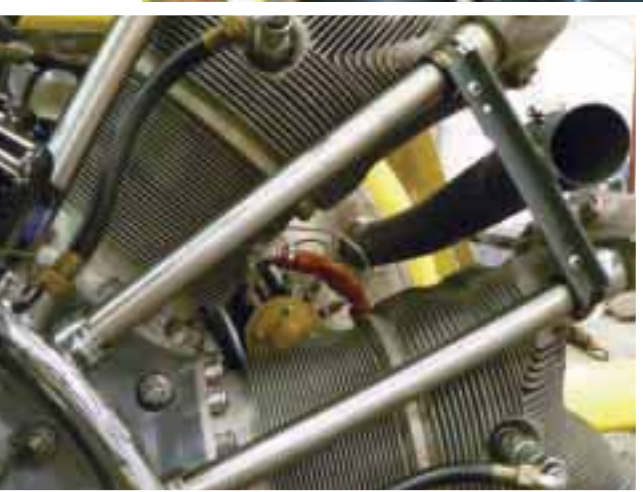


By Lindsay Byrne,
former NAAA Employee



As everyone knows, corn is being converted into ethanol for a more environmentally friendly gasoline. According to the American Coalition for Ethanol (ACE), ethanol fuel is currently available to vehicles at 1,300 gas stations across the U.S. and an ethanol fuel for aircraft will, hopefully, soon be available to pilots. Ethanol is important because we cannot depend on non-renewable fossil fuels; ethanol is sustainable and renewable. As long as corn, wheat, barley, sugar cane and other commodities can grow, there will always be a way to produce ethanol.

*A radial engine on an Ag-Cat, similar to those being converted for ethanol use.
Insert photo: Modified fuel injector allowing for the use off bio-fuels in radial engines.*

Aviation Grade Ethanol

A NEW GASOLINE FOR AVIATION AIRCRAFT

Ethanol Background

Ethanol is an alcohol produced by fermenting sugar or converted starch, usually from grains such as corn or wheat. It can also be made from 'cellulosic' feedstocks, which are corn stalks, grain straw, pulp, wood waste and municipal solid waste. Cellulosic is not a common way to produce ethanol in today's world because it is an expensive technology, but research efforts are underway to make it more cost-effective.

According to the National Corn-to-Ethanol Research Center in Illinois, dry-mill for corn is the most common type of ethanol production in the U.S. In the dry grind process, the entire corn kernel is first ground into flour and the starch in the flour is converted to ethanol via fermentation.

There are a number of reasons why ethanol is used in fuels. Ethanol is a stable and renewable fuel. Ethanol reduces greenhouse gas emissions

that contribute to global warming, Ethanol contains oxygen and promotes a cleaner and more complete combustion when added to gasoline. Ethanol acts as a natural gas line antifreeze in the winter and ethanol has a high octane rating and therefore is useful in increasing the octane level of unleaded gasoline.

ACE states that U.S. ethanol production is reaching unprecedented levels, growing America's ability to supply a portion of its own transportation fuel. Corn is the primary feedstock for U.S. ethanol production and some grain sorghum is also used. In 2006, 20 percent of the U.S. corn crop was used for ethanol production; up from 14 percent in 2005 and 12% in 2004. One billion bushels of corn were used in 2002 and 2003 for ethanol and USDA's Economic Research Service (ERS) projected that 3.1 billion bushels were used in 2007 and 2008.



The root of the cassava, a woody shrub native to South America, can be used in the production of ethanol.

What Countries Produce Ethanol?

The U.S. and Brazil account for most of the world's ethanol production. While the U.S. uses corn for ethanol production, Brazil uses sugarcane. According to USDA's Economic Research Service (ERS), a number of other countries have policy initiatives designed to increase ethanol production, but no country has come close to producing as much ethanol as the U.S. and Brazil. China is currently focusing on trying to produce ethanol from cassava (a cultivated South African Shrub) and sweet potatoes.

In regards to finding alternative fuels, the European Union is the largest biodiesel producer using rapeseed oil as its main feedstock. Brazil and Argentina are using soybean oil and Canada is also using rapeseed oil as a feedstock to expand their biodiesel production.

Aviation Grade Ethanol

Aviation Grade Ethanol, also known as AGE-85 or just AGE, is a high performance fuel, which is 85 percent ethanol-blended fuel for use in aircraft. Researchers hope that this fuel will replace 100 low lead (LL) aviation gasoline (avgas). According to ACE, more than 300 million gallons of avgas are used each year by the piston engine fleet in the U.S. Though avgas is the single largest contributor of lead in the atmosphere today, the Environmental Protection Agency (EPA), for the time-being, has allowed its unregulated use in aviation until a suitable unleaded replacement can be found. Researchers are hoping that AGE is that replacement.

In July 1996, the AGE project was started to develop a fuel based ethanol that could serve as a viable replacement for 100LL aviation gasoline. The South Dakota Corn Utilization Council provided funding

According to a brochure called “Getting the Lead Out” by the National Corn Grower’s Association (NCGA), it is relatively inexpensive to convert an engine to be compatible with ethanol-blended fuels. For blends higher than 85 percent, the modification simply requires allodizing (converting surfaces to be more resistant to corrosion and abrasion) any aluminum fuel-wetted parts, ensuring any rubber parts that come in contact with fuel are ethanol-compatible and modifying the fuel injector unit. If a pilot modifies his engine to burn ethanol, but then decides to go back to avgas, only a simple adjustment to the mixture control is necessary.

to South Dakota State University (SDSU) to pursue this goal. To start the project, SDSU acquired a 1962 Cessna 180 through federal surplus property to serve as a prototype aircraft for the project. Comprehensive flight tests were conducted and FAA Supplemental Type Certification (STC) was obtained to certify Cessna 180s and 182s on AGE fuel. The AGE project at SDSU has also converted an Ag Cat to ethanol power, but they have not yet received an STC for the Ag Cat.

According to Dr. Dennis Helder, Director of Engineering Research at the SDSU and Project Manager Engineer of the AGE project, “We started working on the AGE project with the South Dakota Corn Utilization Council. They purchased the Ag Cat and ultimately donated the aircraft to the University. We decided to do testing with an ag plane because we saw a lot of synergy between the industry and ethanol fuels. It seemed obvious to do testing with an ag plane because applicators spray corn and corn is turned into ethanol. We also thought that we would receive a positive response from the aerial application industry and that they would have a strong interest in ethanol powered aircraft.”

From the researcher’s perspective, “There are significant benefits to the aerial application industry if aircraft are converted to use AGE. Ethanol allows engines to run cooler and it produces a higher horsepower for aircraft than 100LL. We believe that ethanol will extend engine life, which will save money for the operator,” stated Helder. Tests have shown a power output of 600 horsepower on 100LL will increase to 650 horsepower on ethanol. At this time there is not an exact cost available for converting a plane, but Helder thought it might be in the \$5,000 range, although this could change based on many different factors, including the type of aircraft.

“The Ag Cat performance has been great on ethanol. Not only do the engines run better, but they will run longer, will be more reliable and will hopefully save lives,” expressed Helder.

Helder added, “There are two procedures for converting a radial engine aircraft from 100LL to AGE. One is to modify the fuel delivery system to allow the flow of 20 percent more fuel. More ethanol is needed per volume of air for the combustion process. As of right now, the only drawback that we can see to AGE is that fuel flow is higher

and because of this, pilots do have to fill up more often, but if pilots are doing short duration loads, this would not be as big of an issue. This is an issue that we’re continually working on because we want this fuel to be financially rewarding to pilots. The second step in conversion is to ensure that everything touched by the fuel is ethanol compatible, whether it’s rubber or another product.” According to Dr. Jim Behnken of SDSU, while costs related to *fuel consumption* may go up after ethanol conversion, fewer deposits and less wear on the engine will result in lower *overall* operational cost such as maintenance expenses – the related costs of which will typically be less.

An FAA STC for Cessna 180 and 182 aircraft has been obtained, but the FAA has informed the researchers that they would not grant any further STCs for aircraft before working on a specification for the AGE fuel. Based on FAA’s response, Helder stated that they are moving forward to finalize specification of AGE with the American Society for Testing and Materials (ASTM). While the fuel specification is being developed, they hope to recruit some additional ag pilots to conduct beta testing.

The only AGE fuel currently available is in South Dakota and is not available to the public or for sale since it is still being tested.

South American Ethanol-Powered Ag Planes

While there are no U.S. manufacturers currently producing ethanol-compatible engines, in 2004, Industria Aeronautica Neiva of Brazil offered the world’s first factory assembled Ipanema ag aircraft to be supplied with a factory-fitted and certified kit as an option to convert a plane to

– CONTINUED ON PAGE 28

burn ethanol as its primary fuel. Some pilots still have planes that use non-ethanol, so the manufacturer leaves it up to the person buying the plane whether or not they want to convert their aircraft to use ethanol fuel.

According to Alan McCracken, an agricultural engineer and independent consultant who provides support to many applicators in Brazil through his company BDM, “Brazilian Ipanema ag planes are running on 100 percent ethanol with a small gasoline tank for start up only. When a pilot buys an aircraft from Industria Aeronautica Neiva, the factory offers its customers the ethanol conversion kit as an option to operate on pure ethanol. Pilots who already own Ipanema aircraft can also purchase the kits. It is easy and cost effective because pilots are saving a lot of money using ethanol.”

While SDSU scientists advocate reducing or removing water in US ethanol production, according to Helder, the South Dakota team has been following the work in Brazil. “In South America, they work with a

hydrous form of ethanol, meaning that their processing does not remove water from ethanol. The main reason for this is that it’s cheaper to keep water in the ethanol. We are concerned about testing with ethanol that contains a significant amount of water because the ethanol contacts all fuel system components, which could lead to corrosion. The South Americans are ahead of U.S. in the number of aircraft certified for using ethanol, but we hope to get more agricultural and general aviation industry support for our project and receive certification for ethanol fuel in other aircraft.”

According to the Industria Aeronautica Neiva website, as translated by McCracken, the advantages of running an engine on ethanol includes the aircraft are environmentally friendly, the engine runs cooler, there is a possible extension of time between engine overhauls, the power is increased by 7 percent and there is a considerable reduction in operating costs. McCracken further stated that according to ag pilots in Brazil, “The

engines in Brazil are lasting longer, running much cleaner, the oil is cleaner and the engines are requiring less maintenance.”

Also stated on the Industria Aeronautica Neiva website, when considering a fleet of 600 aircraft in Brazil, 4.4 million gallons of Avgas will be eliminated, and there will be a demand for 5.7 million gallons of ethanol. Despite the rise in fuel costs, there will be a reduction in overall operational costs of nearly \$13.5 million per year.

Additional Potential Fuel Options for Aircraft

In an effort to continually find new sources of fuel for airplanes, researchers have found that the Jatropha plant, which is actually a weed, can produce Jet-A bio-fuel. The Jatropha plant has poisonous seeds, which contain 30% to 40% oil that may be refined at a significantly lower cost than crude oil. The plant can grow almost anywhere, it does not need a lot of rain, it is resistant to drought and pests and it can produce seeds for up to 50 years. One hectare (or 2.47 acres) of Jatropha can produce up to 500 gallons of fuel.

Pratt & Whitney Canada announced in July that they are seeking to find alternate biofuels that do not compete with human food sources to fuel their engines. The company is looking into Jatropha plants, as well as algae and biobutanol, which is derived from corn, wheat, sugarcane and beet/cane. It is important to Pratt & Whitney Canada’s objectives in identifying and assessing appropriate biofuels, studying their effect on engine components such as combustors and fuel systems, developing appropriate technologies and design changes to accommodate them, and conducting tests comparing current jet fuels

Why use ethanol in fuels?

Ethanol is a sustainable, renewable fuel that can help reduce our dependency on non-renewable fossil fuels.

On a life-cycle basis, compared to gasoline, ethanol reduces greenhouse gas emissions.

Ethanol contains oxygen and promotes a cleaner and more complete combustion when added to gasoline.

Ethanol has a high octane rating and therefore is useful in increasing the octane level of unleaded gasoline. This in turn reduces pre-ignition or engine ‘knock,’ which under severe conditions may result in serious damage, especially to high performance engines.

Ethanol also acts as a natural gas line antifreeze in the winter.

Courtesy of Ontario, Canada Ministry of the Environment

with first generation ethanol, as well as second generation biofuels. First generation biofuels are limited, according to Pratt & Whitney Canada because they cannot produce enough biofuel without threatening food supplies, they are not cost competitive with existing fossil fuels such as oil, and some of first generation biofuels produce only limited greenhouse gas emissions savings. Second generation biofuels can help solve these problems by supplying a larger proportion of fuel supply affordably, and with greater environmental benefits.

Air New Zealand has been at the forefront of looking for alternative fuels and they believe they have found a great option in the Jatropha plant. Air New Zealand's criteria for sourcing the Jatropha oil was that the land that the plant is grown on could not be a forest or new grassland area within the previous two decades; the quality of the soil and climate is such that the land is not suitable for the vast majority of food crops because they do not want to take land away for producing food; and that plantations are watered by rain and not mechanically irrigated. Air New Zealand, along with Boeing and Rolls-Royce PLC, had test flights scheduled for November 2008, in which they planned to use Jatropha fuel in four aircraft engines of a Boeing 747 powered by Rolls Royce engines.

For more information:

- AGE-85 www.age85.org/
- National Corn-to-Ethanol Research Center
<http://www.ethanolresearch.com/>

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