THE EFFECT OF THE ACCELERATOR POSITION ON THE FUEL CONSUMPTION OF ROAD VEHICLES

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Abstract: *The fuel consumption of road vehicles is influenced by many factors. One of them is the acclerator position. Measurment of the fue lconsumption on a rollingstand was done for the quantification of this effect. The tested vehicle was Kia Cee´d with a petrol engine. The measurments were done in laboratory condiditons to give higher accuracy. The results describe the degree of the effect of the accelerator position. They can be used for the determination the position considering to the actual output power of the engine and for the detrmination of the correctly driver behavour. The correctly usage of the accelerator contributes to the reduction of environmental burden of transport.*

Keywords: ACCELERATOR POSITION, OUTPUT POWER, FUEL CONSUMPTION

1. Introduction

One of the most common bad behaviors of drivers is incorrect usage of the accelerator. His actual position is influencing the fuel consumption. With the decreasing of the distance between the accelerator and the floor, the fuel consumption is increasing very fast and the vehicle´s acceleration is increasing slower. This effect is higher with increasing ratio of the acceleration position.

2. Measurement

The measurement was done on the rollingstand. This equipment allowed to simulate different driving modes with high accuracy. So it is able to simulate vehicle´s drive at a constan speed, uphilldriving, acceleration or the mixture of them. The rollingstand MAHA LPS 2000 with external equipment – engine speed sensor. Except of the driving modes simulations, the rolling stand can measure the maximal wheelpower, engine effective (output) power, velocity and torque.

For the measurement of the fuel consumption was used Flowtronic. This equipment measure the volume of the flowing liquid fuel (petrol) on the principe of the rotating pistons with rated volume.

For the monitoring of the throttle position was used diagnostic unit Kia HiScan. This unit can be connected to the OBD port. It is measuring and visualising all operational data of the engine. It can be used only in the vehicles of the mark Kia.

The tested vehicle was Kia Cee´d with petrol engine of the volume 1,6 l, the output power 90 kW.

The rollingstand, other equipment, the vehicle and laboratory are the property of the Department of the Road and Urban Transport at the University of Zilina.

Fig. 1 *Rollingstand in the laboratory.*

3. Vehicle dynamic specifications

As the basic point of the output power which is needed to reach standard driving dynamic, it is necessary to terminate what is „the standard“. This standard driving and dynamic situations are:

1. Driving at a constant speed (according to the conditions – urban area, extra-urban area, motorway)
2. Accleration needed to reach a constant speed (according to the regulation ECE 101).

3.1. Driving power equations:

Rolling resistance:

(1) $$P_f = G_T.cos\alpha.f.v = m.g.cos\alpha.f.v[W]$$

m – vehicleweight [kg], g – gravityaccleration[m.s^{-2}], α – elevationangle [°], f – rollingcoef. [-], v – velocity [m.s^{-1}]

Aerodynamic drag:

(2) $$P_v = \frac{1}{2}.\rho_v.c_d.S.v^3[W]$$

ρ_V–airdensity [kg.m^{-3}], c_d – dragcoef. [-], S – frontalarea [m^2]

Elevation:

(3) $$P_s = G_T.sin\alpha.v = m.g.sin\alpha.v\ [W]$$

Accleration:

(4) $$\boldsymbol{P_a = m.a.\delta.v} \quad [W]$$

a – drivingacceleration[m.s^{-2}], $\boldsymbol{\delta}$–rotatingmassescoef [-]

Summary of wheelpower:

(5) $$P_k = P_e.\eta_P = \Sigma P = P_f + P_v + P_s + P_a \quad [W]$$

P_k – wheelpower [W], P_e – engine output power [W], $\boldsymbol{\eta_P}$ – gearefficiency [-]

The summary are considered for individual driving modes:

1. Constant speed, no elevation

$$P_1 = P_e.\eta_P = \Sigma P = P_f + P_v \quad [W]$$

2. Constant speed with elevation

$$P_2 = P_e.\eta_P = \Sigma P = P_f + P_v + P_a \quad [W]$$

3. Acceleration (only without elevation)

$$P_3 = P_e.\eta_P = \Sigma P = P_f + P_v + P_a \quad [W]$$

3.2. Input vehicle values

m = 1518 kg (1263 kg empty vehicle + 3 persons á 75 kg and 30 kg luggage)

f = 0,01

c_d = 0,32

S = 2,05 m^2

δ = 1,05 – 1,11 (according to the actual gear)

η_P = 0,93

- Other factors are considered with values in refrence physical conditions

For the calculation of „normal driving power values“ was necessary to set casual acceleration and velocity values. Velocity at constant speed was chosen as border or round values used in cities, local roads or highways. For the set of accleration was chosen as basic the values used in the ECE Vehicle Regulation n. 101.

Table 1: *Acceleration values*

Our values		Reg. No. 101		
Velocity (km.h^{-1})	Acceleration (m.s^{-2})	Acceleration (m.s^{-2})	Velocity (km.h^{-1})	Cycle
15-30	0,8	0,79	(15-32)	urban cycle
30-50	0,5	0,45	(35-50)	urban cycle
50-70	0,45	0,4 - 0,43	(50-70)	urban cycle
70-90	0,25	0,24	(70-100)	extra-urban
90-110	0,25	0,24	(70-100)	extra-urban
110-130	0,3	0,28	(100-120)	extra-urban

Table 2: *Engine output power*

Engine output power (kW)							
Mode	Elevation (%)	Velocity (km.h^{-1})					
		30	50	70	90	110	130
Constatnt speed	0	1,6	3,4	7,1	12,4	20,2	31,1
	3	5,6	10,1	16,4	24,4	34,9	48,5
	6	9,6	16,7	25,7	36,3	49,5	-
	9	13,6	23,4	35,0	48,3	-	-
	12	17,5	29,9	44,2	60,1	-	-
	15	21,4	36,4	53,2	71,8	-	-
Acceleration		Acceleration (from - to, velocity)					
		15 - 30	30 - 50	50 - 70	70 - 90	90 - 110	110 -130
		13,6	16,0	22,4	23,2	33,4	46,6

Table 2 describes the engine output power calculated accroding to the equations of the driving power (Eq.1 - 5). The red numbers are the border values, which occur infrequently during normal operation. The elevation values and the velocity were set according to the border or round values. E.g. the elevation 6% is usualy at local roads where is the speed limit 90 km/h, but i tis rather an exception on highways. So it is not necessary to considere with output power in these columns (-). The power values during accelerations were set as the largest value of the output power in the corresponding interval.

4. Accelerator position and fuel consumption

Table 3: *Accelerator position and output power*

Throttle position (%)	Accelerator position (%)	Engine output power (kW) at rpm					
		2100	2500	2700	3300	3500	3900
78,8	100	29,7	35,6	40,1	48,7	51,9	59,6
32,2	41	26,7	32,1	36,0	43,8	46,7	53,7
20	25	24,0	28,9	32,4	39,4	42,0	48,3
16,1	20	21,4	25,7	28,9	35,2	37,5	43,1
13,7	17	17,9	21,5	24,2	29,4	31,3	36,0
11,4	14	14,6	17,5	19,6	23,9	25,5	29,2
10,2	13	12,4	14,9	16,8	20,4	21,8	25,0
9	11	9,9	11,8	13,3	16,2	17,2	19,8
7,8	10	7,7	9,2	10,3	12,6	13,4	15,4
6,7	9	5,5	6,6	7,4	8,9	9,5	11,0

This table describes the most often used output power and operational engine rotation. These values was calculated according to the previous table. The colour of each column represents driving mode and corresponding elevation from the previous table. This calculated power occurs during the vehicle operation descibed in the previous tables.

Throttle position was identified through HiScan diagnostic. I tis necessary to note, that the accelerator position and the throttle position are not the same values.

The table shows the area of the accelerator position used during the „normal“ operation. The operational range of the accelerator is in the inetrval of 0 – 40 % of its whole range. It seems that every position out of this inetrval is unnecessary, because the output power increases very slowly (see fig. 1), but the fuel consumption considerably (see fig. 2).

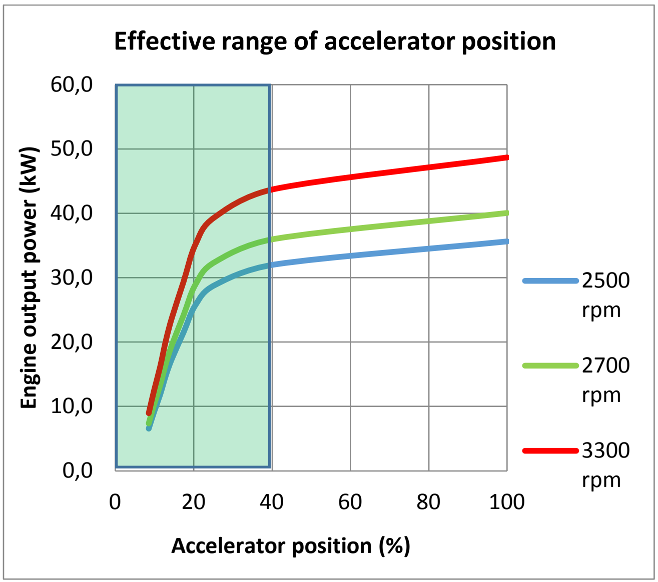

Fig. 2 *Effective range of the accelerator position*

Figure 2 shows the incresing output power according to the accelerator position (0% is idle, 100% is kick down). The output power values and increasing characteristics in the interval up to 40 % is optimal for the vehicle operation.

Table 4: *Accelerator position and fuel consumption*

Accelerator position (%)	Fuel consumption (l/100km)	Output power (kW)
100	25,76	35,6
41	21,09	32,1
25	19,96	28,9
20	15,29	25,7
17	13,84	21,5
14	11,43	17,5
13	9,98	14,9
11	8,37	11,8
10	7,08	9,2
9	7,89	6,6

Table 4 shows the characteristic the fuel consumtion according to the accelerator position. The right column represents the output power needed to drive the vehicle at the velocity 50 km.h^{-1} (colouration to the elevation and acceleration). The blue square borders the output power needed to the accleration to the velocity 50 km.h^{-1} .The fuel consumption values are rusults of the fuel consumption measurement done at engine speed of 2500 rpm using the 3rd gear which corresponds the velocity 50 km.h^{-1}.

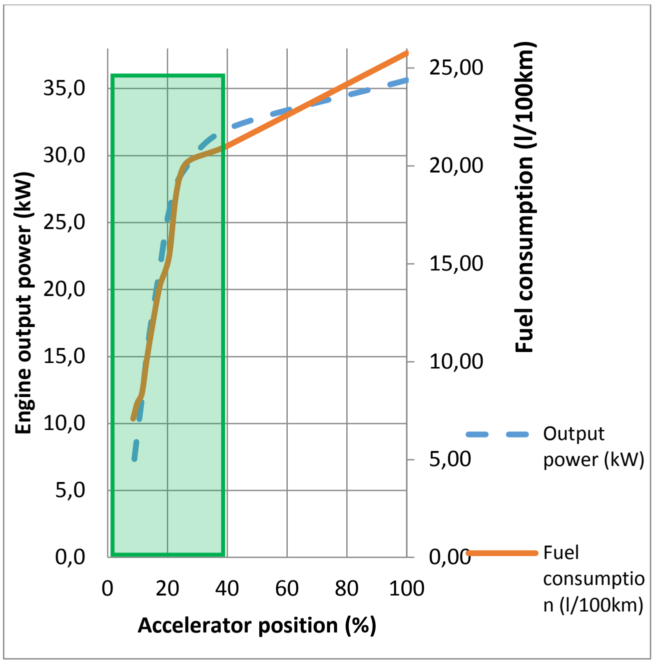

Fig.3 *Course of the fuel consumption and the output power*

5. Conclusion

The results point to the fact to mind during driving. I tis the reality that accelerator position does not correspond with the engine output power, vehicle dynamics and fuel consumption. During the accelerator pushing down (from the idle to the kick down), the output power is increasing less and the fuel cosumtion is increasing more. The optimal operational range of the accelerator is up to 40% of the total range. Over this interval is the vehicle operation less effective from the economic and environmental point.

6. Literature

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