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By: Richard F. Storm and Staff of Storm Technologies, Inc.

**The Art and Science of Heat Rate Improvement  
For Large Pulverized Coal Fueled Power Plants**

Much has been written on the science of "Heat Rate" improvement, but not so much on the Art and Techniques of achieving day to day "Best in Class" heat rate performance. Pointing out the fundamentals is a favorite target for our company. Combustion optimization continues to be a recurring opportunity. In Figure No. 1 below, is an example of "Typical" opportunities for heat rate improvement on a 400MW pulverized coal fired unit. Most of the controllable losses are air in-leakage, air heater leakage and combustion airflow management. All airflows entering the boiler should be measured and controlled.

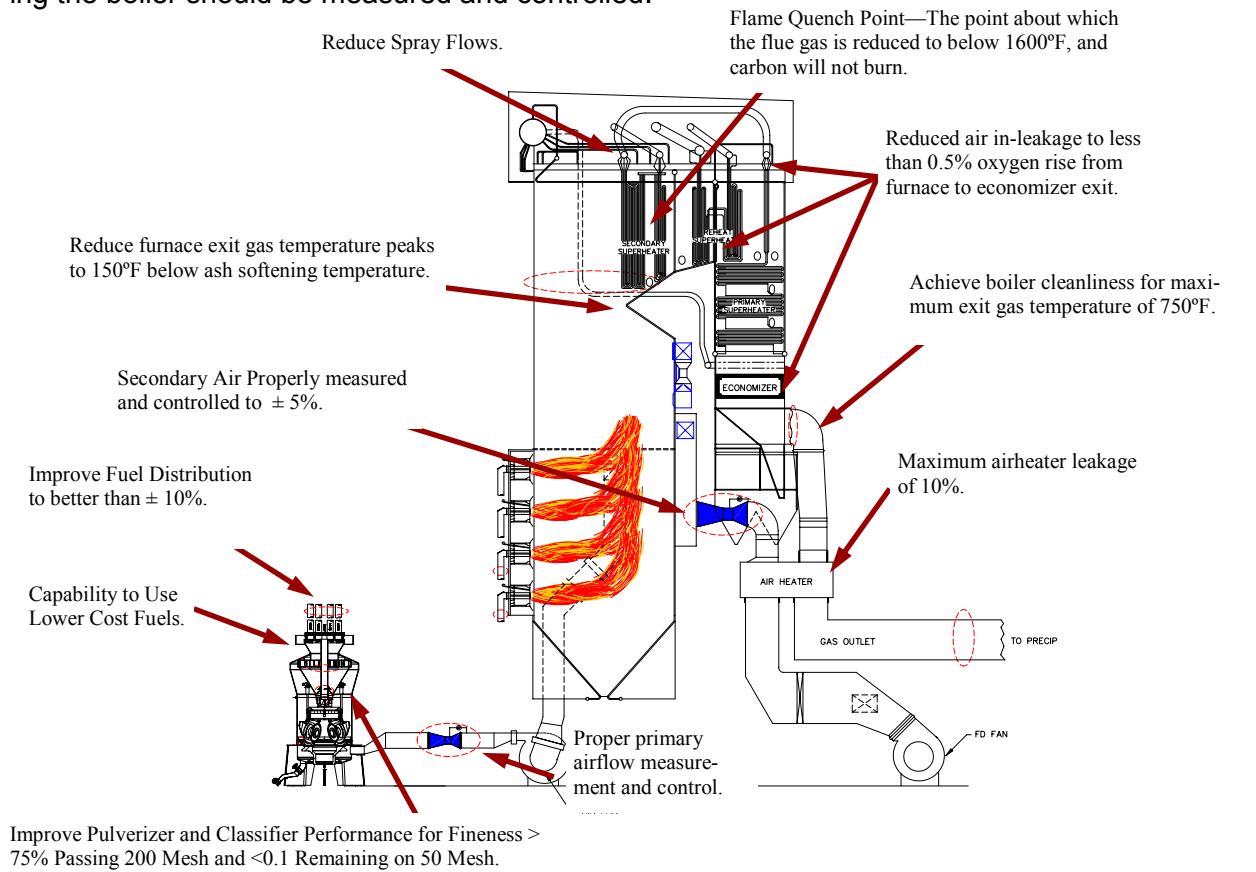


Figure No. 1

The opportunity for excellence in O & M can be shown in Figure No. 2 below:

**Large coal fired power plants have regressed in efficiency over the last 40 years Due to over-regulation and the absence of applying the fundamentals**

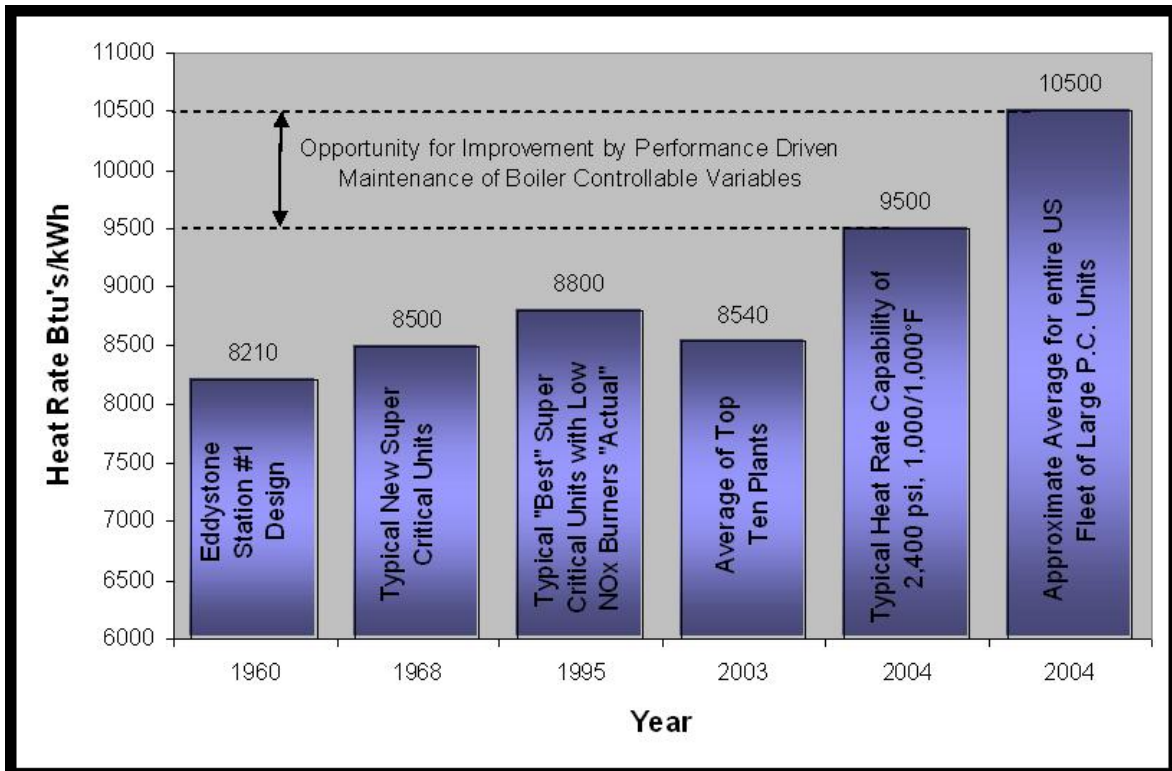


Figure No. 2

It has been our experience that the "average" (Who likes the term average or mediocre?) pulverized coal plant has about 300 to 500 Btu's per kWhr in heat rate improvement. By optimizing combustion, we specifically mean five important general recommendations:

1. Correct air in-leakage
2. Reduce air heater leakage
3. Measure and control all combustion airflows - i.e. primary, secondary and overfire
4. Apply the 13 Essentials for optimum combustion with low NO<sub>x</sub> burners
5. Optimize pulverizer performance.

These are practical and have been accomplished at a number of plants. Key to success is the coordinated and comprehensive application of an action plan that is bought into by all of the plant team. That means, Operations, Results Engineering, Plant Engineering, Performance Engineers, Maintenance Personal and of course, Top Plant Management.

Improvements in combustion optimization can provide increased reliability as well:

### **What is Reliability?**

#### **Reliability and Cost Analysis Example:**

If The Plant Experienced Five (5) Tube Leaks or 10 days (240 Hours) Lost Production and Production Replaced by Gas Turbines. [What is the value of this lost production?](#)

$$(240 \text{ Hrs}) * (400 \text{ Mw's}) * (\$40.00/\text{Mw}) = \underline{\underline{\$3,840,000}}$$

#### **Estimate based on:**

- 400 Mw Production
- Approx. \$60.00/Mw Gas Turbine Production Cost
- Approx. \$20.00/Mw Coal Production Cost
- Approx. \$40.00/Mw Delta

\*\*\*\*\*

### **What is a Total Combustion Performance Optimization Program Worth by implementing a Heat Rate Improvement Program?**

#### **Basis:**

Nominal Unit Capacity:	400 Mw
Present Heat Rate:	10,000 BTU/Kwh
Capacity Factor:	70%
Hours of Operation/Year:	8,000
Fuel Cost/MMBTU:	\$1.50
Estimated Fuel Costs/Year:	\$48,000,000 (100% Capacity)
	\$33,600,000 (70% Capacity)

#### **Example:**

$$((10,000\text{BTU/Kwh}) * (400,000\text{Kwh}) * (0.70) * (8,000\text{Hrs/Year}) * (\$1.50/\text{MMBTU})) / 1,000,000 = \underline{\underline{\$33,600,000}}$$

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### **Economic Benefits of Successful Teamwork**

The economic benefits for application of a concentrated team approach to seize the opportunities for improvement in heat-rate improvement are huge. For example, Based on a 400MW Unit, firing coal purchased at \$1.50/MW Btu, and operating at 70% capacity factor, the savings of 300 Btu's/kWhr would be in the range of \$1 million dollars. Further, by reducing high furnace exit gas temperature peaks, the popcorn ash formation, hot superheater tube metals, and tube attachments overheating damage can be reduced, thereby improving capacity and reliability. Also, economic benefits of a total combustion optimization program, previously discussed.

**What is Total Combustion Performance Optimization Program  
Worth After Heater Rate Improvement Program?**

**Basis:**

Nominal Unit Capacity:	400 Mw
Present Heat Rate:	9,700 BTU/Kwh
Capacity Factor:	70%
Hours of Operation/Year:	8,000
Fuel Cost/MMBTU	\$1.50
Estimated Fuel Costs/Year:	\$48,000,000 (100% Capacity) \$32,592,000 (70% Capacity)

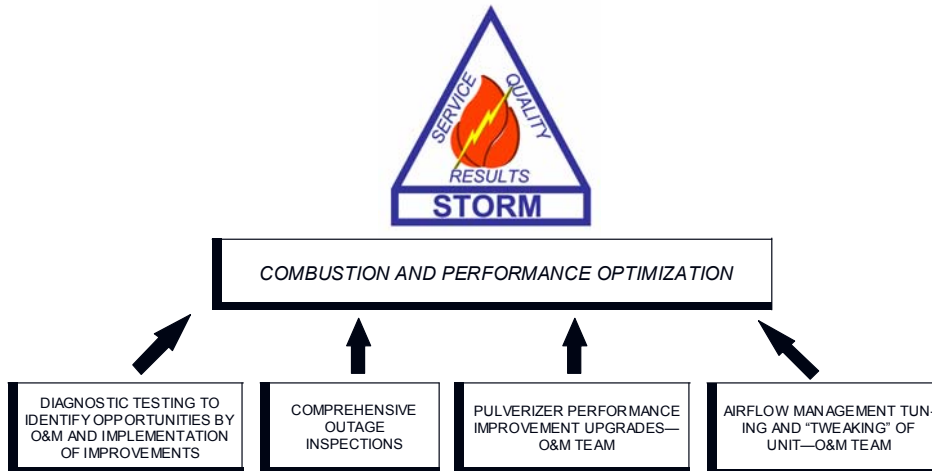
**Example:**

$((9,700\text{BTU/Kwh}) \times (400,000\text{Kwh}) \times (0.70) \times (8,000\text{Hrs/Year}) \times (\$1.50/\text{MMBTU})) / 1,000,000 = \underline{\$32,592,000}$

**Summary of the combination of heat rate and reliability improvements:**

Based on the 300BTU/Kwh heat rate reduction (from 10,000 to 9,700 BTU/Kwh), improving reliability and increasing capacity factor it is possible to see a net gain of: \$3,840,000 (lost production)+ \$1,008,000 (heat rate savings) = \$4,848,000.00

**It's the Commitment that Yields RESULTS!**



Enclosed is our brochure on pulverizer performance kits. Providing that Storm pulverizer performance components are supplied by Storm, and including the installation and set-up by Storm field service engineers, these have been proven to achieve the pulverizers part of the 13 Essentials. Application of Storm flow nozzles and venturis have also been successful in total combustion optimization systems including Fan Boosted Overfire Air, and for primary and secondary airflow measurement and control. We at Storm Technologies, Inc. take pride in being a Results Oriented company.

Let us know if you would like to consider our products and services.

Yours Very Truly,

Richard F. Storm  
President

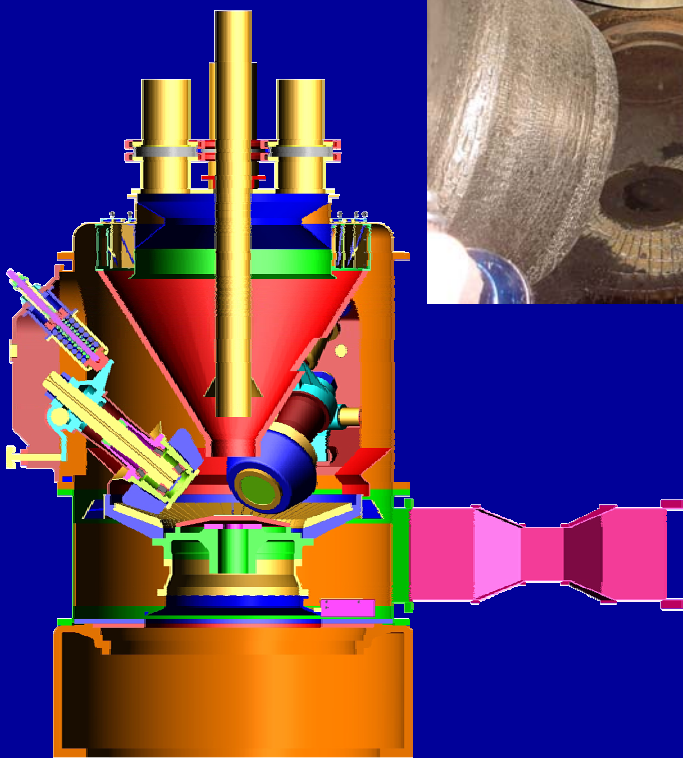
Danny Storm  
Vice President

Julie Curlee  
Sales & Marketing Coordinator

# STORM

*Specialist in Combustion and Power*

## STORM PULVERIZER TOTAL OPTIMIZATION SYSTEM



Optimize the Heart of your system with  
STORM Components for Pulverizers



# Get Results by Modifying your MBF, MPS or Raymond Bowl Mills

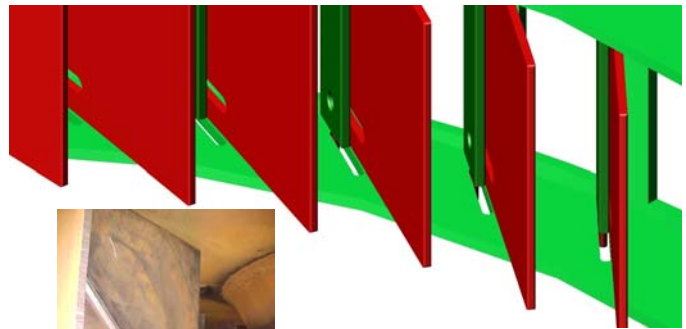
## Benefits & Purpose of a STORM® Design Rotating Throats

- Reduced or eliminated coal rejects, improved vectoring for improved grinding, and improved primary airflow controllability.
- Increased pulverizer & furnace residence time.
- Improved coal fineness.
- Capability to reduce air/fuel ratios.
- Reduced FEGT's with improved combustion lower in the furnace.
- Reduced available "free" oxygen in the high temperature flame core.
- Excessive amounts of primary airflow tend to force ignition points away from the burner as a result of higher burner nozzle velocities, thus allowing infusion of oxygen "rich" air into the flame core and increasing NOX exponentially.
- Reduce pulverizer vibration & rumbling.



## Benefits of STORM® Classifier Modifications

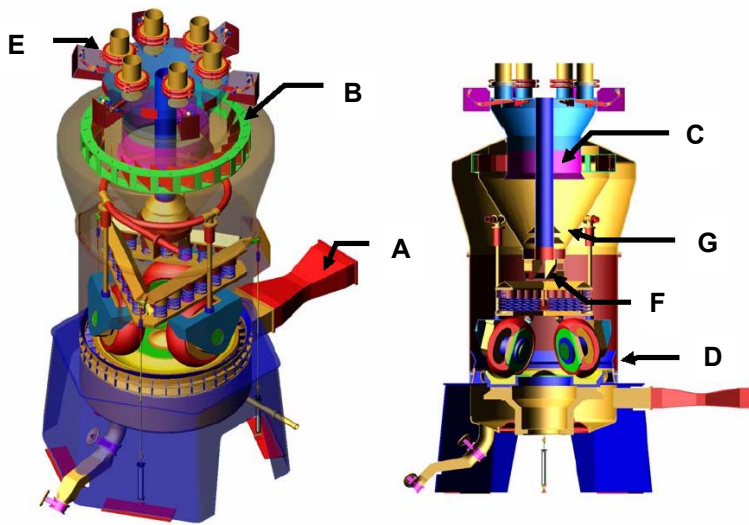
- Reduce 50 Mesh (Coarse particle) bypass.
- Reducing the intensity of "oxidizing" and "reducing" atmospheres within the furnace cavity.
- Installation of STORM classifier blades will create improved swirl, homogenization and fuel distribution. (These must be properly designed and tuned upon installation. Also, the primary airflow ramp and throat configuration must be compatible).



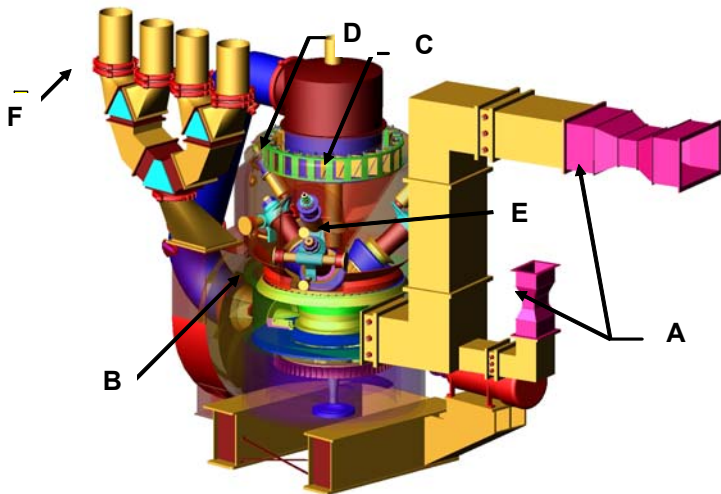
## Benefits of STORM® Primary Airflow Measuring Devices

- 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.



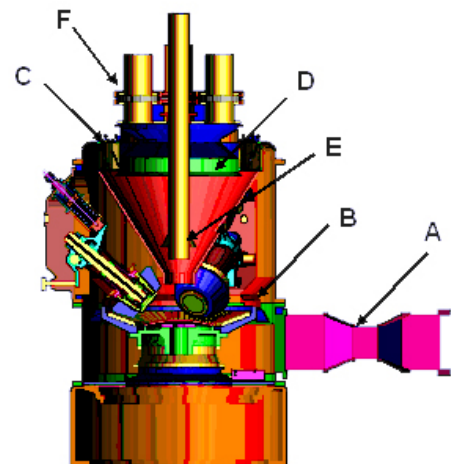


A	Airflow Measuring Venturi for improved measurement accuracy
B	High Spin Classifier Vanes for improved circulation and air/fuel distribution
C	Modified outlet cylinder for improved homogenization & 50 mesh particle rejection
D	Improved Throat & Deflector modification and design for reduced coal rejects, optimum primary classification, vectoring and reduced mill rumbling.
E	Orifices and housings for achieving optimum clean air system resistance
F	Modified flapper doors for improved closure and elimination of large particle bypass of the classifier
G	Inverted cones for coarse particle rejection



A	Airflow Measuring Venturi for improved measurement accuracy --Primary (HOT) & Tempering (COLD) airflow venturis--
B	Improved Throat & Deflector modification and design for reduced coal rejects, optimum primary classification, vectoring and reduced mill rumbling
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F	Orifices and housings for achieving optimum clean air system resistance



## **STORM<sup>®</sup> Results Oriented Services**

**Complete Annual Service Contracts  
Comprehensive Boiler Inspections  
Technical Direction of Outage Repairs  
Complete Testing Programs  
Specialized Testing Equipment**

**Airflow Measurement and Control Devices (Design Fabrication  
and Calibration)**

**Flyash Carbon Reduction Programs  
NOx Emmissions Tuning**

**Combustion Improvement Programs for:**

**Pulverizers**

**Burners**

**Fans**

**Fuel Change Evaluations**

**Boiler Surface Area Evaluations**

**Air In-Leakage**

**Testing and Corrective Plans of Action**

**Pulverizer Capacity and Fineness Improvements**

**Secondary Air Balancing**

**Air Heater Leakage and Performance**

**Heat Rate Improvements Through Boiler Optimization Programs**

**Failure Analysis**

**Consulting**

**Seminars**

**Immediate Technical Responses**

**Access to a Full Service Fabrication and Machine Shop**

**Fast Equipment, Parts, or Service Turn-Around Time**

**Outstanding Fabrication Quality**



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