INVESTIGATION OF IMPACT OF BIOFUEL BLEND ON ARCTIC DIESEL FUEL PROPERTIES

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Abstract. To improve the situation in the biofuel usage sphere, in June, 2009 the Cabinet of Ministers of Latvia accepted modifications to the "Regulations on petrol and diesel fuel conformity assessment" and "Regulations on biofuel quality standards, conformity assessment, market surveillance and the procedure of consumer information". The modifications stated that from the 1st of October, 2009 the 95th gasoline can be distributed only with the 4.5 to 5 % mix of bio-ethanol and diesel fuel – with the 4.5 to 5 % mix of biodiesel, but these requirements are not applied to the arctic diesel fuel. The aim of the investigation is to establish the compatibility of biodiesel with arctic diesel fuel testing the blends B3, B4, B5 and B7 according to the standard LVS EN 590:2005 "Automotive fuels – Diesel Fuel – Requirements and test methods". The main parameters of interest in this research are the temperatures of Cold Filter Plugging Point (CFPP) and Cloud Point (CP) and their change tendencies depending on the biofuel content. Analyzing the results each 1 % of biodiesel mix changes the CFPP temperature by an average of 0.7 %. In absolute numbers the 5 % biodiesel mix lowered the CPFF temperature from –42 ˚C to –40 ˚C. Each 1 % of biodiesel mix changes the CP temperature by an average of 1 %. In absolute numbers the 5 % biodiesel mix lowered the CP temperature from –23 ˚C to –22 ˚C. Adding more biofuel up to 7 %, Cloud Point temperature was –21 ˚C, so such mixture does not satisfy the requirements for the 2nd Arctic class diesel fuel.

Keywords: biofuel, biodiesel, diesel fuel, cold filter plugging point, cloud point.

Introduction

Oil resources that are very important energoresources in the world become exhausted very fast. Every year the amounts of extraction and application of these resources increase causing fast environment pollution. In turn, this environment pollution considerably influences the climatic conditions that could lead to global warming. Latvia depends on import of these energoresources that cover a large part of the energetic needs in the country.

Introduction of biofuel in Latvia has become especially topical with the entrance of Latvia into the EU as due to this reason observation of the EU normative acts has become binding for Latvia, for instance, the EU Directive 2003/30/EK "On the Promotion of the Use of Biofuels or Other Renewable Fuels for Transport" [1], the execution of which could be ensured by implementation of the program "Production and Usage of Biofuel in Latvia" developed and adapted in Latvia. According to the action plan elaborated in it the amount of the used biofuel till the end of 2010 should be 5.75 %. As the time is short in order to implement the adapted directives cardinal measures should be taken on national scale for introduction of biofuel.

In the new biodiesel fuel standard LVS EN 590:2009 the content of fatty acid methylester (FAME) in diesel fuel is included as an index that was not included in the previous standards. It means that biodiesel fuel can be added to fossil fuel up to 5 % of the content volume obtaining B5 fuel.

Important parameters influencing usage of fuel in winter months are the cold filter plugging temperature or point (CFPP, ˚C) and clouding temperature or cloud point (CP, ˚C) [2].

The CFPP determines the cold filter blocking temperature that characterizes the filtration (flow through the fuel filters) in low temperatures. With decrease of the diesel fuel temperature initially some paraffin crystals are formed the number of which constantly increases until the whole volume is paraffined (stiffened). At present in the standards the initial temperature of the crystal formation is not most important when fuel still flows through the filter, or the final temperature when fuel is stiffened, but the CFPP temperature which is by ~10 ˚C lower than the initial crystal formation temperature and in which diesel fuel cannot flow through the filter any more as it is already full with paraffin crystals.

In turn, the clouding temperature is the initial crystal formation temperature when fuel still flows through the filter. The Cabinet of Ministers of the Republic of Latvia has determined that in diesel fuel retail sale places in the winter period (November 1 – March 31) not only the climatic class of the diesel fuel but also its clouding initial temperature should be indicated.

The standard determines that the Cold Filter Plugging Point cannot be higher than:

- six climatic gradations determined for moderate climate (designated by letters A, B, C, D, E and F): A = +5 ˚C, B = 0 ˚C, C = –5 ˚C, D = –10 ˚C, E = –15 ˚C, F = –20 ˚C;
- five climatic classes determined for arctic climate and severe winter conditions (numerated by 0, 1, 2, 3, 4): class 0 –20 ˚C, class 1 –26 ˚C, class 2 –32 ˚C, class 3 –38 ˚C and class 4 –44 ˚C.

The diesel fuel standard determines also the cold filter blocking temperature in the arctic climate: class 0 –10 ˚C, class 1 –16 ˚C, class 2 –22 ˚C, class 3 –28 ˚C and class 4 –34 ˚C.

The regulations of the Cabinet of Ministers No. 772 that were affirmed on 25.06.2009 "Regulations on biofuel quality standards, conformity assessment, market surveillance and the procedure of consumer information" determine that in Latvia diesel fuel (gas oil) with added biodiesel fuel in the amount of 4.5-5 volume per cent of the total amount of the final product is related to diesel fuel of the categories A, B, C, D, E, F, in turn, the requirements are not ascribed to diesel fuel of the classes 0, 1, 2, 3, 4 that is used in arctic and severe winter conditions [3]. As the qualities of biodiesel fuel are closer to diesel fuel of the classes A, B, C, D, E and F, this decision is understandable. Nevertheless, in order to clarify the compatibility of biodiesel fuel with arctic diesel fuel, the cold filter blocking temperature (CFPP) and the clouding temperature of arctic diesel fuels and biodiesel fuel mix B5 should be determined.

Analyzing the fossil and biodiesel blend studies performed in other countries, Cold Filter Plugging Point and Cloud Point quality assurance is highlighted as one of the most significant factors in biofuel application efficiency. For instance, in China an artificial neural network model is established to predict CFPP of the blended diesel fuels, using input parameters of kinematical viscosity, density, refractivity intercept, CFPP and weight percentages of constituent diesel fuels [4]. In order to exploit the proximity of South Asian and South-East Asian countries, blends of Jatropha and Palm biodiesel have been examined in India to study their physical-chemical properties and to get an optimum mix of them to achieve better low temperature properties with improved oxidation stability [5]. Unfortunately, experimental studies the results of which could be directly applied to the Latvian climatic conditions were not found.

The research was performed in co-operation with the Latvian Investment and Development Agency and the following tasks were set:

- to evaluate the possibilities to add 5 % of biofuel mix to diesel fuel of class 2 used in arctic and severe winter conditions in compliance to the standard LVS EN 590:2005 "Automotive fuels – Diesel Fuel – Requirements and test methods";
- to determine the cold filter blocking temperature of arctic (at least class 2) diesel fuel with 3 %, 4 % and 5 % biodiesel fuel mix and to investigate the trend of changes;
- to determine the clouding temperature of arctic (at least class 2) diesel fuel with 3 %, 4 % and 5 % biodiesel fuel mix and to investigate the trend of changes;
- to purchase fuel from at least two or several fuel traders and test it also before mixing.

Materials and methods

The fuel to be tested was purchased in three different fuel filling stations (further designated as D1, D2 and D3) and tested before forming the mix. The same way biodiesel fuel B100 was purchased and tested before forming the mix. Three different mixtures were formed: B3 (with 3 % biodiesel mix), B4 (with 4 % biodiesel mix) and B5 (with 5 % biodiesel mix) from the purchased fuel samples and the mixtures were analysed in order to determine the CPFF temperature and the clouding temperature. In order to specify the trend alongside with the mixtures determined in the tasks of the research also analysis with the mix B7 (with 7 % biodiesel mix) was carried out.

The analyses were performed at the Latvian Certification Center using standardized testing methods:

- determination of the cold filter blocking temperature CPFF was done according to the method of the standard LVS EN 116+AC: 2002;
- determination of the clouding temperature CPFF was done according to the method of the standard LVS EN 23015:2002.

Results and discussion

Purchasing arctic diesel fuel in three different fuel stations it turned out that in two of them the cold filter blocking temperature and the clouding temperature correspond to the arctic class 2 (according to the standard LVS EN 590:2009) but in the third only to the arctic class 0. Due to this the fuel purchased in two fuel stations was used for carrying out the direct task of the research, but the third (D3) – for comparison of the trends of parameter changes, i.e., whether the measured parameters are changing in percent by the same value also if the initial indices of the diesel fuel are sharply different. The results of the CFPP and CP analyses are summarized in Figures 1 and 2.

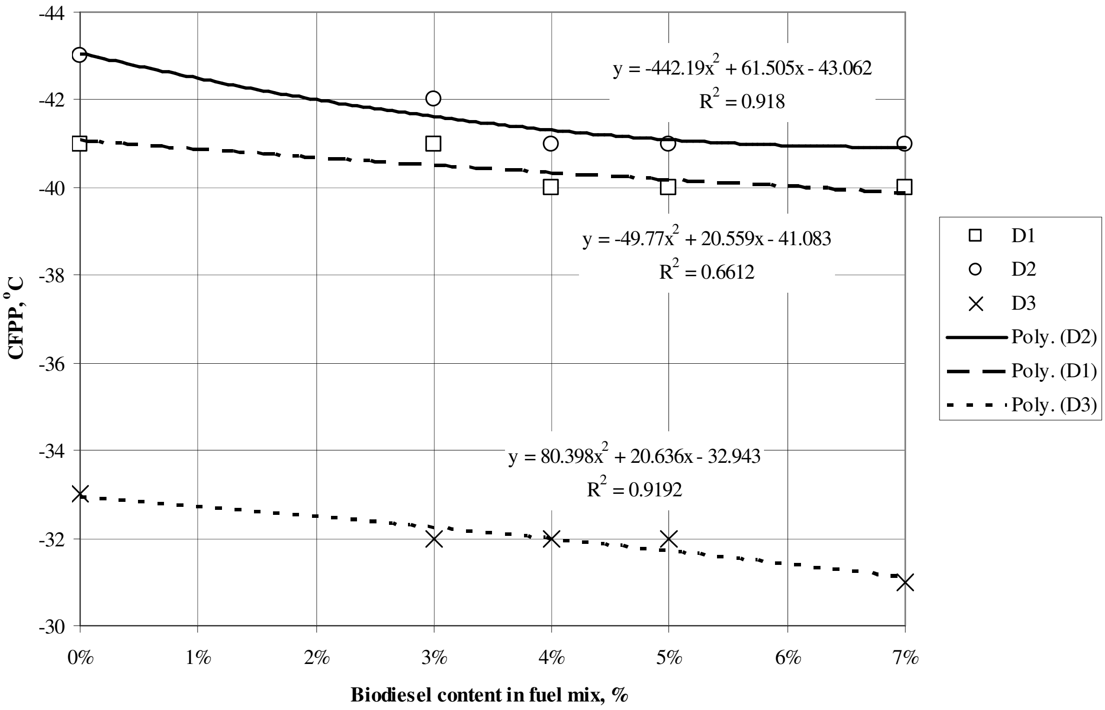

Fig. 1. **CFPP changes depending on biodiesel fuel mix to arctic diesel fuel**

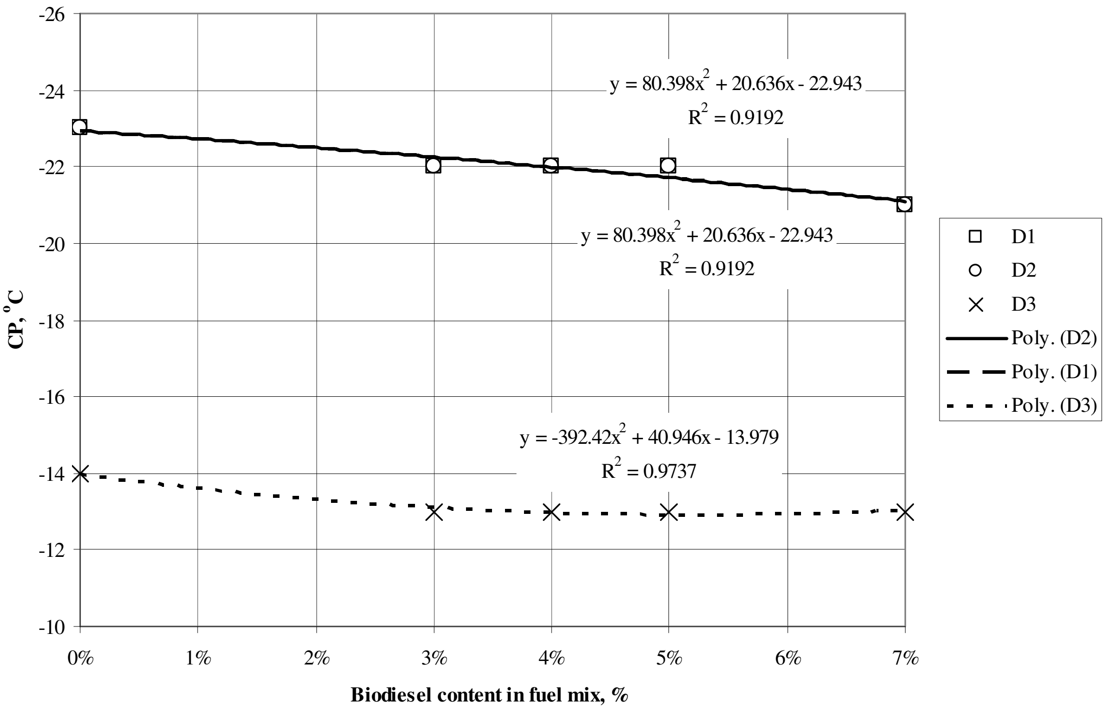

Fig. 2. **Clouding temperature changes depending on biodiesel fuel mix to arctic diesel fuel**

Analysing the cold filter blocking temperature of the class 2 in arctic conditions in diesel fuel mix with different content of biodiesel it can be concluded that every biodiesel fuel mix percent (up to 5 %) changes the cold filter blocking temperature in the average by 0.7 %. This trend of the changes was observed for class 2 as well as class 0 diesel fuel in arctic conditions. Such tendency was observed also in the additionally carried out experiment with 7 % biodiesel fuel mix. In absolute figures CPFF changes did not exceed 2 ˚C. The validity of the results is confirmed by the correlation coefficient obtained by approximation that was in the range from 0.81 to 0.96 for definite fuels.

Analysing the clouding temperature of the class 2 diesel fuel in arctic conditions in mixture with different content of biodiesel it can be concluded that every biodiesel fuel mix percent (up to 5 %) changes the clouding temperature in the average by 1 % and absolute figures the clouding temperature changes did not exceed 1 ˚C. This trend was observed for class 2 as well as class 0 diesel fuel in arctic conditions. Such tendency was observed also in the additionally carried out experiment with 7 % biodiesel fuel mix. The correlation coefficient for definite fuels was in the range from 0.95 to 0.99.

Conclusions

1. Tracing the experience of the researchers on B5 mixes in Europe it can be stated that they have used mainly diesel fuel that is not applied in arctic climate, therefore the results of the present research cannot be directly compared with the data of other researchers, besides, in future experiments with changes of other parameters (for instance, ignition temperature, water content, cetane number) will be required.
2. Analyzing the cold filter blocking temperature of class 2 diesel fuel in arctic conditions in diesel fuel mix with different content of biodiesel mix it can be concluded that every biodiesel fuel mix percent (up to 7 %) changes the cold filter blocking temperature in the average by 0.7 %, but the clouding temperature in the average by 1 %.
3. Analysing the mix up to 5 % of class 2 diesel fuel BioDD in arctic conditions the cold filter blocking temperature and the clouding temperature ensure the compliance of the mix to the arctic class 2 (according to the standard LVS EN 590:2009). Mixing 7 % biodiesel the clouding temperature was –21 ˚C, instead of the permissible –22 ˚C, so such mix corresponds only to arctic class 1.
4. Considering the small number of analyses these results can be evaluated as pre-research and in future it would be purposeful to continue the research increasing the scope of investigations as well as the parameters to be determined. Besides, it is necessary to clarify how the parameters of the mixtures change during storage at least for three months.

References

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