THERMAL LOADS OF ENGINES FOR DIFFERENT PROPERTIES OF COMMERCIAL FUELS

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Abstract

It is oblivious, various properties of fuels cause different thermal loads of engines. Question is, how big is this effect and what fuel compound and its property play insignificant part. This paper is focused on problem of quality of diesel commercial fuels in Polish market and it is a challenge to find answer for question mentioned above. The academic staff from Wroclaw University of Technology organized tests with different commercial fuels. Chemical and physical properties of these fuels were studied and used for investigation to define relationships between them and thermal load during simulation process. All researches were done in the lab of Division of Motor Vehicles and Internal Combustion Engines at the Wroclaw University of Technology. Tests have showed differences in chemical and physical properties of fuels, but there is no statistics effect on engine parameters. Results have not also pointed any important differences in thermal loads of engine VW1,9 TDI and its components according to different physical and chemical properties of tested fuels. It is probably because there are differences of calorific values from one side but from other hands various density and specific fuel consumption compensated these differences. To burn unit of fuel contains higher level of oxygen, engine needs lower amount of air, so it gives, for the same fuelling system, lean mixture. It causes higher temperature of exhaust gases and a bit higher exhaust losses.

Keywords: *diesel engine, thermal loads, fuels*

1. Introduction

Supplying combustion engine with fuels getting various properties, it is obvious causing its thermal load, which is defined as a heat flux for actual operation conditions (see Form. 1).

$$q=W_pB_o\xi, \tag{1}$$

where:
W_p - calorific value o f fuels,
B_0 - fuel consumption at time unit,
ξ - heat release ratio in combustion chamber.

That thermal load is an overall ration of thermal state of whole engine and does not describe real thermal loads of each separate part of engine. Thermal state of engine depends:
- thermal conductivity (heat diffusion),
- shape of combustion chamber,
- activity of burning process.

Heat transfer for whole as well as for separate engine components can be describe by: charge temperature and heat transfer coefficient on the tested surface. These factors show boundary conditions of heat exchange. They are inconstant and heterogeneous is the space of combustion chamber [1, 2, 5].

Do not looking deeply at sharp mathematical formulas, it can be pointed simply relationship between temperature as well as heat conductance and mole exchange coefficient of fresh charge. It depends next on physical and chemical compositions of fuel. For typical diesel fuel with carbon amount of 85.5% and hydrogen of 14.5%, theoretical air access is 14.9 kg to burn completely 1 kg of fuel. Using fuels, made of different compounds, working parameters and performances of engine are different, so thermal loads are different, too [7].

2. Fuel samples and lab tests

Samples of diesel fuel, taken from four different tank stations were tested. Investigation was done in Wroclaw city. Selection of fuel suppliers belonged to hazard. There were:
1. PKN Orlen S.A.,
2. BP station,
3. PKN Orlen Swojec store,
4. CityDiesel from MPK Wrocław enterprise.

Each of samples were taken from tank stations following standard rules of PN-EN ISO 3170:2002. Next, they were divided into two parts: first for chemical checking and the rest for tests of real operating engine in lab bench. The chemical components and physical properties of the fuels were measured in the Division of Chemistry and Fuel Technology at the Wroclaw University of Technology (WUT). Real engine tests were organized at the Division of Motor Vehicles and internal Combustion Engines WUT. Diesel engine VW1.9TDI was the object of research. For its loading, electrodynamometer AVL Alpha 240 was applied (fig. 1.). All measurement data was recorded and analyzed directed in computer [1].

Fig. 1. IC engine on the test bench

Chemical analyses have given results as in Tab. 1. There are elementary composition of the fuels and energetic factors, first of all. At engine bench, different engine parameters like revolution, power, load, temperature, toxicity etc. were measured to build engine performances and next for thermal loads analyses.

Tab. 1. Physical and chemical properties of tested fuels

Fuels	Carbon	Hydrogen	Nitrogen	Sulfur	Oxygen	Density at 20°C	Calorific value
	%	%	%	%	%	g/cm3	kJ/kg
Orlen	85.09	13.78	0.09	0.0004	1.04	0.8251	46000
BP	85.82	13.78	0.09	0.0004	0.31	0.8362	46169
Swojec	86.12	13.13	0.11	0.0004	0.64	0.8347	46110
CityDiesel	86.18	13.64	0.08	0.0004	0.10	0.8243	46193

Analysis of data presented in table 1 shows various chemical compositions of each of the fuel. The differences in oxygen content more than hundred percentage were measured (fig. 2). There is between standard fuel and blends with RME (Rape Methyl Ester) [3]. Differences of calorific values were also noticed.

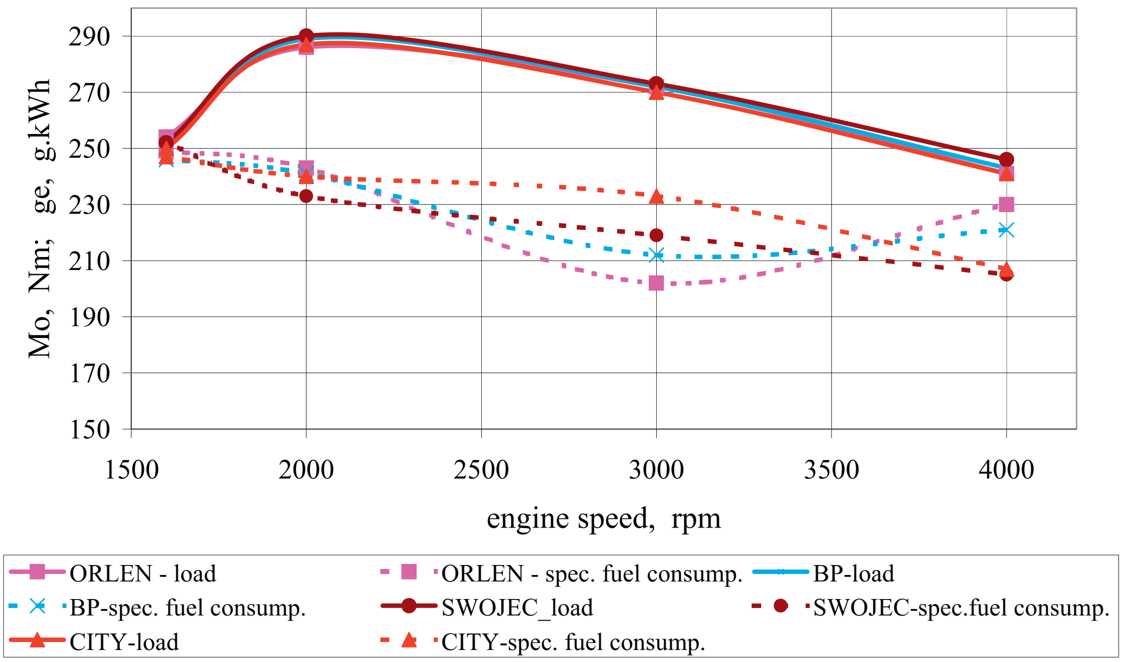

Fig. 2. Full load performances of VW1,9 TDI for tested fuel

Full load performances for different fuels are very similar one to another, except characteristics of specific fuel consumption (ge). It is because ECU (engine control unit) made compensation of differences in calorific values, density and oxygen content to keep stechiometric combustion process.

Differentiations of calorific values as well as oxygen contents gave the reason to calculate the heat release of fuel dose (Fig. 3).

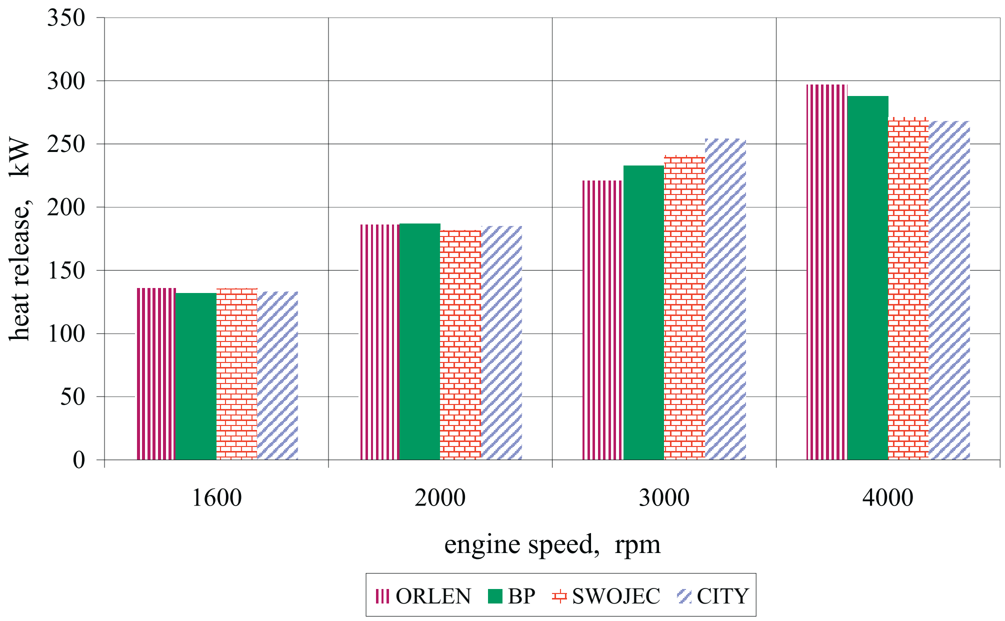

Fig. 3. Differences of heat release for different fuels

As was said early, heat release does not give any information about thermal loads of each engine component, separately. So, based on test data and theoretical pressure graphs for different fuels, Sankey's diagrams were created (Tab. 2), following description as on Fig. 4.

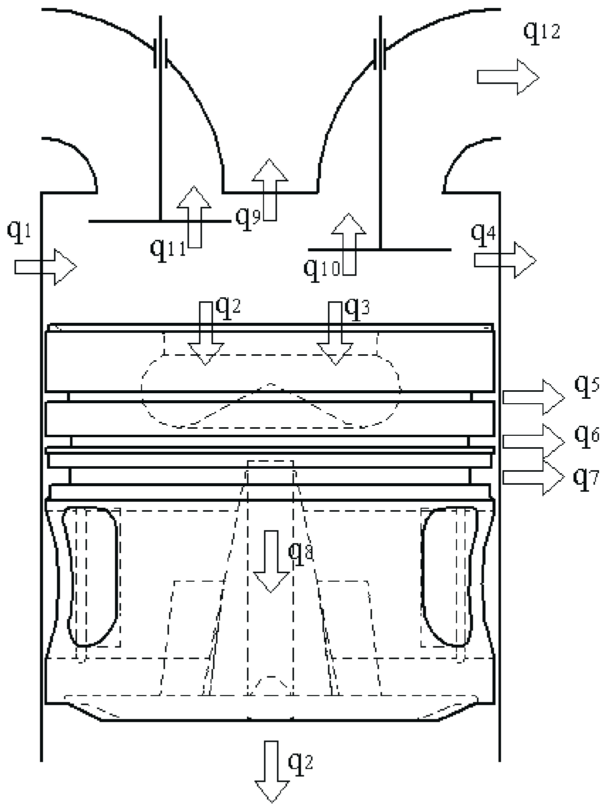

Fig. 4. Scheme of heat transfer in combustion chamber q_1 - total energy contained in the fuel, $q_2 = N_e$ - useful power, q_3 - heat flow going to piston, q_4 - whole heat flow to cylinder (cooling losses) , q_5 - heat flow going to cylinder through 1st piston ring, q_6 - heat flow going to cylinder through 2nd piston ring, q_7 - heat flow going to cylinder through 3rd piston ring, q_8 - heat flow to crank case through inner surface of piston, q_9 - heat flow to cylinder head, q_{10} - heat flow to exhaust valve, q_{11} - heat flow to inlet valve, q_{12} - heat flow to exhaust(outgoing gases losses).

Data, to calculate heat transfers of different fuels, were measured at full load for revolution of 2000 rpm.

Tab. 2. Heat flow in combustion chamber of one cylinder diesel 1.9 TDI supplied with different fuels at conditions of Mo = 290 Nm and n = 2000 rpm

Description (see fig. 3.)	Heat flows, kW			
	ORLEN	BP	SWOJEC	CITY
q1	46.50	46.86	45.39	46.21
q2	14.96	15.08	15.18	15.03
q3	2.57	2.59	2.51	2.55
q4	5.68	5.71	5.53	5.63
q5	2.20	2.22	2.15	2.19
q6	2.22	2.24	2.17	2.21
q7	0.82	0.83	0.80	0.82
q8	0.12	0.12	0.12	0.12
q9	0.29	0.29	0.28	0.29
q10	0.09	0.09	0.09	0.09
q11	0.30	0.30	0.29	0.30
q12	17.25	17.39	16.27	16.99

3. Summary

Tests have showed differences in chemical and physical properties of fuels, but there is no statistics effect on engine parameters. Results have not also pointed any important differences in thermal loads of engine VW1,9 TDI and its components according to different physical and chemical properties of tested fuels. It is probably because there are differences of calorific values from one side but from other hands various density and specific fuel consumption compensated these differences. To burn unit of fuel contains higher level of oxygen, engine needs lower amount of air, so it gives, for the same fuelling system, lean mixture. It causes higher temperature of exhaust gases and a bit higher exhaust losses.

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