Research of synthetic fuels hopes to cut oil dependence

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Purdue doctoral students, from left, Indraneel Sircar, Brent Rankin, Rohan Gejji and Anup Sane created this gasifier to learn precisely how coal and biomass break down in the reactors. The research, funded by the U.S. Air Force Office of Scientific Research, aims to strengthen the scientific foundations of the synthetic fuel economy. (Purdue University photo/Mark Simons)

Researchers at Purdue University have developed a facility aimed at learning precisely how coal and biomass are broken down in reactors called gasifiers as part of a project to strengthen the scientific foundations of the synthetic fuel economy.

"A major focus is to be able to produce a significant quantity of synthetic fuel for the U.S. air transportation system and to reduce our dependence on petroleum oil for transportation," said Jay Gore, the Reilly University Chair Professor of Combustion Engineering at Purdue.

The research is part of work to develop a system for generating large quantities of synthetic fuel from agricultural wastes, other biomass or

coal that would be turned into a gas using steam and then converted into a liquid fuel.

Other aims are to learn how to generate less carbon dioxide than conventional synthetic-fuel processing methods while increasing the yield of liquid fuel by adding hydrogen into the coal-and-biomass-processing reactor, a technique pioneered by Rakesh Agrawal, Purdue's Winthrop E. Stone Distinguished Professor of Chemical Engineering.

Researchers are using the facility to learn how coal and biomass "gasify" when exposed to steam under high pressure in order to improve the efficiency of the gasification process.

"We want to show that our system is flexible for using coal and biomass," Gore said. "The aim is to create a sustainable synthetic fuel economy. What's daunting is the size of the problem - how much oil we need - how much energy we need."

Findings published last year showed carbon dioxide might be reduced by 40 percent using the technique. And new findings will be detailed in a research paper being presented during a January meeting of the American Institute of Aeronautics and Astronautics in Orlando.

The research is based at the university's Maurice J. Zucrow Laboratories.

Synthetic fuels currently are being blended with petroleum fuels for performance improvement in automobile and aircraft applications and also are used in equipment trials in commercial aircraft. However, new techniques are needed to reduce the cost and improve the efficiency of making the fuels.

"At the right price, synthetic fuels could replace fossil fuels in all conceivable applications," Gore said.

The 2-meter-tall stainless steel reactor is part of a system that borrows technology from aerospace applications, including a "spark igniter" used in space shuttle engines. Materials inside the spark igniter may briefly reach temperatures of up to 3,000 degrees Celsius, or more than 5,400 degrees Fahrenheit - hot enough to burn holes in steel.

The researchers also integrated an advanced optical diagnostics system: A laser is transmitted through a window in the stainless steel vessel, passing through the gases being processed inside. An optical sensor on the other side of the vessel decodes the light to determine the precise temperature and composition of the gases.

"It's a modular design, so the optical diagnostics part can be moved to various points to analyze how the gasification proceeds," said Robert Lucht, the Ralph and Bettye Bailey Professor of Combustion in Mechanical Engineering.

Doctoral students also designed a special feeder to transport the coal or biomass into the reactor vessel.

"One of the challenges is feeding this at high pressure - about 10 atmospheres," Gore said. "This sort of feeder could not be bought off the shelf, so it had to be specially designed."

Gore and Lucht are working with faculty from Purdue's schools of Aeronautics and Astronautics and Chemical Engineering and other Purdue faculty members, as well as mechanical engineering doctoral students Anup Sane, Indraneel Sircar, Rohan Gejji and Brent Rankin.

Students are working on doctoral theses on the system's mechanical design, the optical diagnostics and approaches for integrating aerospace-related technologies.

Provided by Purdue University