

Bursa Uludağ University

Engineering Faculty

OTEKON 2024

**ULUSLARARASI 11. OTOMOTİV TEKNOLOJİLERİ
KONGRESİ BİLDİRİLER KİTABI**

**Proceedings of the International 11th
Automotive Technologies Congress
September 9-10, 2024, Bursa, Türkiye**

Editörler / Editors :

Burak Aydoğdu

Emre Bulut

Necmettin Kaya

BURSA – 2024

İÇİNDEKİLER / CONTENTS

KURULLAR / COMMITTEES	5 - 6
SPONSORLAR / SPONSORS.....	Hata! Yer işareti tanımlanmamış.
ÖNSÖZ / PREFACE.....	8
BİLİMSEL PROGRAM / SCIENTIFIC PROGRAM	9 9
BİLDİRİLER / PAPERS	12
İNDEKS / INDEX	1260

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ISBN: '978-625-6443-24-2'

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ÖNSÖZ / PREFACE

OTEKON2024, 11th International Automotive Technologies Congress was held on 9th and 10th of September 2024. It is our pleasure to express gratitude to all those who attended this congress and made this event a great success. OTEKON 2024 congress was held with technical papers, opening and keynote speeches and exhibitions.

OTEKON Congresses were 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 OTEKON2024 Congress, please use the OTEKON2024 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 OTEKON2024 proceedings.

It is our great pleasure to invite you to join us for next OTEKON Congress, 12th International Automotive Technologies Congress, OTEKON2026 which will be held on 7th and 8th September, 2026 in Bursa, Türkiye..

Congress Chair

Prof. Dr. Necmettin Kaya
*Department of Mechanical Engineering,
Bursa Uludağ University*

Honorary Congress Chair

Prof. Dr. Ferruh Öztürk

BİLİMSEL PROGRAM / SCIENTIFIC PROGRAM

09 September 2024, Monday

10.00 - 10.20 Opening Ceremony

Prof. Dr. Ferudun Yılmaz (Rector of Bursa Uludağ University)

Prof. Dr. Necmettin Kaya (Department of Mechanical Engineering, Bursa
Uludağ University)

10.20 - 12.00 Keynote Speakers – Session 1

Moderator: Assoc. Prof. Dr. İbrahim Korkmaz (Nişantaşı University, İstanbul
- Türkiye)

Automated Vehicles and Pedestrians: Scenarios, Simulation and Testing

Prof. Dr. Ümit Özgüner (Ohio State University, USA)

Improving Vulnerable Road User Safety in Traffic

Prof. Dr. Levent Güvenç (Automated Driving Lab., Ohio State University, USA)

Goal-Oriented Driving Automation and Safety

Prof. Dr. Wen-Hua Chen (Chair in Autonomous Vehicles, Department of
Aeronautical and Automotive Engineering, Loughborough University, UK)

Empowering Automated and Electric Vehicles Through AI and Fluid H2M Dialogue: ESCALATE and HADRIAN Projects

Prof. Dr. Ahu Ece Hartavi Karcı (Head of Centre of Automotive Engineering,
University of Surrey, UK)

12.00 - 13.00 Lunch

13.30 - 15.10 Keynote Speakers Session - 2 Moderator: Assoc. Prof. Dr. İbrahim

Korkmaz (Nişantaşı University,

İstanbul - Türkiye)

S. Erkan Polat (Vehicle Engineering Director, TOFAŞ - Türk Otomobil Fabrikası A.Ş., Bursa - Türkiye)

Dr. Ziya Caba (Tribe Lead - Ford Trucks Engine Programs & CO2 Strategy, Ford OTOSAN A.Ş. Sancaktepe AR-GE Merkezi, İstanbul - Türkiye) Dr. Mert Büyükköprü (System Functions Leader, Semi/Active-Suspension System, Global Chassis Control, OYAK Renault Otomobil Fabrikaları, Bursa - Türkiye)

Dr. Kamil Armağan Gül (Innovation Project Specialist, Interior and Exterior Trims Vehicle Engineering, OYAK Renault Otomobil Fabrikaları, Bursa - Türkiye)

14.30 - 15.00 **Coffee Break**

15:00 - 16:30 **Session 1**

16:30 - 17:00 **Coffee Break**

17:00 - 18:30 **Session 2**

10 SEPTEMBER 2024, Tuesday

09:00 - 10:30 **Session 3**

10:30 - 11:00 **Coffee Break**

11:00 - 12:30 **Session 4**

12:30 - 13:30 **Lunch**

13:30 - 15:00 **Session 5**

15:00 - 15:30 **Coffee Break**

15:30 - 17:00 **Session 6**

17:00 - 18:30 **Session 7**

BİLDİRİLER / PAPERS

HİBRİD OTOMOBİLLERDE EGZOZ SİSTEMİNDEKİ EMİSYON REAKSİYON SÜREÇLERİNİN İNCELENMESİ	17
ELECTRIC DRIVE UNIT (EDU) SYSTEMS MULTIBODY SIMULATION FOR VIBRATION ASSESSMENT AND OPTIMIZATION	32
WEIGHT & COST OPTIMIZATION ON ELECTRIC LIGHT COMMERCIAL VEHICLES – A CASE STUDY	46
DEVELOPMENT AND TESTING OF AN ASR CONTROL ALGORITHM FOR AN ARTICULATED BUS EQUIPPED WITH ELECTRIC MACHINES AT MIDDLE AND REAR AXLES	60
3 EKSENLİ OTOMASYON KONTROLLÜ ESNEK PRES İÇİ TRANSFER SİSTEMİ	71
WEIGHT REDUCTION ON THE SEMI TRAILER CHASSIS BY USING DP STEELS AND ITS EFFECT TO VEHICLE FUEL CONSUMPTION	81
ACKERMANN GEOMETRY SET-UP FOR ALL-WHEEL DRIVE COMMERCIAL VEHICLE.....	94
MOTOR SOĞUTMA SUYUNUN PWM KONTROLLÜ ELEKTRİKLİ FANLAR İLE SOĞUTULMASI	105
YÜKSEK AKIM GÜÇ DEVRELERİ İÇİN PASİF SOĞUTUCU TASARIMI VE TERMAL PERFORMANS ANALİZİ	112
THERMAL ANALYSIS OF ELECTRIC SCOOTER MOTOR DRIVER CARD USING NUMERICAL AND EXPERIMENTAL METHODS	124
4X4 BİR ARAÇTA AKS PERFORMANSININ İZLENMESİ AMACIYLA GELİŞTİRİLMİŞ TORK ÖLÇÜM SİSTEMİ VE SAHA TESTİ UYGULAMASI	132
İSTANBUL METROBÜS HATTI ÇEVİRİMİNİN GELİŞTİRİLMESİ	139
AĞIR TİCARİ ARAÇ UYGULAMALARINDA KULLANILAN ASKININ RULMAN ÇAKMA KUVVETİNİN ANALİTİK, NÜMERİK VE TEST VERİLERİ İLE DOĞRULANMASI	149
TİCARİ YOLCU OTOBÜSÜNÜN CNG TANKLARININ ECE 110 REGÜLASYONU KAPSAMINDA SANAL ANALİZLER İLE İNCELENMESİ	159
BİR ŞEHİR İÇİ MİDİBÜSÜN DİREKSİYON TİTREŞİMİNİN DEĞERLENDİRİLMESİ	172
THE EFFECT OF AXIAL AND NON-AXIAL BLADE SURFACE CONSTRUCTION IN DIFFERENTLY SIZED CENTRIFUGAL ELECTRICAL WATER PUMPS	179
OTOMOTİVDE KULLANILAN ELEKTRİK ELEKTRONİK FONKSİYON GEREKSİNİMLERİ VE TEST UYGULAMALARI	187
EXPLORING THE POTENTIAL OF CONNECTED VEHICLE DATA FOR INTERNAL VALUE GENERATION	199
MODELING OF A PEM FUEL CELL SYSTEM IN MATLAB	208
B SEGMENTİ BİNEK BİR ARAÇTA B SÜTUNU PARÇASININ YAN KAPILARA ENTEGRASYONU VE RİJİT DİREĞE YANDAN EĞİMLİ ÇARPMA ANALİZİ	215
MEKANİK SİSTEMLERDE TORK SINIRLAYICI MEKANİZMALARIN İNCELENMESİ.....	225
OPTIMAL DESIGN OF 8X8 STEERING SYSTEM USING SIMULATION AND TAGUCHI METHODS ..	240
MOTOR BRAKET PARÇASININ EKLEMELİ İMALATA UYGUN TASARIMLA HAFİFLETİLMESİ	254

KARDAN MILLERİNDE KULLANILAN BİRİM PARÇALARDAN ÜÇ KOLLU FLANŞ PARÇASININ SICAK DOVME YERİNE YASSI METAL MALZEMEDEN SOĞUK ŞEKİLLENDİRME İLE TASARIMI VE ÜRETİMİ	265
CUP DRAWING DIE DESIGN THROUGH AN ANISOTROPIC PLASTICITY MODEL	275
THE ANALYSIS OF OPEN DATA USAGE IN THE DEVELOPMENT OF ADVANCED ITS SERVICES ...	284
DEVELOPMENT OF THE WHEEL CORNER MODULE CONCEPT: INTEGRATING MULTI-BODY DYNAMICS, MODEL BASED SYSTEMS ENGINEERING AND SAFETY ANALYSIS	297
IMPROVING AIR DUCTS AND SERVICE SETS FOR 12.3M URBAN BUSES WITH USING CFD	310
METROBÜS BİRİNCİ KABİNİN SONLU ELEMANLAR METODU İLE İNCELENMESİ	322
RELIABILITY ASSESSMENT OF THE OUTER SURFACE FOR FORGED RAILS WITH NUMERICAL AND TEST METHODS	333
COOLING PLATE IMPROVEMENT ANALYSIS WITH CFD FOR MICRO TRUCK CLASS ELECTRIC VEHICLES	343
COMPARISON VEHICLE COMMUNICATION PROTOCOLS FOR AUTOMOTIVE SYSTEMS	352
MODELLING AND PATH TRACKING CONTROL OF A FOUR WHEEL DRIVE FRONT STEERING AUTOMATED GUIDED VEHICLE	358
OPTIMIZING THE ACOUSTIC PERFORMANCE OF AN INTERNAL COMBUSTION ENGINE MUFFLER	370
YÜKSEK MUKAVEMETLİ DÜŞÜK ALAŞIMLI ÇELİKLERİN MİKROYAPI ŞEKİLLENDİRİLEBİLİRLİK VE MEKANİK ÖZELLİKLERİNİN İNCELENMESİ.....	383
DUAL FAZLI DP800 ÇELİKLERDE PUNTA KAYNAK PROSES PARAMETRELERİNİN ETKİSİNİN VE HASAR BAŞLANGICININ DENEYSSEL VE NÜMERİK OLARAK İNCELENMESİ	392
AN OPTIMIZATION FRAMEWORK FOR MINIMIZING THE PRODUCTION COST OF LITHIUM-ION BATTERIES IN ELECTRIFIED VEHICLES	404
ELEKTRİKLİ ARAÇ BATARYA SİSTEMLERİNİN 3 BOYUTLU TERMoeLEKTRİK HAD YÖNTEMLERİ İLE ZAMANA BAĞLI MODELLENMESİ	414
KAMYON ÖN AKS GÖVDESİNİN KESİT OPTİMİZASYONU ÜZERİNE SAYISAL BİR İNCELEME	422
DESIGN, SIMULATION AND VALIDATION OF HEAD EXPANDER TO REDUCE/ELIMINATE AMPLIFIED VIBRATIONAL BEHAVIOR EFFECT IN VIBRATION TESTS.....	431
İÇTEN YANMALI MOTOR HAVA EMİŞ SİSTEMİNDE FARKLI REZONATÖR TİPLERİNİN SES OLUŞUMUNA ETKİLERİNİN İNCELENMESİ	443
EDGE COMPUTING IN INFOTAINMENT AND CONNECTIVITY APPLICATIONS	454
ELECTRIC VEHICLE CHARGER STATION WITH SECOND-LIFE BATTERY STORAGE SYSTEM	465
DOMAIN BASED AND ZONE BASED ARCHITECTURES FROM INFOTAINMENT AND CONNECTIVITY PERSPECTIVE	475
ROTİL ÇIKMA YÜKÜNÜN SONLU ELEMANLAR YÖNTEMİYLE ANALİZİ VE SONUÇLARIN DOĞRULANMASI	486
GEOMETRICAL MODIFICATION OF GASOLINE INJECTOR TIP TO REDUCE DEPOSIT FORMATION AND EMISSIONS.....	493
WORKFLOW INTEGRATION AND ANALYSIS RESULT PREDICTION OF LEAF SPRING ANALYSES	506
ELEKTRİKLİ ARAÇLARDA İZOLASYON İZLEME DİRENCİNİN İNCELENMESİ	518
DATA DRIVEN INTERNAL DEFECT COST REDUCTION.....	526

ENERGY CONSUMPTION ANALYSIS AND REAL-LIFE ROAD SIMULATION OF A SOLAR ASSISTED REEV	535
OTOMOTİV ENDÜSTRİSİNDE ALTERNATİF MALZEMELERLE OPTİMUM ÜRÜN TASARIMI	548
ELEKTRİKLİ ARAÇ BATARYA KUTU ELEMANLARININ İÇ MONTAJINDA KULLANILACAK KAYNAK/YAPIŞTIRMA PROSES PARAMETRELERİNİN, MEKANİK DAYANIM ODAKLI, DENEYSSEL İNCELENMESİ	558 ONE
DIMENSIONAL MODELLING AND VERIFICATION OF LITHIUM-ION BATTERY CELL	570
PREDICTION OF DESIGN PARAMETERS OF A VEHICLE SLIDING DOOR SYSTEM USING NEURAL NETWORKS AND BAYESIAN OPTIMIZATION	581
DETERMINATION OF A HANDBRAKE SUPPORT BRACKET IN A PASSENGER VEHICLE USING TOPOLOGY OPTIMIZATION METHOD	597
RESEARCH ON THE EFFECTS OF BRAKE FORCE DISTRIBUTION ON ENERGY RECOVERY IN A FULLY ELECTRIC VEHICLE	609
MECHANICAL BEHAVIOR AND FORMABILITY OF LASER-WELDED DISSIMILAR JOINTS BETWEEN QP980 AND QP1180 STEELS	623
MOTOR SOĞUTMA SİSTEMİ TASARIMI VE BOYUTLANDIRILMASINDA YAPAY ZEKÂ KULLANIMI	635
AN EVALUATION STUDY ABOUT POLYPROPYLENE BASED TEXTILE STRUCTURES FOR AUTOMOTIVE INTERIORS UTILIZATION	645
FARKLI MAKARA TASARIMLARINA GÖRE POLY-V KASNAĞIN SONLU ELEMANLAR MODELİ İLE İNCELENMESİ	652
BIO-INSPIRED CRASH BOX DESIGN AND OPTIMIZATION	663
GEOMETRICAL PATH PLANNING FOR AUTONOMOUS PARALLEL PARKING OF A FOUR-WHEEL STEERED VEHICLE ON DOUBLE SIDE PARKED NARROW STREETS.....	668
TASARIM DEĞİŞİKLİKLERİNİN AĞIR TİCARİ HAVALI DİSK FRENLERİNİN YAPISAL DAYANIMI ÜZERİNDEKİ ETKİSİ	681
COMPOSITE MATERIALS DAMAGE ASSESSMENT WITH THE YOLO ALGORITHMS	692
USING AI-GENERATED IMAGES AS SYNTHETIC DATA FOR OBJECT DETECTION	706
SİNİRSEL AĞ KULLANILARAK BİNEK ARAÇ JANTININ TASARIM OPTİMİZASYONU.....	716
DESIGN OF ABS ALGORITHMS FOR COMMERCIAL VEHICLES	725
ELEKTRİKLİ ARAÇTA MENZİL ARTIRICI MOTOR UYGULAMASI VE ENTEGRASYONUNDA YAPAY SİNİR AĞLARI UYGULAMASI	736
L7 CLASS ELECTRIC VEHICLE FRONTAL CRASH PERFORMANCE STUDY	747
AEROJEL KATKILI POLİÜRETAN KÖPÜKLERİN AKUSTİK ÖZELLİKLERİ	760
SAFETY OF THE INTENDED FUNCTIONALITY BASED ON SYSTEM THEORETIC PROCESS ANALYSIS FOR AUTOMATED LANE CENTERING	770
BRAKET GEOMETRİSİNİN EMNİYET KEMERİ TOKA BAĞLAYICISI ÖMRÜNE ETKİSİNİN DENEYSSEL İNCELENMESİ	783
KUMANDA TELLERİNDE ROTA DOĞRUSALLIĞI İLE MEKANİK VERİM ARASINDAKİ İLİŞKİNİN ARAŞTIRILMASI	795
İSTANBUL'DA KULLANILAN TOPLU TAŞIMA ARAÇLARI İÇİN SÜRÜŞ ÇEVİRİMİ GELİŞTİRİLMESİ	804
PREDICTING THE REMAINING-USEFUL-LIFE OF BATTERIES IN ELECTRIC VEHICLES UTILIZING	

DATA-DRIVEN METHODS	813
KURUMLAŞMAYA HASSAS MOTOR UYGULAMALARI İÇİN ENJEKTÖR MEMESİ TASARIMI VE GELİŞTİRİLMESİ	828
MAPPING THE AI STANDARDIZATION LANDSCAPE FOR THE TRANSPORTATION SECTOR: A COMPREHENSIVE REVIEW AND ANALYSIS	839
TİCARİ YOLCU OTOBÜSLERİNİN KOLTUKLARINA ECE R80 REGÜLASYONUNUN UYGULANMASI	850
BURÇLARIN SONLU ELEMANLAR VE MAKİNE ÖĞRENİMİ TABANLI TASARIM PARAMETRE OPTİMİZASYON METODOLOJİSİ	864
ACCURATE RANGE PREDICTION IN ELECTRIC VEHICLES: INTEGRATING INTERNAL AND EXTERNAL DATA FOR ENHANCED PERFORMANCE	877
SEÇİCİ LAZER ERGİTME METODUNDA TARAMA HIZININ FARKLI KAFES GEOMETRİSİNE SAHİP NUMUNELERİN BASMA DAYANIMINA ETKİSİNİN İNCELENMESİ	885
TEKERLEKLİ YÜKLEYİCİLERDE OTOMATİK KEPÇE YÜKLEME İÇİN ZAMAN GECİKMELİ SİNİR AĞLARI İLE OPERATÖR KOMUTLARININ TAHMİNİ	895
ELEKTRİKLİ ARAÇ ISI POMPASI EŞANJÖRLERİNİN ÜZERİNDE OLUŞAN KARLANMANIN NÜMERİK ANALİZİ	908
A COMPREHENSIVE STUDY FOR DISSIMILAR WELDING USING LASER TECHNOLOGY IN THE AUTOMOTIVE INDUSTRY	918
DAMPING PERFORMANCE ASSESSMENT OF A REGENERATIVE SUSPENSION SYSTEM	924
KORUYUCU GAZ KARIŞIMININ GAZALTI KAYNAK PROSESİNE ETKİSİ.....	937
SALINCAK KOLU KAYNAK BİRLEŞİMLERİNDEKİ YORULMA DAVRANIŞININ NÜMERİK VE DENEYSEL OLARAK DEĞERLENDİRİLMESİ	946
EXPERIMENTAL INVESTIGATION OF TRIBOLOGICAL BEHAVIOURS OF POLYMER MATERIALS IN UNDER DRY SLIDING	957
DESIGN OF A WIRELESS CHARGING TEST SETUP FOR LIGHT DUTY ELECTRIC VEHICLES	984
TELEOPERATION-BASED ROUTE TEACHING METHOD FOR UNMANNED GROUND VEHICLES	1000
ENHANCING EARLY DESIGN PHASE: MEASURING PERCEIVED QUALITY IN AUTOMOTIVE DEVELOPMENT	1012
DESIGN AND ANALYSIS OF CONTACTOR DRIVE CIRCUIT FOR HIGH VOLTAGE BATTERY MANAGEMENT SYSTEMS	1023
STROKE DEPENDENT DAMPING IN AUTOMOTIVE SUSPENSION SHOCK ABSORBERS	1037
MASKING FORE AND AFT VIBRATION UNDER TWO AXIAL WHOLE BODY VIBRATION	1046
SHOCK ABSORBER TIRE CLEARANCE INCREASE APPLICATION “DENT”	1052
STRUT TİP AMORTİSÖRDE STAB BRAKETİN YAPISAL DAYANIMININ KAYNAK PARAMETRELERİ VE GEOMETRİK TASARIM DEĞİŞİKLİĞİ İLE ARTTIRILMASI	1059
GLASS FIBER REINFORCED ELIUM IN AUTOMOTIVE CARRIER PARTS –DESIGN AND FINITE ELEMENT ANALYSIS OF COMPOSITE CARRIERS: COMPARISON WITH STEEL	1069
RULE-BASED ENERGY MANAGEMENT STRATEGY FOR FUEL CELL HYBRID ELECTRIC TRUCK	1080
WIRELESS BATTERY MANAGEMENT SYSTEM PERFORMANCE EVALUATION	1095
PERFORMANCE EVALUATION OF POWER JUNCTION BOX DESIGNED FOR HIGH VOLTAGE BATTERIES AND ELECTRIC VEHICLES.....	1106

AĞIR VASITA ARAÇ HİBRİTLEŞMESİNİN FAYDALARI ÜZERİNE SAYISAL BİR ÇALIŞMA	1115
3D MODELLING OF A LIGHT DUTY VEHICLE SUSPENSION IN MATLAB/SIMULINK SOFTWARE	1127
ELEKTRİKLİ ARAÇLARDA BATARYA TAŞIYICI PARÇA İÇİN BURULMA RİJİTLİĞİNİN ARTTIRILMASINA YÖNELİK TOPOGRAFYA OPTİMİZASYONU VE ŞEKİLLENDİRME ANALİZİ ...	1138
OTOMOTİV GÜVENLİK PARÇALARI İÇİN GELİŞMİŞ YÜKSEK DAYANIMLI ÇELİK GELİŞTİRİLMESİ	1148
ELEKTRİKLİ ARAÇ BATARYA GÜVENLİĞİ İÇİN ALÜMİNYUM KÖPÜĞÜN BATARYA MUHAFAZASI YAN DARBE EMİCİ BÖLGESİNDE KULLANIMI	1162
AN OVERVIEW OF WEIGHT AND CO2 REDUCTION GOALS IN THE AUTOMOTIVE INDUSTRY WITH A SPECIAL FOCUS ON MATERIAL AND PROCESSES DURING THE DEVELOPMENT PHASE OF A B- SEGMENT VEHICLE	1175
DEVELOPMENT OF B-SEGMENT VEHICLE ROOF STIFFENER ACOUSTIC ELEMENTS	1186
VEHICLE LEVEL OPTIMIZATION OF BUSHING PROPERTIES TO IMPROVE A PICK-UP NVH PERFORMANCE	1195
COMPARATIVE STUDY OF DIESEL AND DIESEL-HYDROGEN DUAL FUEL USE IN RCCI ENGINE UNDER VARIOUS LOAD CONDITIONS	1217
IMPROVEMENT OF OPERATION PERFORMANCE OF ROD ENDS	1230
RECYCLE SOURCED PP PLASTIC MATERIAL APPLICATION ON MOULD IN COLOUR BUMPERS PRODUCED BY INJECTION MOULDING PROCESS WITH CHEMICAL FOAMING	1240
GAZ METAL ARK KAYNAK YÖNTEMİNDE ISI GİRDİSİNİN KAYNAK DİKİŞ GEOMETRİSİ ÜZERİNDEKİ ETKİSİNİN NÜMERİK OLARAK İNCELENMESİ.....	1252

MASKING FORE AND AFT VIBRATION UNDER TWO AXIAL WHOLE BODY VIBRATION

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ABSTRACT

The existence of masking effects for fore and aft vibration under two axial broadband random vibrations of seated subjects was investigated. Subjects had to adjust equal level of stimulus sensation. Level of excitation (0.55 m/s^2 r.m.s., 1.75 m/s^2 r.m.s. and 2.25 m/s^2 r.m.s.) and seat backrest position (position *K* inclined 14° with respect to vertical axis and position *S* in vertical position without inclination) were varied. Masking Threshold (MT) was determined for r.m.s. head acceleration in fore and aft direction. Sitting position as well as level excitation influenced on masking threshold. Linear regression can be used between MT and level of random excitation. Finally, some indicators explaining this phenomenon are presented.

Keywords: fore and aft vibration, dual axis vibration, masking threshold, vehicle

1. INTRODUCTION

The human body is exposed to vibration in the transportation systems, especially in the vehicles. Vibrations have influence on the health, working capabilities and comfort. (Standardization, 1997), (M. S. Demić & Lukic, 2008). Behavior of the human body exposed to whole body vibrations were analyzed a lot in reviewed literature. Parameters such as: direction of vibration, level of excitation, type of excitation, source of vibration, seat backrest inclination, etc. were investigated, but there are not exact and detailed explanation of human body behavior under random multi axis vibration, (Deubel et al., 2023), (Liu & Qiu, 2021), (Basri & Griffin, 2011), (Kato & Hanai, 1998). Authors (M. S. Demić & Lukic, 2008; Lukic et al., 2002) investigated transmission of broadband random vibration through human body by application of seat to head transfer function in order to develop human body model of driver. In (M. S. Demić & Lukic, 2008), subjects had to match equal sensation of fore and aft and vertical vibration. In frequency domain with application Multi Input/Multi Output model liner effect of one axial vibration were analyzed. Conducted investigation involved both objective and subjective responses of subjects.

Vertical vibration in the vehicle is dominant. Fore and aft vibration of the backrest is one of the principal sources of the vibration in the vehicle. Sensation of fore and aft vibration respect to vertical vibration with same intensity showed effect of masking which is well known in acoustics, (Morioka & Griffin, 2002), (Morioka & Griffin, 2015).

In the (Rosa Hernandez & Parizet, 2012) masking effects of vertical sinusoidal vibrations were investigated. The presences of the noise were investigated too. Frequency dependence of the absolute threshold was similar to the results in published references.

Vertical vibration masks fore and aft vibration. It is important to determine Masking Threshold (MT) and its influence on ride comfort. Changes in automotive industry respect to broader Electric Vehicle (EV) application should have to take into consideration different level of vibration direction influence. The level of the influence of vibration caused Internal Combustion (IC) engine is not the same as well as in the EV.

The conducted laboratory study aim was to investigate Masked Threshold (MT) for random fore aft vibration under dual axis broadband random excitation. In the (Morioka & Griffin, 2015) MT was determined for sinusoidal stimulus and it depended on frequency of stimulus.

The frequency dependence of the masking threshold is evident in reviewed references. Acceleration of the head represents the vibration level transmitted through human body. The influence of sitting position, level

of excitation on the fore and aft acceleration of the head will be analyzed in the present of broadband random vibration. Subjective assessment of equal sensation level will be taken into consideration.

2. METHODS

2.1 Subjects

Seven subjects aged between 18 and 54 years, with mean age of 39.86 years (Standard Deviation SD=10.99), a mean stature of 1.79 m (SD=0.04) and mean weight of 79.43 kg (SD=14.21) participated in the experiment. All subjects were with no history of occupational exposure to vibration.

An electro-hydraulic motion simulator was used in subjective experiment. The simulator was designed to provide the test bandwidth from 0.3 to 30 Hz, but with very small (negligible) 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, the investigators had to define frequency bandwidth and magnitude of excitation, (Lukic et al., 2002), (M. S. Demić & Lukic, 2008). First, subjects were exposed to dual axis vibration of equal amplitude. After that, they were asked to adjust level of fore and aft vibration in order to have equal sensation to vertical vibration.

Seat backrest angle (position *K* inclined 14° with respect to vertical axis and position *S* in vertical position without inclination) and excitation magnitude (0.55 m/s² r.m.s., 1.75 m/s² r.m.s. and 2.25 m/s² r.m.s.) were varied (M. Demić et al., 2002), (M. Demić & Lukić, 2009).

Each signal recording lasted 27.3 s and was repeated 4 times. Number of data points was 2048. Frequency domain was 0.037-37.5 Hz.

Acceleration on the head of the subject was measured in fore and aft and vertical direction as well as on the seat buttock interface. In this investigation only signals of the head acceleration in fore and aft direction were analyzed.

2.2 Analysis

Human body is more sensitive on vertical vibration than on fore and aft or lateral vibration. Vibration masking is reduction of perception of vibration in fore and aft or lateral direction. In the vibrational environment, with multi axial excitation, for example in the vehicle, vertical vibration masks vibration in other direction.

Masked Threshold is threshold for the perception of the stimulus determined in the presence of another stimulus. In this case energetic masking is analysed. Root Mean Square (r.m.s) of the acceleration of the human body is measure of sensitivity on vibration.

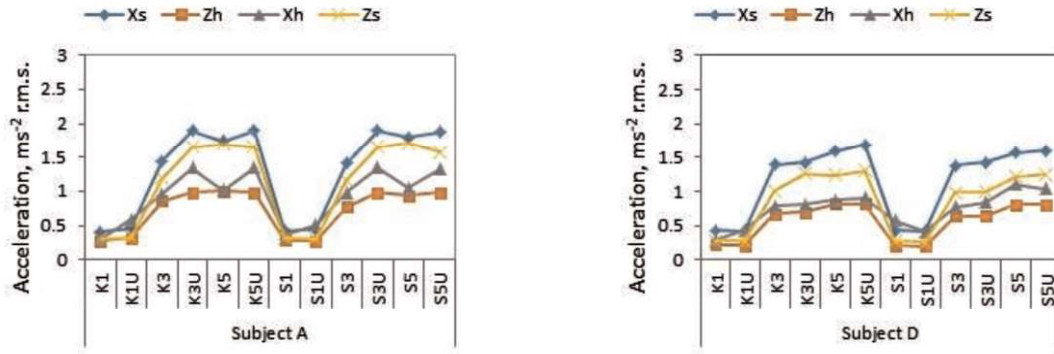
Masked Threshold (MT) is expressed in decibels:

$$MT(dB) = 20 \cdot \log_{10} \left(\frac{a_{hA}}{a_h} \right) \quad (1)$$

where a_{hA} is amplified head acceleration in ms⁻² r.m.s. and a_h is head acceleration ms⁻² r.m.s.

3. RESULTS

Accelerations of the head (index h) and on seat buttock interface (index s) are measured in fore and aft direction (X) and vertical direction (Z). For illustration, part of experimental results are given in **Hata!**
Başvuru kaynağı bulunamadı..



a)

b)

Figure 1 Measured r.m.s. acceleration in vertical (Z) and fore and aft direction (X) of the head (h) and seat (s) under (K) and (S) inclination of the seat backrest and dual axis excitation levels: - 1 - 0.55 ms⁻² r.m.s. , - 2 - 1.75 ms⁻² r.m.s. , - 3 - 2.55 ms⁻² r.m.s.; U – adjusted level of fore and aft vibration for equal sensation

The highest level of r.m.s. acceleration is on the seat in fore and aft direction (Xs) with adjusted equal sensation of vibration. Level of acceleration of the seat in fore and aft direction is higher than in vertical direction. Non linearity of the seat-head system, with respect to level of excitation, is shown in **Hata! Başvuru kaynağı bulunamadı..**

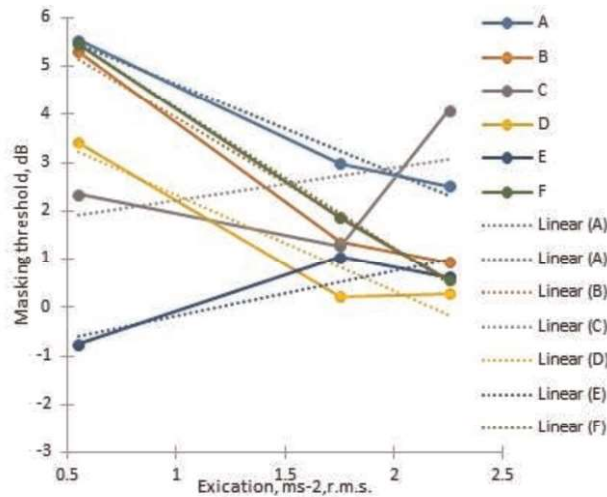


Figure 2. Masking Threshold of head acceleration in the fore and aft direction, K position of seat backrest

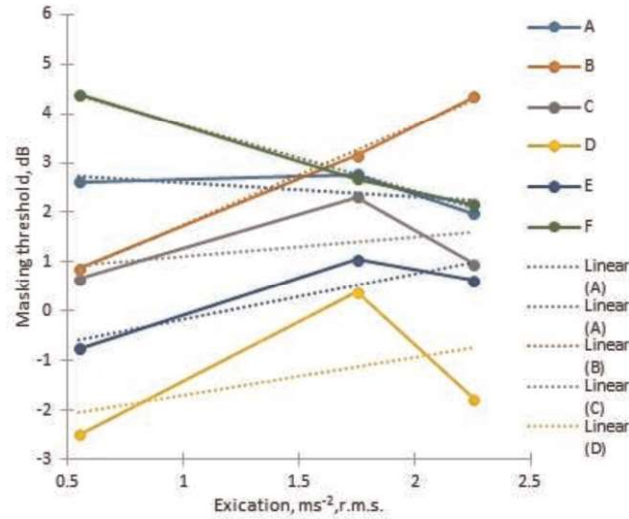


Figure 1. Masking Threshold head acceleration in the fore and aft direction, S position of seat backrest

Increase of seat backrest inclination angle increases MT.

Linear regression model is applied on MT data for each subject, given in Figure 2 and Figure 3. Regression equation data is given in Table 1.

Coefficient of determination, given in Table 1, shows good fit of linear regression between level of excitation and MT.

Median of all linear regression coefficient for all subjects is determined based on data given in Table 1 and is given in Figure 4.

Table 1 Linear regression data

Subject	Backrest position	Linear regression equation	Coefficient of determination
A	K	$y = -1.5067x + 6.6884$	$R^2 = 0.8606$
B	K	$y = -2.7039x + 6.6274$	$R^2 = 0.9598$
C	K	$y = 0.6749x + 1.5399$	$R^2 = 0.8724$
D	K	$y = -1.9963x + 4.3324$	$R^2 = 0.91$
E	K	$y = 0.9322x - 1.1121$	$R^2 = 0.7534$
F	K	$y = -2.9081x + 7.0381$	$R^2 = 0.9991$
A	S	$y = -0.2883x + 2.8896$	$R^2 = 0.8496$

B	S	$y = 2.0184x - 0.2766$	$R^2 = 0.9964$
C	S	$y = 0.3971x + 0.7052$	$R^2 = 0.8566$
D	S	$y = -1.683x + 0.3324$	$R^2 = 0.8991$
E	S	$y = 0.9322x - 1.1121$	$R^2 = 0.7534$
F	S	$y = -1.3403x + 5.108$	$R^2 = 0.9956$

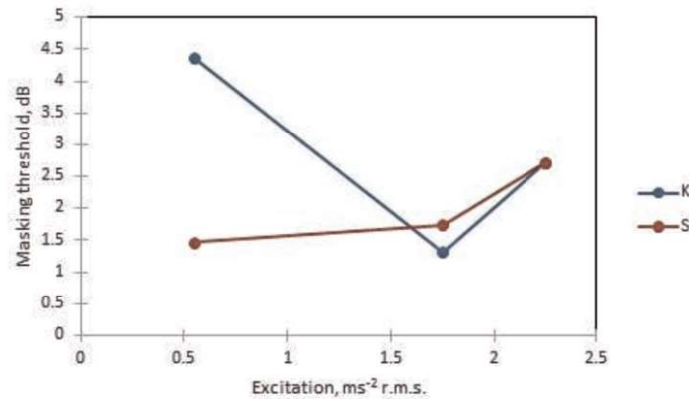


Figure 4 The influence of the seat backrest position on MT

4. CONCLUSIONS

Threshold for the perception of vibration in fore and aft vibration depends on initial excitation transferred to the human body and seat backrest position.

Increase of excitation level increase masking threshold of perception.

Linear regression model can be applied on masking threshold of fore aft vibration respect to excitation level of broadband random vibration.

Performed analysis took into consideration vibration in fore and aft direction under two axial broadband random excitation. Investigation MT respect to one axis excitation should be conducted in the future.

ACKNOWLEDGEMENTS

Paper is financially supported by The Ministry of Science, Technological Development and Innovation of the Republic of Serbia, Contract No. 451-03-65/2024-03/200107.

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