ISSN 1726-9679

DANUBE ADRIA ASSOCIATION FOR AUTOMATION & MANUFACTURING

DAAAM INTERNATIONAL VIENNA

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ANNALS OF DAAAM FOR 2009 & PROCEEDINGS

OF THE 20TH INTERNATIONAL DAAAM SYMPOSIUM
"INTELLIGENT MANUFACTURING & AUTOMATION:
FOCUS ON THEORY, PRACTICE AND EDUCATION"
25-28TH NOVEMBER 2009, VIENNA, AUSTRIA

ORGANIZED BY:
DAAAM INTERNATIONAL VIENNA
VIENNA UNIVERSITY OF TECHNOLOGY, UNIVERSITY OF APPLIED SCIENCES
TECHNIKUM VIENNA, AND AUSTRIAN SOCIETY OF ENGINEERS AND ARCHITECTS - ÖIAV 1848

UNDER THE AUSPICES OF: THE DANUBE RECTORS' CONFERENCE &
RECTORS' HONOR COMMITTEE OF DAAAM INTERNATIONAL

SUPPORTED BY FESTO

EDITOR: B[RANKO] KATALINIC

THE 20TH INTERNATIONAL DAAAM SYMPOSIUM

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ISBN 978-3-901509-70-4
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PUBLISHER: DAAAM INTERNATIONAL VIENNA 2009

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ISSN 1726-9679
9 771726 967007

10.0 DAAAM INTERNATIONAL NETWORK FOR ADVANCED TECHNOLOGIES

The text of the Network founding document: We, the representatives of different Universities, Institutions, and Firms at the meeting initiated and organized by The Danube Adria Association for Automation & Manufacturing, DAAAM International Vienna under the auspices of The Danube Rectors' Conference on the occasion of the Thirteenth International DAAAM Symposium "Intelligent Manufacturing & Automation: Learning from Nature" held at the Vienna University of Technology and Austrian Society of Engineers and Architects in Vienna, Austria, decided to found the DAAAM International Network for Advanced Technologies as a strategic alliance and permanent open platform within European Research Area for long-term co-operation and partnership in all fields and aspects of research, developing, transfer, education and use of advanced technologies.

The co-operation has to be continuously organized and had to be based on the partnership, friendship, tolerance, appreciation and positive experience of international scientific co-operation within the framework of DAAAM International during the last fourteen years. The co-operation can use individual flexible project oriented forms, structures and aspects and support the young researchers' mobility as well. The practical co-operation will be project-based organized. The highest priority is given to the organization of long - term international cooperation projects focused on advanced technologies for balanced development and harmony between men, technology and nature. The network has to be platform for dissemination of relevant information and ideas, supporting international partnership and encouraging of cooperation initiatives. Signed by the founding members in Vienna, Austria, European Union, on the twenty-fifth of October 2002

Activity No. 1: The conference bags and flags for DAAAM 2003 in Sarajevo are sponsored by the Faculty of Textile Technology, University of Zagreb, and organised by Professor Z. Dragcevic as the first activity in the frame of DAAAM International Network for Advanced Technologies.

11.0 DAAAM INTERNATIONAL NETWORK FOR MECHATRONICS AND ROBOTICS

The text of the Network founding document: We, the representatives of different Universities, Institutions, and Firms at the meeting initiated and organized by The Danube Adria Association for Automation & Manufacturing, DAAAM International Vienna under the auspices of The Danube Rectors' Conference on the occasion of the Fifteenth International DAAAM Symposium "Intelligent Manufacturing & Automation: Globalisation - Technology - Men - Nature" held at the Vienna University of Technology and Austrian Society of Engineers and Architects in Vienna, Austria, decided to found the DAAAM International Network for Mechatronics and Robotics as a strategic alliance and permanent open platform within European Research Area for long-term co-operation and partnership in all fields and aspects of research, developing, transfer, education and use of advanced technologies.

The co-operation has to be continuously organized and had to be based on the partnership, friendship, tolerance, appreciation and positive experience of international scientific co-operation within the framework of DAAAM International during the last fiveteen years. The co-operation can use individual flexible project oriented forms, structures and aspects and support the young researchers' mobility as well. The practical co-operation will be project-based organized. The highest priority is given to the organization of long - term international cooperation projects focused on advanced technologies for balanced development and harmony between men, technology and nature. The network has to be platform for dissemination of relevant information and ideas, supporting international partnership and encouraging of cooperation initiatives. Signed by the founding members in Vienna, Austria, European Union, on the fifth of November 2004

12.0 DAAAM INTERNATIONAL SYMPOSIUMS (1990-2009)

One important activity is organising the DAAAM International Symposium. The main objective of the Symposium is to provide a world forum, which takes place annually in Central Europe to exchange knowledge, experience, results and information related to various aspects of the advanced manufacturing and modern automation.
The scope of the Symposium covers scientific, technological and practical concepts concerning research, development and realisation of advanced manufacturing and automation concepts, offering a unique opportunity for experts to meet and exchange ideas. The Symposium is concerned with the current status of automation and manufacturing, methods and results of research and development, as well as application problems and publishes proceedings accordingly.

2009	**20th International DAAAM Symposium "Intelligent Manufacturing & Automation: Theory, Practice & Education"**
On the occasion of	Organised in Order to Celebrate 20th DAAAM International World Symposium
Date & Place	25-28th November 2009, Vienna, Austria

Organized by	DAAAM International Vienna, University of Applied Sciences Technikum Vienna, Vienna University of Technology - Department of Production Engineering / Intelligent Manufacturing Systems (IFT-IMS), ÖIAV 1848 Austrian Society of Engineers and Architects
Under the auspices of	Danube Rectors' Conference & Rectors' Honor Committee of DAAAM International
Organizers	Katalinic, Branko (Chair) / Cesarec, Paulina (Secretary) / Dragcevic, Zvonko / Höller, Liane / Kettler, Roman / Knezevic, Sime / Stopper, Markus
Publication	Annals of DAAAM for 2009 and Proceeding of the 20th International DAAAM Symposium, ISSN 1726-9679, ISBN 978-3-901509-70-4
Authors / Papers	1922 Authors / 974 Published papers
Referred / indexed in	ISI Scientific Proceedings Thomson Reuters
Editor	B[ranko] Katalinic
2008	**19th International DAAAM Symposium "Intelligent Manufacturing & Automation: Focus on Next Generation of Intelligent Systems and Solutions"**
On the occasion of	770 Years of the City of Trnava
Date & Place	22-25th October 2008, Trnava, Slovakia
Organized by	DAAAM International Vienna, Slovak University of Technology Faculty of Materials Science and Technology in Trnava, University of Applied Sciences Technikum Vienna, Vienna University of Technology - Department of Production Engineering / Intelligent Manufacturing Systems (IFT-IMS), ÖIAV 1848 Austrian Society of Engineers and Architects
Under the auspices of	Danube Rectors' Conference & Rectors' Honor Committee of DAAAM International
Organizers	Katalinic, Branko (Chair) / Moravcik, Oliver (Co-Chair) / Cesarec, Paulina (Secretary) / Dragcevic, Zvonko / Höller, Liane / Kettler, Roman / Knezevic, Sime / Resetova, Kvetoslava / Stefankova, Jana / Stopper, Markus / Velisek, Karol
Publication	Annals of DAAAM for 2008 and Proceeding of the 19th International DAAAM Symposium, ISSN 1726-9679, ISBN 978-3-901509-68-1
Authors / Papers	1496 Authors / 781 Published papers
Editor	B[ranko] Katalinic
2007	**18th International DAAAM Symposium "Intelligent Manufacturing & Automation: Focus on Creativity, Responsibility, and Ethics of Engineers"**
On the occasion of	Organised in Order to Celebrate 70th Birthday of Dr Wilfried Stoll 5th Anniversary of Refounding of the University of Zadar (Founded 1396)
Date & Place	24-27th October 2007, Zadar, Croatia
Organized by	DAAAM International Vienna, University of Zadar, University of Applied Sciences Technikum Vienna, Vienna University of Technology - Department of Production Engineering / Intelligent Manufacturing Systems (IFT-IMS), ÖIAV 1848 Austrian Society of Engineers and Architects
Under the auspices of *In cooperation with*	Danube Rectors' Conference & Rectors' Honor Committee of DAAAM International Croatian National Tourist Board
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Publication	Annals of DAAAM for 2007 and Proceeding of the 18th International DAAAM Symposium, ISSN 1726-9679, ISBN 3-901509-58-5
Authors / Papers	803 Authors / 419 Published papers
Referred / indexed in	ISI Scientific Proceedings Thomson Reuters
Editor	B[ranko] Katalinic
2006	**17th International DAAAM Symposium "Intelligent Manufacturing & Automation: Focus on Mechtronics and Robotics"**
On the occasion of	150th Birthday of Nikola Tesla (1856-1943) Inventor of Mobile Robot Teleoperation
Date & Place	8-11th November 2006, Vienna, Austria
Organized by	DAAAM International Vienna, Vienna University of Technology - Department of Production Engineering / Intelligent Manufacturing Systems (IFT-IMS), ÖIAV 1848 Austrian Society of Engineers and Architects , University of Applied Sciences - Technikum
Under the auspices of *In cooperation with*	Danube Rectors' Conference & Rectors' Honor Committee of DAAAM International Vienna Convention Bureau
Organizers	Buchmeister, Borut / Dragcevic, Zvonko / Egorov, Sergey / Höller, Liane / Katalinic, Branko (Chair) / Lazinica, Aleksandar / Malisa, Viktorio / Sagmeister, Nicole / Stuja, Kemajl / Viktorik, Hans / Viktorik, Silvia
Publication	Annals of DAAAM for 2006 and Proceeding of the 17th International DAAAM Symposium, ISSN 1726-9679, ISBN 3-901509-57-7
Authors / Papers	521 Authors / 230 Published papers

Annals of DAAAM for 2009 & Proceedings of the 20th International DAAAM Symposium, Volume 20, No. 1, ISSN 1726-9679
ISBN 978-3-901509-70-4, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2009
Make Harmony Between Technology and Nature, and Your Mind will Fly Free as a Bird
DAAAM World Symposium

INFLUENCE OF BUMPER DESIGN ON PEDESTRIAN INJURIES

SOICA, A[drian]; TARUELSCU, S[telian] & MOTOC LUCA, D[ana]

Abstract: *The impact velocity and motor vehicle frontal structures, including geometry and rigidity, have proved to be important factors that produce trauma.The paper hereby analyzes the impact between the motor vehicle and the bidimensional pedestrian. The motor vehicle has a constructive configuration provided with a double bumper. The second bumper is positioned under the first bumper and it is withdrawn backwards to a certain degree.The bumpers positioning heights, the impact force distribution on the two bumpers will be varied whereas the total impact force remains constant, and the velocities imprinted at the pedestrian thorax and head will be calculated. The motor vehicle rolling condition does not consider pitch movements.*
Keywords: *vehicle, pedestrian, accident, bumper, injuries*

1. INTRODUCTION

Traffic safety as well as the possibility to reduce the social costs of rehabilitation and the seriousness of injuries suffered by pedestrians present a particular complexity, being necessary to take a close approach to these issues.

In order to carry out developments concerning the traffic safety at low costs, there occurs the necessity to prioritize the interventions on the basis of „costs – advantages" analyses, by introducing the criterion of efficiency when drawing up working programs.

The general desire is to diminish the seriousness of injuries by improving the frontal structures of motor vehicles. From a certain speed the aim of reducing the number of injuries is limited; yet, at speeds below about 40 km/h it is likely to significantly reduce the levels of injuries caused to pedestrians involved in frontal impacts with motor vehicles.

The impact velocity and the vehicle's frontal structures, including the geometry and the rigidity proved to be important factors to cause trauma.

Most of the fatal injuries among pedestrians are caused by head injuries. The major causes of serious head injuries are the bonnet and the A pillars. The modern vehicles have rigid components under the bonnet, with spaces even smaller than 20 mm. Thus, the deformation that is likely to occur is too small to allow the absorption of necessary energy. Theoretically, there is required a distance of about 55 mm at an impact with a velocity of 40 km/h in order to maintain the HIC value below 1 000 for an adult head.

The impact velocity has also a major influence upon the resulted trauma. The pedestrians hit with velocities reaching 25 km/h usually suffers minor injuries. More than 95% of the accidents involving pedestrians are produced at impact velocities below 40 km/h.

2. MATHEMATICAL MODEL OF IMPACT

The hereby paper analyses the impact between the vehicle and pedestrian, the vehicle being in constructive configuration with double bumper. The second bumper is considered to be placed under the first one and a little withdrawn backwards.

The bumpers positioning heights will be varied, and the velocities imprinted at the pedestrian thorax and head will be calculated. For simplification there is considered:

- The pedestrian as mono-mass, of constant height and mass throughout the several simulations;
- The impact model is bidimensional;
- The impact upon the pedestrians' legs will be produced simultaneously by the two bumpers;
- The impact force will be distributed in two points corresponding to the bumpers' heights and it will vary on the upper and lower bumper, but the sum of the two values will be the same for each simulation. Practically, this is translated through a similar impact velocity for each simulation.
- The pedestrian is motionless in both longitudinal and transversal direction;
- The vehicle's running system does not manifest through the occurrence of pitching motions and, therefore, the height of impact points upon the leg will not vary within one simulation.

Therefore, it is considered that the pedestrian is an adult having the mass of 73 kg and the height of 1,78 m. The pedestrian centre of mass is considered to be at 0,57 from his height. Due to the fact that the most serious injuries suffered by the pedestrian are head and thorax injuries and considering the regulations in force, these injuries are measured at the level of the pedestrian's head centre of mass (HIC), pedestrian's thorax centre of mass (TTI), the paper considered a height of 1,71 m for the coordinate of the head centre of mass and of 1,135 m for the coordinate of the thorax centre of mass (Rau, 2000).

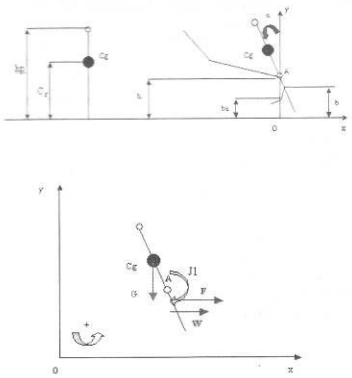

Fig. 1. Impact and forces schema

According to the figure 1 the coordinates of the pedestrian centre of gravity are as follows:

$$\begin{cases} x_{c1} = -(Cg - h)\cdot \sin(\alpha) \\ y_{c1} = h + (Cg - h)\cdot \cos(\alpha) \end{cases} \quad (1)$$

Following the successive derivations and transformations there is obtained the vector of the pedestrian translation and rotation accelerations

$$\{a\} = [A]\cdot\left\{\ddot{\alpha}\right\} + [B]\cdot\left\{\dot{\alpha}^2\right\} \quad (2)$$

where [A] stands for the pedestrian's angular acceleration coefficients matrix;

[B] stands for the pedestrian's square angular acceleration coefficients matrix;

{a} stands for the vector of the body translation and rotation accelerations.

That can be more simply written under the form:

$$[M]\cdot\{a\} = \{Q\} \quad (3)$$

where: [M] stands for the matrix of both the mass and pedestrian's inertia moment;

[Q] stands for the matrix of the forces actuating upon the pedestrian;

Aiming at finding out the unknown out of the equations (2) and (3) by multiplying at the left with $[A]^T$ there will be obtained

$$[A1]\cdot\left\{\ddot{\alpha}\right\} + [B1]\cdot\left\{\dot{\alpha}^2\right\} = \{Q_{ext}\} \quad (5)$$

Where

$$\{Q_{ext}\} = [A]^T\cdot\{Q\} \quad (6)$$

The relation (5) represents the simplified form of the differential equation in the unknown $\alpha = \alpha(t)$. By replacing it in the relation (1) the coordinates of the pedestrian's body centre of mass can be found out.

The vehicle is considered to be equipped with a bumper the impact points of which will vary on height within the ranges limit 0,5 – 0,6 m for the upper bumper and 0,3 – 0,4 m for the lower one. The impact force added to the two impact forces is of 6 kN for each simulation. The bonnet's frontal edge is situated at the constant height "h" during the simulations. The contact point between the bonnet's edge and the pedestrian's leg is considered to be a cylindrical articulation around which the pedestrian will pivot after the impact.

3. IMPACT SIMULATION

In order to answer the proposed problem a MathCad application was conceived to resolve the system by using the Runge Kutta method with the rkfixed function.

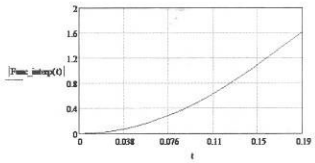

Fig. 2. Time variation of the rotation angle of the body

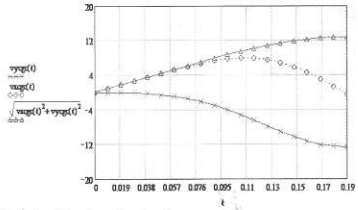

Fig. 3. Pedestrian head velocity

The thorax and head velocity are obtained on the basis of the rotation angle of the body, generated by the impact force, trough replacement and particularization in relation (1).

4. CONCLUSIONS

The impact force was distributed on the two bumpers, the secondary bumper on a lower position and a little withdrawn backwards, actuating with lower or at most equal forces to the one on the main bumper. The length of impact was of maximum 0,19 seconds. The simulations enabled us to obtain the body's angles of rotation at the end of the impact, the maximum velocities of the thorax centre of mass and the maximum velocities of the pedestrian's head centre of mass.

The data analysis leads to the following results:

- The rotation angles, respectively the lowest impact velocities of the pedestrian's thorax and head are obtained when the primary bumper takes a high percentage of the total impact force;
- The lowest impact velocities of both thorax and head are obtained by locating the bumpers at the highest possible height from the ground, the bonnet's edge remaining at the same standard height;
- The bigger the distance between the bumpers' impact points the higher the velocity the thorax and the head hit the vehicle with;
- The velocity the pedestrian's thorax hit the vehicle with rages from 5,42 to 6,4 m/s at a total impact force of 6 kN;
- The velocity the pedestrian's head hit the vehicle with rages from 14,9 to 12,6 m/s at a total impact force of 6 kN;

As further developments, from design and manufacturing point of view can be conceive a complex bumper with higher rigidity, provided with a special structure for pedestrian protection, doubled with a secondary deformable bumper mounted under the main bumper. The structure can be designed to avoid "tibia pulling" under the front-end of the vehicle that seriously injure the ankle.

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