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Cleaner Jet Fuel from Coal

A new process could allow Air Force jets to run exclusively on domestically produced biomass and coal.
By Kevin Bullis

The Air Force is testing a jet fuel made from coal and plant biomass that could replace petroleum-based fuel and emit less carbon-dioxide compared to using conventional jet fuels. The fuel is made with a process developed by Accelergy, based in Houston, using technology licensed from ExxonMobil Research and Engineering Company and the Energy and Environmental Research Center at the University of North Dakota.

Other recently tested experimental biofuels for jets have required that the aircraft still use at least 50 percent petroleum-based product to meet performance requirements, particularly for the most advanced military jets. But the Accelergy process produces fuels that closely resemble petroleum-based fuels, making it possible to do away with petroleum altogether. Because of this, the new process could help the Air Force meet its goal of using domestic, lower-carbon fuels for half of its fuel needs by 2016. Although the first products will be jet fuels, the process can also be adapted to produce gasoline and diesel.

The fuel has passed through an initial round of testing, including lab-scale engine tests, and is on track to be flight-tested in 18 months, says Rocco Fiato, vice president of business development at Accelergy.

Turning coal into liquid fuels is nothing new, but such processes have been inefficient and produced large amounts of CO_2 emissions. Accelergy's approach is different because it uses "direct liquefaction," which is similar to the process used to refine petroleum. It involves treating the coal with hydrogen in the presence of a catalyst. Conventional technology for converting coal to liquid fuels breaks the coal down into synthesis gas, which is mostly carbon monoxide with a little bit of hydrogen; the hydrogen and carbon are then recombined to produce liquid hydrocarbons, a process that releases carbon dioxide. Because the Accelergy process skips the need to gasify all of the coal--which consumes a lot of energy--before recombining the hydrogen and carbon, it's more efficient and produces less carbon dioxide. "We don't destroy the molecule in coal. Instead we massage it, inject hydrogen into it, and rearrange it to form the desired hydrocarbons," says Timothy Vail, Accelergy's president and CEO.

The hydrogen for Accelergy's process comes from two sources--coal and biomass. Accelergy gasifies a portion of the coal they use--about 25 percent of it--as well as cellulosic biomass, from sources such as plant stems and seed husks, to produce syngas. The company then treats the syngas with steam. In this reaction, carbon monoxide reacts with water to form hydrogen and carbon dioxide. Using biomass reduces the net carbon-dioxide emissions, since the biomass absorbed CO_2 from the atmosphere as the original plants grew.

The technology also uses biomass in another way. The company processes seed crops,

such as soybeans or camelina, which contain large amounts of oil. After extracting that oil (which leaves behind cellulosic materials that are gasified), the oil is processed to remove oxygen atoms, forming long chains of straight hydrocarbon molecules. These are then treated to make the straight molecules into branch-like molecules that remain liquid at lower temperatures, making them useful in jet fuel.

The use of biomass reduces net carbon dioxide emissions, but so does the fact that direct liquefaction is more efficient than conventional gasification, says Daniel Cicero, the technology manager for hydrogen and syngas at the U.S. Department of Energy's National Energy Technology Laboratory (NETL), in Morgantown, WV. In gasification, only about 45 percent of the energy in the coal is transferred to the fuel produced. Accelergy claims efficiencies as high as 65 percent using direct liquefaction. Yields of fuel are also higher. Gasification methods produce about two to 2.5 barrels of fuel per ton of coal. Direct liquefaction produces over three barrels per ton of coal, and adding the biomass brings the total to four barrels per ton of coal.

All told, Fiato says, gasifying coal to produce liquid fuel produces 0.8 tons of carbon dioxide per barrel of fuel, while Accelergy's process produces only 0.125 tons of CO_2 per barrel. That makes it competitive with petroleum refining, especially the refining of heavier forms of petroleum. (The fuels produce about the same amount of carbon dioxide when they're burned.)

In addition to reducing carbon emissions compared to conventional coal to liquids technology, a key advantage of the process is the ability to make high-quality jet fuels. The direct liquefaction of coal produces cycloalkanes, looped molecules that have high energy density, giving airplanes greater range. They are also stable at high temperatures, allowing them to be used in advanced aircraft.

One drawback to the process is that it costs more than refining petroleum. Indeed, Cicero says that an NETL study of coal and biomass to liquid fuels technology suggests it would not be competitive until petroleum prices stay above $86 to $93 a barrel. (The study was based on conventional gasification processes.) He says that supplying fuel to the Air Force could sustain one or two small Accelergy plants, but to move beyond this would require a price on carbon-dioxide emissions of about $35 a ton.