Oxygen-Enhanced Coal Based Reburning

2004 Conference on Reburning for NOx Control

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Discussion Points

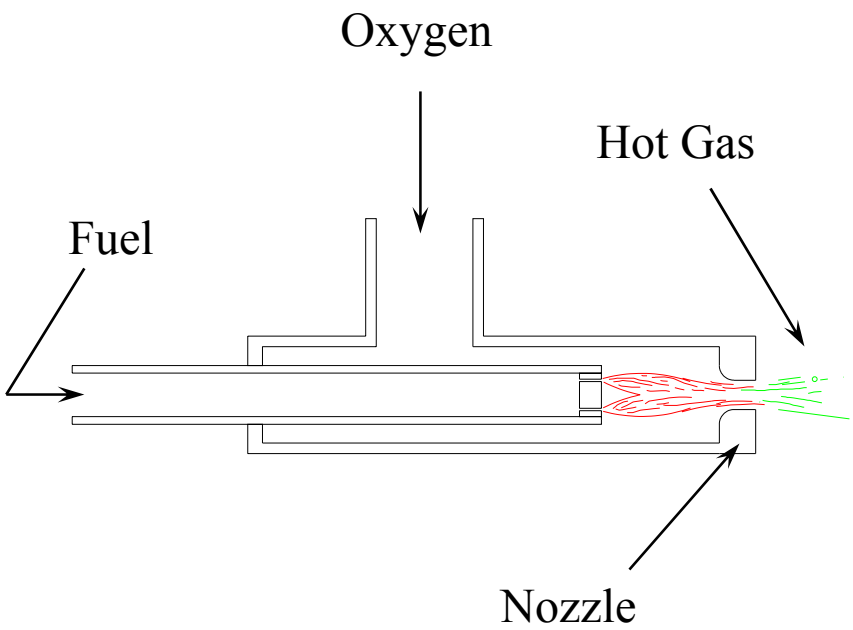
- Oxygen-enhanced reburning concept
- “Thermal nozzle”
- Small-scale burner tests
- Large-scale burner tests
- Economic considerations

Oxygen-Enhanced Reburning Concept

PRAXAIR

- The hot oxygen burner (HOB) overcomes many issues with coal-based reburning
  - LOI is reduced
  - standard coal grind can be used
  - good mixing possible with flue gas
- A HOB is used to devolatilize the reburn coal before it is fed into the boiler
  - oxygen/high temps have been shown to significantly increase devolatilization rate
  - provides high momentum stream into boiler

Hot Oxygen Burner*



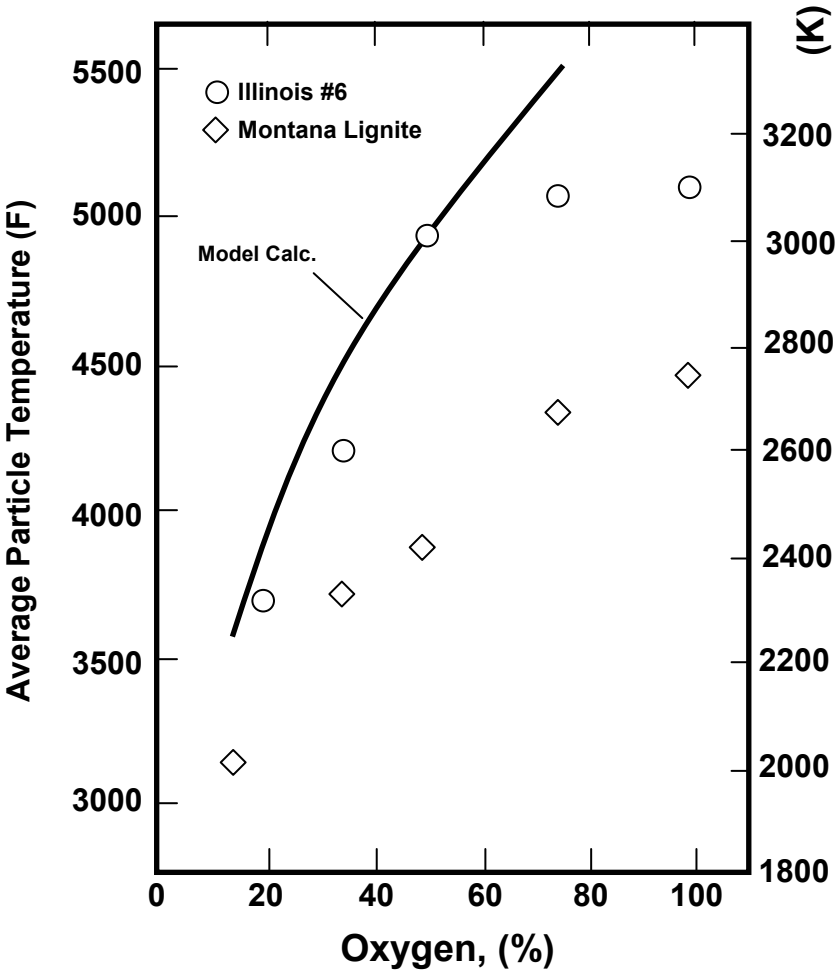
- Fraction of O_2 burned to heat O_2 stream
- Hot gas exits nozzle to form high velocity jet
- Turbulent hot gas jet has high shear forces and entrainment rates
- Mates with coal system and feeds into chamber or boiler

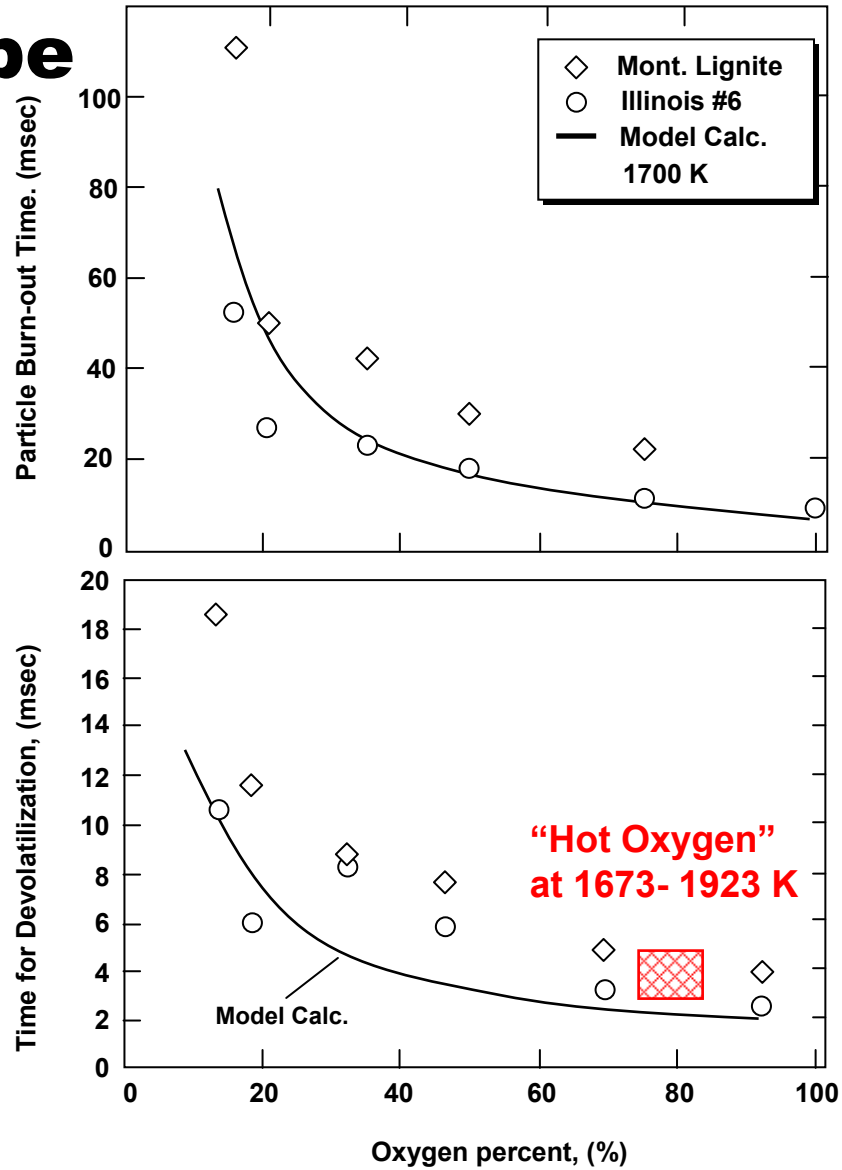
*"Thermal Nozzle Combustion Method" US Pat. 5,266,024

“Hot Oxygen” Characteristics

Oxygen Temperature °C	Reactants	Product Composition percent	Sonic Velocity m / s
1400	Oxygen 100 m3 Natural Gas 6.6 m3	Oxygen 81.9 Carbon Dioxide 6.0 Water Vapor 12.1	750
1650	Oxygen 100 m3 Natural Gas 8.2 m3	Oxygen 77.1 Carbon Dioxide 7.6 Water Vapor 15.0	800

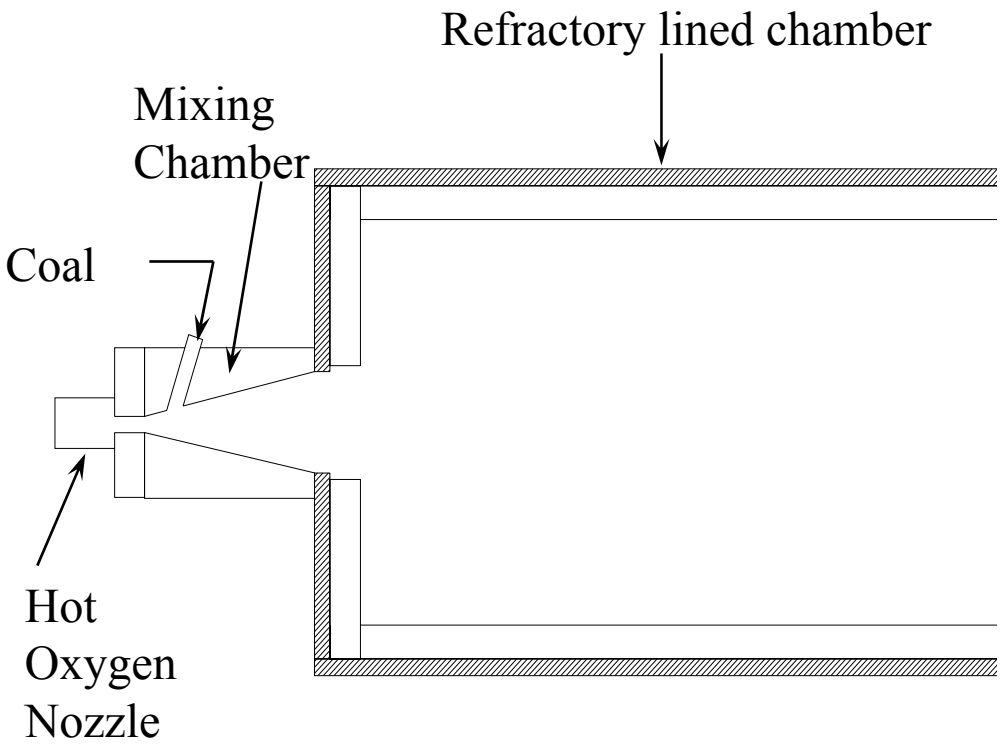
Effects of O_2 Enriched Combustion on a single coal particle combustion in a drop tube





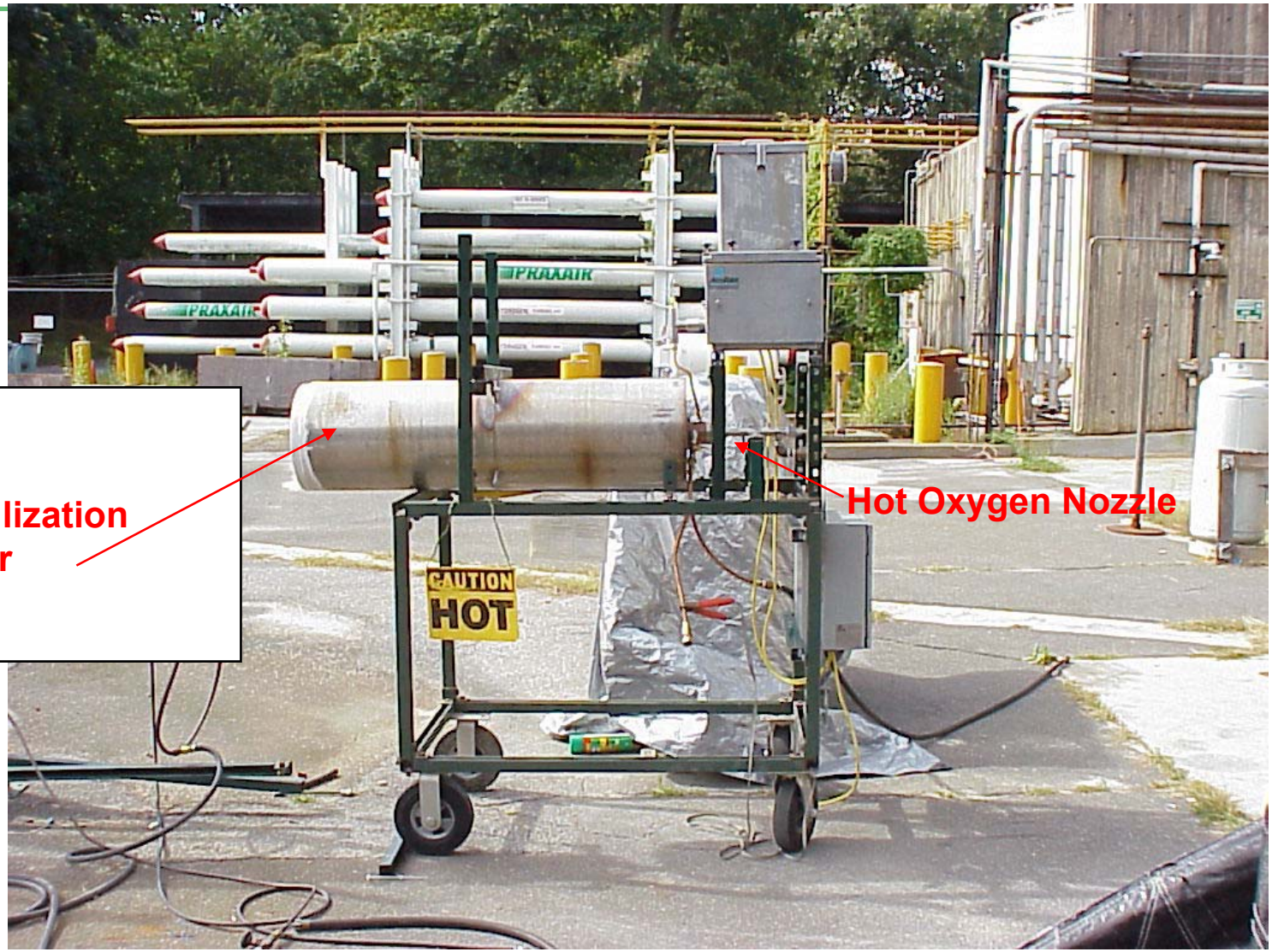
(Data from L.D. Timothy, A. Sarofim and J.M. Beer, 1983)

Hot Oxygen Burner

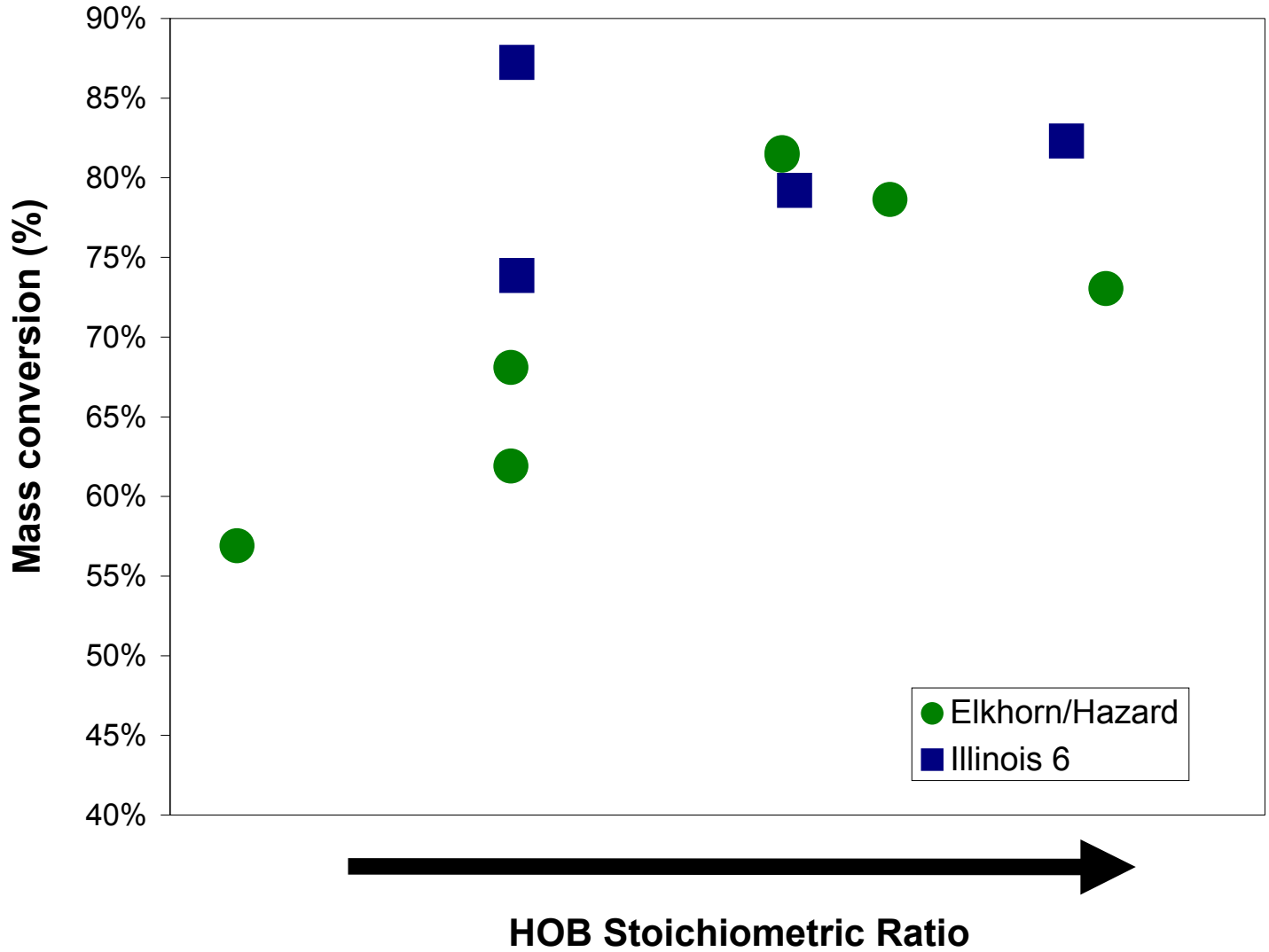


- Coal entrained by hot oxygen
- Coal is devolatilized
- Mixture exits chamber into boiler/heater for reburning
- High momentum stream enhances mixing

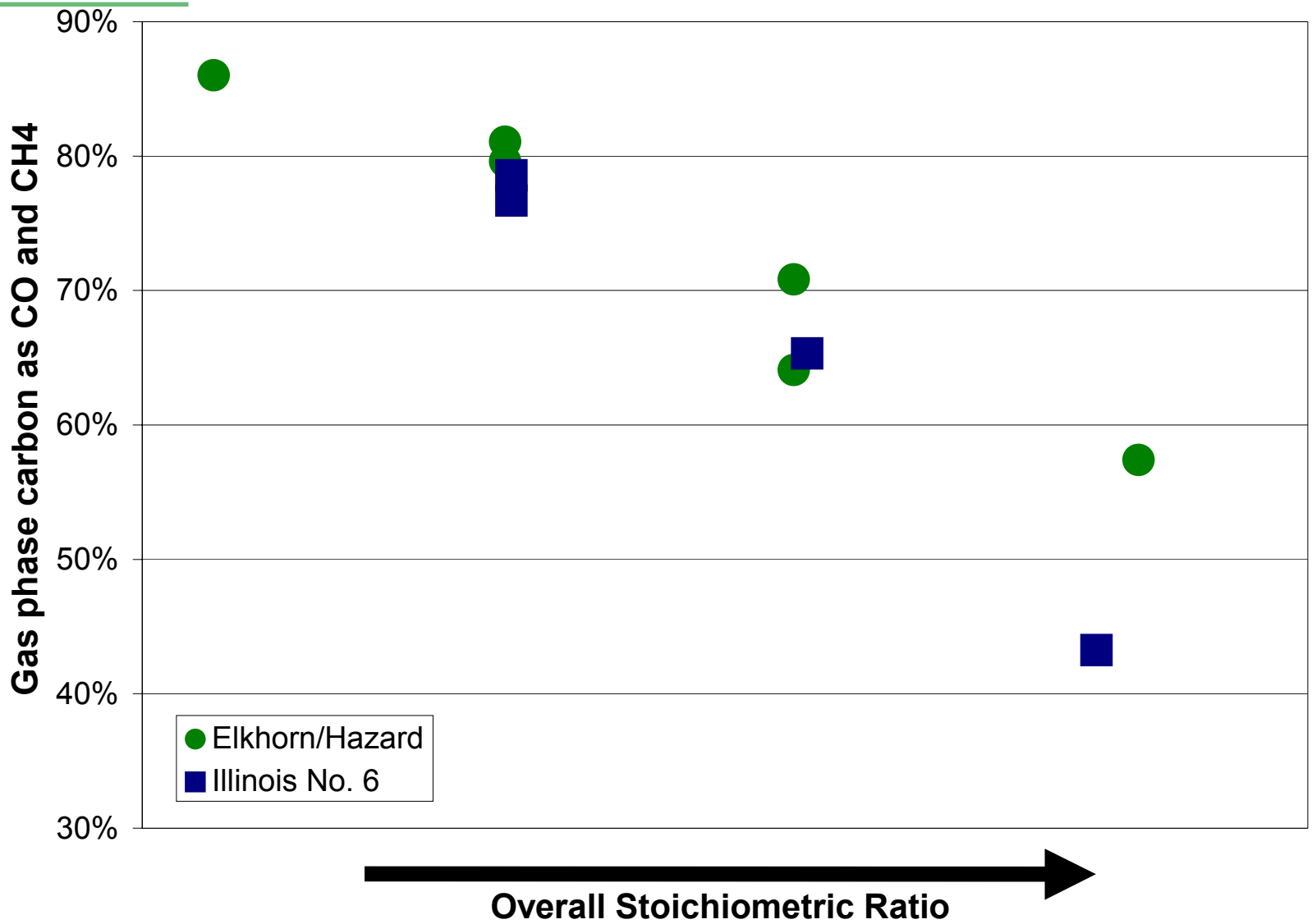
Small-scale Test Rig



Coal Conversion



Gas Phase Carbon



Results from Small-scale Rig

- Small-scale tests showed significant devolatilization possible with minimal oxygen use
  - results understate conversion as tars recondense during sampling are counted as 'LOI'
- Most gas products are combustibles
  - fraction as combustibles increases with decreasing SR
- High momentum product stream possible

HOB Tests at the PTC

- Scaled up HOB tested with sewage sludge
- ~ 20 MMBtu coal equivalent tested

- Good dispersion with hot O_2
- Only burner block used

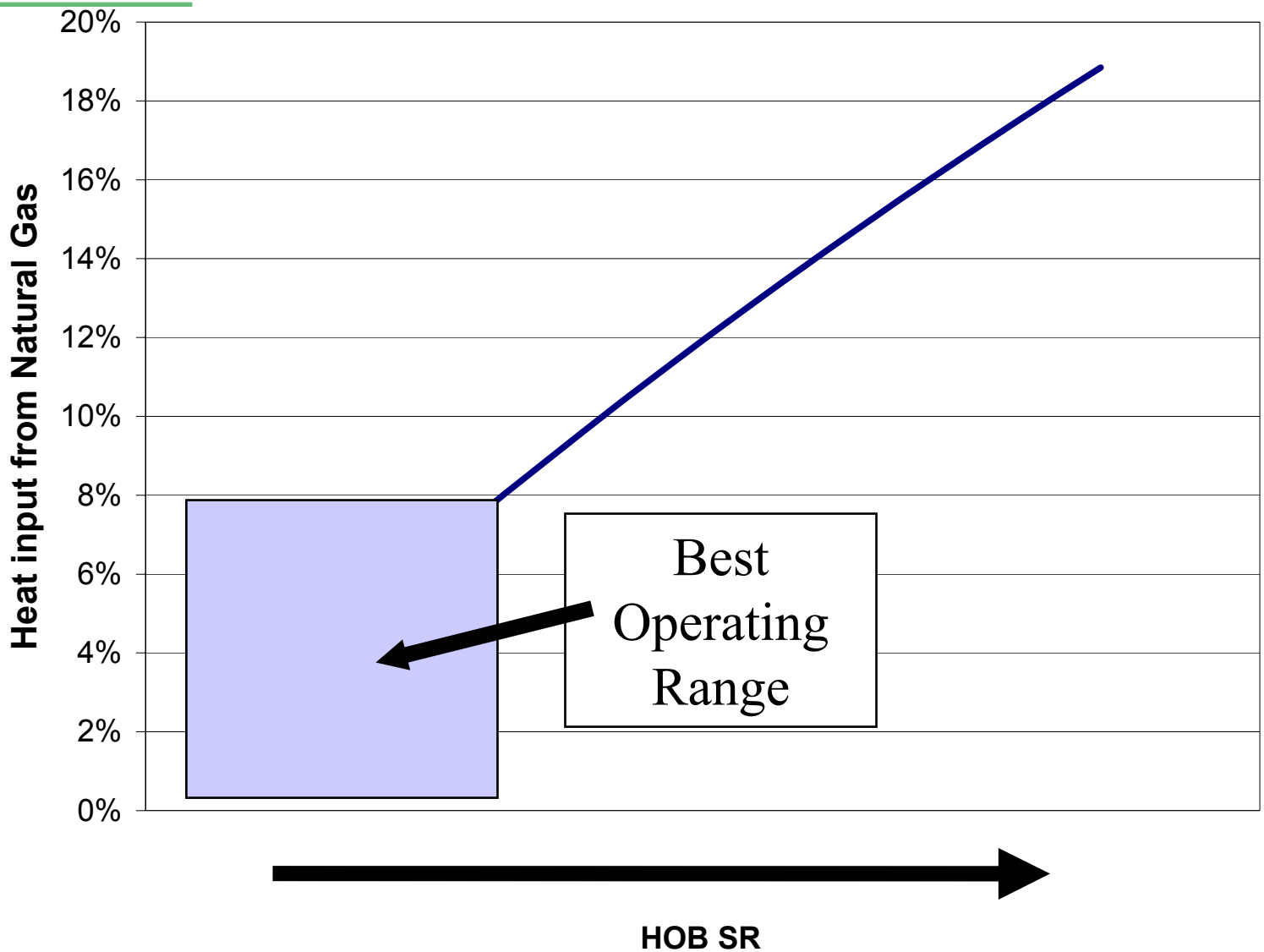
Results of Full-Scale HOB Tests

- Digested sewage sludge cake (23% solids, HHV of dry sludge around 5,300 Btu/lb) was atomized and combusted *completely*.
- Good stable operation with only burner block using material that is substantially more difficult to burn than coal
  - complexity of ‘chamber’ may not be required

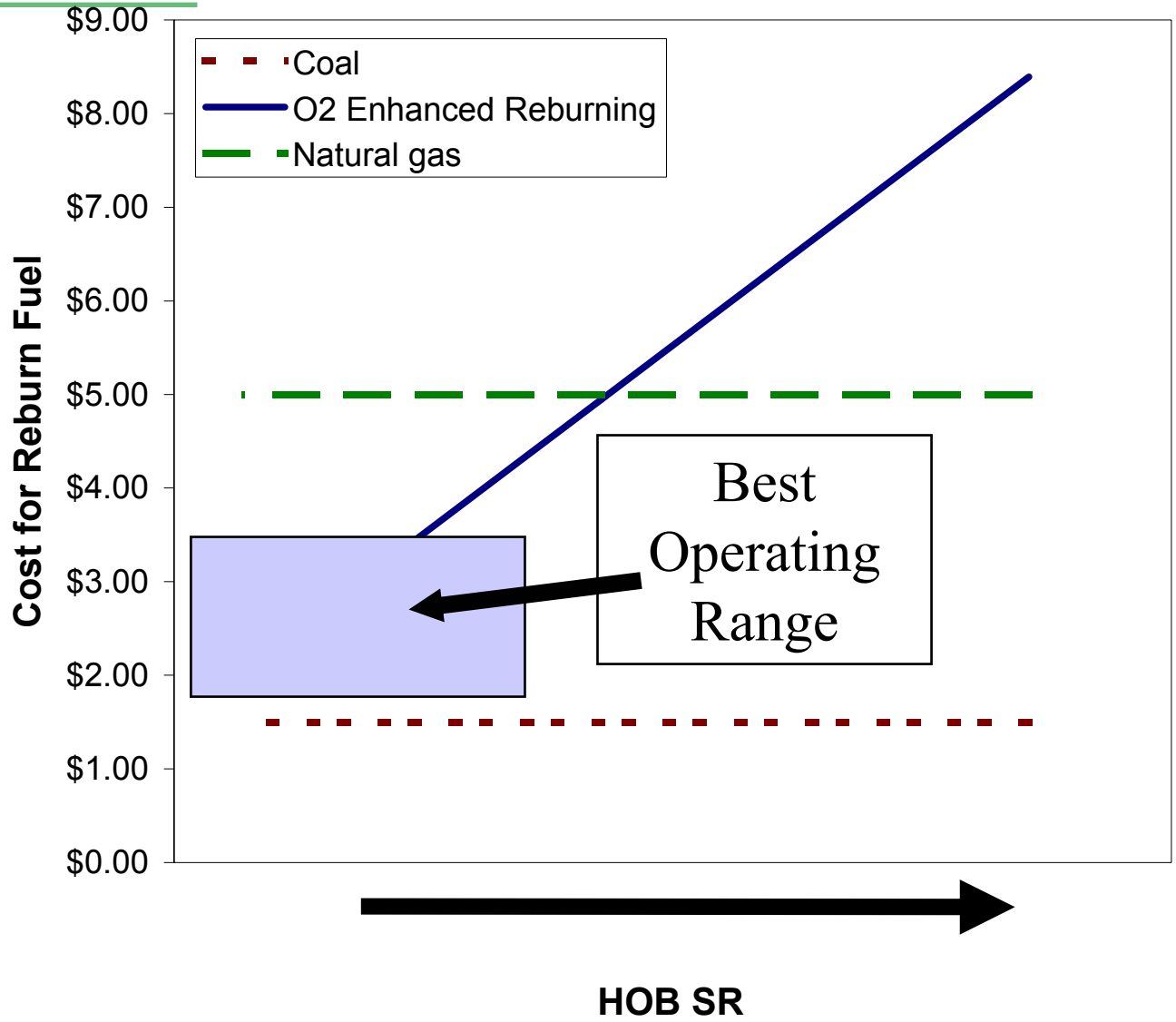
Economic Considerations

- HOB-enhanced reburning allows a cheaper fuel to substitute for a more expensive fuel
  - assumes no new pulverizers needed
  - includes capital in cost of oxygen
  - some natural gas required to heat oxygen
- Some natural gas (or similar) fuel needed to heat oxygen so there is some dependence on natural gas prices
  - how much of the reburn heat input is from natural gas compared with coal?

Heat Input from Natural Gas



Estimated Cost



Summary

- Burner tests suggest HOB can promote coal-based reburning
  - can use standard grind pulverized coal
  - minimizes residual char
  - create high momentum gas product stream
- Economics are attractive when natural gas prices are high and hot oxygen use is held to minimum required
- Tests must be run to evaluate effectiveness of HOB products as reburn fuel (compared with natural gas)