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THE ALTERNATIVE FUELS FOR AVIATION TRANSPORT – PROSPECTS AND BARRIERS TO THE IMPLEMENTATION

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Abstract

The aim of this article is presentation the current situation in biofuels implementation in air transport. Since last decade, intensive actions are being undertaken to reduce emissions by the air transport. One of the significant ways is to replace fossil jet fuels with biofuels. Biofuels are produced from biomass and it is assume, that all CO_2 emitted by engines powered by biofuels is assimilated by plants. In 2009 IATA (The International Air Transport Association) concluded, that alternative fuel is an important part of the aviation industry's future [5]. Five years later, in 2014 IATA [6] stresses, that biojet fuels production in no profitable from economic point of view. Authors of [6] showing the diagram of biojet fuels development they stresses existing of "valley of death". They concluded that without "the bridge" under valley of death the biojet fuels development is impossible. This was concluded, that: a) development of biojet fuels is at the beginning of long chain shown on Fig. 1; b) the prospects are dependent on the mechanisms of support – the important part of governments policy; c) ASTM has accepted 5 technologies of biojet fuels production, but it is unclear what does it mean "accepted"; d) commercialization of biojet fuels needs the solution of many, important technical – logistic problems, like biojet fuels miscible.

Keywords: *biohydrocarbons technology, biojet fuel, biofuels logistic*

1. Introduction

Intensive development of alternative fuels in the world`s transport for over 20 years has been focused on road transport. The main reason of alternative fuels development is reduction of greenhouse gases (GHG) emission and air quality improving. Transport is responsible for more than 30 % energy consumption and ca 45 % GHG emission. Air transport was not considered a significant source of emissions of CO_2 as well as CO, hydrocarbons (CxHy) and particle matters (PM). Since 10 years, intensive actions are being undertaken to reduce emissions by the air transport. One of the significant ways is to replace fossil jet fuels with biofuels. Biofuels are produced from biomass and it is assume, that all CO_2 emitted by engines powered by biofuels is assimilated by plants.

Biofuels can be produced from various kinds of biomass using a number of technologies [1-4]. Since ca 20 years production of bioethanol and FAME has been developed and these biocomponents are blended with gasoline and diesel fuel in every country of the world. FAME is commonly blended with diesel fuel, but cannot be added to jet fuel because of its different chemical structure than fossil jet fuel and different properties, like low temperature properties.

The last decade researches are focused on biofuels consisting of synthetic hydrocarbons, which chemical structure is much more similar to fossil fuels structure. These biofuels consisting of hydrocarbons constitute the potential for bio-jet fuels development.

Implementation of biofuels consisting of hydrocarbons in air transport is widely discussed on four levels:

- Technologies of biofuels production,

– Logistic,
– Economical,
– Technical aspects of implementation to supply aviation turbine engines.

The aim of this article is analysing the possibility of biojet fuels implementation on a large scale in aviation transport. In the article, there are listed prospects and barriers. Authors of this article focus on technological and technical problems, which have be solved in case the biojet fuels will be developed on large scale.

2. Prospects and barriers

The prospects mainly the result of international organisations and governments determination to reduce GHG emission, including emission from air transport. The volume of fuel consumed by air transport has been increasing every year (Fig. 1). It is estimated that this will continue to increase by 3 % each year hereafter [5]. Proportionally to this will increase emission of CO_2.

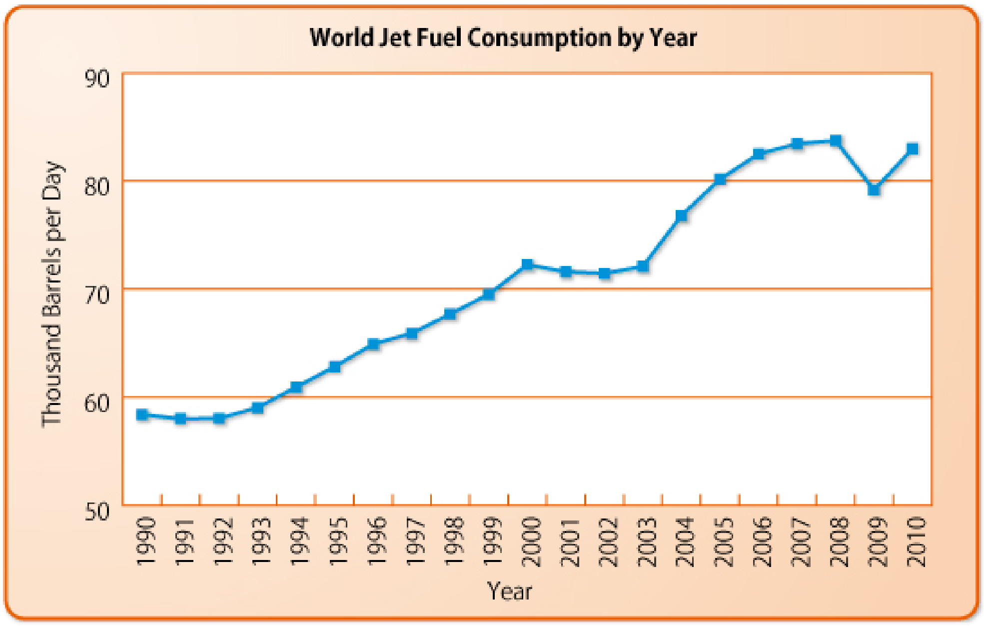

Fig. 1. Trends in global jet fuel consumption [1]

In 2009 IATA concluded, that alternative fuel is an important part of the aviation industry's future [6]. Five years later, in 2014 IATA [7] stresses, that biojet fuels production in no profitable from economic point of view. The cost of biojet production is higher than the cost of conventional jet fuels production. IATA forecasts, that biojet costs should decrease with the scale-up of production. Furthermore, there are generally no policies to support the development of biojet fuels in aviation while incentives and mandates are in place for road transportation. As IATA reports "Recent developments in biofuels policy, both in the USA and Europe, where established targets for biofuel penetration were reconsidered, have also reinforced the demand for stable and long term-oriented supporting policies" [7].

Authors of [7] showing the diagram of biojet fuels development they stresses existing of "valley of death". They concluded that without "the bridge" under valley of death the biojet fuels development is impossible. This bridge should be built by policy, including the mechanisms of economical support of the research, technology transfer and commercialization. The diagram shown on Fig. 2 does not account for a very important element, which is the new biojet fuels authorization for use in aircraft engines. ASTM D4054 [8] worked out the algorithm of biojet fuels authorization, which is shown on Fig 3.

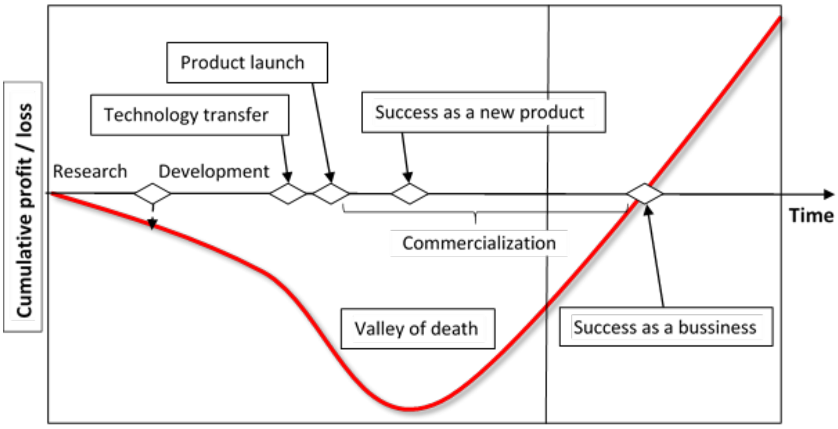

Fig. 2. The path of biojet fuels development [7]

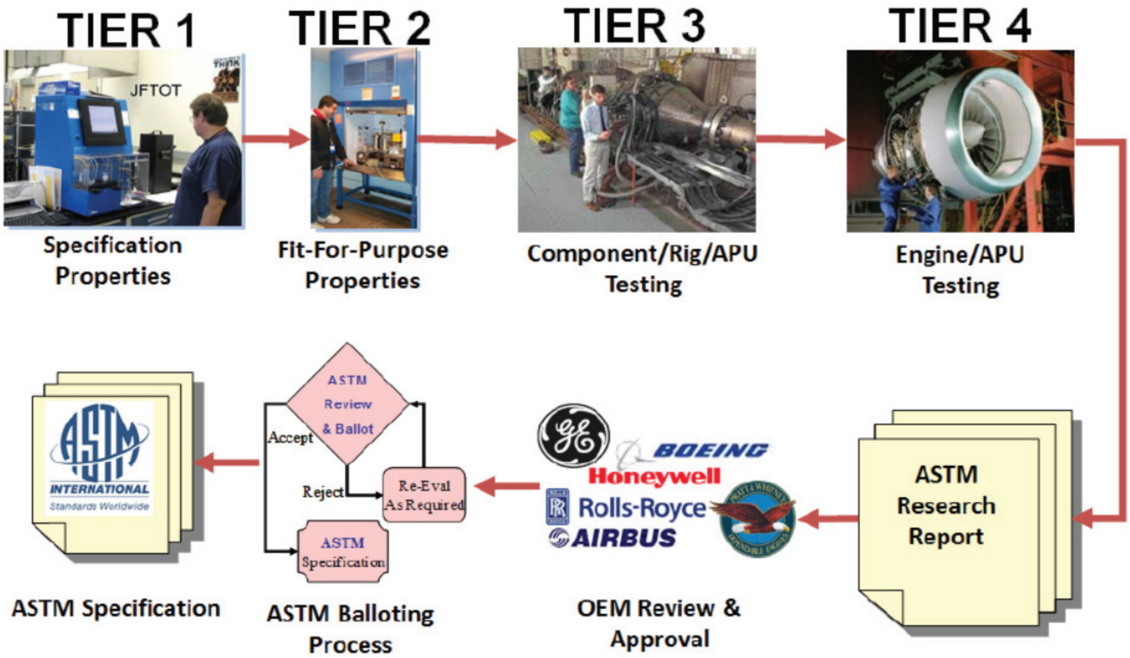

Fig. 3. The algorithm of new synthetic biojet fuels authorization according to ASTM D 4054 standard [8]

This pathway required many lengthy and costly tests on four levels: laboratory tests stand tests, tests in engine house and finally flight tests. At the end of this path is ASTM specification, which determines the quality requirements for authorized new biojet fuel. On the basis of this algorithm ASTM D 7566 [9] has approved five technologies of biojet fuels production:

– FT (Fischer-Tropsch synthesis),
– FT/A (Fischer-Tropsch synthesis products + aromatic hydrocarbons),
– HEFA (hydroprocessed esters and fatty acids),
– SIP synthesized iso-paraffins,
– ATJ (alkohol-to-Jet).

The most important for the subject of this article required parameters are shown in Tab. 1.

The volume of fuels consumed by air transport determines the volume of biofuels / biocomponents, which should be produced. This is limited by:

– Biomass availability,
– The capacity of plants producing biofuels / biocomponents.

The quality requirements of ASTM D 7566 [8] for synthetic jet fuels components are mainly attributed to their chemical composition either directly (the hydrocarbon and non-hydrocarbon components) or indirectly (acidity, volatility, flash point, density and temperature of the coagulation). The chemical composition of the synthetic jet fuel components is compared to the chemical composition of fuels derived from crude oil, whose properties protect all the requirements of manufacturers of jet engines and aircraft. The following is a typical chemical fuel Jet A1:

– about 25 % n-paraffins,
– about 35 % iso-paraffins,
– approximately 20 % cycloparaffins,
– about 20 % aromatics.

Tab. 1. Chosen requirements for biocomponents authorized according to ASTM D 4054 [8]

Property	F T – SPK	HEFA – SPK	SIP	FT – SPK/A	ATJ
Technological process	Fischer – Tropsch synthesis	Hydrodeoxydation of esters and fatty acids	Synthetic isoparaffins	Fischer – Tropsch synthesis + aromatic hydrocarbons	Alcohols to isoparaffins
Blends with fossil Jet A-1	max. 50 % (V/V) in Jet A-1	max. 50 % (V/V) in Jet A-1	max. 10 % (V/V) in Jet A-1	max. 50 % (V/V) in Jet A-1	max. 30 % (V/V) in Jet A-1
Fuels characteristic	The mixture of ca 75-80 % olefin and 20 – 25 % paraffin	The mixture of iso-paraffin and n-paraffin	Iso-paraffin C15	The mixture of n-paraffin, isoparaffin and aromatic hydrocarbons	The mixture of iso-paraffins C8 – C16
Hydrocarbons content:					
Cykloparaffins, % (m/m)	Max. 15	Max. 15	-	Max. 15	Max. 15
Aromatic hydrocarbons, % (m/m)	Max. 0.5	Max. 0.5	-	Max. 20	Max. 0.5
Paraffins, % (m/m)	Report	Report	-	Report	Report
Saturated hydrocarbons, % (m/m)	-	-	Min. 98	-	-
Famezan, % (m/m)	-	-	Min. 97	-	-
Hexahydrofamesol % (m/m)	-	-	Max. 1,5	-	-
C and H content	Min. 99.5	Min. 99.5	Min. 99.5	Min. 99.5	Min. 99.5

As you can see, synthetic components differ significantly in composition from mineral fuels. This has an impact on the behaviour of synthetic fuels in logistic systems, power systems of jet engines and the combustion process. Thus, in most they are allowed to operate only the fuel blends of synthetic mineral Jet A fuel, wherein the maximum content of the synthetic component is different for different technologies.

Presented in Tab. 2 quality requirements for certain technologies required repeatability of the chemical composition, which is important in the selection of raw biomass and supervision of technological processes. These requirements are practically not related to operating properties – impact on combustion process in jet engine and the behaviour of the fuel in the logistics processes.

ASTM D 4054 is an important step in development of biofuels for aviation, but this standard together with ASTM D 7566 introduces unclear situation. ASTM D 4054 contains algorithm of bio jet fuels authorization with no information about procedures required for authorization. This algorithm is based on the principle that each biojet fuel is tested separately (see Fig. 4). Furthermore, the tested biojet fuel was produced by one production facility, which used specific for this production facility biomass as the feedstock. Can the results obtained for such biojet fuel is related to all biojet fuels produced according to this technology, for example FT technology? In authors opinion the answer is NO.

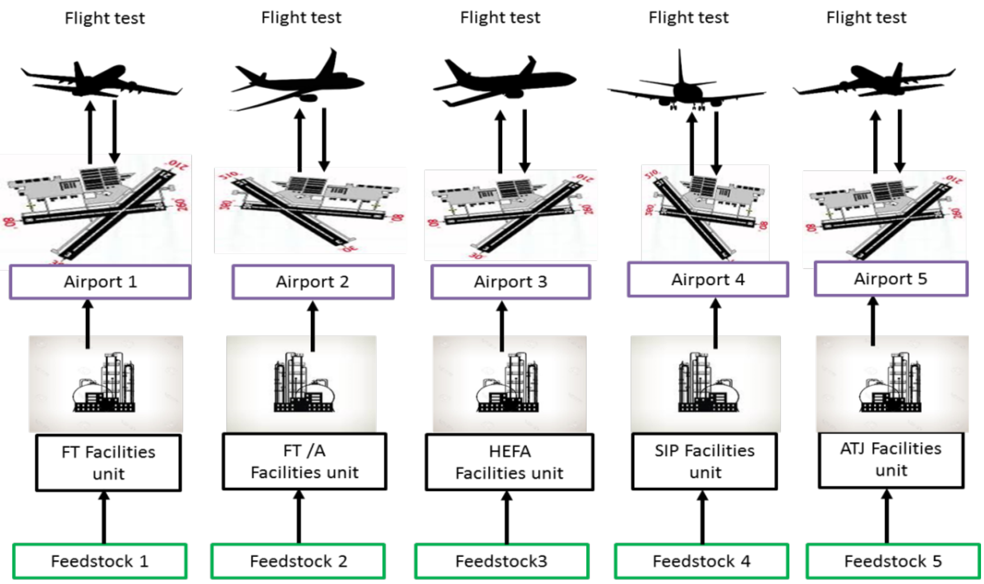

Fig. 4. Current experience in biojet fuels use in aircrafts

ASTM D 7566 determines the list of accepted technologies of biojet fuels production, requirements for the products obtained using these technologies and finally the range of accepted concentration of biocomponent in jet fuel. When the process of commercialization will begin and the biojet fuels will be implemented on a larger scale the following problems will occur:

- Mixing various biojet fuels produced by different production facilities according to different technologies – each airport will be supply by another biojet fuel (see Fig. 5),
- Mixing various biojet fuels produced by different production facilities according to the same or different technologies – given airport will be supply by biojet fuel from different production facilities (see Fig. 6).

There is no data, which confirm that mixtures of different biojet fuels can be use in jet engines without risk.

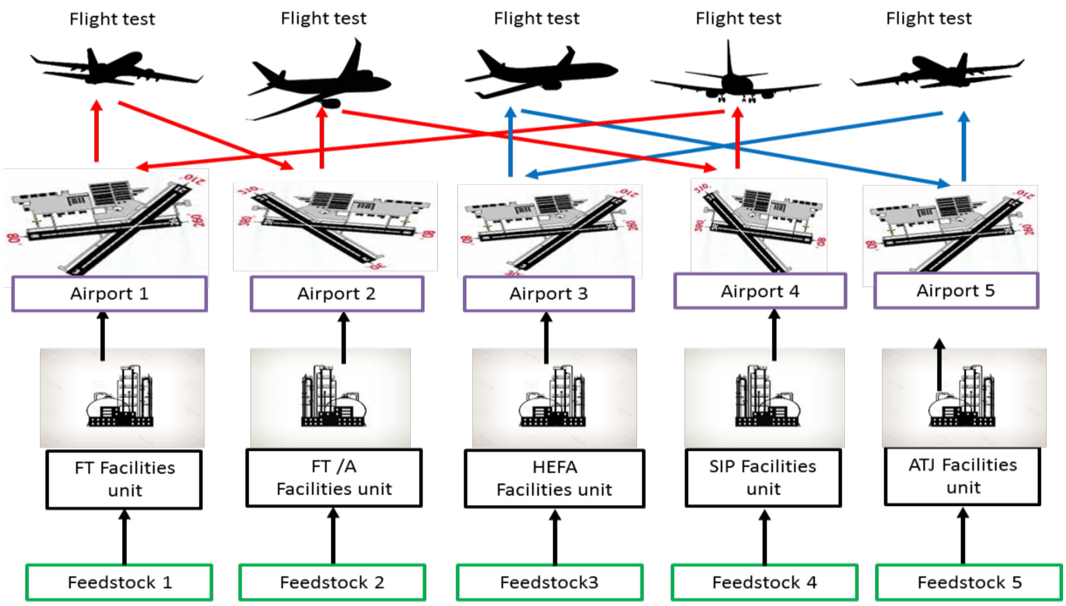

Fig. 5. Technical-logistic problem 1: the same aircraft will be supply with various biojet fuels at various airports

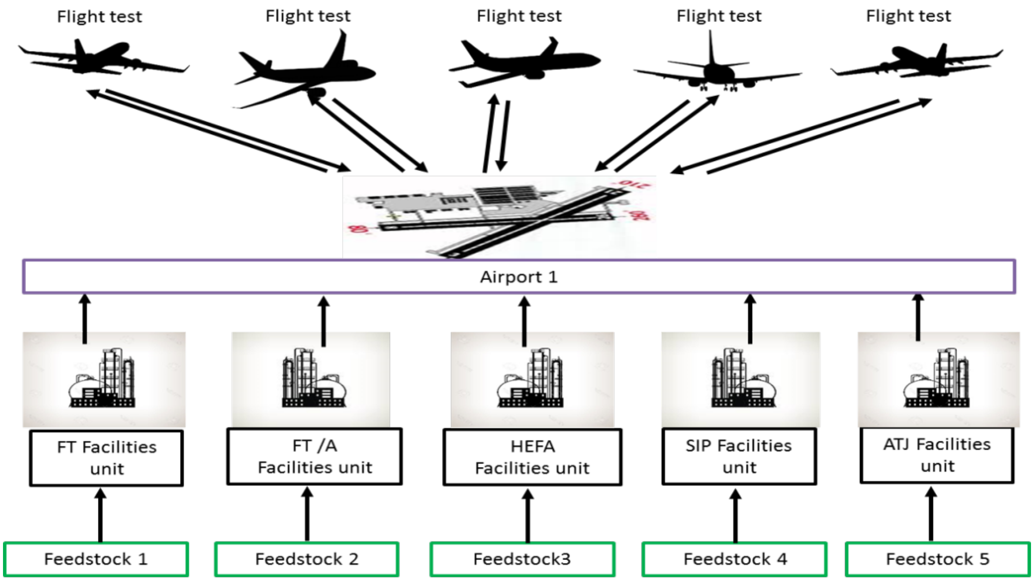

Fig. 6. Technical-logistic problem 2: the same airport will be supply by various production facilities

3. Conclusions

This was concluded, that:

- Development of biojet fuels is at the beginning of long chain shown on Fig. 1,
- The prospects are dependent on the mechanisms of support – the important part of governments policy,
- ASTM has accepted 5 technologies of biojet fuels production, but it is unclear what does it mean "accepted",
- Commercialization of biojet fuels needs the solution of many, important technical – logistic problems, like biojet fuels miscible.

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[9] ASTM D 7566-16b, *Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons.*