Research Paper

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A case Study on Performance of Bowl Mills

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ABSTRACT

Pulveriser performance optimization is the first step to a successful combustion optimization program and the inter-relationships of the pulverisers must be considered when attempting to optimize combustion, overall unit performance, operability, reliability, and capacity. Pulveriser capacity seems to be an industry challenge while many units today are undergoing drastic fuel changes. Considering there seems to be a huge disconnect when correlating mill performance with such issues as fuel line distribution, heat rate, NOX and environmental control equipment performance, it is the intent of this technical paper to provide better understanding of how mechanical optimization & tuning of the pulverisers can yield overall improved plant performance. Low NOX firing and/or optimization of the burner belt combustion with a limited amount of furnace residence time is absolutely essential to optimizing plant performance. For example, when pulveriser performance is poor, it is also often related to not only high furnace exit gas temperatures, increased slagging and/or high LOI, but also degrading electrostatic precipitator (ESP) performance from the coarse particle ash. Furthermore, reliability of the boiler (ie. tube leaks, fouling, and slagging) can also be impacted negatively by secondary combustion and consequent super heater and re-heater tube metals overheating and/or wall wastage often occurs from non-optimized fuel distribution being delivered from the pulverisers. The poor grinding leads to high specific coal consumption & high carbon losses through the bottom ash and fly ash. Whether the reason for improving mill performance is for the aforementioned items and/or perhaps simply to reduce power generation costs with improved fuels flexibility, the purpose of this case study is to review the basics of vertical spindle mill performance improvements. The data used to support this paper is from a compilation of actual field testing & tuning results.

INTRODUCTION

Contrary to the typical industry opinion that 75-80% passing 200 mesh coal fineness is not required for acceptable unit performance on a coal fired boiler. It is our experience that poor coal fineness often compounds issues such as high levels of carbon in ash, increased slagging, dry gas losses, and high de-super heater spray water flows. Over the past decade or so, it has been the experience that a common goal with nearly every successful coal fired optimization project was to first achieve optimum mill performance. Therefore, the purpose of this paper is to help further review this proven approach to vertical spindle mill optimization.

First of all, let's discuss why "great" coal fineness is better than the typical industry accepted "good" coal fineness.

The following indicates "as-found" fineness which indicates the large difference in micron sizing, which impacts the time for "carbon burn-out" due to the particle sizing as well as improving fuel distribution to each burner line with the improved fineness. As we can see, the variance from 60% passing 200mesh results in a mean particle size of about 30 microns vs. a preferable mean particle size of 45-50 microns.

Simply, optimum coal fineness and desirable portions of air & fuel to the burners is absolutely critical for acceptable combustion performance and control of emissions. As fineness increases, fuel balance improves. This is considering the more massive coarse coal particles have more momentum when entrained in air at a certain velocity and are more easily stratified than finer coal particles that have less mass, thus lower momentum.

After coarse and fine coal particles are separated, fuel and air balance is further aggravated by imbalances in airflow. Typically, burner lines that receive the largest quantity of coarse coal particles have the lowest dirty air velocities. Considering this and our experience basis, this is why clean air balancing to achieve equal resistance between fuel lines is critical. This is also why fuel line balancing attempts with adjustable orifices is very seldom repeatable. In addition, improved fuel distribution allows for more uniform burning in the furnace and equitably distributed oxygen across the furnace. Finely distributed 45-50 Micron coal exiting the coal nozzle contributes to a more symmetrical and defined flame shape. This repeatable distribution of fuel and air with a stable and symmetrical flame development combines with combustion air staging to combust the fuel with minimum NO_x formation and reduce and/or minimize slagging. Because of these previous reasons, we stand behind our recommendations for achieving the following pulveriser performance goals for vertical spindle coal pulverisers

PERFORMANCE REQUIREMENTS

Optimization of vertical spindle pulverisers is as follows:

- Fuel feed quality and size shall be consistent (< ¾" - 1" raw coal size).
- Fuel feed shall be measured and controlled as accurately as possible. Load cell, microprocessor equipped, gravimetric feeders are preferred.
- Primary airflow shall be accurately measured and controlled to ±3% accuracy.

Primary air to fuel ratio shall be accurately controlled when above minimum. Primary airflow, when optimized, reduces tempering airflows, which then improves the air heater "X" ratio and reduces dry gas loss. Primary airflow, whenreduced to optimum, also lowers NO_x by reducing the free oxygen into the fuel rich de-volatilization zone of the flames.The optimum primary airflows also reduce flame lengths on wall fired boilers and thereby reduce de super heating spray water flows and auxiliary steam consumption by the soot blowers.

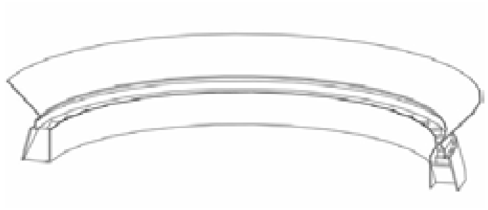
- Fuel line fineness shall be 75% or more passing a 200 mesh screen, and 50 mesh particles shall be less than 0.1% as measured with an isokinetic coal sampler and utilizing proper test connections within the vertical fuel piping.
- Fuel lines shall be balanced by "Clean Air" test to within 2% of average and measured by the two-team, dual traverse method. Re-orifice as required to achieve ±2% balance.
- Fuel lines shall be balanced by "Dirty Air" test to within 5% of average.
- Fuel lines shall be balanced in fuel flow to within 10% of average.
- Coal Rejects - Less then 10 % per hour.
- Pulveriser Power - With fuel changes to low HGI coals or operations with lower BTU coal(exceeding design capacity), mill motors are often undersized to achieve desirable performance.
- Fuel Line Temperature of 165 - 175°F with low volatile coal (may require synthetic lubricant if not already utilized); High volatile coals -150°F

Our experience has been that pulveriser performance optimization is the first step to combustion optimization. The “Essentials of Optimum Combustion” are typically about 70-80% pulveriser and fuel system delivery-related and the inter-relationships with total boiler performance must be considered when attempting to optimize combustion and/or plant efficiency.

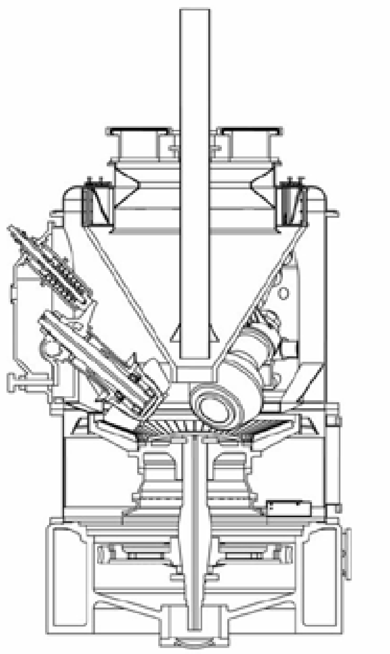
MECHANICAL TUNING STEPS

Obviously, to get results, mechanical tuning steps are required and the approach that STI suggests to achieve the performance goals on vertical spindle mills is as follows:

A. Install proper liners , grinders, rollers with proper material.



B. Regardless of whether the classifier is a static or dynamic design, it must be configured to insure optimum spin and classification is achieved without disruption and/or plugging.
C. Inverted cones, conical baffles, and other internal clearances and tolerances must be optimum while insuring that coarse product doesn’t short circuit the classifier and also insuring circulation disruption is not disturbed.
D. The cone should also be properly insulated by hardened metal ceramic.
E. Classifier cone surface and/or ceramics must also be smooth. We prefer smooth AR400 or greater classifier cones for minimal plugging and optimum circulation.



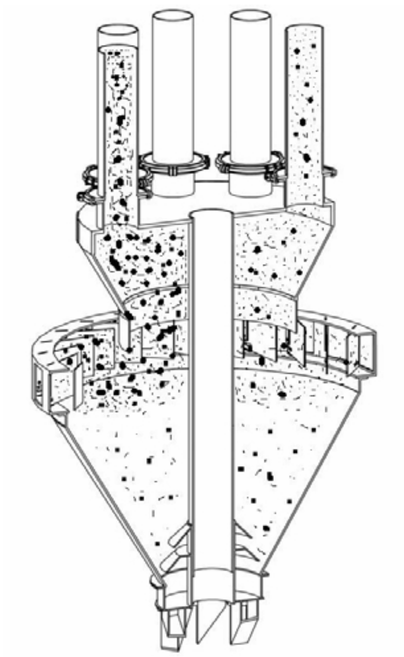
F. Improve primary airflow measurement accuracy must be within ±2-3% as measured by local pitot tube traverse. It is the experience that in order to attain long term & repeatable measurement, venturis or flow nozzles coupled with a high quality smart transmitter and instrument accessories is required.
G. Raw coal inlet sizing should be < 1”.
H. The classifier outlet swing valves must be fully operational. The DCS Logic needs to be optimized for opening & closing of these valves.
I. The grinding element spring tensions must be optimized for optimum pressure between the grinding elements to enhance “once through grinding” and also to prevent stress on the main shaft as associated with unequal pressure settings. Achieving optimum “once thru grinding” is often very important with lower capacity vertical spindle mills.
J. The spring tension of the rollers should be checked and maintained timely.
K. Coal feeder must be set with proper equipment specifications and programmed for confident +/- 1% accuracy of coal delivery.
L. The mill grinding elements must be in first class condition.

The balanced fuel flows are accomplished by balancing the fuel line resistances as the first step, and then applying a Comprehensive Approach to Pulveriser Performance Optimization. Once again, the coal fineness and desirable portions of air & fuel to the burners is absolutely critical for acceptable combustion performance and play a significant role in attaining desirable efficiency and emissions output. Also as previously noted, when fineness increases, fuel balance also improves. This is considering the more massive coarse coal particles have more momentum when entrained in air at a certain velocity and are more easily stratified than finer coal particles that have less mass, thus lower momentum.

Considering there are many tangentially fired units within the industry that are equipped with exhauster mills, it should be noted that with these pulverisers, fuel line balancing can be a bit more challenging. Regardless of whether the system has 1, 2 or 3 sets of riffles, the same principles apply towards fuel line balancing in regards to balancing system resistance and achieving optimum coal fineness. However, with these exhauster mills splatter plates, directional vanes and/or optimum riffle conditions/design are often required to achieve ±10% fuel balance.

SYSTEM MODIFICATIONS

1. Replacement of rollers by HPMS rollers.
2. Replacement of liners.
3. Replacing of bowl assembly.
4. Replacement of bull ring.
5. Setting of spring tension.



CLOSING

Optimum mill performance cannot be achieved with simple fuel line sensors, “bolt on”, “screw in”, or “wire in” approaches, such as variable orifices and neural networks controlling variable orifices in the fuel lines. However, the correct and long lasting approach to mill performance optimization & fuel line balancing is to treat the coal feeder, pulverizer, primary airflow, fuel lines and burners as an entire system.

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Getting the shortest possible flames possible with acceptable mill performance and in conjunction with low NO_X firing has many benefits.

This means less slagging at the upper furnace. So the compounding of benefits of optimizing mill performance apply in at least 9 ways which are as follows:

- Reduced de-superheating spray flows.
- Less required soot blower operation to remove particles on boiler tubes.
- Less ash and less consequent fouling of the SCR or air heater.
- Less draft loss as a RESULT of less fouling.
- F.D. and I.D. auxiliary power.
- Less air heater leakage due to reduced head between the F.D. discharge, an APH exit gas static.
- With proper pulveriser less coal rejects (wasted fuel and fire hazard).
- Capability to lower dry gas losses & excess air with improved fuel balance.

Just the savings from heat rate, slagging and fuels flexibility can be millions of rupees per year and this justified the need for performance driven maintenance (or condition based maintenance). Pulveriser and burner line performance should be driven by periodic testing and then maintenance driven by actual pulveriser fineness and fuel distribution; and not by tons of coal throughput or thousands of hours of operation.

Truly optimum pulverized coal fueled boiler performance can significantly improve the overall plants performance, including heat rate. By improving mill performance, the benefits can easily yield 100 - 400 Btu's in heat rate savings through carbon in ash reduction, reduced furnace exit gas temperatures and de-superheating spray flows alone. Furthermore, typically these improvements which are especially important during peak generation months, also correlate with a reduction in forced outage rates and reliability improvements.

RESULTS

With the changing of the liners, rollers and the bullrings with the HPMS system we find MTTR , MTBF and availability of the system has increased.

The mean MTTR for the system has improved by 9.2%, the mean MTBF for the system has improved by 101% which means the MTBF has almost doubled and the Mean availability of the system has incrased by 0.92%.

MILL	Total Running Hours	Total Breakdown (HRS.)	No. of Stoppages	MTTR	MTBF	Availability (%)	Total Running Hours	Total Breakdown (HRS.)	No. of Stoppages	MTTR	MTBF	Availability (%)
Mill 1A	5760	92	13	7.0769	436	98.40	8640	78	13	6	658.62	99.10
Mill 1B	3600	64	11	5.8182	321.455	98.22	5040	33	8	4.125	625.88	99.35
Mill 1D	7200	171	33	5.1818	213	97.63	6480	28	8	3.5	806.5	99.57
Mill 2A	5760	114	20	5.7	282.3	98.02	7200	104	19	5.4737	373.47	98.56
Mill 2B	3600	70	15	4.6667	235.333	98.06	10080	55	10	5.5	1002.5	99.45
Mill 2C	3600	37	7	5.2857	509	98.97	9360	63	9	7	1033	99.33
Mill 2D	3600	27	6	4.5	595.5	99.25	10080	50	14	3.5714	716.43	99.50

Results of the study

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