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Optimization of Diesel Fuel and Corn Oil Mixtures Composition

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Abstract

Possible ways of utilizing the corn oil as a fuel for diesel engines are considered. The experimental work on the D-245.12S diesel engine fueled with mixture of the corn oil and diesel fuel of different percentage has been carried out. A possibility of exhaust toxicity characteristics' improvement by means of using these mixtures as a fuel for automobile diesel engines is demonstrated. The optimization method of the oil diesel fuel and corn oil mixtures' composition are suggested. Optimization calculations are conducted. The optimal composition of the biofuel mixture is calculated.

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1. Alternative Biofuels for Transport

One of sharp problems in current engine producing and all energy field, as a whole is leaning of oil birthplaces, the growth of oil deficit and the need of alternative energy sources search. Nowadays there is about 5 billion tons of oil is mined. With saving of such mining level, it's supplies may be enough just for some decades. Meanwhile, due to demand of oil growth, deficit is going to rise continuously. It may reach 16 million barrel per day by 2025 [1].

Some last years, different kinds of biofuel are considered as a real alternative to oil diesel fuels. The amount of produced biofuel around the world by 2000 reached 80 million tons per year [2]. Biofuel may be used as a fuel for not modified or specially chemical treated diesel ICEs, and also as a mixture with oil fuels or alcohols. At present, the costs of biofuel and other fuels, based on it, are approximately equal to diesel fuel cost. Thus, biofuel's

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application in number of cases becomes economical beneficial, especially in those countries, where biofuels are in excess.

2. Corn Oil as an Alternative Fuel and its Properties

Full replacement of diesel fuel on biofuel or its products is unlikely. But one must consider, that even small additive (5-10%) of biofuel or its products leads to improvements in exhaust toxicity of diesel engine. Corn oil is one of the most widespread vegetable oils. It has approximately as thermal stability as sunflower oil.

Corn as an agricultural product becomes more widespread. By 2010 world corn production approached to 900 million tons of corn grain. The main world corn producer is USA, where by 2010 about 400 million tons were collected. In Russia, in 2005 sowing square for corn constituted 0.87 millions of hectares, and in 2010 – approached to 1.4 million hectares [2]. In 2010, there was about 3.5 million tons of corn, collected in Russia, while productivity was 2.5 tons of corn from hectare.

Usually corn oil is made of corn fetuses, which are side product of corn grain. Presence of corn fetuses in this product is unlikely, since the oil housed in it, is hydrolyzed and acidified, which causes deterioration of quality. Oil content of corn fetuses is within 32 and 37%.

Corn oil is half-dry vegetable oil, it constitutes the liquid of light-yellow with freeze point $-10\dots-20^{\circ}\text{C}$, density $914-926\text{ kg/m}^3$, dynamic viscosity $63-72\text{ MPa}$ (with 20°C), iodine number $111-113$ [2]. This oil is indissoluble in the water, dissoluble in organic solvents (except to high alcohols), it has flash temperature $>225^{\circ}\text{C}$. In fatty acid composition of corn oil, part of saturated fatty acids with atom number 14-24 is 9-21%. Among unsaturated fatty acids, there are also oleic acid (20-42.2%) and linoleic acid (34-65.6%) (Table 1) [2].

Table 1. Average content of fat acids in corn oil composition.

Fatty acid	Molecular formula	Content, % (in mass)
Saturated fatty acids		
palmitic	$\text{C}_{16}\text{H}_{32}\text{O}_2$	8,6-16,5
stearic	$\text{C}_{18}\text{H}_{36}\text{O}_2$	0-3,3
arachidic	$\text{C}_{20}\text{H}_{40}\text{O}_2$	0,3-1,0
Unsaturated fatty acids		
oleic	$\text{C}_{18}\text{H}_{34}\text{O}_2$	20,0-42,2
linoleic	$\text{C}_{18}\text{H}_{32}\text{O}_2$	34,0-65,6
alpha-linoleic	$\text{C}_{18}\text{H}_{30}\text{O}_2$	0-2,0
gadoleic	$\text{C}_{20}\text{H}_{38}\text{O}_2$	0,2-0,6

One of most important motor fuel and vegetable oil properties is the curve of their fractional distillation, indicating what volume quantity of fuel is vaporized with its heating by the certain temperature [1]. With obtaining data for traditional diesel fuel, beginning distillation (beginning boil) temperature, 10, 50, 90% fuel distillation temperature and completion distillation (ending boil) temperature are distinguished. 10% fuel distillation temperature characterizes fuel aptitude to form vapour stopper in diesel engine supply system. Average vaporization capability temperature is determined by 50% fuel distillation temperature. Presence of heavy hard-vaporized fractions may be determined by 90% fuel distillation temperature.

Fractional distillation curves of corn oil and base diesel fuel are shown on the Fig. 1 [3]. Data of this figure bears witness to corn oil has vastly heavier fractional composition comparing with diesel fuel. Thus, 50% fuel distillation temperature is 260°C , and similar temperature of corn oil is 355°C . One must consider that researched corn oil is exposed to thermal decomposition with temperature, increasing over 360°C .

There are special researches of diesel engines, operating on corn oil and its mixtures with diesel fuel [4, 5, 6]. At the same time, problem of using corn oil as the ecological additive to oil fuels is learnt not enough. Herewith, using mixtures of diesel fuel and corn oil with little part of corn oil has number of advantages comparing as the motor fuel with operation on the “clean” corn oil.

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