Using Hot Oxygen Technology to Simultaneously Gasify Liquid and Gaseous Feeds

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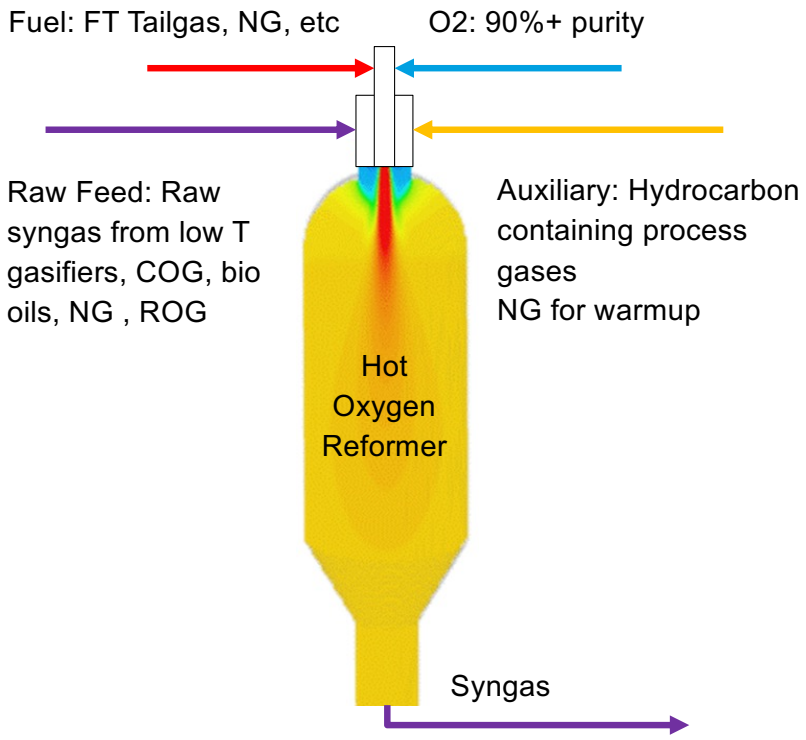
Hot Oxygen Technology for Syngas Production

Multi-feed HOB POx burner enables maximum flexibility

- Enables use of opportunity feeds
- Enables potential capacity increase for integrated systems
- Enables 'tuning' of syngas composition leaving the POx

Multi-feed HOB POx burner enhances system reliability

- Enables fast backup of POx operations in event of loss of feed

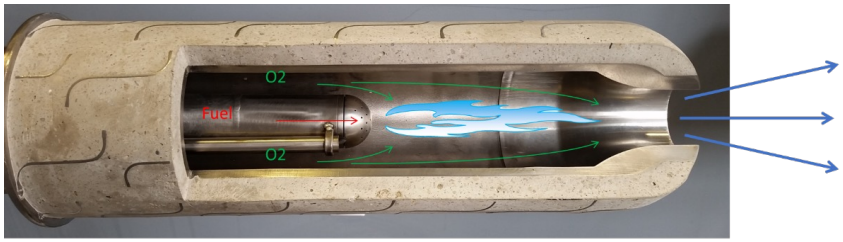


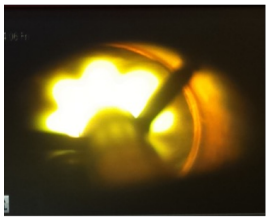
Multi-feed HOB provides maximum operating flexibility

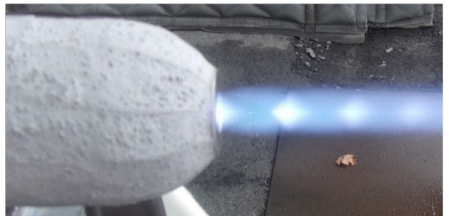
Hot Oxygen Burner

Internal oxy-fired flame

- Very fuel lean
- Designed to minimize or eliminate water cooling requirement
- Very stable and ‘protected’ from downstream process
- Includes flame monitoring (acts as pilot for downstream flame)







Hot oxygen jet creates rapid mixing and reaction

- Hot gas ~ 80-95% O2, 1200-1700°C or higher
- High momentum + low density causes fast mixing with surroundings
- Mixing is easily estimated using standard correlations
- Hot gas is very reactive resulting in rapid ignition and stable flames downstream of nozzle

Combination of stable, monitored, internal flame and very fast mixing enables wide range of uses for hot oxygen

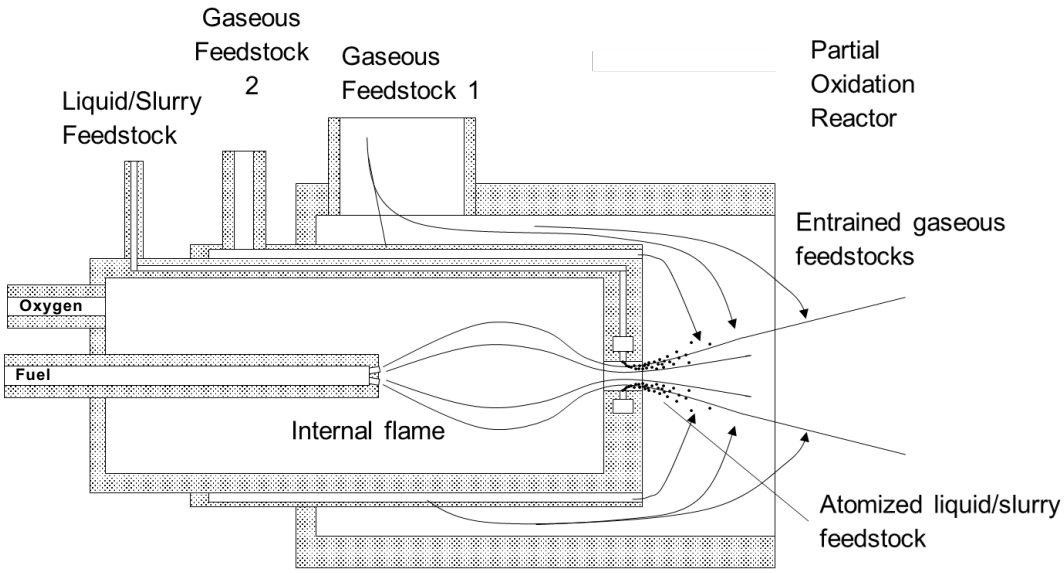
HOT Enables Co-Gasification of Different Feedstocks

Hot Oxygen Burner:

- Basic burner design is similar to conventional HOB
- Multi-gaseous feedstock design proven commercially
- Internal burner design and operation independent of feedstock(s) and overall stoichiometry

High momentum Hot Oxygen jet enables co-gasification

- Liquid feed atomized by high velocity jet
  - High momentum improved atomization
  - Gas momentum is 'consumed'
- Conventional burners may not have adequate momentum to drive mixing with additional feedstocks
- Hot oxygen momentum is high enough to drive mixing with multiple feedstock streams



Example burner design – note pulverized solids can also be supplied through annular or other spaces

Co-Gasification Demonstration: LTC Pilot Unit

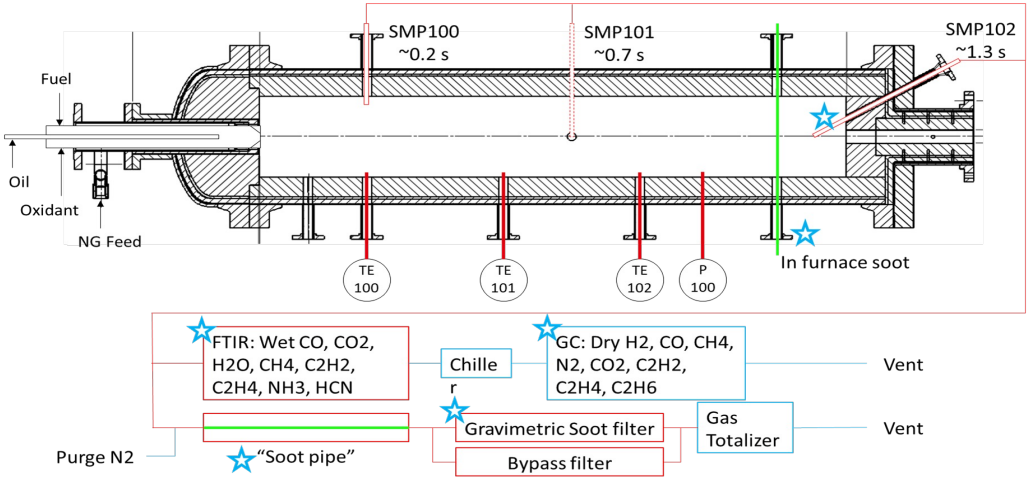
Refractory lined reactor and flare, ~0.8m OD, 3.4m long

Provisions to inject supplementary feeds to modify H_2/CO ratio

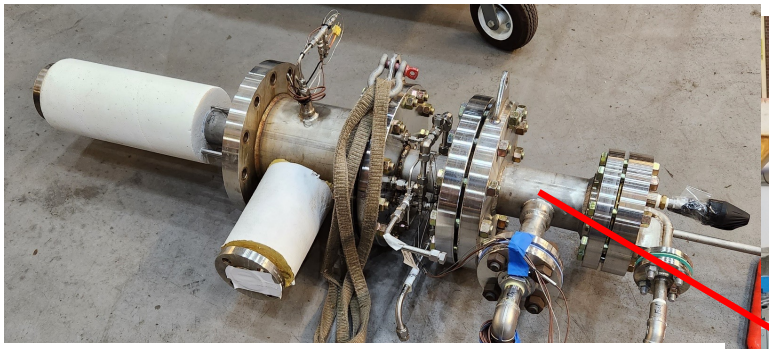
4 barg and ~ 885 Nm3/h syngas

Soot, gas composition, reactor temperatures measured

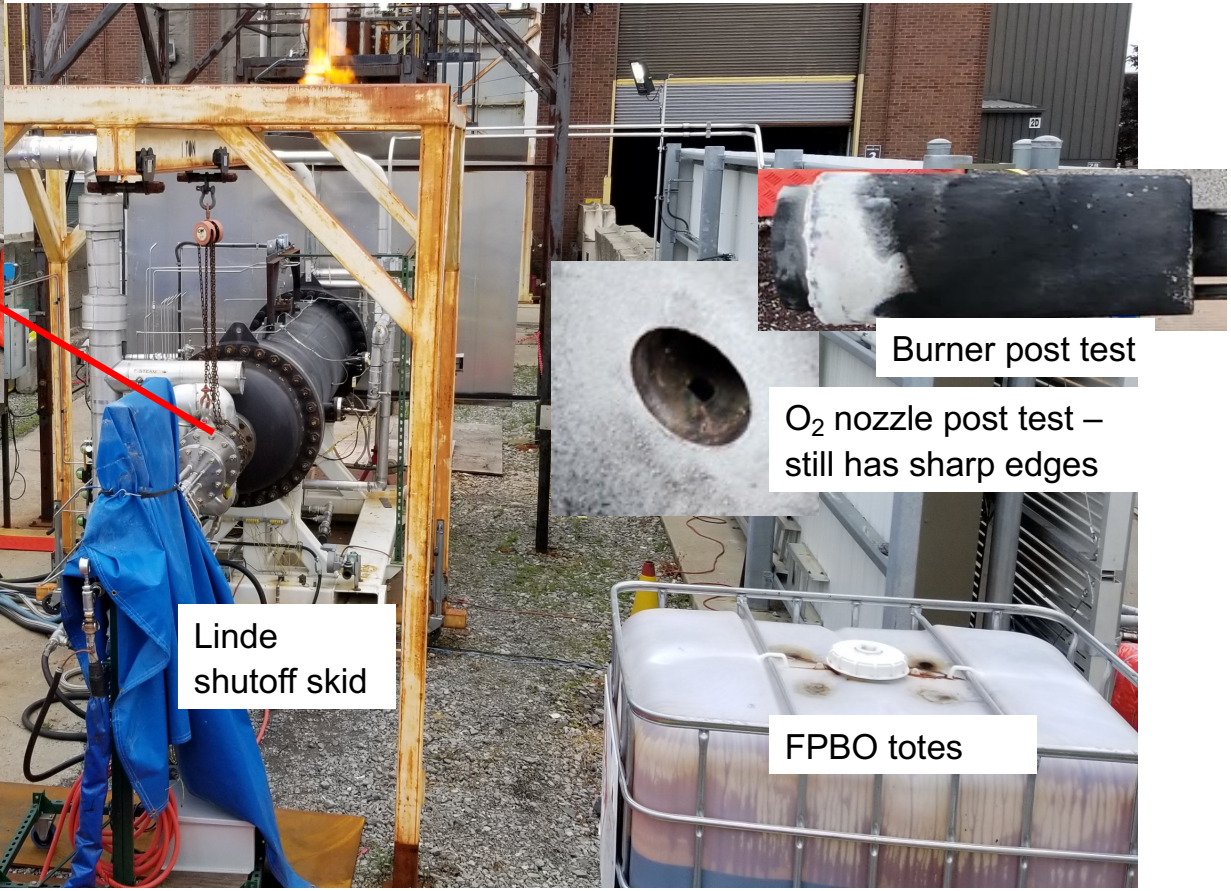
HOT gasification demonstrated with liquid feed and wide range of gaseous feeds



Testing Setup: Co-gasification of NG and Ensyn's FPBO



Liquid POx HOB



Linde shutoff skid

Burner post test

O_2 nozzle post test – still has sharp edges

Ensyn feeder skid

FPBO totes

Pilot HOB Demonstration of Co-Gasification of Natural Gas and Liquid Feeds

Transition from NG POx to Co-Gasification Mode

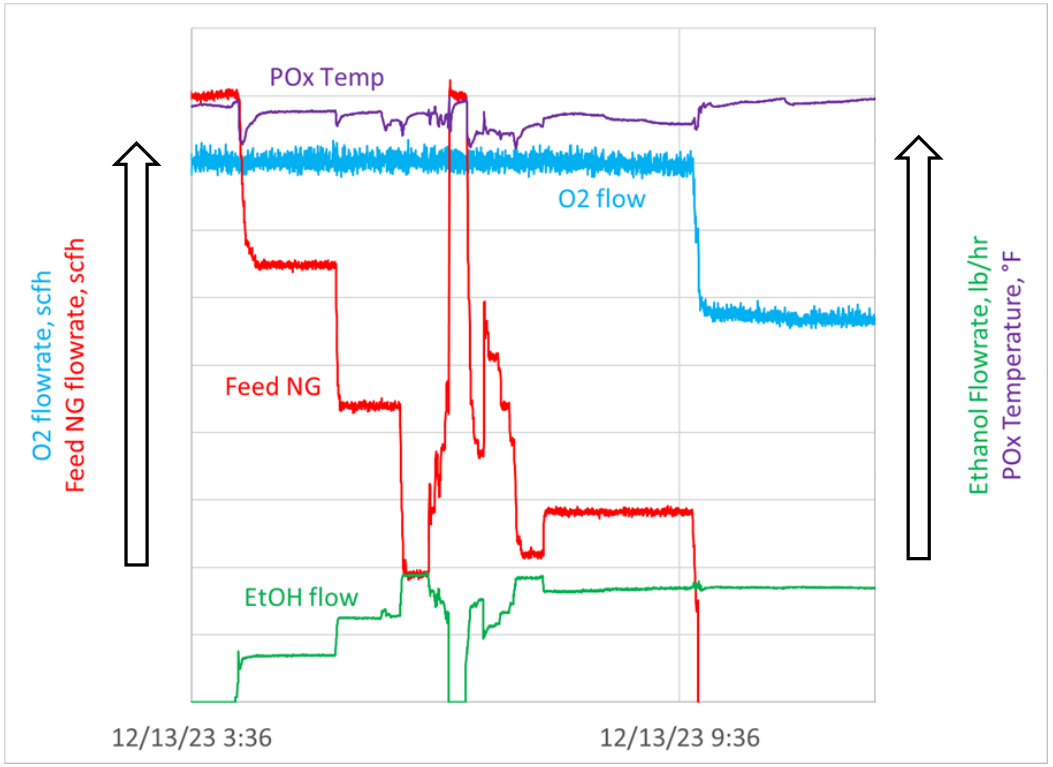
- NG flow reduced as liquid feed increased to maintain temperature within a target range
- Burner operated with different mixtures
- Very stable burner operation
- Demonstrated to revert to 100% gas on loss of liquid feed

Transition from co-gasification mode to liquid POx mode

- In liquid POx mode small purge through gas annulus
- Liquid feed held constant and HOB firing rate changed

General observations

- Smooth transition between conditions
- POx controls identical to NG POx



HOB operation smooth across all operating modes and feedstock mixtures

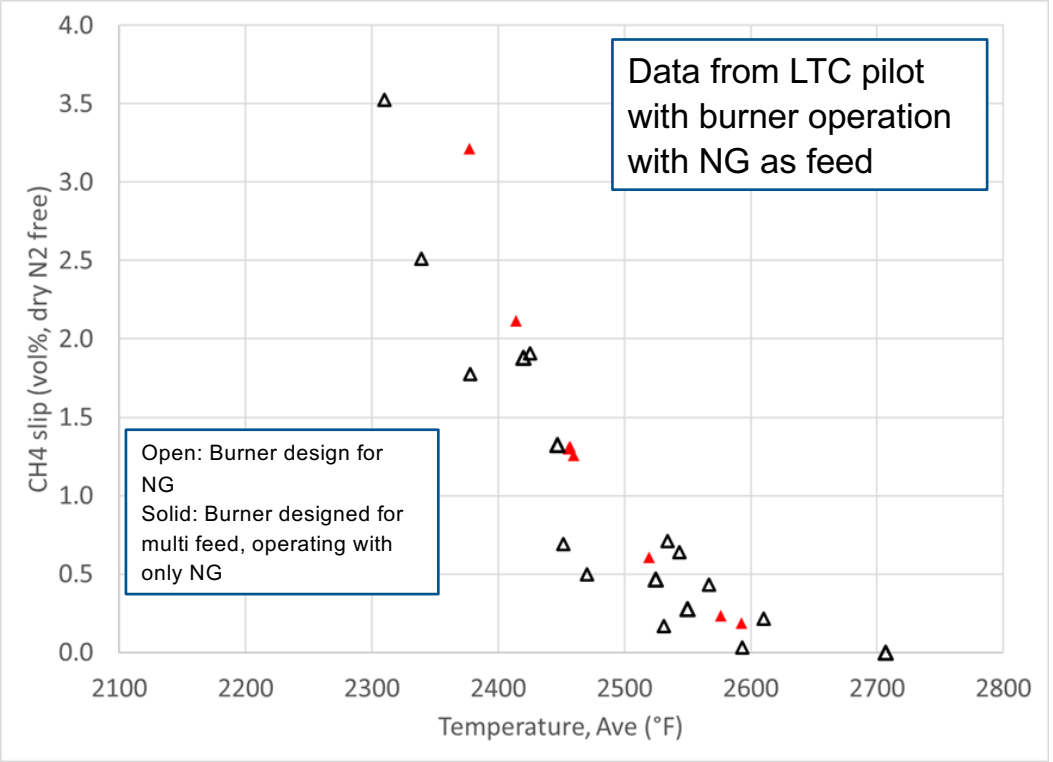
Performance of Mult-Feed Burner with Single Feed

LTC Pilot used to demonstrate operation of multi-feed HOB POx

Multi-feed burner used to heat pilot POx vessel

Multi-feed burner operated on NG POx mode to compare to previous data

- Small N_2 purge flow added through liquid ports
- Very stable burner during all test conditions
- Burner performance (methane slip, yield) essentially identical to previous runs with dedicated NG POx design
- Observed sooting behavior similar to dedicated NG POx design



Multi-feed HOB performs as well when operating a single feed as a burner designed just for that feed

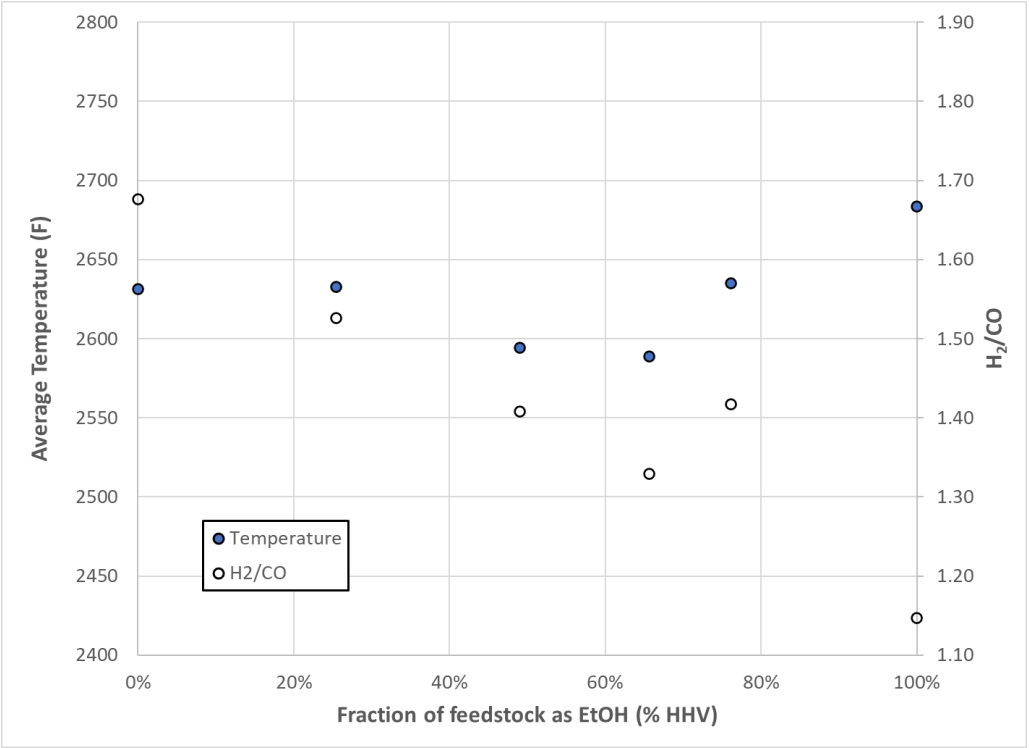
Co-Gasification of NG and EtOH in LTC Pilot POx

Multi-feed HOB POx burner tested at different mixtures of NG and EtOH as feed

- Able to maintain temperature in desired range
- Stable operation at each test point
- Composition data consistent with expectations
- Can easily transition from one mixture to another

Ability to operate at any mixture means HOB can also have 'backup'

- Example: in event of loss of liquid feed a gaseous feed could automatically start to maintain operation
- Small amounts of a gaseous feed could be used to support gasification of very difficult to gasify materials



HOB demonstrated stable operation for wide range of feed mixtures

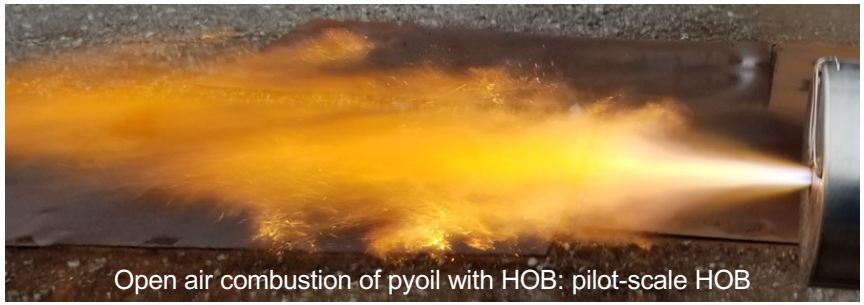
Conclusions

HOB operation is not influenced by feedstocks or overall operating conditions

- Momentum/mixing intensity independent of what happens 'downstream'
- Same burner for wide range of operating conditions and feeds
  - Burner used to preheat the vessel
  - No loss of performance compared to 'single feed only' design
  - Smooth transitions, stable operation at each mixture

Co-gasification of liquid and gaseous feeds with HOB demonstrated

- Enables recycle and gasification of byproduct streams
- Enhances feedstock flexibility


Open air combustion of pyoil with HOB: pilot-scale HOB


Water atomization: large scale HOB


Water atomization: lab-scale HOB

Multi-feed HOB provides maximum operating flexibility

Questions? Comments?

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