POSSIBILITIES OF MEASURING THE BRAKE SPECIFIC FUEL CONSUMPTION IN ROAD VEHICLE OPERATION

Ing. Šarkan B. PhD.[1], Ing. Skrúcaný T.[1], Ing. Majerová Z.[1]
The Faculty of Operation and Economics of Transport and Communications– University of Zilina, the Slovac Republic [1]
sarkan@fpedas.uniza.sk

Abstract: Fuel consumption is one of the most important operating characteristics of road vehicles. In operation of road vehicles there we usually express fuel consumption in l/100 km for driving performance, or l/h when the car engine is idling. The fuel consumption can be quantified by several methods, and it affects a number of factors (driver, vehicle, and environment). It can be considered as a posteriori consumption, i.e. operational consumption. The priori fuel consumption (inserted, pre-defined) based on the construction properties of respective engine. Most often it is the priori fuel consumption expressed by measuring the effective consumption, which defines the amount of fuel consumed per unit of effort and time. It is usually quantified at a time when the engine is mounted to the vehicle itself. The contribution presents a practical example of measuring the effective fuel consumption in operation of road vehicles.

Keywords: FUEL CONSUMPTION, FUEL FLOW METER, ROLLER TESTER

1. Introduction

Specific fuel consumption and other technical parameters of the internal combustion engine are determined in the laboratory with using a dynamometer. Here we can be testing engine for under various operating conditions which are occurring in practice. The results of individual measurements are processed and they putting in diagrams – engine characteristics. [1].

We recognize the following type of fuel consumption formulation.

Fuel consumption per hour – M_p - is mass rate of flow fuel in the combustion engine [kg.h^{-1}].

Brake specific fuel consumption – BSFC is the quantity, which expressing how much fuel uses the engine on perform useful work 1 Joule. This is calculated from the relation:

$$BSFC = \frac{M_p.1000}{P_e}$$

BSCF [g.kW^{-1}.h^{-1}]

P_E - Effective engine power (kW)

Engine speed characteristic is the best known and the most widely used from characteristics. The course of BSFC is part of this characteristic. It is detected by help constantly open throttle valve (usually 100%).

2. Methodology of measuring BSFC in operation of road vehicle

1 Measurement technology

For measuring fuel consumption is needed in the laboratory conditions ensure that is using following measuring technique:

- roller tester with accessories - this type of diagnostic equipment is used in the measurement of fuel consumption as a driving simulator. It allows movement of the vehicle in laboratory conditions with simulating load (air resistance, rolling resistance, resistance gradients) at different speeds.
- device for determining the fuel consumption - measuring technology, whose role is to quantifying the amount of fuel consumed by the engine road vehicle during the implementation kind of measurement.
- additional measuring equipment - in this group may to include, for example. diagnostic equipment to enable communication with the engine control unit to obtain additional data (temperature, vehicle speed, etc.), or densimeter when using the volumetric method.

Tests of the measuring fuel consumption are performs out in laboratory conditions, the Department of Road and Urban Transport on the measuring devices:

- Maha LPS 2000 - representative of roller tester
- Flowtronic 205 - volumetric flow meter for measuring fuel consumption of vehicles with diesel or petrol engine
- Datron DFL-3 - volumetric flowmeter for measuring the fuel consumption of trucks.
- Laboratory balances Kern KB 10000 - laboratory balances that are used at gravimetric method.
- Densimeters

2 *Calculating BSFC*

Measurement requires the recording of the following parameters on the roller tester:

- Effective engine power - P_E [kW] - Performance is quantified from the measured power to the wheels - P_W by adding the power loss - P_L (transmission…)

  $$P_E = P_w + P_L \text{ [kW]}$$

- Engine speed - n [min^{-1}]
- Torque - M [Nm]. Torque is quantified by calculation according to the formula:

  $$M_t = \frac{P_e.1000 * 60}{2.\pi.n}$$

  P_E [kW]

  n [rpm]

- Fuel consumed - FC [cm^3]. It registers the volumetric flowmeter at a specified unit of time (eg, 30 sec, 1 min.)
- Fuel consumption per hour - M_p [kg.h^{-1}]. We calculated according to:

  $$M_p = \frac{3600.FC.\rho_F}{t_M.1000}$$

  FC – fuel consumption [cm^3]

  ρ_F - fuel density [eg. gasoline 0.75 g.cm^{-3}]

t_M – interval measurement of one point of the curve (eg, 30 sec, 60 sec) Accurate measurement ensures a longer measuring period but at higher loads, the engine is occurring of the overheating roller tester. 30 second measuring period is used in practice.

- BSFC can be calculated according to the equation:

$$BSFC = \frac{M_p.1000}{P_e}$$

3. *Practical example of BSFC measurement*

Results were measured in the laboratory of Department of Road and Urban Transport on vehicle Kia Ceed 1.6 CVVT with the following parameters:

Table 1: *Vehicle data*

Car brand	Kia Ceed	Engine code	G4FC
Engine Capacity	1591 cm^3	Length	4265 cm
Fuel	Petrol	Width	1790 cm
Cylinders	4	Height	1480 cm
Max. power	90 kW, 6200 rpm	Empty mass	1163 kg
Max. torque	154 Nm, 4200 rpm	Max. permissible mass	1710 kg
Top speed	192 $km.h^{-1}$		

According the above procedure shall be calculated the individual engine parameters needed for assessment measuring the BSFC. However, it is useful to know duration the special fuel consumption throughout the engine speed range and load. Engine speed characteristics recorded only progressions at full open of the throttle valve (ie when is fully pressed the accelerator). In tab. 2 are recorded the results of the required parameters for setting of specific fuel consumption for constant engine speed 2510 rpm. The first column shows the value of full the throttle valve opening statement of actual values obtained through internal diagnostics HiScan.

Table 2: Measurement results at 2510 rpm

Opening throttle valve (%)	P_W [kW]	Velocity [$km.h^{-1}$]	n [rpm]	FC [cm^3]	P_L [kW]
7,1	5	49,7	2510	27,89	0,65
15,7	21,5	49,7	2510	67,06	2,80
25,1	27,1	49,2	2510	82,34	3,52
35,7	28,6	49,7	2510	88,98	3,72
45,1	29,1	49,7	2510	90,30	3,78
55,3	29,5	49,7	2510	90,30	3,84
65,5	29,7	49,7	2510	92,30	3,86
72,5	31,2	49,7	2510	105,58	4,06
78,8	31,3	49,7	2510	107,57	4,07
Opening throttle valve (%)	**P_E [kW]**	**M_t [Nm]**	**M_p [$kg.h^{-1}$]**	**BSFC [$g.kW^{-1}.h^{-1}$]**	
7,1	5,75	21,87	2,51	436,73	
15,7	24,71	94,02	6,04	244,24	
25,1	31,15	118,51	7,41	237,89	
35,7	32,87	125,07	8,01	243,60	
45,1	33,45	127,26	8,13	242,98	
55,3	33,91	129,01	8,13	239,69	
65,5	34,14	129,88	8,31	243,33	
72,5	35,86	136,44	9,50	264,96	
78,8	35,98	136,88	9,68	269,09	

From results it can be constructed so called Workload characteristics of the engine (Fig. 1). Measurement the load characteristics allows to construct the multiple modes engine complete engine characteristics, from which it is possible count almost all important engine parameters throughout the load range.

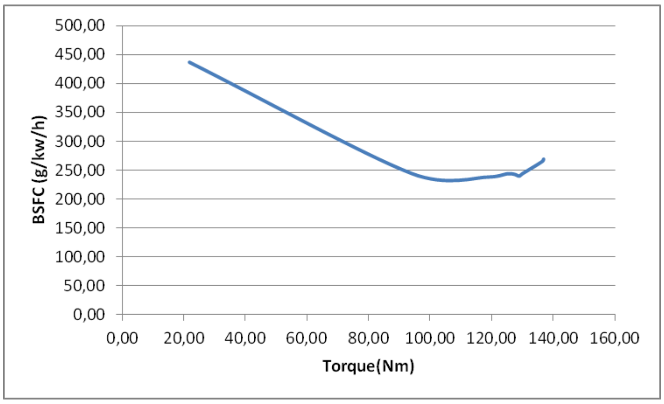

Fig. 1 *Load characteristic*

The engine parameters shall be recorded at full throttle valve opening for compiling the external characteristics of the engine. In the particular example is the final row the measured values in table 2. A value thus obtained defines the external characteristics of the engine for the entire speed range. In Table 3 are the values measured for the Kia Ceed at engine speed 1700-6300 rpm.

Table 3: Values of engine external characteristic

n [rpm]	BSFC [$g.kW^{-1}.h^{-1}$]	P_E [kW]	M_t [Nm]
1700	289,48	21,47	119,90
1900	286,26	24,63	123,81
2100	273,76	28,82	130,41
2300	278,39	32,09	133,25
2500	269,09	34,58	131,56
2700	272,11	38,87	136,98
2900	270,17	41,58	136,46
3100	265,78	44,07	135,76
3300	269,49	47,23	136,27
3500	284,58	50,40	137,12
3700	277,48	54,92	141,36
3900	287,15	57,86	141,30
4100	297,60	63,05	146,51
4300	306,32	66,33	146,97
4500	293,41	68,03	144,04
4700	313,74	70,29	142,81
4900	343,88	71,08	138,24
5100	340,52	76,95	143,81
5300	352,10	75,60	135,95
5500	355,60	77,18	133,52
5700	357,84	76,95	128,70
5900	362,20	80,68	130,15
6100	361,92	80,91	126,25
6300	369,31	80,91	122,45

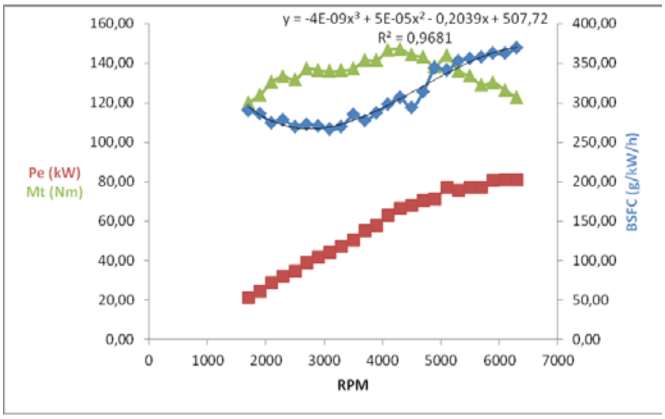

Fig. 3 *Engine characteristic*

4. Conclusion

Measuring the specific fuel consumption is difficult in operation road vehicles. This type of measurement requires a rolling tester and flowmeter. This type of measurement requires a test cylinder and flow meter to record the amount of fuel consumed . This characteristic defines in which areas (speed range) engine operates the most economical, respectively. the most effective in terms of performance parameters. It is area around speed of 3000 min^{-1} in the example of figure 2. It is surprising that when the vehicle is driven in said areas does not reach the lowest operating vehicle fuel consumption (l/100 km), because the engine works enough big output, and vehicle goes either relatively quickly or uphill.

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