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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

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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..

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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

MASKING FORE AND AFT VIBRATION UNDER TWO AXIAL WHOLE BODY VIBRATION

Jovanka Lukić[1], Jasna Glišović[2], Danijela Miloradović[3]

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ABSTRACT

The existence of masking effects for fore and aft vibration under two axial broadband randomvibrations 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, (Mirioka & 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/s^2 r.m.s., 1.75 m/s^2 r.m.s. and 2.25 m/s^2 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.

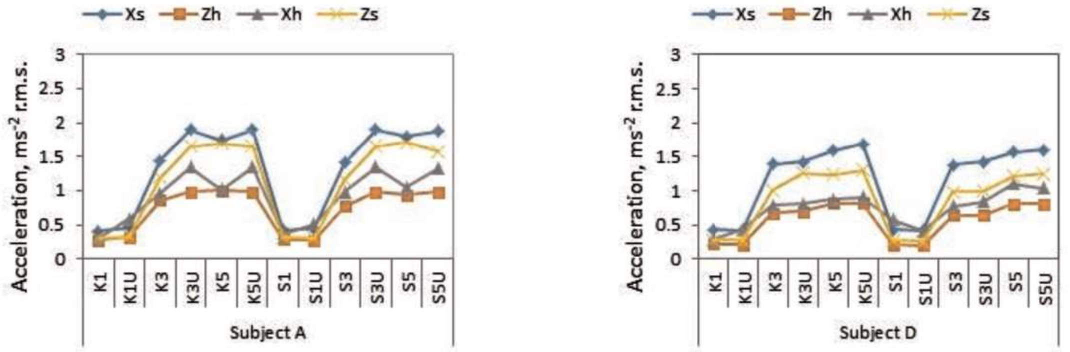
Masked Threshold (MT) is expressed in decibels:

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

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.**.

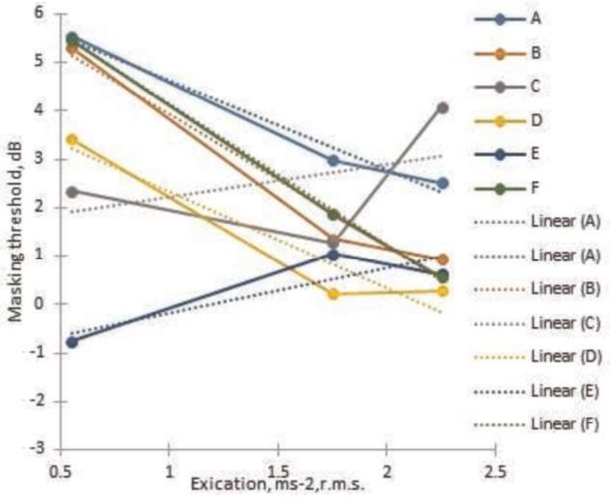


Figure 2. Masking Threshold of head acceleration in the fore and aft direction, K position of seat backrest

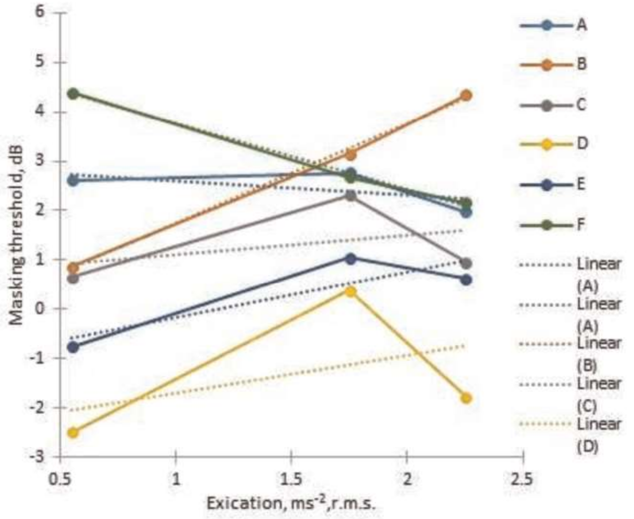


Figure 1. Masking Threshold head acceleration in the fore and aft direction, S position of seat backrest

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	R² = 0.9964
C	S	y = 0.3971x + 0.7052	R² = 0.8566
D	S	y = -1.683x + 0.3324	R² = 0.8991
E	S	y = 0.9322x - 1.1121	R² = 0.7534
F	S	y = -1.3403x + 5.108	R² = 0.9956

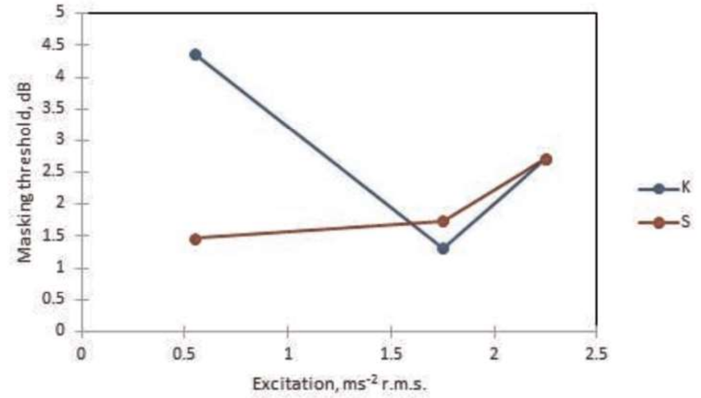


Figure 4 The influence of the seat backrest position on MT

4. CONCLUSIONS

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

Increase of excitation levele increase masking threashold of perception.

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

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

ACKNOWLEDGEMENTS

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