Štefan LIŠČÁK
Vladimír RIEVAJ
Marián ŠULGAN

WARUNKI TECHNICZNE POJAZDU A EMISJA SPALIN

VEHICLE'S TECHNICAL CONDITION AND EMISSION

Artykuł prezentuje wyniki badań mających na celu znalezienie różnic w emisji spalin dwóch silników o zapłonie iskrowym pojazdów osobowych o różnym roku produkcji. Porównania dokonano podczas poziomego ruchu pojazdów ze stałą prędkością. Podczas prowadzonych badań silnik samochodu pokonywał tylko następujące opory: układu napędowego, toczenia oraz powietrza. Do badań wybrano samochody o porównywalnych masach i powierzchni czołowej. Były to Škoda 105 L wyprodukowana w 1983 roku oraz Toyota Yaris 1,0 VVTi z roku 2003.

***Słowa kluczowe**: zużycie paliwa, opory powietrza, opory toczenia*

The article presents the research results aimed to get true differences of pollution production between two cars with spark ignition engine depending on the car's age. A car movement by constant speed on horizontal plane was realised for comparison. The vehicle engine must overcome only mechanical transmission losses, air resistance and rolling resistance, too. The air resistance size depends on the speed, the vehicle frontal area and the air resistance coefficient. It was chosen vehicles with approximated equal weight and approximated equal vehicle frontal area for comparison. These conditions fulfil vehicles Škoda 105 L, made in 1983, and Toyota Yaris 10,0 VVTi, made in 2003.

***Keywords**: fuel consumption, emissions, air resistance, rolling resistance*

1. Introduction

Transport became a fix part of modern people's life. We exploit it for travelling, movement of goods, sometime for relaxation. The vehicle consumes some fuel quantity for each distance. It produces some quantity of pollution into the air therefore it drives. It is matter of common knowledge that low age of the vehicle leads to the lower fuel consumption. We tried to find out real consumption of difference cars with different year of produce by the exact determined conditions.

2. Method of research

We determined car movement by constant speed on horizontal plane for comparison. The vehicle engine must overcome only mechanical transmission losses, air resistance and rolling resistance, too [3÷5]. The mechanical transmission losses depend on construction level.

The rolling resistance loss size depends on vehicle weight. We can calculate it by the help of formula:

$$O_f = f \cdot G \tag{1}$$

where: f - rolling resistance coefficient [-], G - vehicle weight [N].

We can calculate the air resistance by the help of formula:

$$O_V = 0{,}05 \cdot c_x \cdot S \cdot V^2 \tag{2}$$

where: c_x - air resistance coefficient [-], S - vehicle frontal area [m^2], V - car speed [km.h^{-1}].

The air resistance size depends on the speed, the vehicle frontal area and the air resistance coefficient. The air resistance coefficient reflects the level of construction. We chose vehicles with approximated equal weight and approximated equal vehicle frontal area for comparison. It ensures comparability of the cars and only their technical level. These conditions fulfil vehicles Škoda 105 L, made in 1983, and Toyota Yaris 10,0 VVTi, made in 2003. Parameters of both vehicles are listed in Table 1.

We made comparison at speed 40, 50, 60, 70, 80, 90, 100 km·h^{-1}. It was evaluated air resistance size for those speeds. This value was adjusted in measure time of concrete vehicle [1,2]. Value of air resistance calculated for particular vehicle is listed in Table 2.

Fuel consumption for Toyota Yaris was found by using information of on-board computer. On-board computer is able to inform about instant fuel consumption as well as about average fuel consumption. Accuracy of it was tested, by comparison of

Tab. 1. Basic parameter of compared vehicles

	Toyota Yaris 1,0 VVTi	*Škoda 105 L*
Car width [mm]	*1660*	*1595*
Car highness [mm]	*1500*	*1400*
Vehicle frontal area [m^2]	*1,992*	*1,786*
Air resistance coefficient [-]	*0,30*	*0,35*
Car basis weight [kg]	*840*	*890*
Car total weight [kg]	*1320*	*1290*
Useful weight [kg]	*480*	*400*
Tire size	*155/80 R 13*	*165 SR 13*
Maximum speed [km.h^{-1}]	*156*	*130*
Fuel consumption extramural [l/100 km]	*5,1*	*6,4*
Fuel consumption in the town [l/100 km]	*6,9*	*8,4*
Engine cubature [cm^3]	*998*	*1 046*
Compression ratio	*10,0 : 1*	*8,5 : 1*
Maximum power/at engine speed [kW.min^{-1}]	*50/6000*	*33,9/4800*
Maximum torque/at engine speed [N.m.min^{-1}]	*90/4100*	*74,5/3000*
Mixture preparation	*Injection*	*Carburettor*

Tab. 2. Value of calculated air resistance [N]

Speed [km.h^{-1}]	Toyota Yaris 1.0 VVTi	Škoda 105 L
40	48	50
50	75	78
60	108	113
70	146	153
80	191	200
90	242	253
100	299	313

indicated fuel consumption with calculated fuel consumption. We divided the litters tanked into fuel tank by covered distance for calculation. Covered distance was 10 000 kilometres. The on-board computer indicated 0,05 l per 100 km below the calculated consumption. Average fuel consumption was 5,8 litres per 100 kilometres.

We had to install fluid meter Pierburg into fuel system therefore vehicle Škoda 105 L is not equipped by the on-board computer. Fluid meter was installed into extrusion branch behind fuel pump. Computer Correvit calculated fuel consumption with accuracy ± 1%.

It is necessary ensure permanent changeless resistance on the vehicle wheels for comparability of the results. The cylinder power test stand MAHA LPS 2000 fulfils this request. It is possible to set constant resistance in N on the vehicle wheels on that stand. Display of the stand shows value of resistance in N and speed in kilometres per hour. It works with accuracy ± 2 % of measured parameter.

The driver had to warm up tyres to the working temperature by driving and by the arbitrary speed. He had to achieve required speed then for required gear. He was obliged to keep the speed on that value for 1 minute. It was necessary to start new measurement if the speed was higher or lower more than 2 kilometres per hour in that interval 1 minute.

The vehicle engine produces pollutions which are released into the environment by the vehicle exhaust system. Toyota Yaris exhaust system was equipped by the catalytic converter and Škoda exhaust system was without it. Difference in the pollution production was tested by SUN MEA 1500 SL equipment.

3. Received results

The quantity of CO_2 production depends directly on quantity of fuel consumption. Fuel consumption comparison of both vehicles we can see on Fig. 1, 2, 3.

Figure 1 compares fuel consumption if both cars use II. gear for driving. Engine of the vehicle Škoda with mixture preparation by the carburettor indicate more steepness growth of the fuel consumption in opposite to the Toyota Yaris vehicle whose mixture preparation is administrated in accordance to the λ sound signals. Škoda vehicle fuel consumption goes up on 129,33 % and Toyota Yaris consumption go up only to 118,37 % when speed increases from 40 to 60 kilometres pre hour. The Škoda vehicle fuel consumption is 53 % higher than the Toyota Yaris consumption in speed 40 kilometres pre hour.

Figure 2 compares fuel consumption if both cars use III. gear for driving. Fuel consumption goes up to the 172,72 % for vehicle Škoda and to 140,54 % for Toyota Yaris if speed was changed from 40 to 8O kilometres per hour. Curved line of fuel consumption for Toyota Yaris indicates constant growth. Curved line for vehicle Škoda indicates different slope. The reason of it is quality of preparation mixture in the carburettor. Vehicle Škoda fuel consumption is higher about 48 % at speed 40 kilo-

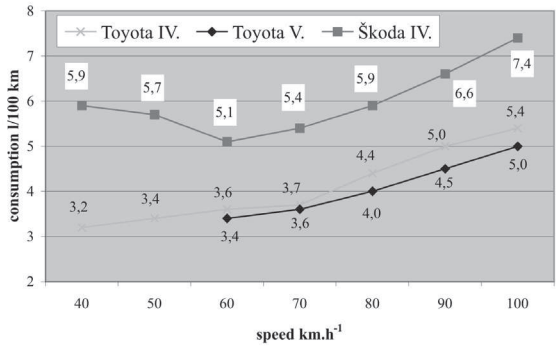

Fig. 1. Vehicle Škoda 105 L and Toyota Yaris 1,0 VVTi fuel consumption by using II. gear

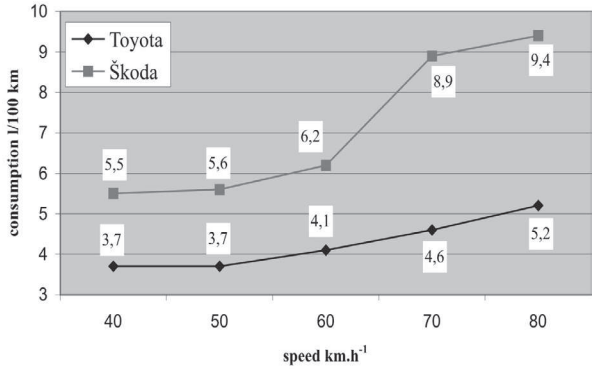

Fig. 2. Vehicle Škoda 105 L and Toyota Yaris 1,0 VVTi fuel consumption by using III. gear

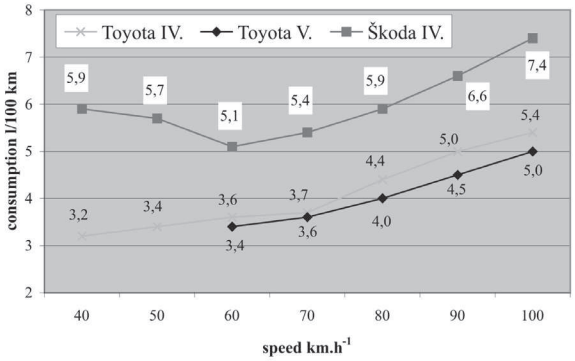

Fig. 3. Vehicle Škoda 105 L and Toyota Yaris 1,0 VVTi consumption by using the highest suitable gear

metres pre hour and difference increase to 80,77 % at speed 80 kilometres per hour.

The vehicles engines work with partial load if they use II. and III. gear. The Fig. 3 indicates fuel consumption if vehicles use the highest possible gear. It manifests in higher load of engine and it starts to work in optimal mode. Vehicle Toyota engine keeps still constant inclination of the consumption, but vehicle Škoda engine change inclination. For speed from 40 to 60 kilometres pre hour it decrease and from 60 to 100 kilometres pre hour it starts to increase.

4. Conclusions

Vehicle Škoda consumption is equal to 184 % of consumption of Toyota at speed 40 kilometres per hour and it decrease to 148 % at speed 100 kilometres per hour.

Tab. 3. Composition of the exhaust fumes

Speed [km.h^{-1}]	Gear	Vehicle	CO [%]	HC [ppm] (parts per million)	λ	CO_2 [%]
40	II.	Toyota	0,00	11	1,017	14,04
		Škoda	1,53	154	1,001	12,76
40	III.	Toyota	0,03	11	1,017	14,02
		Škoda	2,76	228	0,970	11,83
40	IV.	Toyota	0,00	11	1,017	14,04
		Škoda	6,72	317	0,852	9,06
50	II.	Toyota	0,00	11	1,018	14,07
		Škoda	1,50	192	1,040	12,46
50	III.	Toyota	0,03	11	1,016	13,92
		Škoda	1,72	192	1,308	12,26
50	IV.	Toyota	0,02	11	1,017	13,97
		Škoda	2,40	214	1,486	11,83
60	II.	Toyota	0,03	12	1,017	14,05
		Škoda	0,57	72	1,007	13,51
60	III.	Toyota	0,06	11	1,017	14,00
		Škoda	1,28	151	0,986	13,36
60	IV.	Toyota	0,04	12	1,017	13,88
		Škoda	1,53	206	0,990	13,19
60	V.	Toyota	0,03	12	1,017	13,96
70	III.	Toyota	0,0	12	1,016	14,02
		Škoda	1,13	175	0,990	13,40
70	IV.	Toyota	0,04	12	1,017	13,94
		Škoda	1,30	210	0,980	13,22
70	V.	Toyota	0,07	12	1,016	13,91
80	III.	Toyota	0,03	12	1,016	13,91
		Škoda	0,81	149	1,003	13,51
80	IV.	Toyota	0,02	12	1,012	13,93
		Škoda	0,28	211	1,141	12,04
80	V.	Toyota	0,03	13	1,017	13,88
90	IV.	Toyota	0,01	12	1,017	13,94
		Škoda	1,35	182	1,05	13,20
90	V.	Toyota	0,02	12	1,016	13,98
100	IV.	Toyota	0,06	13	1,015	13,83
		Škoda	1,36	180	0,975	13,18
100	V.	Toyota	0,06	14	1,021	13,75

The production of CO_2 depends directly on vehicles consumption. We can draw conclusion that vehicle Škoda had higher fuel consumption in all measured area and so it produced higher quantity of CO_2 in whole measured area, too. Exhaust fumes contains more kind of pollutions, not only CO_2. Composition of the exhaust fumes is indicates in Table 3.

Mixture preparation in carburettor reflects in higher percentage of CO and HC. Carburettor works only on base of underpresure in the intake system. It leads to the worse composition of the mixture.

Toyota engine prepares mixture on base of λ sound signal and its composition is always the best. Redundance of the oxygen in exhaust fume is very closely to the one. The exhaust system of vehicle Toyota includes catalytic conventer. This both reasons lead to the lower contents of the CO and HC in the exhaust fume.

5. References

[1] Liščák Š., Matějka R., Rievaj V., Šulgan M.: *Working Characteristics of Road Vehicles.* EDIS Publishing, Institution of Zilina University 2004, ISBN-80-8070-247-0.

[2] Liščák Š., Matějka R., Rievaj V., Šulgan M.: *Road Vehicles Chassis*. EDIS- Publishing Institution of Zilina University 2006, ISBN-80-8070-588-7.

[3] Kunstscher V.: Kraftfahrzeugmotoren VEB Verlag Technik Berlin, 1987.

[4] Sturm A., Forster R.: Maschinen und Anlagen-diagnostik für die zustands bezogene Instaldhaltung.VEB Verlag Technik Berlin,1988.

[5] Support by VEGA Project 1/2615/05: Economic and qualitative changes and synergetic influences on transport and logistics area after the Slovak integration into the European Union, Zilina University, FPEDAS, 2007.

Prof. Ing. Štefan LIŠČÁK, Ph.D.
Doc. Ing. Vladimír RIEVAJ, Ph.D.
Doc. Ing. Marián ŠULGAN, Ph.D.
University of Žilina
Faculty of Operation and Economics of Transport and Communications
Univerzitná 8215/1, 010 26 Žilina, Slovak Republic
e-mail: Stefan.Liscak@fpedas.uniza.sk,
e-mail: Vladimir.Rievaj@fpedas.uniza.sk
e-mail: Marian.Sulgan@fpedas.uniza.sk