BIOFUELS & BATTERIES THE FUTURE OF AVIATION

Aviation's share of greenhouse gas emissions is growing (it's now between 2 and 3% of all global emissions), and although private pilots are responsible for only a tiny part of this, it's still necessary to reduce our carbon footprint. What better way to do this than by changing the fuel source? Bye bye Avgas and Jet-A, hello biofuels and batteries!

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It's time to go green. General Aviation includes over 360,000 aircraft worldwide, according to GAMA's General Aviation Statistical Databook. Most operators of single engine aircraft rely heavily on aviation gasoline; in 2012 the GA industry in the US used 211 million gallons (about 800m litres) of Avgas. But, apart from the fact that 100ll is expensive and hard to get outside of Europe and the US, it's also not very environmentally friendly.

Avgas 100ll is the only remaining transportation fuel containing tetraethyl lead (TEL). Although lead has the benefit of creating an octane level high enough to prevent engine knock or detonation, it's a toxic substance. In April three environmental groups filed a petition asking the US Environmental Protection Agency (EPA) to reconsider its current position on leaded aviation fuel. Friends of the Earth, Physicians for Social Responsibility and Oregon Aviation Watch want the EPA to start regulating lead emissions for GA aircraft after a previous petition in 2006 was denied. The groups are convinced emissions pose a public health risk and also that 75% to 80% of piston engine aircraft no longer require leaded fuel at all.

AVGAS ALTERNATIVES

Aiming for a transition, the FAA has set the goal that by 2018 all General Aviation aircraft should have stopped using leaded fuel. To accomplish this ban on Avgas, the Piston Aviation Fuels Initiative (PAFI, an FAA/industry partnership) will identify the most viable candidates to replace 100ll; in September this year up to ten fuel suppliers will be selected to participate in laboratory testing at the FAA's William J. Hughes Technical Center. Afterwards two fuels will continue to phase two where they will be further assessed in engines and aircraft. The budget for this multi-year evaluation programme? A whopping $6m.

Apart from aviation authorities, oil companies have also acknowledged the need for a more environmental friendly fuel and are currently attempting to develop a drop-in solution. So how will this replacement look? Aviation fuel for piston-engine aircraft needs to be of high quality, with a low flag point and few contaminants. A low risk of explosion and a disinclination to freeze would also come in handy. Last, but not least, the formula should have a high octane rating (the industry standard is 100); mogas might seem a solution, but its lower octane rating (85) simply doesn't work in high-compression engines.

Instead of trying to change the fuel, some manufacturers have changed their engines, allowing their aircraft to operate on diesel or jet fuel (the most common type being Jet-A, a kerosene type of fuel suitable for most turbine engine aircraft). Piper for example launched a new model for the PA-28 range: the Archer DX powered by Continental Motors' Centurion 2.0s turbodiesel engine which is certified to use both Jet-A and diesel in any mixture ratio. Continental Motors are convinced diesel is the future, offering installation of diesel engines in the most common aircraft. Compression engines are indeed more efficient than piston engines (burning 20-40% less fuel per hour than Avgas), but they are also heavier. And even though diesel fumes don't contain lead, they aren't exactly nice to breath and still leave a carbon footprint (or, to be more precise, a carbon contrail).

FLYING ON PLANTS

A word heard often in the quest to greener flying is 'biofuel'. It sounds nice and organic, but what is it? Instead of fossil fuels which will run out in time, biofuels are derived from organic sources such as plants or nuts. As the biomass grows, it absorbs carbon dioxide from the atmosphere. About the same amount of CO_2 is released again when the fuel is burnt, making for an almost carbon neutral product.

Since biofuels are made from living plants they are a renewable resource and theoretically, they can be produced from any renewable biological carbon material. This does't mean you can empty the contents of your lawn mower into your aircraft's fuel tanks though. After harvesting, oil needs to be extracted and refined to meet specifications. For jet fuel this includes isomerisation (a process by which one module is cracked open and re-arranged to form another shape - trust us, it's too tricky to do in your shed).

Biofuels can be divided in first- and second-generation. The first-generation is derived from food crops such as sugarcane and corn, whereas the sustainable second-generation doesn't consume valuable food resources: it can be grown in harsh conditions requiring little water and soil. Logically, the future is in the second-generation: as much as we want to fly, we also want to eat. Potential sustainable biofuel fed stocks are jatropha (a plant), camelina (a crop), algae, halophytes (salt marsh grasses) and biological waste.

FLOWER POWER

The use of biofuels in aviation started back in 2008, when a Virgin Atlantic flight used a blend of 20% biofuels. Greener blends followed until in October 2012 a formula of 100% biofuels was used to power a Dassault Falcon 20. Mostly used for jets, biofuels can also power GA aircraft, if they've got the correct engine. In March 2013, a Cessna 182 converted to be powered by an SMA jet-fuel diesel cycle piston engine, was the first piston engine aircraft to fly with a 50/50 blend of SkyNRG aviation biofuel (made from recycled cooking oil) and normal Jet-A.

Currently biofuel emissions are being tested in flight. A collaboration between NASA, the German Aerospace Center (DLR) and the Canadian National Research Council (NRC) is sniffing exhaust fumes at altitude as a part of the Alternative Fuel Effects on Contrails and Cruise Emissions (ACCESS II). NASA's DC-8's engines burn different fuel blends while DLR's Falcon 20-E5 and NRC's CT-133 research aircraft measure the emissions and observe close contrail formation. Earlier ACCESS I testing already indicated that biofuel blends, aka flower power, may substantially reduce emissions of black carbon and sulphates.

In these recent tests the focus lies on aviation's effect on the formations and properties of condensation trails. Over 100 scientists and technicians look at the differences between using a one-to-one mixture of Hydroprocessed Esters and Fatty Acids (HEFA, which comes from the oil of Camelina plants) and using regular JP-8 aviation fuel. It is expected that the combustion of biofuels, in addition to a better carbon dioxide balance, will lead to significantly fewer soot and sulphur particles. Hence, a lower level of soot emissions would lead to larger ice crystals in the condensation trails, which may reduce the impact of aviation on the climate by additional cloudiness.

FUEL-LESS

No matter how sustainable the fuel, fact is that aircraft will still produce noise and exhaust fumes – let alone the amount of money it costs to fill the tanks. Therefore why not completely bypass the fuel issue and use batteries instead? Like electric cars, there are aircraft that run on electric motors, with power coming from fuel cells, ultra capacitors, or, most commonly, batteries. Unlike electric cars, aircraft need to take off from the ground, which requires more power and thrust than just a forward propulsion.

An electric battery can't supply as much power for its weight compared to what Avgas can produce. This lack of power means more batteries are needed, adding more weight, causing the need for a bigger engine, which will then need more batteries, adding more .., well, you get the picture. At the moment most batteries aren't powerful enough yet to take over GA, so most electric flying is done in gliders. Another way to deal with the weight issue is to use solar power, as has been done by Solar Impulse's aircraft and Solar Flight's Sunseeker.

Nowadays a very light structure and excellent aerodynamics are needed if you want to power an aircraft with batteries. Plus, you'll have to accept a slower max speed than your average aircraft. However, once battery technology improves and breakthroughs in fuel cell technology, engine and propeller design are made, there is no reason why electric shouldn't work. Compared to a piston engine, an electric motor is small and contains no reciprocating parts.

We've certainly come a long way since the first man-carrying solely electrically powered flight: in 1973, a Brditschka HB-3 motoglider was converted to an electric aircraft, the Militky MB-E1 used Ni-Cd batteries and a 10kW (13hp) DC motor for its 12 minute flight. Many interesting projects have followed, the most recent being the Sunseeker Duo, a solar-powered aeroplane for two people. And in 2014 it seems that electric flight has really taken off in GA: Aero Friedrichshafen is unimaginable without its e-flight-expo and events such as the Comparative Aircraft Flight Efficiency (CAFE) Electric Aircraft Symposium draw more and more participants.

The fuel-future is happening as we speak: Avgas will be banned, unleaded alternatives are developed and Beechcraft has announced it will fly the first King Air ever built around the world using only 100% renewable jet fuel, to name just a few exciting developments. In most cases the only barriers left are cost and certification – once these are overcome there's nothing more standing in the way of aviation going green. Who knows, in the next decade both leaded fuel and Jet-A could be considered as old fashioned as steam engines...