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POTENTIAL ALTERNATIVE TYPE OF FUEL FOR AVIATION – BIOFUEL

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Abstract. Aviation industry ready for implementation of alternative type of fuel – biofuel, which can lead to limitations of harmful influence from air transportation.

Keywords: Biofuels, aviation, generation, environment.

Introduction

Nowadays, air transport is the most demanded type of transport and the rapid growth of air transportation has great influence on the world. In this article, I will consider the alternative types of fuel which can be used in air industry with positive effect.

1. Ecology and aviation fuel

Aviation is field of activity that causes significant damage on the environment, due to the fact the process of flight involves burning fuel, and their breakdown products are released into the atmosphere. Greenhouse gases, such as carbon dioxide, are also side-effect of the aircraft engines. Aircraft that fly at high altitudes (eg, large airliners) emit aerosols, increasing cloud cover over our planet, since it increases the concentration of ozone in the atmosphere.

Most light piston aircraft use avgas, and it, in turns, contains an extremely toxic substance – tetraethyl lead that causes soil pollution around airports (the substance is released into the atmosphere as a product of combustion of fuel in the engine) [7].

It became understandable that air industry need to introduce alternative fuels, particularly sustainable biofuels, it have been identified as one of the key elements in helping to achieve minimization of harmful influence on the ecology.

2. Biofuels concept

In compare with traditional fossil fuels like coal, oil and natural gas, biofuels are produced from renewable biological resources such as plant material [5].

It absorbs carbon dioxide from the atmosphere while plant matter grows, which is then released let out back into the atmosphere when the fuel is burnt.

First-generation biofuels have been used for a number of years in transport, in home heating, power generation from stationary engines, and also cooking.
Second-generation biofuels are derived from new sources which won’t create competition for resources with food supplies and can be used in aviation.

3. Features of biofuel

Biofuels can be produced from any renewable biological carbon material, although the most common sources are plants that absorb carbon dioxide (CO2) and use sunlight to grow [3]. Globally, biofuels are mostly used for transport, home heating, power generation from stationary engines, and for cooking. The most common feedstock sources for making biofuels are plants rich in sugars and bio-derived oils. Crops that are rich in sugars like sugar cane or starch like corn, can be processed to

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release their sugar content. This is fermented to make ethanol, which can be used directly as a petroleum substitute or as addition. These fuels called as first-generation biofuels, which are typically not suitable for use in aircraft, as they do not have the necessary performance and safety attributes for modern jet engine use. However, bio-derived oil, commonly sourced from plants like corn, soybeans, algae, jatropha, halophytes and camelina, is processed and can either be burned directly or converted by chemical processes to make high-quality jet and diesel fuels [8]. These biofuels are known as second-generation biofuels and can be used for aviation.

4. Environmental benefits from biofuel usage

In compare with fossil fuels, sustainably produced biofuels result in a reduction in CO2 emissions across their lifecycle. Carbon dioxide absorbed by plants during the growth of the plant matter is roughly equivalent to the amount of carbon produced when the fuel is burned in a combustion engine – which is simply returning the CO2 to the atmosphere. It allows the biofuel to be nearly carbon neutral over its life cycle. However, there are emissions produced during the manufacturing of biofuels, from the equipment needed to grow the crop, transport the raw goods, refine the fuel etc. When these elements are accounted for, biofuels are still anticipated to provide an estimated 80% reduction in overall CO2 lifecycle emissions in comparing with fossil fuels. For instance, tests of camelina feedstock use for aviation has shown even better results, with an 84% reduction in lifecycle emissions. Furthermore, biofuels contain fewer impurities like sulphur, which enables an even greater reduction in sulphur dioxide and soot emissions than present technology has achieved. Plant matter thrives on carbon dioxide as it is grown, which makes it ideal for removing CO2 from the atmosphere [9].

5. Carbon Neutrality

Biofuels are considered carbon neutral. To understand this classification and why they differ from fossil fuels it is important to understand the biological carbon cycle. In simplest terms, all organic life on earth is based on carbon. For plants this means that in order to grow they must extract carbon from the environment and store it in their plant structure. Carbon in this organic form can be burned as a fuel. For a biofuel this means that all the carbon (CO_2) that is released back into the atmosphere, when it is burned, was originally extracted from the atmosphere in the first place, and so there is no net gain or loss of CO2. For a fossil fuel this is different because, even though it consists of organic plant matter, it was created many millions of years ago and so has not been part of the atmosphere or the carbon cycle for all that time. When fossil fuels are burned they increase the amount of CO2 in the atmosphere beyond what is normal for our time period, and this, as an unnatural condition, contributes to global warming [6].

6. Biofuels can provide diversified supply

The aviation depends on fossil fuels means it is influenced by a range of fluctuations. For example, it is the changing price of crude oil and problems with supply and demand.

Sustainable biofuels could be an attractive alternative because the production is not geographically limited, exists a lot of vacant ground where fossil fuels can be drilled, enabling a more diverse geographic supply. Biofuel feedstock can be grown in many places around the world, where the aviation activity needs it. And while, as for petroleum, there will be major producers of biofuel feedstock and it will likely be transported to where it can best be used, it is also likely that local smaller scale supply chains will be established [3].

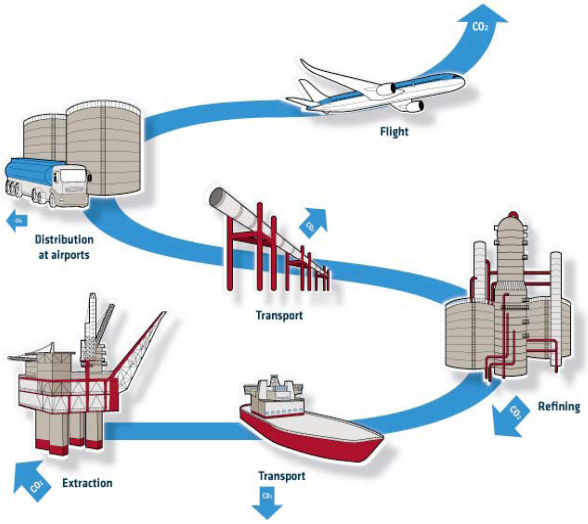

Fig.1. Lifecycle emissions from fossil fuels

At each stage in the distribution chain, carbon dioxide is emitted through energy use by extraction, transport, etc.

Carbon dioxide emitted will be reabsorbed as the next generation of feedstock is grown.

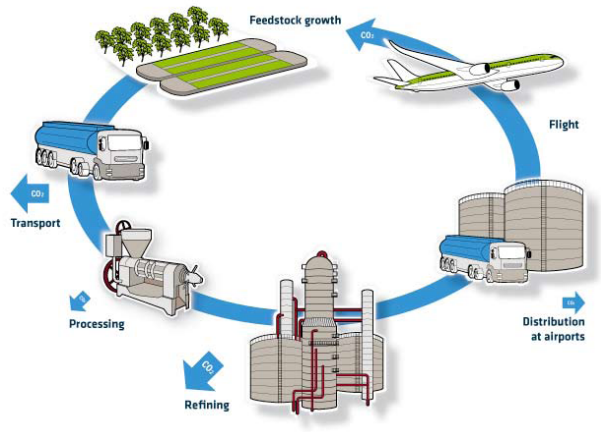

Fig.2. Lifecycle emissions from biofuels

7. Economic and social benefits from biofuel usage

One of the most big operating costs for the aviation industry is fuel. The changing price of crude oil also makes it very difficult to plan and budget for operating expenses long-term [9]. Sustainable biofuels may offer a solution to this problem since their manufacturing can be spread worldwide, and across a number of different crops, thereby reducing airlines' exposure to the fuel cost variability that comes with having a single source of energy. Biofuels can also provide economic benefits to parts of the world that have large amounts of unviable land for food crops, but are suitable for growing second-generation biofuel crops. Many of these countries are developing nations that could benefit greatly from a new industry such as sustainable aviation biofuels.

8. Second-generation biofuels for aviation:

- The usage of sustainable resource to manufacture a fuel that can be considered as a replacement for traditional jet fuel, while not consuming valuable food, land and water resources;
- Can be mass grown almost worldwide, even in deserts and salt water;
- Include bio-derived oil, sourced from feedstocks such as jatropha, camelina, algae and halophytes;
- Have the potential to deliver large quantities of greener fuel for aviation at more stable prices.

9. Distinction of first-generation biofuels from second-generation

The production of first-generation biofuels which derived from food crops like rapeseed, sugarcane and corn – that can also be used as food for humans and animals has raised a number of important questions. These include questions about changes in use of agricultural land, the effect on food prices and the impact of irrigation, pesticides and fertilizers on local environments. Some of the first-generation biofuels like biodiesel and ethanol are not suitable fuels for powering commercial aircraft. Many of these fuels don't create the high performance or safety specifications for jet fuel. Learning from the experience of other industries, the aviation industry is therefore looking at second-generation, biofuels which are sustainable [9]. This second generation of biofuels goes from non-food crop sources. Second-generation biofuels can also be mass grown in a range of locations, including deserts and salt water. Each of the second-generation feedstocks being investigated for aviation use has the potential to deliver large quantities of greener and potentially cheaper fuel. Aviation industry will rely on not just one type of feedstock. Some feedstocks are better suited to some climates and locations than others and so the most appropriate crop will be grown in the most suitable location. Aircrafts will be powered by blends of biofuel from different types of feedstocks along with jet fuel.

10. Potential second-generation biofuel feedstocks

Jatropha is a plant that produces seeds containing inedible lipid oil that can be used for manufacturing fuel. Each seed produces 30 to 40% of its mass in oil. It can be grown in a range of difficult soil conditions, including arid areas, leaving prime land available for food crops. The seeds are toxic to both humans and animals and respectively not a food source [4].

Camelina is primarily an energy crop, with high lipid oil content. The primary market for camelina oil is as a feed-stock to produce renewable fuels. Camelina is often grown as a rotational crop with wheat and other cereal crops when the land would otherwise be left fallow as part of the normal crop rotation program. It therefore provides growers with an opportunity to diversify their crop base and reduce mono-cropping, which has been shown to degrade soil and reduce yields [8].

Algae are the most potential feedstock for manufacturing large quantities of sustainable aviation biofuel. These microscopic plants can be grown in polluted or salt water, deserts and other severe places. They thrive off carbon dioxide, which makes them ideal for carbon capture, absorbing carbon dioxide, from sources like power plants. One of the biggest advantages of algae for oil production is the speed at which the feedstock can grow. It has been estimated that algae

produces up to 15 times more oil per square kilometer than other biofuel crops. Also algae is can be grown on marginal lands that aren't used for growing food, such as on the edges of deserts [2].

Halophytes are salt marsh grasses and other saline habitat species that can grow either in salt water or in areas affected by sea spray where plants would not normally be able to grow [10].

11. Key advantages of second-generation biofuels for aviation

Environmental benefits: sustainably produced biofuels result in a reduction in CO2 emissions across it lifecycle.

Spacious supply: second-generation biofuels propose available alternative to fossil fuels and can substitute traditional jet fuel, with a more various geographical fuel supply through non-food crop sources.

Economic and social benefits: sustainable biofuels provide a solution to the price fluctuations related to fuel cost instability facing aviation. Biofuels can provide economic benefits to parts of the world, especially developing nations, that have unviable land for food crops that is suitable for second-generation biofuel crop growth [4].

Renewability: It takes a very long time for fossil fuels to be produced, but biofuels are much more easily renewable as new crops are grown and waste material is collected.

Security: Biofuels can be produced locally, which decreases the nation's dependence upon foreign energy. By reducing dependence on foreign fuel sources, countries can protect the integrity of their energy resources and make them safe from outside influences.

12. Disadvantages

Despite the many positive characteristics of biofuels, there are also many disadvantages to these energy sources.

Energy output: Biofuels have a lower energy output than traditional fuels and therefore require greater quantities to be consumed in order to produce the same energy level [4].

Production carbon emissions: Analyzing the carbon footprint of biofuels gave the conclusion that they may be cleaner to burn, but there are strong indications that the process to produce the fuel - including the machinery necessary to cultivate the crops and the plants to produce the fuel - has hefty carbon emissions.

High cost: To refine biofuels to more efficient energy outputs, and to build the necessary manufacturing plants to increase biofuel quantities, a high initial investment is often required.

Water use: Massive quantities of water are required for proper irrigation of biofuel crops as well as to manufacture the fuel, which could strain local and regional water resources.

13. Third generation biodiesel feedstock

3rd generation biofuels are made from genetically-modified vat-grown algae. The advantage of using algae rather than other plants is that they can produce considerably more energy for land area used. They don't affect fresh water supplies and can be grown in open ponds or out at sea. 3rd gen biofuels produce very high yields of synthetic oil and petrochemicals [11].

14. Advantages of third-generation biofuels

- Superior yields;
- Not directly affecting the human food chain;
- Grown in places that are not suitable for agriculture;
- Enhanced efficiencies or reduction in cost.

15. Disadvantages of third-generation biofuels

The problem presented by this generation of biofuels is primarily that of developing technologies that will enable biofuels from these to be more cost effective.

16. Technical requirements for aviation biofuels

- A high-performance fuel that can withstand a wide range of operational conditions.
- A fuel that can directly substitute conventional jet fuel for aviation.
- A fuel that does not compromise safety.

17. Regional variations in production capacity and consumption

The current and expected production and consumption of biofuels are both characterized by large regional variations. The biofuel production varies on a regional and global scale, because of differences in many factors including: agricultural circumstances and related feedstock production (land availability, soil fertility, water availability, climate, food demand etc.);

economical conditions; biofuel promoting policies; geopolitical influences etc. The demand for biofuels is influenced by the local production, global markets, as well as by local or regional policies that may boost demand when mandatory biofuel targets have been set, such as in the EU. As a consequence, the biofuel blending shares can differ greatly between world regions. In this respect, potentially higher-blend regions, be SE Asia (palm oil, possibly Jatropha), Latin America (soy, although ethanol from cane will be dominant in this region), Sub-Sahara Africa (palm oil, possibly Jatropha). But the odds of blends higher than 10% are relatively small [7].

18. Conclusions

Currently, biofuels are not a silver bullet for the energy problems of the world. To solve the issue of developing alternative types of fuel that can limit harmful influence of air transportation on the environment, all vital means of harvesting energy should be pursued to their fullest. Nowadays, biofuels are a reliable alternative energy resource. With more development and research, it is possible to overcome the disadvantages of biofuels and make them suitable for widespread consumer use. When the technology is available, many of the disadvantages will be minimized and the market very clearly has potential. Much of this could rely on the ability of energy producers to discover better plants to raise for fuel that use less water, less land, and grows quickly.

References

1. Algae fuel. Available from Internet: <http://www.oilgae.com>
2. An overview of current industry and R&D activities - published by the International Energy Agency in November 2008.
3. *Biofuels.* Available from Internet: <http://climap.net/biofuel>
4. Biojet Fuel. Available from Internet: <http://www.jatrofuels.com/835-0-jatropha>
5. Biomass energy. Available from Internet: <http://www.reegle.info>
6. Brown, M.A.; Levine, M.D.; Romm, JPRAH; Koomey, J.H. Engineering-economic studies of energy technologies to reduce greenhouse gas emissions: opportunites and challenges. *Annual review of energy environment,* 1998, 23: 31-39.
7. *Environmental.* Issues - Alternative *Fuels* Available from Internet: <http://environment.about.com/od/fossilfuels/Environmental_Issues_Fossil_Fuels_Alternative_Fuels.htm >
8. European Biofuels Technology Platform. Available from Internet: <http://www.biofuelstp.eu/air.html>
9. Fuels. Available from Internet: <http://www.berkeleybiodiesel.org>
10. Feedstocks. Available from Internet: <http://www.biofuelsdigest.com/bdigest/tag/halophytes
11. Third-generation biofuel. Available from Internet: <http://www.articlesbase.com/environment-articles/3rd-generation-biofuel-algae-511150.html>