Understanding Slags & Fouling Deposits

TNBF/RCBC

October 9, 2018

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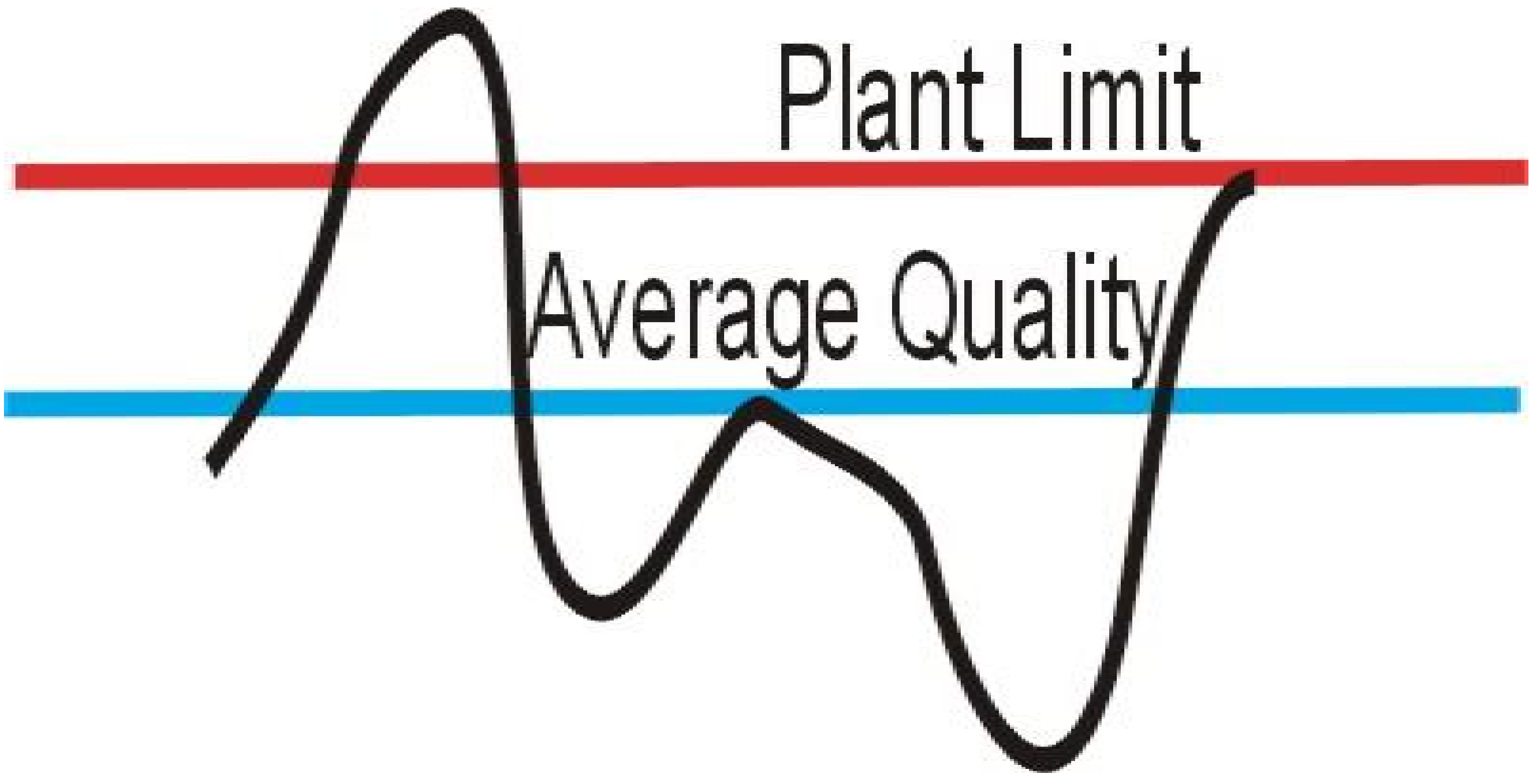
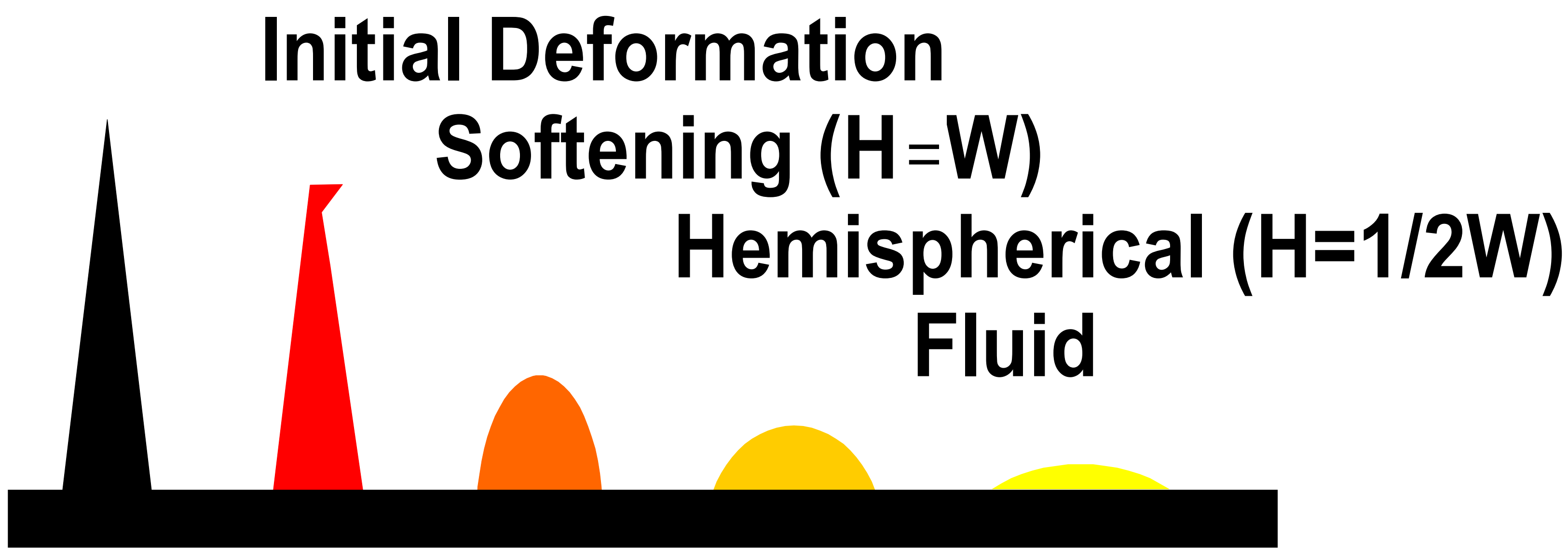
Coal Combustion Inc.
Understanding the business of coal


High Fusion Temp Ash
RAW COAL ASH
CLEAN COAL ASH
Low Fusion Temp Ash


Plant Limit
Average Quality

Why are we using fusion temperatures?

Test for stoker type boilers
No mineralogical data
Not the same reactions for all coals

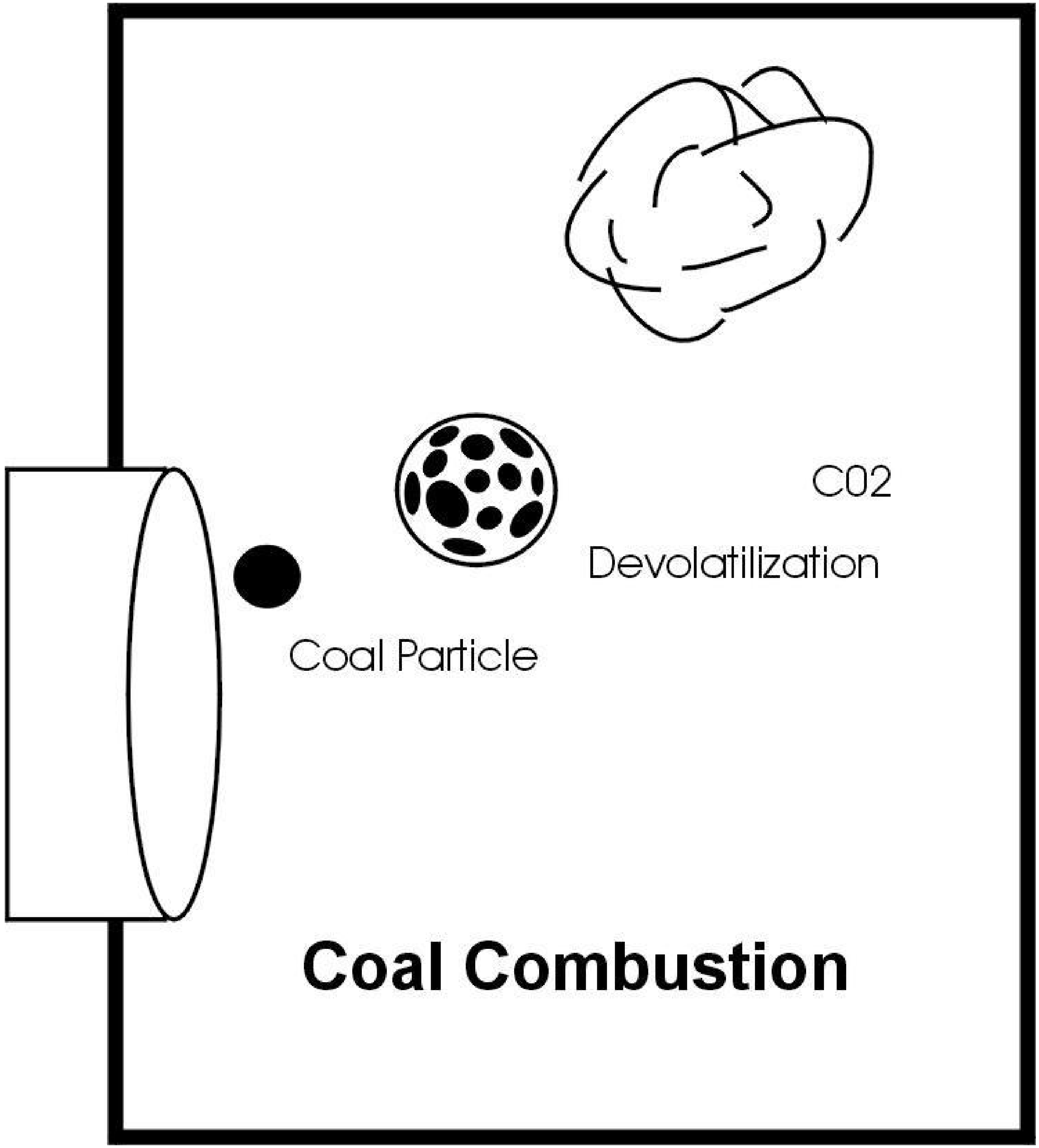

Initial Deformation
Softening (H=W)
Hemispherical (H=1/2W)
Fluid

Physical Test

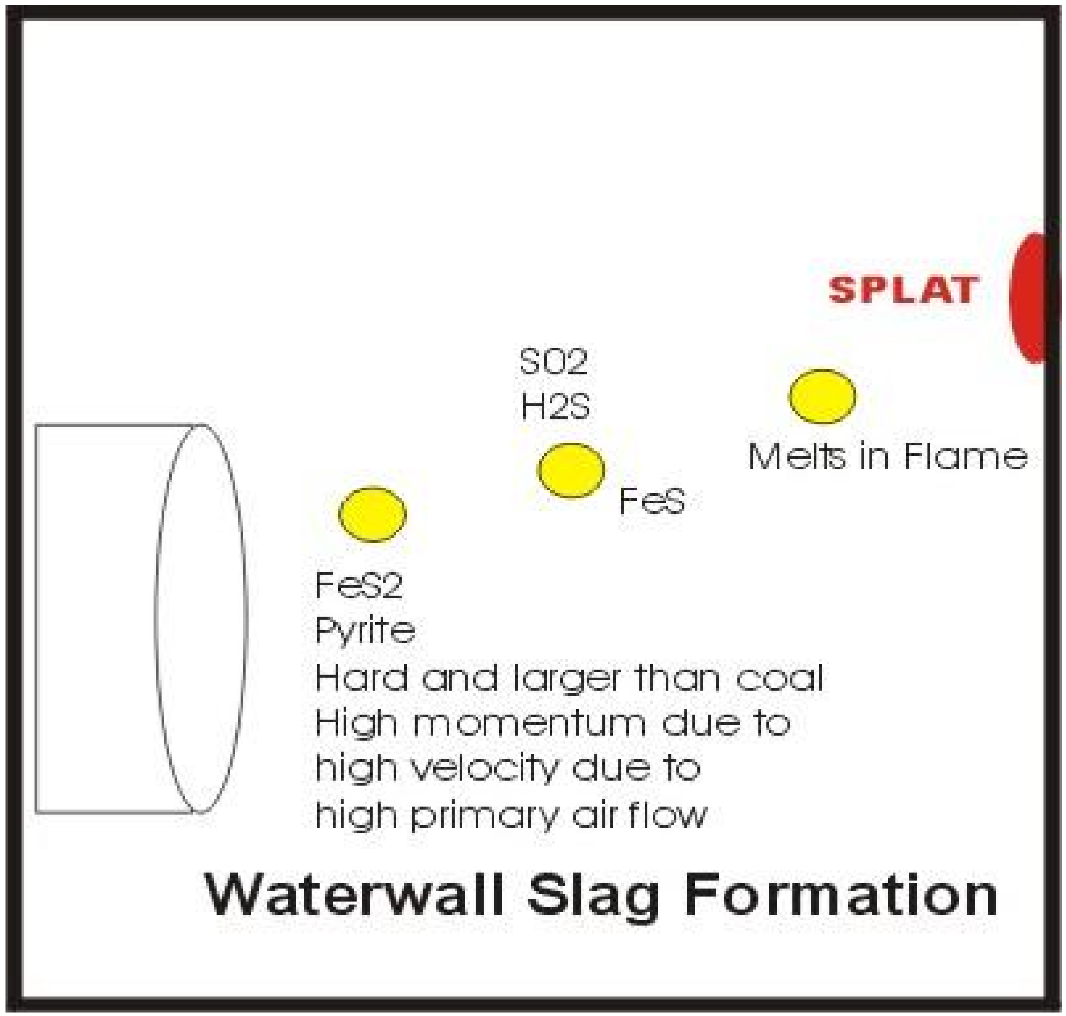
Oxidizing verse Reducing

Combustion Conditions

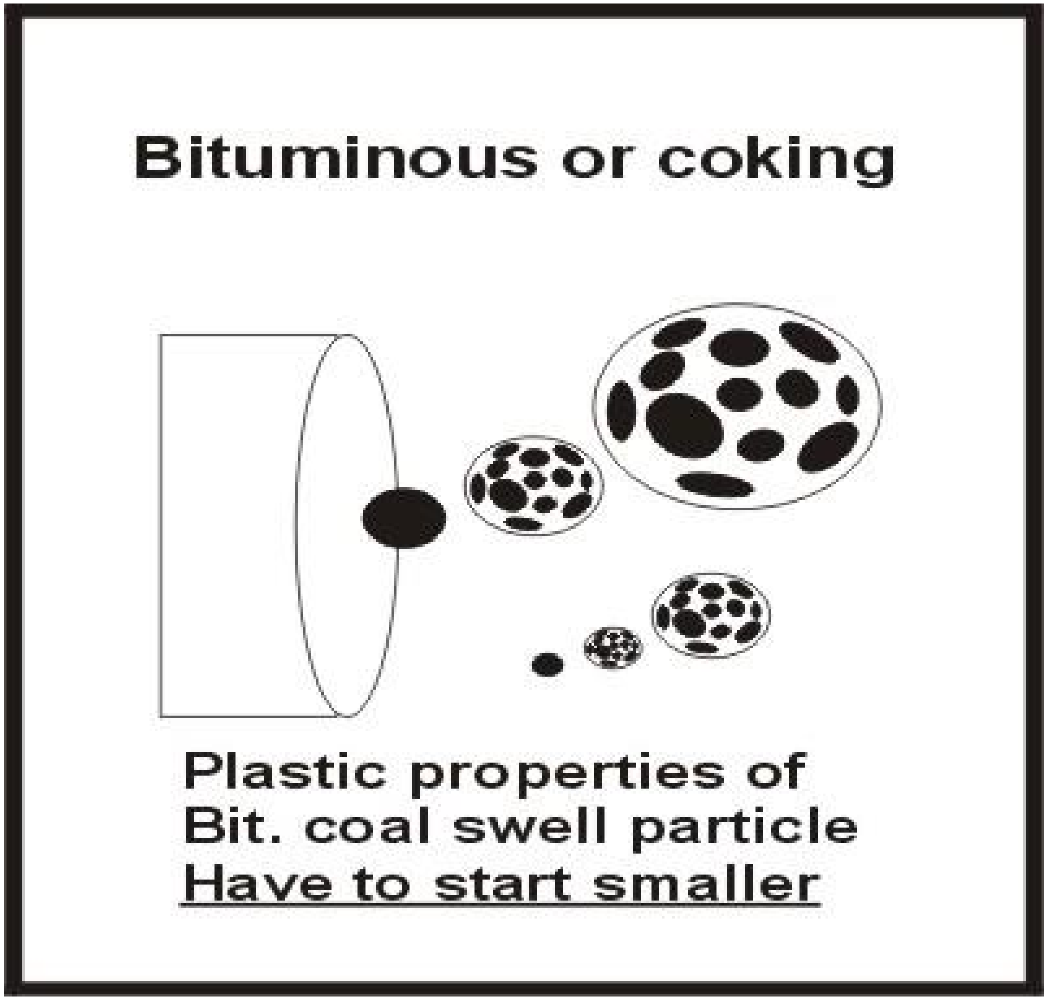
Poor Lab to Lab


C02
Devolatilization
Coal Particle
Coal Combustion

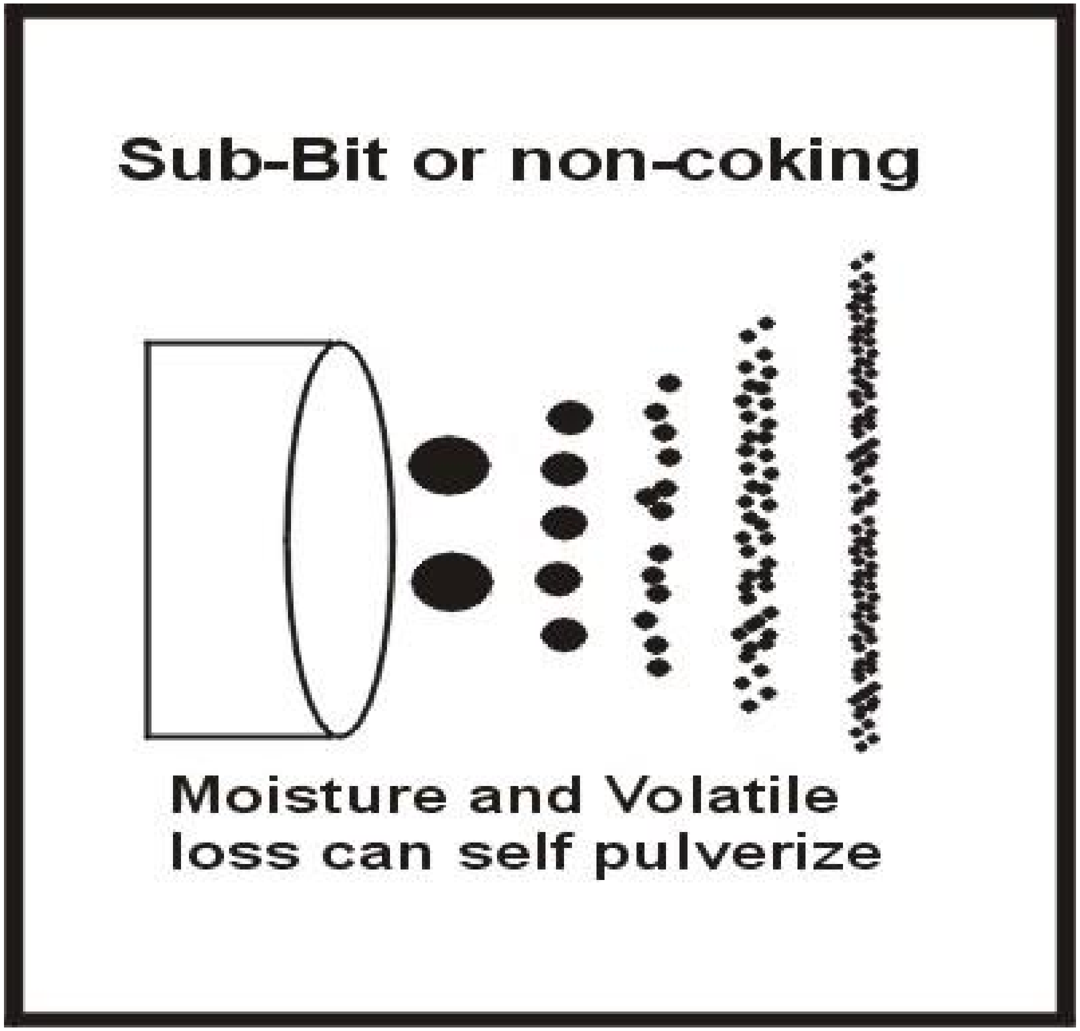
Coal Combustion



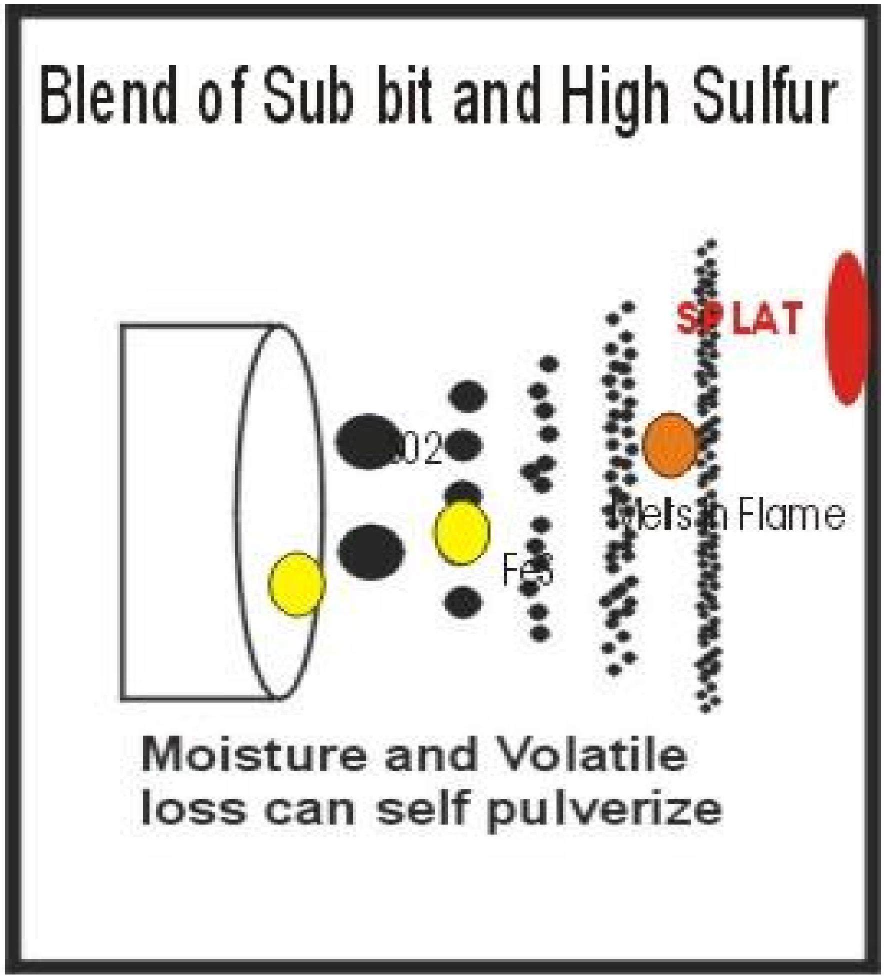
Bit Coal Combustion

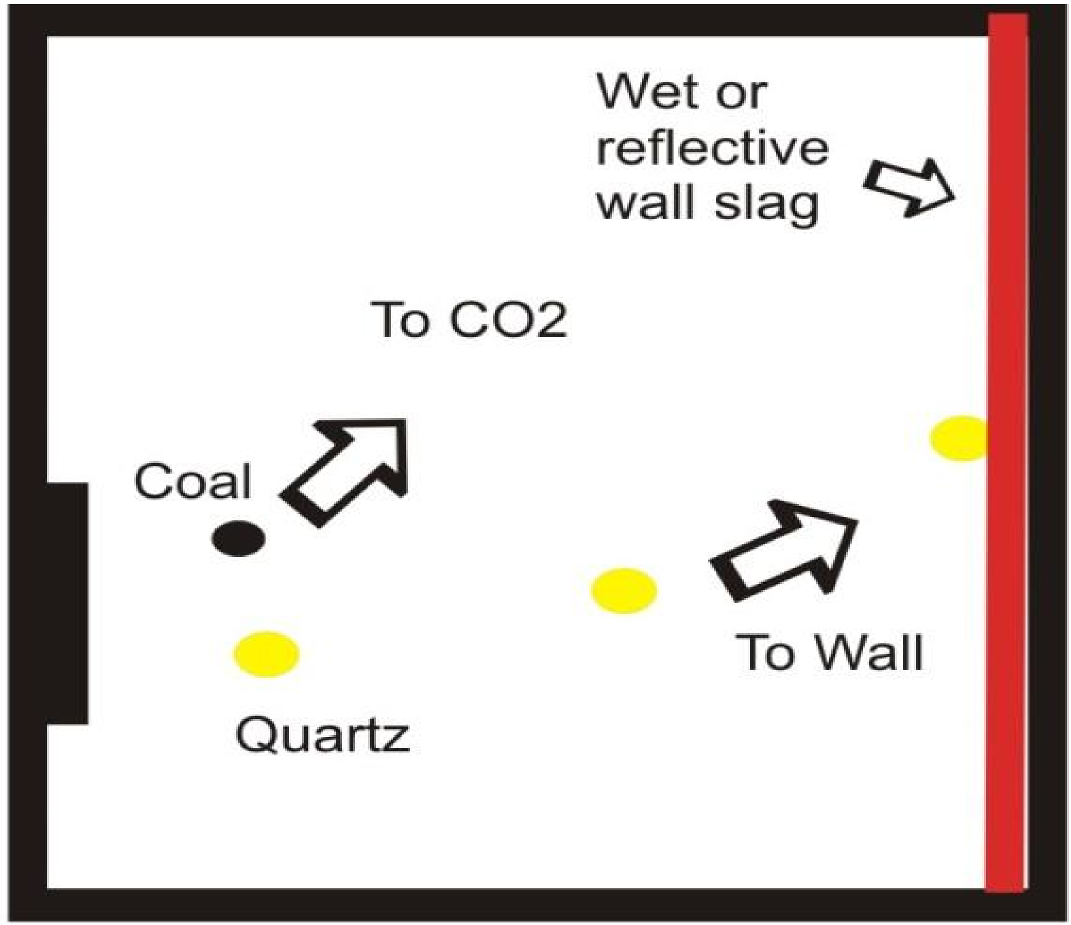


Sub-Bit Coal Combustion



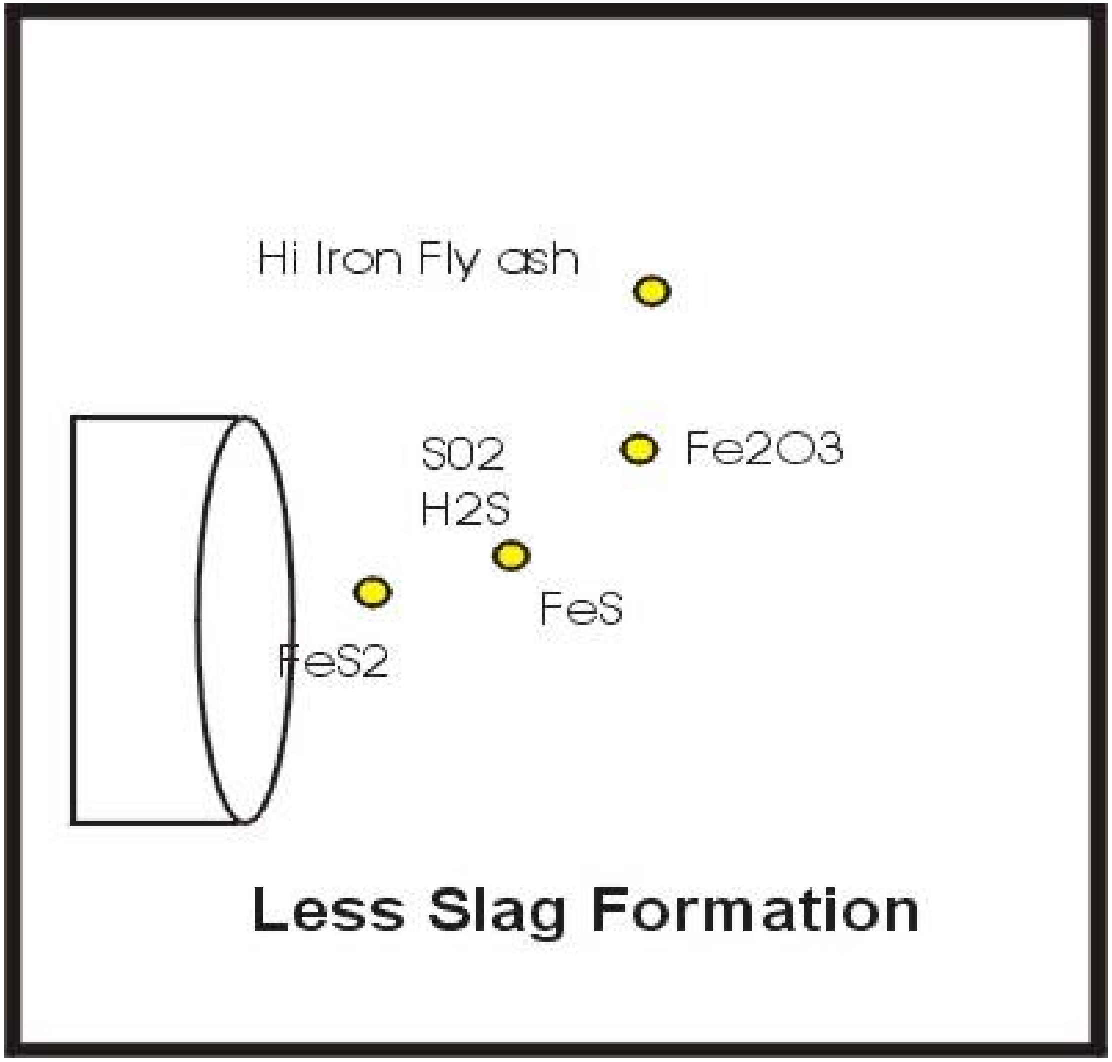
Coal Combustion



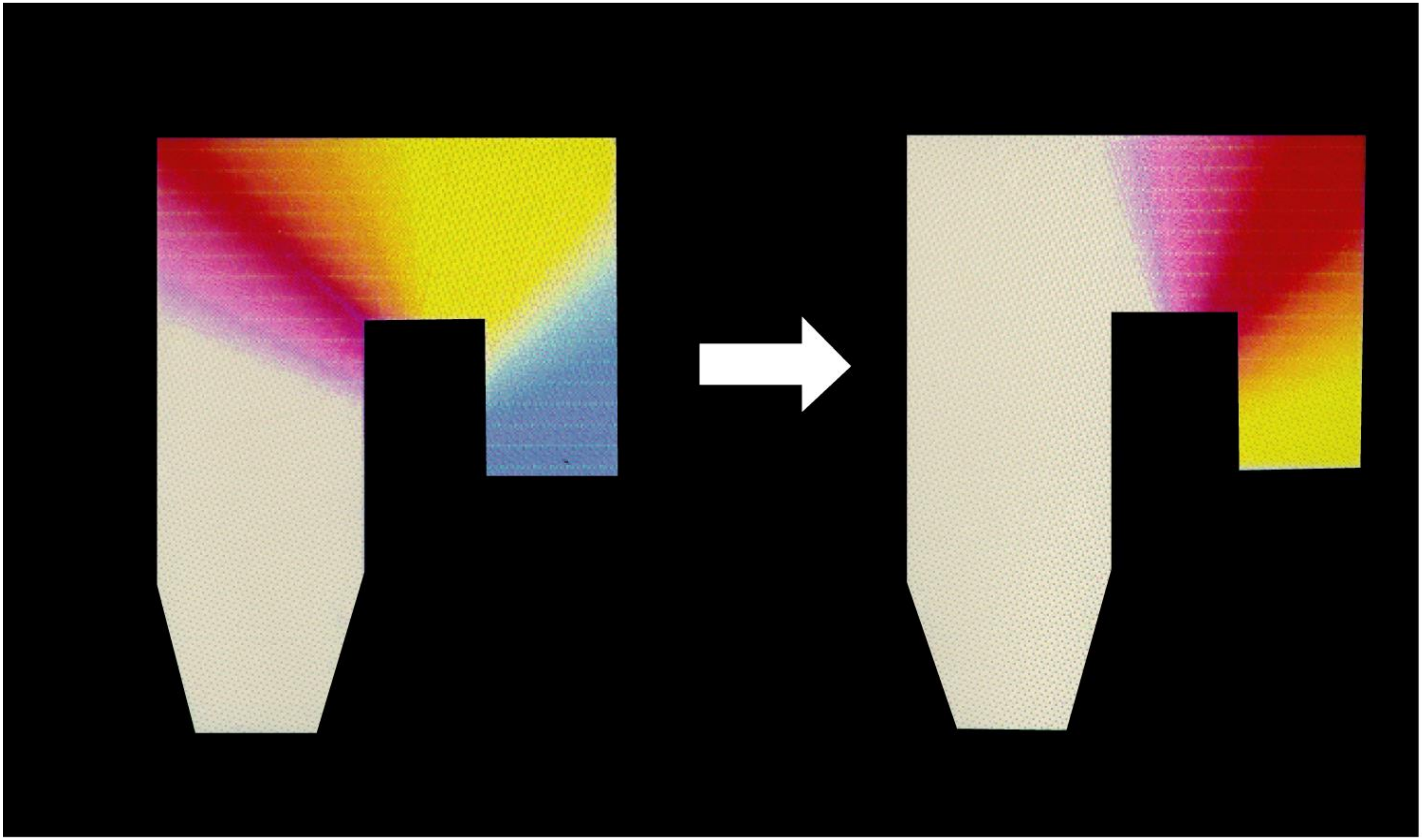


How high ash, high OSD, coals can increase wall slag with raw low ash sub-bituminous coals.

Coal Combustion

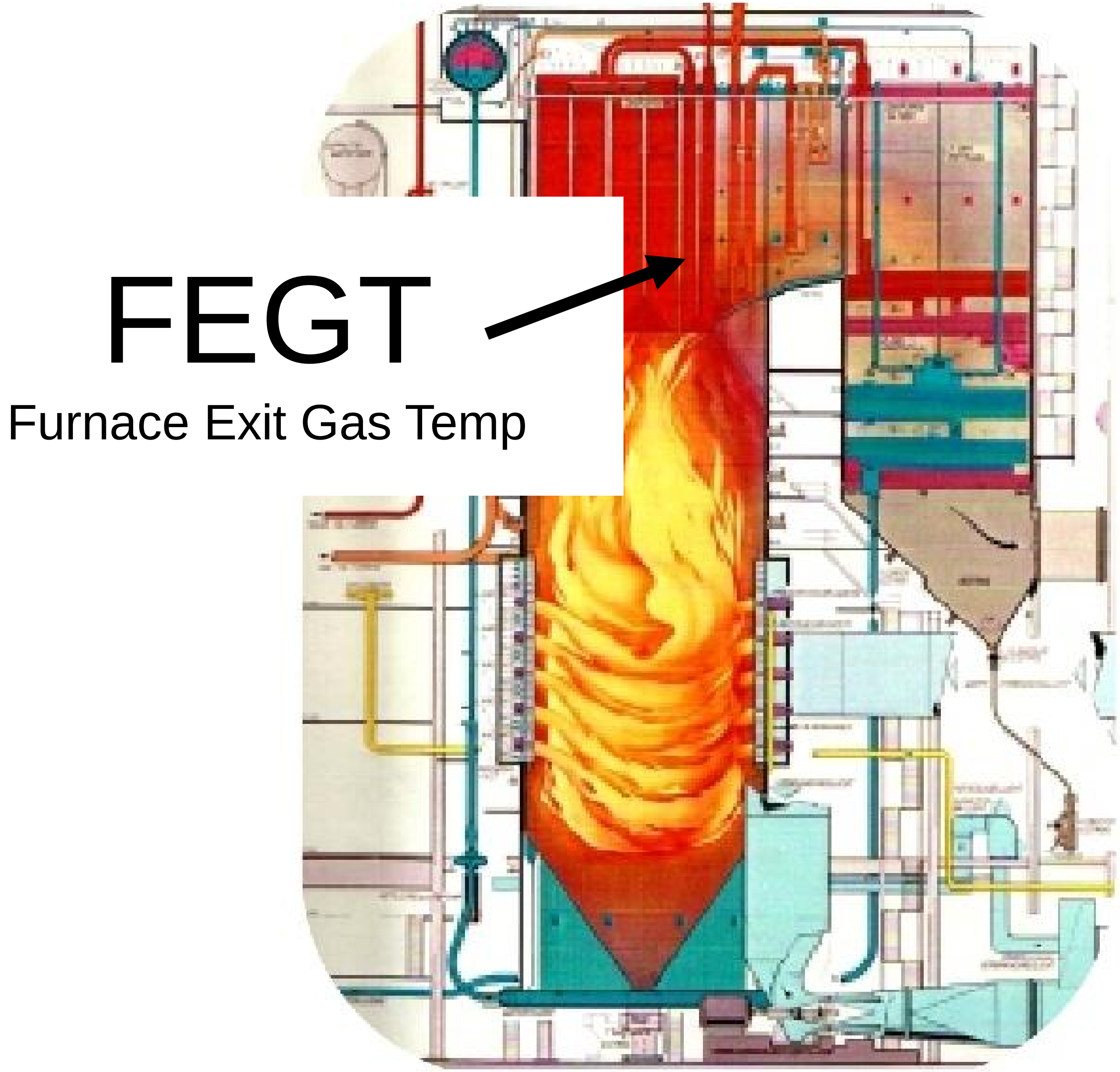


Most Slag Starts on walls



Waterwall deposits force heat to convection pass.


Then goes
To the
Superheater


FEGT
Furnace Exit Gas Temp

Ash Chemistry
Major & Minor Elements

SiO_2
Al_2O_3
TiO_2

Fe_2O_3
CaO
MgO
K_2O
Na_2O

Minerals include

Quartz
Pyrite
Clays and shales
Carbonates

Acid Oxides	Basic Oxides
SiO_2	Fe_2O_3
Al_2O_3	CaO
TiO_2	MgO
	K_2O
	Na_2O
Glass Formers	Fluxes

Role of Iron

Acid	Base
Fe_2O_3	FeO
	Fe_3O_4
Oxidized	Reduced
Good	Poor

Fusion Spread Ox-Red

Iron Level	delta Temp.
5	20
10	70
20	200
25	300

Slag is a build up of rate process so, the amount of ash should matter.

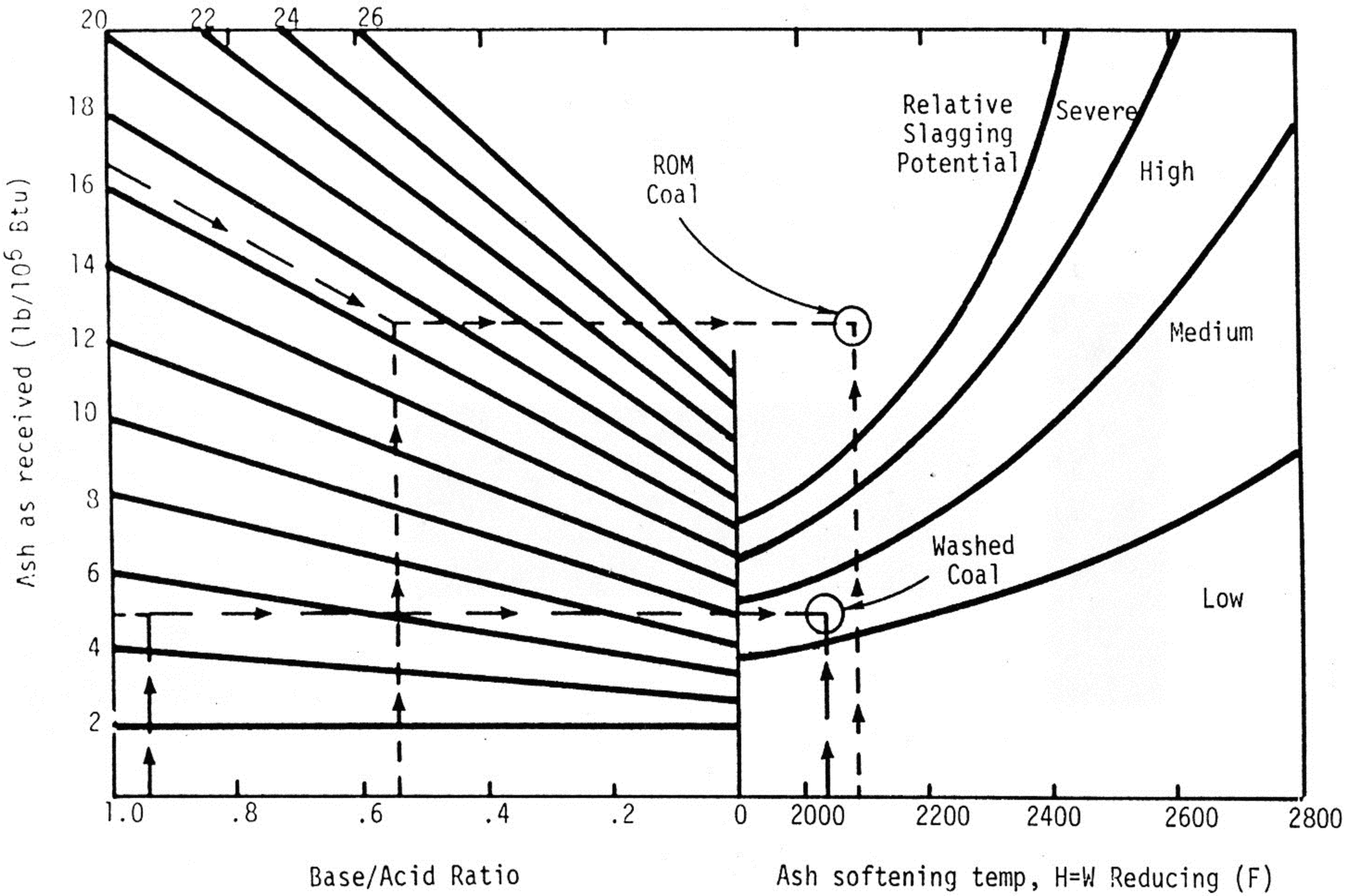


Figure 2-23. AEP slagging index (31).

Kg of ash/MKcal

= %ash / (Kcal/10,000)

Test	Hi Na_2O	Low Na_2O
Btu/lb	5,167	5,000
% Ash	4.0	6.5
% Na_2O	8.0	5.0

Test	Hi Na_2O?	Low Na_2O?
Kg Ash/MKcal	7.7	13
% Na_2O	8.0	5.0
Kg Na_2O/MKcal	0.62	0.65


Splat Factor

Velocity is Important

Kinetic Energy =

$$\frac{\text{Mass x (velocity)}^{2}}{2}$$

Large dense particles
Pyrite Quartz, rock

Coal pipe velocity
Low Btu, Hi Moist.
Hi PA Flow

Kg of Element/MKcal

= %ash / (Kcal/10,000)
X (%Element/100)

SPLAT FACTOR

1. Calculate KE for Quartz and Pyrite particles
2. Multiply KE times Q & P loading levels
3. Multiply result by % on 50mesh screen (>300 microns)

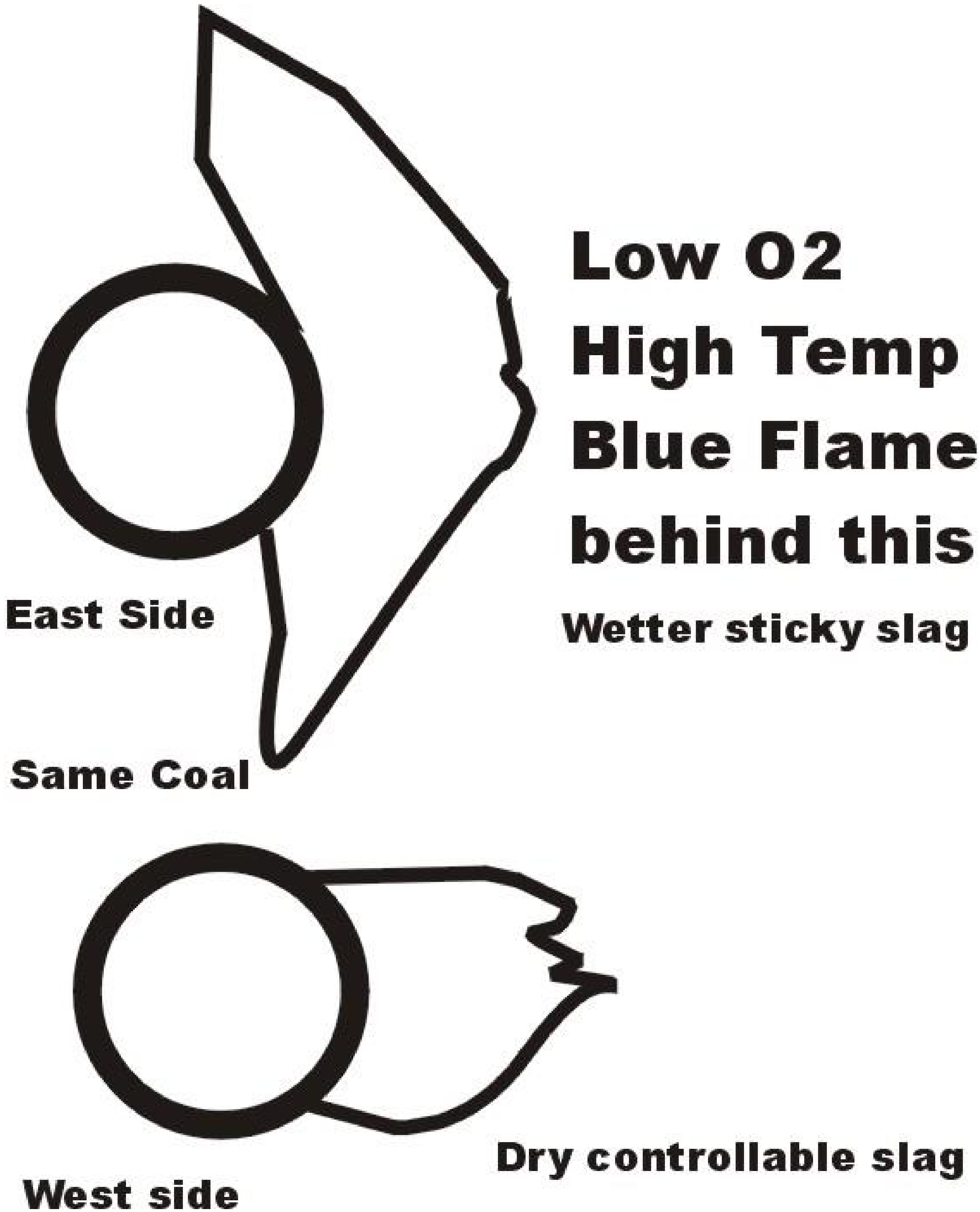
SPLAT FACTOR

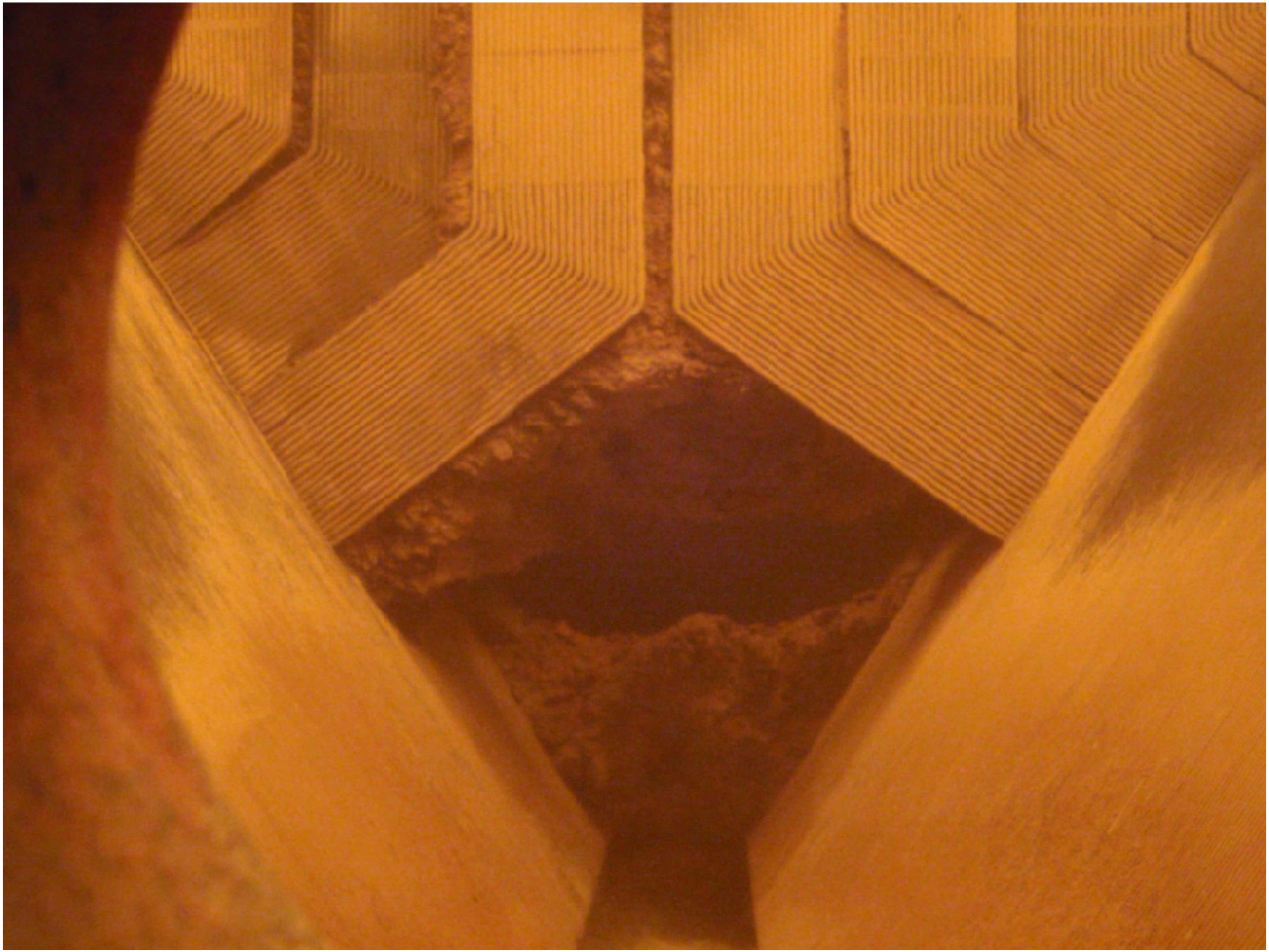
- Low with low levels of large particles
- Low with low levels of ash and sulfur
- Lowers with less PA flow
  - A/F is important

SPLAT FACTOR

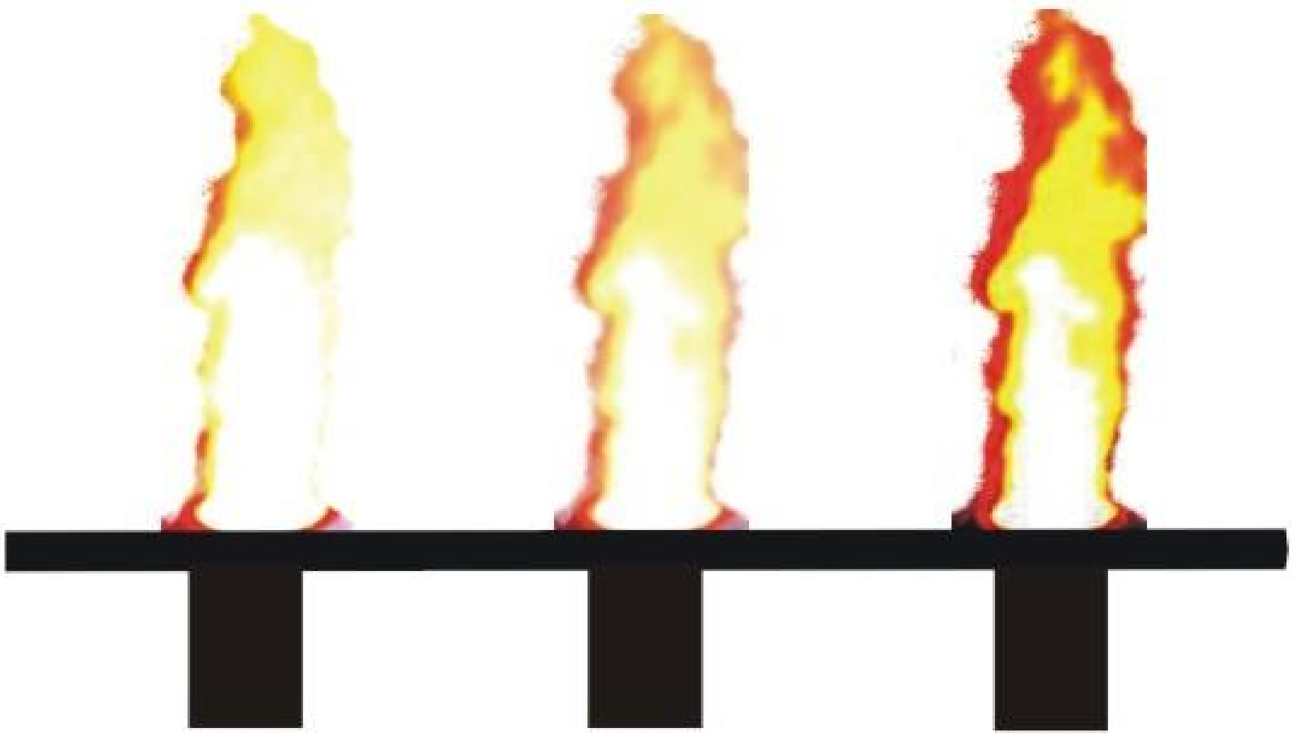
Coal Pipe Velocity increases due to

1. High PA flow (mill A/F)
2. Low CV coal
3. High moisture

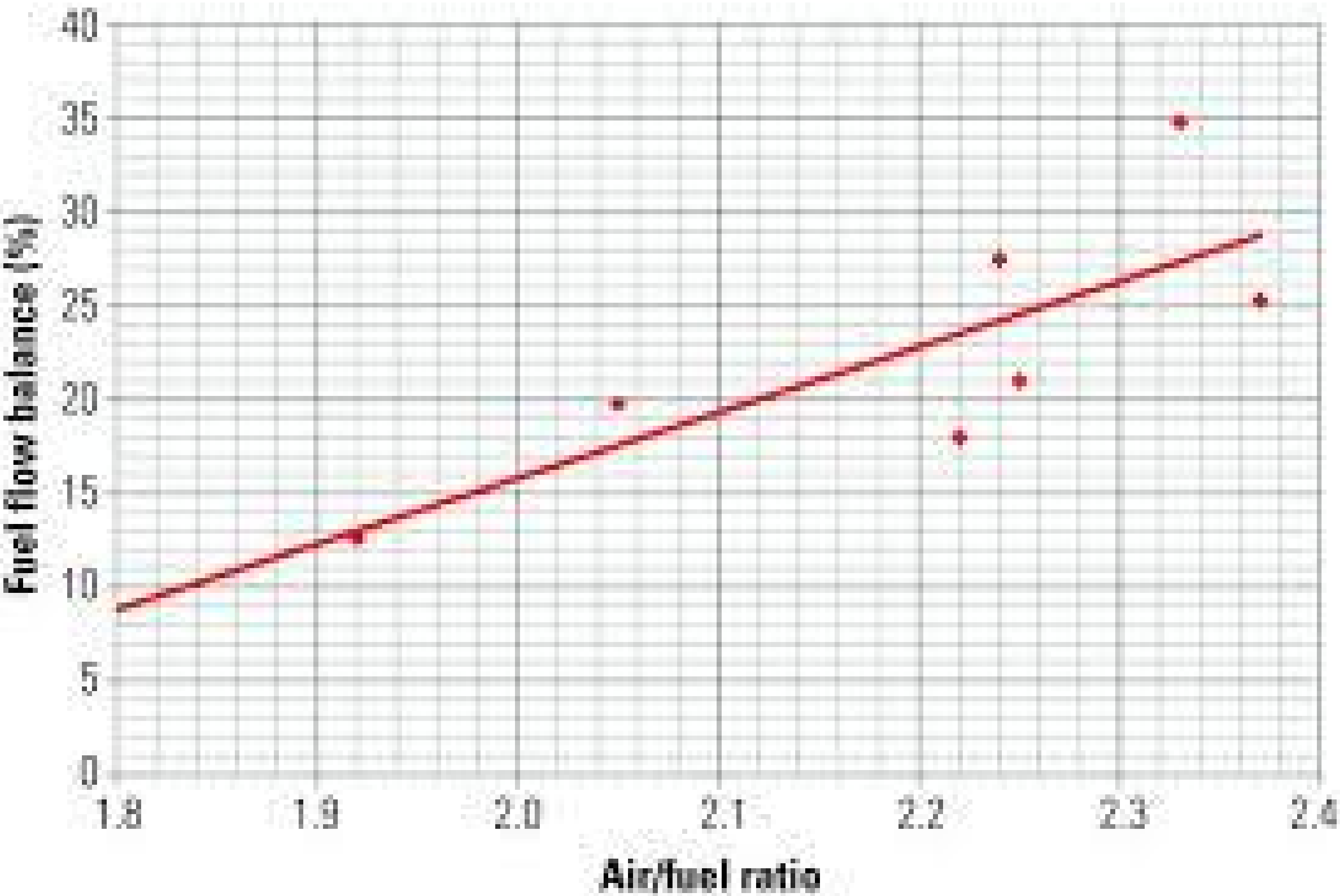

Low O2
High Temp
Blue Flame
behind this
Wetter sticky slag
East Side
Same Coal
Dry controllable slag
West side



How do you balance air if coal is unbalanced?

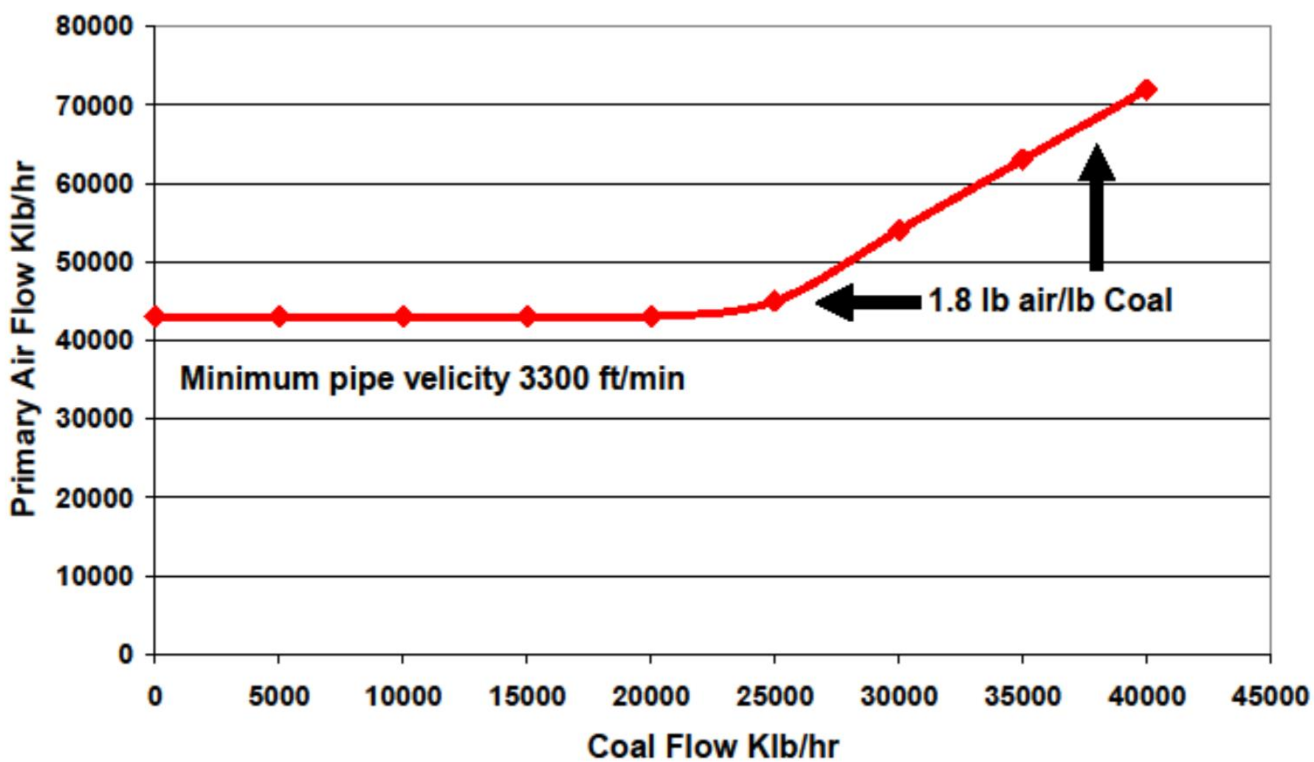


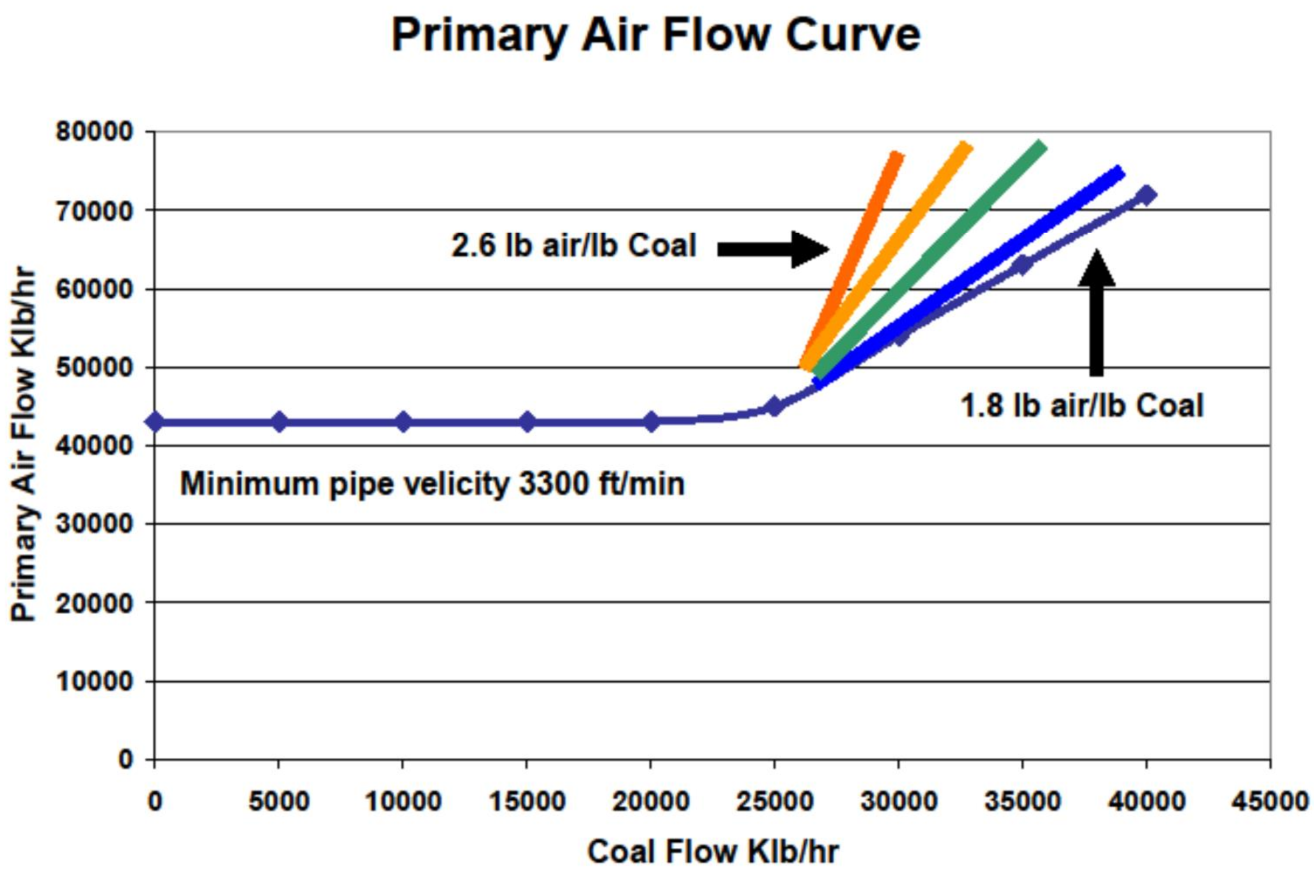
Burners don't always allow much +/- adjustment



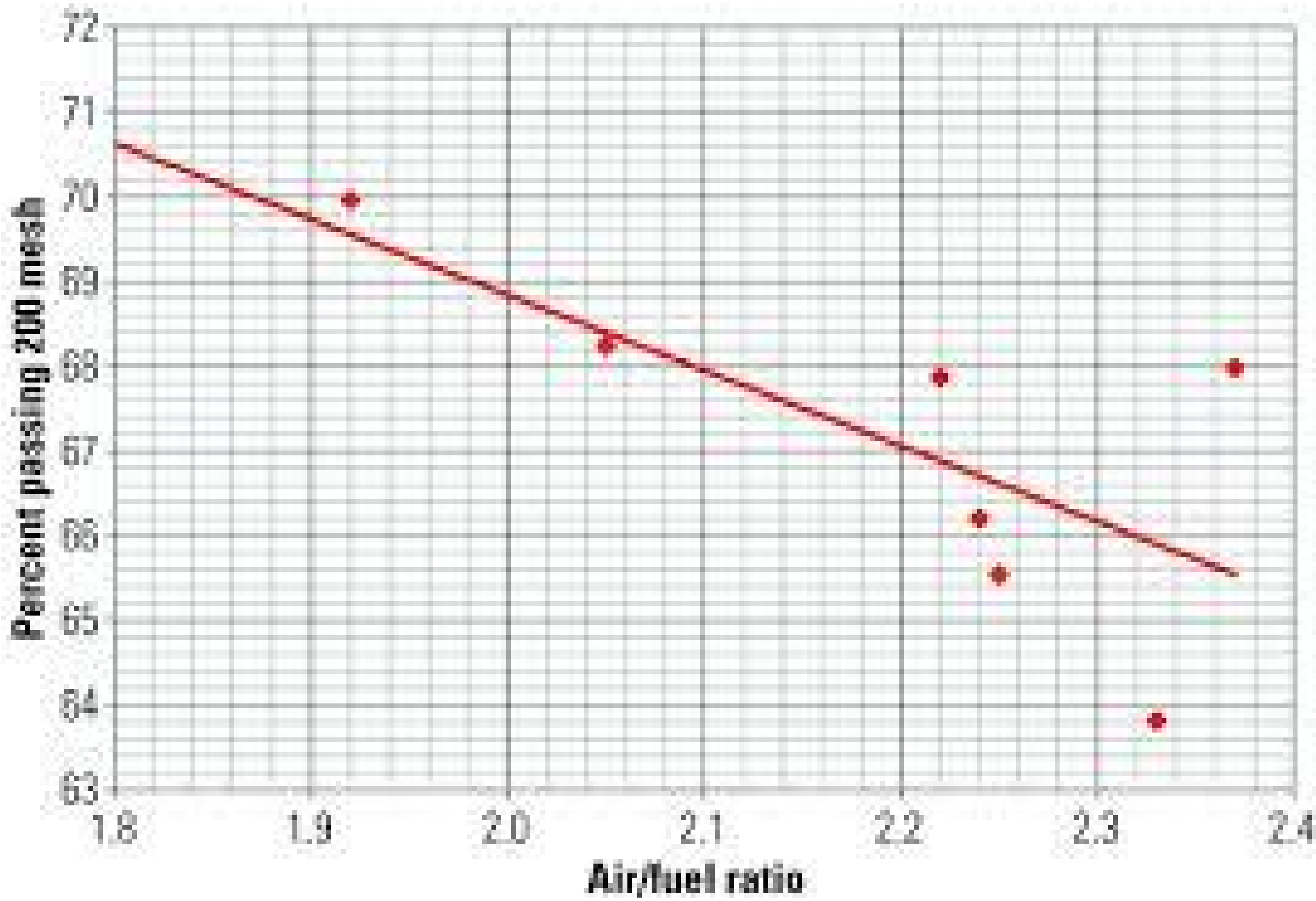
Fuel flow balance (%)
40
35
30
25
20
15
10
5
0
1.8
1.9
2.0
2.1
2.2
2.3
2.4
Air/fuel ratio

Primary Air Flow Curve





What is your Primary Air to Fuel Ratio A/F?



High PA flow hurts fineness

Sizing

Set for Coal type
Set for Slag control
Set for Maintenance

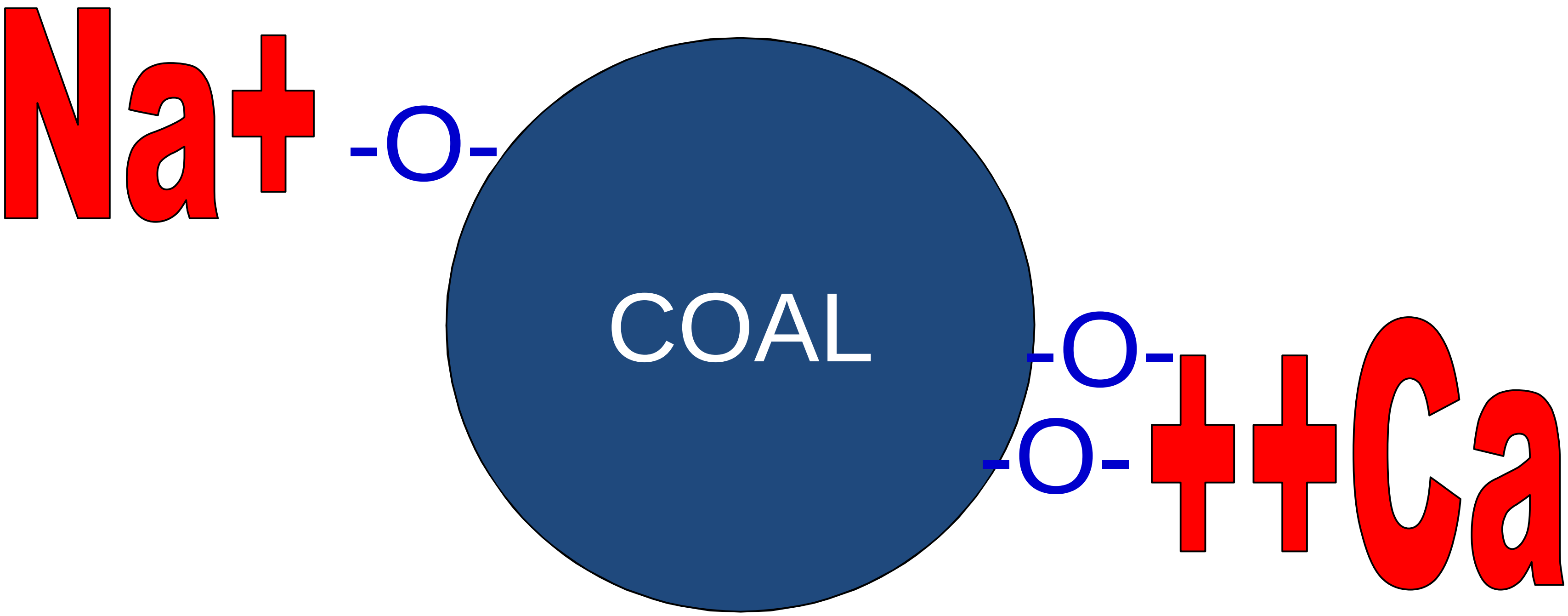
May be opposite directions

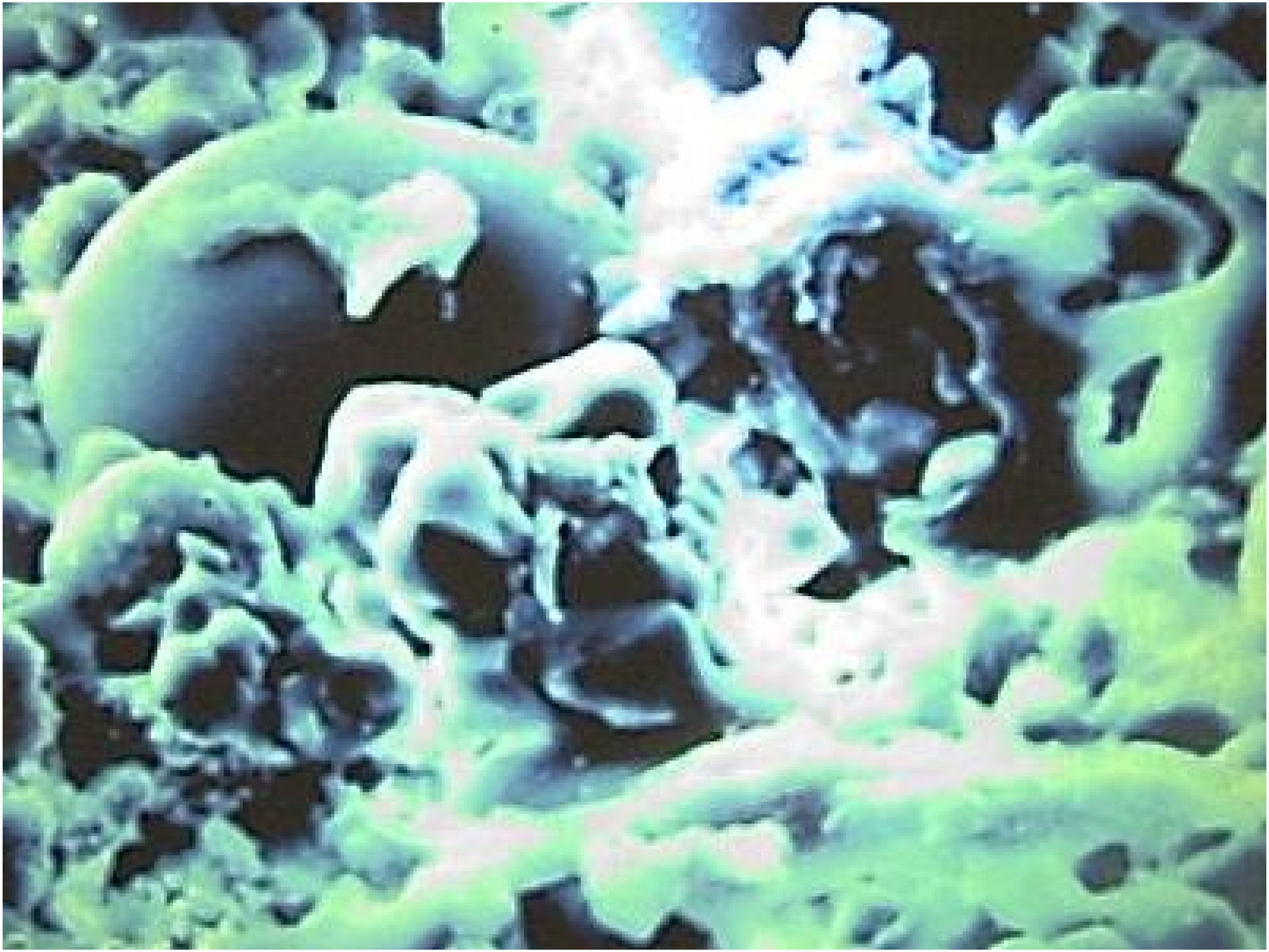
Fouling

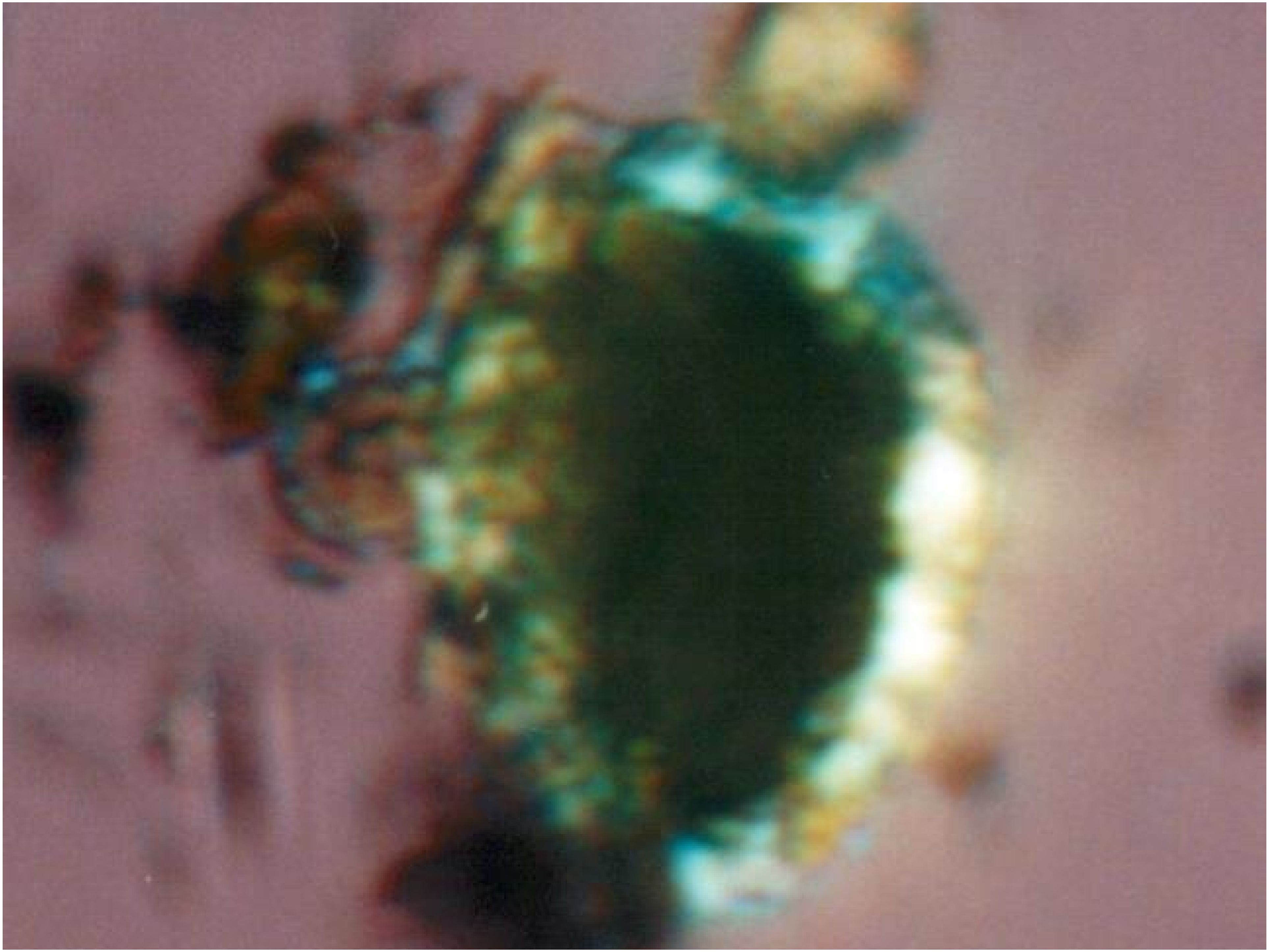
Sodium and Potassium

Calcium

Organically Bound Alkalis







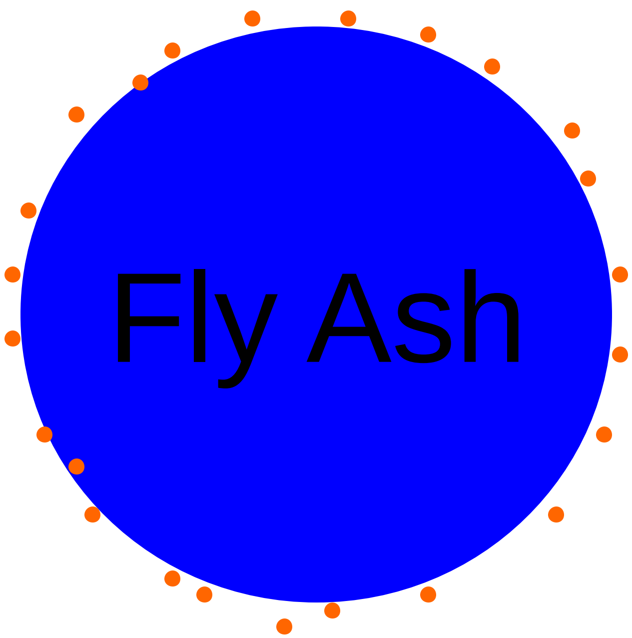
$CaO + SO_3 = CaSO_4$

Think Fluid Bed Boiler

&

Fouling Deposits

Sodium Condenses on Surface



Causing a Molten Layer on Surface

Iron, Fe_2O_3
Calcium, CaO
Sodium, Na_2O
are the glues

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