Bursa Uludağ University
Engineering Faculty
Automotive Engineering Department

OTEKON 2020

ULUSLARARASI 10. OTOMOTİV TEKNOLOJİLERİ KONGRESİ BİLDİRİLER KİTABI

Proceedings of the International 10th Automotive Technologies Congress September 6-7, 2021, Bursa, Türkiye

Editörler / Editors :

Dr. Öğr. Üyesi Erol Solmaz

Prof. Dr. Necmettin Kaya

Prof. Dr. Ferruh Öztürk

BURSA – 2021

İÇİNDEKİLER / CONTENTS

KURULLAR / COMMITTEES V

SPONSORLAR / SPONSORS VIII

ÖNSÖZ / PREFACE IX

BİLİMSEL PROGRAM / SCIENTIFIC PROGRAM X

BİLDİRİLER / PAPERS XII

POSTERLER / POSTERS XIX

İNDEKS / INDEX 1717

Disclaimer:

No responsibility is accepted for the accuracy of information contain in the text, illustrations and advertisements in this Proceedings. Editors, Organization Committee and BURKON do not have any responsibility for the accuracy of the information and opinions expressed in OTEKON 2020 Proceedings.

Kongre Bildiriler Kitabı metin içerikleri ile ilgili bütün sorumluluk yazarlara aittir. Editörler, Düzenleme ve Danışma Kurulları ve BURKON için bağlayıcı nitelik taşımazlar.

Copyright:
No part of this Proceedings may be reproduced, stored, transmitted, or disseminated in any form, or by any means (including electronic, mechanical, photocopying, recording or otherwise) without the prior written permission of the BURKON.

Bu kitabın tamamı veya bir kısmı BURKON' nun izni olmaksızın elektronik, mekanik, fotokopi veya herhangi bir kayıt sistemiyle çoğaltılamaz ve yayınlanamaz.

BURSA
Eylül, 2021 / September, 2021

OTEKON2020 Kongresi Organizasyonu

BURKON TURİZM & KONGRE

444 9 443

Çekirge Cad. No: 51/C 16050 - BURSA

Bursa Uludağ University
Engineering Faculty
Automotive Engineering Department

Proceedings of the International 10th Automotive Technologies Congress
September 6-7, 2020, Bursa, Türkiye

Editors:

Dr. Öğr. Üyesi Erol Solmaz

Prof. Dr. Necmettin Kaya

Prof. Dr. Ferruh Öztürk

ISBN: 978-605-70422-4-8

KURULLAR / COMMITTEES

Onur Kurulu / Honorary Committee
Prof. Dr. A. Saim Kılavuz (Uludağ Üniversitesi Rektörü)

Kongre Başkanı / Congress Chair
Prof. Dr. Ferruh ÖZTÜRK

Kongre Eş Başkanları / Congress Co Chairs
Prof. Dr. Necmettin KAYA
Dr. Öğr. Üyesi Erol SOLMAZ

Kongre Sekreteri / Congress Secretary
Dr. Öğr. Üyesi Erol SOLMAZ

Düzenleme Kurulu / Organizing Committee
Prof.Dr. Ferruh ÖZTÜRK
Prof.Dr. Necmettin KAYA
Doç.Dr. Gökhan SEVİLGEN
Dr. Öğr. Üyesi Erol SOLMAZ

Bilim ve Danışma Kurulu / Scientific and Advisory Committee

Prof. Dr. Orhan ALANKUŞ	OKAN UNIVERSITY	TURKEY
Prof. Dr. Günay ANLAŞ	BOĞAZİÇİ UNIVERSITY	TURKEY
Prof. Dr. Istvan BARABAS	TECHNICAL UNIVERSITY OF CLUJ NAPOCA	ROMANIA
Assoc. Prof. Dr. Çağlar BAŞLAMIŞLI	HACETTEPE UNIVERSITY	TURKEY
Kadir CERAN	TOFAŞ-TURKISH AUTOMOTIVE COMPANY	TURKEY
Prof. Dr. Giuseppe CARBONE	POLITECNICO DI BARI	ITALY
Prof. Dr. Shuming CHEN	JILIN UNIVERSITY	CHINA
Prof. Dr. Giorgio CHIANDUSSI	POLITECNICO DI TORINO	ITALY
Baran ÇELİK	BEYÇELİK AUTOMOTIVE INDUSTRY EXPORTERS ASSOCIATION (OIB)	TURKEY
Prof. Dr. Julian F DUNNE	UNIVERSITY OF SUSSEX	UNITED KINGDOM
Prof. Dr. Hüseyin Aksel EREN	BURSA ULUDAG UNIVERSITY	TURKEY
Prof. Dr. Akın Burak ETEMOĞLU	BURSA ULUDAG UNIVERSITY	TURKEY

Prof. Dr. Ali G. GÖKTAN	EM TEST R&D and TESTING SOLUTIONS	TURKEY
Prof. Dr. Levent GÜVENÇ	OHIO STATE UNIVERSITY	USA
Prof. Dr. Carlos GUARDIOLA	UNIVERSITAT POLITECNICA de VALENCIA	SPAIN
Dr. Mustafa HATİPOĞLU	BTSO-BUTEKOM	TURKEY
Prof. Dr. Murat HOŞOZ	KOCAELİ UNIVERSITY	TURKEY
Prof. Dr. Bilgin KAFTANOĞLU	ATILIM UNIVERSITY	TURKEY
Prof. Dr. İrfan KARAGÖZ	ULUTEK	TURKEY
Prof.Dr.M.İhsan KARAMANGİL	BURSA ULUDAG UNIVERSITY	TURKEY
Assoc. Prof. Dr. Ahu Ece Hartavi KARCI	UNIVERSITY OF SURREY	UNITED KINGDOM
Doç. Dr. İbrahim KORKMAZ	NİŞANTAŞI UNIVERSITY	TURKEY
Prof. Dr. Nusret Sefa KURALAY	DOKUZ EYLÜL UNIVERSITY	TURKEY
Dr. Recep KURT	MARTUR	TURKEY
Prof. Dr. Tae Hee LEE	HANYANG UNIVERSITY	REPUBLIC OF KOREA
Asst. Prof. Dr. Xianke LIN	UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY	CANADA
Prof. Dr. Jovanka LUKIC	UNIVERSITY OF KRAGUJEVAC	SERBIA
Ozan NALCIOĞLU	FORD AUTOMOTIVE INDUSTRY CORP.	TURKEY
Prof. Dr. Henk NIJMEIJER	EINDHOVEN UNIVERSITY OF TECHNOLOGY	NETHERLANDS
Prof. Dr. Valyo NIKOLOV	TECHNICAL UNIVERSITY OF SOFIA	BULGARIA
Prof. Dr. Wojciech SKARKA	SILESIAN UNIVERSITY OF TECHNOLOGY	POLAND
Prof. Dr. Ali SÜRMEN	BURSA ULUDAG UNIVERSITY	TURKEY
Gökhan TUNÇDÖKEN	BOSCH	TURKEY

Ergun TÜRKAY	BUSİAD	TURKEY
Prof. Dr. Deniz UZUNSOY	BURSA TECHNICAL UNIVERSITY	TURKEY
Asst. Prof. Dr. Erdem UZUNSOY	BURSA TECHNICAL UNIVERSITY	TURKEY
Prof. Dr. Yavuz Samim ÜNLÜSOY	MIDDLE EAST TECHNICAL UNIVERSITY	TURKEY
Prof. Dr. Jac WISMANS	SAFETEQ AUTOMOTIVE SAFETY CONSULTING	NETHERLANDS
Prof. Dr. Recep YAMANKARADENİZ	BURSA ULUDAG UNIVERSITY	TURKEY
Oya COŞKUNÖZ	COŞKUNÖZ	TURKEY
Prof. Dr. Serdar YÜCESU	GAZİ UNIVERSITY	TURKEY
Prof. Dr. Babür ÖZÇELİK	KONYA TECHNICAL UNIVERSITY	TURKEY
Prof. Dr. Metin ERGENEMAN	ISTANBUL TECHNICAL UNIVERSITY	TURKEY
Prof. Dr. Mustafa GÖKLER	MIDDLE EAST TECHNICAL UNIVERSITY	TURKEY
Ergün GÜRASLAN	FORD AUTOMOTIVE INDUSTRY CORP.	TURKEY
Prof. Dr. Dan SCARPETE	UNIVERSITY DUNAREA DE JOS OF GALATI	ROMANIA
Prof. Dr. Thomas TRÖSTER	UNIVERSITY OF PADERBORN	GERMANY

SPONSORLAR / SPONSORS

Altın Sponsorlar / Gold Sponsors
TOFAŞ TÜRK OTOMOBİL FABRİKASI A.Ş. · Ford FORD OTOSAN · Oyak Renault Otomobil Fabrikaları
Katkıda Bulunan Diğer Sponsorlar / Other Sponsors and Supporters
FEV

ÖNSÖZ / PREFACE

OTEKON2020, 10th International Automotive Technologies Congress was held with online sessions on 6th and 7th of September 2021. It is our pleasure to express gratitude to all those who attended this congress and made this event a great success with about 700 attendees. OTEKON 2020 Virtual Congress was held with technical papers, posters, opening and keynote speeches and virtual exhibitions.

OTEKON2020 Congress was a unique platform to gain an insight on the latest research activities and discuss the trends that related to the latest automotive technologies and their applications especially in automotive industry.

To view and download the papers presented at OTEKON2020 Congress, please use the OTEKON2020 web page, www.otekon.org.

We do express our sincere thanks to all of opening session and keynote speakers, authors presented their works, reviewers, scientific and advisory committee members and sponsors for their great support to make this event a great success. Our special thanks go to BURKON Congress Organization team for their successful organization and assistance in the preparation of the OTEKON2020 proceedings.

It is our great pleasure to invite you to join us for next OTEKON Congress, 11th International Automotive Technologies Congress, OTEKON2024 which will be held on 5th and 6th September, 2024 in Bursa, Türkiye.

Congress Chair
Prof. Dr. Ferruh Öztürk
Automotive Engineering Department
Bursa Uludağ University

Congress Co Chairs

Prof. Dr. Necmettin Kaya
Mechanical Engineering Department
Bursa Uludağ University

Dr. Öğr. Üyesi Erol Solmaz
Automotive Engineering Department
Bursa Uludağ University

BİLİMSEL PROGRAM / SCIENTIFIC PROGRAM

06 SEPTEMBER 2021, Monday

10.00 - 10.20 **Opening Ceremony**

Prof. Dr. A. Saim Kılavuz (Uludağ University Rector)

Baran Çelik (UİB President / Beyçelik Holding CEO)

10.20 - 12.30 **Keynote Speakers – First Session**

Prof. Dr. Henk Nijmeijer (Eindhoven University of Technology Dynamics & Control Group, The Netherlands)
Prof. Dr. Thomas Tröster (Paderborn University Institute for Automotive Lightweight Design (LiA) Germany)
Prof. Dr. Levent Güvenç (Automated Driving Lab, Ohio State University, USA)
Prof. Dr. Orhan Behiç Alankuş (ARPROGED Koordinatörü Okan Üniversitesi, İstanbul)
Prof. Dr. Ferit Küçükay (Director, Institute of Automotive Engineering, TU Braunschweig, Germany)
Prof. Dr. Serpil Acar (Professor of Design for Injury Prevention Loughborough University England)

Moderator
Doç.Dr. İbrahim Korkmaz (TOFAŞ Türk Otomobil Fabrikası A.Ş., Bursa)

12.30 - 13.00 **Discussions**

13.00 - 13.30 **Lunch**

13.30 - 15.10 **Keynote Speakers**

S. Erkan Polat (Vehicle Engineering Director TOFAŞ, Türk Otomobil Fabrikası A.Ş., Bursa)
Tolga Şenoğuz (Product Development Director, FORD OTOSAN, İstanbul)
Onur Akkozak (Engineering Director, OYAK RENAULT Otomobil Fabrikaları A.Ş., Bursa)
Tuna Arıncı (Manufacturing, Senior Site General Manager, Valeo Otomotiv Sanayi ve Ticaret A.Ş., Bursa)
Engin Meydan (Beyçelik Gestamp A.Ş., General Manager, Bursa)

15.10 - 15.30 **Discussions**

15.30 - 17.30 TECHNICAL SESSIONS

17.45 - 19.45 TECHNICAL SESSIONS

07 SEPTEMBER 2021, Tuesday

09.00 - 10.45 TECHNICAL SESSIONS

11.00 - 12.45 TECHNICAL SESSIONS

13.30 - 15.30	TECHNICAL SESSIONS
15.45 - 17.45	TECHNICAL SESSIONS
18.00 - 20.00	TECHNICAL SESSIONS

BİLDİRİLER / PAPERS

AYRIK AKSTAN HİBRİT BİR PROTOTİP ARACIN ÜRETİMİ VE PROTOTİP TESTLERİ: İKİNCİ KISIM- HİBRİT ENERİ YÖNETİM ALGORİTMALARININ GERÇEK ZAMANLI ŞASİ DİNAMOMETRE TESTLERİYLE SINANMASI 2

SÜRTÜNME KARIŞTIRMA NOKTA KAYNAĞI YÖNTEMİYLE BİRLEŞTİRİLEN AL 5754 SAC MALZEMENİN MİKROYAPI ÖZELLİKLERİNİN ARAŞTIRILMASI 21

DİREKT ENJEKSİYONLU MOTORLARDA İS SINIRINDA DOĞALGAZ İLAVESİNİN MOTOR KARAKTERİSTİKLERİNE ETKİSİNİN SAYISAL OLARAK İNCELENMESİ 30

HOMOJEN ŞARJLI SIKIŞTIRMA ATEŞLEMELİ MOTORDA CNG VE CNG-HİDROJEN KARIŞIMLARI İÇİN MOTOR KARAKTERİSTİKLERİNİN SAYISAL OLARAK İNCELENMESİ 40

NUMERICAL INVESTIGATION OF EFFECTS OF CNG AND CNG-HYDROGEN MIXTURES ON HOMOGENEOUS CHARGE COMPRESSION IGNITION ENGINE CHARACTERISTICS 41

GÖZ ALMAYAN UZUN HÜZME FARLAR İÇİN GERÇEK ZAMANLI GECE VAKTİ ARAÇ TESPİT VE TAKİP SİSTEMİ 51

HANDLING DYNAMICS OF MOTOR GRADERS 57

KINEMATIC MODELLING AND SIMULATION OF A SPECIAL DOUBLE WISHBONE SUSPENSION AND STEERING SYSTEM FOR HEAVY VEHICLES 67

AĞIR HİZMET ARACI FREN DİSKİ SOĞUMA KARAKTERİSTİKLERİNİN İNCELENMESİ 79

RAMOR 500 VE RAMOR 550 ZIRH ÇELİKLERİNİN BALİSTİK PERFORMANSLARININ İNCELENMESİ 88

MASS, CENTER OF BALANCE AND UNBALANCE PREDICTION OF AN ASYMMETRICAL CLUTCH COVER WITH STAMPING SIMULATION 98

UP-HEAT TEMPERATURE REDUCTION OF AIR INTAKE SYSTEM AT HEAVY COMMERCIAL VEHICLES 105

DİZEL ENJEKTÖR MEME GEOMETRİSİNİN KURUMLAŞMA OLGUSUNA ETKİSİNİN İNCELENMESİ 112

DİRENÇ PUNTA KAYNAK ROBOTLARINDA KSR VE IQR (ADAPTİF PUNTA) MODUN SPOT PUNTA PERFORMANSININ KARŞILAŞTIRILMASI 119

FRICTION PROPERTIES OF PLASMA SPRAY COATED DISCS FOR REGENERATIVE BRAKE SYSTEMS 129

İNŞAAT KAMYONU KABİN SÜSPANSİYONLARINDA KULLANILAN TORSİYON MİLİNİN YAPISAL ANALİZİ VE DENEYSEL DOĞRULAMASI 136

OTOMOBİL ÇARPMA KUTUSU VE TAMPON RAYI GELİŞTİRME SÜRECİ 145

UZATARAK BÜKME YÖNTEMİYLE OTOMOTİV PARÇASI TAMPON RAYINDA ŞEKİLLENDİRME SÜRECİNİN GELİŞTİRİLMESİ 153

ÇİNKO KAPLI SACLARLA SIZDIRMAZ YAKIT DEPO İMALATI İÇİN KAYNAK YÖNTEMLERİNİN GELİŞTİRİLMESİ 162

PLASTİK PARÇALARIN ÜRETİLMESİNDE GÖRÜLEN SAPMA SORUNLARININ PARÇA KALİTESİNE ETKİLERİ VE PROBLEMİN ÇÖZÜMÜ İÇİN İYİLEŞTİRME ADIMLARI 170

FULL VEHICLE MODELING OF AN 8X8 VEHICLE FOR SAFETY CRITICAL ASYMMETRIC BRAKING PHENOMENON 181

PVD KAPLAMA METODU İLE FARKLI ALAŞIMLAR KULLANILARAK ALTERNATİF RENKLERDE REFLEKTÖR İÇEREN VE ECE AYDINLATMA REGÜLASYONLARINA UYGUN ARKA STOP ÜRETİLMESİ 192

BENZİNLİ MOTORLARDA KİRLETİCİ EMİSYONLAR İLE POLİHALKALI AROMATİK HİDROKARBON (PAH) EMİSYONLARININ SOĞUKTA İLK ÇALIŞMA DURUMU İÇİN TESPİTİ 206

ALÜMİNYUM EKSTRÜZYONUNDA ENİNE VE BOYUNA KAYNAMANIN SONLU ELEMANLAR ANALİZİ İLE İNCELENMESİ 216

DESIGN OF AN INNOVATIVE AND LIGHT WEIGHT STAB BAR BUSHING 224

MOTOR BRAKETİ YAPISAL ANALİZ İLE TİTREŞİM YORULMASI KAYNAKLI DAYANIMLARININ BELİRLENMESİ 229

GAZETELİK SACININ OPTİMUM BOYUTLARININ BULUNMASI 236

OPTIMIZATION OF MOLDING PARAMETERS BY TAGUCHI METHOD TO MINIMIZE WARPAGE AND SINK MARKS.....243

EKY YÖNTEMİNİN KENARLAMA ZIMBASININ AŞINMA DAYANIMINI ARTTIRMAK AMACIYLA KULLANILMASI 255

OTOMOTİVDE KULLANILAN POLİMERLERE FARKLI DOLGULARIN ETKİLERİNİN İNCELENMESİ 261

YENİ NESİL TBF VE HSLA300 SAC METAL ÇİFTLERİNİN PUNTA KAYNAK ÖZELLİKLERİNİN İNCELENMESİ 266

OTOMATİZE EDİLMİŞ MANUEL ŞANZIMAN KONTROLÜ 274

OPTIMAL INDENTATION PATTERN DESIGN OF THIN PLATES FOR INCREASED BAND GAP 279

ELEKTRONİK KONTROLLÜ POWER SHUTTLE SİSTEMİNİN MODEL TABANLI YAZILIM GELİŞTİRME ÇALIŞMASI 284

YENİ NESİL ELEKTRİKLİ OTOBÜSÜN ŞASİ DİNAMOMETRELİ KLİMATİK TEST ODASI ORTAMINDA ENERJİ TÜKETİM ÖLÇÜM ÇALIŞMALARI 292

IMPROVEMENT OF EXCAVATOR BOOM 304

POWERTRAIN SIZING AND DRIVE LINE OPTIMIZATION OF A FORMULA STUDENT ELECTRIC CAR.....314

ROAD GRADE ESTIMATION FOR A MOTOR GRADER 320

AUTOMATIC TEST CASE GENERATION AND VALIDATION FOR EMBEDDED SOFTWARE BASED ON EULERIAN PATHS...330

VİTES KUMANDA MEKANİZMASI KABLOLARI ŞANZIMAN BAĞLANTI ELEMANIN DENEYSEL VE FEM MODAL ANALİZ KORELASYONU 341

INVESTIGATION OF THE EFFECTS OF THE CORRELATION BETWEEN THE CLOSING FORCE AND THE REMAINING STRESS ON TWIN TUBE SHOCK ABSORBER ENDURANCE 350

STUDY ON LEAD SCREW DESIGN PARAMETERS FOR INFINITE CHECK ARM OF VEHICLE DOOR 357

UNCERTAINTY EVALUATION OF LASER TRACKER SYSTEM AND COORDINATE MEASURING MACHINE FOR LIGHT COMMERCIAL VEHICLE BIW MEASUREMENT 363

CHEST INJURY CRITERIA INVESTIGATION ON HYBRID III AND THOR DUMMIES.....374

SİLİNDİR İÇİ YANMA HAD ANALİZİ İLE ÇİFT BUJİ ATEŞLEMELİ TİCARİ BİR MOTORDA BENZİN, CNG VE LPG KULLANIMININ PERFORMANS VE EMİSYONLARA ETKİLERİNİN İNCELENMESİ 382

ANN DRIVER MODEL BASED ON SEAT TO HEAD TRANSMISSIBILITY 393

AUTOMATED DRIVING ARCHITECTURE AND OPERATION OF A LIGHT COMMERCIAL VEHICLE 400

TERMAL GENLEŞME KATSAYISININ FARKLI SERTLİKTEKİ TABİİ KAUÇUK KOMBİNASYONLARI İLE VULKANİZE EDİLMİŞ TEST NUMUNELERİNİN MEKANİK ÖZELLİKLERİNE OLAN ETKİSİNİN İNCELENMESİ 411

OTOMOTİV ENDÜSTRİSİNDE KULLANILAN EN-AW-6082 ALÜMİNYUM ALAŞIMININ YORULMA DAYANIMININ VE ARTIK GERİLMELERİNİN DERİN OVALAMA YÖNÜNE BAĞIMLILIĞININ İNCELEMESİ.....418

TİCARİ BİR ARAÇ RADYATÖRÜ İÇİN GERÇEKLEŞTİRİLEN HIZLANDIRILMIŞ TİTREŞİM TESTİ METODOLOJİSİ 425

DOĞAL GAZ VE BENZİN YAKITLARININ TEK SİLİNDİRLİ BİR DENEY MOTORUNDA İNCELENMESİ 432

REAR WHEEL STEERING ASSIST IN COLLISION AVOIDANCE 440

RIDE COMFORT PARAMETER OPTIMIZATION OF AN 8X8 MILITARY VEHICLE.....450

EXPERIMENTAL AND NUMERICAL STUDY ON HYBRID FIBER COMPOSITE DRIVE SHAFT FOR AUTOMOTIVE INDUSTRY460

ELEKTRİKLİ ARAÇ TASARIMINDA MOTORUN BOYUTLANDIRILMASI.....468

ISO-26262 STANDARTINA GÖRE FONKSİYONEL GÜVENLİK UYUMLU YAZILIM GELİŞTİRME 474

SHAPE OPTIMIZATION OF METAL BUMPER BEAMS UNDER LOW-VELOCITY IMPACT 481

SAYISAL BENZETİM YÖNTEMİ YARDIMIYLA 7/16 UNF YUVARLAK KAYNAK SOMUNUNUN SOĞUK DÖVME YÖNTEMİYLE ÜRETİLEBİLİRLİĞİNİN İNCELENMESİ 492

ARAÇ KABİNİ İÇERİSİNDE HAVANIN ÇIKIŞ KONUMUNUN ISIL KONFORA OLAN ETKİSİ 497

OTONOM ARAÇLARDA MÜŞTERİ BEKLENTİLERİNİ KARŞILAYAN ÖN KOLTUK GELİŞTİRİLMESİ 505

INVESTIGATION OF THE EFFECTS OF SOME STRUCTURAL PARAMETERS OF AUTOMOTIVE SEAT COVER WOVEN FABRICS ON FRICTION PROPERTIES 516

HİDROJEN ENERJİLİ ARAÇLARDA KULLANILAN PEM YAKIT PİLİNİN MANİFOLD SİSTEMİNİN AKIŞ VE TERMAL PERFORMANSA ETKİSİNİN İNCELENMESİ 522

KULLANICI ODAKLI AKILLI VE YALIN BİLGİSAYAR DESTEKLİ TASARIM PROGRAMI ÇİZEN İÇİN E-KATALOG UYGULAMASI 531

ELEKTRİKLİ OTOBÜSLERDE KULLANILAN HIZLI ŞARJ SİSTEMLERİ 540

EXPERIMENTAL INVESTIGATION OF GEOMETRIC DEFECTS GENERATED VIA LASER METAL DEPOSITION 550

CRASH PERFORMANCE COMPARISON OF AA 2024 AND DP 590 VEHICLE FRONT RAILS 558

PLASTİK VE KAUÇUK MALZEME MODEL PARAMETRELERİNİN YAPAY SİNİR AĞLARI İLE BELİRLENMESİ 562

SAC KALIP/ FİKSTÜR TASARIMINA YÖNELİK KULLANICI ODAKLI AKILLI VE YALIN BİLGİSAYAR DESTEKLİ TASARIM PROGRAMI ÇİZEN İÇİN MODÜLER TASARIM 572

TERMOPLASTİK PREPREG BAZLI KAMYON KOLTUĞU TASARIMI VE ANALİZİ 583

CO_2 LASER DRILLING PROCESS PARAMETERS OF ALUMINUM ALLOYS FOR SURFACE ROUGHNESS 593

DAMPER TUNING IN FREQUENCY DOMAIN FOR A TRAILING ARM TYPE TRACKED VEHICLE SUSPENSION 601

OTOMOTİV ENDÜSTRİSİ PRES HATTI DIŞ KAYNAK KULLANIMI ÇALIŞMASINDA TEDARİKÇİ SEÇİMİ 608

STRATEJİK ÖNEME SAHİP NADİR TOPRAK ELEMENTLERİN (NTE) ELEKTRİKLİ ARAÇLARDA KULLANIMI 618

8X8 TAKTİK TEKERLİKLİ BİR MUHAREBE ARACINI SOĞUKTA ÇALIŞTIRMA TESTLERİ VE ÖN ISITMA SİSTEMİ OPTİMİZASYONU 622

AYRIK AKSTAN HİBRİT BİR PROTOTİP ARACIN ÜRETİMİ VE PROTOTİP TESTLERİ: BİRİNCİ KISIM- BİLEŞENLERİN KARAKTERİZASYONU VE ŞASİ DİNAMOMETRE TESTİNİN HAZIRLANMASI 629

THE EFFECT OF IGNITION ADVANCE FOR GASOLINE-METHANE MIXTURE ON DUAL SEQUENTIAL ENGINE PERFORMANCE AND EMISSION CHARACTERISTICS 639

HYBRID QUENCHING METHOD FOR HOT STAMPING PROTOTYPE PROCESS 649

THE EFFECT OF SPRAY PARAMETERS ON THE COOLING RATE OF HIGH STRENGTH STEEL 22MNB5 659

HAFİF TİCARİ ARAÇLAR İÇİN KONFOR KANALLI AMORTİSÖRLERİN TAŞIT KONFORUNA ETKİSİNİN ARAŞTIRILMASI 668

PCB MATERIAL AND HEAT SHIELD EFFECT ON THE LEDS THERMAL PERFORMANCE IN THE AUTOMOTIVE LIGHTING SYSTEMS 677

VISCOELASTIC MATERIAL MODELLING OF NATURAL RUBBER USING RELAXATION TEST 687

DÖVME PARAMETRELERİNİN OTOMOTİV KAPI MENTEŞESİNİN MEKANİK ÖZELLİKLERİNE VE PRES KALIP ÖMRÜNE ETKİSİNİN ARAŞTIRILMASI 694

COMPARISION BETWEEN TWO DIFFERENT TYPES OF SOLENOIDS DESIGNED FOR AUTOMOTIVE LATCH APPLICATION 702

BİR ŞEHİR İÇİ OTOBÜSÜN MOTOR ODASINDAN YAYILAN YAPISAL VE HAVA KAYNAKLI GÜRÜLTÜNÜN AZALTILMASI .. 707

IMPROVEMENT OF VIBRATION DAMPING PERFORMANCE FOR AUTOMOBILE CLUTCHES 717

DESIGN VERIFICATION OF THE VEHICLE DEVELOPED FOR THE AMERICAN MARKET ACCORDING TO FMVSS-305 REGULATION WITH VIRTUAL ANALYSIS 725

AUTONOMOUS PARALLEL PARKING PATH PLANNING OF A FOUR-WHEEL STEERED VEHICLE AND RELATED PARAMETERS 740

LOOSENING BEHAVIOUR OF CONICAL WASHER USAGE IN BOLTED JOINTS UNDER VIBRATION 749

KANO METODU İLE OTOMATİK KATLANIR DIŞ DİKİZ AYNASININ MÜŞTERİ ÜZERİNDEKİ ETKİLERİNİN İNCELENMESİ 756

OPTIMIZATION OF OVERLAP LASER WELDING PROCESS PARAMETERS IN DP1200 SHEET STEEL USED IN AUTOMOTIVE INDUSTY 762

KARDAN MİLİ ÜZERİNDEN SICAKLIK VE TORK VERİSİNİN GERÇEK ZAMANLI TAKİBİ İÇİN HARİCİ SİSTEM TASARIMI 769

TICARI ARAÇ KARDAN MILLERINDE KULLANILAN AKUSTIK MALZEMELI SES DAMPERLERININ SES YUTUM ÖZELLIKLERININ GÜRÜLTÜ KARAKTERISTIĞI ÜZERINE ETKISI 777

KINEMATIC & COMPLIANCE CORRELATION OF STEERING ANALYSIS OF A PASSENGER VEHICLE 787

ESTIMATION OF BATTERY STATE OF CHARGE USING ARTIFICIAL NEURAL NETWORK IN AN ELECTRIC VEHICLE SYSTEM 791

İKİZ KARDAN MAFSALLI KARDAN MİLLERİNDE SAPMA AÇISININ HIZ DÜZGÜNSÜZLÜĞÜNE ETKİSİ 798

RESEARCH OF BULKHEAD PRODUCTS FOR CUSTOMER SATISFACTION 806

INTERIOR LIGHTING TECHNOGIES AND LIGHTING PERFORMANCE STUDY OF AN INTERIOR LIGHTING COMPONENT .. 823

UNDER-ENGINE SHIELD DESIGN AND ANALYSIS IN NEW PRODUCT DEVELOPMENT PHASE 832

ADVANCED ALUMINUM ALLOYS USED IN LAND COMBAT VEHICLE APPLICATIONS 840

ISITMA VE SOĞUTMA ÖZELLİKLİ ORTA KONSOL TASARIMI VE MÜŞTERİ DENEYİMİ ARAŞTIRMASI 845

VERSİYON LOKMALARI KULLANARAK ÜRÜN ÇEŞİTLİLİĞİNİN DAHA AZ SAYIDA KALIP İLE YÖNETİLMESİ 851

AERODYNAMIC INVESTIGATION OF AN E-SCOOTER & RIDER SYSTEM THROUGH COMPUTATIONAL FLUID DYNAMICS APPROACH 856

KABLOSUZ ŞARJ ÜNİTESİ KURULUMU & TASARIM KRİTERLERİ 866

EV ENERGY AND THERMAL MANAGEMENT THE USE OF DIGITAL TWINS TO ACCELERATE THE DESIGN AND VALIDATION 871

RETROFITTING LIGHT COMMERCIAL VEHICLE WITH IN-WHEEL E-DRIVE AND SUSPENSION SYSTEMS 882

HVAC İÇ ISI DEĞİŞTİRİCİSİ IÇIN YENI PERFORMANS DOĞRULAMA SÜRECİ 891

MISALIGNED ADAPTATION TOOL DEVELOPMENT FOR A DYNAMIC TEST BENCH 899

BENZİNLİ BİR BİNEK ARACIN GERÇEK SÜRÜŞ EMİSYONLARININ VE ŞEHİR MERKEZLERİNDEKİ ETKİSİNİN İNCELENMESİ 907

TASARIMI GERÇEKLEŞTİRİLEN MEKANİK KONTROLLÜ VE FİŞEK REZİSTANS KONTROLLÜ TERMOELEMANLARIN PERFORMANS ANALİZİ 916

TAKVİYELİ ALÜMİNYUM KARE TÜPLERİN ENERJİ ABSORBE ETME KABİLİYETİNİN DENEYSEL İNCELENMESİ 923

INTRODUCING STANDARD DEFINITION DIGITAL MAPS TO AUTONOMOUS LANE CENTERING TO IMPROVE FRONT CAMERA FUNCTIONALITY 934

COMPARISON OF ACCELERATED AGING TEST AND NATURAL AGING PERFORMANCE ON VEHICLE BODY PAINT 946

YAKIT HATLARINDAKİ VİBRASYON AZALTIMI İÇİN YAPILAN DENEYSEL ÇALIŞMALAR 955

BİR KARDAN MİLİNİN KRİTİK HIZ LİMİTİ ARTIRIMI VE AĞIRLIK AZALTIMI ESASLI TASARIMI VE İMALATI 963

PREDICTIVE MODELING BASED ON ANGULAR VARIATIONS OF YIELD STRESS RATIOS AND LANKFORD PARAMETERS FOR DP800 STEEL 974

TRIZ 'İN OLASI UYGULAMASININ OTOMOTİV ENDÜSTRİSİNE SAĞLAYACAĞI AVANTAJLARIN OYAK-RENAULT BAĞLAMINDA İNCELENMESİ 980

COMPARISON OF REVERBERATION CABIN AND IMPEDANCE TUBE MEASUREMENTS 987

OTOMOBİLLERDE ÖN CAM BUZ ÇÖZME PROSESİNİN SAYISAL VE DENEYSEL OLARAK İNCELENMESİ 995

KINEMATIC AND DYNAMIC ANALYSIS OF PUSH ROD VALVE TRAIN SYSTEM 1003

TARIMSAL TRAKTÖRLERDE ASİMETRİK FRENLEME İLE DİNAMİK KARARLILIK PARAMETRELERİNİN İYİLEŞTİRİLMESİ 1014

AUTOMATION OF EXTERIOR PANEL DENT RESISTANCE SIMULATIONS 1026

EFFECTS OF DIFFERENT ELECTRODE NOSE TYPES ON TENSILE STRENGTH OF THE RESISTANCE SPOT WELDING: A NUMERICAL INVESTIGATION 1037

THE INVESTIGATION OF CHEMICAL FOAMING PROCESS BY COMPUTED TOMOGRAPHY FOR INJECTION MOLDED AUTOMOTIVE PLASTIC COMPONENTS 1044

PREDICTION OF EARING PROFILE IN CUP DRAWING TEST USING HILL48 CRITERION 1051

BATTERY THERMAL ANALYSIS METHODOLOGY: CELL TO PACKAGE 1058

NUMERICAL INVESTIGATION OF THE EFFECT OF THE AIR/FUEL RATIO IN A NATURAL GAS POWERED CONVERTED COMPRESSION IGNITION ENGINE 1065

ARAÇ İKLİMLENDİRME SİSTEMİNDE TERS AKIŞLI DAHİLİ ISI DEĞİŞTİRİCİ EŞANJÖRÜNDE BASINÇ KAYBI-ISI TRANSFER VERİMİ İNCELENMESİ VE HAD YÖNTEMİ ANALİZLERİ İLE TEST KORELASYONLARI 1073

4 SİLİNDİRLİ HİBRİT ARAÇLARDA HAVA EMİŞ VE EGZOZ SİSTEMLERİNİN GT-POWERDA TEK BOYUTLU OLARAK MODELLENMESİ, BASINÇ KAYBI VE AKUSTİK ANALİZLERİNİN İNCELENMESİ 1083

STATISTICAL PROCESS CONTROL EMBEDDED ADAPTIVE CLOSED LOOP CONTROL APPROACH FOR RIVETING PROCESS 1096

POWER DIODE TYPES USED IN 12V AUTOMOTIVE ALTERNATORS AND IMPACTS ON ALTERNATOR PARAMETERS 1108

YAKIT HÜCRELİ ELEKTRİKLİ ARAÇ (FCEV) TEKNOLOJİSİ VE ARAÇ MİMARİSİNE ETKİLERİNİN İNCELENMESİ 1120

DEVELOPMENT OF AN AD-HOC CO-SIMULATION PLATFORM FOR LEVEL 3 AUTONOMOUS VEHICLE TESTING 1129

VIBRATION FATIGUE DAMAGE ESTIMATION AND EVALUATION OF DAMAGE MODELS IN METALLIC STRUCTURES 1140

EGZOZ ISIL GERİ KAZANIM SİSTEMİNİN ARACA UYGULANMASI 1151

PİEZO-TETİKLEMELİ SUPAP TAHRİK SİSTEMİNİN SAĞLADIĞI VOLUMETRİK VERİM ARTIŞININ DENEYSEL TESPİTİ 1157

KISMİ ESNEK SİLECEK MEKANİZMASININ DİNAMİK PERFORMANSININ İNCELENMESİ 1167

ELEKTRİKLİ ARAÇLAR İÇİN DEĞİŞKEN MANYETİK ALANLI TEKERLEK İÇİ ELEKTRİK MOTORU MİMARİSİ İLE SÜREKLİ DEĞİŞKEN GÜÇ AKTARMA ORGANINA SAHİP MİMARİNİN KARŞILAŞTIRILMASI 1176

HIGH-ORDER NOISE SOURCE LOCALIZATION ON ECCENTRIC TOP COVER OF A DIESEL ENGINE 1186

INVESTIGATION OF WEATHERING & PERMANENT SET EFFECTS ON ACOUSTICS OF VEHICLE SEALING SYSTEMS.....1194

TAM ELEKTRİKLİ ARAÇLARIN OTOMOBİL MİMARİSİNE ETKİLERİ 1203

BASINÇSIZ DÖKÜM YÖNTEMİNİN SUSUZ BORAKS KATKILI ALÜMİNYUM ALAŞIMLI KOMPOZİT MALZEMENİN MEKANİK ÖZELLİKLERİNE ETKİSİNİN İNCELENMESİ 1214

BİR AĞIR VASITA ARACININ SU GENLEŞME DEPOSUNUN DAYANIMININ GEOMETRİK YÖNDEN İNCELENMESİ 1225

EFFECT OF BATTERY MODULE ON THE BODY-IN-WHITE GLOBAL STATIC STIFFNESS AND MODAL FREQUENCY FOR TYPICAL SEDAN CLASS ELECTRIC VEHICLE 1234

BİYODİZEL YAKITLARA İLAVE EDİLEN NANO-PARTİKÜL MADDELERİN MOTOR PERFORMANSI VE EMİSYONLARINA ETKİSİ 1244

INVESTIGATION OF NUMERICAL ANALYSIS AND EXPERIMENTAL STUDY OF A BULB VERSION FOG LAMP 1255

NONLINEAR FINITE ELEMENT ANALYSIS OF EPDM RUBBER TAILGATE AND DOOR GROMMET TO DETERMINE OPTIMIZED AUTOMATIVE GROMMET DESIGN 1265

INVESTIGATION OF WOVEN FABRIC DEFORMATION IN AUTOMOTIVE SEAT COVER FORM 1275

EGZOZ MANİFOLD MALZEMESİ OLARAK GELİŞTİRİLMİŞ YÜKSEK SİLİSYUMLU SÜNEK DÖKME DEMİRLERİN MİKROYAPISAL VE ISIL ÖZELLİKLERİNİN İNCELENMESİ.....1285

EGZOZ MANİFOLD MALZEMESİ OLARAK GELİŞTİRİLMİŞ YÜKSEK SİLİSYUMLU SÜNEK DÖKME DEMİRLERİN OKSİDASYON ÖZELLİKLERİNİN İNCELENMESİ.....1292

COMPARING THE PRODUCTON SPEED OF AUTOMOBILE PARTS PRODUCED BY SLA METHOD WITH FDM,SLS AND MJF METHODS 1298

ELEKTRİKLİ BİR TİCARİ ARAÇTA MÜŞTERİ KULLANIMINA BAĞLI MENZİLE ETKİ EDEN PARAMETRELERIN MAKİNE ÖĞRENMESİ YAKLAŞIMI İLE ANALİZİ 1302

TAM ELEKTRİKLİ VE DİZEL YAKIT KULLANAN HAFİF TİCARI ARAÇLARIN ENERJİ TÜKETİMİ YÖNÜNDEN KIYASLANMASI 1312

ELECTRIFIED AUXILARY SYSTEM DEMAND CONTROL OF A HYBRID ELECTRIC REFUSE TRUCK 1318

TÜRKİYE YENİ ARAÇ MARKETİNDEKİ TÜKETİCİ TERCİH DEĞİŞİMİ 1328

ARAÇ ÖN FARINDA YOĞUŞMA PROBLEMİNİN HESAPLAMALI AKIŞKANLAR MEKANİĞİ ANALİZİ İLE ÇÖZÜMLENMESİ VE TASARIMA ETKİSİ.....1336

TAILGATE KULLANIMI VE DOĞRULANMASINDA MAKİNE ÖĞRENME KULLANIMI 1347

TİCARİ ARAÇLARDA ÇOK FONKSİYONLU ÖN AYDINLATMA ÜNİTESİ TASARIMI 1353

ASSESSMENT ON HYBRIDIZATION OF HEAVY-DUTY LONG-HAUL DIESEL TRUCK POWERTRAIN.....1359

DEVELOPMENT OF POLYPROPYLENE COMPOSITE MATERIALS WITH ANTIBACTERIAL PROPERTIES 1365

YOLCU KOLTUĞU ŞASESİNİN FARKLI MALZEMELER KULLANILARAK SONLU ELEMANLAR METODU İLE HAFİFLETİLMESİ 1369

PLASTİK DIŞ BORUYA SAHİP BURÇLARDA VULKANİZASYON SONRASI OLUŞAN OVALİTE PROBLEMİNİN TERMAL ANALİZ İLE TESPİTİ.....1378

FARKLI ÇALIŞMA YÖNLERİNDE, BİRDEN FAZLA SERTLİKTE KAUÇUK İÇEREN TİTREŞİM SÖNÜMLEYİCİ BURÇ GELİŞTİRİLMESİ 1387

ŞEHİRLERARASI YOLCU OTOBÜSLERİ İÇİN DÖNER MEKANİZMAYA SAHİP HOSTES KOLTUĞU GELİŞTİRİLMESİ 1397

INVESTIGATION OF COMFORT CONCEPT IN VEHICLES AND TIRE FORCES AFFECTING VEHICLE DYNAMICS 1405

DETERMINATION THE EFFECT OF WEATHER-STRIP COATING APPLICATION CONDITIONS ON COATING PERFORMANCE BY USING EXPERIMENTAL DESIGN 1411

TYPE OF GEOMETRY PARAMETERS IN TIRE UNIFORMITY 1418

DESIGN AND PARAMETER OPTIMIZATION OF SINGLE AND TWO-SPEED TRANSMISSIONS FOR ELECTRIC CARS 1423

SÜREKLİ DEĞİŞKEN SUPAP ZAMANLAMASI İÇİN KULLANILAN PİEZO EYLEYİCİ ELEKTRONİK SÜRÜCÜSÜNÜN BİR MOTOR ÜZERİNDE UYGULANMASI 1430

AN EXPERIMENTAL INVESTIGATION OF THE EFFECT OF VARIOUS SOLID LUBRICANTS ON THE TRIBOLOGICAL PERFORMANCE OF BRAKE PADS 1440

A COMPARATIVE STUDY BETWEEN TPE AND EPDM SEALING MATERIALS ON MECHANICAL AND ACOUSTIC CHARACTERISTICS 1447

KOLEMANİT DOLGU MİKTARININ POLİAMİD-6.6 MALZEMESİNİN TRİBOLOJİK ÖZELLİKLERİNE ETKİSİ 1457

NEW DESIGN SECURITY MEASURES FOR AUTONOMOUS VEHICLES AGAINST CYBER SECURITY RISKS 1466

EXPERIMENTAL ANALYSIS OF HIGH VOLTAGE DIRECT CURRENT VOLTAGE RIPPLE IN BATTERY ELECTRIC VEHICLES .. 1477

ENERGY BENEFIT ANALYSIS OF INDEPENDENT TORQUE VARIATION IN FULLY ELECTRIC OFF-ROAD TRACKED VEHICLES 1489

DEVELOPMENT OF LONG JUTE FIBER REINFORCED POLYPROPYLENE COMPOSITES FOR AUTOMOTIVE INTERIOR TRIM PARTS 1498

TIMER CONTROLLER: RELIABILITY AND PERFORMANCE ANALYSIS OF TIME TRIGGERED SCHEDULER SPECIFIC USE CASE 1507

DETERMINATION THE EFFECT OF INJECTION MOLDING PROCESS PARAMETERS ON EPDM-TPE BONDING PERFORMANCE 1513

EXPERIMENTAL INVESTIGATION OF METAMATERIAL ACOUSTIC EFFICIENCY 1519

KANO MODEL IN THE R&D DEPARTMENT OF THE AUTOMOTIVE SECTOR 1525

OTOMOTİV INFOTAINMENT TESTLERİNDE GÖRÜNTÜ İŞLEME TEKNİKLERİNİN KULLANIMI 1529

OTOMOBİL YAN SİNYAL LAMBASININ LED SÜRÜCÜ KARTINA AİT İLETİLEN EMİSYON TESTİNİN MODELLENMESİ VE BENZETİMİ 1536

ÜÇÜNCÜ NESİL ÇELİKLERİN NOKTA DİRENÇ KAYNAĞINDA SIVI METAL KIRILGANLIĞI 1546

INVESTIGATION OF THE EFFECTS OF HELIX ANGLE AND INLET VELOCITY ON COLLECTION EFFICIENCY IN AN AXIAL CYCLONE SEPARATOR 1556

DERİN ÖĞRENME TABANLI MODEL İLE LİTYUM-İYON BATARYANIN KALAN KULLANIM ÖMRÜNÜN TAHMİNİ 1566

OTOMOBİLDE MODÜLERLİK YAKLAŞIMI İLE KOMPOZİT MALZEMENİN OTOMOBİL YEDEK LASTİK BÖLGESİNDE YENİDEN TASARIMI 1575

QFD METODU İLE TİCARİ ARAÇLARDA KAPI KOLU TASARIMININ MÜŞTERİ ÜZERİNDEKİ ETKİLERİNİN İNCELENMESİ . 1582

ÇEŞİTLİ GEOMETRİK TASARIMLARLA OTOMOTİV AYDINLATMALARINDA KULLANILAN IŞIK KILAVUZLARINDA IŞIK PARLAMA NOKTALARIN İYİLEŞTİRİLMESİ 1589

ASKERİ PALETLİ ARAÇLARIN SÜSPANSİYON SİSTEMİ TASARIMI VE ANALİZİ 1596

ASKERİ ARAÇLARDA BELİRLİ YÜKSEKLİKTEKİ PATLAYICI ŞOK DALGA ETKİSİNİN SONLU ELEMANLAR YÖNTEMİ İLE ANALİZİ 1607

YÜKSEK BASINÇLI DÖKÜM YÖNTEMİ İLE ÜRETİLEN SİLAFONT-36 PARÇALARININ ISIL İŞLEM PERFORMASLARININ İNCELENMESİ 1613

ÇİNKO GALVANİZ KAPLAMALI YENİ NESİL ÇELİKLERDE GÖRÜLEN SIVI METAL KIRILGANLIĞINI OLUŞTURAN VE ETKİLEYEN FAKTÖRLER 1619

OTOMOTİV SEKTÖRÜNDE TEL BESLEMELİ EKLEMELİ İMALAT İLE ANALİZ VE DOĞRULAMA ÇALIŞMASI 1627

OPTIMAL CONTROLLER AND OBSERVER DESIGN FOR ACTIVE SUSPENSION SYSTEMS 1635

NUMERICAL SOLUTION OF WATER DROPLET MOTION IN A FUEL CELL CHANNEL WITH TWO OUTLETS USING VOF METHOD 1642

OTOMOBİLLERDE AKTİF ÖN IZGARA SİSTEMİNİN AERODİNAMİK AÇIDAN NÜMERİK OLARAK İNCELENMESİ 1653

GLOBAL SKYHOOK AND GROUNDHOOK CONTROL OF VEHICLE WITH SEMI-ACTIVE DAMPERS 1664

OBTAINING HEMATITE FROM DOMESTIC SCALE (IRON OXIDE) AND SYNTHESISE IT WITH STRONTIUM CARBONATE AND PRODUCE STRONTIUM HEXAFERRITE BASED FERRITIC MAGNET POWDER 1675

ELECTRIC BATTERY TESTS ON E-DYNAMIC SHAKER SYTEM 1683

POSTERLER / POSTERS

BİR OTOMOBİL GERİ SİS LENSİ ÜZERİNDE KARŞILAŞILAN AKIŞ BİRLEŞME İZİNİN ÇİZGİSİNİN ORTADAN KALDIRILMASI 1692

ROTİLLİ KOL PARÇASINA ETKİYEN KUVVETLERİN TESPİTİNDE SANAL STRAIN GAUGE UYGULAMASI VE STRAIN GAUGE KONUMLARININ DOĞRULANMASI 1697

GOOGLE'DA YAPILAN ARAMALARLA OTOMOBİL VE HAFİF TİCARİ ARAÇ SATIŞLARI ARASINDAKİ İLİŞKİNİN İNCELENMESİ 1704

HAND GESTURE RECOGNITION TECHNOLOGIES AND HUMAN-CAR INTERACTION APPLICATION 1708

ANN DRIVER MODEL BASED ON SEAT TO HEAD TRANSMISSIBILITY

Jovanka Lukić[1], Slavica Mačužić Saveljić[2]
[1,2] University of Kragujevac, Faculty of Engineering, Kragujevac, Serbia
[3] Corresponding Author: Jovanka Lukić, lukicj@kg.ac.rs

ABSTRACT

Protection and prevention of vehicle driver health and working capabilities are the most important task in vehicle design phase. In order to improve and accelerate vehicle design process, different driver models have been developed in last few decades. Models development depends on computer and software improvement. Wide application of artificial neural network (ANN) and deep learning methods caused its application in human body models exposed to vide variety of vibration. In this paper, model of vehicles driver exposed to vertical random vibration is developed based on ANN. Different network structures and activation functions were analyzed in order to obtain optimal network structure in frequency domain. Input data were seat to head transmissibility frequency response function of human body exposed to vertical random vibration obtained in laboratory experiment. Validation of adopted model showed good correlation with experimental data. Amount of transmitted vibration through vehicle drivers body can be predicted by application of proposed model.

Keywords: STHT, ANN, vibration, driver, model

1. INTRODUCTION

Driver comfort is one of the dominant aspects in vehicle design phase. Investigation of ride comfort is focused on research of vibration influence on vehicle driver health. Driver is exposed to whole body vibration (WBV) and local vibrations in the driving condition. In order to utilize performed field and laboratory investigations, biodynamic models of the human body is developed. Biodynamic models should be used to predict ride comfort in different driving conditions without exposure subjects to vibrational excitation. Field and laboratory investigations of driver responses on vibration excitation need time, resources and people and are very expensive.

Interest in human biodynamic models has become significant especially in the last two decades of the 20th century. International standards are developed in order to identify rages of biodynamic responses of the human body in different environment, (Rakheja, Dong, Patra, Boileau, Marcotte, & Warren, 2010). Frequency response functions: mechanical impedance (MI), driving point mechanical impedance (DPMI), apparent mass (AI) and seat to head transmissibility (STHT) are used in order to identify model of human body exposed to WBV in different conditions. Analysis of published results showed significant diversity. Investigations were performed in the laboratory and field conditions. Subjects were in sitting, standing and recumbent postures. Subjects were tested in different body position: sitting, laying and standing. Legs were not supported and supported on the floor. Hands and arms were folded and in driving position or steering wheel. Gender and anthropometrics characteristics of the subjects were different, as well as subjects age, (Rakheja, Dong, Patra, Boileau, Marcotte, & Warren, 2010).

Oscillatory excitations were deterministic or random with different direction of excitation. One axis and multi axis excitations were considered, as well as its correlated effect on human. Magnitude of excitations was different.

The vast majority of published studies concerned about vertical vibration effect on human in sitting position due to dominant oscillatory load especially in passenger vehicle. Dominant vibrational loads of driver are in fore and aft and lateral direction in the off road vehicles, forklifts and portal cranes, (Rakheja, Dong, Patra, Boileau, Marcotte, & Warren, 2010).

The effectiveness of biodynamic models relies on the representative biodynamic responses of the body. Frequency response function STHT represents vibration value transmitted through human body. Also, MI, DPMI and AI are measured at one point and represent point frequency response function. Regardless to number of published results, it is obviously that the vast major of published results consider AM and DPMI. Significantly less amount of papers consider STHT than other frequency response function. Number of published results considered STHT in vertical direction is larger than in fore and aft and lateral directions. (Rakheja, Dong, Patra, Boileau, Marcotte, & Warren, 2010)

The study of biodynamic responses of humans can be classified into statistical (experimental) and analytical methods. Usually, experimental studies involve human corpses and dummies to avoid human injury. Experimental studies have exhibited that humans are most sensitive to WBV in the frequency range of 1–20 Hz, (Rakheja, Dong, Patra, Boileau, Marcotte, & Warren, 2010). The vibrations produced in road vehicles range from 0.5–20 Hz which is also the vulnerable range for human beings. A principal resonance has consistently been found between 4 and 6 Hz reported principal resonance between 4–6 Hz and a second principal resonance between 8–12 Hz. (Harsha, Kumar, & Saran, 2017).

Biodynamic models have been created to represent human body responses to vibration. These models are then grouped to lumped models, multi body dynamic models, and finite element models.

Lumped models consist of sprung masses, dampers and springs. The degrees of freedom (DOF) depend on the number of rigid masses. The earliest established lumped model with single degree of freedom (1 DOF) and later more complex lumped parameter models were developed. Nonlinearity of human body exposed to vibration behavior could not be taken into consideration respect to lumped parameter models. The experimental results had good agreement with Wan-Schimmels 4 DOF in spite of its simplicity, (Cho Chung Liang, 2006).

Finite element models have been developed in recent years and they have significant application especially in vehicles development phase.

In recent years, researchers were eager to use new mathematical models to simulate engineering problems especially artificial intelligent methods such as artificial neural network (ANN), fuzzy logic, genetic algorithm, etc. These methods are flexible and proper to optimization problems. ANN modeling has good potential to predict human body behavior after training with some sets of input-output pairs. In (Gohari M., 2012) established a new ANN biodynamic model based on Wei and Griffin (1998) lumped model which can predict body and head response acceleration signal from the input signal. The accuracy of output signals were over 95%, which made it appropriate to use for other engineering purposes like in seat suspension design or adaptive active seat suspension control.

Based on previous studies with some limitation of lumped models, it seems essential to have ANN biodynamic model. In this paper, a novel biodynamic ANN model was introduced to predict head acceleration from seat acceleration based on experimental method.

In this paper effort has been made to develop ANN model considering the influence of backrests, level of excitation, BMI for prediction of human body response to vibration.

2. EXPERIMENTAL INVSTIGATION

An electro-hydraulic motion simulator was used in subjective experiment. The simulator was designed to provide the test bandwidth from 0,3-30 Hz, but with very small power for the frequencies over 20 Hz, with total loading mass of 200 kg and to obtain vertical and horizontal random excitations simultaneously. In the performed experiment, only vertical random excitation is used. The investigators had to define frequency bandwidth and magnitude of excitation.

Data from accelerometers HBM B12/200 mounted on the seat pad, placed on seat buttock interface, (S) and head (H) in fore and aft (x) and vertical (z) directions were recorded during experiment by the use of HBM DMC9012A amplifier and BEAM 3.1 acquisition data software and stored in data file afterwards.

Group of 30 trained, healthy male and female subjects (aged 43,9±9,7 years, 180±6,6 cm tall and 85,9±14,1 kg mass) were exposed to vertical broadband random vibration. The confident frequency domain of the simulator, the results of frequency contents lower than 0,5 Hz and above 20 Hz were neglected in the analysis.

In the experiment, subjects were sitting on the soft seat, in driving position, with hands on the steering wheel. The seat characteristics and the transfer function of platform-seat system were obtained with the seat loaded with a sandbag of total mass of 40 kg (Demic, Lukic, & Milic, 2002). The seat was excited by one-directional random vibration in vertical direction.

Variation of seat backrest angle was adopted, as well as usually used position in driving condition. Seat backrest angle (position K inclined 14 ° with respect to vertical axis and position S in vertical position without inclination) and excitation magnitude (1,75, m/s^2 r.m.s and 2,25, m/s^2 r.m.s) were varied (Demic, Lukic, & Milic, 2002). In order to determine STHT function, accelerations were measured at the seat-buttock interface and on the head. Accelerometers were also mounted on plastic helmet.

This signal duration, with sampling frequency of 171,8 Hz provided the following (Brandt, 2011):

- Reliability of FFT above 0,0029 Hz, estimated to be acceptable for the lower simulator excitation frequency of 0,3 Hz.
- With 512 averaging of spectra used in FFT, the random estimation errors of the following values were: for auto spectrum – 0,0454 /, for cross spectrum – 0,057 /, and for coherence function – 0,032 /, which are acceptable, according to (Brandt, 2011).

Based on these facts, it was found acceptable to apply the value of signal duration 343,6 s for the analyses performed in the paper.

The preliminary analyses of the time history series have shown that they belong to a group of stationary random processes. It is known that the identification of parameters of random processes can be done in time, amplitude and frequency domain, which is thoroughly described in (Brandt, 2011).

The output STHT is calculated by using the frequency response function H(f) by equation (Brandt, 2011):

$$STHT = \frac{S_{hs}(f)}{S_{ss}(f)} \tag{1}$$

where S_{hs}(f) – cross spectral density of the seat (input) and head (output) motions and S_{ss}(f) – auto spectral density of the seat (input motion)

3. ARTIFICIAL NEURAL NETWORK MODELING

Multilayer perceptron (MLP) among the class of feed-forward networks has the capability of universal approximation of nonlinear phenomena and complex systems, (Kim, 2017). Hence, a multilayer feed-forward neural network with back propagation (BP) algorithm was employed. The MLP neural network architecture consists of one input layer comprising 5 main factors (frequency of vibration, magnitude of vibration, body mass index (BMI), gender, seat back condition) one output layer (STHT), and one hidden layer, as shown in Fig. 1. Input data are classified as continuous (frequency, magnitude of vibration and BMI) and categorized (gender and seatback condition).

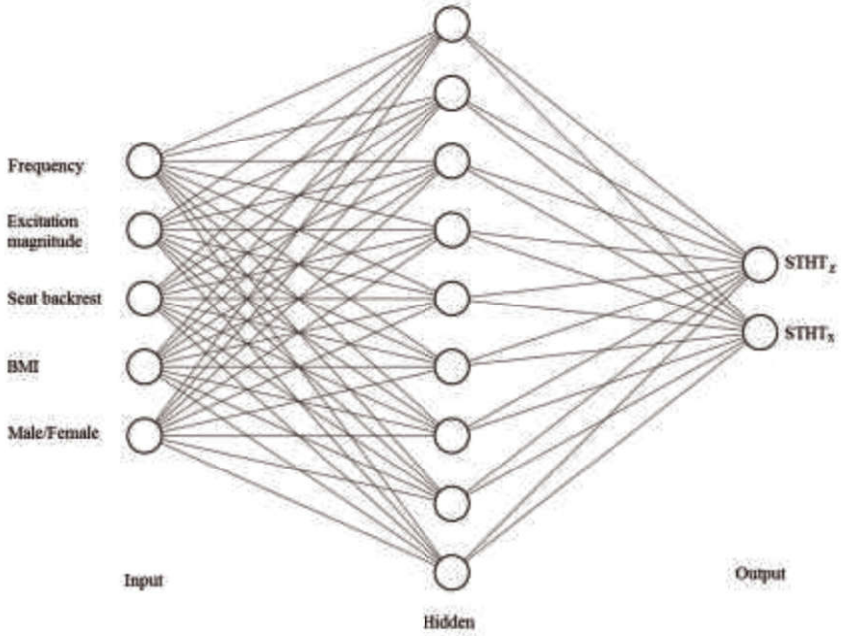

Figure 1. Adopted ANN model of STHT under vertical excitation

The challenging tasks for developing ANN models are to identify optimal number of neurons in each hidden layer, number of hidden layers and training algorithms. Determination of an optimal number of hidden layers generally involves difficult tradeoff between the prediction ability and computational demand of the model. The preliminary simulations performed with the ANN model with a single hidden inputs revealed poor predictions of the STHT over the entire range of body mass and excitation levels. The MLP neural network with more hidden inputs minimum 3 and maximum 11 with neurons ranging from 1 to 20 was subsequently employed, in order to improve convergence in terms of mean squared error (MSE). It is noteworthy that employing greater number of neurons in each hidden layer entails the over-fitting drawback, which reduces the forecasting ability of the model. Upper limit was 20 networks for train and 5 networks for retrain in order to enable adoption of optimal MLP configuration.

From the whole group of tested subjects, data of 10 subjects (male and female, two sitting position, three levels of excitation, BMI and STHT in vertical and fore and aft direction) was adopted to train, test and verify optimal ANN model of STHT. Dimension of data matrix was 48175x7. Data were classified into: train set of 70% of total data, 15% for testing and 15% for validation of adopted model.

The network structure with least MSE over 1000 iterations was explored. To ensure that each input variable provides an equal contribution in the ANN simulation and to reduce the challenge of numerical instability in the process of adjusting the weights, the inputs to the model, excluding the gender and back support condition, were normalized and scaled into the numeric range [0, 1], such that:

$$Z_n = \frac{Z_i - Z_{\min}}{Z_{\max} - Z_{\min}} \tag{1}$$

where Z_n denotes normalized input variable, Z_r is raw input variable, and Z_{min} and Z_{max} denote the minimum and maximum values of the raw input variables, respectively. Different activation functions are tested and all data in input matrix are normalized and scaled according to equation (1), (Gohari, Rahman, Tahmasebi, & Nejat, 2014).

The gender was described as an input with numeric value of 0 and 1 for the female and male subjects respectively. Training algorithm was Broyden Fletcher Goldfarb Shanno, (Kim, 2017).

4. DISCUSSION

In conducted experiment time series of accelerations on the seat and head of driver were measured. As input or output data time signals of accelerations can be used. ANN model can be developed based on acceleration of seat and head time domain. Later, function STHT should be determined. Development of ANN biodynamic model for prediction of human body acceleration in time domain was performed in (Gohari M., 2012).

Analysis of results published in (Cho Chung Liang, 2006), (Gohari, Rahman, Tahmasebi, & Nejat, 2014), (Kumar, 2017), (Taghavifar, 2018) showed that ANN biodynamic models are developed in frequency domain. Input data were frequency, body mass, magnitude of excitation etc.

In this paper development of model for prediction of driver vibrational load under vertical excitation is performed in frequency domain. In order to develop optimal network structure two approaches are applied: network with five inputs and one output data and network with five inputs and two outputs data. Output data was STHT in vertical direction and STHT in vertical and fore and aft direction. This consideration should enable optimal network structure in order to avoid model complexity.

ANN model of STHT in vertical direction is developed by using five input data and one output data. Twenty different network models were applied in order to obtain optimal performance between output and target experimental data. Two networks with best performances in training, test and validation phase are presented in Table 1. Network configuration MLP 5-9-1 has the highest correlation between target and output data. Comparison between experimental data and model data are presented in figure 1.

Table 1. Summary of active networks - output STHT in vertical direction (z), vertical excitation

Network structure	Performance			Error			Activation	
	Training	Test	Validation	Training	Test	Validation	Hidden	Output
MLP 5-11-1	0.85270	0.86367	0.85902	0.14095	0.13196	0.14404	Tanh	Tanh
MLP 5-9-1	0.86986	0.88493	0.87690	0.12568	0.11279	0.12734	Logistic	Logistic

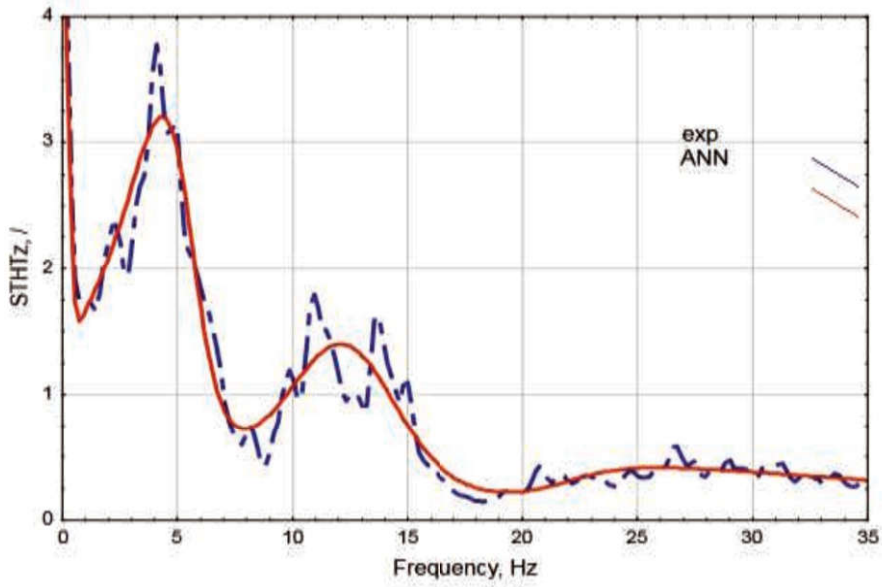

Figure 1. Comparsion of STHT of human body exposed to vertical random vibration in vertical direction obtained in laboratory conditions and obtained by ANN model MLP 5-9-1

Comparison between two determined networks, in model validation, is shown in figure 2. Network MLP 5-9-1 showed better approximation with experimental results than MLP 5-11-1. Also, network structure is less complex respect to hidden layers. Activation function was logistic sigmoid in both cases.

In the second phase ANN model of STHT was developed with same input data as well as in the first phase and output data were STHT in vertical and fore and aft direction. This structure of ANN should be suitable in the case of presence of correlation between output signals in fore and aft direction and vertical direction. In the laboratory environment it is not common, but in the real road conditions it can be appeared.

Obtained results are presented in Table 2 and Figure 3.

Table 2. Summary of active networks - output STHT in both vertical (z) and fore and aft (x) direction (z), vertical excitation

	Network structure	Network performance			Error			Activation	
		Training	Test	Validation	Training	Test	Validation	Hidden	Output
1	MLP 5-9-2	0.82680	0.83643	0.81385	0.32606	0.31589	0.37647	Tanh	Exponential
2	MLP 5-7-2	0.80531	0.81351	0.79457	0.36227	0.35608	0.41084	Logistic	Logistic
3	MLP 5-10-2	0.77859	0.79099	0.77154	0.40662	0.39434	0.45179	Logistic	Logistic
4	MLP 5-11-2	0.77667	0.78487	0.77157	0.40838	0.40312	0.45029	Tanh	Exponential
5	MLP 5-7-2	0.80213	0.81088	0.78910	0.36746	0.36065	0.42099	Logistic	Logistic

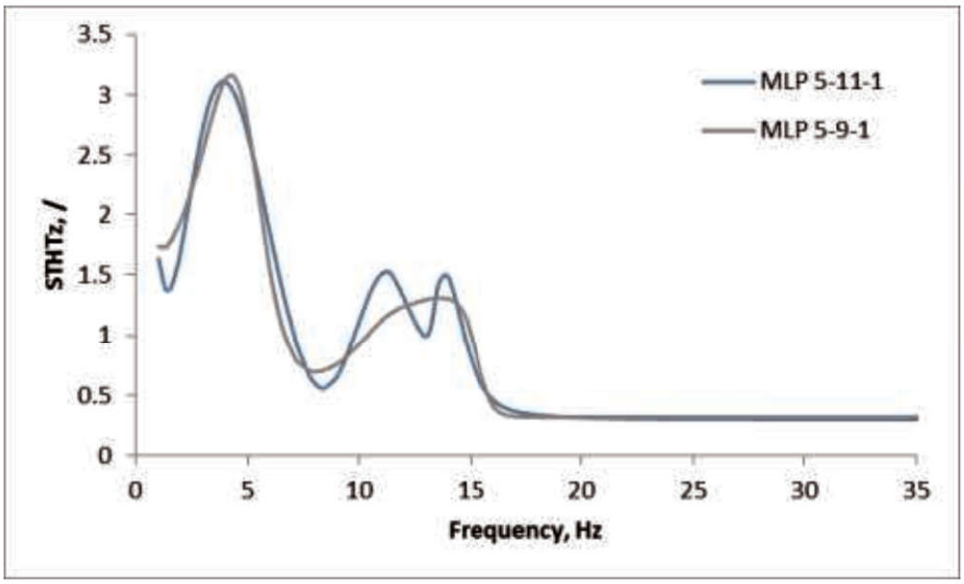

Figure 2. Validation of adopted ANN MLP model of STHT in vertical direction

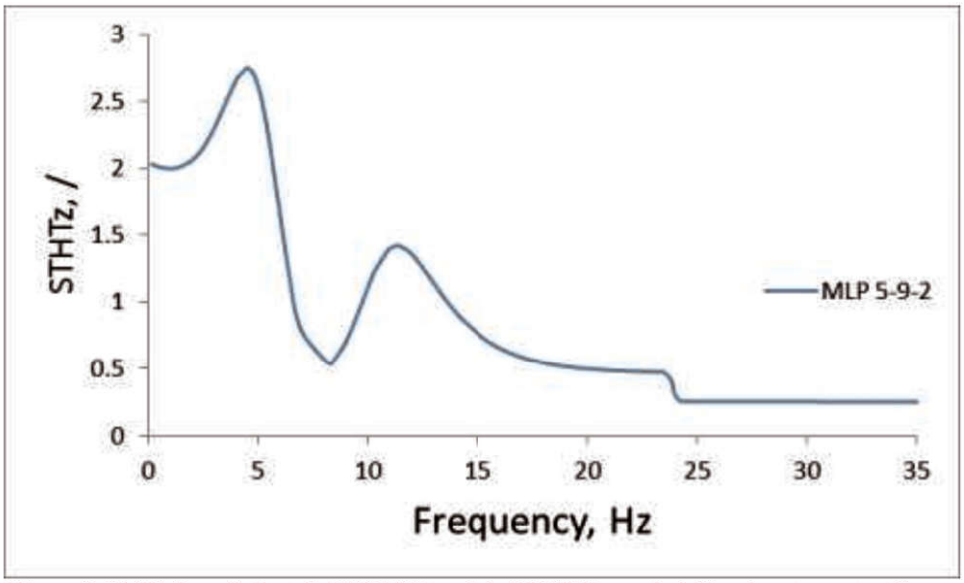

Figure 3. Validation of adopted ANN MLP model of STHT in vertical direction, two output layers

Comparison of output and target data is presented in figure 4 in the process of validation. Network MLP 5-9-2 is adopted as optimal, which performances are the highest between five presented networks. Number of hidden data is the same in both cases. Activation functions are different.

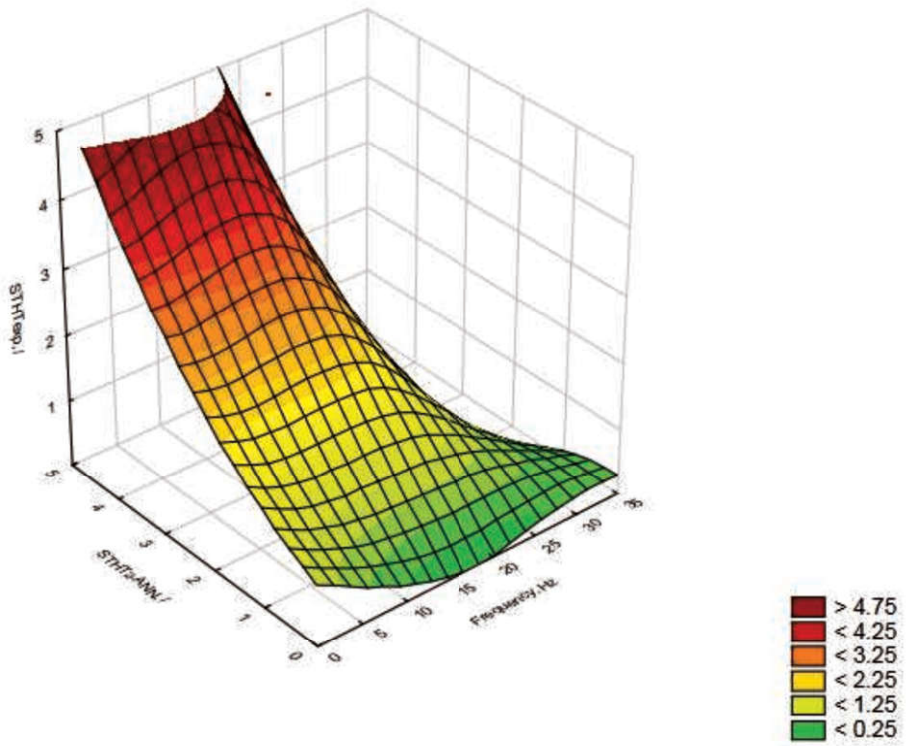

Figure 4. Validation of ANN MLP-5-9-2 model of STHTz under single axis vertical excitation

5. CONCLUSIONS

Conducted investigation presented in the paper showed that biodynamic model of driver exposed to vertical random vibration can be developed based on STHT frequency response function and ANN. Proposed ANN model is sutable to incorporate non linear characetristics of human body. ANN model developed in the frequency domain is sutable with respect to significat frequencies of STHT. After model structure is adopted, there is no need for post procesing data as well as it is necessery when ANN model is developed in time domain.

ACKNOWLEDGEMENTS

Research presented in this paper was supported by Ministry of Education, Science and Technological Development of the Republic of Serbia, Grant TR 35041.

REFERENCES

[1] Brandt, A. (2011), Noise and Vibration Analysis: Signal Analysis and Experimental Procedures, John Wiley & Sons, Chichester, West Sussex, U. K., pages 704

[2] Liang, C. C, Chiang, C. F. (2006) "A study on biodynamic models of seated human subjects exposed to vertical vibration", International Journal of Industrial Ergonomics, 36, 10, pp. 869-890.

[3] Demic, M., Lukic, J., Milic, Z. (2002) "Some aspects of the investigation of the random vibration influence in ride comfort", Journal of sound and vibration, 253, 1, pp. 109-128.

[4] Gohari M., R. R. (2012) "A Novel Artificial Neural Network Biodynamic Model for Prediction Seated Human Body Head Acceleration in Vertical Direction", Journal of low frequency noise, vibration and active control, 31(3), pp. 205-216.

[5] Gohari, M., Rahman, R., Tahmasebi, M., Nejat, P. (2014). "Off-road Vehicle Seat Suspension Optimisation, Part I: Derivation of an Artificial Neural Network Model to Predict Seated Human Spine Acceleration in Vertical Vibration", Journal of low frequency noise, vibration and active controL, 33, 4, pp. 429 – 442.

[6] Kim, P. (2017), MATLAB Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence, Apress, Seoul, pages 162.

[7] Kumar, A. S. (2017) "Biodynamic modelling of seated human body under whole body vibration exposure using ANN", International Journal of Vehicle Noise and Vibration, 13, 3/4, pp. 187-199.

[8] Rakheja, S., Dong, R. G., Patra, S. K., Boileau, P.-E., Marcotte, P., Warren, C. M. (2010) "Biodynamics of the human body under whole-body vibration: Synthesis of the reported data", International Journal of Industrial Ergonomics, 40, 6, pp. 710–732.

[9] Taghavifar, H. R., Rakheja, S. (2018) "Supervised ANN-assisted modeling of seated body apparent mass under vertical whole body vibration", Measurement, 127, pp. 78-88.