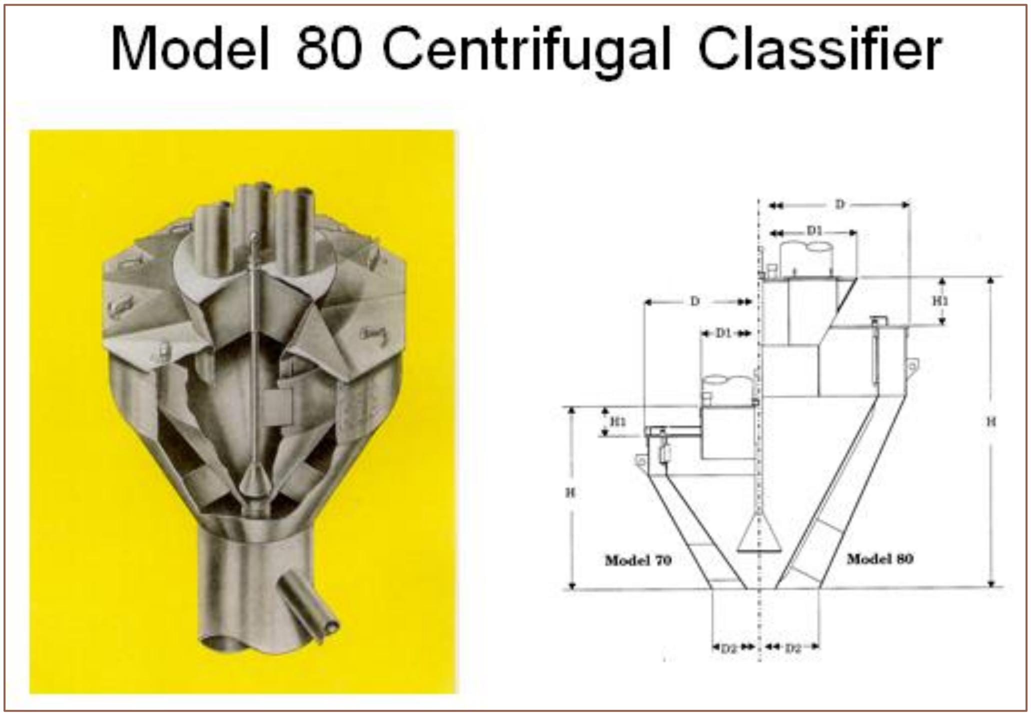

Figure 3: Comparison of Model 70 and 80 classifiers. (Riley Power)

Both classifier models had the ability to manually and externally set the vanes individually. There are eight positions with No. 1 being high spin and maximum classification and No. 8 being fully open and minimal classification. Unfortunately, the pneumatic loss improvements were insufficient with the Model 80 classifiers and the mills have continued operation with the classifier vanes in the most fully open No. 8 position.

The benefits to improving coal article fineness include:

1. Reduced on wall carbon deposition associated with coarse particles. When coal oxidizes on the furnace walls, it produces localized reducing environments and very high levels of corrosive constituents (e.g. H_2SO_4), particularly with the higher sulfur Illinois Basin coals.
2. Increased pulverized coal surface area to volume ratios producing a more rapid and complete burn. This reduces
    a. Deposition and slagging potentials in the pendant secondary superheater.
    b. Carbon in ash potentials.
    c. CO emissions.

Mill/Classifier Adjustments

SAVvy Engineering LLC was approached in June 2015 to address combustion and slagging issues. To date, all of this work effort has been performed on one of the two units. All previous attempts to improve coal fineness involved adjustments to both classifiers associated with a given mill simultaneously. Recognizing the primary air fan limitations and the need to maintain balanced burner line flows and velocities, SAVvy Engineering took a different approach.

To minimize overall draft loses; at least one of the rear wall burner lines should always have a full port, no flow restriction orifice. It was naturally noted that there were smaller, higher differential pressure orifices associated with the front wall classifiers. All of the front wall burner lines had restricting orifices that were fairly significant. The "as found" orifice settings for the front and rear wall burners (designated F# and R#, respectively) are listed in Table 1.

Table 1: As found burner line orifice sizes for balanced flows. Pipe ID is 17.25". All classifier vane settings were at No. 8 position.

2A Mill		2B Mill		2C Mill	
Pipe I.D.	Orifice ID, inches	Pipe I.D.	Orifice ID, inches	Pipe I.D.	Orifice ID, inches
R3	16.25	F1	14.75	F2	15.00
R6	17.00	F4	15.50	F5	16.00
R7	17.00	F9	15.50	F8	15.50
R10	17.25	F12	16.00	F11	15.75
F3	14.25	R1	15.25	R2	17.25
F6	14.25	R4	16.00	R5	17.25
F7	14.50	R9	17.25	R8	15.50
F10	16.00	R12	15.50	R11	15.00

On a mill basis, the front wall orifices were enlarged until at least one matched the pipe ID of 17.25 inches. Meanwhile, the flow balanced was maintained by converting the reductions in static loses from the orifices to uniformly added swirl in only the front wall classifier vanes. The resultant orifice and classifier vane settings are provided in Table 2.

Table 2: Settings after enlarging front wall orifices and adding classifier swirl.

2A Pulverizer		2B Pulverizer		2C Pulverizer	
Burner Pipe	Orifice ID	Burner Pipe	Orifice ID	Burner Pipe	Orifice ID
R3	No change	F1	16.00	F2	17.00
R6	No change	F4	16.00	F5	17.25
R7	No change	F9	17.25	F8	17.25
R10	No change	F12	17.25	F11	17.00
F3	16.50	R1	16.00	R2	No change
F6	16.75	R4	17.25	R5	No change
F7	16.75	R9	No change	R8	15.00
F10	17.25	R12	16.00	R11	No change
Classifier	Vane Setting	Classifier	Vane Setting	Classifier	Vane Setting
2A1 (rear)	8	2B1 (front)	4	2C1 (front)	5
2A2 (front)	4	2B2 (rear)	8	2C2 (rear)	8

During the 2015 testing[1], the adjustments were made on one mill at a time. Fineness testing was then repeated shortly thereafter. The prior mill settings were then restored before proceeding to the next mill. The short-term results and comparison to the baseline fineness produced average improvements of 0.9% in the 50-mesh fraction and 10.2% in the 200-mesh fraction for the front wall burners. In the short term, there was considerably less change in the rear wall classifier outlet fineness, from 0-0.5% improvement in the 50-mesh fraction and 0-5% improvement in the 200-mesh fraction. Again, no adjustments were made to the rear wall classifier vane settings. However, a few orifice adjustments were made to the rear wall burner lines to maintain overall flow balancing.

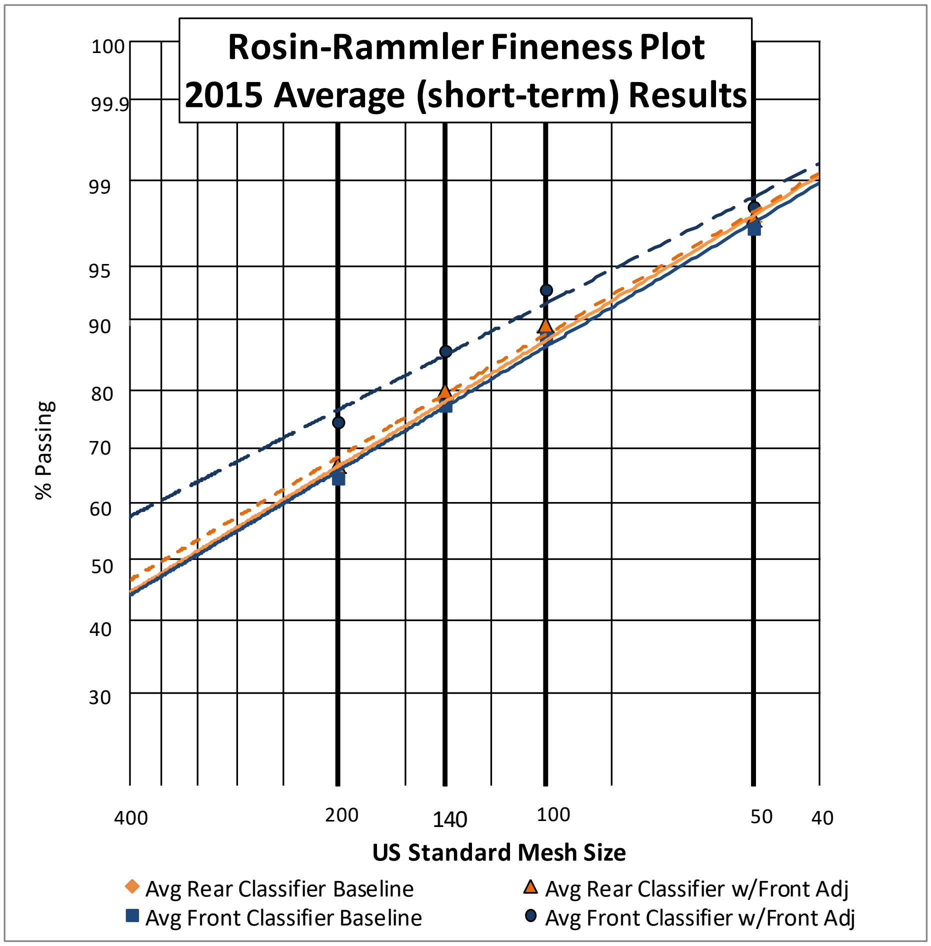

Figure 4: Average 2015 fineness test results before and after front wall classifier and orifice adjustments.

In July 2016, additional (full load) testing was performed. The setting adjustments were repeated on only the 2A mill. The baseline fineness with minimal classifier swirl, No. 8 setting,

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[1] Testing efforts in 2015 and 2016 involved additional combustion related efforts beyond the mill adjustments but which are not discussed here and did not impact the results presented here.

was first tested. The adjustments were then made to the front wall orifices and the front wall classifier vanes were moved to the No. 4 position, adding swirl. These adjustments were left in place for at least 24 hours. Three subsequent fineness tests were performed. The average fineness improvements for the 2A mill for the 50 and 200 mesh fractions are provided in Table 3. These fineness changes represent an increase of approximately 4-5% in the surface area to volume ratio of the pulverized coal.

With the longer-term operation, the fineness associated with the front wall experienced improvements reasonably consistent with the testing in 2015. The rear wall classifier fineness also saw improvements of about half of the magnitudes seen from the front wall classifier. This is believed to be attributed to the gradual improvement in the fineness of the coal charge in the pulverizer barrel due to the additional front wall classifier rejects.

Table 3: Average improvements in 2A mill fineness with added settling times.

	No. 8 Classifier Setting	No. 4 Classifier Setting (3 tests)	% Improvement	Total Average % Improvement
2A Front 50 mesh	98.91%	99.38%	0.47%	0.36%
2A Rear 50 mesh	99.30%	99.55%	0.25%	
2A Front 200 mesh	71.84%	80.63%	8.63%	6.18%
2A Rear 200 mesh	74.64%	78.36%	3.72%	

Measured Effects on Unit Operation

During the second round of testing in 2016, gas sampling at the economizer exit, ash samples at the electrostatic precipitator inlet and panel board data were also collected, corresponding with the adjustments to just one of the three mills, the 2A mill. Although additional repeat testing is warranted to confirm these results, there was a measured order of magnitude reduction in the CO emissions (down to an average 9 ppm, normalized to 3% O_2), and there was a 13% reduction in the NOx emissions. There was also a visible improvement in the ash color[2], suggesting a benefit in the carbon content, below the baseline 3%. Finally, there was also a notable improvement in the visible clarity in the furnace.

Instrumentation Modifications

The unit operators rely on the comparative measurements of the classifier discharge/turret to furnace differential pressures for each mill as an indication of front to rear wall flow balance and potential system pluggage. Changes in primarily the front wall orifices correspondingly change this differential pressure indication even though the front to rear wall flow balance was not was not altered. Therefore, calibration adjustments are warranted in the digital control system in order to equate the two classifier to furnace differentials after the orifice and classifier vane

[2] The ash sample with the 2A front wall classifier adjustments was misplaced. Thus, the corresponding carbon in ash results were not available from the station laboratory.

adjustments. These differential pressure indication calibrations have been developed for the 2A mill and successfully tested at multiple mill loading levels covering the normal full range of operation.

Summary

At the power station involved, we were able to make simple and minimal equipment adjustments at relatively insignificant cost to enhance unit operation and performance. Although these changes were only applied to one of three mills during unit testing, the results were measurably beneficial. The full-time application of these mill adjustments to all three mills are expected to provide further operational enhancements. Similarly, these changes will help mitigate slagging and waterwall corrosion.

Many plants have similar prospects to gain the benefits of low cost improvements, turning existing power investments into more productive results -- taking advantage of opportunities to harvest the "low lying fruits." The key is objectively challenging the historical practices.

Scott Vierstra, P.E. of **SAVvy Engineering LLC** is a 35 year veteran of the utility industry. SAVvy Engineering LLC offers engineering assistance and testing to power plants, other engineering entities and equipment suppliers towards enhancements in their operations, energy conversion and product development.