



Faculty of Engineering



Ministry of Education,  
Science and Technological Development

**9<sup>th</sup> International Congress**  
**Motor Vehicles & Motors 2022**  
**ECOLOGY -**  
**VEHICLE AND ROAD SAFETY**  
**- EFFICIENCY**  
**Book of abstracts**



University of Kragujevac



Department for Motor Vehicles  
and Motors



International Journal for Vehicle  
Mechanics, Engines and  
Transportation Systems

October 13<sup>th</sup> - 14<sup>th</sup>, 2022  
Kragujevac, Serbia

**9<sup>th</sup> International Congress  
Motor Vehicles & Motors 2022**

**ECOLOGY -  
VEHICLE AND ROAD SAFETY  
- EFFICIENCY**

**BOOK OF ABSTRACTS**

October 13<sup>th</sup> - 14<sup>th</sup>, 2022  
Kragujevac, Serbia

*Publisher:* Faculty of Engineering, University of Kragujevac  
Sestre Janjić 6, 34000 Kragujevac, Serbia

*For Publisher:* Prof. Slobodan Savić, Ph.D.  
Dean of the Faculty of Engineering

*Editors:* Prof. Jovanka Lukić, Ph.D.  
Prof. Jasna Glišović, Ph.D.

*Technical preparation:* Asist. prof. Nadica Stojanović, Ph.D.  
Assist. prof. Ivan Grujić, Ph.D.  
Assist. Slavica Mačuzić Saveljić, M.Sc.

*Cover:* Nemanja Lazarević

*CD printing:* Faculty of Engineering, University of Kragujevac, Kragujevac

*ISBN:* 978-86-6335-096-0

*Year of publication:* 2022.

*Number of copies printed:* 200

CIP - Каталогизација у публикацији  
Народна библиотека Србије, Београд

CIP - Каталогизација у публикацији  
Народна библиотека Србије, Београд

629.3(048)(0.034.2)  
621.43(048)(0.034.2)

INTERNATIONAL Congress Motor Vehicles and Motors (9 ; 2022 ; Kragujevac)  
Ecology - vehicle and road safety - efficiency [Elektronski izvor] : book of abstracts /  
9th International Congress Motor Vehicles & Motors 2022, [MVM2022], October 13th-  
14th , 2022 Kragujevac, Serbia ; [congress organizers University of Kragujevac [and]  
Faculty of Engineering of the University of Kragujevac, Department for Motor Vehicles  
and Motors, FE Kragujevac [and] International Journal "Mobility & Vehicle Mechanics"] ;  
[editors Jovanka Lukić, Jasna Glišović]. - Kragujevac : University, Faculty of Engineering,  
2022 (Kragujevac : University, Faculty of Engineering). - 1 elektronski optički disk (CD-  
ROM) ; 12 cm

Sistemska zahteva: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Tiraž 200. -  
Bibliografija uz svaki rad.

ISBN 978-86-6335-096-0

а) Моторна возила -- Апстракти б) Мотори са унутрашњим сагоревањем --  
Апстракти в) Електрична возила -- Апстракти г) Хибридна електрична возила --  
Апстракти  
COBISS.SR-ID 76806921

Copyright © 2022 Faculty of Engineering, University of Kragujevac

*Publishing of this CD Book of proceedings was supported by  
Ministry of Education, Science and Technological Development of the Republic of Serbia*

## SCIENTIFIC BOARD

### **President**

Prof. Jovanka Lukić, Ph.D., UniKg, FE, Serbia

### **Secretaries**

Assist. prof. Nadica Stojanović, Ph.D., UniKg, FE, Serbia

Assist. prof. Ivan Grujić, Ph.D., UniKg, FE, Serbia

Assist. Slavica Mačužić Saveljić, M.Sc., UniKg, FE, Serbia

### **Members**

Dr.-Ing. Oday Abdullah, TU Hamburg-Harburg, Laser- und Anlagensystemtechnik,  
Germany

Prof. dr Giovanni Belingardi, Politecnico di Torino, Italy

Prof. dr Ivan Blagojević, University of Belgrade, FME, Serbia

Prof. dr Valentina Golubović Bugarski University of Banja Luka, FME, Republic of Srpska,  
Bosnia and Herzegovina

Prof. dr Bruno Dalla Chiara, Politecnico di Torino, Italy

Prof. dr Murat Ciniviz, Selcuk University, Turkey

Prof. dr Adrian Clenci, University of Pitesti, Romania

Assoc. Prof. dr Aleksandar Davinić, University of Kragujevac, FE, Serbia

Prof. dr Miroslav Demić, University of Kragujevac, FE, Serbia

Assoc. Prof. dr Jovan Dorić University of Novi Sad, FTS, Serbia

Prof. dr Jasna Glišović, University of Kragujevac, FE, Serbia

Asst. Prof. dr Aleksandar Jovanović, University of Kragujevac, FE, Serbia

Prof. dr Breda Kegl, University in Maribor, Slovenia

Prof. dr Božidar Krstić, University of Kragujevac, FE, Serbia

Prof. dr Zoran Lulić, University of Zagreb, Croatia

Prof. dr Danijela Miloradović, University of Kragujevac, FE, Serbia

Prof. dr Patrizio Nuccio, Politecnico di Torino, Italy

Prof. dr Radivoje Pešić, University of Kragujevac, FE, Serbia

Prof. dr Snežana Petković, University of Banja Luka, FME, Republic of Srpska, Bosnia  
and Herzegovina

Prof. dr Ralph Puetz, Landshut University of Applied Sciences, Germany

Assoc. Prof. dr Dragan Ružić, University of Novi Sad, FTS, Serbia

Assoc. Prof. dr Boris Stojić, University of Novi Sad, FTS, Serbia

Assoc. Prof. dr Dragan Taranović, University of Kragujevac, FE, Serbia

Assist. Prof. dr Predrag Živanović, University of Belgrade, FTTE, Serbia

## **ORGANIZATIONAL BOARD**

### ***President***

Prof. Jasna Glišović, Ph.D., UniKg, FE, Serbia

### ***Secretaries***

Assist. prof. Nadica Stojanović, Ph.D., UniKg, FE, Serbia

Assist. prof. Ivan Grujić, Ph.D., UniKg, FE, Serbia

Assist. Slavica Mačužić Saveljić, M.Sc., UniKg, FE, Serbia

## **CONGRESS ORGANIZERS**

University of Kragujevac  
Faculty of Engineering of the University of Kragujevac  
Department for Motor Vehicles and Motors, FE Kragujevac  
International Journal "Mobility & Vehicle Mechanics"

## **CONGRESS PATRONS**

Ministry of Education, Science and Technological Development of the Republic of Serbia  
City Council of Kragujevac

# CONTENT

## INTRODUCTORY LECTURES

MVM2022-IL1	Giovanni Belingardi Alessandro Scattina	INTEGRATED UNDERBODY AND BATTERY PACK FOR BATTERY ELECTRIC VEHICLES: CHALLENGES AND SOLUTIONS IN THE DESIGN	3
MVM2022-IL2	Ralph Pütz	EUROPEAN POLICY ON FUTURE ROAD MOBILITY - TECHNOLOGY NEUTRALITY RIGHT OF WAY OR HEADED IN THE WRONG DIRECTION?	5

## SECTION A Power Train Technology

MVM2022_002	Vasile Blaga Mihai Blaga	THE STUDY OF THE PROCESSES THAT TAKE PLACE IN GASOLINE INJECTION ENGINES	9
MVM2022_003	Vasile Blaga Mihai Blaga	THE INDICATED DIAGRAMS IN P-V COORDINATES CALCULATED AND MEASURED ON THE ENGINE STAND	11
MVM2022_005	Miroslav Demić Aleksandar Đurić Aleksandar Grkić Momir Drakulić <u>Slavko Muždeka</u>	A CONTRIBUTION TO INVESTIGATION OF OSCILLATORY LOADS OF DRIVING AXLES IN ORDER TO CREATE CONDITIONS FOR LABORATORY TESTS OF TRUCKS	13
MVM2022_014	Vanja Šušteršič Vladimir Vukašinović Dušan Gordić Mladen Josijević	3D PRINTING OF HYDRODINAMIC COUPLING FOR SCHOOL EDUCATION	15
MVM2022_016	Luka Ponorac Ivan Blagojević Aleksandar Grkić	ANALYSIS OF POWERTRAIN'S WORKLOAD DURING THE TURNING PROCESS OF A HIGH- SPEED TRACKED VEHICLE	17
MVM2022_019	Ivan Grujić Aleksandar Davinić Nadica Stojanović Jovan Dorić Sunny Narayan	THE INFLUENCE OF THE FUEL STRATIFICATION ON THE IC ENGINE WORKING CYCLE WITH THE COMPRESSED NATURAL GAS	19
MVM2022_021	Predrag Mrđa Marko Kitanović Nenad Miljić Slobodan Popović	INTERNAL COMBUSTION ENGINE TEST PLAN EXECUTION ORDER OPTIMIZATION USING TRAVELLING SALESMAN PROBLEM HEURISTICS APPROACH	21
MVM2022_022	Nebojša Nikolić Nikola Crnogorac Jovan Dorić Dalibor Feher Stjepan Galamboš	A COMPARISON OF MAIN BEARINGS LOAD OF TWO-CYLINDER "V" AND BOXER MOTORCYCLE ENGINES	23

MVM2022_023	Zoran Masoničić Ivan Grujić Aleksandar Davinić Slobodan Savić Radivoje Pešić	NUMERICAL ANALYSIS OF INTAKE PORT MODIFICATION ONTO FLUID FLOW PATTERN AND FLAME PROPAGATION IN PARTICULAR COMBUSTION CHAMBER	25
MVM2022_045	Saša Milojević Slobodan Savić Radoje Jovanović Blaža Stojanović Dušan Arsić Božidar Krstić	APPLICATION OF LIQUEFIED NATURAL GAS IN MOBILE SYSTEMS	27
MVM2022_047	Marko N. Kitanović Predrag D. Mrđa Slobodan J. Popović Nenad L. Miljić	THE INFLUENCE OF NARX CONTROL PARAMETERS ON THE FUEL EFFICIENCY IMPROVEMENT OF A HYDRAULIC HYBRID POWERTRAIN SYSTEM	29
MVM2022_055	Boris Stojić Aleksandar Poznić	NOVEL MODULAR POWERTRAIN PROPOSAL FOR E-BICYCLE	31

## SECTION B Vehicle Design and Manufacturing

MVM2022_006	Ana Pavlovic Cristiano Fragassa	IMPACT DAMAGE ANALYSIS OF COMPOSITE AUTOMOTIVE COMPONENT	35
MVM2022_011	Saša Jovanović Zorica Đorđević Sonja Kostić Danijela Nikolić Milan Đorđević	SELECTION OF SHAFT MATERIALS USING A MULTICRITERIA APPROACH	37
MVM2022_017	Momir Drakulić Lazar Stojnić Ivan Blagojević Aleksandar Đurić Sreten Perić	DEVELOPMENT OF MATHEMATICAL MODEL FOR DESIGN OF VEHICLE STEERING SYSTEM	39
MVM2022_020	Nina Busarac Dragan Adamović Nenad Grujović Fatima Živić	LIGHTWEIGHT MATERIALS FOR AUTOMOBILES	41
MVM2022_026	Sonja Kostić Bogdan Živković Aleksandra Ivanović Dragan Džunić Suzana Petrović Vladimir Kočović	DEVELOPMENT OF DEVICES FOR TESTING DYNAMIC DURABILITY OF MATERIALS	43
MVM2022_032	Stjepan Galamboš Dalibor Feher Nenad Poznanović Nebojša Nikolić Dragan Ružić Jovan Dorić	EXPERIMENTAL AND NUMERICAL STUDIES OF REDUCING OF DRAG FORCE A SEMI-TRAILER TRUCK MODEL USING THE CABIN SPOILER	45
MVM2022_033	Elena Angeleska Vasko Changoski Tashko Rizov Sofija Sidorenko	MBSE APPROACH FOR FACILITATING THE APPLICATION OF STANDARDS IN THE VEHICLE DEVELOPMENT PROCESS	47

MVM2022_034	Slavica Miladinović Blaža Stojanović Sandra Gajević Lozica Ivanović Aleksandar Skulić	A REVIEW OF HYPEREUTECTIC ALUMINUM PISTON MATERIALS	49
MVM2022_038	Sandra Gajević Jovana Krstić Slavica Miladinović Blaža Stojanović Jasmina Blagojević	POLYMER MATRIX NANOCOMPOSITES FROM THE ECOLOGICAL ASPECT IN THE AUTOMOTIVE INDUSTRY	51
MVM2022_040	Clio Vossou Andreas Nakos Dimitrios Koulocheris	TOPOLOGY OPTIMIZATION OF A MACPHERSON CONTROL ARM	53
MVM2022_043	Gordana Tošić Gordana Bogdanović Dragan Čukanović Aleksandar Radaković	FUNCTIONALLY GRADED MATERIALS IN TRANSPORT VEHICLES - OVERVIEW, FABRICATION, APPLICATION, MODELING	55
MVM2022_044	Marko Delić Vesna Mandić Filip Pavlović	ANALYSIS OF THE IMPACT OF THE MACHINE ON THE FORGING PROCESS OF A CONNECTING ROD USING NUMERICAL SIMULATION	57
MVM2022_050	Miloš Pešić Nikola Jović Vladimir Milovanović Mladen Pantić Miroslav Živković	FE MESH DENSITY INFLUENCE ON BLAST LOADING ANALYSIS	59
MVM2022_053	Isak Karabegović Edina Karabegović Mehmed Mahmić Ermin Husak	HOW THE CORE TECHNOLOGIES OF INDUSTRY 4.0 ARE CHANGING THE AUTOMOTIVE INDUSTRY IN THE WORLD, WITH A FOCUS ON CHINA	61
MVM2022_056	Lyubov Šladkova Aleksandr Siuzev	ANTI-WHEEL SLIP DEVICES	63

### **SECTION C**

#### **Driver/Vehicle Interface, Information and Assistance Systems**

MVM2022_004	Slobodan Mišanović Dragan Taranović Miloš Maljković Branko Miličić	MEASUREMENT NOISE LEVEL OF E-BUS HIGER KLQ6125GEV3 ON THE POLYGON	67
MVM2022_010	Dragan Ružić	THE ERGONOMIC ASPECTS OF A PASSENGER CAR CLIMATE CONTROL PANEL	69
MVM2022_027	Snezana Petković Valentina Golubović- Bugarski Gordana Globočki-Lakić Željko Đurić	INVESTIGATION OF THE PERMITTED LEVEL OF DAMAGE OF VEHICLES SAFETY GLASS	71
MVM2022_028	Slavica Macužić Saveljić Danijela Miloradović	SIMULATION OF PEDESTRIAN THROW DISTANCE IN THE SOFTWARE PACKAGE PC- CRASH - COMPARISON WITH EXPERIMENT AND THEORY	73
MVM2022_0030	Slavica Macužić Saveljić Branko Arsić Igor Saveljić Jovanka Lukić	IN-VEHICLE COMFORT ASSESSMENT DURING FORE-AND-AFT RANDOM VIBRATIONS BASED ON ARTIFICIAL NEURAL NETWORKS (ANN)	75



MVM2022_0035	Dalibor Feher Dragan Ružić Stjepan Galamboš Nebojša Nikolić Jovan Dorić	OPTIMIZATION OF THE AIR DISTRIBUTION SYSTEM IN MOTOR VEHICLE CABIN USING COMPUTATIONAL FLUID DYNAMICS	77
MVM2022_0039	Franci Pušavec Janez Kopač Krsto Mijanović	THE INFLUENCE OF STEP SHAPED ROAD SURFACE ON SAFETY WHEN DRIVING IN A BEND ON THE ROAD	79
MVM2022_0042	Ioana-Alexandra Rosu Ioana Diana Buzdugan Laurentiu Carabulea Csaba Antonya	SIMULATION OF A PEDESTRIAN COLLISION AVOIDANCE USING THE PEDESTRIAN PROTECTION SYSTEM	81

## SECTION D

### Vehicle Dynamics and Intelligent Control Systems

MVM2022_008	Vase Jordanoska Vasko Changoski Darko Danev	COORDINATED CONTROL OF ESC WITH ACTIVE FRONT STEERING AND ACTIVE SUSPENSION NORMAL FORCE CONTROL FOR BETTER VEHICLE'S DYNAMIC RESPONSE	85
MVM2022_009	Nadica Stojanović Ivan Grujić Oday I. Abdullah Ali Belhocine Jasna Glišović	THE DETERMINATION OF THE DISC BRAKE THERMAL STRESSES FOR DIFFERENT VEHICLE SPEEDS	87
MVM2022_013	Ketan Kotecha Aleksandar Jovanović Katarina Kukić Vaishali Dinesh Khairnar Ana Uzelac Rahee Walambe Likhesh Kolhe	THE ECOLOGY-BASED OPTIMIZATION OF TRAFFIC SIGNAL TIMING ON SUPER STREET	89
MVM2022_024	Saša Vasiljević Branislav Aleksandrović Jasna Glišović Marko Maslač	REGENERATIVE BRAKING ON ELECTRIC VEHICLES: WORKING PRINCIPLES AND BENEFITS OF APPLICATION	91
MVM2022_031	Vasko Changoski Igor Gjurkov Vase Jordanoska	IMPROVING VEHICLE DYNAMICS EMPLOYING INDIVIDUAL AND COORDINATED SLIDING MODE CONTROL IN VEHICLE STABILITY, ACTIVE FRONT WHEEL STEERING AND ACTIVE REAR WHEEL STEERING SYSTEMS IN CO-SIMULATION ENVIRONMENT	93
MVM2022_037	Aleksandar Poznić Boris Stojić	NUMERICAL SIMULATION OF AN ELECTROMECHANICAL BRAKE CONCERNING ASSOCIATED DIFFICULTIES	95
MVM2022_041	Clio Vossou Ioannis Katsas Dimitrios Koulocheris	EVALUATION OF THE ROLLOVER THRESHOLD OF TANK VEHICLES	97
MVM2022_046	Boris Stojić Aleksandar Poznić	COMPUTATIONAL ASSESSMENT OF LIGHT EXPERIMENTAL HYBRID VEHICLE BRAKING EFFICIENCY	99
MVM2022_048	Vasko Changoski Ile Mircheski Darko Danev	IMPROVING RIDE COMFORT BY OPTIMISING SUSPENSION SYSTEM OF AN ELECTRIC STREET SWEEPER	101

MVM2022_049	Nikola Nešić Julijana Simonović Milan Blagojević Saša Milojević Srđan Jović	VEHICLE SUSPENSION SYSTEM WITH INTEGRATED INERTER – EXTENDED ANALYSIS	103
-------------	---	--	-----

**SECTION E**  
**Transport Challenges in Emerging Economies**

MVM2022_015	Alin Drosu Corneliu Cofaru Mihaela Virginia Popescu	THE INVESTIGATION OF THE SINGLE VEHICLE ACCIDENTS SEVERITY BY USING A PROBABILISTIC APPROACH	107
-------------	---	--	-----

MVM2022_018	Bojana Bošković Saša Babić Branimir Milosavljević	USE OF ALTERNATIVE INTERSECTIONS IN ORDER TO IMPROVE TRAFFIC SAFETY	109
-------------	---	--	-----


Luka Ponorac<sup>1</sup>  
Ivan Blagojević<sup>2</sup>  
Aleksandar Grkić<sup>3</sup>


## **ANALYSIS OF POWERTRAIN'S WORKLOAD DURING THE TURNING PROCESS OF A HIGH-SPEED TRACKED VEHICLE**


**KEYWORDS:** high-speed tracked vehicles, powertrain workload analyses, tracked vehicle dynamics, tracked vehicle experimental testing, power balance analyses

High-speed tracked vehicles have a great advantage over wheeled vehicles when it comes to overcoming hard condition terrains. In order to maintain high mobility in low adhesion and high moving resistance conditions, these vehicles have robust powertrain components and complex turning mechanisms, which can withstand high torque, while producing a respectful velocity at the same time. This means that the power source, IC engine, has to produce enough power to satisfy all of these requests. Unlike with wheeled vehicles, the selection of the IC engine for a high-speed tracked vehicle is calculated according to the power requirements for the lowest turning radius achieved with the highest vehicle velocity, turning towards the hill of a maximum gradient. To analyze the efficiency of a high-speed tracked vehicle powertrain, it is necessary to understand the powertrain workloads in specific working regimes. Experimental tests are conducted on a specific high-speed tracked vehicle, in various terrain conditions, in order to obtain accurate workload data and isolate the maximum workload regimes. The vehicle is driven on soft soil and in dry conditions, varying turning and rectilinear moving scenarios, with gear and vehicle velocity changes. In order to analyse the power losses during the turning mechanism slip, a scenario where the vehicle is driven with a relatively constant engine input velocity, in specific gear, with field condition change reduced to minimum is selected, varying only the activation pressure of the auxiliary clutch.

The turning process of a high-speed tracked vehicle is evidently the most complex moving scenario, influenced by a large number of variables such as vehicle mass and dimensions, construction of the powertrain and turning mechanism, vehicle velocity, engagement state of the powertrain components, adhesion conditions, moving resistance etc. Given that, special attention is given to analysing the results from power balance point of view. The obtained results indicate that the slip of the turning mechanism friction elements greatly influences the character of the power balance change. For 30% of auxiliary clutch maximum activation pressure value, power delivered to the outer track is 25% lower than when the clutch is fully engaged. When the clutch activation pressure is 60% of the maximum value, the power losses are reduced to 10%. It is obvious that, the lower the activation pressure of the auxiliary clutch, the greater the power loss due to slip, so the logical conclusion is to avoid these working regimes and turn the vehicle with auxiliary clutch fully activated. Unfortunately, these vehicles are most commonly driven in such working regimes, where the vehicle is slightly turned just for trajectory correction. Rarely is the vehicle turned with the lowest values of the turning radius (calculated radius). This means that, for the most of the vehicle usage, the vehicle is turned with great power losses in turning mechanism friction elements.

<sup>1</sup> Luka Ponorac, AMSS-Center for Motor Vehicles Ltd., Kneginje Zorke 58, luka.ponorac@amss-cmv.co.rs,   
<https://orcid.org/0000-0003-2315-8743>

<sup>2</sup> Ivan Blagojević, University of Belgrade, Faculty of Mechanical Engineering, Kraljice Marije 16, iblagojevic@mas.bg.ac.rs,   
<https://orcid.org/0000-0002-5776-5990>

<sup>3</sup> Aleksandar Grkić, AMSS-Center for Motor Vehicles Ltd., Kneginje Zorke 58, aleksandargrkic@amss-cmv.co.rs,   
<https://orcid.org/0000-0002-7890-1787>

The problem of power loss on friction elements can be overcome by modifying the powertrain, in such a way, that the existing turning mechanisms with friction elements are replaced with hydrostatic or electric components, which would provide a continuous trajectory change, with an infinite number of calculated turning radii and no power loss.

ISBN 978-86-6335-096-0



9 788663 350960