Possibilities of biodiesel production and its use as automotive fuel in small and medium-sized farms

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Abstract: Present work aims to examine possibilities of the production and use of biodiesel in small and medium-sized farms. It also reveals the quality of some raw materials and compatibility of obtained biodiesel with diesel fuel. There is an assessment of the environmental and economic effects of the use of biodiesel on agriculture also an assessment of opportunities for the organization of regional biodiesel production

Introduction

The development of agriculture and agricultural production is closely related to the use of agricultural machinery and consumption of large quantities of diesel fuel. This makes agriculture dependent on oil extraction and production of oil. Upward trend in the consumption and depletion of fossil fuels leads to higher fuel prices, and hence higher cost of agricultural production.

On the other hand, the use of fossil fuels is associated with environmental pollution and increased environmental risk due to emissions of greenhouse gases and poor biodegradability of fossil fuel.

In the past, agriculture was entirely independent of external resources. An achievement of partial or complete independent agriculture today would have a positive effect on the world economy as cost of agricultural production on the one hand, as well as the redirection of fossil resources into other productive sectors on the other.

After 1990, the cultivated land in our country is divided into many small (20 to 100 ha) and medium (100 to 1000 ha) farms. Each of them, in most cases, has its own agriculture machinery. The ability to independently sourcing and reducing fuel costs could enable sustainable development of these manufacturers.

The use of vegetable oils as a raw material for obtaining alternative diesel fuels would reduce dependence on agriculture, but before that have to be solved some important problems related to the production and consumption of this type of fuel:

- Compatibility of alternative diesel fuel with conventional diesel engines;
- Selection of appropriate oilseeds suitable for production of this fuel and opportunities to use a wide range sources;
- Production organization and ensure the necessary amounts of plant oils;
- Efficient production facilities and technologies for the production of fuels based on vegetable oils;

- Opportunities for various period of time fuel storage without change fuel properties

However straight use of vegetable oil as an alternative fuel is not appropriate at this stage, because of: high viscosity of vegetable oils, low volatility, poor low temperature properties, oxidative instability. Despite of advantages: excellent lubricating properties, high calorific value, renewables and biodegradability biodiesel couldn't be used without changes in engine design [1, 11]. Therefore they have to be processed to products suitable performance for direct use in conventional diesel engines [12]. These products are alkyl esters of higher fatty acids (usually methyl esters) obtained as a result of the replacement of glycerol with methanol, ethanol, etc. Esters of fatty acids, which are the main constituent plant oils, called biodiesel [5].

Materials and methods

Different countries use different oilseeds as a raw material for biodiesel. For example, in Europe the main feedstock is rapeseed, soybeans in North America and Asia use palm oil. Various fatty acids content in used oils gives difference between qualities of obtained biodiesel. Most used oils could be seen in Table 1 [4]:

Table 1 Free fatty acid content in common oils at percent.

	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3
Sunflower oil	6,4	0,1	2,9	17,7	72,9	---
Soybean oil	13,9	0,3	2,1	23,2	56,2	4,3
Rapeseed oil	3,5	---	0,9	64,1	22,3	8,2
Palm oil	42,6	0,3	4,4	40,5	10,1	0,2
Cottonseed oil	28,7	---	0,9	13,0	57,4	---

In addition, except vegetable oils waste oil from households and food industry are more widely used for biodiesel production. They are of lower quality but better price [10]

It is necessary to ensure stability in terms of raw materials, when use vegetable oils as feedstock for alternative diesel fuel for agriculture. This appears to be an easy task for smaller producers because much "flexibility" in terms of resources and opportunities for fast replacing one material with another, even for relatively small quantities of raw materials [14].

Methyl alcohol is most commonly use as source for transesterification of vegetable oil because of: small and mobile molecule, low cost and easy availability and good performance of the methyl esters of higher fatty acids such as diesel fuel [9].

Process of transesterification is present at Figure 1:

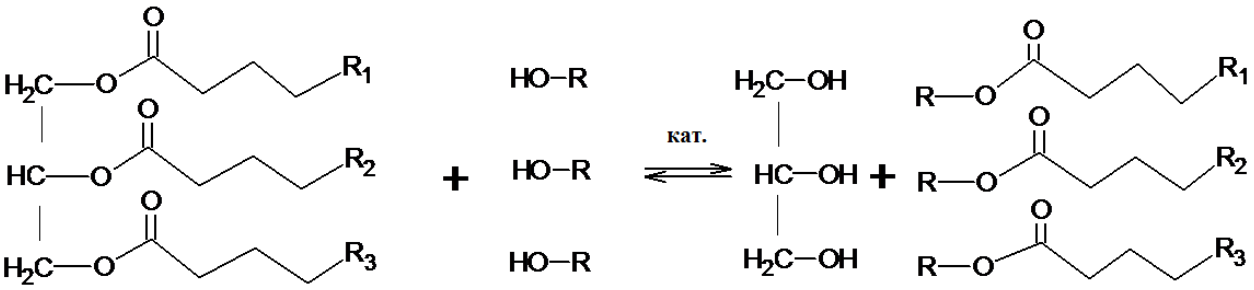

Fig.1 Transesterification of triglyceride with alkyl alcohol

The quality of raw materials is crucial for the choice of catalyst [13]. Acid catalyzed process is suitable for oils with high free fatty acid (high acid number, but this requires a large excess of methanol, duration and temperature of the process [7]. Currently, the preferred method is alkaline catalyzed reaction. There are “soft” conditions short reaction times with lower cost of raw materials [6]. However the high acid number restricts process and reduces its effectiveness. To avoid side products some authors offer two stage transesterification. The first step is acid catalyzed reaction with subsequent alkaline one [2].

Possibilities for diesel fuel replacement with methyl esters of fatty acids

Compatibility between diesel fuel and biodiesel is shown at Table 2:

Table 2 Compatibility between diesel fuel and biodiesel

Properties	Мерни единици	Дизелово гориво	Бидизел	Тест метод
Density at 15˚C	kg/m^3	820-845	860-900	EN ISO 3675
Viscosity at 40˚C	mm^2/s	2 - 4,5	3,5-5,0	EN ISO 3104
Flash point	˚C	> 55	> 101	EN ISO 2719
Sulfur content	mg/kg	<10	< 10	EN ISO 20846

Carbon residue (at 10% distillation remnant)	% (m/m)	< 0,3	< 0,3	EN ISO 10370
Cetane number	-	>51	> 51	EN ISO 5165
Water content	mg/kg	< 200	< 500	EN ISO 12937
Total contamination	mg/kg	<24	< 24	EN ISO 12662
Copper band corrosion	Level	Клас 1	Клас 1	EN ISO 2160

Several studies indicate the possibility of complete replacement of diesel with biodiesel, as well as the possibilities of using mixed diesel / biodiesel in different ratios (B5, B10, B20, B50) [8] The requirements for biodiesel are regulated by standard EN 14214 .

Ecological effects of biodiesel usage as automotive fuel

One of the major advantages of biodiesel is its non-toxicity and complete biodegradability. Regardless of the chemical modification this fuel remains environmentally friendly product and even leakage from the fuel system would not contaminating the soil.

On the other hand, the use of biodiesel in its pure form or as a blend with diesel fuel significantly alters exhaust emissions [3]. Comparative data are presented in Table. 3

Table 3 Comparison of fuel emission

Emissions kg/kg fuel	Diesel	B20	B100
CO_2	8,529	7,50	3,423
Pollution emission	$15,27 \times 10^{-3}$	$14,21 \times 10^{-3}$	$9,931 \times 10^{-3}$
SO_2	3×10^{-2}	$2,4 \times 10^{-2}$	---
NO_X	4×10^{-2}	$4,04 \times 10^{-2}$	$4,2 \times 10^{-3}$

Total	3,161	2,689	0,71

As is apparent, tendency is to reduce harmful emissions by increasing the percentage of biodiesel. Only nitrogen oxides have slightly increased emissions.

Economical impact of biodiesel

For processing of 1 ha (10 000 m^2) of agricultural land are used on average 70-100 liters of diesel per year. The most common oilseeds in our country are sunflower seed and rapeseed Average seed yields have been respectively 2500 to 2800 kg / ha of sunflower and 3000 to 4000 kg / ha of rapeseed. Obtained oils are 40-42 m/m %, and it is around 1000-1200 kg sunflower oil per ha and 1200-1600 kg rapeseed oil. If you keep spending norms using vegetable oil as an alternative fuel, this means that 1 ha of oil oilseeds would be sufficient to process 12 to 22 ha of farmland.

The current prices of biodiesel are in the range 1000 - 1150 € /t if rapeseed oil used, and in range 1200 - 1300 €/t for sunflower oil biodiesel. Methyl alcohol which is mostly used in transesterification have a price 400 to 450 € /t. Rough biodiesel price calculation is in the range of 1,100 to 1,150 € / t for rapeseed biodiesel and 1250 - 1300 €/t for sunflower biodiesel. When it is current excise duty on biodiesel in Bulgaria (290 € /t) added price reaches 1400 to 1450 €/t and 1550 to 1600 €/t for the two types of oils, respectively. These rates compared to current diesel prices in Bulgaria (1700 - 1750 €/t) show that the price of biodiesel is 10-20% lower than that of diesel. In practice, the price depends on the price of oil used and fuel prices could be adjusted when a wide variety of feedstock.

Conclusions

Biodiesel is a fully viable as alternative diesel fuel in pure form (in 100) or a mixture of biodiesel /diesel (B20, B50). This kind of fuel has a significant effect on emissions of greenhouse gases and pollution. Moreover, its complete degradation reduces the risk of contamination of soil and agricultural production.

On the other hand there is a possibility to use a wide range of vegetable oils for biodiesel and the price of this fuel is lower than that of diesel fuel, which would help to reduce costs of agricultural production.

Small and medium-sized farms could use part of its production of oil seeds for fuel obtaining, but it is necessary to build capacity for processing the seeds into biodiesel. This could happen in two ways:

- Associations of several farms and construction of small plants that would provide "flexibility" in terms of raw materials;

- Establishment of regional centers (plants) for processing of vegetable oils They could buy oil seed production on the one hand and ensuring manufacturers fuel supply on the other.

The first case would be more effective in areas with fewer farms, while the second would contribute to the development of rural areas.

It's also important government policy on excise duties on biofuels. Low levels on excise duty or its abolition would have a positive effect on the production and use of this fuel, and hence the development of sustainable organic agriculture.

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