Low-Emissions Burner Technology using Biomass-Derived Liquid Fuels

Saving Energy and Reducing Emissions with Fuel-Flexible Burners

This project developed fuel-flexible, low-emissions burner technology capable of using biomass-derived liquid fuels, such as glycerin or fatty acids, as a substitute for natural gas, thereby reducing energy consumption, lowering greenhouse gas emissions, and increasing fuel flexibility.

Introduction

The metal processing industry, one of the most energy-intensive manufacturing sectors in the United States, commonly uses natural gas in industrial process heating and boilers. Although natural gas is a clean, high-energy fuel source, it has been subject to price volatility in recent years.

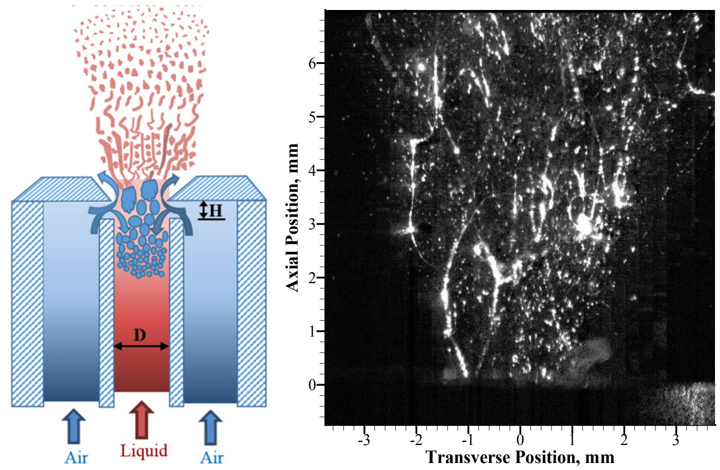
Biomass-derived liquid fuels, including the byproducts of biodiesel production, present a viable alternative to natural gas for process heating applications. Two components of biodiesel production are glycerin and fatty acids. Glycerin is a colorless, odorless, viscous liquid with thousands of uses in its pure form. The glycerin created in biodiesel production, however, is in a crude form and has little commercial value today. Crude glycerin contains significant energy, but its high viscosity at room temperature and high auto-ignition temperature make it difficult to burn glycerin using the standard fuel injectors found in fuel oil burners.

This project developed fuel-flexible burners operating on biomass-derived liquid fuels with low carbon emissions. The burner system primarily used glycerin or fatty acids, but also offered the flexibility for use with other high-viscosity fuels such as pyrolysis oil or vegetable oils as well as conventional fuels, including diesel and natural gas. The project employed a novel flow-blurring injector to effectively atomize different liquid fuels. Having overcome the challenges associated with glycerin/fatty acid combustion, the project resulted in a product that can be used by biodiesel producers, boiler operators, and the metal casting industry.

Benefits for Our Industry and Our Nation

Manufacturing industries consume approximately one-third of the national energy budget. The development of fuel-flexible, low-emissions burners to displace or co-fire natural gas with biomass-derived liquid fuels will produce significant environmental, energy, and economic benefits. Commercialization of this technology has the potential to achieve the following:

- Reduce energy consumption



Working principle of the injector (left), visual image of glycerol spray near the injector (right).
Graphic courtesy of The University of Alabama

- Lower greenhouse gas emissions by using renewable fuels
- Convert a waste stream of biodiesel production into a value-added commodity, increasing the revenue of the biodiesel industry
- Enable the metal processing industry to hedge against the price volatility of natural gas

Applications in Our Nation's Industry

The fuel-flexible burners will be used initially in the metal processing industry (e.g., aluminum and steel) to reduce natural gas consumption, but could also become viable alternatives for other industries that use boilers and process heating systems, including biodiesel processing plants.

Project Description

The project developed fuel-flexible burner technology for the metal processing industry using biomass-derived liquid fuels in place of natural gas. Various biomass-derived high-viscosity liquid fuels were used with new combustion techniques to investigate net carbon emissions and heat release rates.

Barriers

- Input quality of crude glycerin, as its composition can differ widely depending on the process used in biodiesel production
- Degree of standardization of the biodiesel refining process, as production regulations are not always consistent
- Natural gas price volatility

Pathways

The project was structured in four research and development stages. In stage one, extensive research was conducted to define the low-emissions burner concept. In stage two, a lab-scale burner was designed and tested using different fuel grades of glycerin and fatty acids. Based on these test results, stage three involved a scale-up of the prototype burner system for lab testing and use at a pilot test site. In stage four, the pilot system was designed, optimized, built, and tested at an aluminum processing company, and the pilot burner was evaluated for net carbon emissions and heat release rates.

Milestones

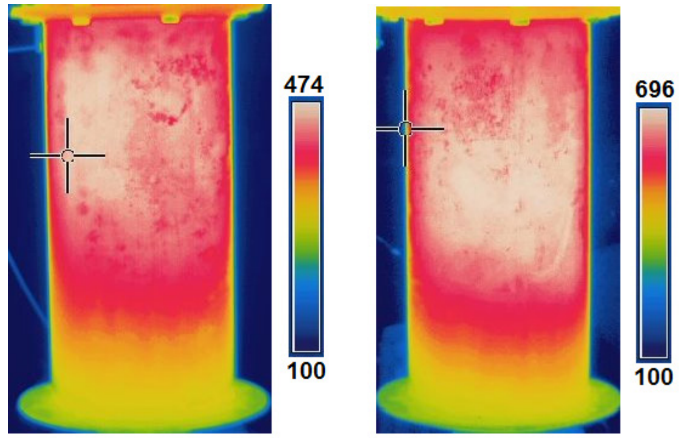
- Evaluation of a fuel-flexible, low-emissions burner concept at laboratory scale
- Demonstration of low nitrogen oxide (NO_x) and carbon monoxide (CO) emissions in lab experiments
- Development of a prototype burner system to test biodiesel byproducts and source fuels
- Construction of a pilot-scale burner system for testing and demonstration at an industrial site, with the goal of evaluating the net carbon emissions and heat release rates

Accomplishments

- The flow-blurring (FB) injector was proven to be effective in atomizing fuels with very different physical properties, and it offered a path forward to utilize both fossil and alternative liquid fuels in the same combustion system.
- Low-emission combustion of glycerol/methane was achieved by utilizing a fuel-flexible FB injector to yield fine droplets of highly viscous glycerol.
- A low-emission burner technology capable of operating cleanly on natural gas as well as crude glycerin and/or fatty acids found in biodiesel plants was developed; it is likely the burner can be used with other opportunity fuels, such as bunker oil and heavy fuel oils

Commercialization

Several industrial partners participated in the project and contributed to the successful development of the novel burner technology.



Infrared images of the Combustor operated on glycerol at heat release rate of 41 kW. *Graphic courtesy of The University of Alabama*

Wise-Alloys, an aluminum processing company, committed to partially cost-share in the project and assisted in technology development and field verification. Leading biodiesel producers provided industrial oversight and supplied different grades of glycerin and fatty acids for laboratory tests. Industrial partners were consulted to identify potential natural gas replacement opportunities in the steel casting industry using the new technology. Industrial burner designers were consulted for help developing pilot-scale and commercial-scale burner products.

Project Partners

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