Labeckas G., Slavinskas S., Kanapkienė I.
Power and Transport Machinery Engineering Institute at Aleksandras Stulginskis University,
Student Str. 15, P.O. Box LT-53361, Kaunas Academy, Lithuania

THE EFFECT OF THE CETANE NUMBER OF VARIOUS DIESEL-HVO FUEL BLENDS ON THE COMBUSTION PROCESS OF A TURBOCHARGED DIESEL ENGINE

The paper presents effect of the cetane number and chemical-physical properties of diesel-HVO fuel blends oxygenated with ethanol (E) or biodiesel (B) on the autoignition delay, combustion phenomenon, maximum heat release rate, and the peak in-cylinder pressure of a turbocharged CRDI diesel engine. Diesel-HVO fuel blends oxygenated with anhydrous (200 proof) ethanol OE1-OE3 or rapeseed biodiesel OB1-OB3 (4.5 wt% oxygen) in such proportions by mass to assure the variation within a wide range of the cetane (C) number 51.2-67.3 were tested for brake mean effective pressure of p_e = 1.24, 1.37 and 1.40 MPa at the respective speeds of 1500, 2000 and 2500 rpm. Analysis of the changes occurred in compression ignition delay, burn angles MBF 50 and MBF 90, maximum heat release rate and the peak in-cylinder pressure made by using oxygenated fuel blends OE1-OE3 or OB1-OB3 was performed on comparative bases with the corresponding values measured with blends CE1 or CB1 to reveal the potential developing trends of the combustion parameters.

Keywords: Diesel engine; Diesel-HVO fuel blends; Ethanol; biodiesel; Autoignition; Combustion; Heat release; Maximum in-cylinder pressure.

Introduction. Transport is one of the biggest user of a fossil diesel fuel and the most contributing factor to the environment polluting. The scientists worldwide continue intensive investigations on alternative renewable fuels to partially at least replace fossil origins fuel and, thus, elevate this problem. There potentially are many alternatives to replace fossil diesel fuel with renewable and more environment friendly. However, due to different chemical and physical properties still is not completely clear in what percentages (by mass) the alternative fuel could be premixed with a fossil diesel to achieve efficient combustion in the engine cylinder and energy conversion efficiency without a risk to damage an engine while producing minimal negative impact on the environment.

Chemical and physical properties of the fuel affect the injection and atomisation characteristics and, thus, have impact on the autoignition, overall combustion process, brake specific fuel consumption and engine out emissions. The cetane number (CN) of the fuel is, perhaps, the most important and dominant factor, which affects compression ignition and following combustion in the cylinder. This parameter is determined by the European standard EN 5165 and it should be no less than 51 equally for the normal fossil origin diesel fuel and biodiesel.

The cetane number largely depends on both the composition of the fuel and the chemical structure of the fuel molecules. The highest cetane number possess paraffinic hydrocarbons, slightly lower unsaturated hydrocarbons, and aromatic compounds [1, 2]. The more atoms is in double bounds and the more branched is the chemical chain of the molecule, the lower will be the cetane number of the fuel [3].

The higher cetane number of the fuel predicts that compression ignition delay will be shorter and the combustion will start sooner in an engine cycle [4, 5, 6], whereas when running with the fuel possessing lower CN rating, the autoignition delay period is expected to be reasonably longer. The lower CN rating may reduce the fuel-heat energy conversion efficiency, increase engine noise and emissions of the exhaust. The researcher noted that the increased cetane number of the fuel shortens the autoignition delay, reduces the amount of the fuel premixed for rapid combustion and thus contributes to lower NO_x emission.

It was revealed that the autoignition delay and performance parameters of a naturally aspirated diesel engine are strongly affected not only be the cetane number value, but also by chemical structure of the fuel, but also by the amount of fuel-bound oxygen stored in ethanol-diesel-biodiesel fuel blends [7]. To produce oxygenated fuel blends, normally is used ethanol or biodiesel (RRME) as oxygenator source. Ethanol includes the highest amount of fuel-bound oxygen (34.78), however its wide using as diesel fuel supplement in compression ignition engines is largely restricted by chemical and physical properties, namely extremely low cetane number of ethanol (Table 1). Whereas RRME is popular in transport sector to completely or partially replace fossil-origin diesel fuel despite slightly higher density of biodiesel. The investigations conducted with aviation JP-8 fuel treated with CN improving agent 2-ethylhexyl nitrate [8] and JP-8 oxygenated with biodiesel-bound oxygen [9] did not disclose completely which of them - the cetane number, fuel-bound oxygen mass fraction or widely different chemical-physical properties of the fuel play a key role in changes in the combustion process, engine performance efficiency and emissions.

The purpose of experimental study was to examine the effect of the cetane number of purposely-designed diesel-HRD fuel blends on the autoignition delay and following combustion in a turbocharged CRDI diesel engine running over a wide range of loads and speeds when fuel-bound oxygen mass fraction of various origins is maintained of the same value of 4.5 wt%.

Research methodology, experimental procedures and engine test set up. The fuel components used to prepare fuel blends for diesel engine tests: fossil origin diesel fuel (LST EN 590:2014+AC standard, Ltd. „Orlen Lietuva“); hydrotreated vegetable oil (HVO) (NESTE OIL, Finland); neat (99,9 wt%, by mass) dehydrated ethanol (LST EN 15376:2015 standard); Rapeseed Oil, Fatty Acids Methyl Ester – Biodiesel named in abbreviations RRME (LST EN 14214:2014 standard, UAB „Rapsoila“).

Table 1. Chemical and physical properties of the fuels.

Properties of the tested fuels	*Evaluation methods*	*Diesel fuel (class 1)*	*HVO*	*Ethanol*	*RRME*
Density at 15 0C, kg/m3	EN ISO 3675/EN ISO 12185	833	780	790	884
Kinematic viscosity at 40 ^{0}C, mm^2/s	EN ISO 3104	2.1	2.9	1.4	4.4
Flash point in open cup (FP), ^{0}Co	EN ISO 2719/3679	57	80	13	168
Cold Filter Plugging Point (CFPP) ^{0}C	EN ISO 116	-31	-40	≤-38	-15
Cetane number	EN ISO 5165/EN 15195/ASTM D7689	51,4	78,9	8,0	51,0
Sulphur content, mg/kg	EN ISO 20846	5,6	<1	-	3,9
Iodine number, (J2g)/100g	EN 14111	6	-	-	110
Acidity, (mg KOH)/g	ASTM D3242/EN 14104	0,06	0,001	≤0,01	0,11
Fuel-bound oxygen content, max %	-	0	0	34,78	10,9
Carbon-to-hydrogen atoms ratio (C/H), kg/kg	-	6,62	5,58	4,00	6,48
Net heating value, MJ/kg	EN ISO 8217/ASTM D4809	43,00	43,82	26,95	37,23
Stoichiometric air-to-fuel ratio, kg/kg	-	14,5	15,1	9,1	12,6
Total contamination, mg/kg	EN ISO 12662	4	3	-	11,6
Ash content by mass, wt%	EN ISO 6245/EN3987	0,01	<0,001	-	<0,005
Water content, mg/kg	EN ISO 12937	35	17	0,01	420

Chemical and physical properties of the respective fuel components are listed in Table 1.

Purposely-designed fuel blends with different cetane number, but still the same fuel-bound oxygen content (4.5 wt%) were prepared for these experiments. The content of renewable oxygen-free HVO fuel was increased for every next fuel blend to improve the cetane number of diesel-HVO fuel blends, whereas ethanol and biodiesel have been added in constant contents (by mass) to maintain the same fuel-bound oxygen fraction in the tested fuel blends (Fig. 1)

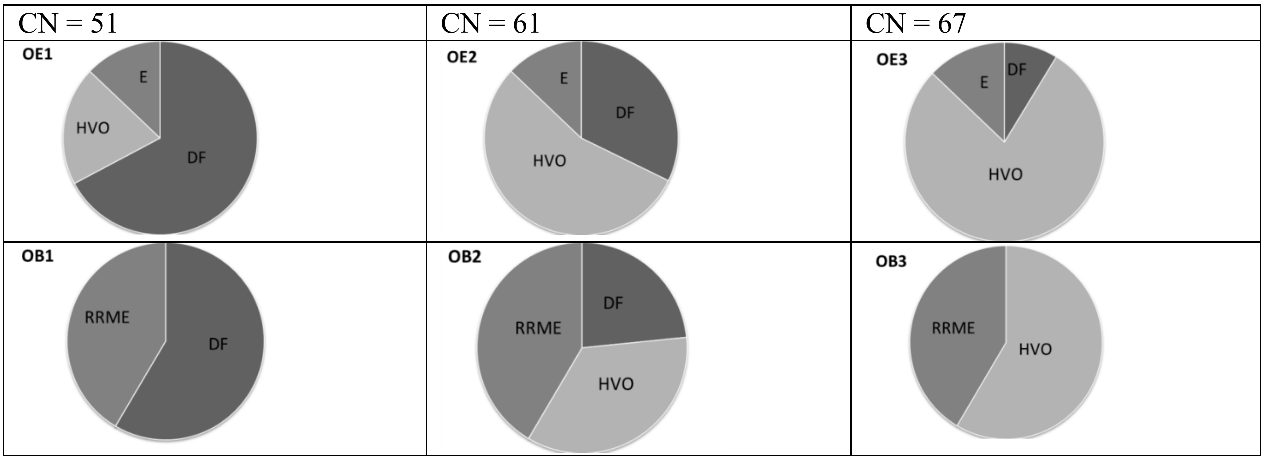

Fig. 1. The composition of the fuel blends possessing different cetane numbers, but still the same fuel-bound oxygen mass fraction of 4.5 wt% (by mass) used in the engine tests.

Experimental engine conducted at Power and transport machinery engineering institute, Engineering faculty of Aleksandras Stulginskis university (ASU). A turbocharged Common Rail Direct Injection (CRDI) diesel engine FIAT 192A1000 was used for the experiments (Table 2).

Table 2. Basic engine parameters.

Engine code	192A1000
Engine model	FIAT 1.9JTD 8v 115 HP (85 kW)
Engine type	Four-cylinder, in-line, turbocharged, JTD
Turbine code	712766-1
Turbocharger	Garrett GT1749V, variable geometry
Fuel injection system	Common rail, direct injection (CRDI)
Total splash volume	1910 cm^3
Compression ratio	18.0±0.45:1
Rated power	85 kW (115 HP)
Maximal torque	255 Nm (EEC), at 2000 rpm
Idle speed	850±20 rpm
Maximum injection pressure	1400 bar (140±0.5 MPa)
Codes injection pump / injector	0445010007 / 0445110119, 6 injection holes

The schematic view of the test stand, equipment, and apparatus used for the experiments shows Fig. 2.

During experiments basic control parameters were engine torque, rotation speed of the crankshaft and maintained constant boost pressure of p_k = 1.60 bar in the suction manifold.

Load characteristics with hydrotreated vegetable oil (HVO) fuel involving ethanol (E) or biodiesel (B) components were taken at maximum torque speed of 2000 rpm, whereas additional speeds of 1500 and 2500 rpm are also chosen to have a wider view for sound interpretation of the test results. Changes in the autoignition, combustion, and heat release characteristics revealed with oxygenated fuel blends OE2-OE3 / OB2-OB3 were compared with those obtained with the reference blends OE1 / OB1 for engine loads of p_e = 1.24, 1.37 and 1.40 MPa at the respective speeds of 1500, 2000 and 2500 rpm.

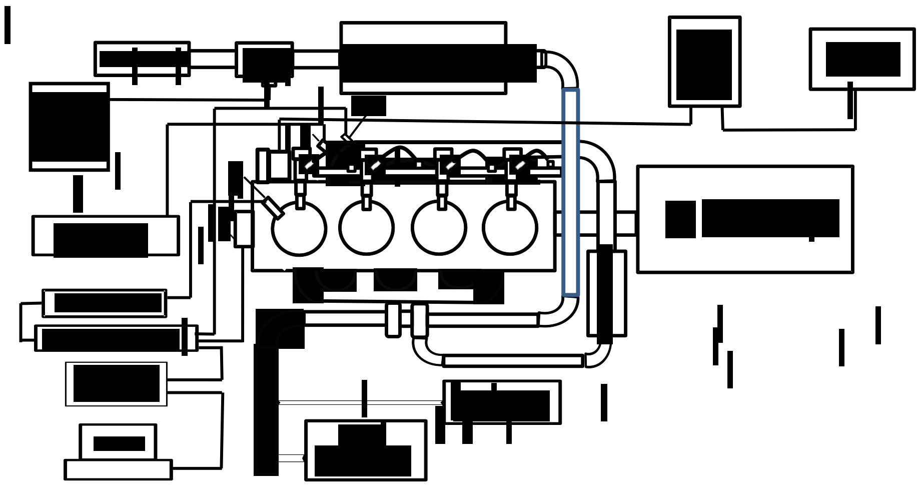

Fig. 2. Schematic arrangement of the engine test stand: (1) AVL crank-angle encoder; (2) piezoelectric in-cylinder pressure transducer; (3) fuel high-pressure line transducer at the injector; (4) air boost pressure sensor in the intake manifold.

A high-speed multichannel indicating system, which consisted of the AVL angle encoder 365C and high-performance pressure transducer GU24D coupled to the AVL microIFEM piezoelectric amplifier and signal acquisition platform IndiModul 622, was introduced for the recording, acquisition, and processing of fast crank-angle gas pressure signals in the first cylinder. Summarized over the 100 engine-cycles averaged in-cylinder pressure-data, instantaneous cylinder volume, and their first order derivative with respect to crank angle have been used. The data post-processing Sotware AVL CONCERTO™ advanced version 4.5 was used to increase productivity and improve accuracy of the measured test results. The total heat release rate was calculated by using the AVL BOOST program.

The start of injection (SOI) was recorded by using the Kistler piezoelectric pressure sensor ASMB 470004-1 connected on a high-pressure tube in front of the injector. The autoignition delay determined as a period in CADs between start of injection (SOI) and start of combustion (SOC) with an accuracy of $\pm 0.1^0$. As the start of injection was taken crank angle, at which the fuel pressure in a high-pressure tube drops temporally down due to the opening of the nozzle-needle-valve of the injector. As the start of combustion taken crank angle, at which the total heat release-rate crosses the zero line and changes its value from the minus side to the plus side.

The engine test results and analysis. The development trends in compression ignition delay shows Fig. 3. As can be seen in columns, the autoignition delay in CADs almost always increased with increasing engine speed. A bit higher changes in compression ignition delay with increasing cetane rating were noted when running with ethanol-oxygenated fuel blends OE1-OE3. The increase of the cetane number of ethanol-oxygenated blends up to about CN = 61 contributes to shorter compression ignition delay at all speeds. The longest autoignition delay period was measured when running with ethanol-treated fuel blend OE3, which possesses the highest CN rating at all speeds tested. In such a case, the cetane number improvement from 51 to 67 the autoignition delay increased by 10.4% when running at maximum speed of 2500 rpm. Whereas in case of using biodiesel (RRME) as oxygenator source, the autoignition delay increased only by 2.9% responding to cetane number improvement within the same range of 51-67 at the high speed of 2500 rpm.

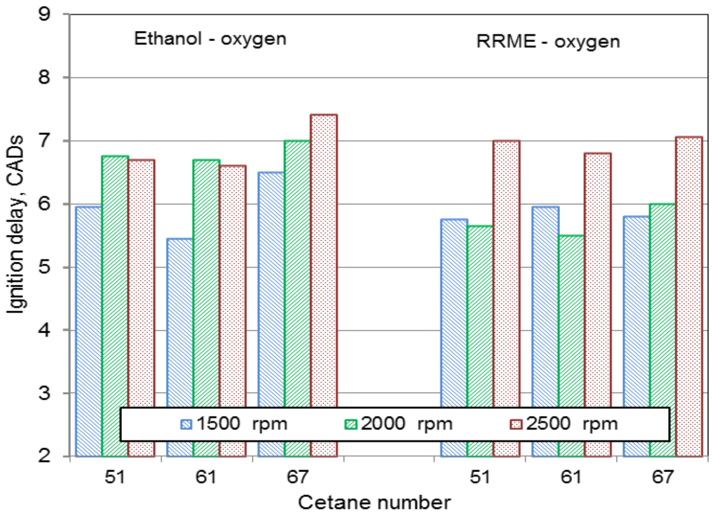

Fig. 3. Dependencies of the autoignition delay on the cetane number of diesel-HVO fuel blends involving identical contents of ethanol or biodiesel fuel-bound oxygen (4.5 wt%) when running under 1.24, 1.37 and 1.40 MPa loads at the respective speeds of 1500, 2000 and 2500 rpm.

Thus, changes in the autoignition delay period with increased CN ratings of diesel-HVO fuel blends oxygenated with the added ethanol or biodiesel components are minimal. This can be reasonably attributed to the fact that Common Rail injection system with a pilot fuel injection and delivery of main fuel portion under high averaged pressure of 140 MPa improved the atomisation quality of the fuel droplets and, thus, suppressed the effect of physical properties the fuel on the subject investigated. A high-pressure CR injection system has possibility to adjust time and quality of multiple fuel portions injected. In such a case, only marginable changes in the autoignition delay probably caused not only the variation of the cetane number, but most likely, the different physical properties (density, viscosity) of the tested fuel blends. Whereas overall longer autoignition delays for fuel blends involving ethanol as oxygenator source perhaps caused about three-fold as much higher latent heat of vaporisation of ethanol and lower heating value of the fuels OE1-OE3 compared with those OB1-OB3 oxygenated with biodiesel.

As can be seen in Fig. 4, maximum (net) heat release rate (W_{max}) decreased by 2.6% due to the cetane number increased from 51 to 67 when running with ethanol-oxygenated blends under full load (p_e = 1.24 MPa) at the low speed of 1500 rpm. Whereas in case of using biodiesel (RRME) oxygenated blends OB1-OB3 maximum heat release rate slightly (0.53%) increased due to the cetane number improved from 51 to 67 under the same test conditions. Maximum heat release rate equally increased by 1.3% for fuel blends of both types after transition from CN 51 to 61 at a higher speed of 2000 rpm. Further the cetane number increase to maximum value of 67, differently affected maximum heat release rate: W_{max} decreased by about

1.9% (OE3) against that measured with blend (OE1); W_{max} increased by 2.0% (OB3) against that the combustion of blend OB1 produces at 2000 rpm. However, maximum heat release rate (W_{max}) increased by 15.0% (OE3) and by 1.9% (OB3) after transition to the highest speed of 2500 rpm (p_e=1.4 MPa) where the time-span required to perform an engine cycle became extremely limiting factor.

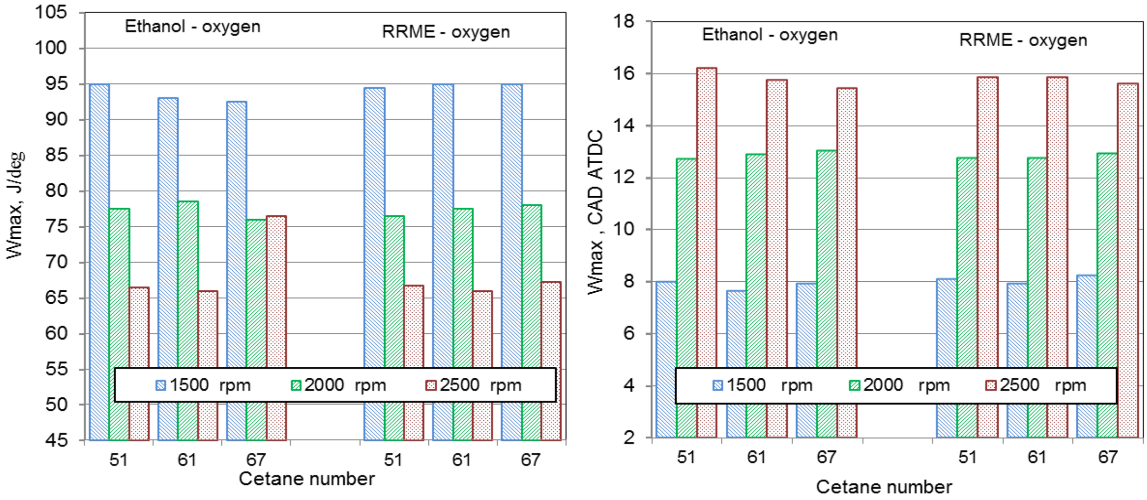

Fig. 4. Dependencies of maximum heat release rate on the cetane number of diesel-HVO fuel blends involving identical contents of ethanol or biodiesel fuel-bound oxygen (4.5 wt%) when running under 1.24, 1.37 and 1.40 MPa loads at the respective speeds of 1500, 2000 and 2500 rpm.

Burn angle MBF 50 represents the center of a gravity of differential heat release curve and, thus, affects fuel-energy conversion efficiency of an engine. The shorter the crank angle ATDC at which 50% of energy releases in the cylinder, the lower heat losses during the expansion stroke are and thus higher thermal efficiency of engine cycle can be achieved. The cetane number-made changes in burn angles MBF 50 and MBF 90 presents Fig. 5. The columns show that a half portion (MBF 50) of ethanol-oxygenated blends OE1-OE3 burned sooner in an engine cycle than the respective fuel blends OB1-OB3 involving biodiesel (RRME) burned at all engine loads and the respective speeds. There only small changes (0.2^0 CADs) occurred in burn angle MBF 50 due to the increased cetane number of both fuel types when running at a fully loaded engine at the low speed of 1500 rpm and maximum torque speed of 2000 rpm. The biggest decrease of 0.65^0 CADs in burn angle MBF 50 with regard to TDC was measured when running with the most flammable (CN = 67) ethanol-oxygenated blend OE3 at the highest speed of 2500 rpm.

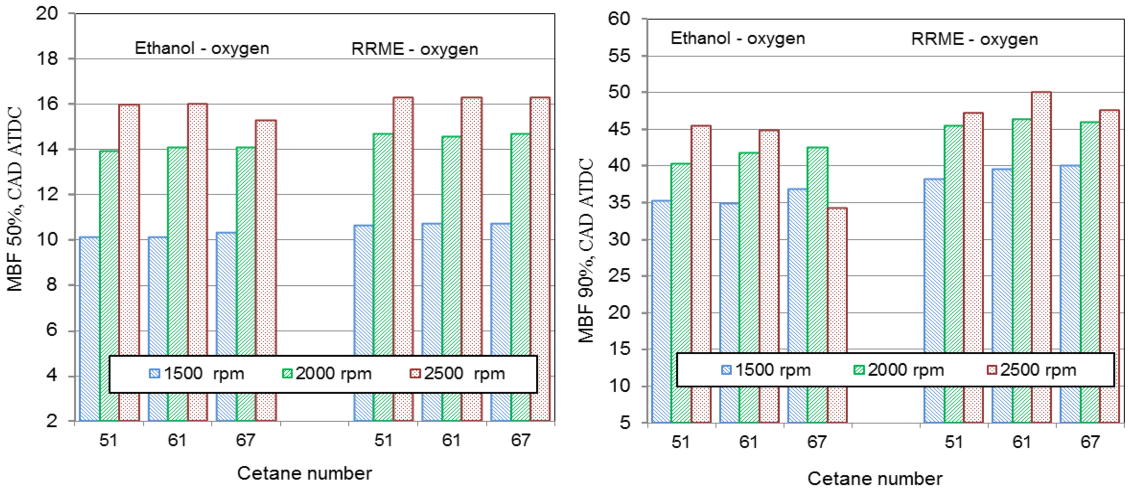

Fig. 5. Dependencies of mass burned fractions MBF 50 and MBF 90 on the cetane number of diesel-HVO fuel blends involving identical contents of ethanol or biodiesel fuel-bound oxygen (4.5 wt%) when running under 1.24, 1.37 and 1.40 MPa loads at the respective speeds of 1500, 2000 and 2500 rpm.

Burn angle MBF 90, with some assumptions, represents the end of combustion since the remaining unburned 10% portion of the fuel does not have significant effect on total heat release. Using of ethanol-oxygenated fuel blends OE1-OE3 with the improved cetane number slightly increased burn angle MBF 90 for the lower speed range of 1500 and 2000 rpm. Whereas the fuel blend OE3 burned about 4.5% sooner in an engine cycle because the autoignition delay was 9.4% longer when running a fully loaded engine with the most flammable blend OE3 than with blend OE1 at the high speed of 2500 rpm.

Whereas when using biodiesel (RRME) oxygenated fuel blends OB1-OB3 with improved CN ratings within the same range of 51-67, both MBF 50 and especially the end of combustion representing angle MBF 90 took place later in an engine cycle than when running with ethanol-oxygenated blends OE1-OE3 at all loads and the respective speeds. In general, the effect of the cetane number and the widely different properties of the fuel blends derived from biomass of various origins on burn angle MBF 90 is greater than on burn angle MBF 50. Burn angle took place 1.6^0 (OE3) and 1.9^0 (OB3) CADs later due to increased CN rating of the tested blends at the low speed of 1500 rpm. Similar MBF 90 changing trends with increasing CN rating remained in value when using fuel blends of both ethanol and biodiesel origins at maximum torque speed of 2000 rpm (p_e=1.37 MPa). The end of combustion representing angle MBF 90 occurred relatively 2.2^0 later for blend's OE3 case and 0.5^0 CADs later when using blend OB3.

The importance of the improved cetane number gained more advantages after transition to a higher speed of 2500 rpm. Now burn angle MBF 90 decreased by 0.7^0 (CN = 61) and by 11.2^0 CADs against that measured with fuel blend OE1 (CS = 51). The sooner the combustion ends up, the better is brake thermal efficiency of an engine due to the lower heat losses to the cooling system. Whereas the difference in the end of combustion compiled only 0.3^0 CADs due to transition from biodiesel-oxygenated blend OB1 (CN = 51) to the most flammable blend OB3 (CN = 67) at the high speed of 2500 rpm. The fuel blend OB2 (CN = 61) up to 2.8^0 later than blend OB1 with normal CN rating of 51 probably because the autoignition delay was too short (Fig. 3) when using this blend at the highest speed of 2500 rpm. This negatively affected the quality of air-fuel mixture and increased the overall combustion process.

The longer combustion (bigger angles MBF 50 and MBF 90) of biodiesel-oxygenated blends may occur due slower evaporation of biodiesel (RRME) droplets of a bigger size.

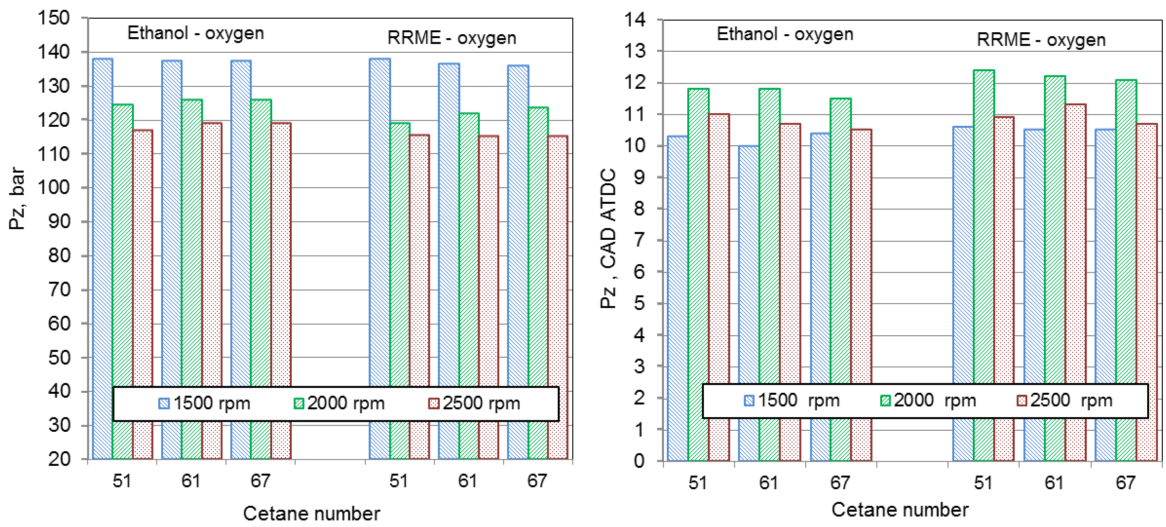

Fig. 6. Dependencies of maximum in-cylinder pressure on the cetane number of diesel-HVO fuel blends involving identical contents of ethanol or biodiesel fuel-bound oxygen (4.5 wt%) when running under 1.24, 1.37 and 1.40 MPa loads at the respective speeds of 1500, 2000 and 2500 rpm.

The in-cylinder gas pressure changed only marginally with the increasing cetane number of ethanol-oxygenated blends OE1-OE3 at lower speeds of 1500 and 2000 rpm (Fig. 6). Promising increase (1.7%) emerged only after transition with blends OE3 (CN = 67) to the high speed of 2500 rpm. This can be attributed to the longer autoignition delay (Fig. 3) that contributed to sooner combustion of the fuel, i.e. the end of combustion took place close to TDC (Fig. 5) and, thus, lower heat losses to the cooling system [10]. To faster combustion probably contributed also higher volatility and better mixing of ethanol-diesel-HVO fuel vapours with the in-cylinder compressed air charge. Maximum combustion pressure did not changed greatly when using more-flammable biodiesel-oxygenated fuel blends OB2-OB3 at the low speed of 1500 rpm too. However, the in-cylinder pressure increased by 3.8% when running with the most flammable blend OB3 (CN = 67) at maximum torque speed of 2000 rpm. Whereas the cetane number improved within a wide range of 51-67 almost did not affect the peak in-cylinder pressure when running at the high speed of 2500 rpm.

Specific angles matching the locations of maximum heat release rate and maximum in-cylinder pressure did not change greatly with regard to TDC due to the cetane number improvement within the range of 51-67 for both types of diesel-HVO fuel blends oxygenated with ethanol or biodiesel. This means, the in-cylinder volume occupied by the flame remained almost unchangeable and, therefore, its potential effect on the studied combustion parameters was negligible.

Conclusions. To reveal the effect of the cetane number or physical properties of the fuel on the combustion process, the fuel blends were treated with ethanol or biodiesel (RRME) in such percentages by mass to assure the same variation range (51-67) of the cetane number, while maintaining identical fuel-bound oxygen mass fraction of 4.5 wt% (by mass). The above study revealed that:

- The improved cetane number of the fuel blends involving ethanol or biodiesel almost did not shorten the autoignition delay period when running a fully (100%) loaded turbocharged CRDI diesel over wide range of speeds. It was always longer when using the most flammable ethanol-oxygenated fuel blend OE3 (CN = 67) and the biggest 10.4% relative increase in CADs occurred when running at the high speed of 2500 rpm. Whereas the autoignition delay increased only by 2.9% when using diesel-HVO fuel blend OB3 (CN = 67) involving RRME at the same test conditions.
- The cetane number improvement from 51 to 67 of the fuel blends of both ethanol or biodiesel origins did not have a big effect on maximum heat release rate in the cylinder. W_{max} relatively decreased by 2.6% and about 1.9% when running with fuel blend (OE3) at speeds of 1500 and 2000 rpm, but it increased by 0.5% and 2.0% when running with blend OB3 over the same range of speeds. Maximum heat release rate relatively increased by 15% when using diesel-HVO blend oxygenated with ethanol OE3 at the high speed of 2500 rpm.
- The improved cetane number of both fuel types did not have a big impact on the development of burn angle MBF 50, but chemical-physical properties of the fuel affected burn angle MBF 90. The end of combustion (MBF 90) always occurred later in an engine cycle when running with fuel blends involving RRME (OB1-OB3). Burn angle MBF 90% relocated away from TDC by about 1.6^0 and 1.9^0 when running with fuel blends OE3 or OB3 at speeds of 1500 and 2000 rpm. However, the end of combustion occurred by 11.2^0 (OE3) and 0.3^0 CADs earlier (OB3) when running at the high speed of 2500 rpm.
- The biggest relative increase in maximum in-cylinder pressure took pace when running with the most flammable diesel-HVO fuel blend involving ethanol OE3 (1.7%) at the high speed of 2500 rpm or fuel blend involving biodiesel OB3 3.8% at maximum torque speed of 2000 rpm.
- The cetane number of oxygenated fuels can be improved up certain extent depending on biomass from which the oxygenator source was derived that suggests advantages in combustion and heat release characteristics when running a fully loaded turbocharged diesel engine at the high speed of 2500 rpm and higher (rated speed 4000 rpm).

REFERENCES

1. Hui Liu, Shuangshuang Jiang, Jieni Wang, Chao Yang, HongshuangGuo, Xinjing Wang, Sheng Han. Fatty acid esters: a potential cetane number improver for diesel from direct coal liquefaction. Fuel. 153 (2015):78-84
2. Sivaramakrishnan K. Ravikumar P. Determination of cetane number of biodiesel and it's influence on physical properties. ARPN Journal of Engineering and Applied Sciences. ISSN 1819-6608. 2012. p. 205-211
3. Gerhard Knothea, Andrew C. Matheausb , Thomas W. Ryan III. Cetane numbers of branched and straight-chain fatty esters determined in an ignition quality tester. Fuel 82 (2003) 971−975.
4. Suzuki S, Hori M, Nakamura H, Tezuka T. Study on cetane number dependence of diesel surrogates/air weak flames in a micro flow reactor with a controlled temperature profile. Proc Combust Inst 2013;34 (2):3411−7.
5. Z.Q. CHEN, X.X. MA, S.T. YU, Y.N. GUO, J.S. LIU. Physical-chemical properties of ethanol-diesel blend-fuel and its effect on the performance and emissions of a turbocharged diesel engine. International Journal of Automotive Technology. No. 3, pp. 297−303 (2009).
6. Lu Xing-cai, Yang Jian-guang, Zhang Wu-gao, Huang Zhen. Effect of cetane number improver on heat release rate and emissions of high-speed diesel engine fuelled with ethanol−diesel blend fuel. Fuel 83 (2004) 2013−2020.
7. Labeckas G., Slavinskas S., Mažeika M. The effect of ethanol-diesel-biodiesel blends on combustion, performance and emissions of a direct injection diesel engine. Energy Conversion and Management, 2014, Vol. 79, Issue 3, p. 698-720.
8. Labeckas G., Slavinskas S., Vilutienė V. Effect of the cetane number improving additive on combustion, performance, and emissions of a DI diesel engine operating on JP-8 fuel. Journal of Energy Engineering, 2015, Vol. 141, Issue 2, p. C4014005-1-14, http://dx.doi.org/10.1061/(ASCE)EY.1943-7897.0000.222.
9. Labeckas G., Slavinskas S. Combustion phenomenon, performance and emissions of a diesel engine with aviation turbine JP-8 fuel and rapeseed biodiesel blends. Energy Conversion and Management, 15 November 2015, Vol. 105, p. 216-229.

10. Willard W. Pulkrabek (University of Wisconsin -·.. Platteville). Engineering fundamentals of the Internal Combustion Engine. -Prentice Hall, Upper Saddle River, New Jersey 07458, 2009. 411 p.

Лабецкас Г., Славинскас С., Канапкиене І. Влияние цетанового числа различных смесей дизельного топлива и гидробработанного растительного масла (hvo) на процесс сгорания турбоннаддувного дизельного двигателя.

В статье приводится анализ влияния цетанового числа и хемико-физических свойств смесей дизельного топлива и гидрообъработанного растительного масла (HVO) различной концентрации обогащенных кислородом этанола (E) или биодизеля (B) на период задержки самовоспламенения, процесс сгорания, максимальную скорость тепловыделения, и пиковое давление в цилиндре турбонаддувного CRDI дизельного двигателя. Смеси дизельного топлива и гидрообъработанного растительного масла (HVO) обогащенные чистым (200 proof) этанолом OE1-OE3 или эстером рапсового масла (биодизелем) OB1-OB3 (4.5 wt% кислорода) в таких пропорциях по массе чтобы обеспечить вариацию в широких пределах цетанового (C) числа 51.2-67.3 были испытаны при средних эффективных давлениях p_e = 1.24, 1.37 и 1.40 МПа на соответствующих скоростных режимах 1500, 2000 и 2500 мин$^{-1}$. Сравнительный анализ изменений оказавшихся в периоде задержки самовоспламенения, специфических углов сгорания MBF 50 и MBF 90, максимальной скорости тепловыделения и максимального давления в цилиндре в следствие использования топливных смесей обогащенных кислородом OE1-OE3 или OB1-OB3 выполнен по отношения к соответствующим значениям замеренным при работе на смеси с нормальным цетановым числом CE1 или CB1 чтобы выявить потенциальные тенденции развития параметров сгорания.

Ключевые слова: Дизельный двигатель; дизель-HVO топливные смеси; этанол; биодизель; самовоспламенение; сгорание; тепловыделение; максимальное давление в цилиндре

АВТОРЫ:

ЛАБЕЦКАС Гвидонас, доктор технических наук, профессор Института инженерии силовых и транспортных машин, университет им. Александраса Стульгинскиса, e-mail: gvidonas.labeckas@asu.lt;

СЛАВИНСКАС Стасис, доктор технических наук, профессор Института инженерии силовых и транспортных машин, университет им. Александраса Стульгинскиса, e-mail: stasys.slavinskas@asu.lt;

КАНАПКИЕНЕ Ірена, докторант Института инженерии силовых и транспортных машин, университет им. Александраса Стульгинскиса, e-mail: kanapkiene.irena@gmail.lt

AUTHORS:

Gvidonas LABECKAS, Ph.D. in Engineering, Professor of Power and Transport Machinery Engineering Institute, Aleksandras Stulginskis University, e-mail: gvidonas.labeckas@asu.lt;

Stasys SLAVINSKAS, Ph.D. in Engineering, Professor of Power and Transport Machinery Engineering Institute, Aleksandras Stulginskis University, e-mail: stasys.slavinskas@asu.lt;

Irena KANAPKIENĖ, PhD student at Power and Transport Machinery Engineering Institute, Aleksandras Stulginskis University, e-mail: kanapkiene.irena@gmail.lt

Стаття надійшла в редакцію 13.05.2017р.