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PECULIARITIES OF THE DEVELOPMENT AND IMPLEMENTATION OF AVIATION BIOFUELS IN UKRAINE

S. V. Boichenko, Dr. Sc., Professor; ***O. O. Vovk***, PhD, Associated Professor;
A. V. Iakovlieva, ***M. S. Boichenko***

National Aviation University

*pinchuk_anya@ukr.net

The modern environmental problems caused by the activity of aviation industry are figured out in the article. The tendency for transition to alternative jet fuels all over the world is described. Attention is paid to the policies of developed countries intended to the implementation of biofuels in aviation, and introduction of new standards for alternative jet fuels. Contemporary state of jet fuels production and use in Ukraine is discussed. Ukrainian experience in development of national policy for introduction of alternative jet fuels into civil aviation is described. The current problems and future benefits of jet biofuels implementation in Ukraine are emphasized.

Keywords: alternative energy, jet fuels, civil aviation, biofuels, concept, flight safety, environment, plant oil.

Розглянуто сучасні екологічні проблеми, пов'язані з діяльністю авіаційної галузі. Описано основні світові тенденції щодо переходу на альтернативні авіаційні палива. Приділено увагу політиці розвинених країн світу, що спрямована на впровадження біопалив у авіацію, а також введенню нових стандартів щодо якості авіаційних палив. У статті висвітлено сучасний стан виробництва та споживання палив для повітряно-реактивних двигунів в Україні. Репрезентовано досвід України в розробленні національної політики щодо впровадження альтернативних авіаційних палив у цивільну авіацію. Розкрито сучасні проблеми, а також наголошено на майбутніх перевагах упровадження альтернативних авіаційних палив в Україні.

Ключові слова: альтернативна енергія, палива для повітряно-реактивних двигунів, цивільна авіація, біопалива, концепція, безпека польоту, навколишнє середовище, мастило.

Introduction

Today application of alternative energy sources in various spheres of human activity becomes more and more popular all over the world and in Ukraine in particular.

Possibilities of traditional motor fuels substitution with biofuels derived from plant feedstock are actively discussed [1]. Today such biofuels include: bioethanol, used as alternative to motor gasoline and biodiesel, derived from plant oils and used in automobile diesel engines.

Along with development and implementation of alternative motor fuels, scientists study perspectives of partial or total substitution of traditional jet fuels with their alternative analogues. Following the world tendencies there is need to consider Ukraine's potential in development and application of alternative jet fuels [2].

The world community is concerned about worsening of ecological situation in a result of aviation industry activity. One of the global problems is climate change caused by increasing greenhouse effect that is a result of CO_2 emissions during production and use of jet fuels [1].

According to the data presented by the Intergovernmental Panel on Climate Change and International Energy Agency, modern aviation is the source of about 2 % of the world CO_2 emissions (Fig. 1) [1]. About 71,5 kg of CO_2 per km is emitted into the atmosphere during the aircraft flight.

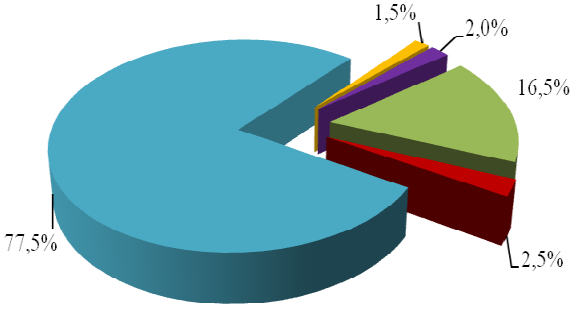

Fig. 1. Share of CO_2 emissions from aviation comparing to other kinds of transport:
1,5 % — world aviation; 2 % — world marine;
16,5 % — motor transport; 2,5 % — other kinds of transport;
77,5 % — other kinds of energy resources

Exhaust aircraft gases contain number of other components that negatively influence on the state of environment. Among them are: sulfur oxides, nitrogen oxides, carbon monoxide, methane, soot, particulate matter and others.

The onrush development of aviation causes growth of aircraft's park and volumes of carriages. Thus the consumption of jet fuels growth annually. According to some data, world civil aviation consumes about 2 billion barrels of fuel for air-jet engines [1; 2].

Problem statement

Traditionally fuels for aircraft engines are produced from crude oil [9]. The most part of existing technologies is still intended for processing

of crude oil and some other fossil fuels, such as coal, natural gas, oil sands and oil-shales [12]. Technologies used for processing of these raw materials allow obtaining of high-quality fuel and varying certain characteristics if required. However, these technologies are quite energy-intensive and highly complicated. Refining of kerosene fractions from crude oil requires hydrotreating and other destructive methods of oil processing; at the same time, refining of non oil-derived feedstock requires additional processes like pyrolysis, FT-synthesis, gasification etc.

However, crude oil and other fossil fuels are inevitably exhausting and thus causing constant growth of prices for jet fuels. According to the data of the International Air Transport Association the price for jet fuel in February 2013 was equal to around 1100 $ per ton. These factors determine the necessity of aviation transition to fuels derived from renewable energy sources [2–4].

In this regard number of non-govermental organizations like IATA, ICAO and government authorities brought up an issue about implementation of alternative fuels in aviation. The resolution of European Parliament about minimization of the consequences of aviation activity for climate change (INI/2005/2249) clearly states that: "European Parliament strongly demand the cooperation in implementation of jet biofuels, in such a way promoting minimization the consequences for climate changes". International Air Transport Organization has announced the task to reduce CO_2 emissions on 50 % by 2050. IATA also plans to reach the 10 % share of biofuels among fuels for air-jet engines by 2017 %. At the same time European Commission has adopted policy on the reduction of CO_2 emissions on 60 % by 2050. The share of low-carbon aviation fuels should reach 40 % by 2050.

Analysis of publications

In 2009 American Standard ASTM D7566 was enacted. It describes production of jet fuels, which consist of a mixture of traditional and synthetic components. It determines certain types of fuels for AJE for civil aviation that contain synthetic hydrocarbons, and that are satisfactory for use in aircrafts. It is intended for determination of jet fuel and its synthetic components quality during the whole life cycle: starting from production process and up to fueling of aircrafts. This standard provides two grades of jet fuel: Jet A and Jet A-1 — distillate fuels of kerosene type, with a relatively high flash point. According to the standard, fuel for AJE should consist of traditional fuel grades Jet A or Jet A-1, which are in compliance with Standard D1655, and up to 50% of the synthetic component, defined by this standard. For today Standard ASTM D7566 determines only two technologies, used for synthetic components production:

1. Hydrogenated synthetic kerosene produced entirely from synthetic gas by the Fischer-Tropsch (FT) synthesis with further application of such traditional processes as hydrotreatment, hydrocracking, hydroisomerization, and also polymerization, isomerization and fractionation.

2. Hydrogenated synthetic paraffinic kerosene derived entirely from esters of fatty acids and free fatty acids by their hydrogenation and deoxygenation, followed by processing with the above mentioned processes.

As we can see, the enlargement of raw materials for jet fuels production was reflected in the normative base by amending the standards Def Stan 91-91 and ASTM D1655, as well as introduction of a new standard ASTM D7566, which regulates jet fuels production from alternative raw materials [3; 4].

Considering the variety of developing technologies for jet fuels production, several groups are determined according to the feedstock used [5; 9; 11]:

1. Derived from conventional oil;

2. Derived from unconventional oil (oil sands and oil shale);

3. Derived synthetically from natural gas, coal, or combinations of coal and biomass via the FT-process;

4. Derived from renewable oils (biodiesel, biokerosene, hydroprocessed renewable jet — HRJ or Hydrotreated Vegetable Oil — HVO);

5. Derived from alcohols (ethanol and butanol). However, they are suitable for motor transport but not for aviation.

Among the mentioned above technologies, the most perspective kinds of fuels are derived from plant feedstock or biomass — the so called biofuels. Today the share of biofuels comparing to oil-derived fuels in the USA is 6–7 %, Brazil — 15%, China — 2,5%, EU countries up to 5–6 %. International Energy Association forecasts that till 2030 world production of biofuels will increase up to 150 mln ton of oil energy equivalent. Annual temps of production growth are about 7–9 %. Thus, the share of biofuels in total fuel balance in transport sector will reach 4–6 % till 2030 [15]. According to other data [16] the share of biofuels in total energy resources balance will be about 10–12 %.

Aim

Ukraine as well as other European countries is characterized by deficiency of oil deposits. But at the same time, use of alternative fuels in aviation is commonly accepted in Europe and other developed

states [17; 18]. In general, level of biofuels branch development in Ukraine, is significantly lower than in EU countries. According to [17] the total supply of primary energy sources in Ukraine is more than 130 mln ton of oil equivalent, but amount of biofuel is just 1,48 mln ton that is only 1,13 % in general structure of energy supply. At the same time in EU countries this index reaches 6,72 %. The total supply of primary energy in EU countries is estimated at 1759 mln ton of oil equivalent with the share of biofuels of 118 mln ton.

Ukrainian industry has some experience in production of biofuels for motor transport (biodiesel and bioethanol). There are already adopted normative documents that regulate production process, quality control and application of biofuels. Numbers of scientific-research organizations actively investigate these kinds of alternative fuels. Despite well-developed biofuel industry for motor transport, Ukraine still doesn't have practical experience in application of alternative jet fuels [10].

Because of that, keeping up with the times, the scientists of the National Aviation University carry out researches intended for development of alternative jet fuel. These actions are stipulated by the number of reasons: exhausting crude oil deposits, therefore increasing of prices for crude oil and so for jet fuels; increasing "greenhouse effect", caused by carbon dioxide emissions in a result of hydrocarbons burning and worsening of ecological situation caused by aviation industry activity [6; 7].

Main material

Today in Ukraine only two grades of jet fuel are produced: "PT" and "TC-1". The main producers of fuel for AJE are Odessa, Kremenchuk and Lisichanskiy oil processing plants. Requirements to these fuels, are regulated by industry standards ГСТУ 320.00149943.007 "Fuel for jet engines of "PT" grade. Specifications" and ГСТУ 320.00149943.011 "Fuel "TC-1" for jet engines. Specifications". Requirements to fuel of grade Jet A-1 that is imported into Ukraine are set by the State Standard ДСТУ 4796:2007 "Aviation Fuel for gas-turbine jet engines Jet A-1. Specifications". All these jet fuel grades are derived from conventional crude oil [4; 5].

Generalizing the world's experience in alternative jet fuels development we have concluded that the most optimal kind of aviation biofuels is biokerosene, which is derived from renewable oils. This kind of biofuel is obtained by processing of oily plants [7; 10]. Biokerosene is a mixture of traditional kerosene, produced from crude oil and biocomponents in certain concentrations. Biocomponent is a fatty acids methyl or ethyl ethers (FAME or FAEE) that are obtained during etherification of vegetable oils [7; 10]. Today technology of biokerosene production is seemed to be the most optimal for Ukraine. It is explained by number of factors, such as availability of feedstock, maturity of technology, presence of necessary equipment, satisfactory physical-chemical and exploitation properties of such kind of biofuel and also its ecological safety [8; 9; 12].

Feedstock for biocomponents production is oils, obtained from seeds of various agricultural oily plants: rape, sunflower, jatropha, canola, palm oil, etc. [16]. While choosing the necessary feedstock, the following factors should be taken into account: volumes of oil production (cultivated areas, fertility of the culture, main consumers of products, content of oil in plant, potential of its cultivation), and also its physical-chemical characteristics. Today there is a great experience all over the world in growing and processing of various oily plants. The main factor for feedstock selection is surely geographical and climatic conditions typical for country-producer and optimal for certain oily plant cultivation [13; 17]. The most widespread plant in the USA is soy, in Canada — canola (kind of rape). During recent years camellina oil is actively investigated and used in these countries. Palm oil is popular in Mexico as well as jatropha. Countries of the Asia region, such as Indonesia, Philippines, Malaysia use to produce palm and coconut oil, India — jatropha, Africa countries — jatropha, soy, Brazil — castor oil [5; 13]. Basis of European biofuel industry is rape and during last years — camellina. Production of biofuel is seemed to be quite beneficial. For example, cultivation of rape on 1 ha territory requires about 170 l of diesel fuel; at the same time, yield from this area can be processed into 1,2–1,5 ton of biofuel [20].

Ukraine traditionally is an agricultural country with well-developed oil production branch [16]. Due to this it has a great potential for development of jet biofuels manufacturing. The most typical oil cultures in Ukraine are sunflower, rape, soy, camellina and corn (Fig. 2).

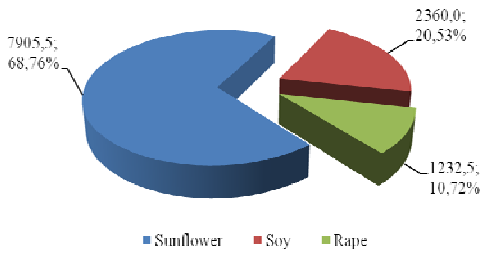

Fig. 2. Production of main oily plants in Ukraine in 2012 (thousand ton)

During last 10 – 15 years volumes of oily plants production are constantly growing.

According to [18] during 1990–2011 cultivating areas under oily plants have increased in 3,7 times: in 1990 they were 5,7 % of all agricultural territories, and in 2011 already 21 %. In general, such strong development of the industry is explained by stably-high profitability of mentioned cultures, annually growing demand for feedstock both in food industry, animal farming and biofuel industry.

Technology of ethyl (methyl) ethers production is quite simple and similar to process of biodiesel manufacturing. Basis of the process in reaction of etherification of fatty acids containing in plant oils using methanol or ethanol and basic catalyst. After purification of obtained substances ether of plant oils (biofuel) and glycerine are obtained [7].

Today this technology of biofuel production is quite popular and mainly used for manufacturing of biodiesel fuel. This technology is realized successfully both in laboratories and industrial; enterprises [26]. Taking into account experience of European countries, biofuel manufacturing in Ukraine can be organized at the following types of installations and factories: low-tonnage installations (local level for certain enterprises) with productivity 300–3000 ton/year, regional factories, producing 10000–30000 ton/year and large-scale industrial factories [23].

Technological process of jet biofuel production from plant oils is significantly simpler comparing to crude oil refining and profitability of the process in two-three times higher. Except that, plant feedstock is a renewable resource and thus it is comparatively unlimited. Ecological advantages of alternative fuel for air jet engines are also obvious and are proved by the world practice. For example, biofuel producing factories in Germany are able to provide almost waste-less production, using closed water cycle [27].

The Concept of biofuels implementation into Ukrainian aviation

Tending toward European integration Ukraine sees the necessity in strong social, economical and industrial development. Development of biofuel industry and alternative energy sources in general is considered to be one of the key directions in this development. Comparing to motor transport, aviation is seemed to be more resistant to such cardinal innovations as use of biofuels. It is mainly connected with provision of flight safety, reliability and durability of aircraft. There also some economical and legislative barriers for aviation biofuels implementation in Ukraine [4].

The large-scale process of alternative fuels implementation into aviation requires development of complex general concept that will cover all activities in this sphere. The researchers of the National Aviation University have developed the Concept of biofuels implementation into aviation [1]. The Concept is oriented on the main principles of European policy in sphere of alternative jet fuels application and at the same time it takes into account internal peculiarities of Ukrainian economics and legislation.

This Concept comprises development of scientific-practical principles for rational use of new ecologically safe fuels and lubricants for aviation technique. Timelineness of the development and implementation of the Concept may be described by the following factors [10; 11]:

- Constant increase of cost for aviation kerosene in a result of exhausting crude oil deposits and growing volumes of its consumption;
- Emissions of exhaust gases after jet fuel combustion, that negatively influence the environment;
- Increase of greenhouse gases volume in the atmosphere;
- Reinforcement of ecological requirements to civil aviation that are set by international organizations;
- Ukraine's movement toward European Integration;

The main idea of the Concept – is decreasing of civil aviation dependence on energy resources and decreasing of the technogenic impact on the environment during exploitation of aviation technique. As it was mentioned before, today Ukraine experiences lack of energy resources for production fuels &lubricants. Thus the Concept is intended to supply Ukrainian aviation with renewable raw materials [1; 3]. This will give possibility to decrease the dependence of our country on the external suppliers of crude oil and oil products. Implementation of alternative jet fuels & lubricants we allow solving the number of urgent ecological problems connected with the activity of aviation industry.

The aim of the Concept — is development of scientific and practical principles for the rational use of new ecologically safe fuels & lubricants for aviation technique.

The task of the Concept — is implementation of biologically-derived fuels & lubricants into Ukrainian Civil Aviation. The use of various oily plants traditional for agricultural complex of our country is foreseen by the Concept.

The Concept comprises interconnection of two inseparable constituents: theoretical and practical.

They should develop and complete each other (Fig. 3).

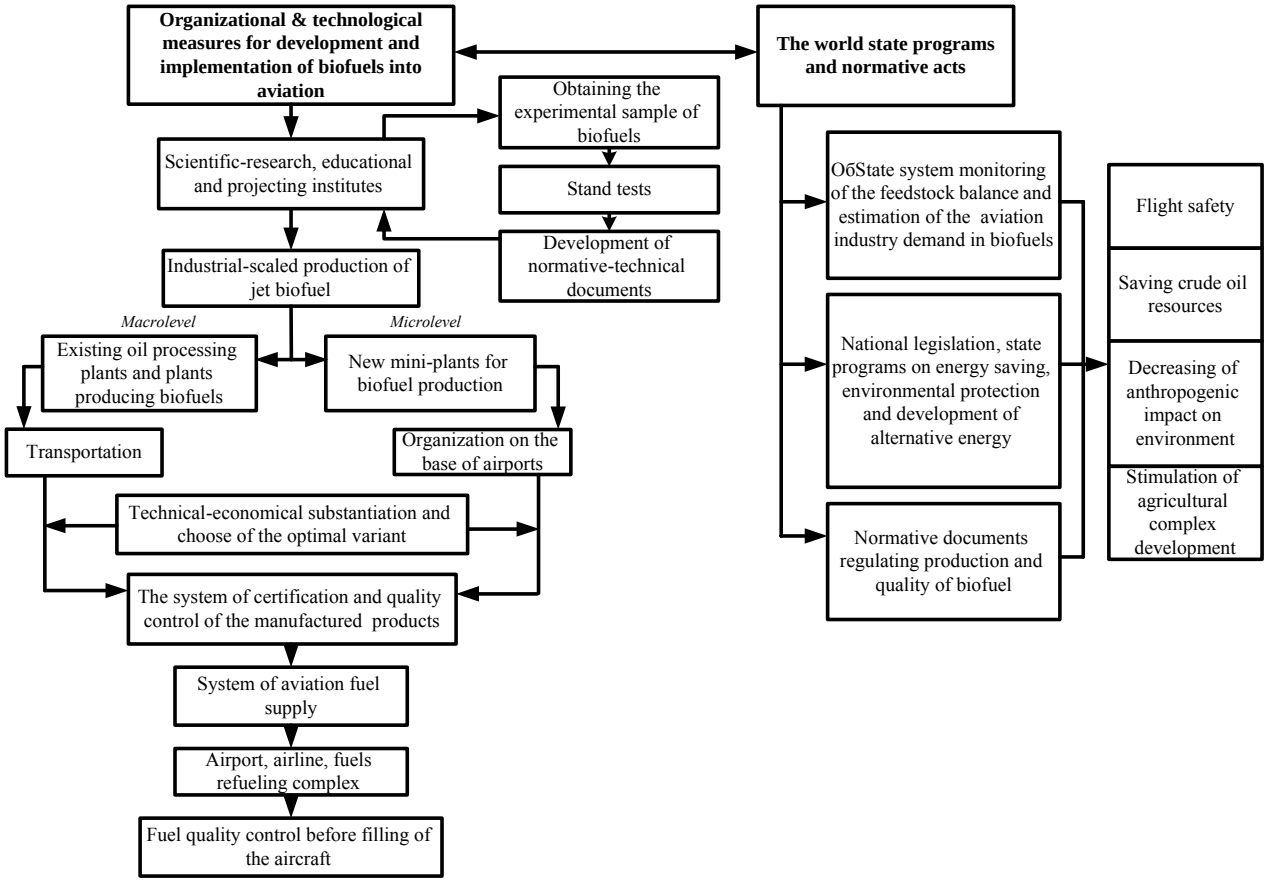

Fig. 3. Schematic description of the Concept of biofuels implementation into aviation

The notion of theoretical constituent has a normative & legislative sense that is based on the world and national legislative programs and acts. These documents are intended to stimulate and coordinate development and introduction of ecologically safe jet fuels & lubricants.

According to the Concept it is necessary to carry out systematic monitoring [10] of Ukrainian raw material balance and estimation of aviation industry needs in fuels. It will give possibility to evaluate Ukrainian potential and ability for industrial production of alternative jet fuels

Today development and implementation of alternative jet fuels is stimulated by the number of factors:

- necessity in development of ecologically safe and highly effective technologies for renewable feedstock processing;
- promotion of agricultural industry development;
- creation of new directions for development of small and middle enterprises (SME) with orientation on their territorial location (vicinity to suppliers of plant feedstock and consumers of final products);
- production of biologically derived fuels & lubricants allows replacing about 20–25 % of mineral or synthetically derived materials with ecologically safe biosynthetic materials;
- production of lubricating and cooling materials for wide range of use.

The Concept is oriented on national Ukrainian legislation and involves key principles of state policy in sphere of energy saving, rational management of natural resources, environmental protection and development of alternative energy. These directions are prior at the modern stage of Ukrainian development and are stated in fundamental laws of Ukraine: the Law of Ukraine on Alternative Energy Sources, the Law of Ukraine on Energy Saving, the Law of Ukraine on Alternative Kinds of Fuel, the Law of Ukraine on Environmental Protection, and some others.

The system of normative & legislative documents has to be developed before practical realization of the Concept, other words, before industrial production of biological fuels & lubricants and their use. These documents must set the requirements to quality of new products and processes of their manufacturing [11]. The practical constituent of the developed Concept is an advanced complex of scientific-research and organization-technologic measures intended to direct use of alternative jet fuels in Ukrainian aircraft park.

Practical realization of the Concept includes the following steps: development and production of experimental samples of biofuel with execution of series of bench tests, development and accumulation of normative-technical documents base, development and implementation of unified technology for biofuel production, development of the system of biofuel transportation to airports, development of the system for biofuel quality control at the airport and before aircraft filling.

Conclusion

In general Ukraine among other countries has considerable resource potential for jet biofuel production from plant oils due to its favorable natural climatic conditions, availability of feedstock base and relatively cheap human resources. Ukraine has all possibilities for jet biofuel manufacturing not only for satisfaction of its own needs but for export also.

Implementation and realization of the Concept will be an instrument for qualitative solution of the following tasks:

- Provision of flights safety;
- Saving of crude oil resources and decreasing of energy dependence of the state;
- Decreasing of price for jet biofuel comparing to traditional oil-derived kerosene;
- Decreasing of CO_2 and other greenhouse gases emissions and also toxicity of aircraft exhaust gases, thus protection of air quality in lower atmosphere layers. Other words it will help in decreasing of anthropogenic impact on the environment;
- Stimulation of the development of Ukrainian agricultural complex.

It is foreseen that application of aviation biofuels derived from plant feedstock will allow solving number of problems connected with the lack raw materials. At the same time this will help to minimize negative impact on environment and human health, moreover will positively influence on development of national agriculture.

Thus, implementation of alternative jet fuels will provides further development of Ukrainian aviation within the principles of sustainability. On our opinion, development and implementation of technologies for production of alternative fuels and lubricants for aviation technique is one of the most priority directions for development of modern aviation, mainly for Ukrainian conditions.

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