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Research Article

MEASUREMENT OF FUEL CONSUMPTION OF A ROAD MOTOR VEHICLE BY OUTDOOR DRIVING TESTING

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ABSTRACT
This paper presents the chosen significant parameters affecting vehicle fuel consumption during the vehicle operation. The conducted measurement results define important practical operational functions in the actual operation of the vehicle, which allows for further processing of the input data in order to measure fuel consumption in laboratory tests. The proposal of the methodology for measuring the fuel consumption based on actual operation conditions in the city of Žilina and its surroundings was shown.

Keywords: road transport, motor vehicle, operation.

INTRODUCTION

It is commonly known that properties and operational parameters of internal combustion engines change in working conditions. Fuel consumption of modern means of transport, and especially road vehicles, is the parameter that interests every manufacturer and user [4]. It is the consequence of a significant share of fuel on the whole transport expenses [4]. This task involves recording important parameters having impact on vehicle fuel consumption during its operation. The performed practical measurements should define important operational features in common operation of the vehicle with the aim of future processing of such input data for measurements of fuel consumption under laboratory conditions. The proposal of the methodology for measuring the fuel consumption will be based on actual operation conditions of the city of Žilina with its surroundings. In order to compose the methodology, we defined routes most closely reflecting urban traffic (maximum 50 km/h), outside urban traffic (for speed from 50 km/h to 90 km/h) and we also performed measurement for driving on a highway (maximum 130 km/h). We measured and evaluated each single route in both directions. We recorded data for individual measurements about the fuel consumption, route length, course of speed, total time necessary for the route, individual times of idle run (neutral), communication altitudinal route and environment temperature.

MEASUREMENT METHODOLOGY

Literature sources analysing vehicle tests in conditions of real operation show differences in classifying methodology of possible tests [2]. From the measured data we have composed an altitudinal profile of the route using the program Google Earth Pro, which displays the course of speed in accordance with the distance and time in addition to the altitudinal profile. With this course we are able to determine a current speed by moving the pointer on the particular moment in time, i.e. place, in which the vehicle was in the particular moment. The example of such an altitudinal profile is shown in the Figure 1.

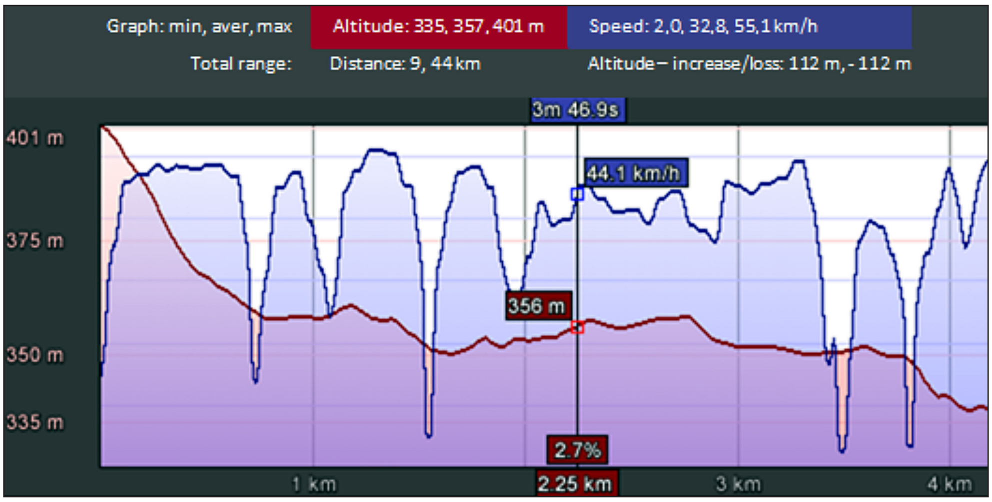

Fig. 1. Part of the altitudinal profile of the proposed route

On the grounds of such speed determination for individual moments of time we can categorise individual time sections into speed intervals, where they belong with regard to their values, i.e. we are able to determine the percentage value out of the total time of the route that the vehicle was driven with a speed up to 15 km/h, up to 32 km/h and up to 50 km/h, etc. When defining limit speed values we were inspired by the values that are simulated during the European driving cycle imitating urban traffic (ECE 15).

For the urban traffic, we evaluated speed in intervals and total time of idle run:

- 0 – 15 km/h,
- 15 – 32 km/h,
- 32 – 50 km/h,
- t_{vb} (s).

For the outside urban traffic, we evaluated speed in two intervals:

- 50 – 70 km/h,
- 70 – 90 km/h.

For the highway driving, we evaluated speed in intervals:

- 100 – 115 km/h,
- 115 – 130 km/h.

Basing on the percentage share of individual speeds in the total length of the route (e.g. the vehicle was driven with speed 30 km/h for 50% of the total time of the route), we use determined individual time sections assigned to particular stabilised speed on the basis of which we will measure the fuel consumption on the rolling dynamometer. Under conditions of the Department of Road and Urban Transport it is not possible to simulate driving cycles and resulting accelerations and decelerations on the rolling dynamometer Maha LPS 2000 because this dynamometer cannot simulate changing resistance during driving. Therefore, we prepared a methodology only for stabilised speeds and idle run. With such methodology we attempted approximate fuel consumption achieved under real conditions of vehicle operation during performed measurements in the city of Žilina. We also compared the results to the data in the vehicle registration certificate.

Measurement of input data for the preparation of the methodology was performed on previously planned routes with the passenger vehicle and using installed measuring devices. Measured data were processed and evaluated with relevant applications – the application Google Earth Pro was used for visual display on the digitalized map and for the altitudinal profile of the route and the spread sheet editor Microsoft MS Excel was used for the subsequent processing of measured results [1].

DESCRIPTION OF VEHICLE AND RELEVANT MEASURING DEVICES

Measurement was performed with a passenger vehicle Škoda with trade name Fabia Combi. Table 1, shows a brief description of the vehicle. The vehicle is equipped with a device enabling vehicle drive with LPG fuel, however, it was operated on gas fuel during all our measurements.

We recorded the route with the standard GPS navigation device Garmin Nüvi 1490 T displayed in the Figure 2.

Table 1. Vehicle parameters

Category	M1
Brand	Škoda
Trade name	Fabia Combi
Engine capacity	1397 cm^3
Catalyser	RKAT
Maximum performance of the engine/rotations	50.00 kW / 5000 rev. min^{-1}
Fuel type	BA 95 + LPG
Gear/number of levels	MT /5
Operating weight	1100 kg
Maximum admissible total weight	1615 kg
Dimensions and type of tires on the axle	1. 185/60 R14 82T 2
	2. 185/60 R14 82T 2
Maximum designed speed of the vehicle	164 km/h
Combined fuel consumption	7,2 l/100 km
Tire inflation	200 kPa/tire

Fig. 2. Navigation device Garmin Nüvi

The device enables recording routes, storing into memory and following downloading into the PC through USB interface. We used flow meter type Flowtronic 205 for recording the fuel consumption on particular routes. Measuring devices Flowtronic were applied. The schematic connection of the device into the fuel system is shown in the Figure 3. [3, 5].

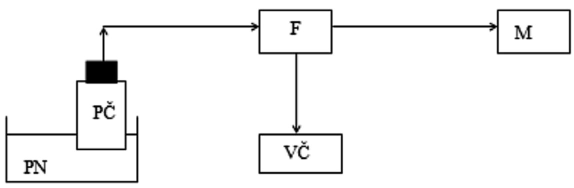

Fig. 3. Schematic connection of the Flowtronic device into the fuel system:_PN – fuel tank, PČ – fuel pump, F – Flowtronic 205, VČ – evaluating component, M – engine.

DESCRIPTION OF DEFINED ROUTES

Urban traffic is represented by Route No. 1 and Route No. 2. When planning the routes, we tried to include light-controlled crossings, roundabout crossings, pedestrian crossings, various altitudes of routes and especially those sections which have typical speed of maximum 50 km/h under the applicable legislation for urban traffic. Table 2 shows basic description of these two routes.

The outside urban traffic is represented by Route No. 3, whereas this is Class I road connecting the towns of Žilina and Kysucké Nové Mesto. The description of the route is also shown in Table. 2. The highway is represented by Route No. 4. The route leads to highway D3 and we measured the section between Žilina and Bytča. The proposed route is described in Table. 2.

EVALUATION OF MEASURED INPUT DATA

Table 3 summarises the analysis of individual routes with regard to percentage representation of individual speeds on given routes. We do not take into account the percentage share of individual speeds for the highway driving and we consider only average speed at the level of 120 km/h, due to the fact that variations, i.e. differences between average speed and maximum value of speed and the differences between average speed and minimum value of speed were insignificant. Driving was adjusted to current traffic conditions on the above mentioned infrastructure in time of measurement (condition of the road surface, weather conditions and traffic intensity).

The measured data on individual routes with regard to the total fuel consumption in cm^3 and v litres, fuel consumption in litres per 100 km, environment temperature and total weight of the vehicle are shown in Table 4. The measured values of fuel consumption will serve us for the following comparison with consumption values achieved by measurements on the rolling dynamometer, according to the prepared methodology on the grounds of measured input data.

CONCLUSION

The fuel consumption in l/100 km was calculated on the grounds of real total fuel consumption on a particular route in litres and measured in kilometres (passing distance). This is a simplified

Table 2. Description of defined routes for the preparation of methodology

Route	Direction	Distance (km)	Time (s)	Average speed (km/h)	Average inclination (%)
Route No. 1	V. Diel, Predmestská, Vysokoškolákov, V. Diel	9.44	1035	32.8	2.1 – 2.5
	Opačne	9.62	997	34.7	2.4 – 2.2
Route No. 2	Vysokoškolákov, V. Okružná, Predmestská, Vysokoškolákov	7.94	1053	27.2	1.6 – 1.7
	Opačne	8.06	1074	27.0	1.6 – 1.7
Route No. 3	ZA – KNM	6.58	303	78.2	1.9 – 1.8
	KNM – ZA	6.63	290	82.3	1.4 – 1.6
Route No. 4	ZA – BY	10.2	303	121.1	1.8 – 2.1
	BY – ZA	10.5	306	123.9	2.4 – 2.4

Table 3. Overview of the share of individual speeds on routes

Route	Route No.1 there				Route No.1 back			
Interval/ units	0 – 15 (km/h)	15 – 32 (km/h)	32 – 50 (km/h)	t_{vb} (s)	0 – 15 (km/h)	15 – 32 (km/h)	32 – 50 (km/h)	t_{vb} (s)
Time (s)	95.8	135.5	667.1	137	76.7	162.8	569	184.6
∑ (s)	1,035.4				993.1			
Proportion (%)	9.25	13.09	64.43	13.23	7.72	16.39	57.3	18.59
∑ (%)	100				100			
Route	Route No.2 there				Route No.2 back			
Interval/units	0 – 15 (km/h)	15 – 32 (km/h)	32 – 50 (km/h)	t_{vb} (s)	0 – 15 (km/h)	15 – 32 (km/h)	32 – 50 (km/h)	t_{vb} (s)
Time (s)	63	124.4	572	294	101	286.7	512.3	169
∑ (s)	1,053.4				1,069			
Proportion (%)	5.98	11.81	54.3	27.91	9.45	26.82	47.92	15.81
∑ (%)	100				100			
Route	Route No. 3 there				Route No. 3 back			
Interval/units	50 – 70 (km/h)		70 – 90 (km/h)		50 – 70 (km/h)		70 – 90 (km/h)	
Time (s)	131		172		66		224	
∑ (s)	303				290			
Proportion (%)	43.23		56.77		22.76		77.24	
∑ (%)	100				100			

Table 4. Measured values on individual routes

Route	Consumption			Distance	Enviroment temperature	M_{total}
	cm^3	l	l/100 km	km	˚C	kg
Route No.1 there	771.568	0.771568	8.182	9.43	10.5	1340
Route No.1 back	826.68	0.826680	8.593	9.62	14.0	1340
Route No.2 there	817.384	0.817384	10.295	7.94	15.0	1340
Route No.2 back	800.784	0.800784	9.948	8.05	15.5	1340
Route No.3 there	347.272	0.347272	5.278	6.58	16.5	1340
Route No.3 back	387.112	0.387112	5.830	6.64	16.0	1340
Route No.4 there	810.744	0.810744	7.948	10.2	15.5	1340
Route No.4 back	817.384	0.817384	7.785	10.5	15.5	1340

calculation of consumption on the particular route, because the actual fuel consumption in l/100 km does not have to be at a given level also in reality due to the conditions changing rapidly in urban traffic (delays on crossings, congestions etc.).

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