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Biofuels in Brazilian aviation: Current scenario and prospects

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ABSTRACT

The aviation industry accounts for 2% of all carbon dioxide released into the atmosphere. Based on that, various companies and agencies have developed a growing interest in developing alternative fuels for aviation in recent decades. Few studies related to the production and use of biofuels in aviation can be found in the literature, and some of them are even contradictory. Thus, this study aims at discussing the current scenario and prospects for the use of aviation biofuels in Brazil, coming to the conclusion that despite Brazil having vast farmland and several oilseed crops with potential for biofuel production, the high demand caused by the current use of biodiesel added to diesel oil in the Brazilian vehicle fleet compromises the use of these materials with other energy purposes.

Contents

1. Introduction

Biofuels have been considered as one of the most sustainable alternatives aimed at replacing fossil energy sources due to their renewable condition [1]. Moreover, a great argument in favor of increased production of biofuels is that they reduce the emission of greenhouse gases (GHG). Currently, many governments have promoted and encouraged the production of biofuels by means of subsidies and tax exemptions, plus goals and standards for fuels [2].

Although the airline industry is 70% more efficient today than 40 years ago, due to lighter aircraft and modern engines [3], this industry is growing at an accelerated rate, with estimation of growth of 5% per year until 2030; these values are higher than the expected increase in fuel efficiency over the same period (3% per year) and lead to increased fuel consumption and increased emissions [4].

The aviation sector accounts for approximately 2% of all carbon dioxide released into the atmosphere. Even when considering some other methods of quantification these values reach 3.5% [5,6].

In that sense companies associated with the International Air Transport Association industry pledged to increase their efficiency

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in fuel use by 2020 in 1.5% per year and reduce their emissions in 50% by 2050, in comparison to data obtained from 2005, thus stimulating the search for alternative fuels that have low production of greenhouse gases and that can be used without requiring changes in infrastructure or distribution [7,8].

Because of these environmental factors along with economic issues in which current fluctuations in oil prices exert direct pressure on the aviation industry, a growing interest in developing alternative fuels for aviation in recent decades has been promoted. Several demonstration flights were conducted in recent years by many major airlines and aircraft production companies [9].

Several requirements must be met for the fuel to be classified as aviation fuel, among these requirements there are: high energy density, aiming to maximize the reach and reduce the carried fuel load; rapid evaporation and atomization; low risk of explosion; appropriate viscosity; physical and chemical stability and low freezing point [10–12].

Few studies related to the production and use of biofuels in aviation can be found in the literature, and some are even contradictory [13], however, with the rampant growth of the transport sector, particularly by air, quick actions and energy solutions must be taken in the coming years. Thus, this work aims at discussing the current situation and prospects for the use of aviation biofuels in Brazil including the main technologies used and in potential, in addition to the impacts caused by the use of these.

2. Biofuels in Brazilian aviation

Currently, several initiatives and flight tests are being performed with the intention of developing renewable and sustainable biofuels in many countries, including Brazil. Although many of these initiatives have ASTM's technical certificate, none of them is still considered commercial.

Much of the effort is focused on refining and developing fuels with constituents that are similar to those of kerosene; however, using sustainable raw materials and even organic waste [14].

Several technologies are being developed in order to mitigate the growth in the use of aeronautical fossil fuels, due to the inherent environmental consequences of their use. There is also a need to establish a comfortable position of energy security in the sector in light of the depletion of oil reserves [15]. In this scenario various fuels from renewable sources are being studied worldwide in order to meet such demands from the airline sector, especially in Brazil.

2.1. Bioethanol in aviation

The condition of Brazilian biofuel production strengthens the country's position as a regional power, besides the noted expression of political leadership regarding the use, production and quality control of these fuels in Latin America. Aiming at the production of bioethanol, Brazil has the sugarcane, the main raw material used in hydrated fuel production. Also the country still has large soybean crops and other oilseeds in order to produce biodiesel. The areas for the cultivation of these crops were expanded significantly in the last three decades, and by this increase in productivity, yields of recent years reached record values [16].

Brazil leads the use of biofuels in Latin America since the 60s when it was also responsible for 85% of all sugarcane produced in MERCOSUR member countries, reaching 97% by means of investments in technological advances [17]. This jump came mainly from Law no. 737 of 1938 and subsequent Law no. 723 of 1993 which determines the obligatory mix of ethanol in gasoline. Nevertheless, that was not based on environmental issues but on energy self-sufficiency and as a way to overcome the economic crisis of that time [18,19].

Ethanol is presented with an interest as an aviation fuel because it has known molecular formula and behaves in a predictable way, regardless of its application process or raw materials used in its synthesis [20].

Apart from conventional sources, ethanol can also be obtained from the conversion of cellulosic biomass. Various industrial ventures of alcohol production use waste from crops, forestry residues, and others, which present low cost and high availability [21–23].

Light aircraft have operated for years in Brazil using only ethanol [24]. The main appeal of using ethanol as an aviation fuel in Brazil is that it is directed to agricultural aviation, especially in single-engine airplanes. The development of flexible-fuel engines was particularly encouraged because of the high price of aviation gasoline, produced in just a few refineries in the country, and because of the environmental issue, in which ethanol burned in agricultural aircraft engines comes from the own crops where the machines are used.

The use of ethanol as an agricultural aircraft fuel is still related to high fuel production and availability in various areas of Brazil. The increase in ethanol production began in the 70s due to the great oil crisis, in which the country created the Pro-Alcohol program aiming at reducing dependence on fossil fuels [25].

As shown in Fig. 1, with the expansion of sugarcane crops, ethanol production has evolved significantly from 594,985 m³ in 1974/75 to values near 27,604,120 m^3 in 2010/11 [26]. Thirty years after the creation and implementation of the first phase of the ethanol introduction program in Brazil, a new phase of expansion in the production of sugarcane began: production of automotive fuel on a large scale. In 2003, with the production of flex-fuel vehicles, which may run on ethanol, gasoline or a mixture of both compounds, there was a boost in the domestic production of ethanol. Currently, the fleet of flexible-fuel vehicles is larger than the fleet of mono-fuel vehicles operating in the country [27], thus justifying the increase in production and consumption of ethanol in Brazil.

The trend in ethanol production is linear for the next years (Fig. 2). This factor is an incentive to the use of this fuel in the aviation industry.

Major global problem that motivates the development of research on technologies for ethanol production is related to water consumption. Water is necessary for ethanol production, both in field, for sugarcane production, as in industrial processing [129].

Water use in the field for the Brazilian case by irrigation is very small, given the climatic conditions of the country, focusing mostly on the northeast region [130].

In addition, methods of fertigation are much studied in the country mainly for sugarcane crops using the main residue of the production process, stillage. The fertigation technique with vinasse is widely used not only for irrigation but also for fertilizing the soil by terrestrial infiltration process, due to its high potassium content. Its efficient use reduces the environmental liability related to the proper disposal of nutrients and, moreover, reduces the cost of chemical fertilizers because it is a residue of low cost [131,132]. This method is considered old and very used in sugarcane cultivation, but the practice of fertigation with vinasse is also common in other cultures [133–136].

For the processing of sugarcane for ethanol production, large quantities of water were required. Macedo [137] estimated that for the year 1997, the total water consumption was 21 m³ per ton of cane processed, being mostly used in sugarcane washing processes. Less than a decade later, this consumption was substantially reduced by high water reuse and efficient treatment system, reaching on average 1.83 m³ per ton processed [130]. In addition, sugarcane dry washing processes are being developed and tested further reducing water use.