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Effects of synthetic GTL and conventional fuels on diesel engine crankcase oil

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Abstract: In today's increasingly globalized world, transportation plays a vital role for humanity. As a result, continuous investments are being made in vehicles and their energy sources. Various types of energy sources are used for transportation. For modern vehicles, fuel efficiency and environmental sustainability are considered highly important factors. This article presents a comparative analysis of the effects of synthetic GTL (Gas-to-Liquid) and conventional petroleum diesel fuels on engine crankcase oil degradation. The analysis of the research results shows that the chemical composition of the fuel, in particular the cetane number and sulfur content, is the main environmental factor of synthetic fuels. The soot deposited in the crankcase oil as a result of fuel combustion is one of the main factors affecting the service life of the oil. It is stated that synthetic fuels have higher environmental and other indicators than conventional diesel fuels.

Keywords: synthetic GTL fuel, crankcase oil, soot, crankcase oil resource, abrasive wear, cetane number, sulfur content

1. Introduction

In our rapidly developing world, where the demand for energy and fuel resources is growing, diesel fuel is an important source. Given this, the use of alternative fuel sources and environmentally friendly fuels in vehicles is becoming more urgent than ever. The period for changing crankcase oil in modern internal combustion engines depends not only on the quality of the oil, but also on the combustion properties of the fuel used. Aromatic compounds and sulfur contained in traditional diesel fuel are the main sources of crankcase oil pollution during combustion. The use of synthetic motor fuels, in particular synthetic diesel fuels synthesized from various sources (coal, shale, natural gas, biomass) in road transport is important in meeting modern energy and environmental requirements in this area [2]. Synthetic fuels obtained using GTL technology allow solving this problem due to their high cetane number and low aromatic content.

1 ton of fuel with a sulfur content of 1% produces 20 kg of sulfuric acid when burned. As a result, when using such fuel, the corrosion of engine parts increases by 2-3 times (compared to fuel with a sulfur content of 0.2%). Compared to conventional diesel fuels, synthetic fuels have a much lower sulfur content (Table 1), which reduces the emission of harmful gases into the atmosphere and the corrosion of engine parts. Sulfur forms acid. As a result, when using such fuel, the corrosion of engine parts increases by 2-3 times (compared to fuel with a sulfur content of 0.2%) [6]. Compared to conventional diesel fuels, synthetic fuels have a much lower sulfur content, which reduces the emission of harmful gases into the atmosphere and the corrosion of engine parts [4].

The Resolution of the Cabinet of Ministers of the Republic of Uzbekistan dated November 23, 2017 established the General Technical Regulation on the requirements for diesel and marine fuel, aviation and automotive, jet engine fuel and fuel oil. established [1]. This ensures the safety of automobiles and aviation. It is aimed at controlling the supply of high-quality fuel to consumers and reducing the harmful effects of fuels in accordance with environmental standards.

On December 25, 2021, the opening ceremony of the Uzbekistan GTL plant took place. The total area of the plant is 135 hectares, and the plant produces four types of fuel (jet fuel, compressed gas, diesel, naphtha). Uzbekistan GTL is one of the 5 largest plants in the world (the other 4 are built in Qatar, Nigeria, South Africa and Malaysia) [14]. The constructed plant is considered an environmentally friendly fuel.

Literature review

1.1 Soot and abrasive wear. Soot is a carbon particle formed as a result of fuel combustion. As a result of a certain part of the carbon particles formed as a result of fuel combustion, a decrease in the thickness of the lubricating layer is observed, which indicates an increase in friction and abrasive wear between metal surfaces [5].

The negative effects of soot in diesel engine oil are as follows:

Wear in mechanisms. First of all, it causes abrasive wear. An increase in the concentration of soot has a negative effect on the oil reaching the lubricating surfaces and accelerates the rate of wear.

Tribofilm problems. Soot particles can absorb zinc dithiolphosphate additives that protect the engine or mechanically scrape off the protective layers formed on the surfaces of friction parts.

Change in oil properties. The increase in soot content in the oil during operation increases the viscosity of the oil. This, in turn, leads to a decrease in lubrication efficiency and increased fuel consumption.

Protective measures: If the amount of detergent additives is increased, the accumulation of soot can be reduced, but if the soot content reaches a very high level, the correct balance of zinc dithiophosphate can effectively reduce wear [6].

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The almost complete absence of aromatic hydrocarbons in GTL fuel reduces soot formation compared to conventional petroleum fuels.

If the soot content is low, its viscosity is maintained stable and the risk of damage to the lubricating film is reduced.

1.2 Effectiveness of ZDDP additives. ZDDP (Zinc dialkyl dithiophosphates) additives absorb soot particles in the oil, which reduces wear on parts [7,8]. When using GTL fuel, due to the low soot content, ZDDP additives maintain their function longer. This, in turn, ensures that the crankcase oil can last longer without losing its protective properties.

1.3 Chemical kinetics and acidity. The high cetane number of GTL fuel ensures complete combustion [9]. However, conventional diesel fuel has a low cetane number, and the sulfur content in it creates an acidic environment, quickly reducing the base number (TBN) of the oil [10]. The absence of sulfur in GTL fuel slows down the oxidation of the oil and helps to maintain its anti-corrosion resource.

2. Research methodology

The research is conducted to study the effect of synthetic GTL and conventional diesel fuels on crankcase oil using experimental and analytical methods and continuously analyze it.

As the object of research, a diesel engine (bus and truck), GTL and conventional diesel fuels, and motor oil complying with the SAE standard are selected.

As the experimental conditions, a diesel engine is operated in certain operating modes and under different weather conditions. Separate tests are conducted on both types of fuel, namely synthetic and conventional diesel fuel. Oil samples are taken at certain intervals and examined in the laboratory.

The wear intensity and friction coefficient are determined through tribological analysis. Viscosity, acidity (TAN), alkali number (TBN) are determined by physicochemical analyzes. The amount of composition is determined using an infrared spectrometer. Statistical analyses and graphs are drawn based on the results obtained.

3. Results and Discussions

Justification of crankcase oil change intervals. Summarizing the results of the research conducted by scientists, it is possible to develop methods for extending engine life and reducing maintenance costs by monitoring the condition of the oil [11]. It is proposed to use machine learning and statistical methods to predict oil change intervals in heavy-duty diesel engines. In this case, by analyzing indicators such as TBN, TAN, wear elements and viscosity to solve the problem, it is possible to reduce costs by up to 30-40% [12].

Table 1

Impact of using GTL fuel on crankcase oil

№	Status	Reason
1	Oil thickening slows down	Due to lack of funds
2	The filtration system resource increases	Filters fill up later due to fewer solid particles
3	Thermo-oxidative stability	Clean combustion products do not alter the chemical composition of the oil
4	Low turbidity	Clean fuel combustion reduces tar and impurities

In particular, all vehicles in the world use petroleum fuel. It is the main source of energy. The use of alternative fuels is an urgent issue, as their use can increase efficiency and reduce harmful exhaust gases, noise and vibration [3]. The most important factor affecting the crankcase oil change interval is the clean combustion of synthetic GTL fuel and minimal soot formation. GTL fuel, with its high cetane number and almost zero sulfur content, allows you to maintain the operational properties of motor oil for up to 20-30% longer. This is a key factor in reducing maintenance costs and increasing engine life. [Table 1] Laboratory testing of the condition of the oil allows you to predict unexpected breakdowns by determining wear on engine parts and the amount of contamination in the oil [13].

4. Conclusion

In conclusion, it can be said that the above work is relevant, and by analyzing changes in the composition of the oil during operation, it is possible to identify and diagnose possible engine failures in advance, which in turn allows you to significantly reduce maintenance costs. Also, according to the results of tribological and chemical analyzes, the almost complete absence of aromatic hydrocarbons and sulfur compounds in synthetic GTL allows for complete combustion and reduced soot formation, which significantly reduces the amount of abrasive particles in the oil. Wear of rubbing parts is reduced. The low amount of soot helps to preserve protective additives such as ZDDP in the oil for a longer period. As a result, it helps to preserve the tribological layer.

The use of synthetic GTL fuel is environmentally superior to traditional fuels. If we consider it from a tribological and economic point of view, it is effective. Diesel engine crankcase oil allows for increased overall

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operating efficiency in direct proportion to the duration of use.

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