PULVERIZER PUFFS ARE PREVENTABLE. ARE YOUR PULVERIZERS OPERATING SAFELY? PART I

It is too late to conduct preventative primary airflow calibrations or internal mill once a pulverizer puff has occurred. Storm Technologies, Inc. has been a proponent of quarterly testing programs since the company was founded in 1992. While most plants do not conduct testing this frequently, plants that do complete this testing along with performance inspections on an annual basis are much more likely to not experience a mill puff that is related to poor airflow control, throat geometry, or even a change in fuels. In this two-part technical newsletter series, we are providing several examples where these variables can cause or have caused puffs to occur.

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Primary Airflow Measurement and Control

Primary airflow, in most cases, makes up 15% - 20% of the total air that is supplied to a pulverized coal-fired boiler. However, accurately measuring and controlling this airflow to each of the pulverizers is particularly important. There are two velocities that you should keep in the back of your mind when it comes to primary airflow. The first being 3,300 ft./min. and the second 7,000 ft./min. 3,300 ft./min. is Storm's recommended minimum fuel line velocity. Velocities at or above this range will allow for the pulverized coal to stay flowing in suspension through the fuel lines and burner nozzles. The second velocity noted, 7,000 ft./min., refers to the minimum velocity required to keep coal from spilling through the rotating/stationary throat or primary airport openings around the outside of the grinding segments. Operating conditions that result in velocities below either one of these can be a root cause of plugged fuel lines, fires, or even a puff.

In Part I of this two-part newsletter, we will discuss two case studies Storm has been involved with where pulverizer puffs and/or fires have occurred due to errors with plant instrumentation or operating curves that result in dangerous operating conditions.

Case Study #1: Temperature Compensated Flow

Bernoulli's equation for fluid flow is an energy conservation equation that includes kinetic, potential, and pressure energy components. One of the variables in Bernoulli's equation is the density of the fluid. With that being said, temperature compensation is a critical piece in the plant's ability to accurately measure and control airflow within the plant. This is easily seen when comparing volumetric and mass flow with varying densities as illustrated in Table 1.

Volumeric Flow	ft^3/min	45,000	45,000
Primary Air Temperature	deg. F	80	450
Barometric Pressure	"Hg	29.92	29.92
Primary Air Static Pressure	"w.c.	30	30
Air Density	lbm/ft^3	0.0790	0.0469
Mass Flow	lb/hr	213,403	126,635

Table 1: Volumetric Flow vs. Mass Flow

Following any pulverizer puff, it is imperative that a “cold-k” calibration test (i.e. no coal flow) be completed before re-starting the pulverizer. In most cases, this will ensure that the pulverizer can be started safely with a relatively accurate flow. Furthermore, if any repairs are required to the primary air ductwork calibration testing must be completed.

At this particular facility, following the recent puff, the pulverizer had to be operated with a +20% primary air bias to eliminate coal from spilling through the rotating throat of that pulverizer. STORM was contracted to evaluate the accuracy of the plant’s primary airflow indication. Initial “cold-k” calibration test indicated that the plant indicated flow as approximately 14% higher than what was measured in the field during a velocity traverse of the duct. This was corrected with a change to the K-factor in the primary airflow control logic within the plant's DCS prior to starting the pulverizer. However, once the pulverizer was operating, the “hot-k” calibration tests were completed; which consist of traversing the primary air duct with a calibrated velocity probe at three points across the operating range of the pulverizer. STORM expected the airflow to be close to the indicated flow, but the three tests revealed that the indicated flow was still 12% higher than measured in the field traverse. While there can often still be a large deviation following a “cold-k” calibration. The calculated K-factor from the “hot-k” test also indicated something was not correct with the flow indication in the control room. The K-factor is simply a multiplier to adjust the indicated flow in the control room up or down to match the actual flow and what the results indicated was that the K-factor needed to be increased closer to the original DCS K-factor prior to the “cold-k” calibration change. However, by increasing the K-factor at this facility, the indicated primary airflow would increase. This contradicts the test results that show approximately 12% less flow than indicated. In this case, if the K-factor was changed to the average 185.66 (Table 2), the control logic would begin closing the primary air damper to meet the primary air demand; further driving the actual flow lower, causing an increase in coal spillage and the probability of another pulverizer puff or fire.

Test #	Indicated PA Flow (lb/hr)	Field Meas. PA Flow (lb/hr)	Deviation (%)	Calculated K-factor	DCS K-factor
Cold Test #1	160,500	139,492	15.1%	167.76	181.75
Cold Test #2	173,000	152,253	13.6%	176.99	181.75
Cold Test #3	200,000	177,154	12.9%	172.94	181.75
Cold Test #4	183,500	179,155	2.4%	172.07	167.00
Hot Test #1	157,500	142,033	10.9%	186.32	167.00
Hot Test #2	171,500	152,072	12.8%	185.54	167.00
Hot Test #3	188,500	166,716	13.1%	185.12	167.00

Table 2: Primary Air Testing Results

After reviewing the results, STORM began to investigate the primary air control logic. During a review of the logic, it was found that there were two primary air temperature measurements. The primary air duct is equipped with a dual-element thermocouple that was sending two temperature measurements to the logic; one going to the control room operator’s screen indicating the correct inlet temperature (~350°F) and the second, indicating 80°F, was feeding into the temperature compensation block for the primary airflow calculation. The temperature compensation factor for the lower temperature resulted in a higher indicated airflow than was being supplied to the pulverizer; causing the pulverizer's throat velocities to be insufficient in keeping the coal suspended inside the pulverizer. Raw coal that spills through the throat is in an area that is air rich with temperatures that often exceed the required temperature to ignite the coal which will result in fires and puffs.

Case Study #2: Lack of Primary Airflow Measurement

Those of you lucky enough to have a CE boiler with Raymond Bowl mills that are designed with an exhauster you most likely have no indication of the total primary air flow entering the pulverizer. This is due to the fact that most of these pulverizers are designed with a small tempering air duct at the immediate inlet of pulverizer as shown in the following figure. The primary airflow through the pulverizer instead is controlled via a damper at the inlet to the exhauster fan at the discharge of the pulverizer. This damper operates on a curve versus feeder speed for the pulverizer.

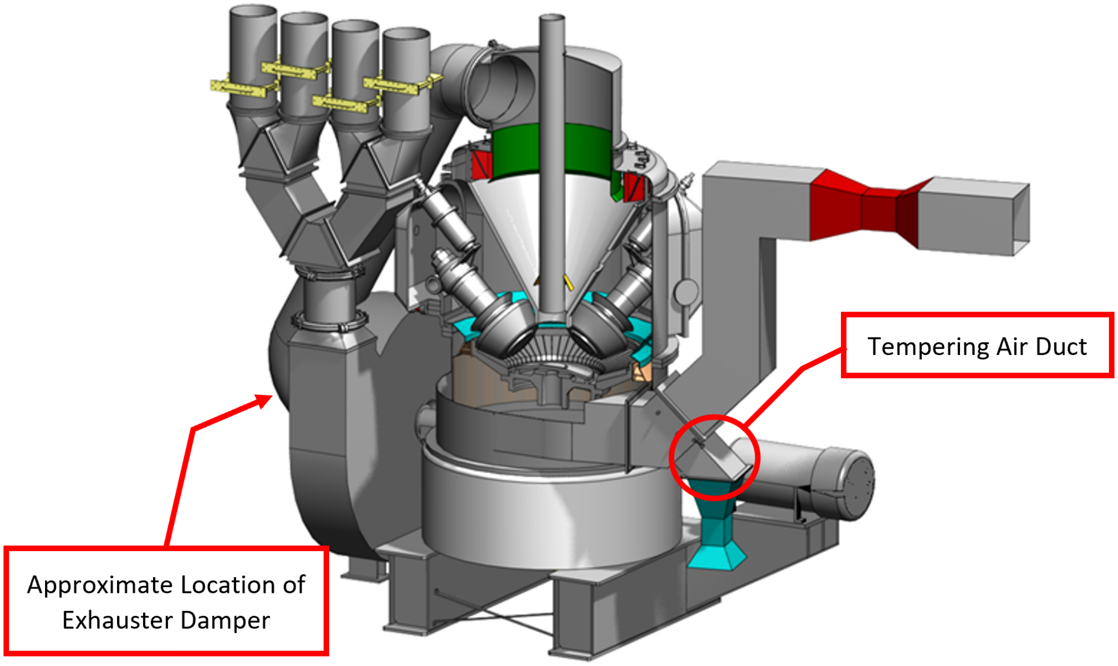

Figure 1: Raymond Bowl Mill with Exhauster

Often, we find that the exhauster damper versus feeder curve installed in the DCS provides little to no control over the actual airflow due to the fact that the minimum damper position in many cases starts at 50% and ramps to 100% as shown in the following figure. This type of curve can result in 100% of the available primary airflow supplied to the pulverizer under minimum load conditions. Why is this a problem? This can result in extremely high air to fuel ratios that can be conducive to fires and smoldering coal within the mill. These types of conditions during startup or shutdown have been known to be the root cause of a pulverizer puff.

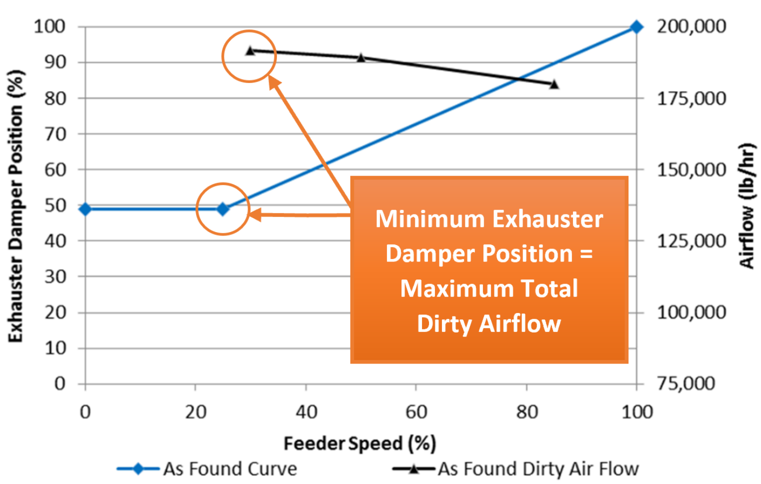

Figure 2: General Exhauster Damper Curve vs. Total Dirty Air Flow

Careful review and tuning of the exhauster curves have been extremely helpful in improving the operation of these style pulverizers and in reducing the air to fuel ratios within the pulverizer. However, just like in Case Study #1, routine field testing must be completed to accurately control the primary air flow to these pulverizers and limit the possibility of unfavorable conditions within the pulverizer, fuel lines, and burners.

Understanding the Heat Balance Surrounding your Pulverizer

While field calibration testing led to the discovery of temperature compensation error and elevated air to fuel ratios in the previous two case studies, understanding a basic heat balance surrounding the pulverizer can help raise some red flags in your facility surrounding primary airflow accuracy without performing calibration testing. To maintain a desired mill outlet setpoint, the primary air inlet temperature will be much hotter to raise the temperature of the coal to that desired outlet temperature. The required inlet temperature varies based on several factors such as coal flow, moisture content of the coal, and air to fuel ratio.

As you can see in the following example, highlighted by the blue line, if all the pulverizers at your facility are operating with the same coal feed rate, a 1.8 air to fuel ratio at a mill outlet temperature setpoint of 170°F and the fuel moisture content is 10%, the required mill inlet temperature is going to be roughly 470°F. Now if you are standing in the control room and five of the six pulverizers have mill inlet temperatures around 470°F while the sixth pulverizer operating with the same fuel feed rate and outlet temperature while the mill inlet temperature is 415°F or lower, then that is a good indication that the primary airflow entering that mill is higher than indicated.

Next time you are in the control room at your facility, take some time to review the pulverizer inlet and outlet temperatures along with the feed rates and if the inlet temperature varies from pulverizer to pulverizer for the same coal quality and feed rate then it may be time to conduct primary air calibration testing on your pulverizers.

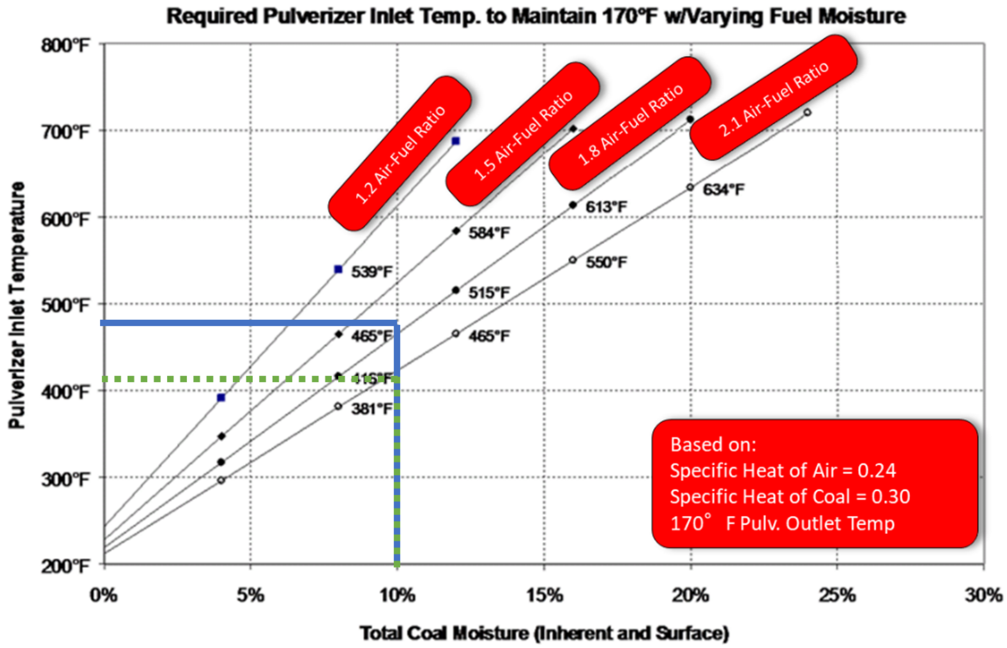

Figure 3: Pulverizer Heat Balance Example

STORM Primary Air Engineered Solutions

In addition to STORM's field service, we also have a fabrication shop that provides our customers with engineered solutions that can also help reduce the likelihood of pulverizer puffs. As previously mentioned, accurate measurement and control are critical to reducing the types of conditions that can lead to a pulverizer puff. STORM has been extremely successful with long-term flow measurement accuracy with our STORM-designed venturis when compared to other devices such as pitot tubes and airfoils. Our engineering and fabrication team can provide a solution for applications that appear to have no good solution. Figure 4 illustrates just this, an engineered solution tailored to fit the needs of the very difficult to measure primary airflow on a Raymond Bowl pulverizer equipped with an exhauster. We finalize our designs based on years of experience with field-proven methods that are also backed by test results and CFD modeling (if requested).

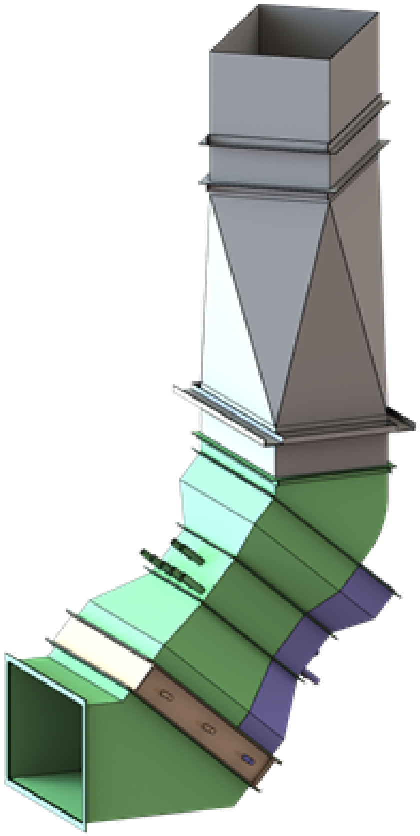

Figure 4: Engineered Solution for Raymond Bowl Primary Air Measurement and Control

In addition to STORM-designed performance-enhancing components, our shop also specializes in "in-kind" replacement parts to replace your primary air ductwork, rotating throats, and flow control damper assemblies that may have been compromised during a pulverizer puff or fire. All our components are custom fabricated for your plant and are fabricated here in the USA. The craftsmanship of our fabricated components is second to none and we stand behind everything that is shipped out of our shop.

Figure 5: Storm Fabricated Components

Standby for Part II of this two-part technical newsletter where we will discuss the impact that throat geometry and coal quality changes can have on pulverizer puffs. Please reach out to us at 704-983-2040 if you would like to discuss in more detail primary airflow testing at your facility or need a reliable fabrication shop to provide you with custom-engineered solutions or if you simply need a last minute "in-kind" replacement component that was discovered during your scheduled outage.

Respectfully,

Shawn Cochran, P.E.

Disclaimer: These suggestions are offered in the spirit of sharing our favorable experiences over many years. Storm Technologies, Inc. does not accept responsibility for actions of others who may attempt to apply our suggestions without Storm Technologies' involvement.

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