ANNALS OF FACULTY ENGINEERING HUNEDOARA
– International Journal of Engineering
Tome XI (Year 2013) – FASCICULE 4 (ISSN 1584 – 2673)

1. Valéria NAGY, 2. Ferenc FARKAS

TESTS OF DIESEL FUELS IN THE ENGINE TESTING ROOM

1-2. UNIVERSITY OF SZEGED, FACULTY OF ENGINEERING, TECHNICAL DEPARTMENT, HUNGARY

ABSTRACT: Many studies demonstrate that production and utilization of biofuels - including the vegetable oil-based fuels - are environmentally sustainable and have positive impact for the security of energy supply [9][10]. However, bench testing of vegetable oil-based fuels and comparative analysis of commercially available diesel fuels [6] should be done simultaneously to answer that under the same experimental conditions, whether there are differences in diesel fuelled internal combustion engine parameters such as torque, power and specific fuel consumption etc. [11]. Based on the answer it can be made reliable assessments, evaluations and made professional statement generally in respect of the biofuels compared to the diesel fuel parameters, and analyze the status of biofuels and their impacts on the engines and the future prospects. Because the provisions of the Renewable Energy Directive (RED) with ambitious targets for the use of renewable energy. These include targets for renewable energy in the road transport sector. By 2020 10% of the final consumption of energy in transport in the EU and each of its Member States should come from renewable sources. This energy could come from biomass. However, the overall contribution of renewable energy systems in Europe are low and it is expected that the renewable energy for the 2020 target will come primarily from biomass in the form of biofuels. In 2020 it is expected that the dominant production route for biofuels will still be through the use of edible parts of plants ('first-generation' biofuels) [3][12][13]. In this paper we would like to illustrate the results of the comparative analysis on the test bench with commercially available diesel fuels.
KEYWORDS: fuels, internal combustion engine, engine parameters

INTRODUCTION

In several research topics we had opportunity to perform engine tests for different purposes (study of the operational characteristic of the internal combustion engine operating on different kinds of fuels). The intention of the comparative analyzes is to determine whether there are some differences between parameters of the internal combustion engine operating commercially available diesel fuels. It is absolutely necessary to determine concrete numerical values or the range of potential differences.

THE TEST ENGINE AND MEASURING FACILITIES

In order to implement the objectives of research task the comparative analyzes were made with three different diesel fuels (D1; D2; D3) in the engine testing room. In the Figure 1 you can see the measuring apparatus – Perkins 1104C type, Euro-II environmental class diesel engine with direct injection, equipped with Junkers type Schönebeck D-4 water-brake and a computer based control and evaluating system connected to it.

Engine specification:
- number of cylinders: in-line 4 cylinder
- cycle: 4 stroke
- cubic capacity: 4.4 litres (269 cu.in.)
- combustion system: Direct Injection
- bore and stroke: 105 × 127 mm
- compression ratio: 19.3:1
- engine rotation: 1000 rpm

Performance data
- power output: 64 kW (86 bhp)
  - speed: 2400 rpm
- peak torque: 302 Nm
  - speed: 1400 rpm

The measuring apparatus available for the testing:
- revolution measuring: ABS brake encoder together with serrated wheels, made by WABCO,
- consumption meter: AI-2000 type (works such as measurement of mass), made by VILATI,
- Torque measuring: torque measuring cell fitted in ENERGOTEST 2000 type test bench, made by KALIBER.

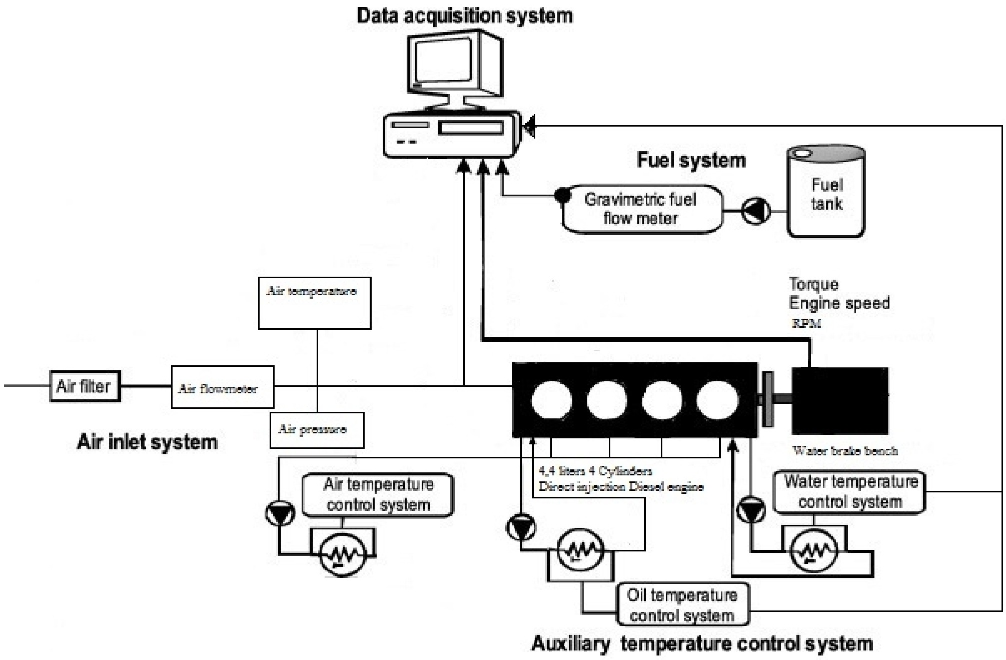


Figure 1. Instrument system

The engine test was made according to directives of ECE 24 standard [1][2], so the engine was fitted with the original intake and exhausting systems and these drove the moving parts. The measurements were made in 7 operating points between 1400 rpm and 2300 rpm. The values of torque (M), effective power (P_{eff}) and specific fuel consumption (b) were measured in case of full throttle and fixed dispenser lever position in every operating point [2][9][14]. After selecting a given operating point the control of the measurement, together with the collection and the evaluation of the data are completely automated.

During the testing process the current values of the measured parameters were displayed steadily on the screen of the computer system connected to the test bench. The measured engine parameters were corrected according to the status indicators (temperature and pressure) of the intake air. The following correlation – suggested also by Dezsényi et al. [2] – could be applied to determine the corrected power:

$$P_0 = P \cdot a_d \quad [W] \qquad (a)$$

where: P [W] – power output

$a_d = (f_a)^{fm}$ – correction factor

$$f_a = (99 \cdot p_{sz}^{-1}) \cdot (T \cdot 298^{-1})^{0,7} \text{ – atmospheric factor} \qquad (b)$$

where: 99 [kPa] – dry air pressure

p_{sz} [kPa] – dry atmospheric pressure (difference between the total pressure of air and the partial pressure of water vapor)

T [K] – the temperature of engine intake air

298 [K] – reference temperature

$$f_m = 0.036 \cdot q_c - 1.14 \text{ – engine factor} \qquad (c)$$

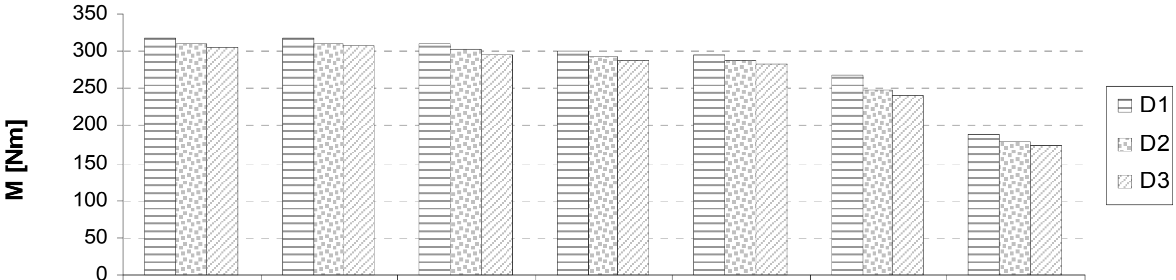
where: q_c [mg·(litre·cycle)$^{-1}$] – specific fuel-dose

In case of diesel engines the calculated correction factors are $0.9 \le a_d \le 1.1$. In our case the calculated value of the correction factor is $a_d = 0.9839$, so the further evaluation was done with the corrected parameters.

RESULTS OF THE ENGINE TESTS

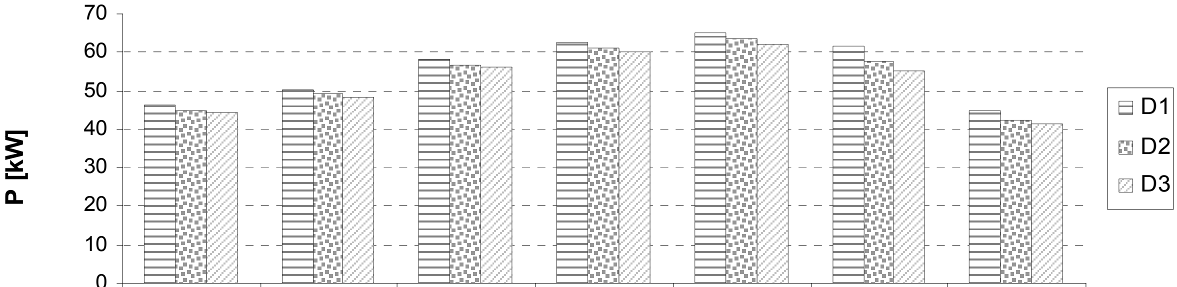
Simple bar diagrams were used to demonstrate and evaluate the numerical measurement results which definitely show the potential differences in the parameters of the engine fuelled by the diesel fuels under testing. As it can seen in Figure 2 the torque values of engine fuelled by D2 and D3 diesel fuels are lower at every measured revolution than torque values of the engine fuelled by D1 diesel fuel. The range of differences (consideration the minimum and maximum torque values at a given revolution) is from 3.15% to 10.42%. The differences of the torque values approach the lower limit of the range at lower revolutions (1400-2100 rpm), while the torque values at 2200-2300 rpm represent the higher values of the range.

The measured power values at given revolution can be seen in Figure 3, however the tendency is shown in the Figure 2 on the basis of $P_{eff} = M \cdot \omega$ correlation. Due to the inaccuracy of the measurement the range of the difference has been changed slightly: 2.93% -10.07%. The reason of the change is explained by accuracy of the measuring system and accuracy of stored values in the background program. (Note: The displayed values are decimal precision.)



	1400 1/min	1500 1/min	1800 1/min	2000 1/min	2100 1/min	2200 1/min	2300 1/min
D1	317,5	317,5	309,4	299,7	294,6	267,9	188,8
D2	310,2	310,5	302,8	292,3	288,5	249,3	178,4
D3	305,2	307,5	296,2	287,3	282,7	240	173,3

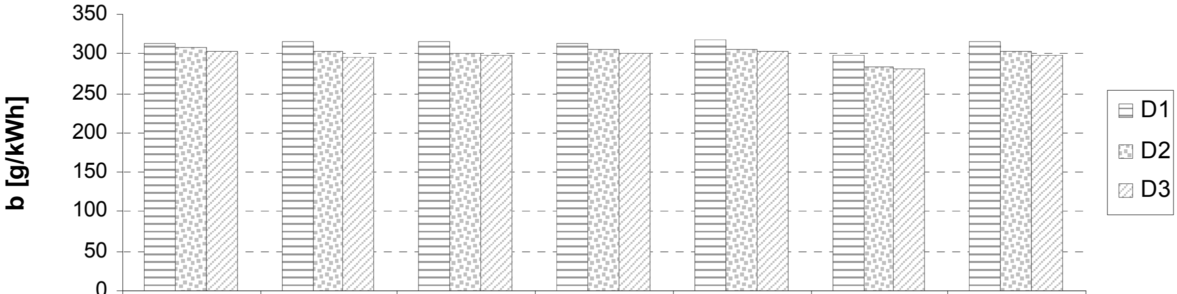
Figure 2. Torque



	1400 1/min	1500 1/min	1800 1/min	2000 1/min	2100 1/min	2200 1/min	2300 1/min
D1	46,1	50,4	58,1	62,6	65,0	61,6	45,0
D2	44,9	49,4	56,5	61,3	63,4	57,6	42,5
D3	44,5	48,1	56,4	59,9	62,0	55,4	41,4

Figure 3. Power output

Figure 4 shows the values of the specific fuel consumption. The specific fuel consumption of engine fuelled by D1 diesel fuel exceeds at every measured revolution point the values with D2 and D3 diesel fuels. The range of deviation (based on the maximum and minimum consumption values at a given revolution) is from 3.63% to 4.68%.



	1400 1/min	1500 1/min	1800 1/min	2000 1/min	2100 1/min	2200 1/min	2300 1/min
D1	314,2	314,9	314,7	312,7	316,8	298,8	315,5
D2	309,2	302,3	301,3	305,3	305	284,5	302,1
D3	302,8	296,4	297,7	300,4	302	281,1	298,1

Figure 4. Specific fuel consumption

The specific fuel consumption of a given engine depends on its operating status, loading and revolution. The effective operational range of the engine is well-determined by plotting the character field of the specific fuel consumption – so called shell curves of Alfred Jante [5][7][8] – on the whole operation range. To plot the shell curves the different values of the fuel consumption concerning to different loads and effective mean pressure (p_{eff}) should be known at the given revolutions [2][4].

$$p_{eff} = P_{eff} \cdot i \cdot (2 \cdot n \cdot V_H)^{-1} \qquad [Pa] \qquad (d)$$

where: P_{eff} [W] – effective power
i [-] – number of strokes
2 – stroke constant
n [s^{-1}] – revolution
V_H [m^3] – overall stroke volume

The diagram area defined by binary function (revolution and effective mean pressure) provides the opportunity to present all the important parameters of the engine in one diagram.

CONCLUSIONS

Whereas today the importance of the sustainable development and sustainable survival is determinant, it is essential to recognize the engine parameters induced by both fossil fuels and renewable fuels from both energetic and environmental aspects that is the engine tests have to be performed with different quality fuels to facilitate to define the optimal engine operation ranges. Illustrating the parameters of an internal combustion engine fuelled by different kinds of fuels in function of the revolution presents clearly the differences due to quality properties and combustion technical parameters of the fuels. The measure parameters facilitate the energetic qualification of the used fuels.

In conclusion, we can say that the differences in the parameters of an engine fuelled with different diesel fuels can reach 10% under unfavourable conditions, beyond the all possible cases, which are significant differences in the machine operation. Therefore the engine tests performed with vegetable oil base biofuels always has to be preceded by investigations performed to define the engine parameters of the diesel fuel in order to facilitate the reliable analyzes and evaluations, furthermore to compose well-established, universal, innovative professional statements.

With knowledge of the experimental results, the further direction of the research can be the elaboration of a mathematically well-manageable energetic system model, in which all the characteristics and parameters influencing the energetic operators can be taken into consideration, of course observing the priority requirements. It can be determined that further researches are needed to compare systematically the environmental and energy performance of biofuels.

In summary, results of the research show that different kinds of vegetable oils will have significant role in the future. As the renewable energy carriers promote continuous innovative development of our country and the EU, help fulfil energy efficiency criteria and sustainable criteria (e. g. as regards greenhouse gases, biodiversity, quality requirements).

REFERENCES

[1] Bosch Automative Handbook (8th edition) – Reference handbook for academic and personal use. Robert Bosch GmbH, 2011. (p 366-441)

[2] Dezsényi Gy., Emőd I., Finichiu L., Belsőégésű motorok tervezése és vizsgálata (Design and analysis and design of internal combustion engines); p 122-137; p 825-827, Tankönyvkiadó, Budapest 1990.

[3] Europe 2020 – Europe's growth strategy (A strategy for smart, sustainable and inclusive growth), European Commission, Brussel 2010

[4] Fülöp Z., Belsőégésű motorok (Internal combustion engines); p 36-38, Tankönyvkiadó, Budapest 1990.

[5] Gál P., Examination of the friction processes taking place in the control mechanisms of gas exchange for internal combustion engine; p 93-98, Budapest 2005.

[6] Hancsók J., Lakatos I., Valasek I., Üzemanyagok és felhasználásuk (Fuels and their use); Tribotechnik, Budapest 1998.

[7] Jante, A., Vorlesung Verbrennungsmotoren, Als Manuskript gedruckt, Technische Universitat – Dresden 1976

[8] Jante, A., Grundlagenprobleme der Verbrennungsmotoren anhand Thermodynamischer Kreisprozesse dargestellt, Technische Universitat – Dresden 1976

[9] Kalligeros, S. et. al., An investigation of using biodiesel/marine diesel blends on theperformance of a stationary diesel engine, In: Biomass and Bioenergy Vol. 24, 2003 pp. 141-149

[10] N. Kapilan, Ashok Babu T. P., Reddy, R. P., Performance and emissions of a dual fuel operated agricultural diesel engine, Annals of Faculty Engineering Hunedoara Tome VIII, Fascicule 1, 2010 pp. 159-162

[11] Orlin Stoyanov: Development and testing a Diesel engine diagnostic system, Annals of Faculty Engineering Hunedoara Tome XI, Fascicule 2, 2013 pp. 37-40

[12] The current status of biofuels in the European Union, their environmental impacts and future prospects. European Academies Science Advisory Council Policy Report 19 (Sustainable biofuels), December 2012

[13] Republic of Hungary national renewable energy action plan for 2010-2020. Deputy Secretariat of State for Green Economy Development and Climate Policy for the Ministry of National Development, May 2010

[14] Vas A., Belsőégésű motorok az autó- és traktortechnikában (Internal combustion engines in automobile and tractor technics); p 68-85, Mezőgazdasági Szaktudás Kiadó, Budapest 1997.