TEKA Kom. Mot. Energ. Roln. – OL PAN, 2009, 9, 17–23

AN ANALYSIS OF TRACTION DRIVING PARAMETERS IN A MOTORWAY INFRASTRUCTURE WITH THE SID STATISTICAL METHOD

Zbigniew Burski, Joanna Tarasińska[*], Izabela Mijalska-Szewczak

[*] University of Life Sciences in Lublin, Faculty of Production Engineering,
Department of Power Industry and Vehicles Department of Applied Mathematics and Informatics

Summary. The work presents a comparative analysis of driving traction parameters depending on disperse phase, accelerate and braking, on motorway in Germany and Spain. The analysis is grounded on similarity indicator distribution (SID). The driving conditions include the external factors and a subjective driver's behaviour. The external factors are: road characteristics, like elevations, features affecting rolling resistance, driving conditions, weather conditions (mainly the wind force and direction). The conclusions concern the driving conditions in the aforementioned EU countries.

Key words: transportation logistics, communication infrastructure, profile of driving speed, traction parameters.

INTRODUCTION

Progressive globalization of production and transport processes cause the maximization of economical vehicles operating in the domestic and international logistics. Minimisation of fuel consumption is nowadays an important factor of the costs of vehicles operation reduction. Apart from the changes in the construction, it can be obtained keeping the good technical standard and a proper driving style [Sovran and other 1981; Dębicki 1984; Januła and other 1989; Siłka 1990; Siłka 1994].

We need certain energy to accelerate the vehicle so that it has a specific speed. It is needed not only to break the rolling and aerodynamic resistance but also to give the acceleration to the vehicle mass. Each process of braking is connected with an irreparable loss of energy achieved during the previous acceleration. An evident conclusion is to use a smooth driving style, which greatly depends on the qualities of a driver and road co-users [Staska 1984; Siłka 1993; Siłka, Hetmańczyk 1995; Siłka 1997; Siłka 1998].

PURPOSE OF THE RESEARCH

The aim of the present research is to define the changes that take place during the vehicle acceleration and braking in communication infrastructure (motorway) in Germany and Spain with a special concern to driving hours.

RESEARCH METHOD

In the researches on energy- consumption in vehicles within the transportation logistics which have been done so far the statistical method SID was used to rate it in view of loss of kinetic energy between acceleration and braking in the infrastructure. The data was presented in the previous paper [Burski 2008; Burski and other 2008; Burski, Mijalska-Szewczak 2008].

Statistical arithmetic algorithm of using SID in the analysis of traction driving parameters

Denotation of calculated parameters:
x_i – sequence of values for which the values of empirical distribution functions F1 and F2 are calculated,
h – distance between two following points x_i and $x_{i+1,}$
k – number of intervals of x_i distributive series,
x – x_i arithmetic mean,
P – total area between empirical distribution functions F1 and F2,
D_{-} average distance from each observed point smaller than the calculated average,
D_{+} average distance from each observed point bigger than the calculated average,
n_{-} – number of values smaller than the average,
n_{+} number of values bigger than the average,
Pu – mean value of area P,
SID – similarity indicator distribution.

1. Counting the difference between empirical distribution function area (histograms):

$$P = \sum_{i=0}^{k} | F_1(x_i) - F_2(x_i) | * h,$$

$$\bar{x} = \frac{x_0 + x_k}{2} = \frac{x_0 + x_0 + k*h}{2} = x_0 + \frac{k}{2} * h.$$

2. Counting of dispersion of the obtained point values assuming that k is an even number (k = 10):

$$x_i < \bar{x} \Leftrightarrow x_i = x_0 + i*h \text{ for i = 0,1,.., } \frac{k}{2} - 1$$

$$\sum_{x_i<\bar{x}} (x_i - \bar{x})^2 = \left[x_0 - (x_0 + \frac{k}{2} * h) \right]^2 + \left[x_0 + h - x_0 - \frac{k}{2} * h \right]^2 + \left[x_0 + 2h - x_0 - \frac{k}{2} * h \right]^2 + ... +$$

$$+ \left[x_0 + (\frac{k}{2} - 1) * h - x_0 - \frac{k}{2} * h \right]^2 = \frac{h^2}{4} k^2 + \frac{h^2}{4} (2-k)^2 + \frac{h^2}{4} (4-k)^2 + ... + 2^2 =$$

$$= \frac{h^2}{4} \left[k^2 + (k-2)^2 + ... + 2^2 \right].$$

$$n_{-} = \frac{k}{2}.$$

$$x_i > \bar{x} \Leftrightarrow x_i = x_0 + i*h \text{ for i = } \frac{k}{2} + 1....k.$$

$$\sum_{x_i>\bar{x}} (x_i - \bar{x})^2 = \left[x_0 + (\frac{k}{2} + 1) * h - (x_0 + \frac{k}{2} * h) \right]^2 + \left[x_0 + (\frac{k}{2} + 2) * h - x_0 - \frac{k}{2} * h \right]^2 + ... +$$

$$+ \left[x_0 + k * h - x_0 - \frac{k}{2} * h \right]^2 = \frac{h^2}{4} \left[2^2 + 4^2 + ... + k^2 \right],$$

$$n_{+} = \frac{k}{2}$$

so: $D_{-} = D_{+} = \sqrt{\dfrac{\dfrac{h^2}{4} * \left[2^2 + 4^2 + ... + k^2\right]}{\dfrac{k}{2}}}$,

for k = 10.

$$D_{-} + D_{+} = \frac{2}{k}\left(2^2 + 4^2 + 6^2 + 8^2 + k^2\right) = \frac{2}{10}(4 + 16 + 36 + 64 + 100) = 44.$$

3. Computation of mean SID area value:

$$P_u = \frac{\sum \left|F_1(x_i) - F_2(x_i)\right|}{\sqrt{44}}.$$

$$P_u = \frac{P}{D_{-} + D_{+}} = \frac{h\sum_{i=0}^{k}\left|F_1(x_i) - F_2(x_i)\right|}{2\dfrac{h}{2}\sqrt{\dfrac{2(2^2 + 4^2 + ... + k^2)}{k}}} = \frac{\sum_{i=0}^{k}\left|F_1(x_i) - F_2(x_i)\right|}{\sqrt{\dfrac{2}{k}(2^2 + 4^2 + ... + k^2)}}.$$

SID = 1- Pu^2.

SUBJECT AND RESEARCH OBJECT

The research subject was to analyze the driving speed profile of a truck (TIR) in conditions of communication infrastructure type motorway in EU (Germany, Spain).

RESEARCH RESULTS

Table 1. a, b. Results of cumulative distribution function calculations of distribution v; minimum speed: F1- Germany (a – time 22:00-24:00; b – time 4:00-6:00),
F2 – Spain, (a – time 24:00-2:00; b – time 17:00-19:00)

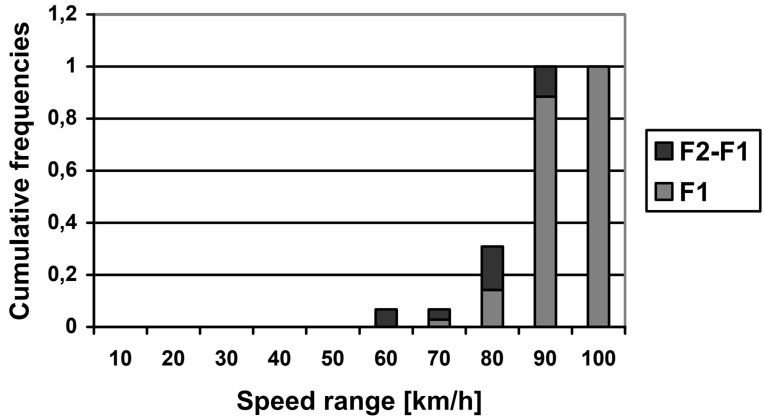
a)

V	F1	F2-F1	F2
10	0	0	0
20	0	0	0
30	0	0	0
40	0	0	0
50	0	0	0
60	0	0,068	0,068
70	0,028	0,04	0,068
80	0,142	0,167	0,309
90	0,885	0,115	1
100	1	0	0

b)

v	F1	F2-F1	F2
10	0	0	0
20	0	0	0
30	0	0	0
40	0	0	0
50	0	0	0
60	0	0	0
70	0	0,03	0,03
80	0	0,151	0,151
90	0,842	0,158	1
100	1	0	1

a)



b)

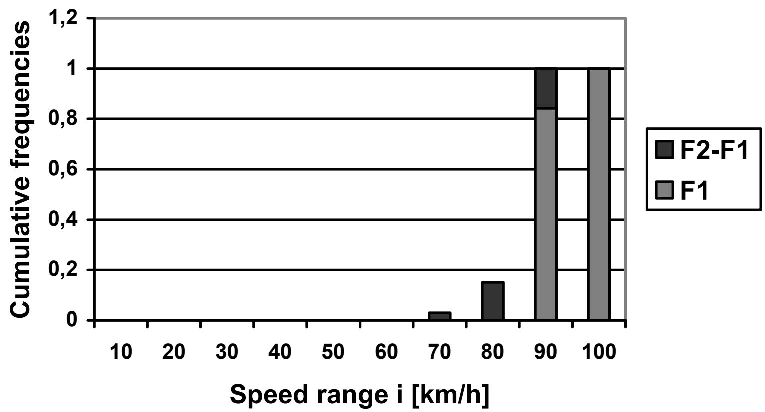


Fig. 1. a, b. Graph of empirical distribution functions F1 and F2 and value of surface content between them; minimum speed: : F1- Germany (a – time 22:00-24:00; b – time 4:00-6:00), F2 – Spain (a – time 24:00-2:00; b – time 17:00-19:00)

Table 2. a, b. Results of cumulative distribution function calculations of distribution v; maximum speed: F1- Germany (a – time 22:00-24:00; b – time 4:00-6:00), F2 – Spain, (a – time 24:00-2:00; b – time 17:00-19:00)

a)

V	F1	F2-F1	F2
10	0,108	0,032	0,076
20	0,108	0,032	0,076
30	0,108	0,032	0,076

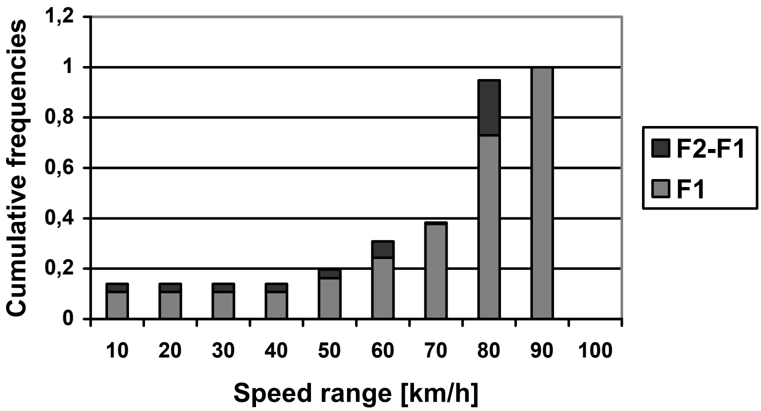
b)

v	F1	F2-F1	F2
10	0	0,037	0,037
20	0	0,037	0,037
30	0	0,074	0,074

40	0,108	0,032	0,076
50	0,162	0,035	0,127
60	0,243	0,065	0,178
70	0,378	0,005	0,383
80	0,729	0,218	0,947
90	1	0	1
100	0	0	0

40	0	0,111	0,111
50	0,048	0,063	0,111
60	0,143	0,032	0,111
70	0,191	0,068	0,259
80	0,62	0,139	0,481
90	1	0	1
100	0	0	0

a)



b)

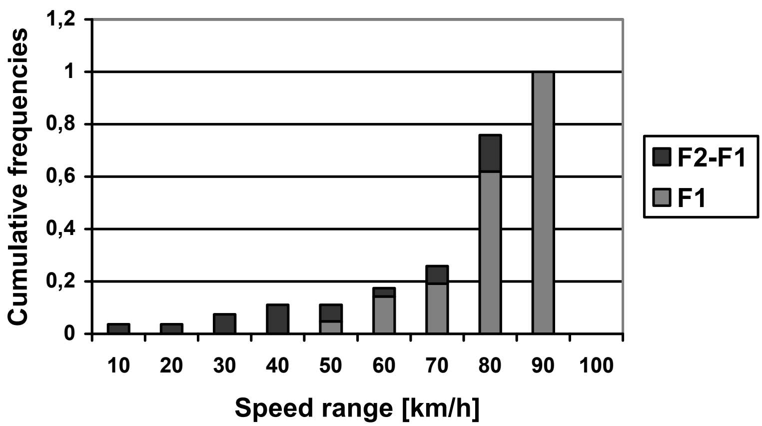


Fig. 2. a, b. Graph of empirical distribution functions F1 and F2 and value of surface content between them; maximum speed: F1- Germany (a – time 22:00-24:00; b – time 4:00-6:00), F2 – Spain, (a – time 24:00-2:00; b – time 17:00-19:00)

ANALYSIS OF RESEARCH RESULTS

The analysis of research results is presented in Table 1, 2 and in graphs. Table 3 presents the track record. The indicator of arrangement similarity [Bochniak 2006] shows that there is a big similarity of the SID results (from 0,992847 up to 0,995377) as far as the maximum speed accelerations are concerned.

Table 3. Summary of calculation results

GERMANY	SPAIN		Area F1-F2	Pu	Pu^2	SID
TIME						
4:00-6:00	17:00-19:00	MIN.	3,39	0,051106	0,002612	0,997388
		MAX	5,61	0,084574	0,007153	0,992847
22:00-24:00	24:00-2:00	MIN.	3,9	0,058795	0,003457	0,996543
		MAX	4,51	0,067991	0,004623	0,995377

There are also similar results of minimum speed values dispersion (from 0,996543 up to 0,997388), which are caused by traffic delay (braking and acceleration).

The results concern the conditions of the analyzed traffic agglomeration – a motorway in Germany and Spain.

CONCLUSIONS

The researches focused on the analysis of traction driving parameters in international logistics with the statistical method (using SID rate) have shown that driving on the motorway as an optimal infrastructure is characterized by changeless statistical standards provided for comparisons.

The comparison of the data in Tables and dispersion values of acceleration and braking indicates that they do not depend on the analyzed driving time. It means that a driver has an optimal influence on driving economy.

REFERENCES

Bochniak A. 2006. Distribution similarity indicator of resilience module of stalks for cereals tributary to magnetic field stimulation. Typescript KZM WIP AR in Lublin.

Burski Z. 2008. Standardization of a vehicle’s power effectiveness on the basis of indicator of similarity of speed distribution. TEKA VIII, Lublin.

Burski Z., Krasowski E., Mijalska-Szewczak I., 2008. Utilization of mathematical statistics of vehicle’s exploitation Power – intersivity on example of metropolita agglomeration. Agro Industrial Complex, September 17-18, 2008.

Burski Z., Mijalska-Szewczak I., 2008 . Evaluation of energy – consumption in the vehicles of EU international Communications infrastructure. TEKA VIII A, Lublin.

Dębicki M. 1974. Theory of vehicle. Theory of driving. WNT, Warszawa.

Januła J., Szczeciński J., Szczeciński S. 1989. Improvement of economy and dynamics of personal vehicles. Wydawnictwo Komunikacji i Łączności.
Siłka W. 1990. Traffic energy-consumption as significant compound of vehicle's energetic balance Zeszyty Naukowe WSI w Opolu, nr 162, Seria Mechanika z. 39, Problematyka samochodowa.
Siłka W. 1993. Energetic analyze of vehicle's acceleration process. Zeszyty Naukowe WSI w Opolu, Studia i Monografie, z. 67, Opole.
Siłka W. 1994. Theory of vehicle motion. Unit II. Energy-consumption of motion and fuel usage. WSI w Opolu, Skrypt Uczelniany nr 165, Opole.
Siłka W. Hetmańczyk I. 1995. Parameters of driving process and vehicle's motion energy-consumption. Zeszyty Naukowe USI w Opolu, nr 210, Seria Mechanika z.51, Problematyka samochodowa.
Siłka W. 1997. Energy-consumption of vehicle motion. Wyd. N-T, Warszawa.
Siłka W. 1998. Analyze of driving parameters influence for energy-consumption of vehicle motion. Monograph 2. TEKA KN-PM, Z. 14, Kraków.
Sovran G., Bohn M.1981. Formula for the Traction – Energy Requirements of Vehicles Driving the EPA Schedukes. SS Paper nr 810184.
Staska G. 1984. Bestimmung der Fahrwiderstande In Fahrversuch. Automobiltechnische Zeitschrift nr 4/1984.

ANALIZA PARAMETRÓW TRAKCYJNYCH POJAZDU W INFRASTRUKTURZE KOMUNIKACYJNEJ METODĄ STATYSTYCZNĄ WPR

Streszczenie. W pracy przedstawiono analizę porównawczą parametrów trakcyjnych pojazdu w zakresie dyspersji przyspieszeń i hamowania w warunkach jazdy po autostradzie niemieckiej i hiszpańskiej. W analizie wykorzystano statystyczną metodę matematyczną WPR (wskaźnika podobieństwa rozkładu profilu prędkości jazdy). Na analizowane warunki jazdy składają się: czynniki zewnętrzne oraz subiektywne zachowanie kierowcy. Do czynników zewnętrznych zaliczono: własności drogi (wzniesienia oraz własności decydujące o oporach toczenia), warunki ruchu drogowego oraz czynniki atmosferyczne (głównie kierunek i siłę wiatru). Wyprowadzono wnioski o istniejących warunkach jazdy w wymienionych krajach UE.

Słowa kluczowe: logistyka transportowa, infrastruktura komunikacyjna, profil prędkości jazdy, parametry trakcyjne.