Agronomy Research **14**(2), 400–406, 2016

Effect of gasoline contamination on the quality of arctic diesel fuel

V. Hönig[1,*], Z. Linhart[2] and M. Orsák[1]

[1]Czech University of Life Sciences Prague, Faculty of Agrobiology, Food and Natural Resources, Department of Chemistry, Kamýcka 129, CZ16521, Prague 6, Czech Republic
[2]Czech University of Life Sciences Prague, Faculty of Economics and Management, Department of Management, Kamýcka 129, CZ16521, Prague 6, Czech Republic
[*]Correspondence: honig@af.czu.cz

Abstract. Fuel quality is affected predominantly during its transport between producer and user as hired transporting companies may use one transport vehicle for more different fuels. Therefore, gasoline from previous transport may cause contamination of diesel fuel in next transport. Many drivers add gasoline as additive to diesel fuel to improve start of engine avoiding difficulties of cold winter temperatures. Therefore, the objective of this article is to assess maximum gasoline content added still compliant with default values of standard EN590 and values certified by producer. Only 2% maximal gasoline content in arctic diesel fuel was found safe for both machine and operator. Distillation curve, kinematic viscosity, density, lubricity and cetane index were influenced unimportantly. Cloud point, CFPP were not changed at all.

Key words: diesel, gasoline, distillation, blend, limits.

INTRODUCTION

Purposeful cheating allowing excise duty reduction, price decrease diesel fuel dilution by technical gasoline and by HC oil appears often, but is not discussed in this article. The purpose of this article is to observe arctic diesel fuel quality in official distribution channel, which can be compromised by accident. Usually, residual fuel from previous transport may cause the most serious contamination of diesel fuel due to lacking technological treatment of transporting tank. Therefore, quality of delivered diesel fuel is sampled, analysed and fuel quality differences from norm are reported at petrol station or fuel storage (Kamimura & Sauer, 2008; Arapatsakos, 2009; Catillo-Hernández et al., 2012; Pirs & Gailis, 2013; Aydogan, 2015).

Flash point, eventually diesel fuel distillation properties are the most seriously affected in such cases. Volume of gasoline added or diesel fuel properties of casual impurities damaging engine (Mužíková et al., 2010; Hönig et al., 2015) were discussed. Therefore, objective of this article is to assess still acceptable gasoline contamination of diesel fuel excluding any damage of engine.

Fuel allowing proper diesel engine performance has to overcome problems of:

- density, viscosity, lubricity, purity and in winter also filter ability being timely, regularly and in needed volume transported to cylinder;
- viscosity and composition of fractions by precise dispersion and evaporation;
- composition of fractions, density and cetane number to shorten ignition delay allowing normal combustion;
- ending distillation, carbonization residue, purity, ash, content of aromatic hydrocarbons and methyl esters of fatty acids to avoid sediments in fuel system, filters, injections and combustion chamber;
- oxidation stability, sulphur content, water, eventually quality of added methyl ester of fatty acids preventing corrosion of flue (Yuksel & Yuksel, 2004; Rakopoulos et al., 2008; Schlaub & Vetter, 2008; Karabektas & Hosoz, 2009; Singh et al., 2015).

MATERIALS AND METHODS

It was expected that gasoline may appear in diesel fuel during transport and storage about few tenth or units of percents. Therefore, gasoline concentration in diesel fuel samples with 1%, 2%, 3% and 5% (vol.) were prepared to find impacts on fuel system. Sample of diesel without methyl esters of fatty acids was compliant with EN 590 for second class conditions for extremely cold arctic climate. Content of polycyclic aromatic carbohydrates was 7% wt. Gasoline complying with EN 228 for winter period of first class containing 32.21% (vol.) of aromatic carbohydrates, 10.31% (vol.) olefins and 0.57% (vol.) of benzene was used to simulate contamination of diesel in samples. Water content of samples was 51.00 mg kg^{-1} and oxidation stability has exceeded 360.0 minutes.

Three groups of sampled diesel with immision of gasoline in repeated experiments were performed according to quality norm (Table 1).

Table 1. Limiting values of EN590 standard

Limiting values	
Distillation 10%	min 180 °C
Distillation 90%	max 340 °C
Flash point	min 55 °C
Kinematic viscosity at 40 °C	min 1.5 $mm^2 s^{-1}$
Density at 15 °C	800–845 kg m^{-3}
Cetane index	min 46
Lubricity	max 460 µm
Cloud point	max -22 °C
CFPP	max -32 °C

Laboratory tests were performed according to the requirements of standard EN 590:
Distillation test according to EN ISO 3405;
Cetane index according to EN ISO 4264;
Flash point according to EN ISO 2719;
Density at 15 °C according to EN ISO 3675;
Kinematic viscosity at 40 °C according to EN ISO 3104;
Cloud point according to EN 23015;

Cold Filter Plugging Point (CFPP) according to EN 116;

Lubricity HFRR (corrected wear surface diameter WSD 1.4 mm) at 60 °C according to EN ISO 12156-1.

Above listed standards have allowed us to indicate changes only due to tested diesel fuel contamination of each sample. Each experiment was repeated three times, arithmetic averages was calculated from measured values and used for presentation of final results according to general conditions for reproducibility and conformance for experimentation. The High Frequency Reciprocating Rig (HFRR) was used to measure wear area in environment of sampled fuels.

RESULTS AND DISCUSSION

Three groups of experiments were performed to distinguish different points of view on contaminated diesel fuels by gasoline according to conditions set in methodology.

The first group of diesel fuel with added gasoline has strongly influenced flash point. Compliance with EN 590 was lost with gasoline above 0.5% vol. in diesel (Fig. 1).

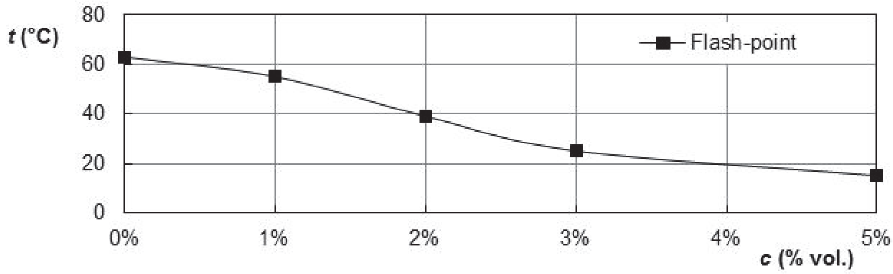

Figure 1. Flash point affected by gasoline content.

Distilled volume in % (vol.) on horizontal and temperature in °C on vertical axis are shown. Defined and below limit flash point values in interval 0.5 and 0.75% (vol.) of diesel contaminated by gasoline depend also on how full the tank is and how much time is needed for evaporation of volatile hydrocarbon vapours.

Second group pushing quality parameters out of reach of experimental methods but, still under compliance with EN 590, are:

1. Distillation experiment according to EN 590 is distilled volume up to 180 °C temperature is reached.

2. Kinematic viscosity and density below reproducible results (Fig. 2) in comparison with default values of pure diesel with added 1.5–2% (vol.) of gasoline. But, 5% (vol.) of gasoline in diesel keeps the fuel performance above minimum fuel viscosity and density according to EN 590.

3. Worsened lubricity was found from 3% (vol.) of gasoline immission upwards (Fig. 6), but found values are still reproducible.

Volume in % (vol.) of gasoline on horizontal, density by 15 °C on primary vertical and kinematic viscosity by 40 °C in $mm^2 s^{-1}$ on secondary vertical axis are shown. Low concentration of gasoline in diesel decreases density seriously.

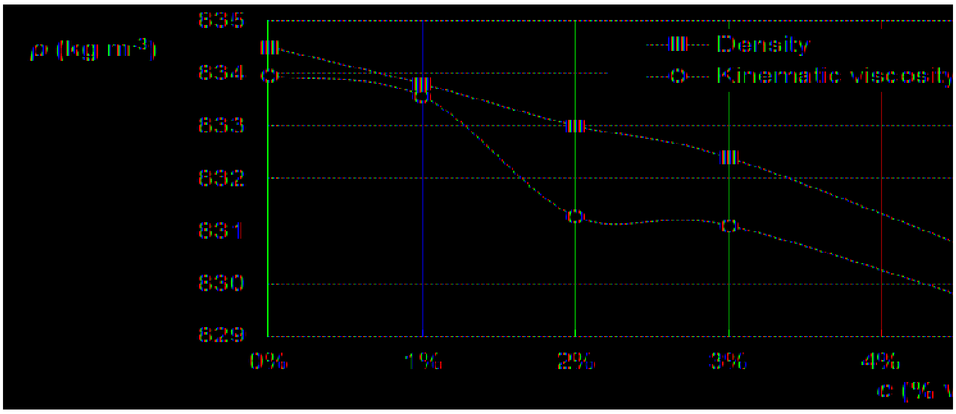

Figure 2. Effect of gasoline on diesel fuel density and kinematic viscosity.

But, high 5% (vol.) concentration of gasoline in diesel keeps density still above default value min. 820 kg m^{-3} at 15 °C. Decreased density corresponds to difference of densities between diesel and gasoline. Therefore, the higher gasoline concentration the lower performance of diesel engine occurs due to volume based fuel injection into diesel engine. Volume of injected fuel increases with specific weight. Engine performance decreases from 0.4% to 1.6% if density (specific weight) is decreased below 10 kg m^{-3}.

Values of kinematic viscosity under 40 °C (Fig. 2) develop differently than values of density. Bigger bias of viscosity curve can be explained by both higher gasoline content and carbohydrate chain. Tested maximal content 5% (vol.) of gasoline didn't moved viscosity out of default values in range from 2.0 to 4.5 $mm^2 s^{-1}$ according to EN 590. Therefore, tested maximal gasoline content cannot harm moving parts of fuel system due to low viscosity causing lost thin lubricity layer. Similarly, neither pumped nor filtered fuel volume or fuel dispersion are threatened.

Horizontal axis shows distilled fuel % (vol.) and main vertical axis temperature in °C.

Distillation curve (Figs 3 and 4) allows fuel quality assessment. 1% (vol.) of gasoline decreases temperature of diesel distillation seriously in its beginning. 2.5% (vol.) of gasoline content has moved 10 and 20% values of diesel distillation point out of reproducible range. And, 5% (vol.) of gasoline has moved 30 and 40% values of diesel distillation point out of reproducible range. Absence of values of distillation points in EN 590 allows to emphasize that maximum 5% of gasoline added to diesel keeps distillation still in compliance with EN 590 (Figs 3 and 4).

Horizontal axis x shows changes of distilled fuel volume in % (vol.) and main vertical axis is showing temperature in °C.

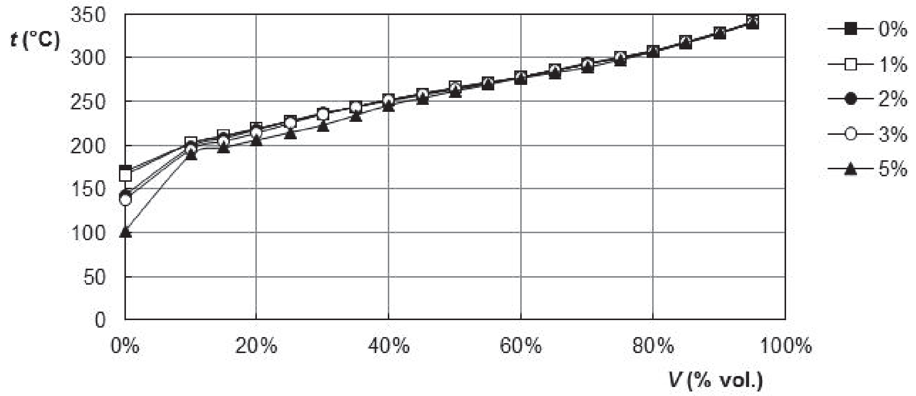

Figure 3. Distillation curve of diesel containing gasoline.

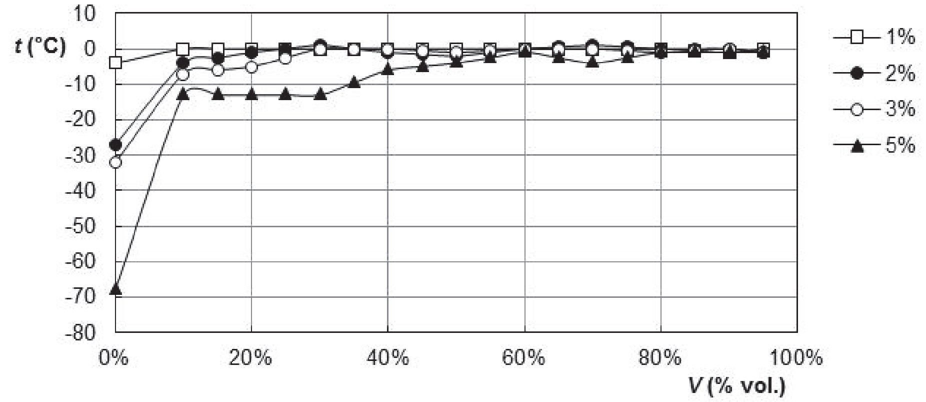

Figure 4. Change in distillation temperature of diesel blends with gasoline.

Gasoline content in % (vol.) at horizontal axis x and temperature in °C at vertical axis y (Fig. 5). Added gasoline is decreasing CFPP point down to gasoline crystallization. This property may explain why some drivers are adding gasoline to diesel during winter period to improve low temperature properties of diesel. If Arctic diesel was used, significant difference of temperatures on measured parameters was not shown.

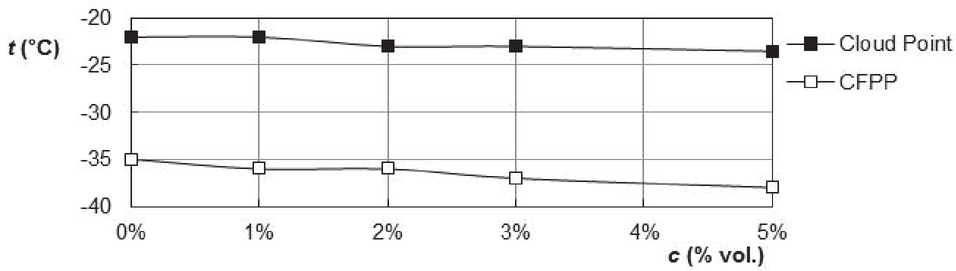

Figure 5. Cloud point and cold filter plugging point of diesel affected by gasoline.

Gasoline content in % (vol.) at horizontal axis x, cetane index on primary vertical and lubricity (HFRR) in $mm^2.s^{-1}$ on secondary vertical axis are shown.

The third group follows parameters expectedly not affecting or without found impact of gasoline added on diesel quality. Predominantly, these parameters are as follows:

1. Cetane index (Fig. 6);
2. Could point (Fig. 5);
3. CFPP Cold filter plugging point (Fig. 5);
4. Sulphuric content (if gasoline has less sulphur than diesel);
5. Content of PAH (polyaromatic hydrocarbons);
6. Content of methyl esters of fatty acids (not in gasoline).

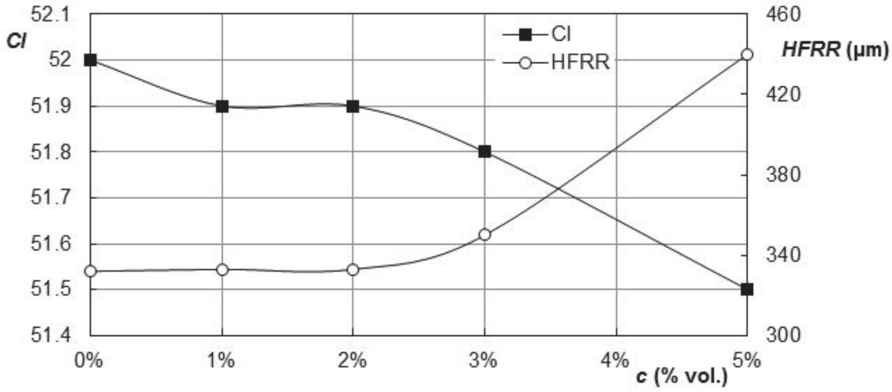

Figure 6. Cetane index and lubricity of diesel affected by gasoline added.

Gasoline added to diesel is decreasing cetane index (Fig. 6). The decrease depends on initial value of pure diesel. Fuels with high octane number as gasoline, has low cetane index and vice versa. Serious problem may occur if frost resistance of diesel is increased (HFRR). 5% (vol.) of gasoline added in diesel has approached closely to limiting value of EN 590. Found loss of lubricity of diesel due to presence of gasoline may cause serious problems, which are associated with loss of operability of machine. Diesel engine performance is affected by following parameters: distillation, density, viscosity, carbon sediment, cetane number or index, corrosiveness of fuel and its flue, purity and also filterability and temperature of emergence of paraffin in winter period. Flash point is informing about evaporation of diesel fuel and is related to initial boiling point but, is not related to combustion in combustion chamber of diesel engine. Therefore, default value of diesel flash point is set and should be understood as fire protection for safety of garages (III. flammable class is decreased to I).

CONCLUSIONS

Three serious consequences of contamination by added gasoline to diesel fuel was found above 2% in performed experiments affecting kinematic viscosity, density and distillation. Firstly, any contamination by gasoline is affecting safety of manipulation and storage of diesel fuel. The flash point with 5% of gasoline in diesel fuel has reached first class of flammability. Secondly, distillation curve, kinematic viscosity, density and lubricity were influenced by gasoline in diesel fuel but still in accordance with standard for diesel fuel EN 590. Thirdly, no impact on values of cloud point, CFPP with unimportant change of cetane index were found.

ACKNOWLEDGEMENTS. The paper was created with the grant support project CIGA CULS Prague 20153001 – Utilization of butanol in internal combustion engines of generators.

REREFRENCES

Arapatsakos, Ch. 2009. Application of diesel - ethanol mixtures in tractor engine, *International journal of energy and environment* **3**, 77–84.

Aydogan, H. 2015. Prediction of diesel engine performance, emissions and cylinder pressure obtained using Bioethanol-biodiesel-diesel fuel blends through an artificial neural network, *Journal of Energy in Southern Africa* **26**(2), 74–84.

Catillo-Hernández, P., Mendoza-Domínguez, A. & Caballero-Mata, P. 2012. Analysis of Physicochemical Properties of Mexican Gasoline and Diesel Reformulated with Ethanol, *Ingeniería, investigación y tecnología* **13**(3), 293–306.

EN 228. 2009. Automotive fuels – Unleaded petrol – Requirements and test methods, ČSNI, 16 pp. (in Czech).

EN 590. 2013. Automotive fuels – Diesel – Requirements and test methods, ČSNI, 16 pp. (in Czech).

Hönig, V., Orsák, M., Pexa, M. & Linhart, Z. 2015. The distillation characteristics of automotive gasoline containing biobutanol, bioethanol and the influence of the oxygenates. *Agronomy Research* **13**(2), 558–567.

Kamimura, A. & Sauer, I.L. 2008. The effect of flex fuel vehicles in the Brazilian light road transportation. *Energy Pol.* **36**(2), 1574–1576.

Karabektas, M. & Hosoz, M. 2009. Performance and emission characteristics of a diesel engine using isobutanol-diesel fuel blends, *Renewable Energy* **34**(6), 1554–1559.

Mužíková, Z., Pospíšil, M. & Šebor, G. 2010. The use of bioethanol as a fuel in the form of E85 fuel. *Chemické listy* **104**(7), 678–683 (in Czech).

Pirs, V. & Gailis, M. 2013. Research in use of fuel conversion adapters in automobiles running on bioethanol and gasoline mixtures. *Agronomy Research* **11**(1), 205–214.

Pospíšil, M., Mužíková, M & Šebor, G. 2007. Volality and distillation properties of ethanol-petrol blends. *Goriva i maziva* **46**(4), 335–353.

Rakopoulos, D.C., Rakopoulos, C.D., Karakas, E.C. & Giakoumis, E.G. 2008. Effects of ethanol–diesel fuel blends on the performance and exhaust emissions of heavy duty DI diesel engine, *Energy Conversion and Management* **49**, 3155–3162.

Schlaub, G. & Vetter, A. 2008. Biofuels for Automobiles – An Overview, *Chemical Engineering and Technology* **31**, 721–729.

Singh, S.B., Dhar, A. & Agarwal, A.K. 2015. Technical feasibility study of butanol-gasoline blends for powering medium-duty transportation spark ignition engine, *Renewable Energy* **76**, 706–716.

Yuksel, F. & Yuksel, B. 2004. The use of ethanol-gasoline mixture as a fuel in an SI engine. Renewable Energy **29**, 1181–1191.