Novel Heat Generation for Power and Process Systems

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Better Plants - Technology Days
Reacting flow research at Berkeley Lab

- Burner technologies for next-generation advanced thermal systems
  - Thermal output for 5kW to 200 MW systems
  - Fuel-flexible, high turndown, ultra-low NOₓ
  - Stable, scalable lean premixed flames
  - Customizable flame pattern to maximize efficiency

- Optimizing thermal systems for gas turbines and industrial applications
  - Combined heat and power
  - High efficiency combined cycle systems
  - Boilers and residential appliances

- Fundamental research of thermal systems and alternative fuels
  - Experimental analysis of flame flow field and turbulence interactions
  - Low-volume, alternative fuel characterization coupled with machine learning
Berkeley Lab’s burner technologies for power and process systems

• Ring Burner
  – Lean, premixed, ultra low NO\textsubscript{X}
  – Tested heat output from 4kW to 12 kW
  – Flame pattern can be customized

• Low-swirl Burner
  – Fuel flexible and high turndown (tested up to 50:1)
  – Lean, premixed, ultra low NO\textsubscript{X}
  – Simple and scalable design
  – Lifted flame prevents material thermal degradation
  – Tested thermal output from 5kW to 20 MW
LBNL’s Low-Swirl Burner for Honeywell’s Maxon Corp. Heating systems

“Achieved industry best emissions without sacrificing cost or performance”

M-PAKT burners (0.5 – 3.5 MMBtu/hr)
• Fuel flexible with natural gas, propane and butane
• Hundred of units installed
• First unit operating continuously since 2002
• Improved product quality

OPTIMA SLS burners (12 – 90 MMBtu/hr)
• Gas/liquid dual-fuel
• Units installed & in production

Development supported by DOE-EERE
Cost-Effective, Ultra-Low Emissions Industrial Boiler System with Real-time Response to Fuel Stock Variability

Demonstrated system capable of real time biogas/natural gas/propane fuel switching

- Combined LBNL’s low-swirl burner technology and UC Irvine fuel sensor technology (2MBTU thermal)
- Integrated system into a boiler at the Chiquita Water Reclamation Plant

Development supported by California Energy Commission

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LBNL’s Low-Swirl Injector for Solar Turbine’s 7.7 MW Taurus 70 Engine

- Developed “drop-in” injector retrofit
  - Built from existing parts
  - No special requirements for materials and control
- Met Performance Goals
  - Exceptional engine performance
    - < 5 ppm NO\textsubscript{x} (@ 15% O\textsubscript{2})
  - Durable for at least 8000 hours
  - Cost effective
- Featured article in Gas Turbine World
- 2007 R&D100 award winner

Development supported by DOE-EERE
Low Swirl Injector for Integrated Gasification Combined Cycle (IGCC) Plant with Carbon Capture and Storage

- Developed a cost-effective, fuel-flexible technology for IGCC Power plants
  - Burns coal-derived syngas, high hydrogen, and natural gas
  - Ultra low-NO\textsubscript{X} (< 10 ppm)

- Pilot scale prototype demonstrated stable operation

Georgia Tech Collaboration

20 m/s
40 m/s
60 m/s

99% H\textsubscript{2}
99% H\textsubscript{2}
99% H\textsubscript{2}

NETL Collaboration

Development supported by NETL

April 2019
Combustor for residential CHP microturbine generator

• Developed low-emission combustor for novel microturbine generator
  – Smallest low-swirl burner developed and tested
  – Combined LBNL’s low-swirl burner technology with Scaled Power microturbine generator

• Met emission and performance targets

Development supported by ARPA-e in collaboration with Scaled Power Inc.
Combustor and heater head for Stirling Engine

- Designed and developed burner head and combustor
  - Optimized burner and flame shape to provide isothermal heat transfer
  - Heater head designed to minimize pressure drop and maximum recuperation
  - Design maximizes efficiency while maintaining low emissions

- Final design met performance targets

Development supported by ARPA-e in collaboration with multiple Stirling engine companies
Increasing Turndown for tankless water heaters

- Developed technology for supplying hot water at very low flows (e.g. hand washing)
  - Increase turndown, enabling greater load following, while meeting current performance and emissions targets
  - Achieved turndown of ~50:1 (5 times higher turndown than current designs)
  - Single burner with no staging or multiple port design
- Meets ultra low NO\textsubscript{X} emissions (SCAQMD Rule 1146.2)

Development supported by NYSERDA
Efficient, low-NO$_x$ burner residential gas appliances

- Developed cost-effective burner for residential appliances
  - Efficient, low emissions burner for cooktop application
  - Met emission cooktop targets (NO$_x$ < 15 ppm)

- Developing burners for additional residential appliances
  - Target NO$_x$ < 10 ppm

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Thanks to all our sponsors and collaborators
Questions? Learn and see more on the tour

Team

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