STORM TECHNOLOGIES, INC. October 2012

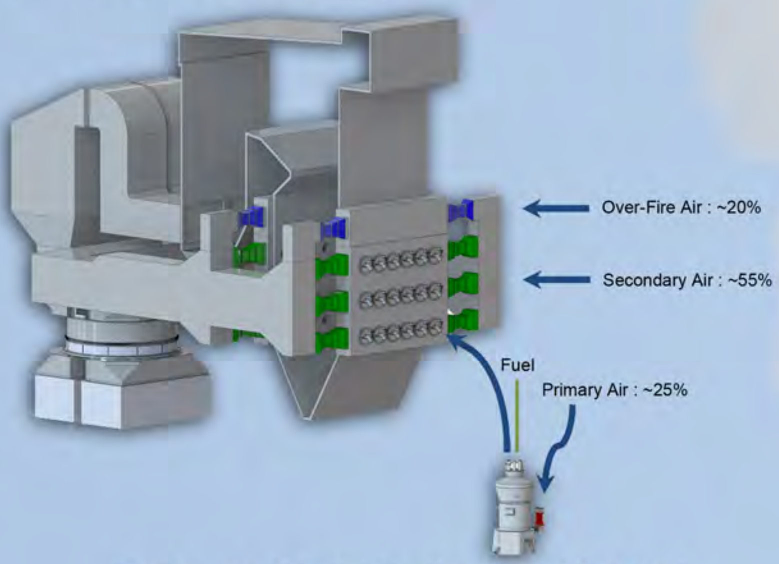
Measurement of Combustion Airflow

Why Venturis and Flow Nozzles are the Best Primary Elements for Measurement

The Case for Accurate Airflow Measurement – Why?

The chemistry of combustion is based on molecular weights of the products of combustion (mole's as combustion engineers refer to them). Everything we do in efficient, clean, low NO_x combustion is or should be based on precise fuel measurement and control. To do so requires the most accurate and reliable measuring of primary elements. These will be discussed in more detail later.

One interesting fact is that all coal fuels require about the same amount of combustion airflow per million Btu's of heating value. At 110% theoretical air that number is 850 pounds of air per million Btu's. This is for all coal fuels ± 5%. The word "all" is not one I use very often, but it is true for this example.



Optimum Air Distribution for PRB Coal

IN THIS ISSUE:

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To the right are some common fuels and the weights of air required for complete combustion and 10% extra air for a theoretical air of 110% or a stoichiometry of 1.1 at the furnace exit.

Type of Coal	Theoretical Air Req'd (lbs of air/MMBtu)
PA Anthracite	855
CAPP Bituminous	845
Illinois Basin	843
PRB	833
North Dakota Lignite	825
Texas Lignite	827
Average	838
Deviation from min to max	30

These are examples of the broad spectrum of coals used in North America, yet they "all" use within 3.6% of the same amount of air for combustion. Some engineers believe that this being the case, it is not necessary to precisely measure primary airflow, secondary airflow or overfire airflow. We disagree on this point! Sure it does in fact require the same quantities (weighted not volumetric) of air to satisfactorily complete combustion. However, we better be precise with the measurement and control of the various paths of combustion airflow to ensure optimal tuning of furnaces for low NO_x, low or near trace amounts of CO, best temperatures, minimum slagging, etc. See next page for an example.

Primary airflow for the best combustion of PRB, Bituminous and Illinois Basin coals should usually be 1.8 lb. of air per lb. of fuel for vertical spindle pulverizers. Although the total weight of air for combustion at the furnace exit is similar at 850#s/million Btu's the proportions of primary air, secondary air and overfire air all change drastically.

Recommended % of Primary Air for A/F Ratio of 1.8lb. of air / lb. of fuel

PRB..................25% of Total Air for Combustion
Bituminous........16% of Total Air for Combustion
Illinois Basin......17% of Total Air for Combustion

PRB uses about 50% more combustion airflow for primary air as a total than central APP or Illinois Basin fuels. So the proportions of secondary air and overfire air need to be measured and controlled as precisely as possible to accomplish the best tuning and day to day 24/7 operation at optimum combustion.

The furnace residence time is only one or two seconds from the top of the burner belt to the superheater flue gas inlet. Therefore, the available residence time for optimum furnace combustion must utilize precisely measured and controlled paths of airflow.

What is the Best Airflow Measuring Primary Element for Coal Fueled Boilers?

Venturis are the very best. However, our second choice would be flow nozzles, often the only choice due to space and duct arrangements. You can check our website to see numerous successful application photographs along with our experiences of applying flow nozzles and venturis for many years is well known and well documented. What are the advantages of flow nozzles and venturis? Here are some:

- **Reliability**
- **Accuracy**
- **Rugged**
- **Repeatable**
- **Ease of Calibration**
- **Large impulse holes for low pressure (LP) and high pressure (HP) connections are more resistant to plugging with flyash**
- **Proven**

What are Some of the Myths About Venturis and Flow Nozzles?

Unrecovered pressure drop is the usual and largest criticism of flow nozzles and venturis. However, this becomes a mute point when the overwhelming advantages are considered as listed above, specifically reliability and accuracy! These are boiler proven and not HVAC quality as some of the other primary elements. In coal fired boilers, flyash is a given and with regenerative airheaters, flyash entrainment in the primary, secondary and overfire air streams is a fact that must be handled.

Back to pressure drop. Some years ago I was involved with a 750MW corner fired boiler that we wanted to install flow nozzles in the primary air ducts. The customer was concerned that we would restrict the primary airflow by installing flow nozzles with 4" of water column differential at full load. Well first of all, most of the change in pressure across the flow nozzle is recovered downstream. In this case, 2" w.c. was recovered, which resulted in a net change in pressure of the nozzle of 2" w.c.

Secondly, when we measured the static pressures from the primary air fans to the mill inlets, we found the hot air dampers were controlling at a differential of 14" w.c. Therefore, after installing the flow nozzles the hot and tempering air dampers simply were required to be open slightly more. On this job and several others, due to the better response, accuracy and confidence in the reliable primary elements, the primary air fan plenum pressure could actually reduce several inches of water, thus saving auxiliary power and reducing air heater leakage. So in our experience, which is many years and many boilers, we find the unrecovered change in pressure of flow nozzles and venturis to be a non-issue.

Why are “Hot-K” Calibrations Required?

No matter what type of primary element for flow measurement, we strongly recommend “Hot-K” calibrations. Whether it is an airfoil, averaging pitot tube, venturi or flow nozzle, the sensing lines for the high pressure tap and the low pressure taps are subject to internal duct stratifications and surface discontinuities. Let’s face it, the inside of boiler air ducts do not have the same attention to surface finish as a Boeing airplane wing does. Besides the surface discontinuities, such as expansion joints, duct stiffeners and damper frames, there is the density factor. For example, if a primary air flow nozzle used to control 450°F primary air is calibrated in 70°F cold air, at a velocity of 70 fps and a density of 0.075 pounds per cubic foot; the same airflow weight at operating temperature of 450°F will have a density of about 0.044 pound per cubic foot which results increase the velocity to roughly 120 fps. You may say, so what, that is what the transmitter temperature compensation is for? True, if the surfaces were like a wind tunnel’s with many diameters of straight lengths of ductwork. But in the real boiler world of dampers, expansion joints, internal stiffeners and other factors, the flows over the static pressure taps (HP and LP) can vary drastically. We have seen variations from cold air to hot air as much as 30% in what we call, “K Factor shift”. This is a huge factor when it involves primary airflow or overfire airflow measurement and control. Keep in mind, everything that we do in combustion is based on mass flow of air, not volumetric flow. If you wish to receive more information on how to conduct a “Hot-K Calibration” send us an email and we will provide further information.

Summary

For those of us old enough to remember the muscle cars of the 1960s, we remember 427 cubic inch V8s with two four barrel carburetors, headers, and blistering brute horsepower; fun, noisy, and tough on tire wear. Well, today with modern fuel injection engines, precise airflow to each cylinder, catalytic, converters and electronic ignition, a new Shelby GT 500 Mustang can put out 650HP, do zero to 60 in a few seconds and reach 200 mph top speed on a closed course speedway. The same car can achieve more than twice the fuel mileage of a 1967 Shelby driven similarly.

1967 Shelby GT500 Mustang

2013 Shelby GT500 Mustang

Well for boilers, the advancements are much the same! What are the parallels? Airflow plus fuel flow measurement and control to the cylinders of a high output V8 is similar to the challenge we have on a large utility boiler. Think about the residence time that we have to work with compared to the engineers that deal with valves opening and closing at 60 times a second! Two seconds seems like enough time to get combustion complete, providing the air plus fuel is measured precisely!

One closing thought: It is election time and there are some candidates for office that respect America’s treasure of fossil fuels. You know who they are. Spread the truth of energy from within America’s borders to your friends! Take some time and visit the Facebook page “I Love Fossil Fuels” and check out Alex Epsteins websites http://industrialprogress.net/ and http://alexepstein.com/ Alex has a debate on November 5 at Duke University with Bill McKibben on manmade global warming. Is it true or false? I plan to be there to support Alex!

Have a great month,

Richard F. Storm

Richard F. (Dick) Storm, P.E.
CEO/Senior Consultant

Picture Sources:
“1967 Shelby GT500 Mustang” source: 67mustangblog.com
“2013 Shelby GT500 Mustang” source: Autoweek.com

Large Electric Utility Boiler Combustion and Performance Optimization Seminar

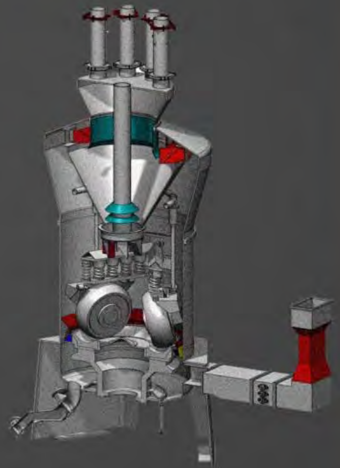
SERVICE QUALITY RESULTS STORM

When : January 30th & 31st, 2013
Where : Charlotte Marriott SouthPark
2200 Rexford Road
Charlotte, NC 28211

Pricing Includes : registration, learning materials, breakfast & lunch
Standard Rate : $995 / person
Groups of 5-9 (15% discount) : $845 / person
Groups of 10+ (25% discount) : $745 / person
*Limited to 25 Participants

Registration:
Phone: Contact Laura Lorch at (704) 983-2040
Fax: (704) 982-9657

Course Topics:



- Basic Steam Generation
- Evolution of Steam Generators
- Boiler Fundamentals & Design
- Water & Steam Properties
- Basic Thermodynamics
- Boiler Reliability
- The Fundamentals of Combustion
- Typical Plant Performance Challenges
- Comprehensive Diagnostic Testing
- Heat Rate Awareness
- Applying the Essentials
- Coal Quality Fundamentals
- Coal Pulverizers
- Boiler Design
- Fuel / Ash Properties
- The Solid Fuel Injection Systems Approach to Air & Fuel Flow Management
- Low NOx Firing Systems
- Biomass Combustion
- Case Studies
- Circulating Fluidized Bed Boilers (Time Permitting)
- Oil & Gas Firing (Time Permitting)
- Energy, Economics and the Enviroment (Time Permitting)

Instructors:

Richard (Dick) F. Storm - CEO of Storm Technologies, Inc., is a registered PE with over 40 years experience in the industry. This experience has been accumulated as a results and start-up engineer for OEMs, as a principal engineer and superintendent of operations for a major utility, and as a department head for a technical services department of a boiler maintenance contractor. These experiences preceded the last 20 years at Storm Technologies, Inc.

Danny Storm serves as President of Storm Technologies, Inc. with over 20 years of experience. His experience includes conducting combustion optimization programs and providing engineered solutions for utility and industrial plants. As a seasoned professional in the industry, Danny's expertise has been refined by leading numerous field service testing projects, developing fan-boosted OFA systems from concept to completion, and producing pulverizer performance components and airflow management systems for large steam generating plants. Danny has degrees in Mechanical Drafting and Design and Mechanical Engineering Technology.

Adam McClellan (VP of Engineering) & Shawn Cochran (VP of Field Services) are both registered professional engineers. They have worked in the field leading numerous domestic and international service and engineering projects that focus on the topics covered in this course. Both Adam and Shawn graduated from North Carolina State University with degree s in Mechanical Engineering.

Therefore, the topics discussed are presented from a perspective of design, best operation, maintainability, objectivity and with a practical focus on getting the most cost-effective RESULTS!