NEW PERSPECTIVES FOR BIOFUELS IN AVIATION

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Abstract

All producers of fuels are agree that hydrogen could be the major energy carrier in the future, but still is not clear how safety to input hydrogen into aviation. The Institute of Aviation provided laboratory experiments, engine bench tests, long term road and sea tests concerning proecological Diesel fuel based on RME (Rapeseed methyl ester) i.e. FAME mainly and with mixture of ethanol, methanol with Diesel fuel.. It is expected to use of all type of biofuels in aviation engines (piston and turbine too), according their all known advantages.

1. Introduction

The Institute of Aviation (IoA)provided laboratory experiments, engine bench tests, long term road and sea tests concerning proecological Diesel fuel based on RME (Rapeseed methyl ester) mainly and with mixture of ethanol, methanol and RME with Diesel fuel. Comparative tests of domestic and foreign ecological Diesel fuels were performed. The tests covered an investigation of physical/chemical properties of fuels and performance of domestic and foreign Diesels. Pilot parcel of Polish RME was produced by few different technologies from pure, half and non rectified rapeseed oil. Institute of Aviation prepared draft Polish standard for RME (Paliwo rzepakowe PN-93/C…Projekt). The results of investigation have enabled us to understand the application of biofuels. Laboratory tests were confirmed by road tests (fueled by pure RME) of Polish experimental car "Polonez 1.9 L Diesel" on 170 000km, sea tests of Polish yacht s/y "Politechnika" on more then 1060 miles near Arctic Circle and more then 5000h of fuel pump tests on special long term stand . IoA with co-operation with "Chemadex" S.A. Warsaw, Poland built the first Polish agrorafinery capable of producing up to 1200tonnes of RME fot. 1. With CPN Wrocław, Poland IoA market a mixture 5%RME in 8 Diesel filling station. In Poland possible area to production of rapeseed is about 2000 000 ha and the same area for ethanol production. In the future it gives more then 20% of total fuel market in Poland. It is expected to use of all type of biofuels in aviation engines (all type piston and turbine too), according their all known advantages .

Fig.1. "Polonez Caro Diesel" fueled by FAME in agrorafinery "Mochełek"

2. New fuels in aircraft

All producers of fuels are agree that hydrogen could be the major energy carrier in the future, however still is not clear how to input hydrogen with satisfactory to aviation. First steps with hydrogen like aviation fuel begins in 1937 (Pratt&Whitney) and are repeated successively: 1956-8 (P&W, J-57 engine), 1957 (Boeing, B57) 1970 (General Electric and NASA), !988 (TU-154), 1990 (Airbus , APU engine A321) and 2000 (EC-funded project CRYOPLANE). Liquid highly cooled hydrogen would reduce the emissions to water vapour and low quantities of NO_x. All emissions containing carbon and sulphur would be eliminated, but the low energy content per volume requires re-designing of aircraft and engines with fuel system. Synthetic kerosene produced from carbon non resolve problem however has the another advantage of being compatible with today's fuels. Since the days of Henry Ford, who prepared Ford Model T on ethanol, very interesting way of using of renewable biofuels in aviation are efforts introduced lately by the Renewable Aviation Fuels Development Center (RAFDC) at Baylor University, Waco, Texas in USA. The most notable sign of new era was the first ethanol fuelled transatlantic flight in 25 September ,1989. The aircraft "Velocity" with engine HIO 360 was flown from Waco in Texas to Paris, France. For this flight Dr Max Shauck received The Harmon Trophy, most known award, received in the past by aviation stars like Charles Lindbergh, Amelia Earhart and Chuck Yeager. Last year Dr Shauk with his wife Gracia Zanin (Baylor's Director of research and II pilot across Atlantc!) visited Institute of Aviation and presented seminar "Review biofuels activities in aviation". They input the idea of using ethanol like fuel in IS-2 "Manager" because this design of Institute of Aviation is equipped with the same type of Lycoming 360 like the engine using in the flight across Atlantic. According benefits of ethanol and RAFDC we received offer of conversion engine to ethanol with SCT (Supplementary Certificate Type). Engine of Lycoming HIO 360 modified by our guests in RAFDC produces more power, is more economical then "avgas" and offers longer time between overhauls. It is very interesting for all Europe because the costs of Avgas is expected to increase as Europe producers will remove lead from aviation gasoline. At the same time the price of ethanol is predicted to decrease according of better technologies and low cost biomass.

Fig.2. Dr Max Shauck and Grazia Zanin with author before IS-2 „Manager"

3. The first ethanol fuelled transatlantic flight

The first transatlantic flight on ethanol fuel was prepared on very well known Lycoming 360. According fuel characteristics (see table below) i.e. high octane, high oxygen ethanol burns more completely end clean without detonation, low RVP have less tendency to vapor

lock. Ethanol replaces in gasoline that chemicals which are listed as carcinogenic hydrocarbons (mainly benzene and ETBE). Emissions of hydrocarbons is less then 50%. Emission of carbon monoxide decrease 40%, increase emission NOx up to 19%. On the margin emission of aircraft engine in USA and Europe (apart from Sweden and Swiss) is non regulated. Simple modification of fuel system to allow more fuel flow was needed. The drawback was slight reduction in range to max 20% depending from compression ratio.

Parameter	AVGAS	Ethanol
Specific gravity	.69 -.79	.789
Lower Caloric Value MJ/kg	44.2	27.2
Motor Octane	100	112
Stoich. A/F	14.7	9.0
Reid Vapor Pressure Kpa	38-48	16
Latent heat, MJ/kg	.34-.35	.92
% oxygen m/m	0.0	34.7

In Lycoming HIO-360 compression ratio was raised from 7.5 to 10.5 by reducing of the deck height and installing new high compression pistons. The cylinders walls were chrome plated.

In fuel system according reaction of ethanol on certain Al alloys short fuels lines were modified. There was only a short fuel line, which was allodized. The rest of the fuel lines from buna-N rubber as inner core were compatible with ethanol like wing fuel tanks made from fiberglass. Compatibility with ethanol of all material were tested. New digital fuel meter was installed. Preliminary tests were conducted with good results. The flight across Atlantic is very precisely described and no problem related to fuel is confirmed. Considering price of fuel in USA for ethanol transatlantic flight cost is 160 USD- if avgas would have been used it increase up to 230 USD!

4. New perspectives for biofuels

Growth in consumption of fuels increases annually about 2.9%, in aviation fuels about 4%. Maximum production of crude oil is estimated in 2020. Most of the growath will occur in developing countries. Total carbon dioxide emission are projected to increase more the 60%

In order to stop dependence from crude oil biofuels are very interesting, but it is very hardly predict in which direction the technology of new fuels will take us in the future. With regards to biodiesels (FAME) the European Union hopes to receive level of 5 milion tonn in 2002/3. Outlook for ethanol has never been better. USA continue to be the leading ethanol producer, however Brasil still dominates. Poland announced new biofuels regulations for biofuels.

RAFDC showed us not only ethanol like biofuel. After ethanol and ETBE as fuel for piston engine aircraft RAFDC developed blends of Biodiesel from soya (SME) and Jet A for turbine engine aircraft. RAFDC has obtained Federal Aviation Administration (FAA) certifications for different engines and aircraft powered by ethanol (Lycoming IO-540, O-235 series of Lycoming engines, the Cessna 152 series of training aircraft, Piper Pawnee - an agricultural spray aircraft, acrobatic Pitts Special, and lately in Reverenge M-10, powered by standard Rotax 912XUL. The Reverenge M-10 is a “new concept in general aviation” and costs only 48 000 USD and conversion of Rotax costs only 3000 USD. (For I-23 “Manager” with Lycoming IO 360 dr Max Shauck predicted costs no more then 1000USD and STC).

After new fuels are coming new perspectives for new engines like Diesels using Jet A fuel. Addition only 1% of Biodiesel (SME RME, FAME too) increases lubricity by 65 % and will be used in turbine engines, where very well clean injectors from deposits. In laboratory

tests were checked in USA winterized blends having between 10 –30% of SME to determine their compability with jet fuel JP8. “Blended biodiesel fuels can function safely in commercial and military aircraft” says Robert O.Dunn from USDA-ARS Oil Chemical Research Unit. Very interesting concept was tested in Institute of Aviation on high speed, turbocharged, intercooled Diesel engine like an concept of aviation blends to Diesel in aviation (below).

Parameter at DF=75%, RME=20%, ETHANOL 5%	Change in % according DF
Power	-0.4
Max. Torque	-2.3
Smoke (Power/Max. Torque)	-20/ -42
Reg. ECE 49 CO HC NOx PT	 -11 -15 -7 -50

New study documents in USA shows that new US biofuels regulation could boost the U.S. economy by 300 billion USD and creates as 300 000 new jobs. Increased gross production and job creation would generate an additional 71 billion dollars.

In Poland, after new regulation of biofuels is expecting rise of economy up to 2.7 - 3.2 mld zł and about 12-15 000 jobs in agriculture and additional 50000-70 000 new jobs in co-operation

6. Conlusions

- The use of biofuels in aviation is recommended for wider investigation in Poland and Europe.
- Comparison with USA indicated that is needed harmonization of efforts in this direction.
- The rigorous testing regime in aviation should be performed on a Community basis rather then as national initiatives

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