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INFLUENCE OF THE ETHANOL ADDED INTO PETROL AND DIESEL FUEL

The paper deals with the problem scope of ethanol (as biologically decomposable compound) adding into petrol and diesel fuel on the final lubricity of motor fuels. It analyses the subject of tribology and automobile fuels in connection with modern technologies in construction of automobile engines. The mentioned properties and characteristics were measured by commonly used laboratory method on Plint TE 82 (PLINT & PARTNERS LTD). Measured data show, that diesel fuel with ethanol has better lubricity parameters and lubricity persists longer, than in case of petrol fuel with ethanol. One problem occurred, when diesel fuel was mixed with ethanol, which contained more then 0,5 % of water. This problem was solved by eliminating of the water from ethanol, eventually the suitable solubility additive is recommended.

Keywords*: diesel fuel, petrol, ethanol, bioethanol, lubricity*

1. Introduction

On 8th of March 2003 were issued regulation 2003/30/EC about support of using biofuels or other renewable fuels as a replacement of diesel fuel or petrol assigned for transport purposes in each EU member state. In regulation 2003/30/EC in section 3 in point 1. there is mentioned, that member states would ensure to implement minimum quota of biofuels and another renewable fuels into their market and for this purpose there would be defined national indicative goals. Reference value for these purposes was 2 %, calculated on the basis of energy content of all types of petrol and diesel fuels for transport, introduced to their markets before 31st of December 2005 and 5.75 % before 31st of December 2010.

Alternative fuels, as biofuels, natural gas, hydrogen and LPG (liquefied petroleum gas – propane/butane), can directly substitute standard motor fuels (petrol, diesel) produced from petroleum. Significant subgroup are biofuels, which are concurrently the most perspective form of alternative fuels. It is concerned about group of substances, which are made on the basis of vegetable or animal sources. First of all is bioethanol or by conversion of bioethanol obtained ETBE (ethyl-tercbutyl ether) and methyl/ethyl esters from vegetable and animal oil. These substances are usually blended in motor fuels produced from petroleum, in order to substitute some amount of petroleum fuel by bio-compound. Biofuels, as a subgroup of alternative fuels, have an important role in agricultural and country development. However, the costs of production of alternative fuels are higher then the costs of fuels produced from fossil resources, support for compensation is necessary. Where the support doesn't exist or was cancelled, production didn't started or was aborted.

The lubricity characteristics of fuels were tested in this work. The subject of measurement were fuels (petrol and diesel), commonly used for transport in EU, in which there was blended bioethanol. Diesel fuel has lubricity regulated by standards, petrol not by that time, so therefore measured values for petrol have only informative character.

2. Importance of lubricity of motor fuels in modern automobile engine

Modern petrol engine for road vehicles is nowadays engine with injection into inlet pipe or directly into combustion chamber. It will be probably 50 % of engines with direct injection into combustion chamber (GDI, FSI, ...) in near future. Engine is directed by electronic motormanagement, it has low emissions production on the score of recirculation of exhaust fumes whether 3-way catalyzer.

In case of petrol engines, systems with injection directly into combustion chamber are used more and more, even though less than in case of diesel engines. Fuel transport pump transports fuel into high pressure pump, which supplies common rail with necessary pressure, like in case of diesel engines. However, injection pressure is lower. There are still more introduced in-line piezoelectric injectors, which can inject fuels accurately and also divide the main injection into several subinjections. There is a trend, also in case of petrol and diesel engines, to increase injection pressure. In connection with high speed of parts in injector, it means that high quality fuels with good lubricity are needed and will be needed. That's the reason, why the lubricating additions were started to be added into petrol, recently.

Modern diesel engine for road vehicles is usually supercharged, with variable charging pressure, with direct injection into combustion chamber, with high pressure injection directed by electronic management through common-rail system or turbo direct injection (TDI) system.

Present and future engine will require high quality fuel, more and more. Important and necessary attribute of fuel is ability to lubricate. In some parts of an engine (depends on construction of engine) there can be fuel only one medium, which lubricates. It is particularly important in these parts of fuel circuit, where movement between solid parts occurs. This is typical for fuel transport pumps, high pressure fuel pumps, injection units and injectors.

3. Measurement

This work aims at investigating an influence of ethanol added into petrol and diesel fuel on final lubricity of these fuels. These lubricity properties were measured on four ball machine Plint TE82.

3.1. The main goal and subject matter of measurement

The main goal of measurement was to assess the wear preventative characteristics of fuels common used in road transport and to investigate an influence of ethanol added into fuels on final lubricity of these fuels. The subject matter was to find out the

dependency between amount of ethanol added into fuel and final lubricity of measured fuel. The diesel – winter type F and unleaded petrol Super 95 were used for testing. These types of fuels are made and distributed by Slovnaft a.s.. Added compound was ethanol (bio-ethanol), made from grain, from which there was water removed chemically. It's very important for ethanol to not contain the water (because of ability to blend with fuels – especially with petrol) and the ethanol must be made from biomass or made from another biologically decomposable compound. One measurement (petrol + ethanol) was done with ethanol, from which there wasn't water removed. The lubricity properties were measured between solid surfaces of tested balls, where three of them were stable and one was rotating and pressing on the three stable balls. Configuration of the balls shows figure 1.

Three stable balls are fixed in a cup and submerged into the tested fuel sample. The fourth ball is fixed by collet chuck connected to drive spindle and driven by electromotor. During the whole test, all contacts are submerged in the tested fuel sample. The fourth ball, fixed by collet chuck, rotates and creates scars on other balls. The scars are elliptical in shape and maximum and minimum dimensions are recorded. The dimensions of scars are proportional to the quality of lubricity properties.

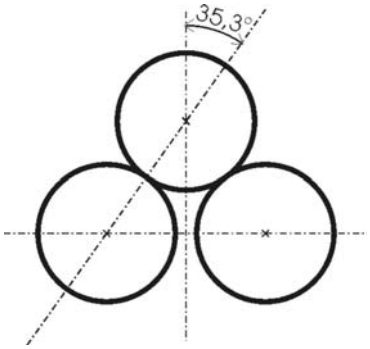

Fig. 1. Geometry of loaded balls in sliding contact

Thus, it is an indirect method to assess the wear preventative characteristics, because the consequences (scars) of friction are measured. Measurements were done under the same conditions, only the fuel sample with particular amount of ethanol was changing. Temperature of the fuel sample in lower cup assembly and sounds were recorded during the test.

In the matter of fuels, there exist standards and testing methods for assessing wear preventative characteristics and lubricity only for diesel and aircraft petroleum. Generally accepted and broadly used standard and testing method for petrol still doesn't exist. Therefore, in this work there was used the same method of testing for petrol and diesel fuel. This method is used by military forces of Slovak republic.

3.2. Measuring machine

For this test there was used machine Plint TE82. This machine was developed in co-operation with the National Engineering Laboratory, East Kilbride, Scotland as a combined low and high speed 4-ball machine. This machine is suitable for many tests, is used in many countries and there are many national standards, connected to this machine.

The upper part of the machine carries the drive spindle which in turn carries the test ball collet chuck. The chuck is removed by inserting the extractor into the top of the drive spindle and screwing down to contact chuck. For high speed tests the spindle is driven by a flat belt and for low speeds by a toothed belt.

The lower part of the machine carries the loading piston which carries the lower test assembly mounted on a thrust race. This assembly incorporates an electrical heater. Configuration of the test assembly shows figure 2.

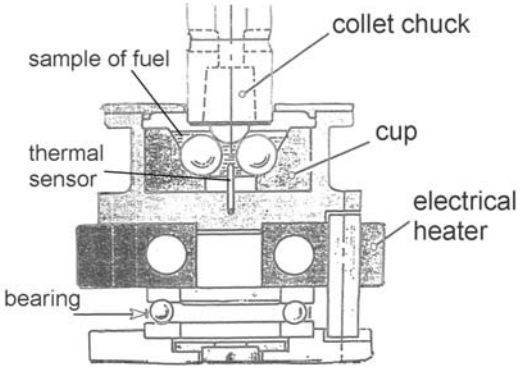

Fig.2 Configuration of the test assemblies

Access to the test chamber is through the window in the side of the casing. For high speed tests the window must be closed with the steel door provided.

The lower test assembly is inserted and removed by using the detachable handles provided. Lower races are removed by removing the grub screws from the base of the housing and knocking out with the three-pinned extractor provided.

The end load is applied to the loading piston by means of a load arm with a ratio of either 20:1 or 10:1. The piston may be lowered to insert or remove the lower test assembly by raising the load arm and engaging the locking lever.

A separate cabinet houses controls and instruments. Control cabinet is in two parts. The lower part of the stand carries the motor thyristor drive, the mains contractor and clutch starter unit. The upper panel carries the two pen chart recorder together with the isolator switch, main motor controls and analogue meters indicating speed and armature current, timer, batch counter and temperature controller.

3.3. Balls

For the test there were used bearing balls, which satisfy the technical requirements by STN 02 3680 with diameter 12.7 mm (0.5 in), degree of accuracy - 16 and hardness 63 - 65 HRC by Rockwell. The balls are specified by these compounds:

C = 0.95 - 1.10 %, Mn = 0.25 - 0.45 %, Si = 0.15 - 0.35 %,
$P_{max.}$ = 0.027 %, $S_{max.}$ = 0.020 %, Cr = 1.30 - 1.65 %,
$Ni_{max.}$ = 25%, $Cu_{max.}$ = 0.25 %, $(Ni+Cu)_{max.}$ =0.50 %.

3.4. Ethanol

For the test there was used ethanol (C_2H_5OH) 96.5 % p.a. – refined ethanol, grain alcohol, mild. Manufacturer: LACHEMA a.s., Neratovice, Tovární 157, Czech Republic. Supplier: SYNTCHEM, Chrenovec – Brusno 198. The ethanol had concentration of 96.3 % after checking by densimeter.

3 measurements were made, where ethanol and dehydrated ethanol was used:

1. Petrol + Ethanol 96.30 %
2. Petrol + Ethanol, dehydrated, 99.80 %
3. Diesel + Ethanol, dehydrated, 99.85 %

The process of dehydration was made by sodium and distilled afterwards.

3.5. Samples of fuels

The results of the test depend on type of used fuel and amount of added ethanol. This is sequence of tested fuels with different concentration of ethanol:

- diesel + ethanol (99,85 %): 0 %; 2.5 %; 5 %; 7.5 %; 10 %; 15 %; 20 %
- petrol + ethanol (99.80 %): 0 %; 5 %; 10 %; 15 %; 20 %
- petrol + ethanol (96.3 %): 0 %; 5 %; 10 %; 15 %; 20 %

The process of dehydration was made by sodium and distilled afterwards as it shows the chemical equation 1.

$$\begin{aligned} &\left(C_2H_5OH + H_2O\right) + Na \rightarrow C_2H_5ONa + H\uparrow + H_2O \\ &H_2O \; + \; Na \rightarrow NaOH \; + \; H\uparrow \\ &C_2H_5ONa + H_2O \rightarrow C_2H_5OH + NaOH \end{aligned} \qquad (1)$$

It was necessary to repeat this process multiple times until we had ethanol nearly without water content. It is also possible to use burned lime (CaO) instead of sodium. This process is very similar, but nevertheless the last step is better to do with sodium. The process with burned lime shows equation 2:

$$\left(C_2H_5OH + H_2O\right) + CaO \rightarrow Ca\left(OH\right)_2 + C_5H_5OH \qquad (2)$$

3.6. Evaluation of the testing

Measuring diameters of the scars must be done under the same light conditions (the same light source, the same angle). There are photography of the scars in figure 3. On the left side there is a scar, when diesel + ethanol were used and on the right side there is a scar, when petrol + ethanol were used. The photography represent the magnification of 54x.

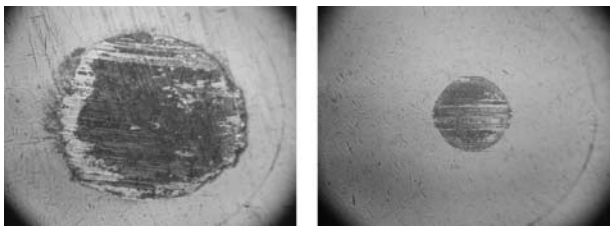

Fig.3. Friction mark on balls with fuel diesel + ethanol on left and petrol + ethanol on right

In the figure 4 there it is shown how lubricity properties depend on the ethanol content in the fuel. The used method in this work was developed for testing the lubricity of diesel fuels. Therefore, in the case of testing diesel + ethanol, we reached better level of reproducibility and lower values of uncertainty. In the case of petrol + ethanol, the reproducibility was worse and it can be also seen in figure 3. The size and the shape of the scars correlate directly with the lubricity properties of the fuel. The scars, when petrol + ethanol were tested, are bigger, have unstable shape and the boundaries of the scars was difficult to localize accurately. According to mentioned facts, it should be desirable to develop new, appropriate method for testing lubricity of petrol fuels with ethanol addition.

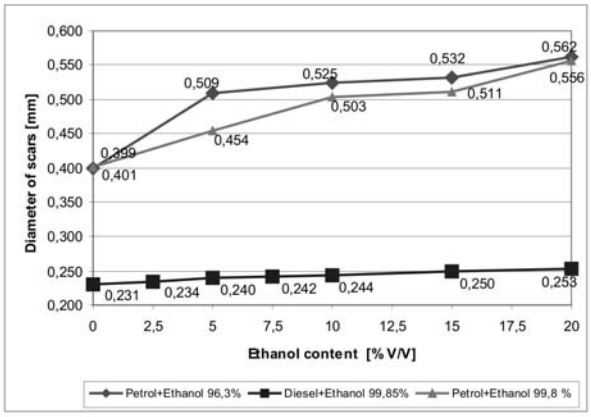

Fig.4. Lubricity of tested fuels

4. Conclusion

Added ethanol decrease ability to lubricate and wear preventative characteristics of tested fuels are worse. Diesel fuel keeps the lubricity properties longer in despite of increasing the amount of added ethanol. In this respect, petrol fuel is not good as diesel. But diesel fuel had another problem, when ethanol (ethanol with more than 0.5 % V/V of water content) was adding. This problem was resolved by using dehydrated ethanol. Dehydrated ethanol contained less then 0.2 % V/V of water.

If ethanol is used as a compound for adding into petrol and diesel fuel, it will be necessary to avoid creating second phase (emulsion and clouding is occurring), because of water content in ethanol. It can be resolved by using dehydrated ethanol or by adding special compound (solubilizer).

When the petrol with ethanol without dehydration was tested, worse lubricity occurred as in the case of petrol with dehydrated ethanol. Thus, it's suitable and necessary to use ethanol without water content (less then 0.5 % V/V of water).

Testing the lubricity properties of petrol by using method used in this work is not suitable, because:

- noise and vibrations were occurring during the test,
- the scars had unstable shape and the boundaries of the scars was difficult to localize accurately.

By reason of these facts, we recommend to develop another, more suitable test method as it was used in this work.

Using ethanol as a compound of fuels (especially in case of bigger amounts), we recommend adding suitable lubricity addition.

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