SELECTED LOAD CHARACTERISTICS OF 1.3 MULTIJET ENGINE

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Abstract

The paper presents results of investigations and the assessment of multi-stage fuel injection in MultiJet 1.3 engine operating under load conditions. Basic work parameters of the examined piston internal combustion engine, such as: effective power, torque, hour and unit fuel consumption and the concentration of the most important noxious components of exhaust gases were provided. Tests were conducted at the test bench stand that comprised the engine under consideration, eddy-current brake by Elektromex EMX company, control and measurement unit to control the test bench and to take measurements of parameters of the engine and brake work, the measurement system for fast-changing quantities, fuel-flow and air-flow meters, and the exhaust gas analyser. During the tests, the engine operated under load conditions at the crankshaft rotational speed: n=1200, 1750, 2400, 3800 and 4200 rpm. Such values of speed were selected because of the multi-stage fuel injection and the engine's being able to reach the maximum torque M=200Nm at the crankshaft rotational speed n=1750 rpm and the maximum power output N=90HP, delivered at n=4200 rpm.

Application of advanced engine technologies and advanced control system allowed meeting high requirements concerning energy and economic as well as environmental indices.

***Keywords**: combustion engines, transport, diagnostics, multi-stage fuel injection*

1. Introduction

Modern internal combustion compression ignition engines are characterised by parameters comparable with compression ignition engines while using less fuel. Due to small size, effective power and torque high value, lower noise compared to the older generation engines, they are now widely used to drive cars, also the smallest ones. Such a progress in the development of compression ignition engines was possible mainly due to the use of modern, electronically controlled power systems with injection units and common rail systems providing multi-stage fuel injection as well as due to the use of effective supercharged systems [1, 2]. Currently, compression ignition engines of small displacement and developing rotational speed to 5500 rpm are used more and more often.

The paper presents the results of investigations into the compression ignition 1.3 Multijet engine with multistage fuel injection, which is manufactured in Poland by Fiat-GM Powertrain Polska Company. The tests were conducted at the stand constructed at the Heat Engines Laboratory of the Kielce University of Technology. For the purpose of the test, economic and energy as well as ecological engine indices has been defined for the engine operating under load conditions at the crankshaft rotational speeds: n=1200, 2400, 3800 and 4200 rpm.

2. Test object

The test object was the FIAT 1.3 Multijet engine manufactured by Fiat-GM POWERTRAIN Polska in Bielsko-Biala in two versions of 70 and 90 bhp meeting the Euro IV emission standards. The engine used for the test is a more powerful version developing maximum power of 90 bhp (66 kW) at the rotational speed of 4000 rpm and maximum torque of 200 Nm at rotational speed of

1750 rpm. Due to the increase in engine power compared to the 70 bhp version, piston crown cooling through the oil channels in the piston crown and oil spray were used. Tab. 1 presents the basic technical data of the test engine.

Tab. 1. Basic technical data of the engine FIAT 1.3 MULTIJET (90 bhp)

Fiat 1.3 Multijet SDE 90 PS compression ignition engine		
Parameter	Unit	Value
Cylinder Layout	-	straight
The number of cylinders, c	-	4
Injection type	-	Direct, multi-stage fuel injection (from 3 to 5)
Cylinder operation sequence	-	1 – 3 – 4 – 2
Compression ratio, ε	-	17.6
Cylinder bore, D	m	$69.6 \cdot 10^{-3}$
Piston stroke, S	m	$82 \cdot 10^{-3}$
Engine displacement, V_{ss}	m^3	$1.251 \cdot 10^{-3}$
Engine nominal power, Ne	kW	66
Revolving speed at nominal power, n_N	rpm	4000
Maximum engine torque, M_e	Nm	200
Rotational speed at maximum torque, n_M	rpm	1750
Rotational speed at idle speed, n_{bj}	rpm	850±20

In the experimental investigations, the engine was fuelled by diesel oil compliant with PN-EN 590:2009 standard [5, 6]. Tab. 2 presents basic physical and chemical properties of the above-mentioned fuels.

Tab. 2. Basic physical and chemical properties of engine fuel used in investigations [5, 6]

Parameter	Value
Cetane number	52.1
Calorific value, MJ/kg	43.2
Density at 15°C, g/m^3	0.8329
Kinematic viscosity, mm^2/s (~ 40 °C)	2.551
Flash point, °C	59.5
Cloud point temperature, °C	-11
Cold filter plugging point, °C	-25
The average elemental composition,%: C H O	87.2 12.7 0
Sulphur content S, mg/kg	6.7
Water content, mg/kg	67
Solid impurities content, mg/kg	8

3. Test bench

The test bench constructed at the Heat Engines Laboratory of the Kielce University of Technology consists of the following elements:

- Fiat 1.3 Multijet (90 PS) compression ignition engine,
- Eddy-current brake type EMX - 100/10 000 manufactured by Elektromex Centrum,
- control cabinet for operation of engine and brake with control system manufactured by Automex,
- pressure measurement system of working medium in the cylinder by means of the GH13G12 AVL sensor,
- Fuel-flow meter type 730 Dynamic Fuel Consumption manufactured by AVL,
- Sensyfolw iG thermal mass air-flow meter manufactured by ABB,
- PC computer allowing controlling the engine test bench with 1.7 software PARM version developed by Automex and engine diagnostics using the KTS 540 module and Bosch software.

Figure 1 shows block diagram of the test bench research stand with 1.3 MultiJet SDE 90 PS. Selected data of the eddy-current brake type brake EMX - 100/10 000 Elektromex Cetrum used during the tests is presented in Tab. 3.

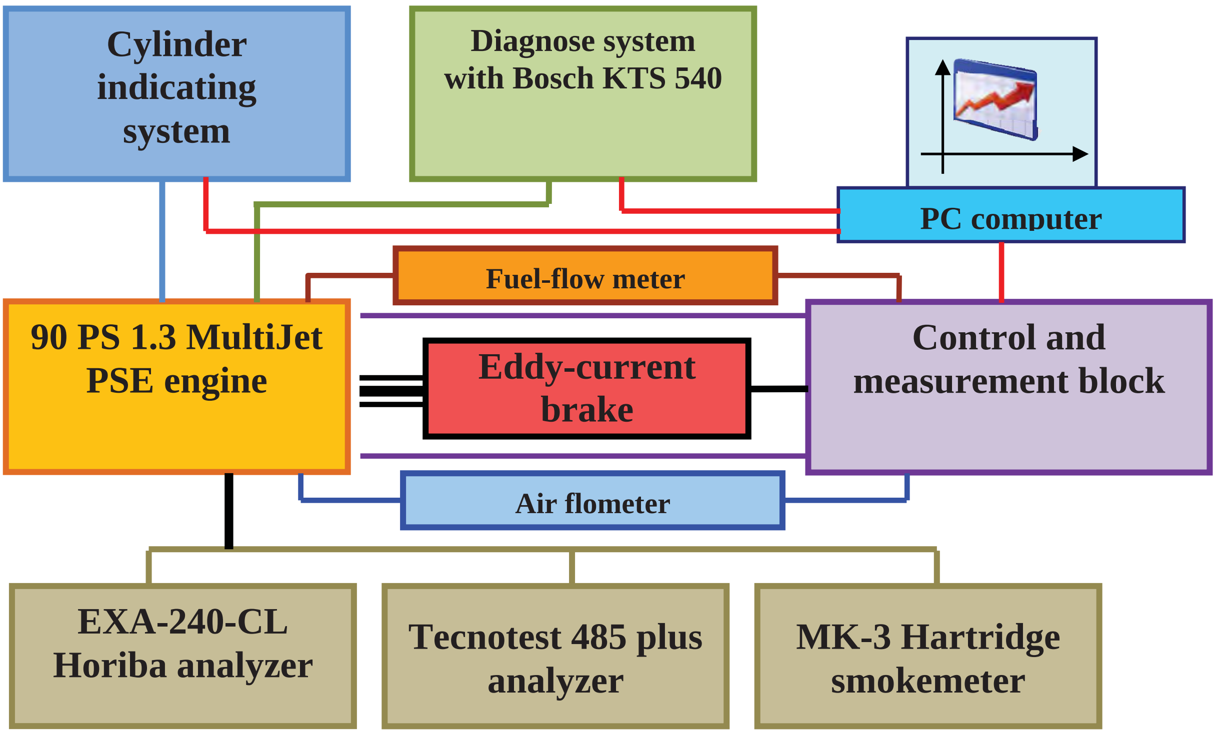

Fig. 1. Block diagram of the test bench research stand

Tab. 3. Basic specifications of EMX – 100/10 000 type eddy-current brake by ELEKTROMEX CENTRUM company

Parameter	Unit	Value
Maximum absorption power	kW	100
Maximum rotational speed	rpm	10 000
Maximum torque	Nm	240
Measuring arm length	m	0.370
Direction of rotation	-	Any
Water requirement	m^3/h	2.5
Water pressure	bar	0.75-1.25
Brake weight	kg	250

4. Research methodology and selected results

In the tests, economic and energy as well as environmental indices of the test engine have been determined. During the tests carried out at the test bench, the engine operated under the load characteristics at n=1200, 2400, 3800 and 4200 rpm and was fuelled with commercial diesel oil. Measurements were performed under fixed engine operating conditions in steps of 200 rpm. In the tests, the following measurements of the engine operation parameters were made: effective power, effective torque, hour fuel consumption, engine boost pressure, air consumption, hazardous exhaust gases components emission such as: carbon monoxide CO, carbon dioxide CO_2, oxygen and nitrogen oxides NO_x.

Figures 2 to 4 show the changes of hour G_h and unit fuel consumption g_e under load condition at n=1200, 1750, 2400, 3800 and 4200 rpm.

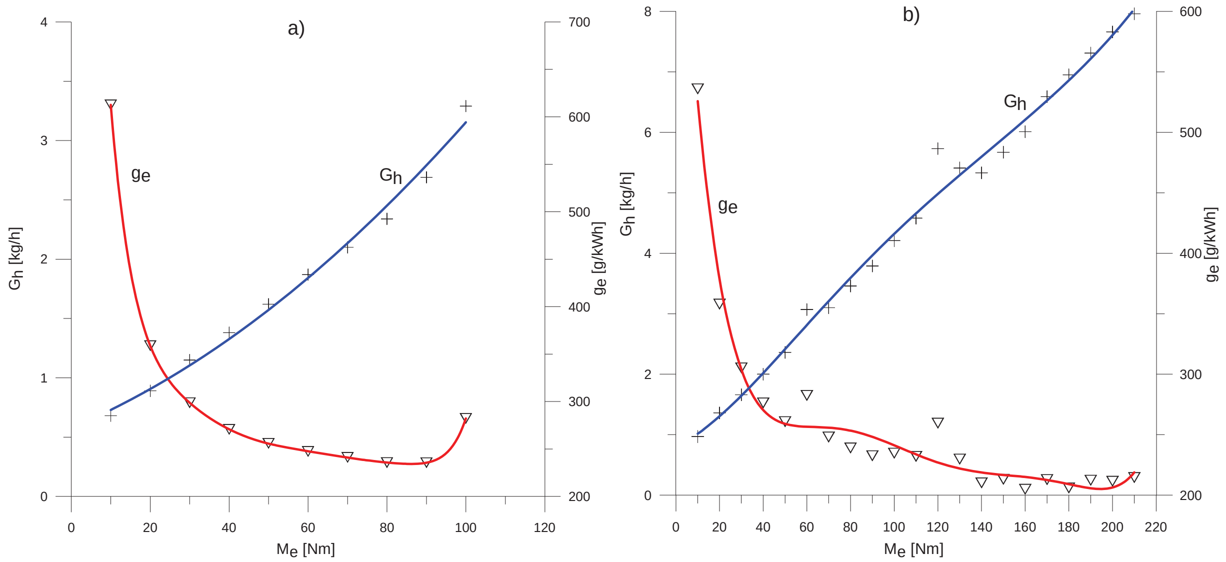

Fig. 2. Hour and unit fuel consumption in 1.3 Multijet engine operating under load condition at the crankshaft rotational speed: a) n=1200rpm and three-stage fuel injection schedule, b) n=1750rpm and two-stage fuel injection schedule

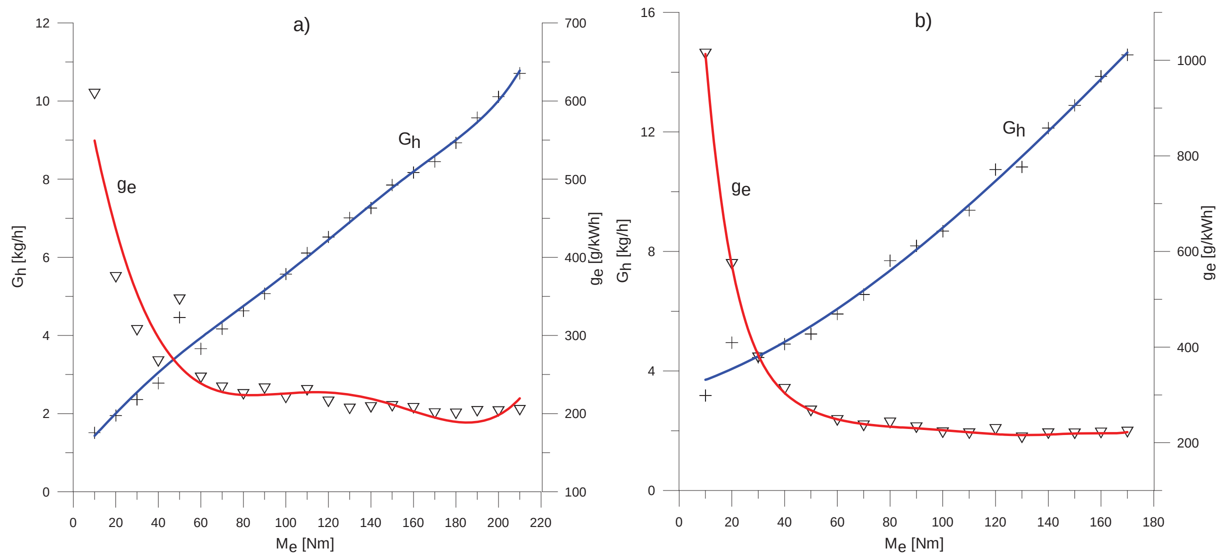

Fig. 3. Hour and unit fuel consumption in 1.3 Multijet engine operating under load condition at the crankshaft rotational speed: a) n=2400rpm and two-stage fuel injection schedule, b) n=3800rpm and two-stage fuel injection schedule

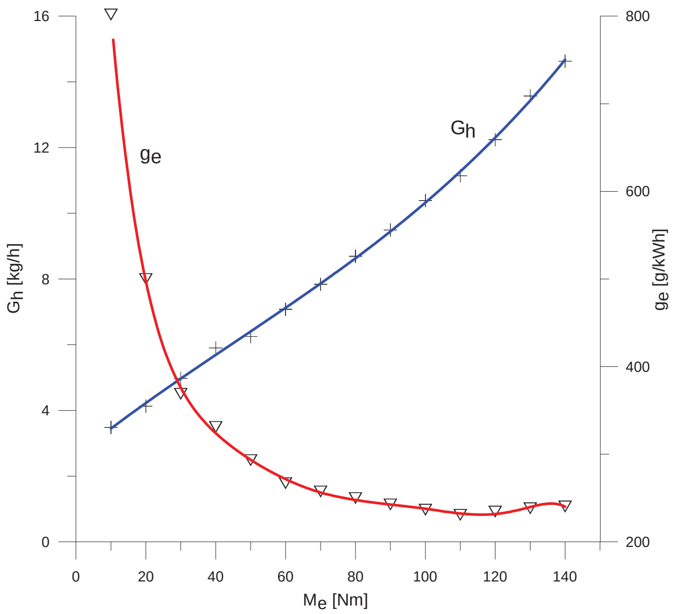

Fig. 4. Hour and unit fuel consumption in 1.3 Multijet engine operating under load condition at n=4200rpm and one-stage fuel injection schedule

Figures 5 to 11 show changes in concentrations of basic hazardous exhaust gas components emissions before the engine catalyst operating under load conditions at n=1200, 1750, 2400, 3800 and 4200 rpm.

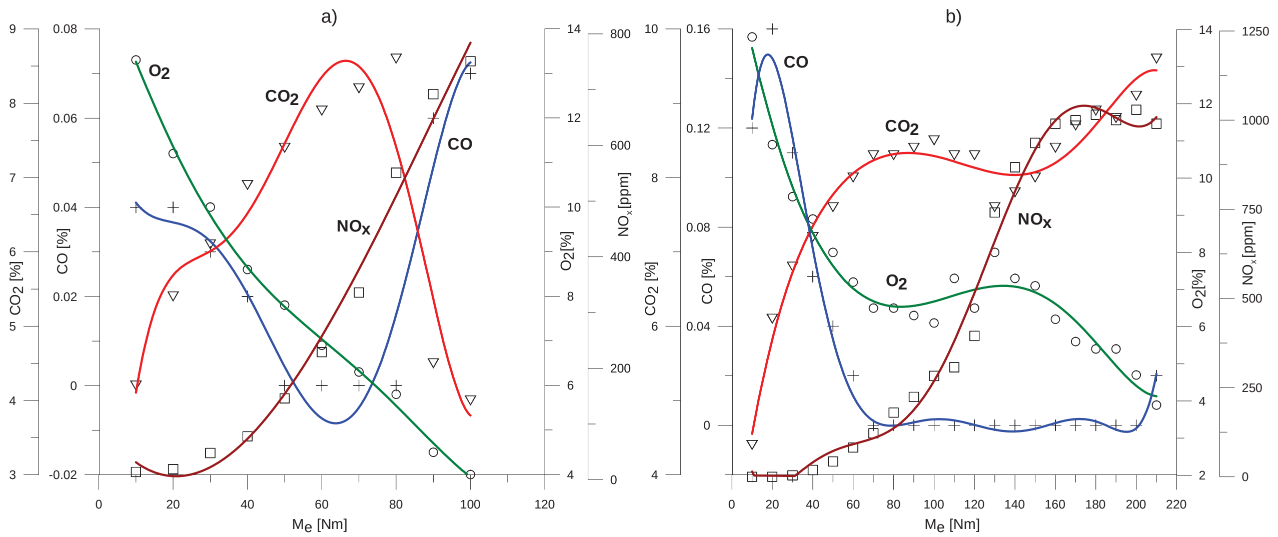

Fig. 5. Basic exhaust gas components emissions from 1.3 Multijet engine operating under load conditions at the crankshaft rotational speed: a) n=1200rpm and three-stage fuel injection schedule, b) n=1750rpm and two-stage fuel injection schedule

5. Summary

The test 1.3 Multijet 90 PS engine is one of the most modern compression-ignition engines which is an upgraded version of the 2003 engine of 70 PS and torque of 180 Nm. Increase of power to 90 PS and torque to 200 Nm was achieved by improving the combustion system, increasing fuel injection pressure to 1600 bar and using turbocharger of variable geometry vanes. Moreover, in the version equipped with a particulate filter, the number of fuel injection stages per cycle was increased from 3 to maximum 5, which is related to the filter regeneration (DPF).

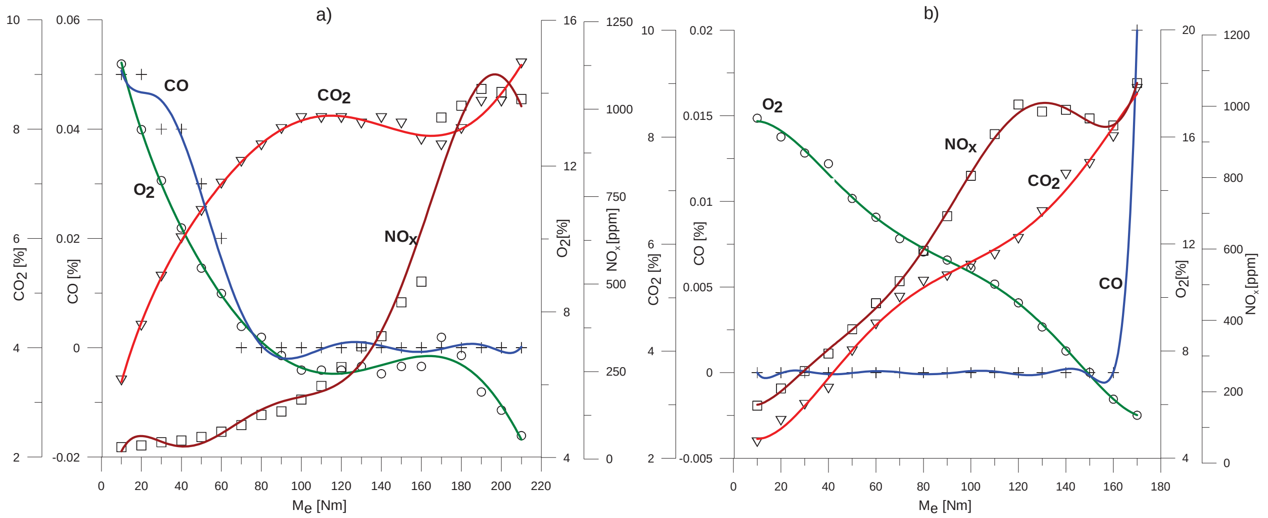

Fig. 6. Basic exhaust gas components emissions from 1.3 Multijet engine operating under load conditions at the crankshaft rotational speed a) n=2400rpm and two-stage fuel injection schedule, b) n=3800rpm and two-stage fuel injection schedule

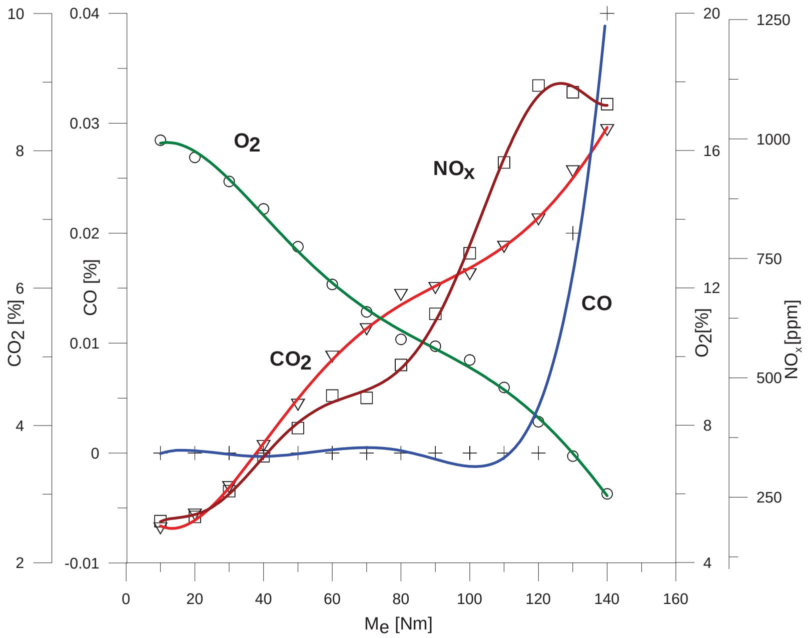

Fig. 7. Basic exhaust gas components emissions from 1.3 Multijet engine operating under load conditions at the crankshaft rotational speed n=4200rpm and one-stage fuel injection schedule

The test bench results of the 1.3 Multijet test engine prove its high performance and low hazardous exhaust gases components emission. The engine is characterised by good responsiveness due to high torque equal to M_e=210 Nm which is maintained in the crankshaft rotational speed range from n = 1750 rpm to about 2500 rpm. The engine reaches minimum unit fuel consumption g_e = 199.60 g/kWh at n = 2400 rpm and M_o = 180 Nm. As to the environment protection, the most important is the NO_x emission which reaches its peak at the crankshaft rotational speed of n = 4200 rpm. This is due to the high combustion temperature at such a rotational speed. In addition, the test results show that the engine has a minimum carbon monoxide emission, which is due to the engine being fuelled by poor mixtures. Application of advanced engine technologies and advanced control system allowed meeting high requirements concerning energy and economic as well as environmental indices.

References

[1] Balawender, K., Kuszewski, H., Lejda, K., Ustrzycki, A., *The effect of multi-phase injection on selected parameters of the common rail fuel system*, Combustion engines, No. 4, 2008
[2] Rokosch, U., *Układy oczyszczania spalin i pokładowe systemy diagnostyczne samochodów OBD*, Wydawnictwo Komunikacji i Łączności, Warszawa 2007.
[3] Imarisio, R., Giardina-Papa, P., Siracusa, M., *The new 1.3 L 90 PS diesel engine*, Silniki spalinowe, No. 3 (122), pp. 22-31, 2005.
[4] Pietras, D., Świątek, P., *Dobór kalibracji sterowania silnika 1,3 Multijet w aspekcie jego osiągów i składu spalin*, Silniki Spalinowe, No. 2 (133), pp. 36-43, 2008.
[5] *Świadectwo Jakości Nr 1113/ON/2010 oleju napędowego Ekodiesel Ultra D*, 2010.
[6] *PN-EN 590:2009 Paliwa do pojazdów samochodowych*, Oleje napędowe, Wymagania i metody badań, 2009.