Oxy-Fuel Combustion: Clean Coal

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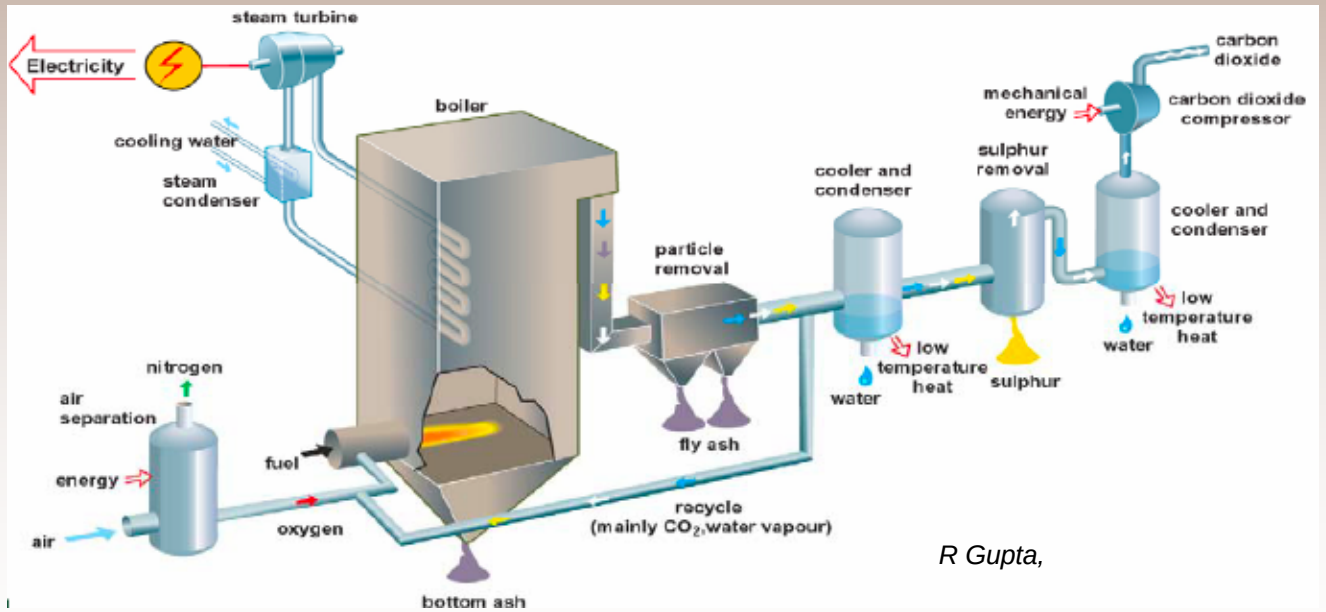
What is oxy-fuel combustion?

- Oxy-Fuel
  - Pure oxygen as oxidizer
  - Reduces or eliminates NOx
  - Increases CO_2 concentration
    - Easier to recover

–Could be used in retrofit coal plants



R Gupta,

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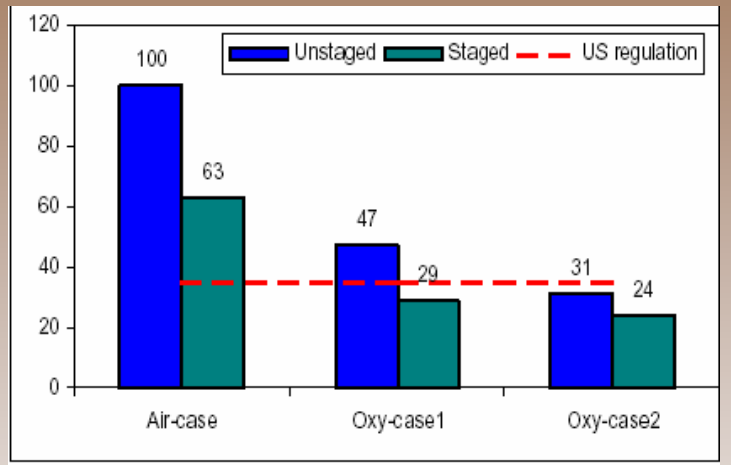
Previous Oxy-Fuel Studies

- Pollutants
  - NO_x reduced
    - Can be further reduced
  - CO_2 concentrated >90%



(a) NOx emissions, normalised assuming the baseline value in air-case is 100. Dash line is US regulation 65 mg/MJ

Oxy-fuel combustion in GHG Context – Status of Research, Technology and Assessment
R Gupta, CRC for Coal in Sustainable Developement
Univ of Newcastle Australia
Advanced Coal Workshop, Brigham Young University, Provo,Utah, 15-16th March 2005

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Previous Oxy-Fuel Studies

- Flame and Heat Transfer
  - Instabilities observed
    - Can be overcome by increasing O_2, but increases cost
    - Can this be overcome by recycling hot exhaust (flue) gas (RFG)? Are optimized ignition and combustion possible?
  - Heat Transfer changed
    - No NO_x, N_2, less CO to carry heat to boiler
      - Transport properties changed
    - Can likely be made to matched air burning with RFG
    - Avoids changing plant electrical output

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Previous Oxy-Fuel Studies

- Retrofit
  - Most necessary technology is mature
    - Optimization should be only changes
  - Must find a place for CO_2
    - No current large scale market
    - Must sequester and store
  - Can be adapted to future technological advances
    - IGCC using air separation unit from oxy-fuel retrofit
  - Pilot Studies already done
    - Companies such as Air Liquide and Alstom

Jupiter Oxy-Fuel plant; Hammond, IN

We are collaborating with Jupiter Oxygen Corporation, who is retrofitting 25 MW plant in Orville, Ohio; as well as developing an oxy-fuel pilot plant in Hammond, IN

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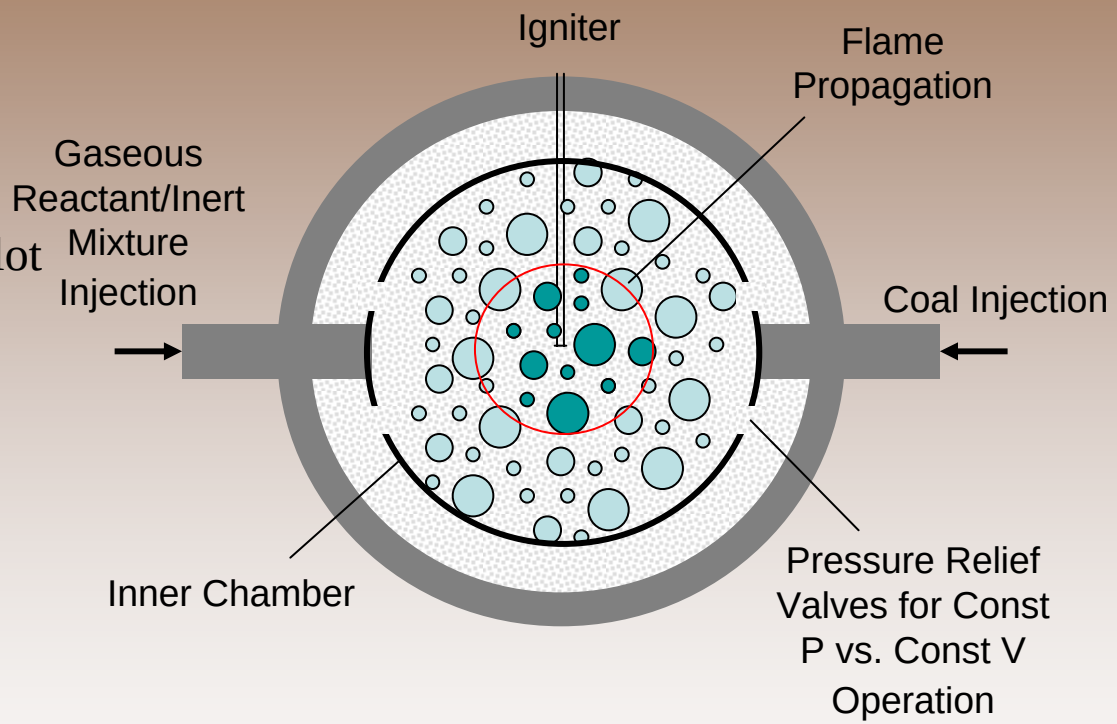
Studies Beginning at Purdue

- Constant volume or pressure ignition and combustion
  - Flame and ignition characterization studies
  - Pollutant concentrations
  - RFG/O_2% optimization
  - Comparisons with Jupiter pilot reactor
  - Indiana coals considered
- Pressurized studies
  - Control flame instabilities?
  - Future technology areas?
    - IGCC pressurized syngas
    - Chemical looping

Funding from Indiana CCTR



Can hot RFG stabilize O_2/CO_2/Coal flame with lower O_2 concentration?

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Work Update

- Pressure Vessel Construction
  - Pressure Seal
    - Reusable and durable
    - Temperature resistant
  - Ignition
    - Matching minimum ignition energy to spark distance
    - Computer control and timing

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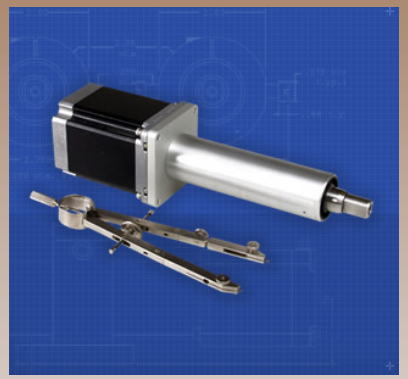
Work Update

- Coal Feed System
  - Computer control
  - Load and feed mechanism



- Pressure Release System
  - Alignment of plates
  - Friction and sealing

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Proposed Industry Survey

- Purpose is to get perspective on clean coal, and specifically views on oxyfuel in Indiana
  - Technology issues (we know cost is the driver, but what else?)
  - What new concerns exist in the clean coal process have arisen?
    - Example Questions:
      - Impact of Additional System Size?
      - Importance of retrofit (historical, newer parts, etc)?
      - Importance of Ease of Operation?

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Proposed Industry Survey

- Potential Contacts
  - Large user: Duke Energy, AEP, Indiana-Michigan Power, Indianapolis Power & Light
  - Small user: Logansport Municipal Utilities, Frankfort Light & Power, Crawfordsville Elec Light & Power Co, Warren County Rural E M C, Darlington Light & Power Co
  - We believe that small users will be the key consumers for Oxy-Fuel Technology (low capital cost vs. IGCC)

    -- Examples: Babcock & Wilcox: Hamilton, OH
    Jupiter Oxygen: Orville, OH

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Proposed Experiments

- Flame Studies
  - Instabilities in Large Coal Cloud
    - Compare to Kiga instabilities
    - Test off-optimum conditions
  - Heat Transfer
    - CO_2/O_2 effects
    - Compare experimental to current/proposed models
    - Thermal radiation (w/ Jupiter)
  - Emissions
    - Complete combustion in coal cloud?
    - SO_2 concentrations

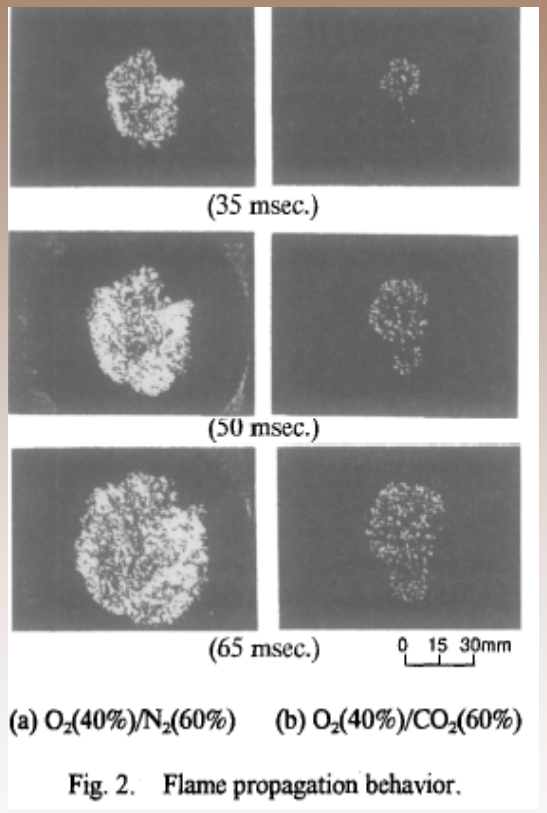

Fig. 2. Flame propagation behavior.

Kiga et al.; Energy Conversion Management 1997; 38: S129-S34

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Jupiter Oxygen Collaboration

- What they can offer us
  - Full size verification of laboratory observations
  - Proposed testing parameters arising in continuous operation
- What we can offer them
  - Theoretical verification of full scale occurrences
  - Data suitable for model generation
  - Use proposed parameters instead of standard
    - Unique conditions testable before implementation

Jupiter Oxygen Facility, Hammond IN

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Penn State Particle Burner

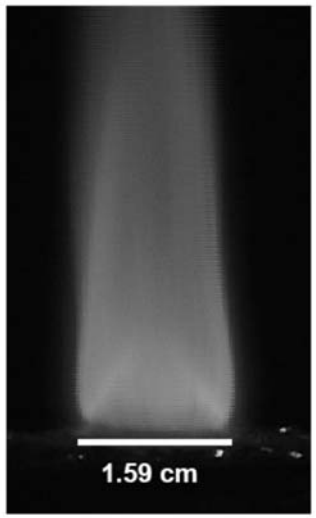
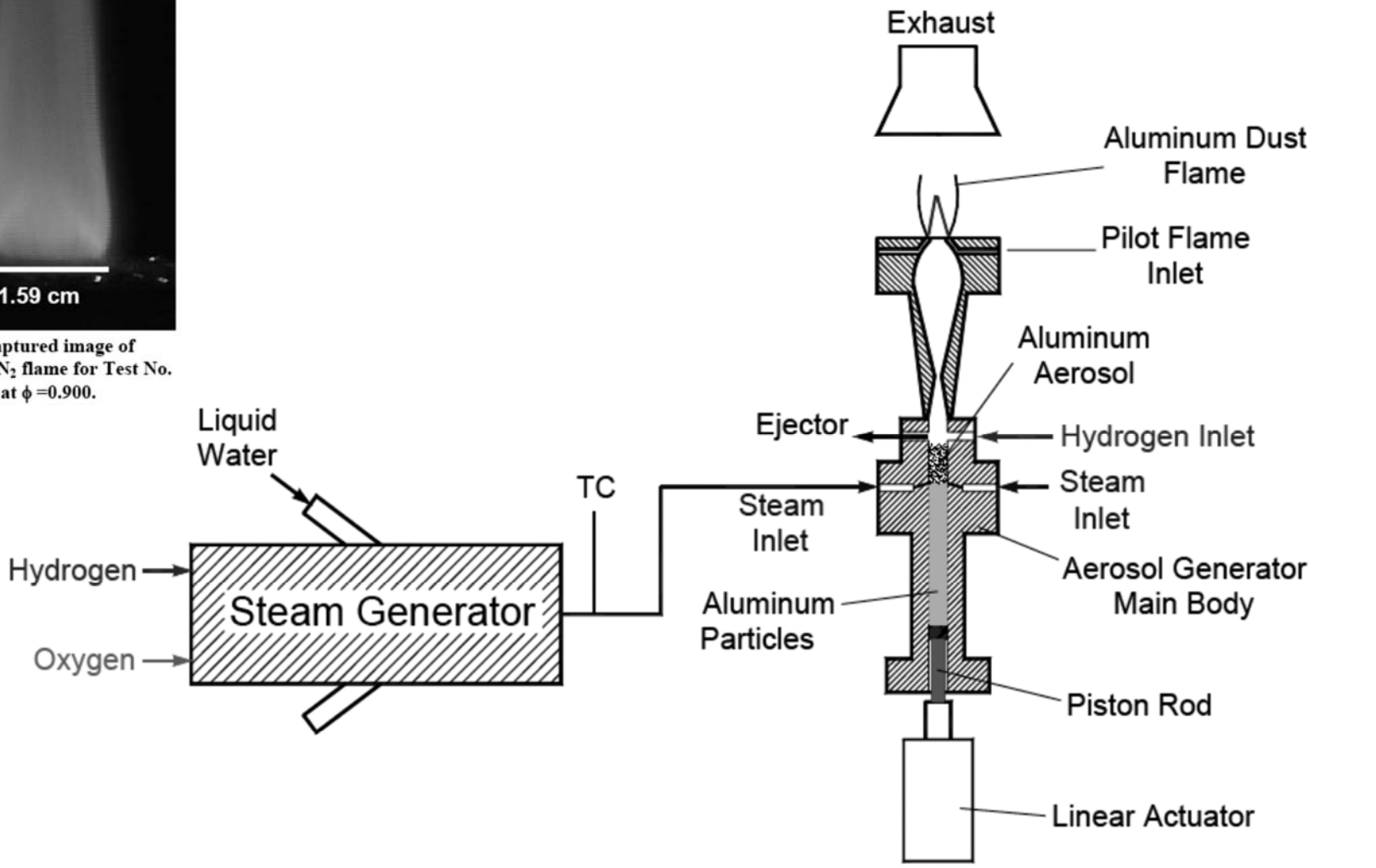


Fig. 5. Captured image of Al/steam/N_2 flame for Test No. ONR-109 at ϕ =0.900.



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Summary of Progress

- New combustor nearly built
  - Testing to begin
- Plans made for survey
- Need to identify and obtain pulverized coal for studies
- Particle burner from Penn State shipped this week to Purdue
  - Will be adapted to coal combustion
  - Complements our combustor

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