Airflow Sciences Corporation

# Coal Pipe Balancing

## Case Study

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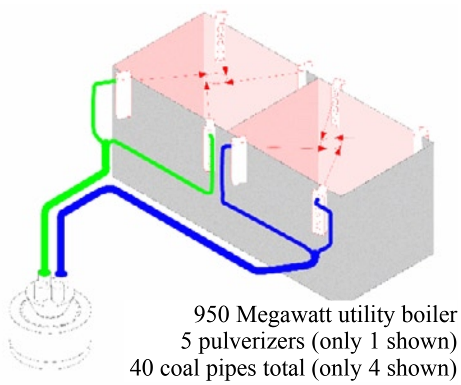


*Figure 1 - Typical pulverizer with multiple coal pipes*

*Figure 2 - Advanced Coal Flow Measurement System*

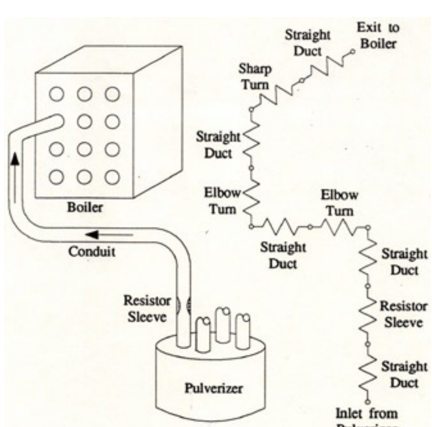


*Figure 3 - FINESSE representation of pipe geometry*

Boilers that utilize pulverized coal are undergoing increasing scrutiny by their owners. The drive towards maximum efficiency of the plants with minimum pollution emissions requires that all aspects of boiler performance be optimized. The wide use of low-NOx burners and combustion techniques has shown the potential gains obtainable when the combustion process is examined in detail.

It has become clear that these systems are very sensitive to the balance of fuel and air delivered to the furnace. Today's goals of high efficiency and low emissions can only be met by carefully controlling the fuel and air at each boiler entry point.

Large fossil fuel boilers can have up to 100 individual burners that inject fuel and air. The pulverized coal is transported from the pulverizer to the burners via an extensive piping system, as shown in Figure 1. Since each pulverizer supplies coal to a number of pipes, there are many opportunities for imbalances to occur.

The primary issue is that the pipes have different destinations, thus creating discrepancies in the length, number of bends, and flow resistance of each pipe. A carefully designed system will ensure that the resistance of each of those branches is equal so that the coal and air split uniformly between the burners.

### Coal Pipe Balancing Methodology

Airflow Sciences Corporation has performed a detailed analysis and design to balance the flow within the coal pipes for numerous plants across North America. The methodology is as follows:

1. Utilize the *Advanced Coal Flow Measurement (ACFM)* equipment to accurately measure both air flow and coal flow rate in each pipe.

2. Analyze the data to determine if the balance is within industry standards of ±5% for the air flow balance and ±10% for the coal flow balance.

3. For those mills that are outside of industry specifications, design flow control orifices for the piping system such that the flow resistance of each branch is equal. A software program called *FINESSE* (Fluid Network System Solver) is employed for this step.

4. Fabricate and install the newly-designed orifices.

5. Repeat testing with the *ACFM* to verify balanced flow exists in the modified piping system.

### Advanced Coal Flow Measurement System

Figure 2 shows the *ACFM*, which combines a computer-controlled data acquisition system with high quality instrumentation. The result is the most accurate isokinetic particulate sampling system available.

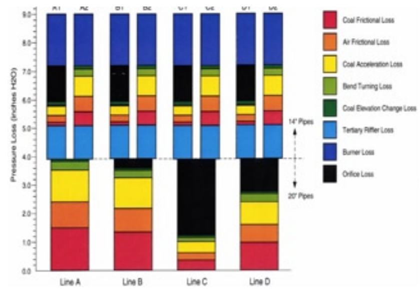

Figure 4 - FINESSE pressure calculations

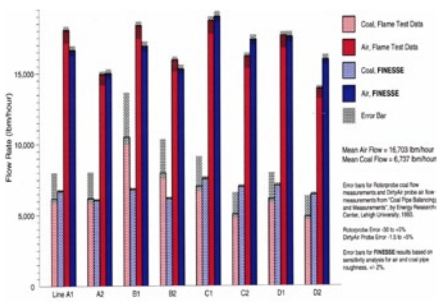

Figure 5 - Correlation of FINESSE Flow Predictions

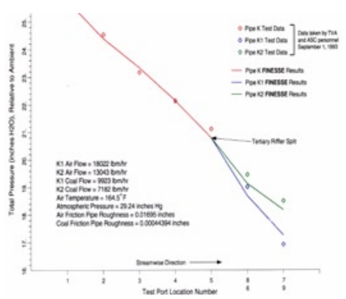

Figure 6 - Correlation of FINESSE total pressures

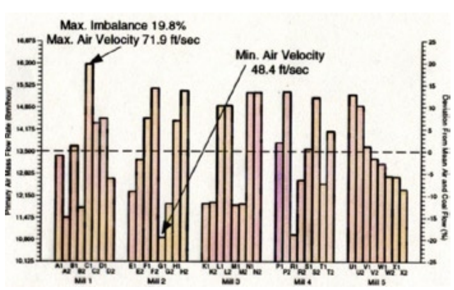


Figure 7 - Coal Pipe Balance - baseline

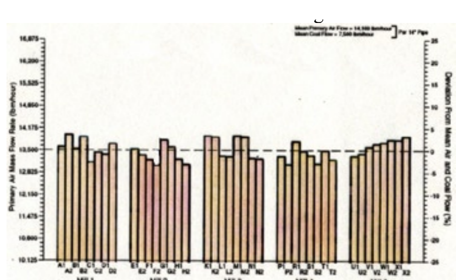

Figure 8 - Coal Pipe Balance - after orfices

## Orifice Design Methodology

For pulverizers with imbalanced flows, orifices are designed using the flow simulation software *FINESSE*, which calculates the resistance, and thus pressure loss, for each branch of the piping system. Orifices are used to balance the loss in certain pipes so that all pipes have the same flow resistance. A generic schematic of a *FINESSE* representation is shown in Figure 3.

*FINESSE* calculates a number of parameters that influence the pressure loss. The critical factor is that the Airflow Sciences method includes both the air-side losses (due to pipe bends, area changes, and surface friction) and the coal-side losses (due to acceleration of the particulate, elevation change, and surface friction). As indicated in Figure 4, the losses associated with the coal flow are of the same magnitude as those related to the air flow.

With this coupling of the air- and coal-induced losses, a correct accounting of all system losses are included. Field test data has proven that orifices designed using only the air-related loss characteristics (so-called "clean air" balance), usually result in imbalanced coal pipe flows under "dirty air" (with coal) flow.

At a 950 MW power plant in the midwest, detailed measurements of air, coal, and total pressure within the coal pipes was performed to compare predictions of *FINESSE* with actual plant data. The graph of Figure 5 shows that the correlation between the *FINESSE* prediction for flow split. Figure 6 shows the correlation for total pressure. In both cases, correlation is excellent.

## Orifice Design Case Study

Figure 7 presents baseline coal pipe data for the five pulverizers at the plant. Each pulverizer feeds 8 pipes. For the baseline case, imbalances are outside of the desired ±5% for air flow on all mills. Mill 1 has the highest imbalance at +20%. Mills 2 and 4 indicate pipes with very low flow (-19%) where velocities would be as low as 48 ft/s. Pipes with velocities this low are susceptible to pluggage as coal can accumulate in horizontal pipe runs.

Orifices were designed using *FINESSE* and installed in the appropriate pipes for each pulverizer. Results indicated that all pipes were balanced to within ±5% as desired. These results are shown in Figure 8.

## Summary

Balancing air and fuel flow to a furnace is important to ensure that combustion is optimized and Low NOx burners function properly. Burner flow balancing can have a dramatic impact on plant performance for relatively low cost.

Utilizing an efficient combination of field measurements with the *ACFM* and orifice design with *FINESSE* allows Airflow Sciences Corporation engineers to provide beneficial results in a cost-effective manner.