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Prospects of Using Different Generations Biofuels for Minimizing Impact of Modern Aviation on Environment

The work is devoted to the overview of prospects of development and implementation of alternative motor fuels from various types of biomass. The article outlines problems of modern transport that is connected to limitation of conventional energy resources used for fuels production. Main environmental problems connected with the use of conventional aviation fuels are determined. Modern trends for transition from conventional aviation fuels to alternative ones are presented. The article gives versatile analysis of well-developed types of biomass for biofuels production and also perspective types, which may be sufficiently used in the near future. The main properties of oil plants used for biofuels production are described, as well as advantages of biofuels use from considered types of biomass. *Bibl. 26, Fig. 1, Tab. 4.*
Key words: energy resources, aviation fuel, emissions, biomass, biofuel, microalgae, sorghum oil, camelina oil, jatropha oil.

Introduction

One of the features of the modern world is the increased attention of the international community to the problems of rationality and efficient use of energy resources, the introduction of energy saving technologies and searching of renewable energy.

Today, renewable energy development in the world, took an accelerated character that is associated with the growing of global multifactorial crisis phenomenas. On the one hand, there is limtation of geological reserves of the main types of fuel resources — oil and gas, which leads to an inevitable rise in prices for them. On the other hand the obvious growth of the negative environmental impacts caused by the effects of human activity.

Object of the article is production of biofuels of different generations.

Subject of the article is methods of production of different generations of biofuels from plants, algae, and so on.

The purpose of the article — study the problem of the use of traditional fuels, and to show the perspectives of alternative fuels production.

Taking into consideration the growing demand on sustainable alternative fuels there is a need to explore the prospects of biofuel production of first, second and third generations.

International strategic actions on «greening» aviation transport

The main environmental damage associated with global climate change of the Earth — greenhouse effect, caused mainly from mining, processing and burning of fossil fuels — coal, oil and gas. The greenhouse effect is up to 75 % share of the anthropogenic environmental damage. In this regard, the satisfaction of growing needs of the world's population in fuel, electricity and heat simultaneously with the environmental safety necessitates the development of renewable energy, because oil — not single raw material for getting of high-efficient organic fuels for engine.

In terms of global pollution, air transport is responsible for direct and indirect emissions of several greenhouse gases: CO_2 (2 % of global emissions by IATA — International Air Transport Agency), tropospheric ozone, methane, etc. [1, 2]. More than once Committee on Environment Impact of Aviation (CAEP) raised the issue of reducing emissions including emissions of NO_x and CO_2. With the support of ICAO the strategic document of 38th Assembly of ICAO has presented strategic plans in the field of environmental protection regarding emissions of aircraft engines that affect on local air quality, on the impact of international aviation on climate change, including progress on the part of new aviation standards on emissions of CO_2, plans of action of countries and assist countries, environmental alternative fuels for the aviation, market activities and global desired goals [2, 3].

The initiator of the development and implementation of alternative (including biological) fuels for aviation is the International Civil Aviation Organization (ICAO). Back in 1983, the ICAO established the structure of the technical committee on environmental protection in aviation (CAEP), in which the active target group (sub-committee) on alternative fuel (AFTF). It AFTF concerned with economic feasibility of aviation biofuels, determined mainly by two criteria:

— the need to improve fuel efficiency in aviation because of the well-known global problem of depletion of hydrocarbon fuels derived from petroleum;

— the need to reduce emissions of harmful substances in the exhaust gas of gas turbine engines, that is, an increase in environmental performance of aviation fuel. This criterion is now the dominant and determining the actions of scientists and practitioners.

Following six years of negotiations, governments meeting at the International Civil Aviation Organization (ICAO) are finalising the design elements of a global market-based measure for international aviation. It is part of a series of actions the aviation industry is taking to reduce its carbon emissions which includes investing in new technology, scaling up the use of sustainable alternative fuels, improving operational performance of aircraft in the fleet already and using more efficient infrastructure.

The carbon offsetting and reduction scheme for international aviation (CORSIA) has been agreed by government negotiators at the 39th ICAO Assembly. The CORSIA will be the world's first market mechanism for dealing with climate change from any industrial sector. The global aviation industry, coordinated by the Air Transport Action Group (ATAG) has been instrumental in proposing the plan and is now encouraging States to support it.

Modern situation in sphere of biofuels porduction

Today the main energy sources are crude oil (~40 % of the world energy consumption), natural gas (~23 %), black and brown coal (~20 %). The minor share is taken by nuclear energy (~6%), hydroenergy (~2.5 %), biofuels (~4 %) and other alternative energy sources [2, 4]. At the same time the world energy demand growths constantly. The question of rapid increase of prices for crude-oil and other fossil fuels became especially important nowadays. First of all it is connected to the deficiency of primary energy and rapidly increasing demand for them (Table 1).

Table 1. Recoverable reserves of primary energy reources and an annual increment of biomass (billion tonnes)

Primary energy sources	Global stocks	World extraction per year	Potential, years
Oil	130	4	30–35
Coal	720	2	350
Natural gas	104	2.1	50
Natural gas in gas hydrates:	22000	no data	no data
underground	50	no data	no data
in the ocean	–	no data	no data
Annual growth of vegetation biomass	80	no data	not limited

Biofuel holds a special place in the structure of renewable energy sources. Being one of the few alternative fuels in the transport sector, biofuels are seen as an important resource in the choice of energy sources and ensuring of energy security, development of agriculture and rural, as well as to mitigate climate change by reducing greenhouse gas emission [1, 4, 5].

Conditionally biomass as feedstock for biofuels production can be divided into three generations [3]. Currently there are following generation of biofuels (Fig.1):

— edible oil and sacchariferous terrestrial plants;

— inedible cellulosic plants;

— inedible aquatic plants, ie algae.

First-generation biofuels

Biofuel of first generation made from sugar, starch, vegetable oil and animal fat using conventional technology. The main sources of raw materials are the seeds or grain. For example, from rapeseed extract vegetable oil, which can then be used as biodiesel. From wheat obtained starch, after fermentation — bioethanol [6].

Deforestation, negative impact on traditional agriculture, the imbalance of agricultural land use in the direction of industrial crops and the threat of the food security — these are some of the problems facing humanity during production of biofuels [7]. The main problem in the production of fuel from biomass is food security, because first-generation biofuels made from agricultural crops entering in the food chain of humans and animals (corn, soybeans, palm oil, rape, sugarcane, wheat, rye). The public has thought suddenly that large areas where food was produced, commercially oriented farmers was given to the technical culture. Because the world population grows and requires more and more food, the use of these areas for the production of biofuels reduces the amount of available food and increases their prime cost.

Second-generation biofuels

Second-generation biofuels produced from non-food raw materials. Sources of raw materials are lignocellulosic compounds the remaining after, as suitable for use in the food industry part of vegetable raw materials are removed. For this purpose, also can be used fast-growing trees and grasses (poplar, willow, miscanthus, jatropha, etc.) [7–9]. They are also called energy forests or plantations. Tested about 20 different species of plants – arboreal, shrubs and herbaceous.The advantage of this biofuel consists in that the plant from which it is obtained, do not compete with food crops for the land. They can grow on the slopes, hills, ravines, as well as on the unproductive and degenerate lands, sometimes even with the prospect of recovery of these lands. For their cultivation is possible to use a minimal amount of water, fertilizers, pesticides and machinery.

Every 4–7 years the trees are cut, their annual yield can reach up to 7 tons per hectare. Between the rows can additionally planting agricultural crops. The collected biomass is used for the production of heat and electricity, and also can serve as raw materials for producing liquid biofuels.

Energy plantations can be divided into several types: plantation of fast growing trees (eucalyptus, willow, poplar, aspen, alder, multicolor rose); dicotyledonous plants (artichoke, Jerusalem artichoke, sida); perennial grasses (gigantic miscanthus); annuals grasses (Sorghum Sudanese, common reed) [9].

In countries such as Italy, Germany, Argentina, Poland, today is widely practiced establishment of special plantations of fast-growing species of willow and poplar (black poplar — Populus nigra, crack willow — Salix fragilis, basket willow — Salix viminalis). Willow acquired popularity as a biofuel also in the Scandinavian countries. It is collected every 3–4 years. In North India, planting of fast-growing poplar and eucalyptus occupy about 50 to 60 thousand hectares. In Germany, the efficiency of energy forests is 20 million cubic meters of wood per year. «Green Fuel» is promising as a valuable renewable energy source [7, 10].

Miscanthus (silvergrass, elephant grass, Miscanthus giganteus) — grass, which is grown for several years in Europe and North America. It is frost and drought-resistant. The plant grows up to 4 m or more, it is possible collect the crop during 30 years, without replanting of fields. Miscanthus can grow on poor soils, it requires little fertilizer, and grows well in moist temperate climates throughout the US, Europe and Asia. At the same time miscanthus does not deplete the land. Moreover, from miscanthus it is possible produce large amounts of biomass at a very small crop area, which distinguishes this plant from other cultures. Yields are of miscanthus up to 10–12 tons per hectare which is roughly equivalent to 36 barrels of oil. Some Miscanthus hybrids with the yield up to 60 tons per hectare were already selected. Experts say that if on 10 % of the European lands to plant

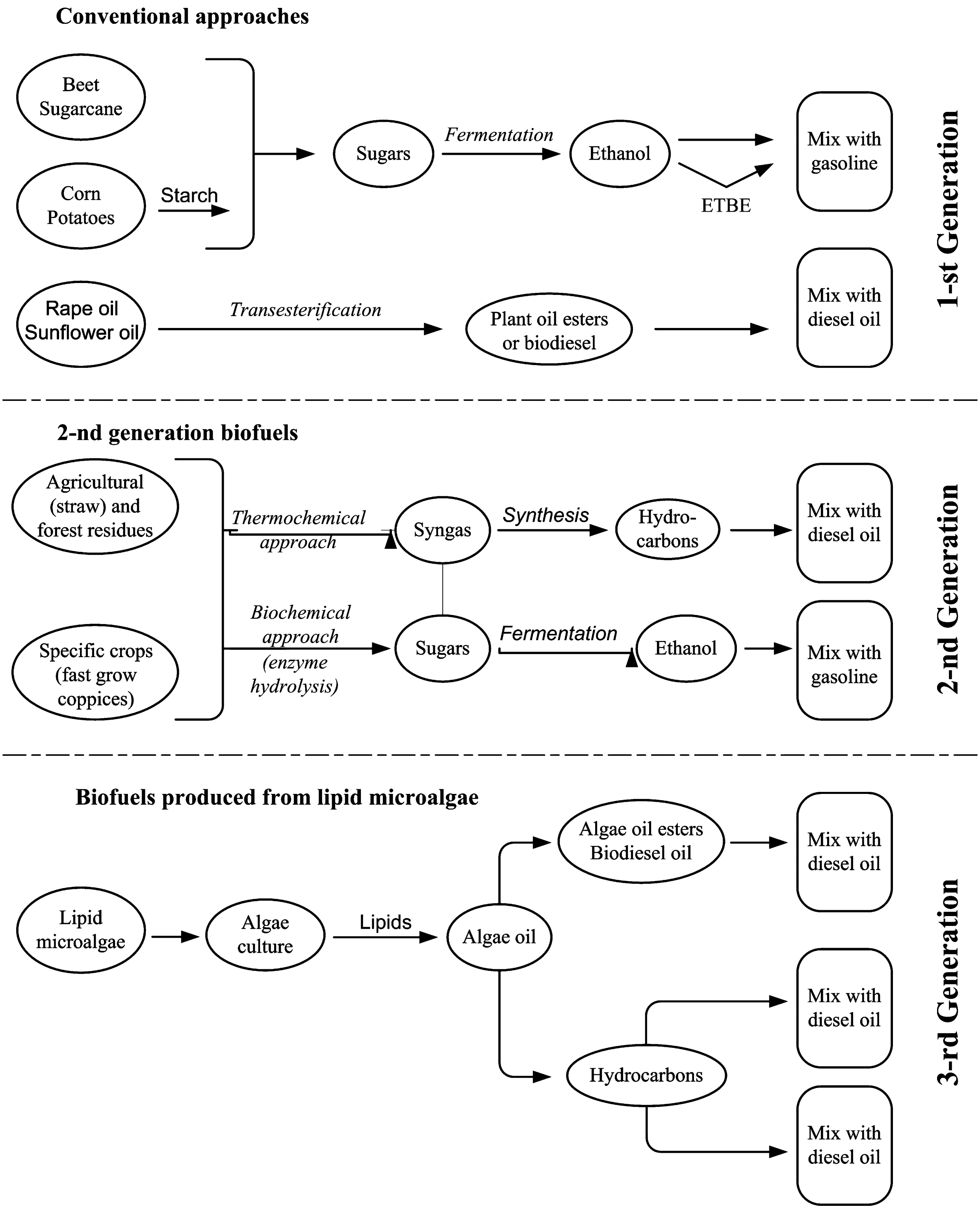

Fig.1. Development of technologies for biofuels production.

Miscanthus, it will be possible additionally to develop to 9 % of the electricity [10, 11].

Jatropha curcas (Jatropha, Jatropha curcas L.) belongs to the spurge family. It is known as a long-term tree weed growing on poor dry soils, propagated by cuttings and easily spread via seeds. It is found all over the planet, but especially thrives in tropical and subtropical climates. The content of nutrients in the soil is not the main factor affecting the productivity of jatropha. This shrub can grow in almost any soil, even on abandoned and unused lands. Jatropha plantations are available in India, China, Burma, Nicaragua, in many African countries, in Philippines and Brazil. Jatropha seeds are toxic to humans and animals, but they contain up to 40 % of various oils. Jatropha has a high oil yield from the seeds in comparison with the major biodiesel crops — soy and rapeseed. From hectare soybean receive nearly 400 kg of oil for biodiesel from rapeseed — 1 tonne, of jatropha — 3 tonne. European breeders are working on breeding of new highly oilseed, early ripening and frost-resistant hybrids of Jatropha curcas [11].

Sorghum (Sorghum bicolor (L.) Moench) is the fifth most important cereal crop in the world in terms of production and area planted. Due to its drought resistance, it forms one of the most important staple foods for millions of people in the semi-arid tropics of Africa and Asia. Sorghum is principally utilized as human food and animal feed. In the main sorghum production regions in Africa and Asia, more than 70 % of the sorghum is consumed as food, and is one of the principal sources of energy, protein, vitamins and minerals among the populations of these regions [12].

Camelina (Camelina sativa) — oleifera annual grass. The genus of Camelina includes 10 species which growing in Europe and Asia in the areas of cool climate of the steppe and forest areas. It can grow on the fields, fallow lands, along roads. Seeding Camelina is derived from weed forms, which in the wild form in Russia are found everywhere. Camelina can be sown when the soil resting from wheat and other grains as part of a crop rotation. Output from camelina oil from 1 hectare is 490 kg. The seeds contain 33–42 % of oil, 25–30 % of protein, and vitamin E [13].

Camelina sativa comes from Asian countries where it was grown up during centuries. In the second half of 19 century in Russia and France they began to plant Camelina sativa. In the 1940s–1950s the sown areas under Camelina sativa were about 400,000 hectares in the ex. Soviet Union. By the 1970s–1980s the interest towards Camelina sativa is gradually going down and the sown areas are reducing till 1000–2000 hectares, now a days it is possible to see the «second birth» of this interesting and useful crop. In order to understand why Camelina sativa is an alternative crop to rape let's compare these crops from the point of view agriculture (Table 2).

As it is seen from Table 2 Camelina sativa has larger potential comparing with rape that is closely connected with its stability in unfavorable soil and climate conditions. As a result it

Table 2. The comparative characteristics of rapeseed, camelina and sorghum agricultural indexes

Features	Oily plant		
	Camelina sativa	Rapeseed	Sorghum
General characteristic	annual plant	annual fodder crop	annual and perennial plants
Drought resistance	low need in water	Liquid living crop	very high resistance to drought
Potential of germination	all kinds of soil are good	very demanding to soil	easily adapts to different soils
Threat of reducing fertility of soil	it is often sowed to ruined crops and is used as an intermediating crop, after harvesting it's possible to row up some other crops	emaciate soil, it's possible to sow rape again on this area only in 3-4 years	used for the cultivation of virgin and reclaimed land
Fertilizers	aren't needed	are surely needed nitrite	aren't needed
Having weeds	secretes ethereal oil which put down growth and evolution of weeds from the phase of stalk formation to full ripe seeds	a lot of weeds	a lot of weeds
The period of vegetation	60–75 days from the moment when crops are already standing	90–100 days and nights	120–130 days and night
Loss of seeds	high firmness of pods from chapping	low firmness of pods from chapping	low firmness of pods from chapping
Vulnerability of crops to vermin	vermin and diseases are not found	badly damaged by vermin	good disease resistance

Table 3. Average fatty acids composition of sorghum, jatropha, rapeseed and camelina oils

Fatty acid	Plant oil			
	Camelina oil	Rape oil	Sorghum oil	Jatropha oil
Myristic acid	–	0–1.5	0–0.1	–
Palmitic acid	5.0–6.3	1.0–4.7	10–14	4.0–5.2
Stearic acid	2.5–3.0	1.0–3.5	0.3–0.6	6.5–7.9
Oleic acid	14.5–16.0	13–38	0.3–47	43.0–44.6
Linoleic acid	15.0–17.0	9.5–22	40–45	33.8–35.0
Linolenic acid	36.0–38	1–10	0–0.1	–
Erucic acid	1.0–4.0	40–64	–	–
Eicosenoic acid	14.8–16.2	0.3–1.0	–	–

Table 4. Physical and chemical properties of sorghum, jatropha, rapeseed and camelina oils

Properties	Sorghum oil	Jatropha oil	Rapeseed oil	Camelina oil
Kinematic viscosity, mm^2/s	31.4	40.4	37.0	31.5
Density, kg/m^3	909.9	920	910–912	920–928
Flash point, °C	225	167	246	257
Iodine value	108–122	101.7	90–120	127–135
Acid value	0.434	5.31	2.8–3.4	3.1–3.7

makes it possible to grow it up in soil of bad quality which is not good for other crops and it means that we have a chance to get vegetable oil good for producing bio-fuel without reducing the production of food. Besides, it gives us a real chance to develop agricultural areas with low-quality soil. Similarly to camelina sorghum is considered to be sustainable plant as it doesn't require high-quality soil and introduction of fertilizers. It may be cultivated in unfavorable climatic conditions and more over, may be used for recultivation of unfertile and exhausted areas. Scientific research work devoted to technological methods of growing up Camelina sativa and increasing its seed productivity taking into consideration soil and climate conditions in Ukraine, paying special attention to determination of optimal thickness and regulation the optimal terms of sowing it, has been done and standards of mineral fertilization have been chosen. In addition, growing up the seeds of Camelina sativa and sorghum is ecologically safe because both cultures are characterized as extremely conditions of growing up, they don't need any fertilizers, pesticide and fungicide.

Considering the suitability of various oils for biofuels production it is necessary to analyze fatty acids composition of oils (Table 3) [14]. It is well known fact that fatty acids composition of oils determines physical-chemical properties of oils and thus biofuels. The degree of unsaturation (amount of acids with single or multiple double bonds) determines chemical stability of oil. Under chemical stability we assume resistance of fatty acids to oxidation under various factor, i.e. temperature, light, presence of other compounds, long-term storage, etc. In general, the higher content of unsaturated fatty acids — the less chemical stability. At the same time the degree of unsaturation influences such important properties as viscosity and melting (or cloud) point of oils. In this case the higher content of unsaturated fatty acids the less viscosity and better low-temperature properties. Usually it may be explained by the curved form of unsaturated fatty acids and less compact mutual displacement [15].

From the Table 3 we may see that all of the studied plant oils are reach in unsaturated fatty acids. Sorghum oil contains high proportion of linoleic acid (with two double bonds) with considerable amount of oleic (one double bond) and palmitic (no double bonds) acid. Similarly, three major long chain fatty acids were detected in the jatrofa oil, which are oleic, linoleic, and palmitic acids. The analysis shows that camelina oil contains high amout of linolenic (three double bonds) acid and eicosenoic acid that has the longest carbon chain. The typical characteristic of rapeseed oil is high content of erucic acid — long-chanin acid with one double bond.

Thus, the fatty acids composition of oils determines their physical and chemical properties (Table 4). Sorghum and camelina oil posess the lowest viscosities. At the same time its density values differ significantly. It means that energy value of camelina oil is comparatively higher than sorghum oil. However, analyzing iodine values, we may predict that chemical stability of these oils is lower that of jatropha and rapeseed oils.

Thus, the second generation biofuels will gradually replace the first generation biofuels, due to its greater environmental friendliness, performance, and in that it is produced from non-food materials. Russia, which has huge areas of land not suitable for agriculture, can easily use them for planting energy crops in order to obtain biomass for biofuels.

Third-generation biofuels

Unfortunately, the economic, social and ethical aspects hamper the development of the production of the first two generations of biofuels. The more acute this problem, the more interesting acquires the development of third-generation biofuels. The effective renewable biomass, which does not need arable land and fresh water are algae. These are simple organisms adapted to growth even in polluted or salt water [16]. The determining factors for the accumulation of algae biomass are:

— intensity of solar radiation;
— water temperature;
— availability of biogenic elements;
— concentration of carbon dioxide.

Algae convert solar energy and carbon dioxide in the low-cost and highly productive raw material for food, biofuels, animal feed and highly valuable biologically active substances. That is, these organisms have an effective apparatus of bioconversion of solar energy. The productivity of microalgae according to biomass exceeds the productivity of terrestrial plants. The maximum value of the real growth of algae biomass with the intensity of solar radiation 5623–7349 MJ per m^2 per year (180–235 W/m^2) make 38–47 g of dry biomass per square meter per day.

Algae comprise a plurality of single-celled and multicellular species of organisms. They are composed of proteins, carbohydrates, lipids and nucleic acids. The percentage of these substances depends on the type of algae. Some strains of algae are ideally suited for the production of biofuels due to the high oil content in them. Microalgae according to the potential energy yield in 8–25 times greater than the palm oil and in 40–120 times than rapeseed, which allows to classify them like typical representatives of vegetable oil crops. There are certain types of these plants, containing up to 40 % of the fatty acids. Botryococcus braunii species of algae can up to 61 % of its biomass converted into the oil. This oil can be extracted from algae and processed into biodiesel. Biofuels derived from algae, contains no sulfur, is non-toxic and well biodegradable. The advantage of obtaining biodiesel from algae is their high growth rate and therefore their high yield of biomass per 1 hectare. The accumulation of fat in the algae typically occurs under conditions of nutrient deficiency [17].

Ten advantages of algae:

— algae are non-food biomass, the use of which for fuel production does not represent threats to food security;

— algae are grow in 20–30 times faster than terrestrial plants (some species can double its mass several times per day);

— they produce in 15–100 times more oil per hectare than alternatives terrestrial crops — rape, palm oil, soya or jatropha;

— they do not have a rigid shell and practically do not have lignin, which makes their processing technology in liquid fuels simpler and more efficient than processing of any ground biomass feedstock;

— production and use of algae as a biofuel not require changes in the legislation, as in the case of ethanol;

— algae are growing in both fresh and salt water, including industrial effluents, which is used for purification;

— algae can be grown in bioreactors by industrial methods or in photobioreactors, illuminated by artificial light sources, or in open containers on uncultivated soils, including deserts;

— photobioreactors embedded in technological lines of already existing industrial enterprises (HPP, petrochemical plants, cement plants);

— algae are reduce emissions of carbon dioxide (absorb to 90 %, °C);

— algae also is sources of oils, proteins, carbohydrates.

Particular interest is the cultivation of algae using secondary resources. CO_2 has been and remains the biggest waste from industry. Algae can use this gas industrial origin for their growth and biomass synthesis because their metabolic processes proceed more rapidly at higher carbon dioxide concentrations in the medium. Thus, the algae can convert carbon dioxide from the negative issues into positive factor which opens up prospects for improving the ecological situation in the world.

Unique conditions for algae cultivation have facilities for wastewater treatment plants. An example is the construction of the TPP on Kuryanovo wastewater treatment plants, running on biogas. Biogas is obtained after the fermentation of sludge in primary clarifiers of treatment facilities. As a result, the fermented sludge has neither a pathogenic bacterium, and it can be used as a high quality fertilizer. If into the TPP scheme embeds a bioreactor with algae, we can receive additional biomass for fuel, optimize costs, since treated wastewater is a favorable environment for the growth of microalgae. Here all year round available all necessary conditions for photosynthesis: warm water, nutrients (into the filtrate of wastewater after cleaning by active sludge present enough phosphate and nitrate — pollutants of the river), carbon dioxide (formed from the oxidation of organic matter and methane combustion at thermal power plants). Supply the exhaust gas from TPP into the culture of microalgae significantly stimulates their growth. During the production of 1 kg of dry biomass of algae consumed 1.9 kg of CO_2, 80 g of nitrogen and 13 g of phosphorus. Obtained biomass is the raw material for a number of valuable products: biofuels, organic fertilizer or animal feed. Thus, can be solved two problems: waste recycling from primary clarifiers of treatment facilities and obtaining of biofuels [18].

The technological process of production of biofuels from algae is practically wasteless. Dry waste from biomass after extraction of biooil preserve all vitamins and valuable substances, so they can be used as feed in aquaculture and livestock farms. Furthermore, it is possible to turn them into another form of energy — briquettes [19].

It may be noted a number of potential benefits of biofuel production based on photosynthetic algae:

— in contrast to the raw materials for the first and second generation of biofuel during production of algae biomass not used fertile soil or fresh water. That is the process of cultivation of microalgae does not compete with agricultural production;

— algae which used for the production of biofuel are highly productive (up to 100 t/ha per year);

— different algae produce bio-oil through natural photosynthesis, which requires sunlight, water and carbon dioxide and nutrients;

— growing algae use carbon dioxide, providing decline of greenhouse gases in the atmosphere;

— algae produce a greater volume of biofuels from the occupied areas than biofuel sources based on agricultural crops;

— produced by algae bio-oil and the final biofuel have a molecular structure similar to crude oil and petroleum products;

— produced by algae bio-oil can be used to produce the range of the fuel, including gasoline, diesel fuel and jet fuel.

By 2030, the volume of production of biofuels in the world can come close to oil production. The basis of this production may be the biomass of algae, which now are almost not used or are used with a low efficiency. This is due to the high cost of even simple algae production systems. At the present time, has not yet developed the technology of mass algae culture, ranging from the selection of highly productive strains of algae that can be stably maintained in open water, and ending low cost of their collection [20]. The main challenge that faces to algologists — the need to achieve significant productivity of algal biomass with high content of vegetable oils, or other biofuel precursors, needed to cover large capital and operating cost during algae production. Nevertheless, all efforts to overcome these limitations are justified, because potential of application of those technologies without a rival in comparison with food crops.

Potential of fourth-generation biofuels

Currently, being developed concepts and technologies for fourth-generation biofuels, which will be more cost-effective and environmentally friendly (with a minimum cumulative of CO_2 emissions in the atmosphere). Modeling of organisms using techniques of genetic engineering is the basis for the creation of such fuels. By replacing some genes to other, scientists can make organisms capable to converting the simple sugar and oil directly into biofuel precursors, allocate these compounds directly into the aqueous environment.

However to radically increase the photosynthesis efficiency by genetic engineering methods apparently will be very difficult.

Today, the main difficulty in obtaining biofuel from grass, sawdust, potherbs of cultivated plants and the like consists in decomposition of a major component of plant cell — cellulose — into the simple components [21].

The scientists used micro-organisms that live in the intestines of ruminant animals — cows. These microorganisms secrete specific enzymes, which decompose cellulose to simple components, which can then be absorbed by the body of the animal.

Genomes of 20 species of bacteria belonging to the genus Clostridium and Thermoanaerobacteraceae were investigated and a special method of analysis of biological material developed, which has allowed deciphering the DNA of the still largely mysterious microorganisms. In this regard, it identified about 30,000 genes potentially capable to performing the functions of cellulose decomposition. Of these were selected 90 genes of enzymes that have been tested for activity in processes of cellulose splitting. About 20 % of this gene showed the ability to actively decompose the cellulose contained in panic grass. Thus, scientists have discovered previously unknown genes of enzymes that can be used for genetic transformation and development of microorganisms for biofuel production from waste crop waste and weeds.

In the United States biologists managed to get a few strains of E. coli bacteria, which are able to immediately implement all the biofuel production process. Biofuel production process involves two steps. During the first stage the bacterium is cleaved cellulose and hemicellulose. During the second stage cleavage products synthesize into biofuels. Set of microorganisms strains combine both challenging stage of biofuel production. These organisms cleaved all components of biomass and converted obtained elements into the sugar from which they themselves create molecules of organic fuel [22].

Scientists inserted into the genome of E. coli genes that are responsible for the breakdown of cellulose and hemicellulose and selection of biofuel. Comparing different types of bacteria that break down biomass, the researchers chose the ten most efficient enzymes and inserted into the genome of E. coli genes corresponding to these enzymes [23]. As a result, the bacteria with genes responsible for the cleavage of hemicellulose, and genes that break down cellulose have earned and began to form the intermediate fragments of oligomers. Genes have earned so that oligomers began to stand out in the growing environment out of bacteria. Similar sets of genes that break down already cellulose oligomers and hemicellulose, connected to the previous so that they began to work when in a nutrient solution accumulated a sufficient number of cellulose and hemicellulose fragments. The last stage of building of «architecture» of bacteria-bioreactors was the accession to the modified genomes of E. coli genes which will synthesize biofuels. In fact, there was a «living conveyor» which produces biofuels. Scientists have tested the viability of new bacteria in practice, for this purpose sown by bacteria processed biomass from the stems and leaves of giant panic grass [24].

Thus, strains of E. coli, which carry out mechanisms of the synthesis of three different types of biofuels have been developed. This allowed demonstrating that synthesis of fuel substitutes or precursors for gasoline, diesel and jet fuel takes place directly in the liquid medium of treated panic grass without adding hydrolase enzymes. Such demonstration is an important step in the implementation of the weakening of differences in the implementation process of biofuel production [25].

Scientists developed the interesting «electromicrobial» system, which at the entrance receives electricity and carbon dioxide, and at the exit produces isobutanol and 3-methyl-1-butanol — substances which can be used as a liquid fuel suitable for internal combustion engines. The main component in this system is a genetically modified bacterium – Ralstonia eutropha. At the cathode synthesized formate (HCOO), which is absorbed by the bacteria. Oxidizing the formate, bacteria produce NADH, which is then used for the synthesis of organic CO_2. Besides the substances necessary for life and growth of micro-organisms, the bacteria synthesize biofuels using the built in their genome complex of genes. This genetic structure has been developed previously and has been tested on the E. coli. The main elements are the genes of enzymes performing decarboxylation of ketoacids that are produced by bacteria as intermediate products during the synthesis of amino acids of valine and leucine [26]. As a result substance «intended» for the synthesis of valine is partially converted to isobutanol, and from a precursor of leucine is produced 3-methyl-1-butanol. As a result, the microbes can grow in the reactor and produce biofuels and carbon dioxide using an electric current as the sole energy source.

Conclusion

The environmental component and the economic performance of different methods of biofuel producing make them insufficiently profitable to completely replace the use of fossil fuels. The problem of obtaining the hydrocarbon biomass in such quantities or such cost price, so they could compete with oil, may be complicated even for the modified microorganisms. The main purpose is to create a genetic code from scratch, by controlling all parameters.

Today, the rapid process of European integration and adopting international environmental standards forcing enterprises of aviation industry stepping up its activities intended to reduction environmental impact.

It should be noted that the actual problem now is to develop effective measures to reduce the negative impact of civil aviation on nature and people. The growing need of international traffic requires more energy expenditure. Compounding this trend depletion of traditional energy resources, decline of oil production and the consequent reduction of liquid fuel, including and jet fuels is expected. The search and widening of new renewable resources, development of progressive technologies of fuels production and their rational use in transport, mainly in aviation, is one of the priority tasks nowadays. Taking into account all the mentioned above factors it is necessary to use renewable environmentally friendly and comparatively chip feedstock. The advantages of renewable energy are: natural origin, rapidity of renewal, absence of extra CO_2 emissions, less negative impact on environment, easy biodegradation in nature

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Перспективы использования биотоплива разных поколений для минимизации влияния современной авиации на окружающую среду

Выполнен обзор перспектив развития и внедрения альтернативных моторных топлив из разных видов биомассы. Освещены проблемы современной транспортной отрасли, связанные с ограничением традиционных энергетических ресурсов, используемых для производства моторных топлив. Определены основные экологические проблемы, связанные с использованием традиционных авиационных топлив. Приведены современные тенденции перехода от традиционного авиационного топлива к альтернативному. Выполнен всесторонний анализ широко изученных видов биомассы для производства биотоплива. Представлены ее перспективные виды, которые могут быть достаточно эффективно внедрены в ближайшее время. Рассмотрены основные свойства масличных растений, используемых для производства биотоплива, а также преимущества использования биотоплива из рассмотренных видов биомассы по сравнению с традиционными моторными топливами. *Библ. 26, рис. 1, табл. 4.*

Ключевые слова: энергетические ресурсы, авиационное топливо, биомасса, биотопливо, микроводоросли, масло сорго, масло рыжея, масло ятрофы.

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Перспективи використання біопалив різних поколінь для мінімізації впливу сучасної авіації на навколишнє середовище

Зроблено огляд перспектив розвитку та впровадження альтернативних моторних палив з різних видів біомаси. Висвітлено проблеми сучасної транспортної галузі, пов'язані з обмеженням традиційних енергетичних ресурсів, що використовуються для виробництва моторних палив. Визначено основні екологічні проблеми, пов'язані з використанням традиційних авіаційних палив. Наведено сучасні тенденції переходу від традиційного авіаційного палива до альтернативного. Зроблено всебічний аналіз широко вивчених видів біомаси для виробництва біопалива. Показано її перспективні види, які можуть бути досить ефективно впроваджені найближчим часом. Розглянуто основні властивості олійних рослин, що використовуються для виробництва біопалив, а також переваги використання біопалив з розглянутих видів біомаси у порівнянні з традиційними моторними паливами. *Бібл. 26, рис. 1, табл. 4.*

Ключові слова: енергетичні ресурси, авіаційне паливо, біомаса, біопаливо, мікроводорості, олія сорго, олія рижію, олія ятрофи.