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Fuel Impact on the Response of AD3.152 UR Engine

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Abstract The paper presents results of investigations into the AD3.152 UR engine running on five fuels: commercial diesel oil DO, rapeseed oil fatty acid methyl esters FAME and their blends B10 (90% DO + 10% FAME), B20 (80% DO + 20% FAME), B30 (70% DO + 30% FAME). During the tests, the engine operated in accordance with the full load characteristics. Those characteristics were used to determine the engine response. The paper provides an assessment of the impact of the type of plant-derived fuel on the engine response.

Keywords diesel engine, engine response, biofuel

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1. Introduction

Rapid developments in piston internal combustion engines, aimed at enhancing the dynamic properties of the vehicle, also contributed to the search for new, environmentally friendly energy sources. Fuels produced from natural raw materials are one of such sources. The advantage those fuels have, when compared with hydrocarbon ones, is that they are renewable, biodegradable and emit less carbon dioxide into the atmosphere [1, 2, 3]. The response of an internal combustion engine involves an ability to react to variable loads and crankshaft speeds. That provides one of the important indicators of the engine functional properties. The response of the torque depends on the profile of the engine torque characteristics. The magnitude of torque depends on numerous structural and functional parameters [4, 5]: the intake system, timing, the fuelling system, physical and chemical properties of fuel, etc. Presently, many research and development centres in the country and in the world conduct investigations to improve the dynamic properties of the internal combustion engine. The purpose of this paper is to analyse whether the use of alternative plant fuels may favourably affect the engine response.

The coefficient of the engine response e is determined on the basis of the profile of curves of variation in the effective power and the engine torque [6, 7]. This is the product of the engine torque response e_M and the response of the crankshaft rotational speed e_n:

$$e = e_M \cdot e_n \qquad (1)$$

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The response of the engine torque e_M is the ratio of the maximum torque M_{omax} to the torque developed at the engine rated power M_{oNemax} [8]:

$$e_m = M_{omax} \; / \; M_{oNemax} \qquad (2)$$

The response of the rotational speed e_n is the ratio of the rotational speed at which effective rated power n_{Nemax} occurs to the rotational speed of the maximum torque n_{Momax}:

$$e_n = n_{Nemax} \; / \; n_{Momax} \qquad (3)$$

2. Object of Investigations and the Test Stand

The experimental investigations were performed on the engine test bed, which included the AD3.152 UR engine, the water brake, and the control and measurement cabinet. The diagram of the test bed is shown in Figure 1.

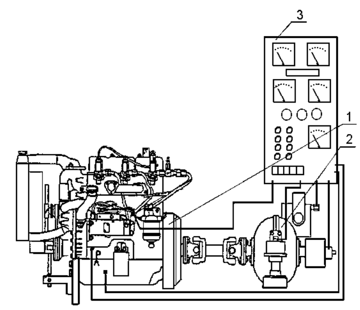

Figure 1. Diagram of the test stand: 1 – AD3.152 UR engine, 2 – water brake, 3 – control and measurement block

The object of investigations was three-cylinder, piston, internal combustion, compression ignition AD3.152 UR engine with fuel direct injection into the combustion chamber located in the piston bottom [9]. The engine was equipped with the fuelling system with the DPA distributor injection pump. The injectors had four-hole nozzles. Parameters and specifications of the AD3.152 UR engine are presented in Table 1.

Table 1. Basic specifications of the engine

Compression Ignition AD3.152 UR engine		
Parameter	**Unit**	**Value**
Cylinder arrangement	-	in-line
Number of cylinders	-	3
Type of injection	-	direct
Cylinder working order	-	1 – 2 – 3
Compression ratio	-	16.5
Cylinder bore	mm	91.44
Piston travel	mm	127
Engine cubic capacity	dm^3	2.502
Connecting rod length	mm	223.80÷223.85
Maximum engine power	kW	34.6
Rotational speed at maximum power	rpm	2250
Maximum torque	Nm	168.7
Rotational speed at maximum torque	rpm	1350
Static angle of injection advance	CA deg	17
Idle rotational speed	rpm	750±50

3. Fuels Used to Power AD3.152 UR Engine

During the tests, the AD3.152 UR engine ran on five fuels, namely Ekodiesel Ultra D commercial diesel oil (DO), rapeseed oil fatty acid methyl esters FAME and blends of those two fuels. Tests were conducted for the following blends of hydrocarbon and plant-derived fuels:

- 10% (V/V) rapeseed oil fatty acid methyl esters FAME + 90% (V/V) Ekodiesel Ultra D diesel oil→ denoted as B10,
- 20% (V/V) rapeseed oil fatty acid methyl esters FAME + 80% (V/V) Ekodiesel Ultra D diesel oil→ referred to as B20,
- 30% (V/V) rapeseed oil fatty acid methyl esters FAME + 70% (V/V) Ekodiesel Ultra D diesel oil→ labelled as B30.

Basic physical and chemical properties of Ekodiesel Ultra D diesel oil and rapeseed oil fatty acid methyl esters FAME are presented in Table 2.

Table 2. Basic physical and chemical properties of engine fuels used in investigations

Parameter	Ekodiesel Ultra D diesel oil	Plant-derived fuel FAME
Cetane number	51.4	51
Calorific value [MJ/kg]	43.2	36.7
Density at 15°C [g/cm^3],	0.8354	0.883
Kinematic viscosity [mm^2/s] (~40°C)	2.64	4.47
Surface tension [N/m] (20°C)	$3.64 \cdot 10^{-2}$	$3.58 \cdot 10^{-2}$
Ignition temperature [°C]	63	above 130
Turbidity point [°C]	-17	-2
Cold filter blocking temperature [°C]	-23	-14
Average elemental composition [%]		
- C	87.2	76.8
- H	12.7	12.1
- O	0	11
Sulphur content, S[mg/kg]	9	8.1
Water content [mg/kg]	43.8	113
Particulate matter content [mg/kg]	5	18

4. Results of Experimental Investigations

Figure 2 shows the full load characteristics of the effective power and torque of the AD3.152 UR engine running on five fuels: DO, FAME, B10, B20 and B30.

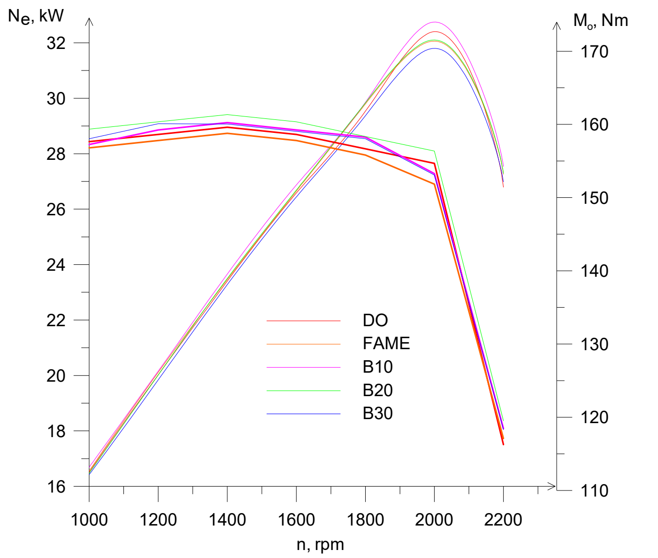

Figure 2. Diagram of the test stand: 1 – AD3.152 UR engine, 2 – water brake, 3 – control and measurement block

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Table 3 presents the values of the determined coefficients of the torque response, the rotational speed response and the response of the AD3.152 UR engine running on five fuels: DO, FAME, B10, B20 and B30.

Table 3. Determined values of response coefficients of the tested AD3.152UR engine

Fuel type	Torque response	Rotational speed response	Engine response
Diesel oil	1.05	1.43	1.502
FAME	1.07	1.43	1.531
B10	1.07	1.43	1.531
B20	1.07	1.43	1.531
B30	1.07	1.67	1.787

5. Conclusions

The following conclusions can be drawn on the basis of experimental results:

- the maximum effective power for the engine powered by the fuels of concern was found at the same rotational speed of 2000 rpm,
- for the engine fuelled by the B30 blend, the maximum torque occurred earlier, i.e. at the rotational speed of 1200 rpm, whereas when engine was powered by the remaining four fuels DO, FAME, B10 and B30, the maximum torque was produced by the engine at the crankshaft rotational speed n=1400 rpm,
- the highest value of the rotational speed response, which was equal to e=1.67, was obtained for the engine fuelled by B30,
- the torque response, which was e_M=1.05÷1.07, was comparable for the engine fuelling with commercial diesel oil, FAME, and also B10, B20 and B30 blends,
- when the engine was powered by FAME, and B10, B20 and B30 blends, the higher value of the engine response was obtained when compared with the engine fuelling with commercial diesel oil. The engine powered by the plant-derived fuel and the blends of this fuel demonstrated the strongest ability to overcome the load.

REFERENCES

[1] Ambrozik A., Ambrozik T., Kurczyński D., Łagowski P.: Comparative assessment of diesel engine fuelled by diesel oil, biodiesel and their blend. 7-th European Conference of young research and science workers TRANSCOM 2007, Żilina 2007. pp. 11-16/ 2007.

[2] Ambrozik A., Ambrozik T., Orliński S., Orliński P.: Impact of the Perkins 1104c engine fuelling with bioethanol on the injection process profile and basic spraying parameters, Logistyka 3/2011.

[3] Kruczyński S.: Performance and emission of CI engine fuelled with camelina sativa oil, Energy Conversion and Management 65 (2013) 1–6, 2013.

[4] Ambrozik T.: Internal Combustion Engine, course 2013, Kielce University of Technology, Online Available: http://wmibm-moodle.tu.kielce.pl/course/view.php?id=21.

[5] Duran Altiparmak, Ali Keskin, Atilla Koca, Metin Gürü: Alternative fuel properties of tall oil fatty acid methyl ester–diesel fuel blends, Bioresource Technology 98 (2007) 241–246, 2007.

[6] Mysłowski J., Kołtun J.: Response of piston internal combustion engines (in Polish), WNT, Warszawa, 2000.

[7] Osipowicz T.: The biofules influence on the diesel engine flexibility, Autobusy 5/2012. Radom 2012. (in Polish)

[8] Mysłowski J., Gołębiewski W.: Elastyczność silników Fiat. Archiwum Motoryzacji. 4, pp. 319-325. 2009.

[9] Ambrozik T., Łagowski P.: Quantities and diagnostic parameters of the combustion process in the compression ignition engine (in Polish), Zeszyty Naukowe Instytutu Pojazdów 1(73)/2009 – Mechanika, Ekologia, Bezpieczeństwo Politechniki Warszawskiej, Warszawa 2009.