Coal Combustion Inc.
Understanding the business of coal

Three-day Coal Quality & Combustion Engineering Workshop

Class by Rod Hatt

114 South Main Street, Versailles, KY 40383 Phone: (859) 873-0188 Fax: (859) 873-0252
Please visit our website at www.coalcombustion.com

Coal Combustion Inc.
Understanding the business of coal

Three-day Coal Quality and Combustion Engineering Workshop

Class Outline
By Rod Hatt

Boiler Basics

Major components of PC - fired boiler

Coal Formation

What is Coal -

Coal Rank

Where are the different coals located?

Coal Mining

- Surface
- Deep

Out of seam dilution

Coal Washing
Drying coal

Transportation Impacts
- Time and Climate
- Barge Coal tends to gain moisture

Sampling coal and coal analyses

- Sampling methods
  - The Good, The Bad and the Ugly
  - Good sampling is hard work
- ISO, ASTM Sampling
  - Guidelines
    - Hand samples
      - Feeder and belt
      - Car top
    - Mechanical Sampling
      - Sampling systems
      - Augers
      - Core holes

Terms

Proximate ï Moisture, ash, volatile, fixed carbon (by difference)
Short Prox ï Moisture, ash, sulfur, Btu/lb
Ultimate ï Moisture, ash, sulfur, + carbon, hydrogen, nitrogen, oxygen (by difference)

Coal Cost

Sold by the ton - $/ton
Boilers want Calorific Value not tons
Evaluated by the Kcal or millions of Kcal (MMcal.)

Coal Handling

Moisture plays a dominant role

Fines
What sizes are important?

Clays and mineral matter

Chemical additives

Spontaneous Combustion

Combustion

The three Tôs in practice

Size the coal and add air!

Coal Reactivity

The Story of NOX

To minimize the formation of NOx

Post Combustion Control

Coal Combustion Inc.
Understanding the business of coal

Combustion Tune-up Procedures

Air Flow and Balancing

Air Heater Leakage
Other Leakage
Balancing

- O2 levels
- Temperature
- Flows
- Opacity
- NOx

Pulverizer Performance

Coal Sizing
Air and Fuel Flow
Clean and Dirty Coal Pipe Measurements
Pyrite Rejects
Primary Air Flow
Adjustments include:

- Roller and journal pressure, alignment, air flow, Classifiers, temperature, ball charge, ball size,

LOI Testing and Combustion Verification

LOI Test
Carbon in Ash
Sampling Location
Sampling Methods
Operator Feedback
CO Analyses
NOx Analyses

Results Engineering

Boiler Efficiency Testing

- Output/Input
- Heat Loss Method
- **Problem areas**

Improving Boiler Efficiency
Improving Combustion
Optimizing Combustion
Optimizing NOx

Unit Heat Rate

Input/Output
Performance Diagrams

Ash Deposits - Introduction

Types of Ash Deposits

Wall Slag
Superheater Slag
Convection Pass Fouling
Low Temperature Deposits

Causes of Ash Deposits

Fuel Related

Equipment Related

Design Related

Analytical Procedures

The ASTM Fusion Temperature Test.

Ash levels used as slagging and fouling indices.

Elemental loading
Pounds of iron per million Btu
Pounds calcium, sodium, and other elements

Slagging with Bituminous Type Ash - High Iron

Ash fusion temperatures
Advanced ash fusion techniques.

Ash Chemistry

Basic Slagging factors

B/A ï Base to acid ratio, sum of total bases divided by sum of all acid elements
Slagging Factor ï
Ash and Elemental Loading

Slagging index
Dry sulfur x B/A
Iron or sulfur squared term

Silica% Raask Quartz, Clay type

Computer Controlled Scanning Electron Microscopy provide some of the best mineralogical information but has not come into common use.

Cyclone and Wet Bottom Furnaces

Ash Viscosity ï
Calculating T-250
Measuring T-250
Temperature verses Ash Viscosity Curves

<u>Fouling Deposits</u>

Sulfate salts ï $CaSO_4$, (K, Fe) SO_4, H_2SO_4, $(NH_4)HSO_4$, $(NH_4)_2SO_4$

Chemical Fractionation
Active alkali
Water soluble
Ammonium Acetate soluble
Weak acid soluble
Micro crystals

Major and Minor Ash Elements
Acid Oxides or Glass Formers
Basic Oxides or Fluxing agents or Gluing Elements

TABLE I - Major Causes of Ash Deposits

Fuel Related	Large pyrite particles that impact the furnace wall before they completely combust
	Clay minerals that contain significant amounts of iron, calcium, sodium or potassium causing them to have low melting temperatures
	Interaction of pyrite, clays and alkalis with alumino silicates to form low viscosity melts
	Extremely fine or organically bound alkalis
Equipment Related	Soot blowers not in operation or used improperly
	Poor pulverization of fuel
	Improper air to fuel ratio
	Burners damaged or improperly adjusted
	Changes in operation of boiler or other equipment
Design Related	Furnace size too small for fuel
	Tube material and/or spacing inadequate
	Soot blowing coverage inadequate
	No means provided to observe slag buildup

Most Slag begins on the Furnace walls and the proceeds up the furnace

Advanced Methods for Slag

- Mineral and Elemental Analyses of Coal
  - Computer Controlled Scanning Electron Microscopy (CCSEM)
    - Uses Energy Dispersive X-ray Analyses (EDAX) to size and quantify elemental composition.
  - Low Temperature Ashing
    - Microscopically identify minerals present
  - Chemical Fractionation
    - Provides information on Organically Bound elements
  - Elemental Analyses of float sink and/or size fractions
    - Can be performed by ASTM coal laboratories
      Pounds of iron per million Btu
    - Pounds calcium, sodium, and other elements
- Ash Deposit Analyses
  - Sampling Procedure for Ash Deposits
    Polarized Light and Scanning Electron Microscopy
    Forms of Iron by chemical fractionation
    Mossbauer spectroscopy

Fouling Deposit Formation

Electrostatic Precipitators

Basic Operation Principles
- High Voltage DC ï Transformer Rectifier Sets
- Voltage Control ï Controlling the wave from and sparking rate
- Sizing ESP ï Plate area (fixed) and Flue gas volume (operational variable?)
- Migration Velocity or why the particle goes to the plate
- Ash Resistivity concerns
- Gas Velocity ï impacts ESP size and treatment time
- Rapping ï important equipment that can be high maintenance
- Hopper Evacuation ï useful for determining ash partitioning
- Dust Collection and Storage

Advanced ESP Methods and Tune-up

- Combustion Influences
- Calculating and Measuring Fly Ash Resistivity
- Correlating and making sense of resistivity data
- Rappers
- High Voltage controls
- Measuring gas flows and particular loadings
- ESP Inspections
- Tune-up Procedures

- Ash Handling
- Scrubber
- Out of stack pollutants
- Trace Elements

Summary

Coal Specifications

Computerized Evaluations

Test Burns

Conclusion