Monitoring of the impact of operating personnel on the transportation efficiency in the intercity bus transport

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Abstract: *The study monitors the impact of operating personnel on the efficiency of bus operation. The aim of our study was to evaluate the impact of operating personnel on the fuel consumption by individual months within a period of one year. Two bus drivers, operating same intercity bus, rotated in regular intervals. Driving records were kept for each bus driver separately and results were recorded in tables according to the current month. The results, which were evaluated from recording sheets according to individual months, were recorded in the final table for each bus driver separately. Subsequently, the amount of used fuel was compared between each bus driver.*

Key words: *intercity bus, evaluation, fuel, consumtion.*

Introduction

The driver is affecting the fuel consumption by his driving technique and overall care of the vehicle, which is an integral part of the driver at work. Correct driving technique requires not only practical experience, but also knowledge of the design of selected type the motor vehicle. The technique of driving at diesel engines may negatively affect fuel consumption by 20-25 %. The actual influence degree of driving techniques on fuel economy is directly related to operating conditions and circumstances. The effort to reduce the fuel consumption of road vehicles must be always based on a specific knowledge of all factors that affect the fuel consumption. This applies chiefly for companies, which operate cars, trucks or buses, because the fuel economy of vehicles is an important factor in overall economic performance for them. The ensuring of economical operation of cars does not affect only their fuel consumption, but also other important factors, such as amount of exhaust gases emissions, reliability, technical readiness of the car etc. Several factors affect the fuel consumption directly and we can evaluate their impact, such as technical parameters of vehicle type and design, while others affect indirectly and we can't precisely define the extent of their influence. Individual factors affecting fuel consumption are influencing each other, meaning that they have reciprocal links. The whole issue of fuel consumption should be understood systematically together with solution approach. The poor driving technique of driver characterized by a hard and penetrative way of driving will be reflected within a short time on the technical condition of the car. Conversely, the best driver can never ride economically with the vehicle in poor technical condition. . The attainable speed and smoothness of driving are affected by route properties and traffic flow characteristics, which affect the fuel consumption as well. Particularly quality of traffic management can generate significant savings in urban traffic. It is important to remove various barriers, which obstruct the fluency of the traffic. Interaction between impact of transport route and driving technique of driver is very important in terms of economy. The optimal driving conditions can be achieved by construction of quality communications, which positively affect the overall fuel economy of vehicles. (Janoško, 2013).

Material and methods

The aim of this work was to assess the impact of drivers on operation economy of bus transport vehicles. The impact of drivers on operational economy was determined on a bus, used for intercity transport of periodic line Nitra - Šaľa, belonging to Veolia Transport Nitra a.s. It was a vehicle Irisbus Iveco Crossway, (Figure 1), with selected technical parameters, (Table1).

Selected technical parameters of Irisbus Iveco Crossway 12M vehicle

Fig. 1 Irisbus Iveco Crossway bus (https://www.flickr.com)

Tab.1 Selected parameters of the vehicle

(Irisbus Iveco Crossway 12M	
Dimensions	
Length	11 995 mm
Width	2 550 mm
Height (without air conditioning)	3 395 mm
Wheelbase	6 200 mm
Height of floor	860 mm
Total weight	18 000 kg
Engine	
Engine Displacement	5.8 l
No of Cylinders	6
Power	220 kW (300 bhp)
Torque	1050 Nm
Gearbox	
Type	Manual 6-step
Wheels and tyres	
Tyres	295/80 R 22,5
Wheels	8.25“ x 22.5“
Brakes	
Type	Disk brakes with ABS, ASR
Fuel tank	
Volume	210 l

Route of bus transport

Two drivers rotated at regular intervals on the mentioned bus line. According to the timetable, the total distance between cities is 30 km, where bus is travelling through following sections: Nitra, bus station – Cabaj - Čápor – Močenok – Šaľa railway station, (Figure 2).

The impact of driver on operational economy of vehicle

The impact examination of driver on operational economy of vehicle focused on the average fuel consumption of individual drivers while driving for 100 km and consequently on total fuel consumption. The amount of consumed fuel was detected by a simple method based on refuelling into the vehicle tank at the end of each working day of driver. Fuel consuption report showed how many litres of fuel were refuelled at the gas station to vehicle. This method is based on the amount of gas pumped into the main tank vehicle (l), during the monitored period and also on the number of kilometres travelled by the vehicle (km) during the monitored period.

The fuel consumption was calculated according to equation:

$$Sp_1 = \frac{V}{L} 100 \ , \qquad (1)$$

where Sp_1 - fuel consumption (l/100 km),

V - amount of refuelled diesel (l),

L- distance travelled by the vehicle (km).

Fig.2. Route of bus transport

Marked points on the map:
A) Nitra, Bus station,
B) Cabaj - Čápor,
C) Močenok,
D) Šaľa, railway station.

Because in the winter months it is necessary to heat the vehicle, while the air temperatures is different for each day, the impact of driver on operation economy of vehicle calculated by selected equation for fuel consumption would be distorted due to fuel consumption for heating of the vehicle. Because the drivers cannot determine the amount of fuel consumed for heating and heating of the vehicle per day, differences in fuel consumption could occured, affecting final fuel consumption of drivers, as well as driver's impact on operational economy of public transport vehicle. Therefore the amount of fuel consumption was calculated by equation (2), which excludes differences in fuel consumption between drivers caused by the consumption of fuel for heating and heating of vehicle. The amount of fuel consumption per ride could be calculated according this equation:

$$Sp_2 = \frac{V - V_{vo}}{L} 100 \ , \qquad (2)$$

where Sp_2 - fuel consumption on a ride (l/100 km),

V - volume of refuelled diesel (l),

V_{vo} - volume of diesel consumed for heating of the vehicle (l),

L - distance travelled by the vehicle (km).

Works Evidence of driver "A" and driver "B".

The selection was focused to determine differences between driving modes of individual drivers. The base for data processing consisted of work evidence of drivers in the form of recording sheets, which focused to determine actual fuel consumption. The obtained data were processed by a quantitative method and were verified by qualitative analysis.

Subsequently, recording sheets designated for drivers were created, which formed data on total kilometres, drivers of bus, average fuel consumption per 100 kilometres and the total fuel consumption. The sheets were created for each driver for the period of December 2012 - November 2013. The obtained data were progressively recorded on these sheets by responsible person. The survey lasted one year. Individual values measured with both drivers were compared with each other. The achieved results were subsequently presented.

Results and Discussion

Data that were recorded after each working day of the bus driver, were inscribed in each record sheets corresponding to each month throughout the year and are shown in the recording sheets as achievements of bus driver "A" and bus driver "B". Since the survey was conducted during the period: December 2012 - November 2013, 12 record sheets were completed. "November 2013" was chosen as an example from 12 recording sheets listed in the survey, referred to as (Table 2).

The resulting values of the 12 individual recording sheets were written into the final table, which consists of the monitored parameters of the driver "A" and driver "B" on a monthly basis during the period December 2012 - November 2013 and is listed as (Table 3).

Tab. 2 Overview the monitored parameters of drivers in November 2013

	Number of working days in the month	Travelled kilometres	Norm l/100 km	Premium to the norm %	Total fuel consumption according to norm in litres	Total fuel consumption in litres - real	Heating and warming-up in litres	between standardized and real fuel consumption in	The average fuel consumption in l/100 km	Total fuel consumption without heating and warming-up in litres	Fuel consumption per ride (l/100 km)
Driver A	1	322	24	0	79.5	72	2.2	7.5	22.36	69.8	21.68
	2	302	24	0	72.5	71	0	1.5	23.51	71	23.51
	3	322	24	0	77.3	74	0	3.3	22.98	74	22.98
	4	242	24	0	60.6	61	2.5	-0.4	25.21	58.5	24.17
	5	322	24	0	77.3	75	0	2.3	23.29	75	23.29
	6	302	24	4.8	77.9	78	2	-0.1	25.83	76	25.17
	7	302	24	4.6	78.3	78	2.5	0.3	25.83	75.5	25
	8	302	24	5.5	76.5	75	0	1.5	24.83	75	24.83
	9	322	24	1	80.6	80	2.5	0.6	24.84	77.5	24.07
	10	302	24	0	74.8	75	2.4	-0.2	24.83	72.6	24.04
	11	302	24	0	74.7	71	2.2	3.7	23.51	68.8	22.78
	12	302	24	-0.1	74.7	70	2.3	4.7	23.18	67.7	22.42
	13	302	24	0	74	74	1.5	0	24.5	72.5	24.01
	14	328	24	0	78.7	78	0	0.7	23.78	78	23.78
	15	322	24	0	79.8	80	2.5	-0.2	24.84	77.5	24.07
	Total	**4 596**			**1 137.2**	**1 112**	**22.6**	**25.2**	**24.22**	**1 089.4**	**23.72**
Driver B	1	302	24	-0.1	74.7	75	2.3	-0.3	24.83	72.7	24.07
	2	268	24	0	64.3	64.1	0	0.2	23.92	64.1	23.92
	3	302	24	0	73	73	0.5	0	24.17	72.5	24.01
	4	328	24	6.7	86.5	87	2.5	-0.5	26.52	84.5	25.76
	5	302	24	0	75	75	2.5	0	24.83	72.5	24.01
	6	322	24	0	77.3	77	0	0.3	23.91	77	23.91
	7	242	24	0	58.1	52	0	6.1	21.49	52	21.49

8	302	24	0	72.5	72	0	0.5	23.84	72	23.84
9	322	24	0	77.3	76	0	1.3	23.6	76	23.6
10	302	24	0	72.5	72	0	0.5	23.84	72	23.84
11	302	24	0	72.5	71	0	1.5	23.51	71	23.51
12	302	24	0	72.5	71	0	1.5	23.51	71	23.51
Total	**3 596**			**876.2**	**865.1**	**7.8**	**11.1**	**24**	**857.3**	**23.79**

Table 2 shows, that driver "A" worked 15 days and travelled 4596 km in November 2013. The total fuel consumption was 1112 litres within 15 days. According to norm, 1137 litres should be consumed within 15 days, thus 25 litres of fuel was saved. Driver "B" worked 12 days and he travelled 3596 km in November 2013, while the fuel consumption was 865 litres. According to norm, 876 litres should be consumed within 12 days, thus 11 litres of fuel was saved.

Tab.3. Final table of monitored parameters during the period of December 2012 – November 2013

	Month	Total number of travelled kilometres	Total fuel consumption according to norm in litres	Total fuel consumption in litres - real	Heating and warming-up in litres	The difference between standardized and real fuel consumption in litres	The average fuel consumption in l/100 km	Total fuel consumption without heating and warming-up in litres	The average fuel consumption on ride l/100 km
Driver A	12/12	4319	1068.2	1055	25.5	13.2	24.31	1029.5	23.75
	1/13	4526	1167.4	1139.6	14	27.8	25.25	1125.6	24.89
	2/13	3764	982.3	944	41.5	38.3	25.17	902.5	24
	3/13	4052	1002.8	965	29.4	37.8	23.83	935.6	23.09
	4/13	4361	1046.9	975	0	71.9	22.38	975	22.38
	5/13	4454	1069.1	990	0	79.1	22.23	990	22.25
	6/13	4656	1117.7	1021	0	96.7	21.95	1021	21.95
	7/13	4254	1021.2	901	0	120.2	21.22	901	21.22
	8/13	4114	987.6	888	0	99.6	21.61	888	21.61
	9/13	4661	1118.8	1061.3	0	57.5	22.76	1061.3	22.76
	10/13	4462	1079.5	1036	8.5	43.5	23.22	1027.5	23.03
	11/13	4596	1137.2	1112	22.6	25.2	24.22	1089.4	23.72
	Total	**52 219.00**	**12 798.70**	**12 087.90**	**141.50**	**710.80**	**23.18**	**11 946.40**	**22.89**
Driver B	12/12	3837	943.9	943	15	0.9	24.6	928	24.21
	1/13	3601	929.1	922.1	12.5	7	25.63	909.6	25.29
	2/13	4012	1053.3	998	42.3	55.3	24.85	955.7	23.82
	3/13	4180	1029.8	1001.5	26.2	28.3	23.97	975.3	23.34
	4/13	3992	958.3	924.4	0	33.9	23.1	924.4	23.1
	5/13	3676	882.4	854.9	0	27.5	23.26	854.9	23.26
	6/13	3924	941.9	878.6	0	63.3	22.36	878.6	22.36
	7/13	4718	1132.6	1048.1	0	84.5	22.22	1048.1	22.22
	8/13	3569	850.2	779	0	71.2	21.83	779	21.83
	9/13	3471	833	802.1	0	30.9	23.12	802.1	23.12
	10/13	4400	1060.6	1022	4.4	38.6	23.22	1017.6	23.12
	11/13	3596	876.2	865.1	7.8	11.1	24	857.3	23.79
	Total	**46 976.00**	**11 491.30**	**11 038.80**	**108.20**	**452.50**	**23.51**	**10 930.60**	**23.29**

Recording sheets indicated that driver "A" drove for 179 days and the driver "B" for 157 days during monitored period. They travelled 99 195 kilometres together and 23 127 litres of fuel was consumed, while 24 290 litres supposed to be consumed according to company's assumption. Driver 'A' travelled 52 219 kilometres and driver "B" travelled 46

976 kilometres. 5 243 kilometres represent a difference of travelled kilometres between drivers. The amount of travelled kilometres per month, recorded for both bus drivers, is presented in Figure 3.

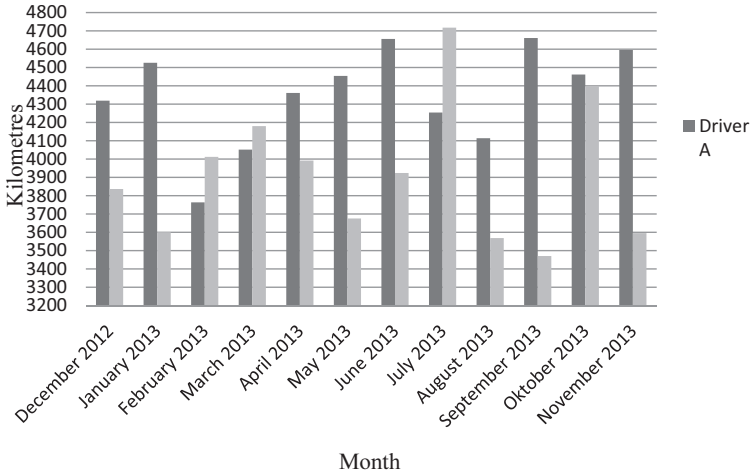

Fig.3. The amount of travelled kilometres per month

Driver "A" supposed to reach 12 799 litres of fuel consumption per his travelled kilometres, which represent 53% of the total norm, while his measured fuel consumption was 12 088 litres, which means, that he reached 94% of the total expected fuel consumption. This consumption includes 142 litres of fuel used for heating and warming-up of vehicle in the winter months. The difference between consumptions represents a fuel saving of 711 litres, 6% respectively. 11 946 litres represent a fuel consumption without heating and warming-up, which is the fuel consumption determined only for driving.

Driver "B" supposed to reach 11 491 litres of fuel consumption per his travelled kilometres, which represents 47% of the total norm, while his measured fuel consumption was 11 039 litres, which means, that he reached 96% of the total expected fuel consumption. This consumption includes 108 litres of fuel used for heating and warming-up of vehicle.

The difference between consumptions represents a fuel saving of 453 litres of fuel, 4% respectively. 10 931 litres represent a fuel consumption without heating and warming-up, which is the fuel consumption determined only for driving. The amount of total fuel consumption per month without heating and warming-up, recorded for both bus drivers, are presented in Figure 4.

The average fuel consumption 23 litres per 100 kilometres of driver "A" in the long term interval and 24 litres per 100 kilometres is an average fuel consumption of driver "B", while the norm established by company for selected type of bus is 24 litres per 100 kilometres. Average fuel consumption without heating reached by driver "A" was 23 litres per 100 kilometres and 23 litres per 100 kilometres reached by driver "B". The amount of the average fuel consumptions per month, reached for both bus drivers, is presented in Figure 5.

Figure 5 indicates that the driver "A" reached a lower average fuel consumption per 100 kilometres in long-term compared to driver "B". This average fuel consumption is probably influenced by driving style of both drivers, because they rotate on the same bus and the same bus route.

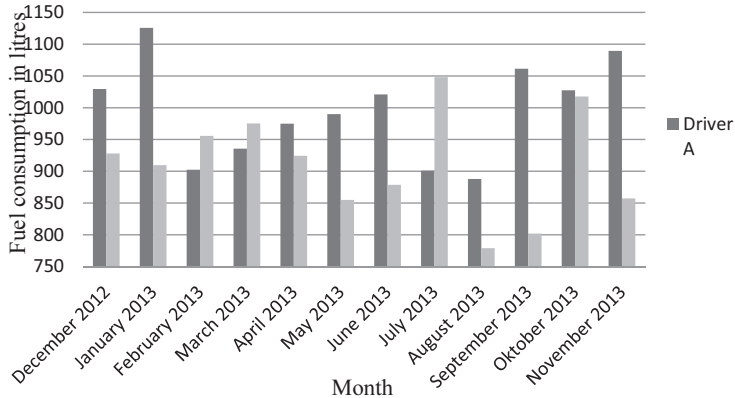

Fig.4 The amount of total fuel consumption per month without heating and warming-up

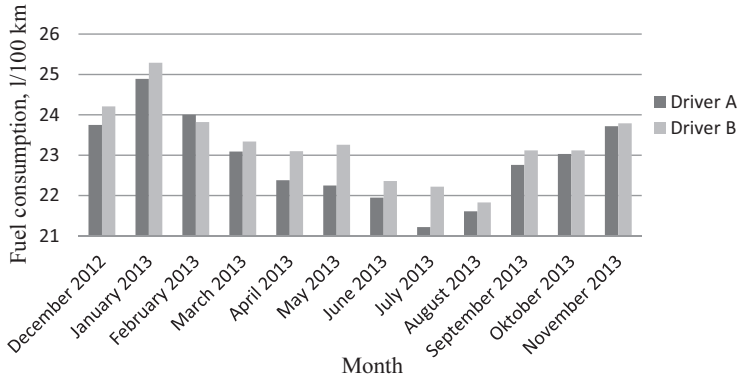

Fig.5. The amount of the average fuel consumptions per month

Conclusions

The recording sheets, used to determine fuel consumption of both bus drivers travelling on the same bus line, were used to the achieve results. The results were processed and subsequently compared. At the end of our experiment, we can allege that driver "A" drove for more days, travelled more kilometres and saved more fuel, than driver "B". Both drivers saved up a considerable amount of fuel. The highest average fuel consumption per 100 kilometres was recorded especially in the winter months, because of conditions such as low air temperatures, poor adhesion conditions, larger tire rolling resistance caused by snow on the road etc. At the same time, during winter months, it is necessary to heat the vehicle with additional heating, because of low thermal efficiency of a diesel engine, resulting in additional fuel consumption. Lowest fuel consumption reached by both drivers was recorded in the summer months, because the air temperature was higher. Of course, this may be due to the fact, that July and August are months of summer holidays, so public transport bus service is not fully overloaded by travellers.

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