



*University of Banja Luka  
Faculty of Mechanical Engineering*



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# PROCEEDINGS

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*Banja Luka  
30<sup>th</sup> May – 1<sup>st</sup> June 2013*



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## Content

### KEYNOTE LECTURES

Konstantinos-Dionysios Bouzakis	
CHARACTERIZATION METHODS AND PERFORMANCE OPTIMIZATION OF COATED CUTTING TOOLS	3
Manfred Hild	
DEFYING GRAVITY – A MINIMAL COGNITIVE SENSORIMOTOR LOOP WHICH MAKES ROBOTS WITH ARBITRARY MORPHOLOGIES STAND UP	23
Niko Herakovic	
DEVELOPMENT TRENDS IN ASSEMBLY AUTOMATION ANFLUID POWER	35
Giovanni Belingardi	
LIGHTWEIGHT DESIGN OF VEHICLE BODY A CONTRIBUTION TOWARD GREENER ENVIRONMENT	49
Dušan Gruden	
QUESTION THAT IS ASKED FOR DECADES: WHO WILL MOVE OUR CARS IN THE FUTURE?	55

### MECHANICS AND DESIGN

1 Djordjevic Zorica, Blagojevic Mirko, Kostic Nenad, Jovanovic Sasa, Marjanovic Vesna	
ADVANTAGES OF APPLICATION COMPOSITE MATERIALS FOR PRODUCTION CARDAN SHAFTS	71
2 Tihomir Mackic, Živko Babic, Mirko Blagojevic, Goran Jotic, Jovan Škundric	
AN ANALYSIS OF LUBRICATION REGIME BETWEEN THE CONTACT ELEMENTS OF CYCLOID REDUCER	77
3 Stevan Maksimovic, Ivana Vasovic, Mirko Maksimovic, Mirjana Djuric	
ANALYSIS OF AICRAFT STRUCTURES WITH RESPECTS TO FATIGUE AND FRACTURE MECHANICS	83
4 Pejašinovic Živko, Jotic Goran, Mackic Tihomir	
ANALYSIS OF ELASTIC ELEMENTS PROPERTIES OF AXIAL FORCE TRANSDUCERS	89
5 Radomir Djokic, Jovan Vladic, Dragan Živanic	
ANALYSIS OF POWER TRANSMISSION SYSTEMS FOR ELEVATORS AND DYNAMIC MODELS	95
6 Ljupco Trajcevski, Tale Geramitchioski	
ANALYTIC SIMULATION OF DAMAGE OF GEAR TOOTH	101
7 Nenad Marjanovic, Nenad Kostic, Mirko Blagojevic, Vesna Marjanovic, Biserka Isailovic	
AUTOMATED GEAR TRAIN MODELING IN CAD ENVIRONMENT	107

8	Gordana Bogdanovic, Dragan Milosavljevic, Ljiljana Veljovic, Aleksandar Radakovic	
	COMPOSITE MATERIALS – MECHANICAL BEHAVIOR OF ANISOTROPIC MEDIA	111
9	Nijaz Hasanagic, Asim Jušić, Milan Jurkovic, Mladen Todic	
	DESIGNING TRANSDUCERS FOR MEASUREMENT OF FORCE IN SHEET METAL FORMING PROCES BY MEANS OF ROLLERS	115
10	Matejic S. Miloš, Veljovic Ljiljana, Marjanovic Vesna, Blagojevic Mirko, Marjanovic Nena	
	DYNAMIC BEHAVIOR OF PLANETARY GEARBOX NEW CONCEPT	121
11	Filip Zdraveski, Ivan Mickoski, Dimitri Kozinakov	
	EXPLORING THE PERFORMANCE OF TUNED MASS DAMPERS-TMD IN MULTY STOREY BUILDINGS	127
12	Aleksandar Borkovic	
	FREE VIBRATION ANALYSIS OF STIFFENED THIN-WALLED STRUCTURES	133
13	Aleksandar Borkovic	
	GEOMETRIC NONLINEAR ANALYSIS OF STIFFENED PLATES USING THE COMPOUND STRIP METHOD	141
14	Ljiljana Veljovic, Dragan Milosavljevic, Gordana Bogdanovic, Aleksandar Radakovic	
	MODELING AND ANALYSIS FOR THE VIBRATION OF A GYROROTOR	149
15	Aleksandar Živkovic, Milan Zeljkovic, Slobodan Tabakovic	
	NONLINEAR MATHEMATICAL MODEL TO DETERMINE THE STIFFNESS OF THE AUTOMOTIVE WHEEL BEARING	155
16	Daniela Ristic, Dragan Milosavljevic	
	NUMERICAL MODEL FOR THE CRITICAL STRESS DETERMINATION IN SPUR GEARS – CASE OF A DRIVEN GEAR	163
17	Strain Posavljak, Katarina Maksimovic, Slobodanka Boljanovic	
	ON IMPORTANCE OF GEOMETRY AND CYCLIC MATERIAL PROPERTIES IN DESIGN OF FATIGUE RESISTANT TURBOJET ENGINE ROTATING DISKS	169
18	Miloš Ristic, Milosav Ognjanovic	
	PLANETARY GEAR TRANSMISSION SET DESIGN WITH UNIFORM RELIABILITY LEVEL	179
19	Enes Mujanovic, Denijal Sprecic	
	POSSIBILITIES OF THE APPLICATION OF MACHINE VISION IN THE ANALYSIS OF THE MICROSTRUCTURE OF DAMAGED MECHANICAL PARTS	185
20	Aleksandar Radakovic, Dragan Milosavljevic, Gordana Bogdanovic, Ljiljana Veljovic, Srba Aleksandrovic	



	SECOND-ORDER FAILURE CRITERIA IN LAMINATE INCLUDING THE EFFECT OF SHEAR STRESS	193
21	Miloš Djordjevic, Nenad Zrnic, Milorad Pantelic SIMPLIFIED LIFE CYCLE ASSESSMENT OF A RETURN BELT CONVEYOR IDLER	201
22	Radivoje Mitrovic, Nataša Soldat, Žarko Miškovic, Nebojša Matic SOME EXPERIENCES IN LABORATORY TESTING OF BEARINGS OF TRANSPORT IDLERS ON BELT CONVEYOR	207
23	Slobodanka Boljanovic, Stevan Maksimovic, Strain Posavljak STRENGTH ANALYSIS OF DAMAGED STRUCTURAL COMPONENTS	213
24	Drago Blagojevic, Mladen Todoc, Valentina Golubovic-Bugarski STRESS STATE OF RAIL VEHICLE WHEEL RIM IN EXPLOATATION	221
25	Andreja Ilic, Lozica Ivanovic, Danica Josifovic, Vukic Lazic, Boris Rakic TESTING OF ELEMENTS AND JOINTS AT MECHANICAL CONSTRUCTIONS	231
26	Dragi Stamenkovic, Katarina Maksimovic, Slobodanka Boljanovic THE EFFECTS OF RESIDUAL STRESSES TO CRACK GROWTH RATE OF WELDED STRUCTURAL COMPONENTS	237
27	Srdjan Bošnjak, Zoran Petkovic, Miodrag Arsic, Nebojša Gnjatovic, Ivan Milenovic BUCKETS OF THE BUCKET WHEEL EXCAVATORS: FAILURES AND REDESIGN	243
28	Srdjan Bošnjak, Zoran Petkovic, Nebojša Gnjatovic, Vaso Mihajlovic, Goran Milojevic STRENGTH PROBLEMS OF THE TRAVELLING MECHANISMS OF THE OPEN PIT MACHINES	249

## **PRODUCTION TECHNOLOGIES AND ENGINEERING**

1	Branko Pejovic, Slavica Cvetkovic, Pantelija Dakic, Aleksandar Todoc, Stefan Pavlovic ABOUT A SUITABLE MODEL OF KINEMATIC ANALYSIS OF COMPLEX MACHINE TOOLS TRANSMITTERS	257
2	Bogdan Maric, Ranko Božickovic, Miloš Sorak, Zdravko Božickovic ALGORITHM FOR PRODUCTION PROCESS MANAGEMENT IN OVERHAUL PRODUCTION SYSTEM	269
3	Bogdan Nedic, Marko Jankovic, Miroslav Radovanovic, Gordana Lakic Globocki AN INVESTIGATION OF QUALITY IN PLASMA CUTTING	275
4	Jovišević Vid, Borojevic Stevo, Globocki-Lakic Gordana, Cica Djordje, Sredanovic Branislav ANALYSIS OF EFFECTIVENESS ON PRODUCTION SYSTEM FOR PRODUCTION OF THE TOOLS FOR HYDRAULIC PRESS BRAKES	283

5	Milan Despotovic, Zoran Kovacevic, Jasna Radulovic ANALYSIS OF OPTIMAL WIRING OF PV PANELS BY MEANS OF NONLINEAR INTEGER PROGRAMMING	291
6	Dragan Adamovic, Vesna Mandic, Milentije Stefanovic, Srbislav Aleksandrovic, Miroslav Živkovic ANALYSIS OF THE TEMPERATURE CHANGE ON THE TOOL AND WORK PIECE DURING THE IRONING PROCESS	299
7	Marin Gostimirovic, Dragan Rodic, Pavel Kovac, Vladimir Pucovsky, Branislav Savkovic APPLICATION OF NEURO-FUZZY SYSTEMS AND GENETIC PROGRAMMING FOR MODELLING SURFACE ROUGHNESS IN ELECTRICAL DISCHARGE MACHINING	307
8	Dušan Petkovic, Goran Radenkovic, Vladislav Blagojevic, Predrag Živkovic, Ivan Ciric APPLICATION OF REGRESSION ANALYSIS AND GENETIC ALGORITHM TO THE OPTIMIZATION OF NITRIC ACID PASSIVATION OF 316L STAINLESS STEEL	313
9	Simo Jokanovic, Slaviša Todorovic AUTOMATIC GENERATION OF 3D CAD MODELS OF STANDARD PARTS AND PRODUCTS BY APPLICATION PROGRAMMING INTERFACES OF CAD/CAM SYSTEMS	319
10	Mathias Liewald, Ranko Radonjic BEHAVIOR OF ADVANCED HIGH STRENGTH STEELS IN DEEP DRAWING PROCESSES	325
11	Dragoslav Dobraš, Žarko Petrovic, Zdravko Božickovic BROWN'S GAS – HEAT SOURCE FOR WELDING	333
12	Zoran Janjuš, Aleksandar Petrovic, Aleksandar Jovovic, Radica Prokic- Cvetkovic CHANGES MECHANICAL PROPERTIES POLYPROPYLENE FILLED GLASS POWDER	339
13	Milena Cosic, Marina Dojcinovic, Zagorka Acimovic-Pavlovic CHARACTERIZATION OF THE MICROSTRUCTURE EVOLUTION IN RHEOCAST HYPEREUTECTIC AL-SI ALLOY	345
14	Vladan Andonovic, Marija Ackovska, Neda Petroska Angelovska CLOUD COMPUTING AS INTERNET OF THINGS PARADIGM FOR BIOMEDICAL INVESTIGATION	351
15	Slobodan Petricevic, Marko Barjaktarovic, Pedja Mihailovic COATED BOARD INSPECTION SYSTEM	357
16	Velimir Todoc, Dejan Lukic, Mijodrag Miloševic, Jovan Vukman, Goran Jovicic COMPUTER AIDED CONCEPTUAL PROCESS PLANNING – A SHORT REVIEW	367

17	Dejan Lukic, Velimir Todic, Mijodrag Milošević, Goran Jovicic, Jovan Vukman	
	SOFTWARE DEVELOPMENT FOR CONCEPTUAL PROCESS PLANNING	375
18	Dejan Lukic, Velimir Todic, Mijodrag Milošević, Jovan Vukman, Goran Jovicic	
	VERIFICATION OF THE DEVELOPED CONCEPTUAL CAPP SYSTEM ON THE EXAMPLE OF ROLLER BEARING	383
19	Branislav Sredanovic, Gordana Globocki Lakic, Davorin Kramar, Janez Kopac	
	CUTTING FORCE MODELING IN HARD ALLOY STEEL TURNING	389
20	Srbislav Aleksandrovic, Tomislav Vujinovic, Milentije Stefanovic, Vukic Lazic, Milan Djordjevic, Dragan Milosavljevic	
	DEFINING OF PRESSURE AND DRAWBEAD HEIGHT FUNCTIONS IN SHEET METAL STRIPE TENSILE TEST OVER DRAWBEAD WITH VARIABLE PARAMETERS	397
21	Mladen Todic, Ostoja Miletic	
	DEFORMATION ZONES AT TWO-LAYER BENDING COMPOSITES	403
22	Dimitri Kozinakov, Filip Zdraveski	
	DETERMINATION OF STIFFNESS CLASS OF SPIRAL PIPES VIA TEST METHOD AND COMPARISON WITH COMPUTER MODEL RESULTS	409
23	Mileta Janjic, Sreten Savicevic, Milan Vukcevic, Nikola Šibalic	
	DETERMINATION OF STRAIN RATE STATE AT FORGING IN OPEN DIE	417
24	Asim Jušić, Nijaz Hasanagic, Milan Jurkovic, Mladen Todic	
	ELASTIC STRAIN TEST FRAME OF PROCESSING SYSTEM FOR PROFILING SHEET METAL BY ROLLERS	423
25	Petar Tasic, Ismar Hajro, Damir Hodžić, Dragoslav Dobraš	
	ENERGY EFFICIENT WELDING TECHNOLOGY: FSW	429
26	Igor Kacmarcik, Miroslav Plancak, Dragiša Vilotic, Dejan Movrin, Aljoša Ivanišević	
	IMPACT OF BILLET SHAPE ON FORGING LOAD AND MATERIAL FLOW IN BI-METALLIC FORWARD Al/Cu EXTRUSION	443
27	Milentije Stefanovic, Vesna Mandic, Zvonko Gulišija, Srbislav Aleksandrovic, Dragan Adamovic	
	IMPROVING THE QUALITY OF AL – ALLOYS HOT FORGING PARTS	447
28	Adnan Mustafić, Sladjan Lovric, Edis Nasic, Mirza Krajnovic	
	INFLUENCE OF POROUS STAINLESS STEEL OBTAINED BY CENTRIFUGAL CASTING ON THE CUTTING ABILITY OF BANDSAW TOOLS	453
29	Isak Karabegovic, Bekir Novkinic, Ermin Husak, Safet Isic	
	INFLUENCE OF SELF-EXCITED VIBRATIONS ON THE SURFACE ROUGHNESS OF WORKPIECES OBTAINED BY LONGITUDINAL TURNING	459

30	Aljoša Ivanišević, Dejan Movrin, Igor Kacmarcik, Branko Štrbac, Milorad Betegalo	
	INVESTIGATION OF NEGATIVE SPRING BACK IN V – BENDING OPERATIONS	465
31	Mirza Krajnovic, Adnan Mustafi c, Mensur Demirovic	
	MODELING OF ELASTIC STRAIGHTENING IN THE PROCESS OF PRODUCTION OF COIL (HELICAL) CYLINDRICAL SPRINGS	483
32	Dusan Jovanic, Zeljko Eremic	
	MODELLING DATABASE OF WELDING PROCEDURE SPECIFICATION	479
33	Sekulic Milenko, Kramar Davor, Kopac Janez, Gostimirovic Marin, Kovac Pavel	
	OPTIMIZATION CUTTING PARAMETERS BASED ON CUTTING TEMPERATURE IN HPJA TURNING PROCESS USING TAGUCHI'S METHOD	487
34	Dijana Nadarevic, Davorin Kramar, Mirko Sokovic	
	PLANNING OF THE CRANKSHAFT GRINDING PROCESS	493
35	Ivan Matin, Miodrag Hadzistevic, Janko Hodolic, Djordje Vukelic	
	PRACTICAL ASPECTS OF INTEGRATION IN THE DEVELOPED MOLD DESIGN SYSTEM	501
36	Slobodan Tabakovic, Mirjana Bojanic, Milan Zeljkovic, Zoran Milojevic	
	PROGRAMMING SOLUTIONS FOR PROCESSING DIGITAL MEDICAL IMAGES	507
37	Saša Živanovic, Miloš Glavonjic	
	SIMULATIONS OF MACHINING BASED ON STEP-NC	513
38	Borut Kosec, Mirko Sokovic, Gorazd Kosec, Blaž Karpe	
	THERMOGRAPHIC AND FAILURE ANALYSIS OF DIES FOR ALUMINIUM AL-LOYS DIE-CASTING	523
39	Emilia Assenova, Mara Kandeva	
	TRIBOLOGY CENTER AT THE TECHNICAL UNIVERSITY – SOFIA	531
40	Dragoslav Dobraš, Zdravko Božickovic, Žarko Petrovic, Mladen Santrac, Petar Tasic	
	VIRTUAL WELDING	537
41	Goran Janjic, Zorana Tanasic, Aurilla Aurelie Arntzen Bechina	
	EFFECTIVE MANAGEMENT OF PERSONNEL DEVELOPMENT IN BUSINESS SYSTEMS	543

## **ENERGY AND THERMAL ENGINEERING**

1	Jasmina Skerlic, Milorad Bojic, Danijela Nikolic, Jasna Radulovic, Dragan Taranovic	
	A KEY REVIEW ON EXERGETIC ANALYSIS AND ASSESSMENT OF SOLAR ENERGY SYSTEMS FOR A SUSTAINABLE FUTURE	553

2	Suad H. Suljkovic, Velimir P. Stefanovic, Saša R. Pavlovic, Marko Ilic A REVIEW OF STRATEGIES AND TECHNOLOGIES TOWARDS NET ZERO ENERGY BUILDINGS THROUGH EXAMPLES ALL OF THE WORLD	561
3	Gordana Tica, Azra Rogovic-Grubic, Kotur Milovan, Petar Gvero AN ANALYSIS OF THE USE OF HCFC – REFRIGERANTS IN THE INDUSTRY AND HOUSEHOLDS IN BOSNIA AND HERZEGOVINA. A REVIEW OF POSSIBLE ALTERNATIVE REPLACEMENTS	567
4	Vladimir V. Jovanovic, Mirko S. Komatina, Dragoslava D. Stojiljkovic, Nebojša Manic APPLICATION OF FUEL FACTOR FOR CALCULATION OF FLUE GAS FLOW RATE IN TPP KOSTOLAC	575
5	Vesna Rankovic, Milorad Bojic, Aleksandar Novakovic, Marko Miletic, Nenad Kostic BUILDING CONTROLLER SYNTHESIS BASED ON THE USE OF MLE+CO- SIMULATION TOOL	583
6	Dušan Gordic, Gordana Stojanovic, Ana Radojevic COMPARATIVE ANALYSIS OF ENERGY INDICATORS IN SCHOOLS IN THE TERRITORY OF THE CITY OF KRAGUJEVAC	589
7	Bosko Bacic, Milan Lecic, Indir Mujanic COMPARATIVE ANALYSIS OF SOME METHODS FOR THE CALCULATION OF HEAT TRANSFER COEFFICIENT DURING THERMAL CALCULATION OF EVAPORATOR WITH NATURAL CIRCULATION	599
8	Marko Miletic, Ivan Miletic, Dragan Cvetkovic, Nenad Kostic, Milorad Bojic COMPARISON OF BUILDING ENVELOPE TYPES DEPENDING ON THE THER-MAL INSULATION LAYER POSITION	605
9	Nenad Kostic, Mirko Blagojevic, Vesna Marjanovic, Marko Miletic, Milorad Bojic DETERMINING SOLAR ANGLES FOR SUN TRACKING SYSTEM DEVEOLPEMENT DURING SPECIFIC TIMES OF THE YEAR	613
10	Aleksandar Novakovic, Vesna Rankovic, Nenad Grujovic, Dejan Divac, Nikola Milivojevic DEVELOPMENT OF NEURO-FUZZY MODEL FOR DAM SEEPAGE ANALYSIS	619
11	Marko Mancic, Dragoljub Živkovic, Velimir Stefanovic, Vladana Stankovic, Goran Jovanovic DYNAMICAL SIMULATION OF A SOLAR-HEAT PUMP SYSTEM FOR ON- SITE ELECTRICITY PRODUCTION	625
12	Elvis Hozdic, Milan Jurkovic, Sulejman Kendic ECOLOGICAL SOLID WASTE DISPOSAL AND EXPLOITATION OF LANDFILL GAS	631
13	Ranka Radic, Aleksandra Stanivukovic, Semin Petrovic, Brian Schjertzer, Petar Gvero	

	EMISSION REDUCTION MEASURES IN LOCAL COMMUNITIES IN B&H AS A RESULT OF SIGNING COVENANT OF MAYORS	643
14	Boris Cosic, Antun Pfeifer, Neven Duic ENERGY SYSTEM PLANNING WITH A HIGH SHARE OF RENEWABLE ENERGY SOURCES: THE CASE STUDY OF BOSNIA AND HERZEGOVINA	649
15	Mica Vukic, Jelena Janevski, Goran Vuckovic, Mirko Dobrnjac EXPERIMENTAL INVESTIGATION ON DRYING KINETICS OF CORN IN PACKED AND FLUIDIZED BED	657
16	Sadoon Ayed, Miloš Jovanovic, Gradimir Ilic, Predrag Živkovic, Mica Vukic, Mirko Dobrnjac, Suzana Kljecanin EXPERIMENTAL STUDY OF TEMPERATURE DISTRIBUTION FOR TURBULENT RAYLEIGH-BÉNARD CONVECTION IN A RECTANGULAR TAN	665
17	Danijela Kardaš, Petar Gvero, Mario Katalinic HEAT PUMP USING WASTE WATER AS A HEAT SOURCE – Student centar „Nikola Tesla“ BANJA LUKA	673
18	Nenad Miloradovic, Ivan Miletic, Marko Miletic, Dragan Cvetkovic, Milorad Bojic INFLUENCE OF PROPER WINDOW SELECTION ON ENERGY CONSUMPTION DURING A YEAR	679
19	Andreevski Igor, Kanevce Gligor, Kanevce Ljubica, Stavreva Sevde, Popovski Kire INVERSE ESTIMATIONS APPLICATION IN THE FIELD OF DISPERSION MODELING	687
20	Mladen Tomic, Predrag Živkovic, Mica Vukic, Mirko Dobrnjac, Gradimir Ilic MATRIX HEAT EXCHANGERS AND THEIR APPLICATION	693
21	Danijela Nikolic, Milorad Bojic, Jasmina Skerlic, Jasna Radulovic, Dragan Taranovic MODELLING OF HYBRID VENTILATION SYSTEM IN BUILDINGS USING ENERGYPLUS SOFTWARE	703
22	Sevde Stavreva, Marko Serafimov, Igor Andreevski, Cvete Dimitrievska USE OF CFD ANALYSIS TO ACHIEVE ENERGY EFFICIENT DATA CENTER	709
23	Igor Shesho, Dame Dimitrovski, Marko Serafimov NEARLY ZERO ENERGY BUILDINGS (nZEB), PLANNING AND POSSIBILITIES FOR APPLICATION	715
24	Žana Stevanovic, Gradimir Ilic, Mica Vukic, Predrag Živkovic, Ivan Lazovic NUMERICAL SIMULATION OF COANDA EFFECT IN MECHANICAL AND VENTILATED OFFICE	721
25	Alexandre Patou-Parvedy, Milan Despotovic OPTIMAL COMPOSITION AND THICKNESS OF THE ABSORBER WALL OF THE SOLAR CHIMNEY	727



26	Novak Nikolic, Nebojša Lukic, Dragan Taranovic OPTIMAL REFLECTOR POSITION OF A DOUBLE EXPOSURE FLATPLATE SOLAR COLLECTOR	737
27	Marko Miletic, Saša Jovanovic, Zorica Djordjevic, Ivan Miletic, Milorad Bojic OPTIMISATION OF ZERO-NET ENERGY HOUSE ORIENTATION FROM SOLAR ENERGY ABSORPTION ASPECT	743
28	Svetlana Dumonjic-Milovanovic, Petar Gvero OPTIMIZATION OF HYBRID SYSTEM FOR ELECTRICITY PRODUCTION BASED ON WIND AND SUN ENERGY CONVERSION WITH ANALYSIS OF ITS APPLICABILITY ON BANJALUKA REGION	749
29	Dragan Cvetkovic, Milorad Bojic, Vesna Rankovic, Marko Miletic, A. P. Parvedy OPTIMIZATION OF THE THERMAL INSULATION OF THE RADIANT PANELS	755
30	Marko Ignjatovic, Bratislav Blagojevic, Mladen Stojiljkovic, Mirko Stojiljkovic, Aleksandar Andjelkovic PRIMARY ENERGY CONSUMPTION DURING HEATING SEASON OF AN OFFICE BUILDING WITH ATTACHED DOUBLE SKIN FAÇADE	765
31	Kire Popovski, Stojance Nusev, Igor Andreevski RING-TYPE WATER SUPPLY NETWORKS	775
32	Djordjevic Zorica, Jovanovic Sasa, Bojic Milorad, Cvetkovic Dragan, Adamovic Dragan THE INFLUENCE OF ELECTRICAL APPLIANCES ON SPENDING ENERGY IN HOUSEHOLDS	779
33	Milovan Kotur, Franc Kosel, Šajn Viktor THE MATHEMATICAL ALGORITHM FOR A MULTI-CHANNEL CTA ANEMOMETER IN SPHERICAL COORDINATES	785
34	Vladimir Cavic, Petar Gvero THE USE OF AGRICULTURAL WASTE FOR A SUSTAINIBLE ENERGY SUPPLY FOR GREENHOUSE PRODUCTION	791
35	Jasna Radulovic, Milorad Bojic, Danijela Nikolic, Jasmina Skerlic, Dragan Taranovic THE USE OF PV IN NET-ZERO ENERGY BUILDINGS: CHALLENGES AND PERSPECTIVES	797
36	Vanja Šušteršic, Slobodan Savic, Dušan Gordic THE USE OF WASTE HEAT FROM WASTEWATER TREATMENT PLANT IN RURAL HOUSEHOLDS WITH HEAT PUMP	803
37	Predrag Živkovic, Mladen Tomic, Dušan Petkovic, Ivan Ciric, Mirko Dobrnjac, Velimir Stefanovic, Žana Stevanovic WIND ENERGY POTENTIALS OF VLASINA REGION	809
38	Andreja Stefanovic, Dušan Gordic ZERO CARBON HOMES, COGENERATION AND ORGANIC AGRICULTURE AS A METHODS OF REDUCING CO <sub>2</sub> EMISSIONS	815

## TRANSPORT AND MEANS OF TRANSPORT

- 1 Velimir Petrovic, Vladan Popovic, Branka Grozdanic, Zlata Bračanovic, Slobodan Jankovic  
A NEW METHOD FOR PARTICLE APPROVAL TYPE TESTING FOR HEAVY DUTY DIESEL ENGINE 823
- 2 Milan Milovanovic  
A RISK OR CONVENIENCE OF APPLYING AVAILABLE GAS SYSTEMS 829
- 3 Mirsad Trobradovic, Boran Pikula, Ivan Filipovic, Dževad Bibic  
AUTOMATED TRANSMISSION – A CHALLENGE FOR THE FUTURE 837
- 4 Hristijan Mickoski  
ANALYZE OF INFLUENCE OF VARIOUS FACTORS TO THE BRAKING ROAD OF RAIL VEHICLES, MODELLING AND SIMULATION IN MATLAB/SIMULINK 843
- 5 Izudin Delic, Izet Alic, Midhat Osmic  
CFD ANALYSIS OF STREAMING CHARACTERISTICS OF VARIABLE GEOMETRY TURBOCHARGER 849
- 6 Predrag Mrdja, Vladimir Petrovic, Nenad Miljic, Slobodan Popovic, Marko Kitanovic  
COMBUSTION PARAMETERS CALIBRATION AND INTAKE MANIFOLD REDESIGN FOR FORMULA STUDENT YAMAHA YZF-R6 ENGINE 855
- 7 Riste Temjanovski  
COMPETITIVENESS TRANSPORT SYSTEM AS A NECESSARY PRECONDITION FOR A SUCCESSFUL EUROPEAN INTEGRATION: MACEDONIAN CASE 861
- 8 Saša Milojevic, Jovanka Lukic, Radivoje Pešic  
CONTRIBUTION TO THE REDUCTION OF TRAFFIC NOISE BY APPLICATION OF THE CNG BUSES 873
- 9 Radivoje Pešic, Aleksandar Davinic, Dragan Taranovic  
ECOLOGICAL AND ENERGY ENGINE CHARACTERISTICS WHEN THE ENGINE APPLIES DIFFERENT WORKING PROCESSES 879
- 10 Slobodan Mišanovic  
EXPERIENCES OF PUBLIC TRANSPORT COMPANY “BELGRADE” IN THE USE OF ALTERNATIVE FUELS AND ENVIRONMENTALLY CLEAN VEHICLES IN URBAN PUBLIC TRANSPORT 887
- 11 Slobodan Popovic, Nenad Miljic, Marko Kitanovic, Predrag Mrdja, Miroljub Tomic  
HIGH-FIDELITY, ANGLE-RESOLVED SIMULATION MODEL FOR PREDICTIONS OF MULTI-CYLINDER ENGINE INSTANTANEOUS SPEED AND TORQUE 893
- 12 Jasmin Luckin, Miroslav Grubišic  
IMPACT OF HARDWARE FAULTS ON CAN BUS ON VEHICLE DISTRIBUTED ELECTRICAL SYSTEM 899



13	Zdravko Božickovic, Dragoslav Dobraš, Valentina Golubovic-Bugarski INFLUENTIAL FACTORS ON THE BRAKING FORCE INTENSITY DURING FORCE CONTROL ON A DEVICE WITH ROTARY ROLLERS	905
14	Drago Soldat, Robert Molnar, Marija Matotek INTEGRATION OF GEOGRAPHIC INFORMATION SYSTEM (GIS) AND LOGISTICS IN ORDER TO GENERATE VEHICLE ROUTES	911
15	Nenad Miljic, Slobodan Popovic, Marko Kitanovic, Predrag Mrdja, Miroljub Tomic NEURAL NETWORKS MODELS USAGE IN METHODS FOR COMBUSTION PROCESS INFORMATION EXTRACTION IN IC ENGINES	917
16	Dobrivoje Ninkovic ON THE USE OF THE DISCHARGE COEFFICIENT CONCEPT IN THE IC ENGINE VALVE MASS FLOW RATE CALCULATIONS	923
17	Milanko Damjanovic, Sreten Simovic IMPACT OF CLEARANCE ON POWER TRANSMISSION DYNAMIC LOAD	937
18	Marko Kitanovic, Slobodan J. Popovic, Nenad Miljic, Predrag Mrdja, Miroljub Tomic SIMULATION STUDY OF A TRANSIT BUS EQUIPPED WITH ANULTRACAPACITOR-BASED HYBRID SYSTEM	943
19	Jasna Glišovic, Jovanka Lukic, Danijela Miloradovic STABILITY ANALYSIS OF DISC BRAKE MODEL: A PARAMETRIC STUDY	949
20	Dragan Taranovic, Radivoje Pešic, Aleksandar Davinic, Saša Milojevic THERMODYNAMIC CHARACTERISTICS OF RECIPROCATING COMPRESSORS FOR MOTOR VEHICLES	955
21	Blažević Almir, Bibić Dževad, Filipović Ivan TURBOCHARGERS PERFORMANCE TESTING WITH SPECIAL EMPHASIS ON THE COMPRESSOR MAP	961
22	Rajko Radonjic, Dragoljub Radonjic, Aleksandra Jankovic VEHICLE DYNAMICS INVESTIGATION	969
23	Vladimir Pajkovic, Mirjana Grdinic AN ANALYSIS OF YOUNG DRIVER ACCIDENTS IN ROAD TRAFFIC USING IN DEPTH CRASH INVESTIGATION DATA	975

## **MECHATRONICS**

1	Corina Daniela Cuntan, Ioan Baciú, Cezara Rat A SELECTION AND DISPLAY SYSTEM FOR NUMERIC INFORMATION DEVELOPED IN LABVIEW	985
2	Vojkan Cvijanovic, Vladimir Kvrđić, Goran Ferenc	

	AN ANALYSIS OF CONTEMPORARY TECHNOLOGIES FOR THE SECURE USER TO USER EMAIL TRANSFERS	993
3	Mitar Jocanovic, Velibor Karanovic, Darko Knežević APPLICATION OF GEAR REDUCER OILS IN FOOD PROCESSING INDUSTRY	999
4	Remigiusz Labudzki APPLICATION THE MACHINE VISION TO PRODUCT PACKAGING	1005
5	Isak Karabegovic, Sanel Karabegovic, Ermin Husak, Safet Isic AUTOMATION OF CONVEYOR LINES IN THE MILK TREATMENT INDUSTRY	1011
6	Tihomir Latinovic, Mihailo Lazarevic, Sorin Deaconu, Gabor Sziebig FUZZY LOGIC COMBINED WITH NEURAL ALGORITHM TO CONTROL INDUSTRIAL ROBOT	1019
7	Sorinloan Deaconu, Razvan Deaconu, Tihomir Latinovic HIGH POWER STATIC CONVERTERS IN INDUSTRY APPLICATIONS	1025
8	Tanja Kerezovic, Gabor Sziebig, Bjørn Solvang, Tihomir Latinovic HUMAN SAFETY IN ROBOT APPLICATIONS – REVIEW OF SAFETY TREND	1031
9	Slaviša Galamic, Trygve Thomessen, Balazs Daniel INTRODUCTION TO A FORCE CONTROLLED BEER POURING ROBOT	1041
10	Mina Vaskovic, Marko Jurišević, Nenad Babajic, Milan Matijević PIONEER 3-DX DISTANCE CONTROL USING DIFFERENT TYPE OF SENSORS	1049
11	Dragan Živanic, Anto Gajic, Jovan Vlastic, Radomir Djokic, Zdravko Ristic PROPERTY OF PROGRESSIVE ZONING IN THE ORDER PICKING SYSTEMS	1053
12	Petar Mandic, Mihailo Lazarevic, Slavoljub Stojanovic, Milan Ristanovic REAL TIME CONTROL OF ROTARY INVERTED PENDULUM	1059
13	Audun Rønning Sanderud, Trygve Thomessen RELEASING THE SYNERGY OF HUMAN-ROBOT COLLABORATION – REDUNDANT ROBOTICS IN PRACTICE	1065
14	Nikola Malešević, Gabor Sziebig, Bjørn Solvang, Tihomir Latinovic SIMULATION OF ROBOTIC TASKS WITH VALIP SYSTEM – PRACTICAL APPLICATION	1071
15	Mihailo Lazarevic, Petar Mandic, Tihomir Latinovic, Trygve Thomessen SOME RESULTS OF CONTROL AND SIMULATION OF NEURO ARM ROBOT	1077
16	Isak Karabegovic, Edina Karabegovic, Mehmed Mahmic, Ermin Husak THE FUTURE AND STRATEGIC DEVELOPMENT OF SERVICE ROBOTS IN THE 21th CENTURY	1083

17	Ivan Ciric, Zarko Cojbašić, Vlastimir Nikolic, Predrag Živkovic, Dusan Petkovic, Mladen Tomic, Misa Tomic THERMAL VISION INTEGRATION IN MOBILE ROBOT VISION SYSTEM	1091
18	Zoran Rajilic TIME SERIES ANALYSIS USING MinLMaxL DIAGRAMS	1099
19	Rodoljub Vujanac, Radovan Slavkovic, Nenad Miloradovic, Mirko Blagojevic VERTICAL RECIPROCATING CONVEYOR AS A PART OF FULLY AUTOMATED MULTI DEPTH PALLET RACK STORAGE SYSTEM	1105
20	Vasilije Vasic, Mihailo P. Lazarevic, Taško Maneski ADAPTRONIC SYSTEM AND VIBRATION CONTROL WITH MR DAMPERS	1113

### **MAINTENANCE OF TECHNICAL SYSTEMS, OCCUPATIONAL SAFETY**

1	Ninoslav Zuber, Rusmir Bajric CHALLENGES OF GEAR FAULT DETECTION BASED ON VIBRATION SIGNAL PROCESSING TECHNIQUE	1121
2	Silvana Angelevska, Ivo Kuzmanov, Zore Angelevski, Vasko Stojanovski MAINTANCE MANAGEMENT AND USING BENCHMARKING AS A TOOL IN THE FRAME OF WORLD CLASS INDUSTRIAL SYSTEM	1127
3	Dušan Djurovic, Miodrag Bulatovic MAINTENANCE AND AVAILABILITY OF MACHINERY	1133
4	Tale Geramitchioski, Ljupco Trajcevski MONITORING THE CONDITION OF THE MACHINERY IN A METAL SMELTER FENI KAVADARCI USING VIBRATION SIGNATURE	1139
5	Kazafer Becic, Veljko Vukovic, Safet Sinanovic TECHNOLOGICAL PROCEDURE OF PROCESSING AND DYNAMIC BALANCING COLLECTOR OF TRACTION MOTORS TYPE 644-8 ISVK	1145
6	Vujadin Aleksic, Ljubica Milovic, Srdjan Bulatovic TESTING OF METALS IN THE FUNCTION OF DETERMINING THE FAILURE OF TURBINE SHAFT – METHODOLOGICAL APPROACH	1153
7	Dragoljub Vujic WIRELESS SENSOR NETWORKS IN AIRCRAFT DESIGN AND STRUCTURAL HEALTH MONITORING	1159
8	Adnan Ramakic, Zlatko Bundalo DATA PROTECTION IN MICROCOMPUTER SYSTEMS AND NETWORKS	1165
9	Vladan Andonovic, Marija Ackovska, Neda Petroska Angelovska RFID AS A MODERN BRAND PROTECTION TECHNOLOGY	1171
10	Nenad Miloradovic, Rodoljub Vujanac, Danijela Miloradovic, Blaža Stojanovic	

	USE OF WORKING PLATFORMS ON FORKLIFT TRUCKS	1177
11 Aleksandar Majstorovic	THE MICROBIOLOGICAL ANALYSIS OF COMPRESSED MEDICAL AIR FROM BREATHING APPARATUS	1183
12 Ivo Kuzmanov, Silvana Angelevska, Zore Angelevski, Vasko Stojanovski	EVALUATING THE INJURIES INTO BITOLA'S REGION IN 2012, REAL ENTERPRISE EXPERIENCE AND WAYS FOR IMPROVING THE SAFETY SYSTEMS INTO REAL ENTERPRISES	1189
13 Biljana Naumovska, Jasmina Chaloska, Ljuben Dudeski	HUMAN VIBRATIONS EFFECTS, MEASUREMENT AND PROTECTION	1197
14 Boban Cvetanovic	LEGISLATION AND STANDARDIZATION RELATED TO WHOLE BODY VIBRATION	1205
15 Petar S. Djekic, Anica Milosevic, Sladjana Nedeljkovic	SAFETY AND HEALTH AT WORK IN THE PRODUCTION OF RUBBER CONVEYOR BELTS	1211
16 Biljana Vranješ	STATISTICS METHODS IN THE ANALYSIS OF INJURIES AT WORK	1217
17 Mihajlo Ivanov, Jasmina Chaloska, Ljuben Dudeski	THE ASSESSMENT OF RISK – BASE OF PREVENTIVE MEASURES LIKE PRIORITY IN THE SYSTEM OF SAFETY AT WORK	1223

## PREFACE

Dear colleagues,

DEMI Conference has brought us together for the 11<sup>th</sup> time to show the current state of research in the field of Mechanical and Electrical Engineering as well as Information Technology.

From the very beginning, the Conference has aimed strengthening cooperation between companies and science. However, we live at the time of a severe economic crisis that even affects the richest economies. Furthermore, stagnation of the real economy and unemployment are present in technologically developed countries, whereas investments in the R&D sector are small, all of which reflects on the field of scientific research.

There was concern that such a state of the economy may cause a lack of interest and potential of scientific workers to participate actively in the work of scientific conferences. However, DEMI will not flinch. With great pleasure, I would like to point out that the DEMI 2013 Conference gathered a record number of participants so far. The Conference Proceedings contains 174 papers by authors from 14 countries. Scientists and researchers have traditionally been the most active in the field of Production Technology and Engineering (41 papers), followed by Energy and Thermal Engineering (37 papers), Mechanics and Design (28 papers), Transport Vehicles and Transportation (23 papers), Mechatronics (20 papers), Maintenance of technical systems, Occupational safety (17 papers).

On behalf of Organizational Board of the 11th International Conference on Accomplishments in Electrical and Mechanical Engineering and Information Technology, DEMI 2013, I wish all our guests a warm welcome to Banja Luka and successful work to all participants. Furthermore, I would like to express my gratitude to all the authors, members of the Scientific Committee, institutions, companies and individuals who have contributed to successful organization of the DEMI 2013 Conference.

In Banja Luka, May 2013  
Chair of DEMI 2013 Organizational Board  
Valentina Golubović-Bugarški

## PREDGOVOR

Poštovane kolege,

Konferencija DEMI okupila nas je po 11. put da prezentujemo trenutno stanje istraživanja u području mašinstva, elektrotehnike i informacionih tehnologija.

Konferencija DEMI odavno je za svoj cilj postavila jačanje oblika saradnje između privrednih preduzeća i nauke. Međutim, živimo u vrijeme teške ekonomske krize koja pogađa i najbogatije ekonomije, stagnacija realne privrede i nezaposlenost prisutni su i u tehnološki najrazvijenijim zemljama, ulaganja u razvoj i istraživanja su mala, što se sve reflektuje i na područje naučnih istraživanja.

Postojala je bojazan da će ovakvo stanje privrede uzrokovati i manjak interesovanja i mogućnosti naučnih radnika da aktivno učestvuju u radu naučnih konferencija. Ipak, DEMI ne posustaje.

S posebnim zadovoljstvom ističem da je Konferencija DEMI 2013 okupila do sada rekordan broj učesnika. U zborniku radova objavljeno je 174 radova autora iz 14 zemalja. Naučnici i istraživači tradicionalno su najaktivniji u području Proizvodnih tehnologija i inženjerstva, a rezultati istraživanja u ovom području saopšteni su kroz 41 radova. Slijede područje Termotehnike i energetike (37 radova), Mehanika i konstrukcije (28 rada), Saobraćaj i transportna sredstva (23 rada), Mehatronika (20 radova) i Održavanje tehničkih sistema i zaštita na radu (17 radova).

U ime Organizacionog odbora Konferencije DEMI 2013 iskazujem svim našim gostima toplu dobrodošlicu u Banju Luku i želim uspješan rad učesnicima Konferencije. Takođe, zahvaljujem se svim autorima, članovima Naučnog odbora, institucijama, firmama i pojedincima koji su svojim angažovanjem doprinijeli da Konferencija DEMI 2013 bude uspješno organizovana.

U Banjoj Luci, maj 2013. godine  
Predsjednik Organizacionog odbora  
Konferencije DEMI 2013  
Valentina Golubović-Bugarški



## CONTRIBUTION TO THE REDUCTION OF TRAFFIC NOISE BY APPLICATION OF THE CNG BUSES

Saša Milojević<sup>1</sup>, Jovanka Lukić<sup>2</sup>, Radivoje Pešić<sup>3</sup>

**Abstract:** *The noise that comes from the road traffic, along with other emitters of environmental noise has a largely negative impact on quality of life. In the Republic of Serbia as in communities everywhere in the world, the noise that comes from the road traffic has become an increasingly noticeable and serious problem which is especially pronounced in large industrialized cities. Regarding to the current situation, as a special contribution to reducing noise in road traffic, it is proposed solution in terms of replacement of the existing city buses with original engines or vehicles on Compressed Natural Gas CNG, that produce less noise emission. This was confirmed with parallel tests of the buses with drive on diesel and CNG. The results obtained by measuring the noise of the vehicles according to the Regulation UN ECE No. 51, are shown a significant noise reduction compared to the situation when used diesel buses.*

**Keywords:** *Road traffic noise, CNG buses, ecology.*

### 1. INTRODUCTION

European Union (EU) indicates the noise emission as one of the ecological problems of modern society. According to the EU statistics, nearly 40% of the population today is exposed to the noise level in excess of 55 dB(A), that is upper limit for clearly residential territory. Through 20% of the population is exposed to the noise level in excess of 65 dB(A), that is upper limit for urban center, commercial and administrative area with residences, zone along highway, main route and city roads, until above 30% of the European population is exposed to the noise level in excess of 55 dB(A) nightly, that challenge the problems with dream [3,7].

Today, increased noise, due to emission from diesel vehicles intensified the applications of CNG vehicles. As a contribution, we started the proper researches during it was realized the reconstruction of the low floor city bus with diesel engine, for CNG drive, by mounting of original CNG engine (eng. dedicated NGV) [4].

During the tests, we are measured the emission of noise on the new bus variant according to the Regulation UN ECE 51R [2]. Based on the results, we are verified the reduction of noise in the case when used gas instead of the diesel engine.

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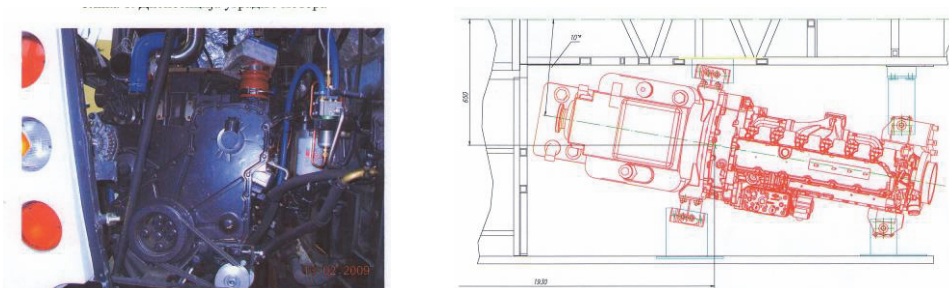
## 2. STANDARDS FOR LIMITING NOISE LEVELS OF MOTOR VEHICLES

Exterior vehicle noise is standardized with the Regulations UN ECE No. 51, Amendment 02. EU Directive 70/157EEC also applied [2,3].

Directive 2002/49/EC relating on the protection of the noise emission and the Regulation about the noise indicators, with defined limits and methods for evaluating the indicators of noise disturbance and adverse effects of noise in the environment also applied. Both are introduced/ legislated in the Republic of Serbia (Official carrier No. 75/10), and have the objective at preventing/ reducing harmful effects on the population, to establish an adequate database, which will be used to determine the strategic measures to reduce noise in the future [3].

## 3. RECONSTRUCTION OF THE DIESEL BUS TO DRIVE ON GAS FUEL

The reconstruction of the city bus powered by diesel engine into dedicated NGV, is started through the adaptation of engine compartment for the mounting of original CNG engine type C Gas Plus, Fig. 1. CNG engine is supported by means of dampers with corresponding damping characteristics. We used the classic engineering methods to calculate the best characteristics of the mounts for engine supporting and joint assembling solution. The position of the CNG engine and rest equipment was confirmed by using Finite Element Method analysis (FEM/ PAK below), developed at the Faculty of Mechanical Engineering in Kragujevac. Specifically we are took into account the requirements regarding to the lowering noise and vibrations.



(a) Rear engine support/ traverse

(b) Engine supporting cross four point

Fig. 1 CNG engine position on the appropriate supports

## 4. EXPERIMENTAL MEASUREMENTS

In order to verify the reconstructions, we are measured the noise emission of the CNG bus at polygon conditions pursuant the Regulative UN ECE No. 51 [2].

### 4.1 Measuring equipment

Table 1 shows the specifications of measuring equipment used for noise measurement according to the Regulation UN ECE No. 51 [2, 4].



Table 1 Measuring equipment specification [6]

Description / Name	Specifications / Type
Sound level meter type	Bruel & Kjaer 2231
Microphone type	B&K 4155
Filter set type	1625
Sound level calibrator type	4230

#### 4.2 Technical characteristics of the experimental buses

The basic dimensions of the reconstructed bus powered by CNG are shown in Fig. 3. The comparative technical characteristics of both analyzed buses, first powered by diesel fuel, and the reconstructed bus powered by CNG, are showed in table 2.

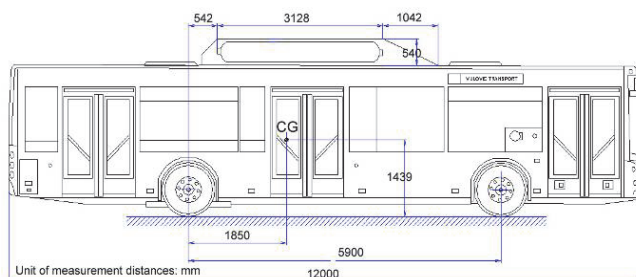


Fig. 3 The main dimensions of CNG bus

Table 2 Technical dates of the test objects – the experimental buses

The technical dates of buses and equipments	Diesel bus type 203	Gas bus type 203 CNG
Engine maker	Mercedes-Benz	Cummins Engine Comp.
- Type - configuration	2005/55-59C01	D553005BX02
- Version	OM 906 LA.V/3 (125 L Kat)	CGe4 280 (TWC)
- No. of cylinders / Cycle	6 in-line / four stroke	6 in-line / four stroke
- Engine capacity (ccm)	6 374	8 268
- Maximum net power	210 kW @ 2200 rpm	206.9 kW @ 2400 rpm
- Maximum net torque	1120 Nm @ 1200-1600rpm	1148.8 Nm @ 1400 rpm
- Combustion system	Compression Ignition - CI	Spark Ignition - SI
- Fuel	Diesel	Natural Gas - CNG
- Type of catalytic action	Selective Catalytic Reduction, SCR- System	Oxidation – Ceramic in Muffler casing
Gearbox maker	Voith	Allison
- Type	D 864.3E	T325 R
- Gear change / number	Automatic / 4 gear speed	Automatic / 6 gear speed

The CNG engine is mounted in compartment behind the rear driving axle, Fig. 1. To lowering the noise emission and vibration is made the coating and isolation of the engine compartment.

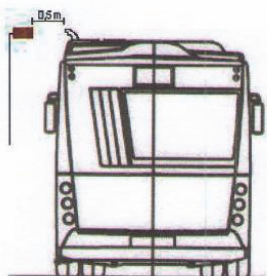
The CNG engine is supported in three points on the anti-vibration mountings Maker VCE, model No. 10-IM.

The noise emission due to compressed air in the pneumatic installation during operation of the air brake and air suspension system also analyzed.

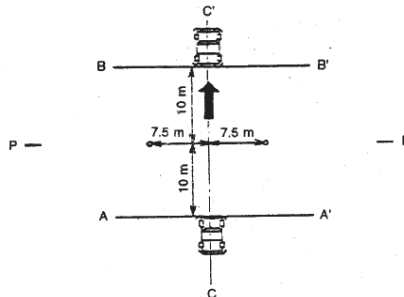
### 4.3. Measuring of the buses noise emission at stationary conditions

Those measurements are realized according to the terms defined in Regulation UN ECE No. 51. We are used the sound level meter with microphone as defined in the table 1. The measuring point was translated for 0.5 m out of exhaust pipe in horizontal direction, Fig. 4.a.

During the measurements, the engine was operated under low idle speed and 1800 rpm (which is 3/4 of the speed at maximal power conditions). It is important to accentuate that the cooling fan was operated in first gear speed that is normal operation, while on the CNG bus exists one more fan speed. All the time, the bus is stopped while the automatic gear change lever is in neutral mode.



(a) Position of gage during exploring at stationary conditions



(b) Position of gage during exploring at drive conditions

Fig. 4 Positions of the gage during exploring

Table 3 Conventional diesel v. CNG stationary internal noise levels - idling, dB(A)

Parameter	Powertrain	Measurement	Engine speed	
			Low idle	High idle, 1800 rpm
Average	Diesel	1 <sup>st</sup>	76	97.5
		2 <sup>nd</sup>	77	98
		<b>Results ...</b>	<b>77</b>	<b>98</b>
	CNG	1 <sup>st</sup>	64*/70**	76
		2 <sup>nd</sup>	63.9*/69**	75
		<b>Results ...</b>	<b>64*/70**</b>	<b>76</b>

Comment: \*1<sup>st</sup> cooling fan speed, \*\*2<sup>nd</sup> cooling fan speed.

In the Table 3 are presented the values obtained by measuring of the noise emission at stationary conditions for two variant of bus type (diesel and CNG). CNG bus meets the limits regulated with standard. The noise emission obtained during the measurement where significantly less than noise emission which demanded by ECE

regulative, where exists the limit value of 80 dB(A). The noise emission of the CNG bus under idle speed is lower for 7 (*1<sup>st</sup> cooling fan speed*) and 13 dB(A) (*2<sup>nd</sup> cooling fan speed*), if we compare the obtained results with those on the diesel bus. During the operation under 1800 rpm, the noise emission of CNG bus is lower for 22 dB(A). The measured values are rounded to the next bigger integer number, according to the standard demands, as presented in the Table 3.

#### **4.4. Measuring of the buses noise emission at drive conditions**

Positions of the measuring device related to the bus under the measuring of the bus noise at drive conditions were presented on the Fig. 4.b. The microphone is positioned at the height of 1.2 m above the ground in the vertical direction and looking in the horizontal direction on the distance of 7.5 m left and right from the reference line CC', which represents a direction of drive. On the polygon marked two lines AA' and BB', positioned at a distance of 10 m ahead and behind of the previous defined microphone position.

The Regulation also defines the measuring conditions in the event if vehicle is equipped with automatic transmission. Then, under drive conditions, the bus approaching to the line AA' at constant speed of  $V=30, 40$  and  $50 \text{ km}\cdot\text{h}^{-1}$ . The driver rapidly accelerates the vehicle from the moment when the front end of the bus reaches the reference line, until the back end of the bus does not pass line BB'.

It was measured the maximal value of noise for both vehicle side, so the measurement repeated twice and the highest measured value is rounded to the decibel, as required by the standard, tables 4 and 5.

Under drive conditions, the noise emission of CNG bus is lower significantly compared to the tolerable limit value of 80 dB(A). The noise emission of CNG bus under drive at speed  $V=50 \text{ km}\cdot\text{h}^{-1}$  is lower for 6 dB(A), compared to the similar measurements with diesel bus. The results marked as (\*) in the Table 6, represent the values obtained by measuring the noise emission of the CNG bus during switched on cooling fan in second gear speed.

Table 4 *Measured diesel bus noise values at drive conditions, dB(A)*

Bus side	Measurement	30 km·h <sup>-1</sup>	40 km·h <sup>-1</sup>	50 km·h <sup>-1</sup>
Left	1.	76.6	76.6	77.7
	2.	76.3	77	78
Right	1.	74.5	73.5	77
	2.	75.9	74.4	76.9
<b>Results ...</b>		<b>77</b>	<b>77</b>	<b>78</b>

Table 5 *Measured CNG bus noise values at drive conditions, dB(A)*

Bus side	Measurement	30 km·h <sup>-1</sup>	40 km·h <sup>-1</sup>	50 km·h <sup>-1</sup>
Left	1.	75.8*	71	70.1
	2.	76.3*	72.4	70.3
Right	1.	69.4	70.7	71.8
	2.	71.2	71.8	70.9
<b>Results ...</b>		<b>76</b>	<b>72</b>	<b>72</b>

## CONCLUSIONS

The noise incurred and generated by city traffic has a negative impact to a large extent to life quality. In the Republic of Serbia as well as in other parts worldwide, the traffic generated noise is becoming a very serious issue, especially in large industrial cities.

Reconstructing buses from diesel fuel drive to CNG applications contributes to noise decline to a large extent. It was also proved during the conducted tests and noise measuring according to methods defined by adequate and referential standards.

When at idle, the bus noise with CNG drive is lower for 7-13 dB(A) compared to the alternative with diesel engine, whereas at 1800 min<sup>-1</sup> at high idle, decline of 22 dB(A) was registered.

The noise of CNG drive buses in motion, at speed limit of 30 km·h<sup>-1</sup>, 40 km·h<sup>-1</sup>, and 50 km·h<sup>-1</sup> is lower for 1-6 dB(A) compared to the same type bus version with diesel fuel drive.

In public transportation of passengers in the city of Kragujevac there are 50 buses which daily make about 250 km as an average, for 315 working days per year. By applying the CNG buses instead of the existing ones with diesel engine, a considerable decline in noise emission would be achieved.

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