Use of coniferous bio additives for diesel fuel mixture

I G Golubev¹, M N Bolotina¹, M I Golubev² and VV Bykov²

¹ Federal State Budgetary Institution "Russian Scientific Research Institute of Information and Technical and Economic Research on Engineering and Technical Support of the Agro-Industrial Complex", 60, Lesnaya st., Settlement Pravdinsky, Moscow region, 141260, Russian Federation
² Moscow State Technical University N.E. Bauman (National Research University), Mytishchi branch, 1, street 1 Institutskaya, Mytishchi, Moscow region, 1141005, Russian Federation

E-mail: i.g.golubev@mail.ru

Abstract. The article analyzes the properties of dietary supplements from various vegetable oils. It was found that for mixed diesel fuel, it is possible to use bioadditives from coniferous trees in the form of pine or turpentine oil. It has been established that their addition to commercial fuel in an optimal ratio improves the operational environmental characteristics of a diesel engine. It is noted that a small upgrade of the engine fuel system is required to operate on such a mixed fuel.

1. Introduction
Currently, mixed fuels with various bioadditives are used for diesel engines of tractors and other agricultural machinery. The most widespread are additives from vegetable oils, including rapeseed, sunflower, soybean, palm, corn, peanuts. However, in Russia and Europe, rapeseed oil is widely used as an additive to diesel fuel. Rapeseed culture is unpretentious and it can be planted on lands withdrawn from circulation. It increases the biological activity and structure of the soil, cleans it of nitrogen. Rapeseed oil is non-toxic, in case of leakage it completely decomposes in the soil within three weeks. In addition, rape is a highly productive crop and the most resistant to the influence of low temperatures [1]. Over the past decade, extensive research has been carried out in the world of various types of blended fuels with bioadditives obtained from vegetable oils. It can be used in diesel engines both in pure form and as mixed (blended). Such fuels can improve the performance and environmental performance of diesel engines. However, when using fuel with bio-additives, problems arise, including due to the high viscosity and thickening of the oil [2-4]. In recent years, oils obtained from coniferous trees have been used as a bioadditive for mixed fuel in the world [5]. Therefore, the purpose of this work is to analyze and generalize the properties of bioadditives and test results for diesel engines running on blended fuel.

2. Materials and methods
Various diesel blended fuel technologies are used for the analysis. Much attention is paid to the study and analysis of foreign technologies presented at various annual exhibitions, including international ones.
3. Results

Recently, pine and turpentine oil (turpentine) has been used for bioadditives in fuel. Pine oil is obtained from pine needles, young branches and cones of pine by steam stripping, and turpentine is obtained from the resin of coniferous trees (resin). Gum turpentine (turpentine oil) is a product of pine resin processing and has a flash point of 34 ºС, and self-ignition of 300 ºС. According to the data of the author of work [5], during the studies, complete dissolution of turpentine in a mixture with various vegetable oils was observed. Based on the study of literary sources, we have given a comparative analysis of bioadditives to mixed fuel from the most used vegetable oils, including rapeseed (table 1).

From the data obtained, it can be seen that the calorific value of turpentine oil is comparable to the calorific value of diesel fuel [6-7].

| Index        | Cetane number | Calorific value, MJ/kg | Kinematic viscosity *, mm²/s | Density *, kg/l |
|--------------|---------------|------------------------|----------------------------|---------------|
| Diesel fuel(summer) | 45            | 42.97                  | 3.6**                      | 0.86**        |
| Sunflower    | 37.1          | 39.6                   | 33.9                       | 0.9161        |
| Rapeseed     | 37.6          | 39.7                   | 37.0                       | 0.9115        |
| Soybean      | 37.9          | 39.6                   | 32.6                       | 0.9138        |
| Palm         | 42.0          | -                      | 39.6                       | 0.9180        |
| Corn         | 37.6          | 39.5                   | 34.9                       | 0.9095        |
| Peanut       | 41.8          | 49.8                   | 39.6                       | 0.9026        |
| Pine         | 11            | 42.8                   | 1.3                        | 0.87          |
| Turpentine   | 38            | 44.4                   | 2.5                        | 0.86          |

Note: * At 40 ºС; ** At 20 ºС

According to some researchers, turpentine can be used in mixtures up to 60–65% of the total volume of mixed fuel with minor changes in the engine design. The operational indicators of the use of turpentine oil, such as specific fuel consumption, exhaust gas temperature and smoke emission, are lower than that of commercial diesel fuel [8]. The work [5] presents the results of testing diesel fuel mixed with pine oil when operating on a 1DT12T diesel generator. Based on research, it has been suggested that the addition of pine oil to the fuel mixture provides improved combustion [5]. In work [9], the operational and emission characteristics of turpentine oil in diesel engines were experimentally investigated. Their results showed that when 75% turpentine is added to the commercial fuel, the performance characteristics are improved at 75% load, the smoke is reduced by 40-45%. However, it is noted that this requires minor modifications to the engine. Some scientists have experimented with the use of turpentine as an additive to diesel fuel. The results showed similar characteristics to diesel and lower emissions of exhaust gases such as CO, NOx, CO2 and soot [10-11]. Idling NOx emissions are the same for both standard diesel and diesel and turpentine oil combinations. This is due to a shorter burning time and a higher ignition delay. It has been shown that fuels containing a moderate percentage of turpentine oil (up to 50%) provide a delicate balance between NOx emissions and fuel economy and braking power. As the percentage of turpentine oil in the dual-fuel mixture increases, NOx emissions decrease [12].

4. Discussion

The studies have shown the fundamental possibility of using pine and turpentine oil for bioadditives in mixed fuel. The results showed that, when added to commercial fuel, turpentine improves performance, reduces smoke and emissions of harmful gases. At the same time, there is an optimal ratio of the content of oils and commercial fuel [13]. If the optimum is exceeded, it makes the combustion of the fuel mixture abnormal. Similar regularities were obtained when using rapeseed oil as bioadditives to diesel fuel. For example, scientists from Dublin (Ireland) studied the motor properties of fuel mixtures containing up to 25% rapeseed oil. They found that at the maximum
content of rapeseed oil in diesel fuel, its cetane number decreases by almost 6 units [2]. Spanish researchers note that when vegetable oil is added to diesel fuel, not only the cetane number decreases, but the content of CO and particulate matter in the exhaust gases [3]. In [4] it is indicated that an increase in the content of rapeseed oil in the mixture leads to a delay in the autoignition of the fuel mixtures [4].

5. Conclusion
Dietary supplements from coniferous trees in the form of pine or turpentine oil can be used in blended diesel fuel. Their addition to commercial fuel in an optimal ratio improves the environmental performance of a diesel engine. However, this requires a small modernization of its fuel system.

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