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ECOLOGY - VEHICLE AND ROAD SAFETY - EFFICIENCY

Book of abstracts

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Department for Motor Vehicles and Motors

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PREDGOVOR

Deveti međunarodni kongres „Motorna vozila i motori 2022“ ponovo je organizovan u neobičnim okolnostima. Dok je svetom još uvek vladala pandemija CORONA virusa, autori iz zemlje i inostranstva prikazali su rezultate istraživanja u radovima prezentovanim na Kongresu čija je tema „Ekologija–Vozilo i bezbednost saobraćaja-Efikasnost“. Imajući u vidu trenutnu situaciju, odziv autora je bio vise nego zadovoljavajući. Za prezentaciju na Kongresu su prihvaćena ukupno 48 radova, koji su recenzirani i vezani sa jednom od postojećih glavnih tema Kongresa:

- Tehnologija sistema prenosa snage,
- Konstrukcija i proizvodnja vozila,
- Dinamika vozila i sistemi inteligentne kontrole,
- Interfejs vozač/vozilo, informacioni sistemi i sistemi za pomoć vozaču i
- Izazovi transporta u ekonomijama u razvoju.

Naši uvodničari, eminentni stručnjaci u oblasti motornih vozila i bezbednosti saobraćaja, pripremili su dva uvodna predavanja koja predstavljaju okvir za ostala istraživanja izložena na Kongresu. Akcenat uvodnih predavanja je bio na izazovima projektovanja i integrisanja baterija u električna vozila i evropskoj regulativi vezanoj za mobilnost i dilemama u vezi postizanja nulte emisije vozila.

Tematske sekcije Kongresa potvrdile su multidisciplinarnost tehnologija vozila i važnost bezbednog okvira njegovog funkcionisanja. Prezentirani su radovi iz oblasti hibridnih vozila, alternativnih pogona, novih materijala i tehnologija u proizvodnji vozila, primene industrije 4.0, naprednih metoda smanjenja potrošnje energije i uticaja vibracija na putnike i raznih aspekata bezbednosti saobraćaja.

Uz tradicionalnu podršku Ministarstva nauke, prosvete i tehnološkog razvoja, Univerziteta u Kragujevcu, Fakulteta inženjerskih nauka i Međunarodnog časopisa “*Mobility and Vehicle Mechanics*“, organizatori Kongresa su odlučili da se, zbog preventivne zaštite zdravlja učesnika, Kongres po drugi put organizuje na Internet mreži (*online*). Organizovana je plenarna sekcija, kao i više radnih tematskih sekcija, na kojima su razmenjena dragocena iskustva stručnjaka iz oblasti automobilske industrije, istraživačkih instituta i akademskih institucija.

Nadamo se da će idući Kongres, čije je održavanje planirano za dve godine, da privuče još veći broj učesnika sa novim, aktuelnim temama primerenim brzom razvoju tehnologija motornih vozila.

Kragujevac,
13. oktobar 2022. godine

Naučni i Organizacioni odbor
Međunarodnog kongresa „Motorna vozila i motori 2022“

FOREWORD

The 9th International Congress "Motor Vehicles and Engines 2022" was organized in unusual circumstances. While the CORONA virus pandemic still ruled the world, authors showed research results in papers presented in Congress entitled "Ecology - Vehicle and Traffic Safety - Efficiency". Given the current situation, the response of the authors was more than satisfactory. A sum of 48 papers was accepted for presentation at the Congress. All papers were reviewed and linked to one of the existing main topics of the Congress:

- Power Train Technology,
- Vehicle Design and Manufacturing,
- Vehicle Dynamics and Intelligent Control Systems,
- Driver/Vehicle Interface, Information and Assistance Systems and
- Transport Challenges In Emerging Economies.

Our keynote speakers, eminent experts in the field of motor vehicles and traffic safety, have prepared two introductory lectures that provide the framework for other research presented at the Congress. The emphasis of the introductory lectures was on the challenges of designing and integrating batteries in electric vehicles and the European regulation related to mobility and the dilemmas related to achieving zero emission vehicles.

The thematic sections of the Congress confirmed the multidisciplinarity of vehicle technologies and the importance of a safe framework for its functioning. Papers in the field of hybrid vehicles, alternative drives, new materials and technologies in vehicle production, application of Industry 4.0, advanced methods for reducing energy consumption and the impact of vibration on passengers and various aspects of traffic safety were presented.

With the traditional support of the Ministry of Science, Education and Technological Development, University of Kragujevac, Faculty of Engineering and the International Journal “Mobility and Vehicle Mechanics”, the organizers of the Congress decided to organize the Congress on the Internet network (online) for the second time. A plenary section was organized, as well as several working thematic sections, where valuable experiences of experts from the automotive industry, research institutes and academic institutions were exchanged.

We hope that the next Congress, which is planned to be held in two years, will attract an even larger number of participants with new, current topics appropriate to the rapid development of motor vehicle technologies.

Kragujevac,
October 13th, 2022

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MVM2022-028

Slavica Mačužić Saveljić[1]
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SIMULATION OF PEDESTRIAN THROW DISTANCE IN THE SOFTWARE PACKAGE PC-CRASH - COMPARISON WITH EXPERIMENT AND THEORY

KEYWORDS: accidents, distance of pedestrian rejection, PC Crash software package, vehicle speed

Pedestrians are the most vulnerable group of road users, especially because of their bodily insecurity. The increased number of traffic accidents involving pedestrians is the result of the increase in vehicle speed. Pedestrians account for about 24% of all seriously injured people in traffic, and when it comes to minor injuries, pedestrians account for about 11%.
The collision of vehicles and pedestrians leaves traces on both the vehicle and the pedestrians in the form of structural damage and in the form of injuries to the body. In order to determine the circumstances under which the accident occurred, it is necessary to analyse the both participants (the vehicle and the pedestrian). Due to the difference in mass between vehicles and pedestrians, as a result of an accident, pedestrian injuries are always more significant. In order to analyse the distance of pedestrian throw using the PC Crash, pedestrian modelling with body dimensions was performed, in the Multibody module. It is possible to get accurate information about the characteristics of the vehicle and the speed of the vehicle within the software database. Seven different vehicle speeds were taken into account: 38.46 km/h, 39.27 km/h, 43.61 km/h, 34.12 km/h, 55.04 km/h, 61.15 km/h and 64.86 km/h, while the weight of the pedestrian was 67 kg and the height was 1.78 m. The total weight of the vehicle was 1872 kg. Experimental data were taken from literature for the purpose of comparison with simulation data.
In this paper, the frontal collision of vehicle (Ford Crown Victoria 2005) and pedestrian was analysed. Based on various tests, the most commonly used theoretical dependence between the vehicle collision speed and the pedestrian throw distance can be presented in the following form:

$$S_{od} = \frac{v_s^2}{144}\left(\pm 10\%\right) \tag{1}$$

where:

S_{od}, m - distance from the place of collision to the final position of the pedestrian (pedestrian throw distance) and

v_s, $\frac{\text{m}}{\text{s}}$ - impact speed.

Value 144 in equation (1) has the dimension of acceleration. Research has shown that equation (1) can be used for real accidents, but the results deviate by ± 10%.
In this paper, empiric Dekra formula (2) is used for the analytical calculation of the pedestrian throw distance and various comparisons:

$$s = 2.5 + 0.38448 \cdot v + 0.05858 \cdot \frac{v^2}{a_{car}} \tag{2}$$

where:

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$v, \frac{\mathrm{m}}{\mathrm{s}}$ – impact speed,

s, m – pedestrian throw distance and

$a_{car}, \frac{m}{s^2}$ – average car deceleration.

The obtained PC Crash software results for the pedestrian throw distance depending on the impact speed of the vehicle are shown in table 1, together with the data obtained experimentally and analytically.

Table 1. Values of pedestrian throw distance for different vehicle speeds

Test number	Vehicle impact speed, km/h	Pedestrian throw distance, m		
		Experimental	Analytic	PC Crash
1	38.46	10.61	10.49	10.54
2	39.27	11.34	10.84	10.94
3	43.61	14.78	12.74	13.25
4	34.12	9.05	8.76	8.65
5	55.04	17.53	18.48	16.98
6	61.15	24.75	21.95	22.90
7	64.86	26.03	24.20	25.23

Based on table 1, it can be concluded that, as the impact speed of the vehicle increases, so does the throw distance of pedestrians. This increase was observed in all three types of analysis: experimental, analytical, and in the PC Crash program, figure 1.

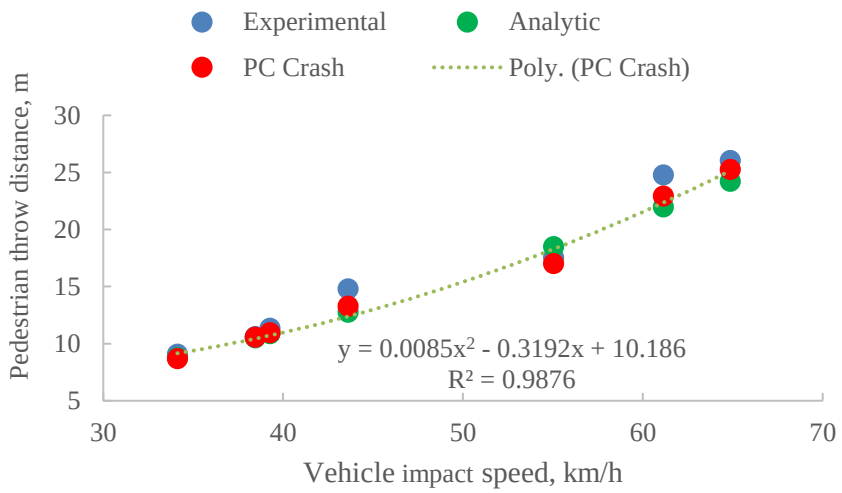

Figure 1. Pedestrian throw distance depending on impact speed.

Figure 1 shows a strong (parabolic) correlation between the pedestrian throw distance and the vehicle impact speed in PC Crash simulation results (R^2=0.9876). The smallest value of the pedestrian throw distance of 8.65 m was obtained numerically, using the PC Crash program, for impact speed of 34.12 km/h. The highest value of the pedestrian throw distance of 26.03 m was obtained by experimental determination, for impact speed of 64.86 km/h. The application of computer programs for the analysis of traffic accidents enables a more precise analysis of the elements of the traffic accident, taking into account the place of the collision, the collision speed as well as the circumstances under which the traffic accident occurred. Based on various comparisons, it was found that the pedestrian model in PC Crash gives good estimates for determining the pedestrian throw distance, better than analytical model. Different vehicle shapes and pedestrian kinematics can be taken into account in the analysis. The pedestrian model in PC Crash proved to be easier to analyse, compared to the analytical way of analysis, because all the parameters that influenced the occurrence of the accident could be taken into account.