SPECIAL MONITORING DEVICE FOR EVALUATION OF DRIVING STYLE OF CAR DRIVERS

Mario Szabo, Radoslav Majdan, Stanislav Lindak, Vladislav Hajdak
Slovak University of Agriculture in Nitra
szabo@dtx.sk, radoslav.majdan@uniag.sk, xlindak@is.uniag.sk, vladislav.hajdak@gmail.com

Abstract. The article is focused on fuel efficiency of cargo trucks, summarizing some factors effecting the fuel consumption, considering the human factor and the method of fuel consumption measurement of transport companies. We designed a special monitoring device to detect an increase in the fuel consumption caused by the driving style of drivers. This device recorded the vehicle logbook, current position, date, time and vehicle speed, as well as the frequency of the brake pedal pressing while driving. The device can be powered by the USB port, a separate source of energy, or by the car cigarette lighter socket utilization. We evaluated the driving style of car drivers by the number and duration of brake pedal pressing. We attached the first part of the contactless sensor to the brake pedal, the second one to the car chassis. A signal from braking lights could be used as well. The designed software calculated braking deceleration, which influenced the fuel consumption, by means of the measured data. Different types of cars are using various ways of driving style recording and these systems are not compatible with each other. The designed device can be universally used for various cars; therefore, we were able to compare different cars with this special monitoring device. After the device construction, we tested the device during operation of road cars. The recorded data were saved on the SD card. The average deviation of the measured data reached a value of 7.94 %. We designed special software to analyse the saved data. Based on the measured data we can conclude that it is possible to achieve fuel savings up to 20 % due to implementation of economic driving skills.

Keywords: human factor, Global Positioning System, brake pressings, fuel consumption .

Introduction

According to [1], exploitation of primary energy sources negatively affects the environment in case of extraction and fuel treatment, but primarily in transformation of one type of energy into the other. Reducing of the fuel consumption has ecological as well as economical reasons.

In addition to fuel consumption, which is necessary for towing vehicles to run, excessive fuel consumption is likely to occur in practice as well. The amount of excessive consumption is influenced by many factors. As the fuel price is increasing dramatically, it is important to recognize these factors and to minimize the fuel consumption [2].

Besides the engine type, other factors influence fuel consumption as well. Many factors depend on the technical condition of vehicles. However, we mention only the factors that we are able to influence [3].

Aerodynamic resistance has a great impact on the overall fuel consumption. This resistance can be reduced considerably by a proper use of spoilers and aerodynamic stabilizers. However, the spoilers, which are used unprofessionally, can increase the fuel consumption [4].

Based on the research carried out by the Renault and Michelin companies, the rolling resistance of tyres represents approximately one third of the overall power of resistance to motion. The tyre warms up during the ride, which is caused by bend stress (bend of the tyre side, bend of the tyre tread). Tyre bend causes friction that releases heat. That heat is the energy that the engine has to overcome. It is one of the fuel consumption factors [3].

Apart from these factors, there is one more factor, which might significantly affect the vehicle excessive fuel consumption level – human factor. Economical driving style might result in fuel saving between 10 % and 25 % – better fuel saving as obtained by any technical solutions [5].

Materials and methods

We designed a special device to detect an impact of drivers on excessive fuel consumption. 5 V supply voltage, operating frequency from 8 000 to 16 000 Hz, 128 kB internal FLASH memory, 4 kB internal SRAM memory were the main technical properties of our device.

We designed and programmed our device (Fig. 1a, b) to save the number of loggings, date, time, speed, driving distance since the last logging, GPS coordinates and the brake pedal position data on SD card within the period of 0.2 s.

a) b)

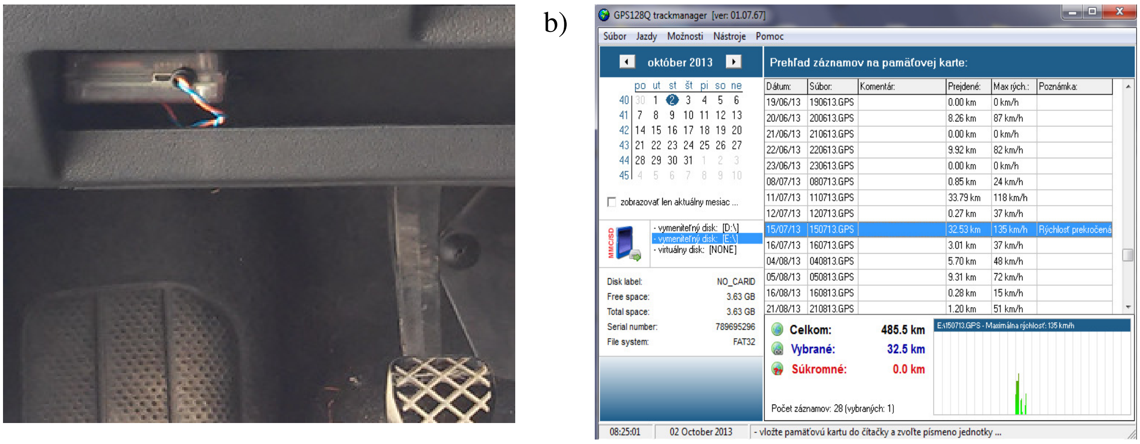

Fig. 1. **Device detecting an impact of driver on fuel consumption:** a – individual parts connection; b – software for logging evaluation

We monitored the position of the brake pedal by means of a contactless scanner attached on the brake pedal. When the brake pedal was pressed in the moment of logging, the device recorded a value of “1” on the memory card; the value of “0” was recorded in the opposite case. Position of the brake pedal was monitored every 0.2 seconds, i.e. five times per second.

By means of such device it was possible to detect, if the driver drove like a “racer”, drove by brake-throttle style or drove economically. We could detect the driver’s acceleration and braking, contravention of traffic rules as well as mistakes in the driving behaviour and style. The device was powered by the USB port connected to the power box with four monocells with a voltage of 1.5 V placed in a holder or the vehicle lighter socket.

Our device can be used to create driving books, to monitor speeding on roads, to control drivers (possible stops on suspicious places), to measure the travelled distances per day, to display the travelled trips on maps (Fig. 1b). We could monitor the vehicle online by means of the installed GPS module, but it was not the object of our study.

XL Meter Pro

Measurement device XL Meter Pro Gamma Medium type (product of company Inventure) was designed to evaluate the driving brake function and it allows measurement of acceleration or braking initial response time during reconstruction of car accidence.

This device allows the measurement of acceleration and deceleration with a digital record. It records three independent measurements and saves them on internal memory. The device contains software that allows evaluation of the measured parameters after a few seconds. RS 323 utilization or USB can connect the device to the computer. The device communicates with computer through XL-Vision TM software. The measured data are saved to PC as ASCII format and they are consequently evaluated.

The measurement device allows measuring MFDD – braking deceleration ($m \cdot s^{-2}$).

An impact of braking on fuel consumption

We realized the measurement with Skoda Octavia vehicle on the 3rd of March 2015 to verify an impact of the driving style on fuel consumption. In this measurement, two drivers used the same car and the same route.

We planned the test route from Diakovce village (Slovak republic) through 1.5 km straight leg to Šaľa city (Slovak republic), then through the traffic jam to Veča residential area and then through longer straight leg to the Duslo Šaľa company, our end of this route.

Both drivers had to respect the Road Traffic Regulations and could not change the planned route. During the verification test, all electronic accessories of the car were turned off and all windows were closed to minimize perturbing influence on resultant fuel consumption.

We installed a special monitoring device in the car to observe the driving style of the drivers. Based on the data from the mechanical position sensor, which was attached to the brake pedal, we recorded information about brake pressing.

The driver "A" respected all principles of economical driving (eco driving) and he intended to drive as economical as possible. We did not inform the driver "B" about the principles of economical driving and he passed the planned route in the shortest possible time.

We recorded information about the fuel consumption and route distance from an on-board computer, which was set to zero before every ride. We did not measure the driving time, we used a special monitoring device for time calculation.

Results and discussion

Measurement of braking deceleration

We realized a measurement with Skoda Octavia vehicle with an installed device to calculate braking deceleration. We used a special monitoring device and XL Meter Pro both together during these measurements. We realized nine decelerations from 50 $km \cdot h^{-1}$ and three measurements from 60 $km.h^{-1}$ to 0 $km.h^{-1}$.

We exported the measured data in TXT format for the next processing in Microsoft Excel software. The XL Vision program generated the maximum and minimum value of braking deceleration. We obtained average braking deceleration by means of the monitoring device. We identified the starting and finishing point of braking from graph display. We calculated an average value by means of AVERAGE function of Microsoft Excel programme.

We detected the starting point of braking at 35.82th second and the finishing point at 39.98th second of measurement no. 1. The device saved the braking deceleration values every 0.01 second (Fig. 2).

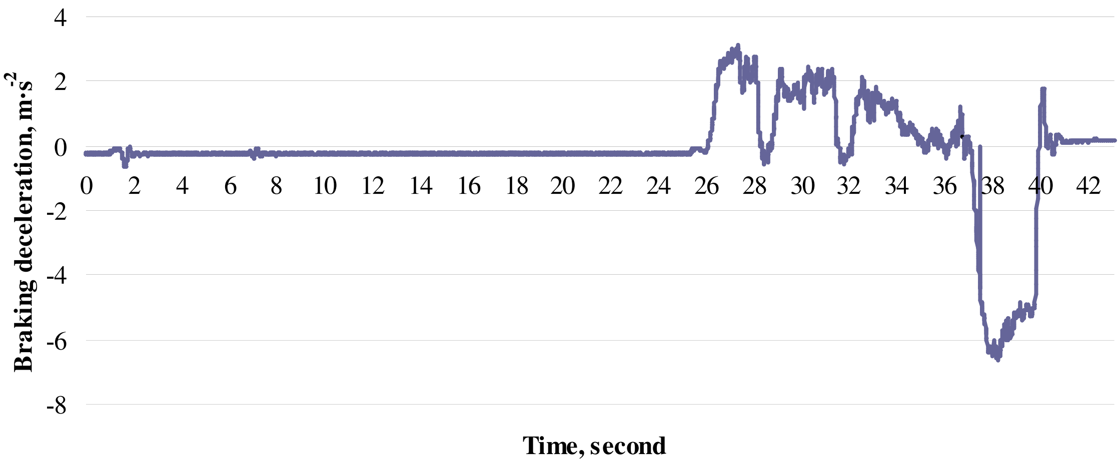

Fig. 2. **Course of braking deceleration during measurement no. 1**

We compared the final values of braking deceleration with the data measured by the designed device. We evaluated the braking measurement no. 1 by Microsoft Excel programme. Table 1 shows the original values for the calculation.

The designed device saved the records about the braking pedal position (value "0" for pressed braking pedal) and actual velocity every 0.2 second on the memory card. We could calculate the total time of braking and the final braking deceleration by utilization of these records.

Table 2 shows final comparison of braking deceleration calculated by XL Meter Pro device and our device together with other parameters.

Table 1

Data table of braking deceleration

No	Deceleration	Speed, m·s^{-1}	GPS	
1522	0	13.33	48.30286	18.10401
1523	0	12.78	48.30288	18.10399
1524	0	12.78	48.3029	18.10396
1525	0	12.50	48.30292	18.10394
1526	0	12.50	48.30294	18.10392
1527	0	12.22	48.30295	18.10390
1528	0	12.22	48.30297	18.10388
1529	0	11.39	48.30299	18.10387
1530	0	10.28	48.303	18.10385
1531	0	9.44	48.30301	18.10383
1532	0	8.89	48.30303	18.10382
1533	0	8.06	48.30304	18.10380
1534	0	7.50	48.30306	18.10379
1535	0	6.67	48.30306	18.10378
1536	0	5.83	48.30307	18.10377
1537	0	4.44	48.30308	18.10376
1538	0	3.33	48.30309	18.10375
1539	0	2.50	48.30309	18.10374
1540	0	1.39	48.30309	18.10374
1541	0	0.00	48.30309	18.10374
t = 4 s	Δv =	12.78	m·s^{-1}	
Braking deceleration	a =	3.28	m·s^{-2}	

Table 2

The final table of measured braking deceleration

No	1	2	3	4	5	6	7	8	9	10	11	12	Average
MFDD, m·s^{-2}	3.28	3.26	3.15	2.96	2.97	2.88	2.75	2.71	3.17	2.99	3.41	3.75	3.11
Device, m·s^{-2}	3.12	3	3.12	2.55	2.75	2.78	2.39	2.42	3.01	2.79	3.15	3.24	2.86
Difference, %	4.88	7.98	0.95	13.85	7.41	3.47	13.09	10.7	5.05	6.69	7.62	13.6	7.94

The difference between the calculated average braking deceleration from the designed device and from XL Meter Pro was 7.94%. This difference was caused by the GPS sensor ineligibility to record the rapid change of velocity. This difference was not significant enough to affect the measured data negatively. Therefore, our designed device can be used for maximum braking deceleration measurement under practical conditions.

An impact of braking deceleration on fuel consumption

Based on the methodology mentioned above, we realized the measurements shown in Table 3.

Table 3

The influence of braking deceleration on fuel consumption

Parameter	Driver "A"	Driver "B"
Distance, km	10.7	
Fuel consumption, l·(100 km)$^{-1}$	7.1	8.3
Braking pedal pressing while driving, %	1.21	15.17
Average braking deceleration, m·s^{-2}	0.63	0.84
Total number of braking	6	50
Time, minute	15:23	14:07

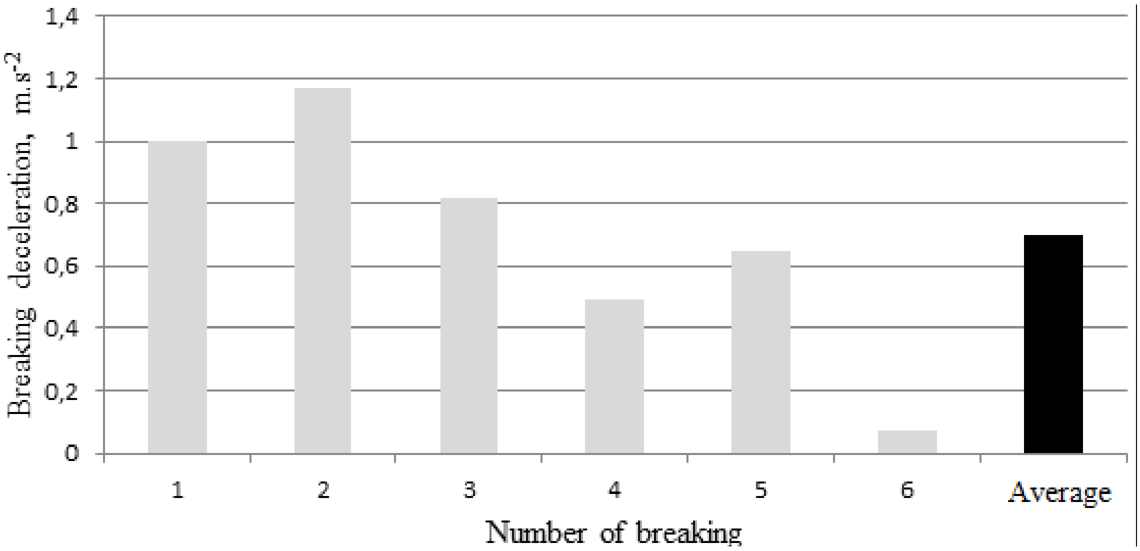

Fig. 3. **Value of braking deceleration of driver “A”**

Fig. 4. **Value of braking deceleration of driver “B”**

We measured lower fuel consumption about 1.2 l·(100 km)$^{-1}$ for the driver “A” compared to the driver “B”, because the driver “A” respected all principles of economic driving. The driver “A” pressed the braking pedal for six 6 times, on the other hand, the driver “B” pressed the pedal for fifty times under the same test conditions. The difference in average braking deceleration in our study was not significant, because the driver “B” did not press the brakes intensively but more frequently (duration of brake pedal pressing while driving). The driver “A” reached the value of 1.21 %, the driver “B” 15.17 %. Therefore, higher fuel consumption of the driver “B” was caused by often brake pedal pressing, because of unrespected economical driving principles and poor traffic prognosis.

Higher fuel consumption can occur, when duration of the braking pedal pressing is similar, but the value of average braking deceleration is higher. This situation can occur, when the driver ignores the traffic situation and responds to traffic events with last minute, instant, full brake pedal pressing.

There are three main parameters presented effecting the fuel consumption [6]. These parameters are the roadway, car and driver. We can decrease the fuel consumption by monitoring the driving regime. Driver with common qualification will reach higher fuel consumption about 5 % compared with the possible minimum [4]. There is presented [4; 5] a decrease in the fuel consumption above 20 % after economic driving training graduation. The motivation of drivers based on the working quality and fuel saving can affect the decrease in the fuel consumption and the costs of all companies.

Conclusions

We can reach better feedback about the driving style of drivers by monitoring of the number of the braking pedal pressing and braking intensity. Full braking occurs mainly if the driver ignores the traffic events and responds to change of the traffic situation instantly. If the driver does not use kinetic energy of the car in the right way, he has to use car brakes frequently, although he does not brake intensively. Based on the measured data, we can distinguish an economically driving driver from the one, who increases the fuel consumption; therefore, negatively effects the technical state of the car and environment.

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References

1. Vitázek, I. 2006. Tepelné procesy v plynnom prostredí. Nitra : Slovenská poľnohospodárska univerzita, 2006. ISBN 80-8069-716-7
2. Tkáč Z., Hujo Ľ., Tulík J., Kosiba J., Uhrinová D., Šinský V. Greening of agricultural and forestry tractors. InActa Universitatis Agriculturae et Silviculturae Mendelianae Brunensis. ISSN 1211-8516, 2014, vol. 62, no. 5, pp. 1135-1139 (2014).
3. Angelovič M., Tkáč Z., Angelovič M. Oilseed rape as feedstock f or biodiesel production in relation to the environment and human health. In Potravinárstvo Online. ISSN 1337-0960, 2013, vol. 7, no. 1, pp. 101-106
4. Szalay Z., Kánya Z. Practical Experiences of an On-Board Technical Inspection Support System for Commercial Vehicles, FISITA 2010 World Automotive Congress, Budapest, 30 May – 4 June 2010. F2010E067.
5. Uhrinová D., Jablonický J., Hujo Ľ., Kosiba J., Tkáč Z., Králik M., Chrastina J. Research of limited and unlimited emission effect on the environment during the burning of alternative fuels in agricultural tractors. In Journal of Central European Agriculture online. ISSN 1332-9049, 2013, vol. 14, no. 4, pp. 1402-1414, online (2013).
6. Szalay Z. “Technologie der Primärretarderprüfung in der periodischen Kraftfahrzeug-Überwachung” Verkerhrsunfall und Fahrzeugtechnik, Vol 43. No 5. Mai 2005., pp. 105-109. ISSN 0724-2050 E 20034