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Good Stewardship in Coal Plant Combustion and PERFORMANCE Improvement

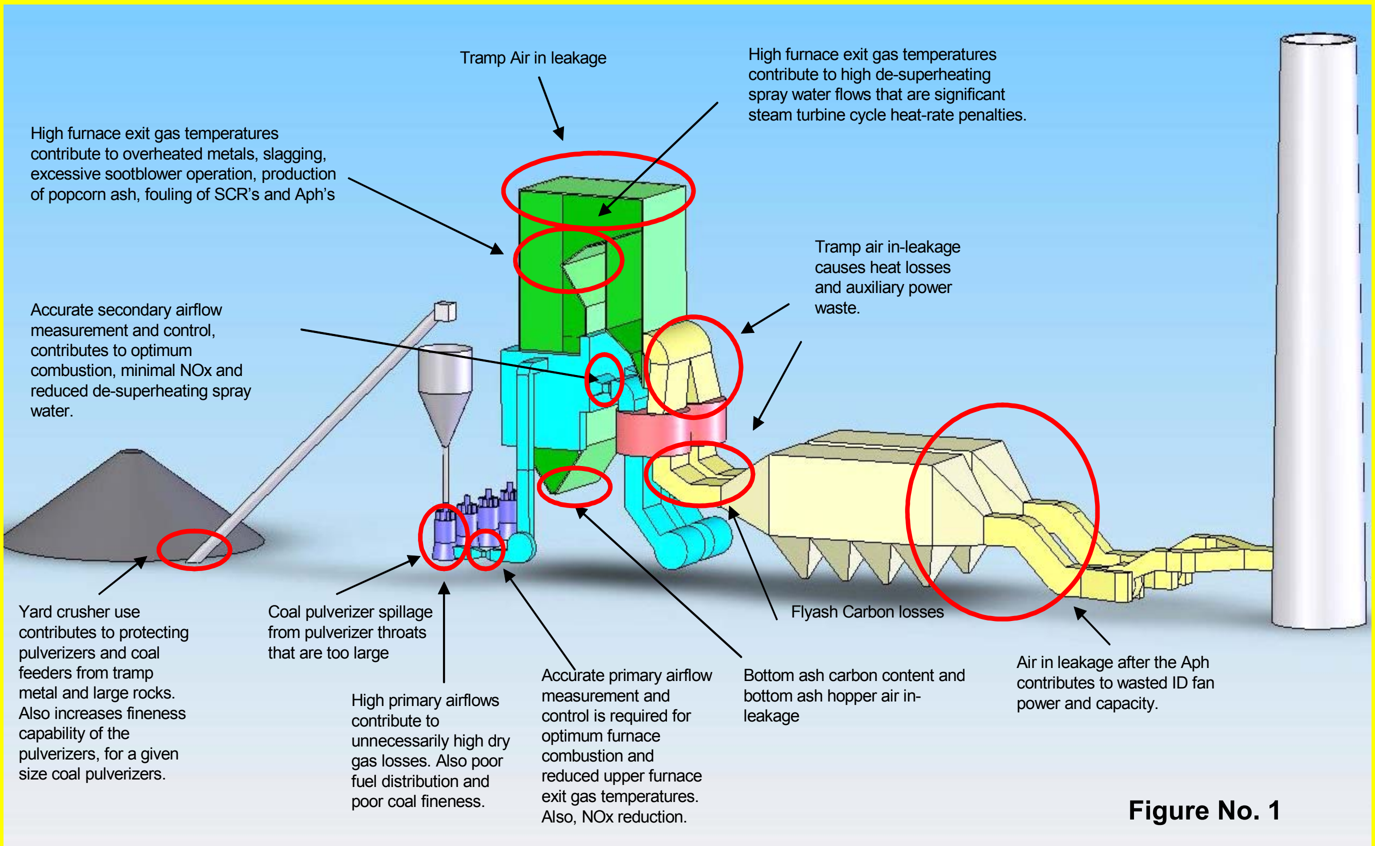


Figure No. 1

<u>These are commonly found opportunities for improvement:</u>

HEAT-RATE, ENVIRONMENTAL, RELIABILITY, FUELS FLEXIBILITY, MAXIMIZING LOAD CAPABILITY.

First, a review of the many factors that comprise “Optimized Combustion” today:

- Environmental Performance - Low NOx, minimum Carbon in ash, low stack opacity.
- Fuels Flexibility - As a result of rising fuel costs, NOx and sulfur concerns and transportation difficulties, fuels flexibility is a very important factor.
- Load Capacity - Maximum unit load capability with acceptable environmental performance and firing the most reasonable (and available) fuels.
- *Unit Heat Rate-Optimization may not have seemed “important” several years ago. Now with ever increasing demand for lower cost coal power production, and ever increasing exposure by the news media on greenhouse gases, just simply doing the “Right Thing” is more than a very Good idea!
  Environmental Stewardship places another valid reason to re-visit heat rate improvement by combustion optimization and accurate combustion airflow management.

It is **RESULTS** that Count!

Furnace size is finite. Getting the “inputs” optimized on a 30 year old pulverized coal boiler are an absolute must. All known low NO_x burner retrofits, must use the original furnace cavity to complete combustion. Residence time is fixed and limited.
Usually in the magnitude of 1 to 2 seconds.

Boilers Retrofitted with low NO_X burners still have the same furnace size and residence time for carbon char burnout

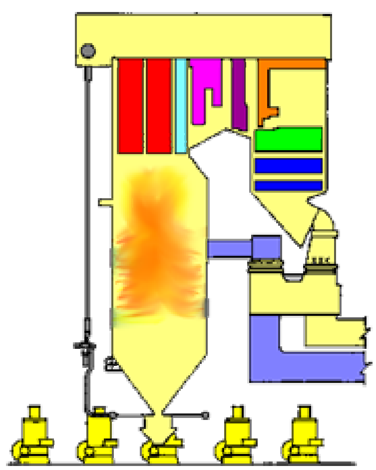


Figure No. 2

*Suggest that the EPA website below be checked out:
http://Yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/RAMR69V4ZT/$File/05energy.pdf
If you are interested in what the EPA has published and spread to the public regarding Greenhouse Gas Emissions, check out this site. Electric Power Production is credited with about 40% of the USA GHG emissions. So, those of us that are “Homegrown Coal Energy” proponents really should get serious about improving our Good Stewardship of using our homegrown energy wisely! By this I mean, **let’s get serious about improving Heat-Rates.** If we are to use “Homegrown Coal” energy for 52% of our Electric Power Production, we should do so using the full efficiency potential that was built into the average coal plant, and work toward overall efficiencies of 40% Plus! If this seems unreasonable, check back to what our industry designed and built at Eddystone No.1, and Chalk Point No. 1 and No. 2, in the early 60’s. Today we have even better metals for higher temperatures and pressures!

The STORM APPROACH is basically a five step process:
(This is to make the Best of what is installed now.)

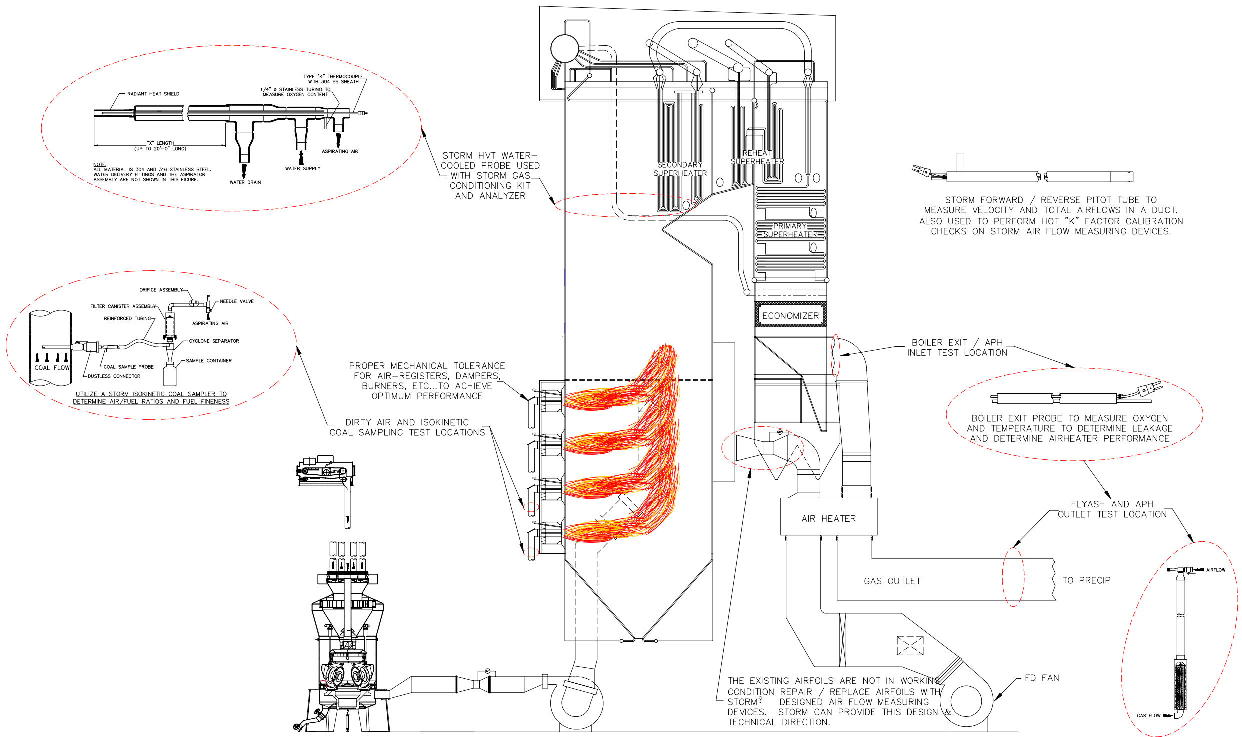
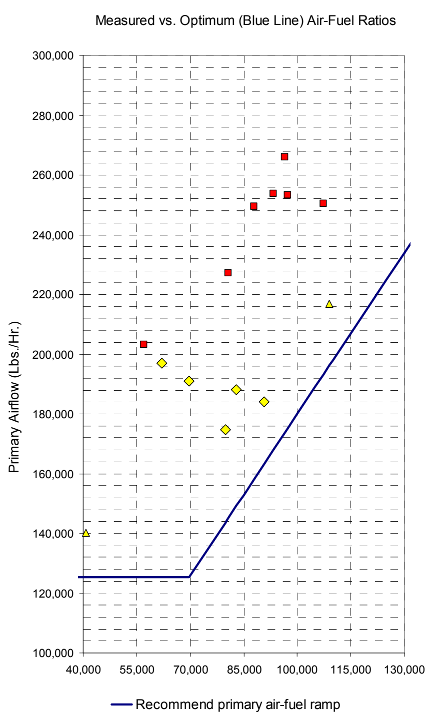


Figure No. 3

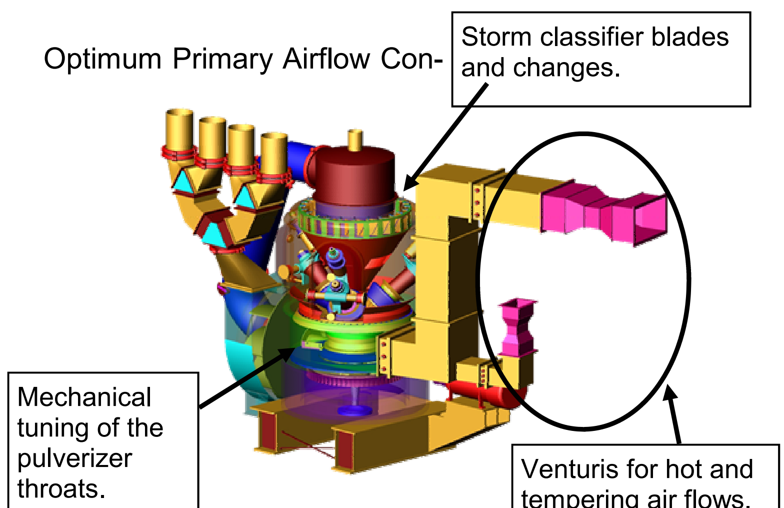
Step 1 - Test to quantify opportunities.

Step 2 - Mechanically tune the pulverizers.

Take a look at a Bowl Mill, and the typical "Opportunities" for improvement:



Optimum Primary Airflow Con-



High tempering airflow bypasses the air heater and contributes to a less desirable "X" Ratio. Therefore, the mills must be optimized to insure that optimum performance is compatible with a desirable air-fuel ramp.

Figure No. 4

The Storm Total Combustion Optimization Approach, using Storm Products and Services for <u>RESULTS!</u>

The improvements as outlined above are **proven and known to be successful**. There are a few recurring details that some owners/users have neglected to implement. Omission of a few details can completely nullify an otherwise successful mill performance/reliability and capacity improvement program.

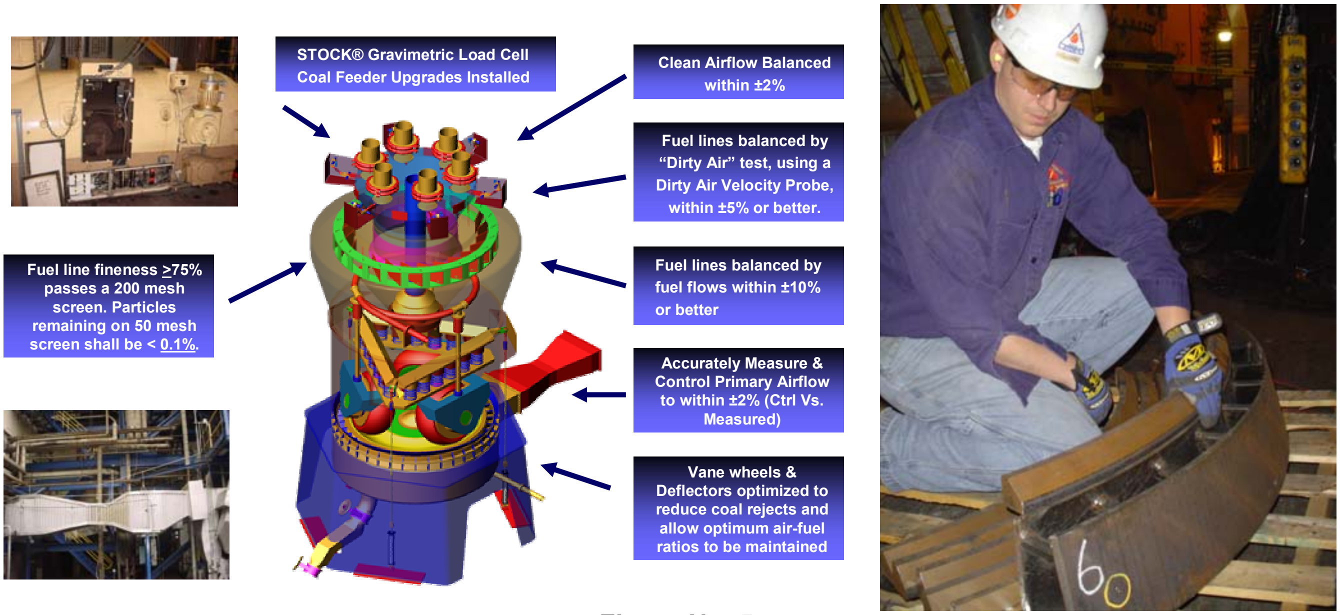
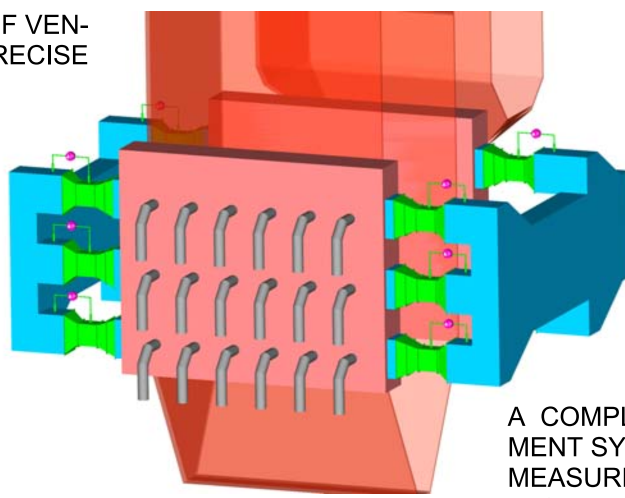


Figure No. 5

<u>Step 3</u> - Measure and control all combustion airflow streams by use of venturis and mechanically "tune" the burners.

IMPLEMENT THE USE OF VEN-TURI SECTIONS FOR PRECISE AIR FLOW CONTROL



A COMPLETE AIR FLOW MANAGE-MENT SYSTEM INCLUDES PRECISE MEASUREMENT OF PRIMARY AIR FLOW AND FUEL LINE VELOCITIES

Figure No. 6

BENEFITS:

- USE OF TWO SENSING LINES GREATLY REDUCES FLYASH PLUGGAGE
- ACCURATE/RELIABLE AIR FLOW MEASUREMENT
- OPTIMUM FURNACE CONDITIONS
- CONTROL AND REDUCTION OF NO_X
- REPEATABLE AND RELIABLE
- SIMPLE TO FIELD CHECK HOT "K" 's

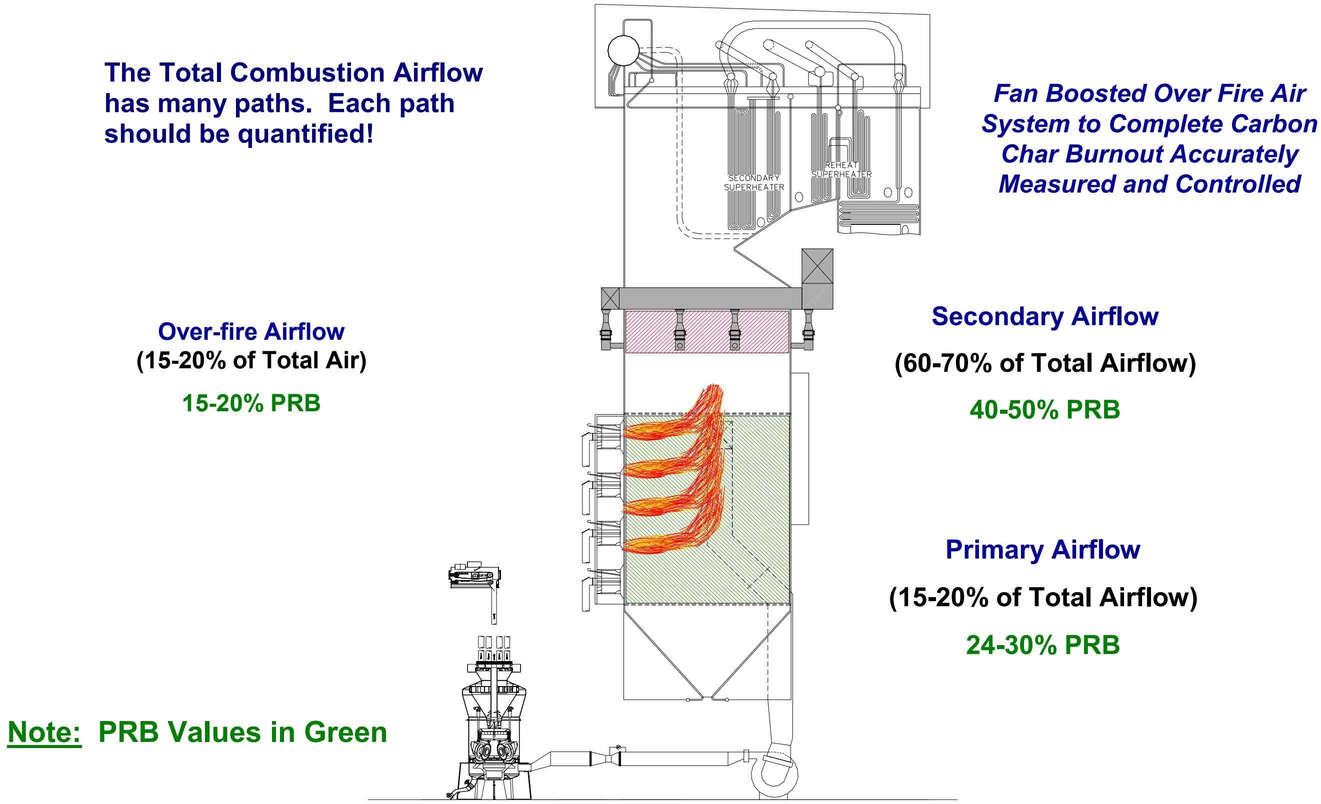


Figure No. 7

Specific burner changes as needed on a unit specific, fuel specific basis:

An example of STORM prescribed burner changes that were implemented as part of a total combustion optimization program.

Figure No. 8

One example of Storm burner changes for good RESULTS.

“As Found”

New S.S. Optimized/Fixed Opening

Figure No. 9

New fixed burner shrouds are installed to improve windbox airflow distribution. The STORM approach is to fix these at a given opening to keep the secondary airflow uniformly distributed.

Step 4 - Install a fan boosted overfire air system.

STORM Boosted OFA System as successfully applied to a wall fired boiler

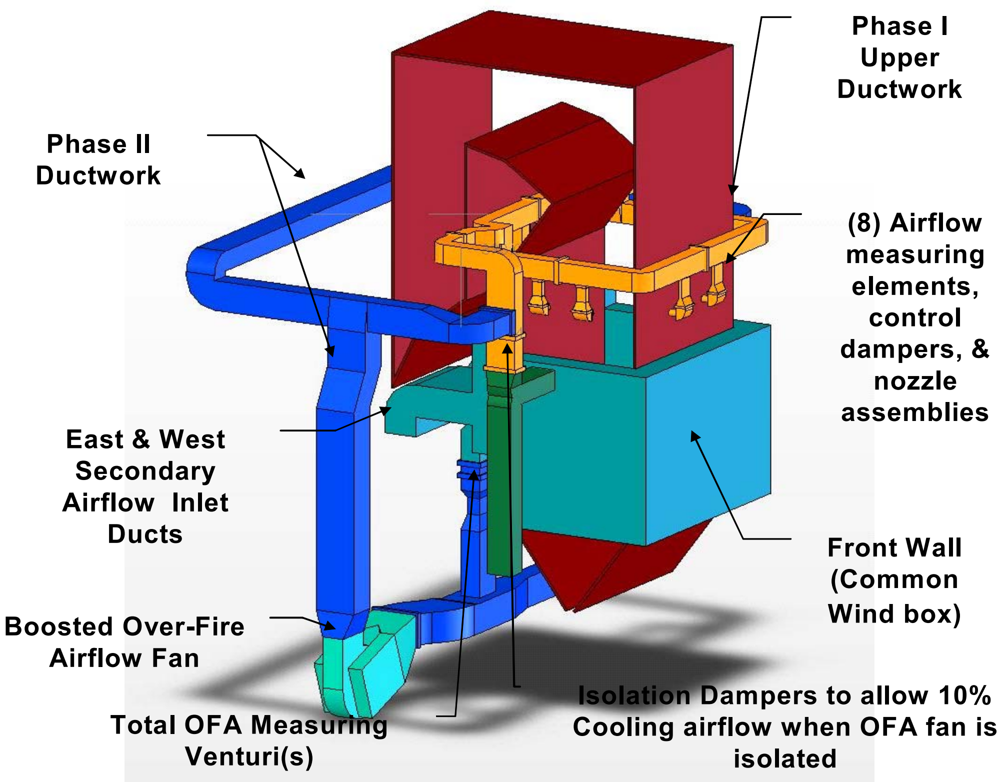


Figure No. 10

For NO_x Reduction, total combustion airflow measurement and control, with a fan boosted OFA System, and total combustion airflow measurement and control.

STORM designed venturis for accurate reliable combustion airflow measurement and control. These venturis are installed on primary air and OFA ducts.

Benefits of STORM® Venturis
Primary Airflow Measuring Devices

- Improved unit & pulverizer controllability by improving the "K" factor accuracy and repeatability. Also, for a smoother differential signal.

- Capability to Improve DCS logic & Control curves so that an optimum air/fuel ratio can be achieved across the normal operating load range.

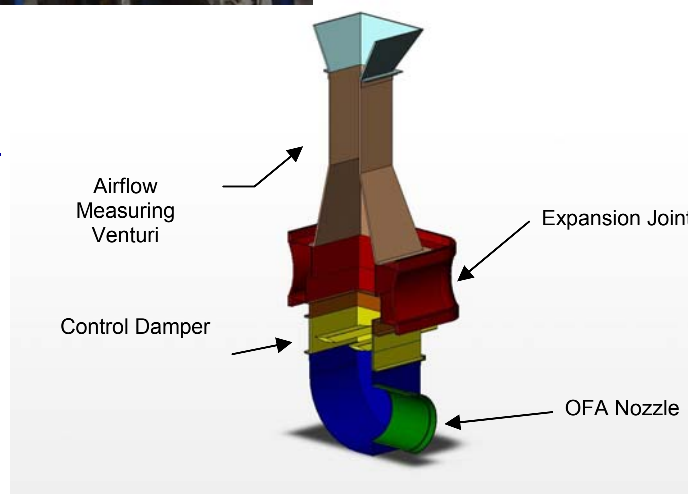


Figure No. 11
OFA Venturi

All combustion airflows should be measured and controlled. Here are examples of OFA venturis above and secondary air venturis below.

Figure No. 12
Secondary Air Venturi

Typical improvements, as successfully applied to a 50’s vintage, corner fired, pulverized coal fueled boiler

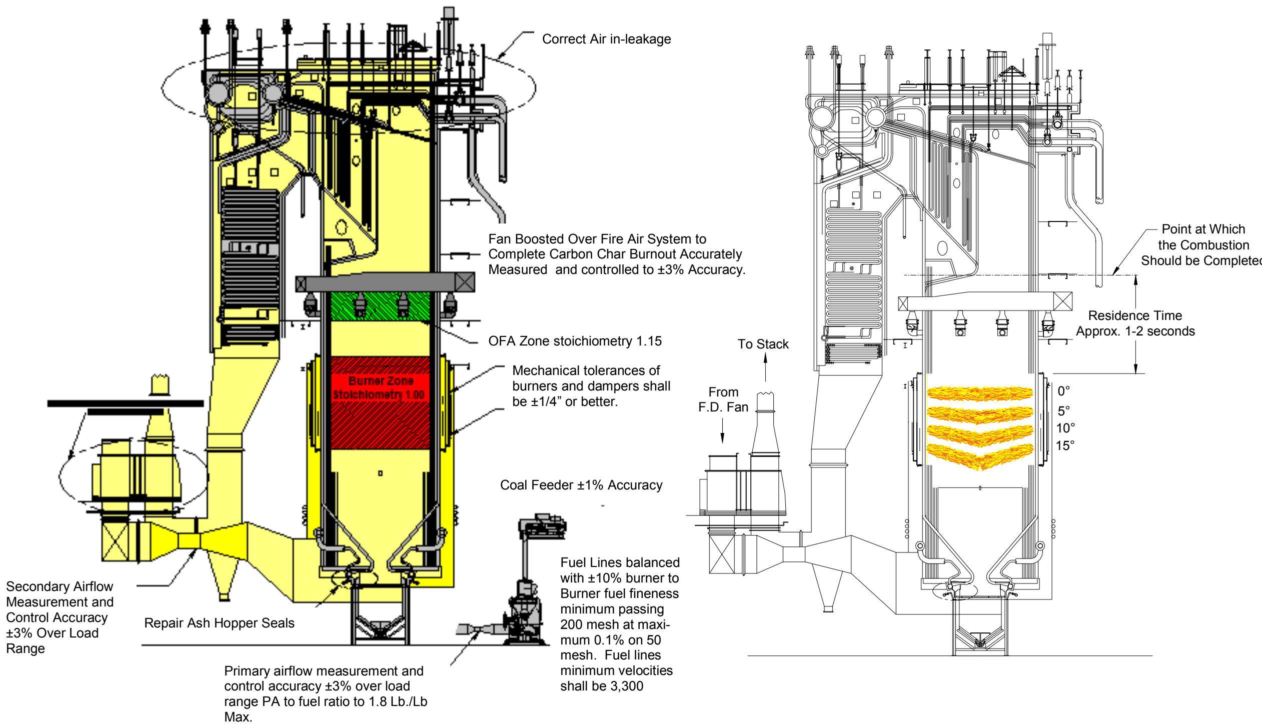
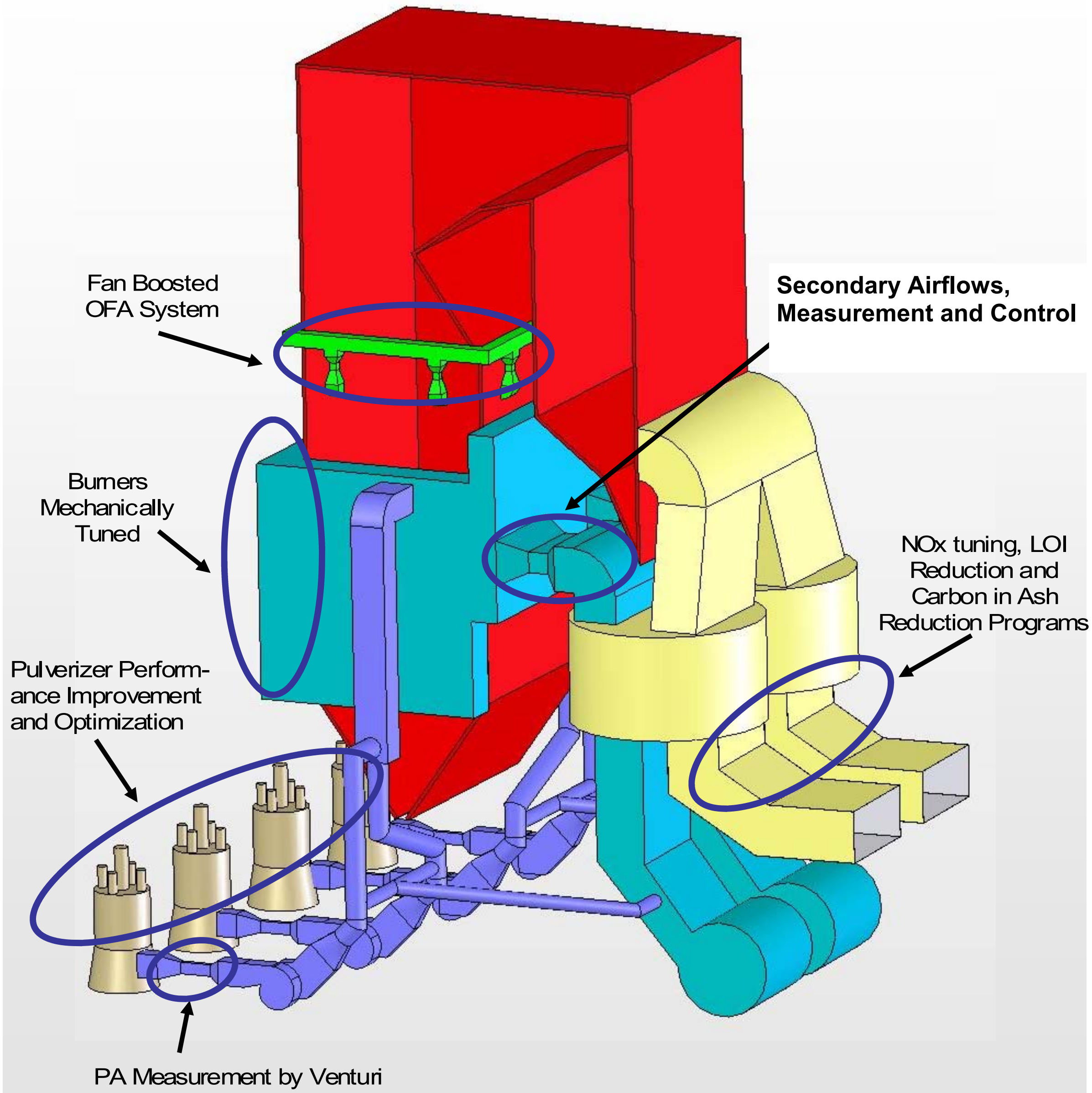


Figure No. 13

Boosted OFA Nozzle Venturi(s)

Figure No. 14

Step 5 - Implement a Storm and owner "Partnership" in PERFORMANCE Preservation for periodic testing, tuning, consulting and continuous improvement of performance.



The Specifics of this 167MW wall fired boiler combustion optimization success are outlined in a technical paper presented to the 2005 Electric Power Conference. A copy of the paper will be sent upon request.

- **Weekly representative flyash carbon content sampling**
- **Monthly coal fineness tests**
- **Monthly airheater performance tests**
- **Quarterly oxygen rise tests from the furnace to the stack**
- **Quarterly coal feeder calibrations**
- **Quarterly high precision coal fineness and distribution tests**
- **Semi-annual airflow device calibrations (Primary Air, Secondary Air, OFA), (Including hand traverse hot "K" calibration checks.)**
- **Semi-annual fuel line clean-air testing to prove ±2% balance**
- **Pre-outage comprehensive boiler evaluation tests to fine tune the outage work list.**

Summary

Achieving combustion and performance optimization has been my passion as well as providing me a good living for many years. For the support of our many friends and customers, I am thankful and appreciative. **My concern for our industry is, that** we (as an industry) are leaping off into sophisticated, bolt on, screw in, or wire in changes to major power generation equipment, and **are overlooking the simple** fundamentals. Instead of using tried and proven venturis, some engineers specify unreliable averaging pitot tube arrays. Instead of training operators and tuning the controls, "Neural Networks" have been installed as a "wire-in" performance preservation program substitute. Neural Networks have a place - after the fundamentals have been applied! Instead of balancing air and fuel by tried and proven methods, some are making plans to install variable orifices in pulverized fuel lines. At some plants, low NO_x burners have been installed without the requisite pulverizer fineness and fuel line balancing. When it is known that air in-leakage, and high primary airflows impact heat rate. Instead of fixing it, the high P.A. flows are ignored and larger I.D. fans are purchased.

These are just six contributing examples of why the average coal plant heat rates in the US Utilities are about 10,500 Btu/kWhr, instead of say 9,900 or 10,000 Btu's/kWhr. What is that worth in cost? Do the math. What is that worth in public relations for permitting new coal plants? I have no idea how to calculate that one. As an example of important fundamentals, let me re-iterate 22 Operations and Boiler Maintenance Controllable Variables that impact Heat-Rate.

- Flyash LOI
- Bottom ash carbon content
- Boiler and ductwork air in-leakage
- More precise primary airflow measurement and control, by reducing tempering air
- Reducing pulverizer air in-leakage on suction fired mills
- Pulverizer throat size and geometry optimization to reduce coal rejects and compliment operation at lower primary airflows
- Secondary airflow measurement and control for more precise control of furnace stoichiometry, especially important for low NOx operation
- Reduction of extremely high upper furnace exit (FEGT) peak temperatures, which contribute to "Popcorn Ash" carryover to the SCR's and ApH's, High spray water flows, Boiler slagging and fouling, and high draft losses due to fouling. The high draft losses cause increased in-leakage, increased fan auxiliary power wastage and increased associated losses with the high spray water flows
- High de-superheating spray water flow to the superheater
- High de-superheating spray water flow to the reheater
- High air heater leakage (note: Ljungstrom regenerative airheaters should and can be less than 9% leakage)
- Auxiliary power consumption/optimization i.e., fan clearances, duct leakage, primary air system optimization, etc
- Superheater outlet temperature
- Reheater outlet temperature
- Airheater outlet temperature

- Airheater exit gas temperature, corrected to a “no leakage” basis, and brought to the optimum level
- Burner “inputs” tuning for lowest possible excess oxygen at the boiler outlet and satisfactory NOx and LOI. Applying the “Thirteen Essentials”
- Boiler exit (economizer exit) gas temperatures ideally between 650°F to 750°F, with zero air in-leakage (no dilution!)
- Cycle losses due to valve leak through – i.e. spray water valves, reheater drains to the condenser, superheater and re-heater drains and vents, and especially any low point drains to the condenser or to the hot well
- “Soot blowing” Optimization – or smart soot blowing based on excellence in power plant operation (Remember, soot blowing medium is a heat rate cost, whether compressed air or steam)
- Feed water heater level controls and steam cycle attention to detail
- Steam purity and the costly impact of turbine deposits on heat rate and capacity

Now, let’s take a very **common problem of “High Desuperheating Spray Water Flows**”. This is often a symptom of secondary combustion, and scorching hot flue gas entering the boiler superheater and reheater. Excessively hot flue gases leaving the furnace can contribute to the following:

- Superheater slagging
- Popcorn ash to plug the SCR’s and the APH
- High spray water flows, which have an adverse impact on Heat-Rate
- High tube metal temperatures, which have an adverse impact on superheater and reheater tube metal life; i.e. tube failures and reliability issues
- Waterwall wastage from extremely fuel rich zones in the furnace (reliability) and more

So, what can be done? Try applying the 13 Essentials with the Storm Approach. That is the complete involvement of Storm to do the testing, provide the recommendations, and to provide the components. Most experienced Power Plant Engineers know that it is the Comprehensive Approach that achieves RESULTS. The 13 Essentials are a tried and proven check list and are cited below for easy reference:

- **Furnace exit must be oxidizing preferably, 3%**
- **Fuel lines balanced to each burner by “Clean Air” test ±2% or better**
- **Fuel lines balanced by “Dirty Air” test, using a Dirty Air Velocity Probe, to ±5% or better**
- **Fuel lines balanced in fuel flow to ±10% or better**
- **Fuel line fineness shall be 75% or more passing a 200 mesh screen, 50 mesh particles shall be less than 0.1%**
- **Primary airflow shall be accurately measured & controlled to ±3% accuracy or better**
- **Overfire air shall be accurately measured & controlled to ±3% accuracy**
- **Primary air/fuel ratio shall be accurately controlled when above minimum**
- **Fuel line minimum velocities shall be 3,300 fpm**
- **Mechanical tolerances of burners and dampers shall be ±1/4” or better**
- **Secondary air distribution to burners should be within ±5% to ±10%**

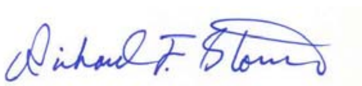
- **Fuel feed to the pulverizers should be smooth during load changes and measured and controlled as accurately as possible, load cell equipped gravimetric feeders are preferred**
- **Fuel feed quality and size should be consistent, consistent raw coal sizing of feed to pulverizers is a good start**

A Few Words on the 13 Essentials

These have expanded from the 10 pre-requisites for optimum combustion, first promoted in the 1980's. The point is, they are simple, have been around a long time, and they make a great "punch list" for resolving slagging, heat-rate, reliability, LOI, and NOx issues in large P.C.-fired utility boilers.

Let's stick to the FUNDAMENTALS that work. If you would like our involvement in doing just that, we have the Best Team, the Best Equipment and the highest enthusiasm for Excellence in coal combustion. Let Storm help your plant become a good "Steward" in the production of environmentally friendly, reasonable cost electricity.

Sincerely,



Dick Storm