PROCEEDINGS OF ABSTRACTS

UNIVERSITY OF NIŠ
FACULTY OF OCCUPATIONAL SAFETY
Department of Preventive Engineering
Noise and Vibration Laboratory

"POLYTECHNICA" UNIVERSITY OF TIMISORA
FACULTY OF MECHANICAL ENGINEERING
Department of Mechanics and Vibration
Noise and Vibration Laboratory

BULGARIAN ACADEMY OF SCIENCES
Institute of Mechanics

28th INTERNATIONAL CONFERENCE

NOISE & VIBRATION

24 - 25, October 2024.
Niš, Serbia

PROCEEDING OF ABSTRACTS
OF 28th INTERNATIONAL CONFERENCE

NOISE AND VIBRATION

BUKA I VIBRACIJE

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28. MEĐUNARODNE KONFERENCIJE

Niš, 24-25. 10. 2024.

Urednici:
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Dr Darko Mihajlov, vanr. prof.

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2nd Yugoslav Conference	Belgrade	1979
3rd Yugoslav Conference	Belgrade	1980
4th Yugoslav Conference	Belgrade	1981
5th Yugoslav Conference	Belgrade	1982
6th Yugoslav Conference	Belgrade	1983
7th Yugoslav Conference	Belgrade	1984
8th Yugoslav Conference	Belgrade	1985
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12th Yugoslav Conference	Belgrade	1989
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14th Yugoslav & 2nd International Conference	Niš	1993
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17th Yugoslav Conference with international participation	Niš	2000
18th Yugoslav Conference with international participation	Niš	2002
19th Conference with international participation	Niš	2004
20th Conference with international participation	Tara	2006
21st Conference with international participation	Tara	2008
22nd Conference with international participation	Niš	2010
23rd Conference and 4th International Conference	Niš	2012
24th International Conference	Niš	2014
25th International Conference	Tara	2016
26th International Conference	Niš	2018
27th International Conference	Niš	2022
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TOPICS OF INTEREST

- Noise generation and propagation
- Noise control
- Environmental noise
- Vibration generation and propagation
- Vibration control
- Effect of noise and vibrations
- Analysis of noise and vibration
- Requirements

TEMATSKE OBLASTI

- Generisanje i prostiranje buke
- Kontrola buke
- Buka u životnoj sredini
- Generisanje i prostiranje vibracija
- Kontrola vibracija
- Efekti buke i vibracija
- Analiza buke i vibracija
- Standardi i propisi

SCHEDULE OF EVENTS - SATNICA

Thursday 24. 10. 2024. Četvrtak

09.00 - 10.00	Registration - *Registracija*
10.00 - 10.30	Opening ceremony - *Svečano otvaranje*
10.30 - 11.00	Coffee break - *Kafe pauza*
11.00 – 12.00	Presentation of invited papers - *Prikaz radova po pozivu*
12.00 - 12.15	Break - *Pauza*
12.15 – 14.00	Presentation of papers - *Prikaz radova*
14.00 – 16.00	Break - *Pauza*
16.00 – 18.00	Presentation of papers - *Prikaz radova*
19.30	Dinner party - *Večera*

Friday 25. 10. 2024. Petak

10.00 - 12.00	Presentation of papers - *Prikaz radova*
12.00 - 12.30	Coffee break - *Kafe pauza*
12.30 - 13.00	Summary and closing remarks - *Usvajanje zaključaka i zatvaranje*

PROGRAMME - PROGRAM

Thursday **24. 10. 2024.** **Četvrtak**

Meeting place: Faculty of Occupational Safety - Room 7

Mesto održavanja: Fakultet zaštite na radu u Nišu - Sala 7

11.00 - 12.00 Presentation of invited papers
Prikaz radova po pozivu

Miomir Mijić, Dragana Šumarac Pavlović
Sound insulation paradox of double rigid walls in buildings

Ivana Kovacic, Zeljko Kanovic, Ljiljana Teofanov, Vladimir Rajs
Vibration mitigation-based machine learning-driven design of metastructures

Branko Radičević
Models for predicting sound absorption of porous materials

❖

Meeting place: Faculty of Occupational Safety - Room 7

Mesto održavanja: Fakultet zaštite na radu u Nišu - Sala 7

12.15 - 14.00 1st session / *1. sekcija*

Dragan Cvetković
The contribution of standards and standardization in achieving acoustic comfort

Roumen Iankov, Milan Rashevski, Abed Nodira
Finite element modelling of impedance tube test

Alexander Alexiev, Sergey Bukharov, Darko Mihajlov, Nodira Abed, Aminjon Bozorov
Experimental study on the dynamic mechanical properties of epoxy based acoustic composites containing silicate and carbon nano-additives using Oberst beam method

Nikola Holeček
A case study of low frequency noise

Koleta Zafirova, Elena Tomovska
Polyester apparel cutting waste as sound insulation material

❖

Meeting place: Faculty of Occupational Safety - Room 7

Mesto održavanja: Fakultet zaštite na radu u Nišu - Sala 7

16.00 - 18.00 2nd session / *2. sekcija*

Emir Ganić, Aleksandar Gajicki, Bojana Mirković, Matija Sindik
Strategic noise map for Belgrade Nikola Tesla airport

Ingrid LeGriffon, Elise Ruaud, Emir Ganić, Tatjana Krstić Simić, Bojana Mirković, Miguel Baena, David Mocholí, Marta Alonso, Cristina Barrado, Jovana Kuljanin
Evaluating urban air mobility noise impacts

Snežana Jovanović, Milica Ivić Nikolić, Martin Jovanović, Dragan Stojadinović
Noise review of reconnaissance drones

Marina Donić, Emir Ganić, Jelena Ruso
Comparative analysis of ISO 3744 and ISO 5305 standards for UAS noise measurement

Momir Praščević, Darko Mihajlov, Petar Jovanović
Methodology for uncertainty estimation of short-term total environmental noise measurements

Jelena Malenović-Nikolić, Bojana Zlatković, Uglješa Jovanović
Application of indicators in noise control

Darko Mihajlov, Momir Praščević, Petar Jovanović
Environmental noise in vicinity of the brewery - a case study

Danica Boljević, Damir Savković, Aleksandar Milenković
Noise level measurements of road traffic at different heights in relation to the noise source

Anica Ranđelović, Jelena Malenović-Nikolić, Branko Radović, Predrag Ilić
Measurement of noise levels in the environment around the „Stanari“ mine

Branko Radović, Predrag Ilić, Anica Ranđelović, Bojana Zlatković
Examination of the noise level in the environment in the area of the Stanari municipality thermal power plant

Ljubica Stojković, Dragoslav Pavlović, Gradimir Cvetanović, Saša Pavlović, Milan Grozdanović, Nikola Krstić, Filip Filipović
Measuring the noise level of municipal vehicles during waste disposal at the Niš landfill

Jovan Miočinović
Proposal of the rule for rating levels of industrial impulsive noise regarding the risk of hearing damage

Friday **25. 10. 2024.** **Petak**

Meeting place: Faculty of Occupational Safety - Room 7

Mesto održavanja: Fakultet zaštite na radu u Nišu - Sala 7

10.00 - 12.00 3rd session / *3. sekcija*

Nicolae Herisanu, Bogdan Marinca, Vasile Marinca
Nonlinear vibration of a beam subjected to mechanical impact and Winkler-Pasternak foundation

Bogdan Marinca, Nicolae Herisanu, Vasile Marinca
Dynamic analysis of a nanobeam under the influence of an electromagnetic actuator and a mechanical impact

Milena Mančić, Dragan Jovanović, Miomir Raos, Marko Mančić
Vibrations measurements in industrial plants and their influence on machines

Tihomir Trifonov, Yavor Boychev, Ivan Ivanov
Advantages and disadvantages of vector sensors compared to classical acoustic sensors and acoustic antennas

Mladena Lukić, Katarina Đorđević, Žarko Ćojbašić, Dragan Markushev
Sensing with sound: furthering gases and solid analysis by photoacoustic spectroscopy

Vasile Bacria, Nicolae Herisanu
Ensuring an acoustically unpolluted living environment

Mihaela Picu
A study of the hearing health of ambulance drivers

Milica Ivić Nikolić, Snežana Jovanović, Branislav Djordjević, Aleksandar Sedmak
Application of ultrasound in different purposes with examples

Slobodanka Galović, Katarina Đorđevic, Mladena Lukić, Dalibor Chevizovich
Vibration phenomena induced by pulsed laser heating of micromechanical structures

❖

Meeting place: Faculty of Occupational Safety - Room 7

Mesto održavanja: Fakultet zaštite na radu u Nišu - Sala 7

12.30 - 13.00 Summary and closing remarks - *Usvajanje zaključaka i zatvaranje*

24. 10. 2024.

11:00 – 12:00

Room 7 - Sala 7

INVITED PAPERS – RADOVI PO POZIVU

Chairman / *Predsedavajući*:

Dragan Cvetković, Ph. D.

Ivana Kovacic[1], Zeljko Kanovic[2], Ljiljana Teofanov[2], Vladimir Rajs[2]

[1]*University of Novi Sad, Faculty of Technical Sciences, Centre of Excellence for Vibro-Acoustic Systems and Signal Processing CEVAS, Novi Sad, Serbia*

[2] *University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Serbia*

VIBRATION MITIGATION-BASED MACHINE LEARNING-DRIVEN DESIGN OF METASTRUCTURES

DIZAJN METASTRUKTURA ZASNOVAN NA SMANJENJU AMPLITUDE VIBRACIONOG ODZIVA MAŠINSKIM UČENJEM

Abstract - *This research is concerned with the development of a longitudinally excited metastructure, featuring periodically distributed external units, each equipped with internal oscillators functioning as vibration absorbers. Initially, the metastructure designed for vibration attenuation around the first structural resonance, is characterized by uniformity, with all absorbers being identical and consisting of cantilevers integrated into the external components, each cantilever terminating in a concentrated mass block. This study employs a machine learning approach to maximize vibration attenuation efficiency around the second resonance, as well as concurrently at the first and second resonant frequencies in two associated optimality criteria related to the width of the attenuation region and the amplitude reduction, respectively. The new metastructures redesigned based on these criteria are fabricated by 3D printing, and their enhanced vibration mitigation capabilities are verified experimentally.*

Key words: *metastructure, vibration mitigation, auxiliary oscillators, machine learning.*

Rezime - *Ovo istraživanje se bavi razvojem longitudinalno pobuđene metastrukture, sa periodično raspoređenim spoljašnjim jedinicama, od kojih svaka sadrži unutrašnje oscilatore koji funkcionišu kao apsorberi vibracija. Prvobitna metastruktura, dizajnirana za smanjivanje amplitude vibracija oko prve rezonancije, karakteriše uniformnost, pri čemu su svi apsorberi identični i sastoje se od konzola integrisanih u spoljašnje jedinice, pri čemu se svaka konzola završava blokom koncentrisane mase. Ova studija koristi pristup mašinskog učenja kako bi se maksimizirala efikasnost smanjenja vibracija oko druge rezonancije, kao i istovremeno na prvoj i drugoj rezonantnoj frekvenciji u dva povezana kriterijuma optimalnosti koja se odnose na širinu oblasti ublažavanja vibracija i smanjenja amplitude, respektivno. Nove metastrukture, redizajnirane na osnovu ovih kriterijuma, proizvedene su 3D štampom, a njihove poboljšane mogućnosti smanjenja amplitude vibracija su eksperimentalno verifikovane.*

Ključne reči: *metastruktura, ublažavanje vibracija, pomoćni oscilatori, mašinsko učenje*

Miomir Mijić, Dragana Šumarac Pavlović

University of Belgrade, School of Electrical Engineering, Belgrade, Serbia

SOUND INSULATION PARADOX OF DOUBLE RIGID WALLS IN BUILDINGS

PARADOKS ZVUČNE IZOLACIJE DVOSTRUKIH MASIVNIH ZIDOVA U ZGRADAMA

Abstract - *The "box within a box" is well-known in literature as a solution for achieving the highest possible level of room's sound insulation. This approach involves using double partitions between all surrounding spaces. There are practical examples of double solid walls implemented in residential buildings to ensure effective sound insulation between apartments. This concept is further supported by the need for adequate thermal insulation, as it allows for the installation of thermal insulation material in the space between the two solid layers. However, in buildings where this system has been applied, residents have reported inadequate sound insulation. Measurements conducted in these buildings have shown that the sound reduction index of a double solid brick wall is lower than that of a wall where the two thinner partitions are combined into one thicker solid partition, that is, without an internal air layer. To explore this issue, a study was organized. It was determined that in double solid walls, the influence of lateral junctions and sound paths through them becomes higher. Specifically, the attenuation of sound energy at the junctions of partitions Kij is less when the partition is lighter. Consequently, the transmission of sound energy through lateral joints in double walls is more pronounced than in a single solid wall with the same total surface mass. Thus, the inevitable local phenomena at the joints of double walls with surrounding partitions makes the use of a double solid wall between two concrete ceilings acoustically irrational.*

Key words: *double rigid walls, flanking transmission, sound insulation, sound reduction index, vibration reduction index*

Rezime - *U literaturi je poznat sistem „kutija u kutiji" kao rešenje za najviši mogući domet zvučne izolacije neke prostorije. To podrazumeva da se prema svim okolnim prostorima nalaze dvostruke pregrade. Postoje primeri iz prakse gde su dvostruki masivni zidovi primenjeni u stambenim zgradama sa ciljem da se obezbedi dobra zvučna izolacija između stanova Ta ideja je dodatno podržana potrebom da se postigne odgovarajuća toplotna izolacija između stanova, jer to omogućava postavljanje termoizolacionog materijala u prostor između dva masivna sloja. Međutim, u zgradama gde je to primenjeno pojavile su se žalbe stanara na neadekvatnu zvučnu izolaciju. Merenja koja su u njima organizovana pokazala su da je izolaciona moć dvostrukog masivnog zida od opeke manja nego zida u kome bi ta dva tanja zida bila spojena u jedan deblji masivni zid, to jest bez unutrašnjeg vazdušnog sloja. Zbog toga je pokrenuto istraživanje da bi našlo objašnjenje. Utvrđeno je da kod dvostrukih masivnih zidova postaje dominantan uticaju bočnih čvorišta i putanja zvuka preko njih. Naime, slabljenja zvučne energije u čvorištima na spojevima pregrada K_{ij} manja su kada je pregrada lakša. Zbog toga je prenos zvučne energije preko bočnih spojeva kod dvostrukih zidova izraženiji nego kod jedinstvenog masivnog zida koji ima istu masu. Tako neumitne lokalne pojave na spojevima dvostrukih zidova sa okolnim pregradama čine da je primena dvostrukog masivnog zida postavljenog između dve betonske tavanice u zgradama akustički neracionalna.*

Ključne reči: *bočno provođenje, dvostruki masivni zid, zvučna izolacija, indeks slabljenja vibracija, izolaciona moć*

Branko Radičević

University of Kragujevac, Faculty of Mechanical and Civil Engineering in Kraljevo, Kraljevo, Serbia

MODELS FOR PREDICTING SOUND ABSORPTION OF POROUS MATERIALS

MODELI ZA PREDIKCIJU APSORPCIJE ZVUKA POROZNIH MATERIJALA

Abstract - *Porous materials have been widely used in the field of noise control. The acoustic properties of these materials are best characterized by the sound absorption coefficient, which can be predicted using various mathematical models, which are presented in this paper: empirical, phenomenological, statistical. Optimization models based on biologically inspired algorithms were used to determine non-acoustic parameters of acoustic models. In addition to mathematical models for predicting acoustic parameters of porous materials, the paper also presents models for identifying non-acoustic parameters that are input parameters of empirical and phenomenological models. Air flow resistance is one of the most significant non-acoustic parameters of porous materials, and its values shown in this paper were measured according to the SRPS EN ISO 9053-1:2019 method. In empirical models, resistance to air flow is the only input parameter, while in phenomenological and optimization models it is one of several input parameters that establish a connection between microstructure and acoustic performance of porous materials. Based on the experimental values of the sound absorption coefficient, the non-acoustic parameters of the phenomenological models were determined using biologically inspired optimization algorithms. Statistical models are based on ANOVA analysis and establishing the dependence of the sound absorption coefficient on the thickness of the material layer and frequency. Predictions of the sound absorption coefficient of open-cell polyurethane foam were determined using the above models and compared with impedance tube measurements. In this way, the accuracy of the prediction of mathematical models for determining sound absorption was determined. Based on the experimental values of the sound absorption coefficient, the non-acoustic parameters of the phenomenological models were determined using biologically inspired optimization algorithms. In addition, this research shows that low-density, open-cell polyurethane foams have good sound absorption performance over a wide frequency range, and as such can be used for noise protection.*

Key words: *porous materials, acoustic models, sound absorption coefficient*

Rezime - *Porozni materijali naširoko se koriste u području kontrole buke. Akustična svojstva ovih materijala najbolje karakterizira koeficijent apsorpcije zvuka, koji se može predvidjeti korištenjem različitih matematičkih modela koji su prikazani u ovom radu: empirijski, fenomenološki, statistički. Optimizacijski modeli temeljeni na biološki inspiriranim algoritmima korišteni su za određivanje neakustičkih parametara akustičkih modela. Osim matematičkih modela za predviđanje akustičkih parametara poroznih materijala, u radu su prikazani i modeli za identifikaciju neakustičkih parametara koji su ulazni parametri empirijskih i fenomenoloških modela. Otpor strujanju vazduha jedan je od najznačajnijih neakustičkih parametara poroznih materijala, a njegove vrijednosti prikazane u ovom radu izmjerene su prema metodi SRPS EN ISO 9053-1:2019. U empirijskim modelima otpor strujanju vazduha jedini je ulazni parametar, dok je u fenomenološkim i optimizacijskim modelima jedan od nekoliko ulaznih parametara koji uspostavljaju vezu između mikrostrukture i akustičkih svojstava poroznih materijala. Na temelju eksperimentalnih vrijednosti koeficijenta apsorpcije zvuka, pomoću biološki inspiriranih optimizacijskih algoritama određeni su neakustički parametri fenomenoloških modela. Statistički modeli temelje se na ANOVA analizi i utvrđivanju ovisnosti koeficijenta apsorpcije zvuka o debljini sloja materijala i frekvenciji. Predviđanja koeficijenta apsorpcije zvuka poliuretanske pene s otvorenim ćelijama određena su korištenjem gornjih modela i uspoređena s mjerenjima impedancije cijevi. Na taj je način utvrđena točnost predviđanja matematičkih modela za određivanje apsorpcije zvuka. Na temelju eksperimentalnih vrijednosti koeficijenta apsorpcije zvuka, pomoću biološki inspiriranih optimizacijskih algoritama određeni su neakustički parametri fenomenoloških modela. Osim toga, ovo istraživanje pokazuje da poliuretanske pene niske gustoće s otvorenim ćelijama imaju dobre performanse apsorpcije zvuka u širokom frekvencijskom rasponu, te se kao takve mogu koristiti za zaštitu od buke.*

Ključne reči: *porozni materijali, akustički modeli, koeficijent zvučne apsorpcije*

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24. 10. 2024.

12:15 – 14:00

Room 7 - Sala 7

1st SESSION – 1. SEKCIJA

Chairman / *Predsedavajući*:

Nikola Holeček, Ph. D.

Dragan Cvetković

University of Niš, Faculty of Occupational Safety in Niš, Niš, Serbia

THE CONTRIBUTION OF STANDARDS AND STANDARDIZATION IN ACHIEVING ACOUSTIC COMFORT

DOPRINOS STANDARDA I STANDARDIZACIJE U DOSTIZANJU AKUSTIKOG KOMFORA

Abstract - *Acoustic comfort in the context of the harmful effect of noise on human health in the living space of a residential building can be viewed based on the definition of the World Health Organization (WHO), according to which health is "a state of complete physical, spiritual and social comfort". Based on this definition, health action does not mean only physical damage to health, but also impaired subjective comfort, which in a long period of damage can lead to physical damage to health. This paper presents a view of one position in attempt to improve the process of establishing evidence of exposure to noise in the living space of a residential building and to contribute to a more objective presentation of evidence on the consequences of disturbing acoustic comfort with contents that violate privacy and human health. The growing influx of complaints about the phenomenon of noise in the environment, as well as its impact on mental and physical health, requires a higher level of professional attitude towards a complex-multidimensional problem and a layered analysis of the spectrum of negative effects that imply sleep disturbance, auditory and extra auditory disturbances. Achieving acoustic comfort is a complex, multi-functional problem, which includes numerous external and architectural factors such as: purpose of living space, nature of noise in the environment, acoustic values of building structures and materials. Unfortunately, numerous examples of "bad practice" are known, where the owners - buyers noticed all construction defects hidden under the luxurious surface only after moving in, and the largest number of customer complaints is related to acoustic comfort.*

Key words: *noise, acoustic comfort, customer satisfaction, public health*

Rezime - *Akustički komfor u kontekstu štetnog delovanja buke na zdravlje čoveka u boravišnom prostoru stambenog objekta, može se posmatrati na temelju definicije Svetske zdravstvene organizacije (WHO) po kojoj je zdravlje "stanje potpune fizičke, duhovne i socijalne udobnosti". Na osnovu ove definicije se pod zdravstvenim delovanjem ne podrazumeva samo fizička povreda zdravlja, već i narušena subjektivna udobnost, koja u dužem periodu narušavanja može dovesti do fizičkog narušavanja zdravlja. Ovaj rad predstavlja prikaz jednog stava u pokušaju da se unapredi proces utvrđivanja dokaza o izloženosti buci u boravišnom prostoru stambenog objekta i da doprinos za objektivnije izvođenje dokaza o posledicama narušavanja akustičkog komfora sadržajima koji narušavaju privatnost i zdravlje čoveka. Sve veći priliv žalbi na fenomen buke u životnoj sredini, kao i njen uticaj na psihičko i fizičko zdravlje zahteva povišeni nivo profesionalnog odnosa prema složenom više dimenzijalnom problemu i slojevitu analizu spektra negativnih efekata koji impliciraju ometanje spavanja, auditivne i ekstra auditivne smetnje. Postizanje akustičkog komfora je kompleksan više funkcionalni problem, koji uključuje brojne eksterne i arhitektonske faktore poput: namene boravišnog prostora, karaktera buke u okruženju, akustičkih vrednosti građevinskih konstrukcija i materijala. Nažalost, poznati su i brojni primeri „loše prakse" gde su vlasnici - kupci tek nakon useljenja primetili sve nedostatke gradnje koji se kriju ispod luksuzne površine, a najveći broj žalbi kupaca odnosi se na akustički komfor.*

Ključne reči: *buka, akustički komfor, zadovoljstvo kupca, javno zdravlje*

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A CASE STUDY OF LOW FREQUENCY NOISE

STUDIJA SLUČAJA NISKOFREKVENCIJSKE BUKE

Abstract - *Sound waves below 20 Hz, which are generally inaudible to humans, are called infrasound. When infrasound and the less audible sound of the lowest frequencies (10 to 200 Hz) appears as an element that disturbs people and is harmful to health, it is low-frequency noise (LFN). This air-borne noise has a much greater range than normal audible frequency sound and LFN travels much further on the ground. Stronger or longer-lasting infrasound around 7-20 Hz directly affects the human central nervous system and can cause disorientation, anxiety, panic, depression, nausea, discomfort, vomiting, etc. Sooner or later, the waves can lead to damage to the nervous and/or cardiovascular system. It is estimated that about 2.5 % of the population may have a low-frequency threshold that is at least 12 dB more sensitive than the average threshold, which corresponds to almost 1,000,000 persons in the age group 50 to 59 years in the EU-15 countries. LFN is recognized as a particular environmental noise problem, especially for sensitive people in their homes. Conventional noise assessment methods are not suitable for LFN and lead to wrong conclusions and consequently to wrong decisions. An LFN source is more difficult to localize, difficult to suppress, and spreads rapidly in all directions so that it can be heard over great distances. All existing sound field visualization methods have a lower frequency limit of 125 Hz. Low-frequency waves surround the noise source and such a source is practically "undirected". In the paper, we described the LFN assessment carried out, which we identified in a commercial/residential building. The measurements were carried out in the immediate vicinity (2-3 km as the crow flies) of the object in question, at the site of industrial facilities (V1 and OM2), the pond complex, the gas and transformer station. The LFN in the facility was initially unidentified, and the source search diagnostics was based on the method of comparing the generic spectral distributions of the LFN in the facility with other selected measurement positions.*

Key words: *low frequency noise, low frequency noise identification method*

Rezime - *Zvučni talasi ispod 20 Hz, koji su generalno nečujni za ljude, nazivaju se infrazvukom. Kada se infrazvuk i manje čujan zvuk najnižih frekvencija (10 do 200 Hz) pojave kao element koji uznemirava ljude i šteti zdravlju, radi se o niskofrekventnoj buci (LFN). Ova buka koja se prenosi vazduhom ima mnogo veći domet od normalnog zvuka čujne frekvencije, a LFN putuje mnogo dalje po zemlji. Jači ili dugotrajniji infrazvuk oko 7-20 Hz direktno utiče na centralni nervni sistem čoveka i može izazvati dezorijentaciju, anksioznost, paniku, depresiju, mučninu, nelagodnost, povraćanje itd. Pre ili kasnije, talasi mogu dovesti do oštećenja nervnog sistema i/ili kardiovaskularnog sistema. Procenjuje se da oko 2,5 % stanovništva može imati prag niske frekvencije koji je najmanje 12 dB osetljiviji od prosečnog praga, što odgovara skoro 1.000.000 osoba u starosnoj grupi od 50 do 59 godina u zemljama EU-15. LFN je prepoznat kao poseban problem buke u životnoj sredini, posebno za osetljive ljude u njihovim domovima. Konvencionalne metode procene buke nisu pogodne za LFN i dovode do pogrešnih zaključaka i posledično do pogrešnih odluka. LFN izvor je teže lokalizovati, teško ga je potisnuti i brzo se širi u svim pravcima, tako da se može čuti na velikim udaljenostima. Sve postojeće metode vizuelizacije zvučnog polja imaju donju granicu frekvencije od 125 Hz. Talasi niske frekvencije okružuju izvor buke i takav izvor je praktično „neusmeren". U radu smo opisali izvršenu LFN procenu koju smo identifikovali u poslovno-stambenoj zgradi. Merenja su vršena u neposrednoj blizini (2-3 km vazdušne linije) predmetnog objekta, na lokaciji industrijskih objekata (V1 i OM2), kompleksa ribnjaka (P1), gasne i trafo stanice. LFN u objektu je prvobitno bio neidentifikovan, a dijagnostika pretrage izvora zasnovana je na metodi poređenja generičkih spektralnih distribucija LFN-a u objektu sa drugim odabranim pozicijama merenja.*

Ključne reči: *niskofrekvencijska buka, metoda identifikacije niskofrekvencijske buke*

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FINITE ELEMENT MODELLING OF IMPEDANCE TUBE TEST

MODELIRANJE METODOM KONAČNIH ELEMENATA ISPITIVANJA U IMPEDANSNOJ CEVI

Abstract - *Impedance tubes are used to characterize porous acoustic materials. The paper proposes a suitable model for numerical simulations of the test of materials in an impedance tube. Numerical simulations make it possible to generate synthetic data on the acoustic characteristics of the material when varying the parameters in the material model. These data are suitable for using machine learning algorithms as well as for solving inverse problems for identifying the material parameters in the mathematical model. The Johnson-Champoux-Allard model is used in the paper, which is suitable for a wide class of porous acoustic materials.*

Key words: *impedance tube, finite element, acoustic parameters, Johnson-Champoux-Allard model*

Rezime - *Impedansne cevi se koriste za karakterizaciju poroznih akustičkih materijala. U radu se predlaže odgovarajući model za numeričke simulacije ispitivanja materijala u impedansnoj cevi. Numeričke simulacije omogućavaju generisanje sintetičkih podataka o akustičkim karakteristikama materijala pri promenama parametara u modelu materijala. Ovi podaci su pogodni za korišćenje algoritama mašinskog učenja, kao i za rešavanje inverznih problema za identifikaciju parametara materijala u matematičkom modelu. U radu je korišćen model Johnson-Champouk-Allard, koji je pogodan za široku klasu poroznih akustičkih materijala.*

Ključne reči: *impedansna cev, konačni element, akustički parametri, Johnson-Champoux-Allard model*

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EXPERIMENTAL STUDY ON THE DYNAMIC MECHANICAL PROPERTIES OF EPOXY BASED ACOUSTIC COMPOSITES CONTAINING SILICATE AND CARBON NANO-ADDITIVES USING OBERST BEAM METHOD

EKSPERIMENTALNO ISTRAŽIVANJE DINAMIČKIH MEHANIČKIH SVOJSTVA AKUSTIČKIH KOMPOZITA NA BAZI EPOKSIDA KOJI SADRŽE SILIKATNE I UGLJENIKOVE NANO-ADITIVE PRIMENOM OBERST BEAM METODE

Abstract - *Acoustic materials are man-made materials designed to dissipate sound energy. There is a distinction between acoustic materials with sound-absorbing and sound-insulating properties. The sound-insulating capacity of acoustic materials is determined by their bulk density and dynamic mechanical properties. Dynamic mechanical properties are expressed in the sound-insulating characteristics of materials through two main factors – the dynamic modulus of elasticity (Ed) and the loss coefficient (tan δ). The temperature and frequency dependencies of Ed and tan δ of polymer materials and composites with polymer matrix are determined by their chemical structure and molecular mobility, as well as intra- and intermolecular interactions. At low temperatures, when the polymer matrix of the composite is in a glassy state, the Ed of linear amorphous polymers can reach several GPa. With increasing temperature and transition to a highly elastic state, the Ed of polymers decreases to 105 – 106 Pa. Changes in the composition and structure of composites and their constituent polymer matrices significantly affect the temperature-frequency dynamic mechanical properties, and, consequently, the characteristics of the acoustic composites. The introduction of micro- and nano-sized modifiers into polymer matrices to enhance the sound-absorbing and sound-insulating properties of composites is aimed at augmenting the viscous-elastic losses of the fibrous framework's mechanical energy and refining the pore structure. In this paper, the influence of two different types of nano-modifiers (montmorillonite silicate nanofiller and carbon nanotubes) on the dynamic mechanical properties of acoustic composites based on epoxy resin was studied using the Oberst Beam Method. The obtained results are compared with experimental data from non-resonant dynamic mechanical analysis (DMA) using dual-cantilever test scheme.*

Key words: *polymer materials, composites, dynamic modulus of elasticity, loss coefficient, Oberst Beam Method, dual-cantilever test scheme*

Rezime - *Akustički materijali su veštački materijali dizajnirani da rasipaju zvučnu energiju. Postoji razlika između akustičkih materijala koji apsorbuju zvuk i onih koji imaju svojstva zvučne izolacije. Kapacitet zvučne izolacije akustičkih materijala je određen njihovom zapreminskom gustinom i dinamičkim mehaničkim svojstvima. Dinamička mehanička svojstva izražavaju se u zvučno-izolacionim karakteristikama materijala kroz dva glavna faktora – dinamički modul elastičnosti (Ed) i koeficijent gubitka (tan δ). Temperaturne i frekvencijske zavisnosti Ed i tan δ polimernih materijala i kompozita sa polimernom matricom određene su njihovom hemijskom strukturom i molekularnom pokretljivošću, kao i intra- i*

intermolekularnim interakcijama. Na niskim temperaturama, kada je polimerna matrica kompozita u staklastom stanju, Ed linearnih amorfnih polimera može dostići nekoliko GPa. Sa porastom temperature i prelaskom u visokoelastično stanje, Ed polimera opada na 105 – 106 Pa. Promene u sastavu i strukturi kompozita i njihovih sastavnih polimernih matrica značajno utiču na temperaturno-frekvencijska dinamička mehanička svojstva, a samim tim i na karakteristike akustičnih kompozita. Uvođenje modifikatora mikro- i nanoveličina u polimerne matrice radi poboljšanja svojstava apsorpcije zvuka i zvučne izolacije kompozita ima za cilj povećanje viskozno-elastičnih gubitaka mehaničke energije vlaknastog okvira i oplemenjivanje strukture pora. U ovom radu je proučavan uticaj dva različita tipa nanomodifikatora (montmorilonit silikatnog nanopunila i ugljeničnih nanocevi) na dinamička mehanička svojstva akustičnih kompozita na bazi epoksidne smole primenom Oberst Beam metode. Dobijeni rezultati su upoređeni sa eksperimentalnim podacima iz nerezonantne dinamičke mehaničke analize (DMA) korišćenjem šeme ispitivanja sa dvostrukom konzolom.

Ključne reči: *polimerni materijali, kompoziti, dinamički modul elastičnosti, koeficijent gubitka, Oberst Beam metoda, dvokonzolna ispitna šema*

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POLYESTER APPAREL CUTTING WASTE AS SOUND INSULATION MATERIAL

OTPAD OD SEČENE POLIESTERSKE ODEĆE KAO MATERIJAL ZA ZVUČNU IZOLACIJU

Abstract - *This study developed an insulation structure using waste from apparel cutting and examined its sound insulation capabilities. Shredded polyester apparel cuttings served as the primary material for this structure. Results indicate that the insulation made from apparel waste exhibits superior sound absorption properties compared to conventional sound and thermal insulators. The average sound absorption ranged from 54.7 % to 74.7 % across frequencies from 250 to 2000 Hz. This research proposes a method to reduce environmental pollution by repurposing polyester apparel waste for insulation in roofs and internal walls.*

Key words: *apparel cutting waste, sound insulation*

Rezime – *U ovoj studiji je prikazan razvoj izolacione strukture koja koristi otpad od sečene odeće i rezultati ispitivanja njene zvučne izolacije. Usitnjeni poliester iz odsečaka odeće je služio kao glavni materijal za ovu strukturu. Rezultati pokazuju da izolacija napravljena od tekstilnog otpada ima superiorna svojstva apsorpcije zvuka u poređenju sa konvencionalnim zvučnim i toplotnim izolatorima. Prosečna apsorpcija zvuka kretala se od 54.7 % do 74.7 % na frekvencijama od 250 do 2000 Hz. Ovo istraživanje predlaže metodu smanjenja zagađenja životne sredine preusmeravanjem poliester otpada iz odeće za izolaciju krovova i unutrašnjih zidova.*

Ključne reći: *otpad od sečene odeće, zvučna izolacija*

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APPLICATION OF CONTEMPORARY MATERIALIZATION OF INTERIOR PARTITION IN INDUSTRIAL BUILDINGS AS AN ACOUSTIC CHALLENGE

PRIMENA SAVREMENE MATERIJALIZACIJE UNUTRAŠNJIH PREGRADA INDUSTRIJSKIH OBJEKATA KAO AKUSTIČKI IZAZOV

Abstract - *In recent years, the construction of industrial buildings in local areas has been dynamically increasing. In the context of modern architecture and construction, besides functionality in terms of meeting basic structural requirements, technological processes, and building design, achieving acoustic comfort within the workspace has become one of the primary design challenges. Analyzing contemporary design trends in the field of industrial building architecture reveals an increasing prevalence of using "flexible" interior partitions, both in their materialization and in architectural-functional organization. The tendency to use "light materialization," which aims to provide visual interaction as well, represents a unique engineering-architectural challenge. This paper investigates the impact of applying modern materialization of interior partitions, through a case study of an industrial building in Niš, on the potential to achieve adequate acoustic comfort. The aim of the study is to explore to what extent and in what way the application of different types of materialization, determined by the functional requirements of the space, influences the creation of an appropriate acoustic environment. The paper will analyze the possibilities of optimizing the materialization of interior partitions to achieve adequate acoustic ambiance while respecting architectural-design requirements. By simulating the acoustic performance of several models of modern materializations of interior partitions, an analysis of their acoustic characteristics (insulation power) will be conducted. The simulation of the models was carried out using the INSUL program, specialized for calculating sound insulation through various elements and construction assemblies. The obtained results will provide a preliminary "path to follow" in the architectural search for adequate acoustic comfort in the interior spaces of industrial buildings.*

Key words: *industrial buildings, interior partitions, contemporary materials, insulation power, acoustic, comfort*

Rezime - *Poslednjih godina je izgradnja industrijskih objekata ovdašnjih prostora u dinamičnom porastu. U kontekstu savremene arhitekture i graditeljstva, pored funkcionalnosti u smislu ispunjenja osnovnih konstrukcijskih zahteva, tehnološkog procesa i samog oblikovanja zgrade, postizanje akustičnog komfora unutar radnog prostora, postaje jedan od primarnih projektantskih izazova. Analizom savremenih projektantskih tendencija u oblasti arhitekture industrijskih objekata, može se uočiti sve veća zastupljenost primene ”fleksibilnih” unutrašnjih pregrada, kako u njihovoj materijalizaciji tako i u arhitektonsko-funkcionalnoj organizaciji. Tendencija upotrebe ”lake materijalizacije”, koja nastoji da obezbedi i vizuelnu interakciju, predstavlja svojevrstan inženjersko-arhitektonski izazov. Rad istražuje uticaj primene savremene materijalizacije unutrašnjih pregrada, studijom slučaja jedne industrijske zgrade u Nišu, na potencijal ostvarivanja adekvatnog akustičkog komfora. Cilj rada je da se istraži u kojoj meri i na koji način primena različitih vrsta materijalizacije objekata, determinisana funkcionalnim zahtevima prostora, utiče na stvaranje odgovarajućeg akustičnog okruženja. Radom će biti analizirane mogućnosti optimizovanja materijalizacije unutrašnjih pregrada u svrhu postizanja adekvatnog akustičnog ambijenta uz adekvatno poštovanje arhitektonsko-projektantskih zahteva. Simulacijom akustičkih performansi nekoliko modela savremenih materijalizacija unutrašnjih pregrada, biće izvršena analiza njihovih akustičkih karakteristika (izolaciona moć). Simulacija modela izvršena je u programu INSUL, specijalizovanom za proračun zvučne izolacije kroz različite elemente i konstrukcijske sklopove. Dobijeni rezultati će pružiti preliminaran ”put kojim treba ići” prilikom arhitektonskog pronalaženja odgovarajućeg akustičkog komfora unutrašnjeg prostora industrijskih zgrada.*

Ključne reči: *industrijski objekti, unutrašnje pregrade, savremena materijalizacija, izolaciona moć, akustika, komfor*

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MULTI-SLOPE ENERGY DECAY CURVES GENERATED BY MOVING AVERAGE APPROACH

KRIVE OPADANJA ZVUKA SA VIŠE STRIMINA GENERISANE PRISTUPOM USREDNJAVANJA

Abstract - *Sound energy decay is typically represented by an energy decay curve (EDC), which shows the decrease in sound energy over time after the sound source in a room is turned off. In spaces with single-slope decay, the EDC appears as a straight line. Such curves can be analyzed using linear regression to calculate parameters such as reverberation time. However, due to factors like room geometry, absorption, and other effects of sound transmission in enclosed spaces, an EDC may exhibit multi-slope decay. When linear regression is applied to such a curve, the results strongly depend on the range over which the curve is approximated by a straight line. This paper analyzes EDCs generated using the moving average approach, based on impulse responses measured in two rooms: a reverberation chamber and a classroom. The focus is on multi-slope EDCs and a comparison of moving average EDCs with those generated traditionally using Schroeder's backward integration method. The moving average EDCs exhibit a greater dynamic range than the Schroeder-integrated EDCs, revealing the final part of the reverberation decay that is obscured in the latter due to cumulative summation of background noise.*

Key words: *sound energy decay, energy decay curve, moving average, multi-slope decay*

Rezime - *Opadanje zvučne energije u prostoriji se obično predstavlja krivom opadanja energije, koja prikazuje smanjenje zvučne energije tokom vremena nakon što je zvučni izvor u prostoriji isključen. U prostorima sa eksponencijalnim opadanjem zvuka, kriva opadanja ima samo jednu strminu opadanja, odnosno reverberaciono opadanje je predstavljeno pravom linijom. Takve krive se mogu analizirati primenom linearne regresije kako bi se izračunali parametri poput vremena reverberacije. Međutim, zbog faktora kao što su geometrija prostorije, apsorpcija i drugi efekti prenosa zvuka u zatvorenim prostorima, kriva opdanja može biti zakrivljena – reverberaciono opadanje može imati više strmina. Kada se linearna regresija primeni na takvu krivu, rezultati u velikoj meri zavise od opsega u kome se kriva aproksimira pravom linijom. Ovaj rad analizira krive opadanja zvuka generisane korišćenjem pristupa usrednjavanja, na osnovu impulsnih odziva merenih u dve prostorije: reverberacionoj komori i učionici. Fokus je na krivama sa više strmina opadanja i poređenju krivih dobijenih metodom usrednjavanja sa onima generisanim na tradicionalan način koristeći Šrederovu metodu integraljenja unazad. Krive opadanja generisane metodom usrednjavanja imaju veći dinamički opseg od krivih dobijenih Šrederovim integraljenjem. Kod prvo pomenutih krivih, poslednji deo reverberacionog opadanja postaje vidljiv, što nije slučaj kod Šrederovih krivih zbog kumulativnog sabiranja ambijentalne buke i elektronskog šuma.*

Ključne reči: *opadanje zvučne energije, kriva opadanja zvučne energije, usrednjavanje, opadanje sa više strmina*

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EFFECTIVENESS OF THE CONSTRUCTION OF SOUND BARRIERS ON TWO HIGHLY BUSY ROADS IN BELGRADE

EFIKASNOST IZGRADNJE ZVUČNIH BARIJERA NA DVE IZRAZITO PROMETNE SAOBRAĆAJNICE U BEOGRADU

Abstract - *The application of sound barriers is considered to be one of the important environmental and occupational noise protection measures, especially when it comes from noise sources such as road traffic. It represents a secondary measure of noise protection, because it is applied on the path of propagation of sound waves from the sound source to the place of immission, while the primary measure is applied at the source itself or its immediate surroundings. In this case, the place of immission is the place where a person resides as the main subject of noise protection. In this paper, the efficiency of this application of protection is discussed on the example of two sections of extremely busy traffic roads in Belgrade: a) Boulevard Arsenija Čarnojevića along KBC Bežanijska kosa (former section of highway E-70 Belgrade-Zagreb) and b) Boulevard Franše d'Eperea along the building of the City Institute for Emergency Medical Assistance (former section of the E-75 Belgrade-Niš highway).*

Key words: *sound barrier, noise, sound, sound insulation, noise level, sound attenuation, efficiency*

Rezime - *Kao jedna od značajnih mera zaštite od buke u životnoj i radnoj sredini smatra se primena zvučnih barijera, naročito kada se radi o izvorima buke kakav je drumski saobraćaj. Ona predstavlja sekundarnu meru zaštite od buke, jer se primenjuje na putu prostiranja zvučnih talasa od izvora zvuka do mesta imisije, dok se primarna mera primenjuje na samom izvoru ili njegovoj neposrednoj okolini. Mesto imisije je u ovom slučaju mesto gde boravi čovek kao osnovni subjekat zaštite od buke. U ovom radu obrađena je efikasnost ovakve primene zaštite na primeru dve deonice izrazito prometnih gradskih saobraćajnica u Beogradu: a) Bulevar Arsenija Čarnojevića duž KBC Bežanijska kosa (bivša deonica auto-puta E-70 Beograd-Zagreb) i b) Bulevar Franše d'Eperea uz zgradu Gradskog zavoda za hitnu medicinsku pomoć (bivša deonica auto-puta E-75 Beograd-Niš).*

Ključne reči: *zvučna barijera, buka, zvuk, zvučna izolacija, nivo buke, slabljenje zvuka, efikasnost*

Violeta Stojanović[1], Zoran Milivojević[2]

[1]Academy of Applied Technical and Preschool Studies, Niš Department, Serbia
[2]MB University Belgrade, Serbia.

THE POLAR CHARACTERISTIC OF AN ACOUSTIC PARABOLIC REFLECTOR

POLARNA KARAKTERISTIKA AKUSTIČKOG PARABOLIČNOG REFLEKTORA

Abstract - *The first part of the paper presents the geometry of the acoustic parabolic reflector. After that, analytical formulas for calculating the gain and polar characteristics of the reflector are shown. The second part of the paper describes the experiment in which measurements were made and the acoustic characteristics of the parabolic reflector located in the yard of the Academy of Applied Technical and Preschool Studies, Department of Niš, in Niš were calculated. First, acoustic impulse responses for acoustic excitation at angles from -90° to 90° were measured. After that, the polar characteristic of the radiation was calculated. Finally, the beamwidth, spatial angle of the radiation beam, and directivity of the acoustic parabolic reflector were determined. The results of the experiment are presented numerically and graphically.*

Key words: *impulse response, polar characteristic, directivity*

Rezime - *U prvom delu rada prikazana je geometrija akustičkog paraboličnog reflektora. Nakon toga prikazane su analitičke formule za izračunavanje pojačanja i polarne karakteristike reflektora. U drugom delu rada opisan je eksperiment u okviru koga su vršena merenja i izračunate su akustičke karakteristike paraboličnog reflektora koji se nalazi u dvorištu Akademije tehničko-vaspitačkih strukovnih studija Odseka Niš u Nišu. Najpre su izmereni akustički impulsni odzivi za akustičku pobudu pod uglovima -90^o ÷ 90^o. Nakon toga je izračunata polarna karakteristika zračenja. Na kraju je odredjena širina snopa zračenja, prostorni ugao snopa zračenja i direktivnost akustičkog paraboličnog reflektora. Rezultati eksperimenta su prikazani numerički i pomoću grafika.*

Ključne reči: *akustički impulsni odziv, polarna karakteristika, direktivnost*

Tanja Dulović, Branko Radičević, Mišo Bjelić, Marina Ivanović

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OPTIMIZATION OF ACOUSTIC PARAMETERS OF FIBROUS MATERIALS USING BIOLOGICALLY INSPIRED ALGORITHMS

OPTIMIZACIJA AKUSTIČNIH PARAMETARA VLAKNASTIH MATERIJALA KORISTEĆI BIOLOŠKI INSPIRISANE ALGORITME

Abstract - *This paper deals with the optimization of the acoustic properties of samples made of fibrous materials, using biologically inspired algorithms. Samples with a thickness of 10 mm were tested, and the results showed that cotton fibers bonded with polyurethane resin have excellent absorption properties in a wide frequency range. GWO, BW and PUMA were used for optimization. The optimization results showed significant improvements in the acoustic properties of the material, opening up possibilities for further application in sound insulation and other relevant areas.*

Key words: *non-acoustic parameters, porous materials, biologically inspired algorithms*

Rezime - *Ovaj rad se bavi optimizacijom akustičnih svojstava uzoraka napravljenih od vlaknastih materijala, koristeći biološki inspirisane algoritme. Testirani su uzorci debljine 10mm, pri čemu su rezultati pokazali da pamučna vlakna vezana poliuretanskom smolom imaju odlična apsorpciona svojstva u širokom frekvencijskom području. Za optimizaciju su korišćeni GWO, BW i PUMA. Rezultati optimizacije pokazali su značajna poboljšanja u akustičnim svojstvima materijala, otvarajući mogućnosti za dalju primenu u zvučnoj izolaciji i drugim relevantnim oblastima.*

Ključne reči: *akustički impulsni odziv, polarna karakteristika, direktivnost*

Biljana Beljić Durković, Jovan Miočinović

TEHPRO d.o.o., Belgrade, Serbia

CASE STUDY: PREDICTION OF THE EFFECT OF PERFORMED ACOUSTIC INSULATION ON MACHINE PARTS ON REDUCING OCCUPATIONAL NOISE EXPOSURE

STUDIJA SLUČAJA: PREDVIĐANJE EFEKTA IZVEDENE AKUSTIČKE IZOLACIJE NA DELOVIMA MAŠINE NA SMANJENJE IZLOŽENOSTI BUCI NA RADNOM MESTU

Abstract - *In the plastic injection moulding plant, at the operator's position at the machine, the noise was measured in situ before and after acoustic insulation lining of the parts of the machine to determine whether the intervention has an impact on reducing occupational noise exposure. As the work environment is variable (different modes of operation of the machine and other machines in the plant), a model of the contribution of the noise sources to the measured noise was made, and based on the model, the effect of the intervention was predicted.*

Key words: *occupational noise, indoor noise reduction, indoor noise model*

Rezime - *U proizvodnom pogonu brizganja plastike na radnom mestu rukovaoca kod mašine ispitivana je buka in situ pre i posle oblaganja delova mašine radi akustičke izolacije kako bi se ustanovilo da li intervencija ima uticaj na smanjenje nivoa buke u radnoj okolini. Kako je radno okruženje promenljivo (različiti režimi rada mašine i rada drugih mašina u pogonu) napravljen je model doprinosa izvora buke izmerenoj buci i na osnovu modela izvršeno predviđanje efekta intervencije.*

Ključne reči: *buka u radnoj sredini, smanjenje unutrašnje buke, model unutrašnje buke*

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24. 10. 2024.

16:00 – 18:00

Room 7 - Sala 7

2nd SESSION – 2. SEKCIJA

Chairman / *Predsedavajući*:

Momir Praščević, Ph. D.

Emir Ganić[1], Aleksandar Gajicki[2], Bojana Mirković[1], Matija Sindik[1]

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STRATEGIC NOISE MAP FOR BELGRADE NIKOLA TESLA AIRPORT

STRATEŠKA KARTA BUKE ZA AERODROM NIKOLA TESLA BEOGRAD

Abstract - *Environmental noise management is a critical aspect of public health policy, particularly within the European Union, which established Directive 2002/49/EC to standardize noise assessment and mitigation efforts across member states. Serbia has integrated the Directive's provisions through its Law on Environmental Noise Protection and accompanying by-laws. This paper presents the strategic noise mapping process for Belgrade Nikola Tesla Airport, Serbia's largest international airport, marking a significant milestone as it is the first time a strategic noise map is being developed for a major airport in Serbia. The legal framework, methodology, and results of this mapping process are discussed in detail. Utilizing the CNOSSOS-EU:2015 method and the Aviation Environmental Design Tool (AEDT) for acoustic calculations, the study defines the affected areas, noise indicators, and population exposure based on 2023 air traffic data. The analysis also includes the estimated number of residences, schools, hospitals, and people affected by different noise levels, providing necessary data for developing action plans aimed at mitigating noise pollution. Additionally, the study examines the potential health impacts, including population annoyance and sleep disturbance, using dose-effect relationships as defined by the European Commission. The results underline the importance of ongoing noise monitoring and the need for timely revisions of strategic noise maps and action plans to ensure compliance with both national and EU regulations. This research contributes to the broader effort of environmental noise management, offering insights into the methodologies and challenges of strategic noise mapping for airports in Serbia.*

Key words: *environmental noise, noise mapping, airport, noise indicators, aircraft noise, population exposure*

Rezime - *Upravljanje bukom u životnoj sredini je ključni aspekt politike javnog zdravlja, posebno unutar Evropske unije, koja je uspostavila Direktivu 2002/49/EC radi standardizacije procene buke i mera za njeno smanjenje u zemljama članicama. Srbija je integrisala odredbe Direktive kroz Zakon o zaštiti od buke u životnoj sredini i prateće podzakonske akte. Ovaj rad prikazuje process izrade strateške karte buke za Aerodrom Nikola Tesla Beograd, najveći međunarodni aerodrom u Srbiji, što predstavlja značajnu prekretnicu jer se po prvi put razvija strateška karta buke za jedan glavni aerodrom u Srbiji. Pravni okvir, metodologija i rezultati ovog procesa mapiranja su detaljno razmotreni. Korišćenjem metode CNOSSOS-EU:2015 i softverskog alata za akustičke proračune Aviation Environmental Design Tool (AEDT), studija definiše pogođena područja, indikatore buke i izloženost populacije na osnovu podataka o vazdušnom saobraćaju iz 2023. godine. Analiza takođe uključuje procenjeni broj stambenih jedinica, škola, bolnica i ljudi pogođenih različitim nivoima buke, pružajući neophodne podatke za razvoj akcionih planova usmerenih ka smanjenju zagađenja bukom. Pored toga, studija ispituje potencijalne zdravstvene uticaje, uključujući uznemiravanje stanovništva i poremećaje sna, koristeći relacije doza-efekat definisane od strane Evropske komisije. Rezultati naglašavaju važnost kontinuiranog monitoringa buke i potrebe za blagovremenim revizijama strateških karata buke i akcionih planova kako bi se obezbedila usklađenost sa nacionalnim i EU propisima. Ovo istraživanje doprinosi širem naporu upravljanja bukom u životnoj sredini, nudeći uvide u metodologije i izazove strateškog mapiranja buke za aerodrome u Srbiji..*

Ključne reči: *buka u životnoj sredini, mapiranje buke, aerodrom, indikatori buke, buka vazduhoplova, izloženost stanovništva*

Ingrid LeGriffon[1], Elise Ruaud[1], Emir Ganić[2], Tatjana Krstić Simić[2], Bojana Mirković[2], Miguel Baena[3], David Mocholí[3], Marta Alonso[3], Cristina Barrado[4], Jovana Kuljanin[4]

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[3] *Nommon Solutions and Technologies, Madrid, Spain*
[4] *Polytechnic University of Catalonia, Barcelona, Catalunya, Spain*

EVALUATING URBAN AIR MOBILITY NOISE IMPACTS

PROCENA UTICAJA BUKE U OKVIRU URBANE VAZDUŠNE MOBILNOSTI

Abstract - *This research introduces a novel methodology for assessing noise pollution caused by Urban Air Mobility (UAM) activities, with a particular emphasis on how these impacts vary across different population segments, including distinctions by age and gender. This study is conducted within the framework of the Horizon Europe MUSE project (Measuring U-Space Social and Environmental Impact), focusing on the development of a performance framework to evaluate the social and environmental impacts of UAM, with an emphasis on noise. Utilizing an innovative simulation toolset, drone-generated noise is modelled and these data are integrated with dynamic population distribution maps, derived from mobile network data and GPS information. For the illustrative purposes, the toolset has been tested on three case studies based in Madrid: evaluating the noise impact of a drone during its cruise phase over residential and downtown areas, assessing the effects of take-off in a residential neighborhood, and examining the cumulative impacts of multiple drone flights. The findings provide crucial insights into the local environmental impacts of UAM and are expected to inform the development of more targeted U-space regulations and strategies for enhancing social acceptance. The outcomes of this research are anticipated to be valuable to a wide range of stakeholders, including ATM experts, regulators, policymakers, urban planners, health officers, environmental health specialists, authorities of European cities and regions, citizens' associations, and many others.*

Key words: *urban Air Mobility (UAM), drone-generated noise, social acceptance, noise mapping, noise indicators, performance framework*

Rezime - *Ovo istraživanje predlaže novu metodologiju za procenu zagađenja bukom uzrokovanom aktivnostima urbane vazdušne mobilnosti (UAM), sa posebnim naglaskom na to kako ovi uticaji variraju među različitim segmentima populacije, uključujući razlike po starosnoj dobi i polu. Studija se sprovodi u okviru Horizon Europe MUSE projekta (Measuring U-Space Social and Environmental Impact), fokusirajući se na razvoj okvira za procenu performansi socijalnih i ekoloških uticaja UAM, sa naglaskom na buku. Koristeći inovativan alat za simulaciju, modelovana je buka koju proizvode dronovi i ovi podaci su integrisani sa dinamičkim mapama raspodele populacije, koje su dobijene kombinovanjem podataka mobilnih mreža i GPS informacija. U svrhu ilustracije, skup alata je testiran na tri studije slučaja u Madridu: procena uticaja buke drona tokom faze krstarenja iznad stambenih i centralnih gradskih područja, procena efekata poletanja u stambenoj četvrti, i ispitivanje kumulativnih uticaja više letova dronova. Nalazi pružaju ključne uvide u lokalne ekološke uticaje UAM-a i očekuje se da će doprineti razvoju ciljanijih U-space propisa i strategija za unapređenje društvenog prihvatanja. Rezultati ovog istraživanja mogu biti korisni širokom spektru zainteresovanih strana, uključujući stručnjake za upravljanje vazdušnim saobraćajem (ATM), regulatore, donosioce politika, urbaniste, zdravstvene službenike, specijaliste za zaštitu životne sredine, vlasti evropskih gradova i regiona, udruženja građana, i mnoge druge.*

Ključne reči: *urbana vazdušna mobilnost (UAM), buka dronova, društveno prihvatanje, mapiranje buke, indikatori buke, okvir za procenu performansi*

Snežana Jovanović, Milica Ivić Nikolić, Martin Jovanović, Dragan Stojadinović

Technical Test Center, Military Scientific Research Institution of the Serbian Army, Belgrade, Serbia

NOISE REVIEW OF RECONNAISSANCE DRONES

PREGLED BUKE IZVIĐAČKIH DRONOVA

Abstract - *This paper analyzes the sound profiles of three types of small reconnaissance drones at different heights in order to investigate the acoustic detection. Acoustic detectors - drones from the server updats the list of sound profiles of interesting drone. The flight of a drone is always tracked by sound, so it is a reliable parameter for their detection, especially for small reconnaissance aircraft.*

Key words: *drones, noise of drones, exposure to noise, annoying noise, psychoacoustics*

Rezime - *U radu se analiziraju zvučni profili tri tipa malih izviđačkih dronova na različitim visinama u cilju istraživanja akustičke detekcije. Akustički detektori – dronovi sa servera ažuriraju listu zvučnih profila njima interesantnih bespilotnih vazduhoplova. Let drona je uvek praćen zvukom, pa je to i pouzdan parametar za njihovo otkrivanje, naročito kod malih izviđačkih letelica.*

Ključne reči: *dronovi, buka dronova, izloženost buci, uznemiravajuća buka, psihoakustika*

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COMPARATIVE ANALYSIS OF ISO 3744 AND ISO 5305 STANDARDS FOR UAS NOISE MEASUREMENT

UPOREDNA ANALIZA STANDARDA ISO 3744 I ISO 5305 ZA MERENJE BUKE BESPILOTNIH VAZDUHOPLOVA

Abstract - *The rapid development and expansion of Unmanned Aircraft Systems (UAS) necessitate stringent regulatory frameworks to mitigate their environmental and societal impacts, particularly noise pollution. This paper presents a comparative analysis of two key ISO standards – ISO 3744 and ISO 5305 – used for measuring noise emissions from UAS. The study aims to explain the strengths, limitations, and applicability of each standard within the context of the unique acoustic challenges posed by UAS operations. ISO 3744, traditionally applied to various noise sources, provides a general framework for determining sound power levels based on sound pressure measurements. In contrast, the more recent ISO 5305 offers a specialized approach tailored specifically for UAS, taking into account the distinct acoustic profiles and operational contexts of UAS. Through a detailed examination, this paper highlights the differences in measurement methodologies and their respective capacities to address the unique noise characteristics of UAS. The findings underscore the importance of standardization in reducing noise pollution from UAS, which is crucial for minimizing their impact on both the environment and residential communities. The paper concludes with recommendations for the adoption and further refinement of these standards to better serve the needs of industry stakeholders and policymakers.*

Key words: *drones, standardization, noise impact, noise measurement*

Rezime - *Brzi razvoj i širenje sistema bespilotnih vazduhoplova (eng. Unmanned Aircraft Systems, UAS) zahtevaju stroge regulatorne okvire kako bi se ublažili njihovi uticaji na životnu sredinu i društvo, posebno kada je u pitanju zagađenje bukom. Ovaj rad prikazuje uporednu analizu dva ključna ISO standarda—ISO 3744 i ISO 5305—koji se koriste za merenje emisija buke bespilotnih vazduhoplova. Studija ima za cilj da objasni prednosti, ograničenja i primenljivost ovih standarda u kontekstu jedinstvenih akustičnih izazova koje postavljaju operacije bespilotnih vazduhoplova. ISO 3744, koji se tradicionalno primenjuje na različite izvore buke, pruža opšti okvir za određivanje nivoa zvučne snage na osnovu merenja zvučnog pritiska. S druge strane, noviji ISO 5305 nudi specijalizovan pristup prilagođen specifično za bespilotne vazduhoplove, uzimajući u obzir različite akustične profile i operativne kontekste UAS. Kroz detaljno ispitivanje, ovaj rad ističe razlike u metodologijama merenja i njihove sposobnosti da odgovore na jedinstvene karakteristike buke bespilotnih vazduhoplova. Rezultati naglašavaju značaj standardizacije u smanjenju zagađenja bukom od UAS, što je ključno za minimiziranje njihovog uticaja na životnu sredinu i stambene zajednice. Zaključak rada daje preporuke za usvajanje i dalje unapređenje ovih standarda kako bi bolje služili potrebama industrije i donosilaca odluka.*

Ključne reči: *dronovi, standardizacija, uticaj buke, merenje buke*

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METODOLOGY FOR UNCERTAINTY ESTIMATION OF SHORT-TERM TOTAL ENVIRONMENTAL NOISE MEASUREMENTS

METODOLOGIJA ZA PROCENU NESIGURNOSTI KRATKOTRAJNIH MERENJA BUKE U ŽIVOTNOJ SREDINI

Abstract - *The third edition of ISO 1996 series describes the methods for measuring and assessing environmental noise from different noise source types (road, rail and air traffic and industrial plants). Additionally, these standards provide guidelines for assessing the uncertainty of short-term and long-term environmental noise measurements, considering the impact of various sources of uncertainty. The procedure described for assessing measurement uncertainty refers to the specific noise of individual noise sources (road, rail and air traffic and industrial plants) and cannot be directly applied when considering the total noise contributed by multiple, diverse, near and far sources in each situation at a specific time, along with the corresponding measurement uncertainty. The limit values of the noise indicators specified by the Serbian regulations refer to the total noise, so it is necessary to determine the noise indicators for the total noise to assess environmental noise in each situation and at a given time. Although Serbian legislation does not require the use of measurement uncertainty in environmental noise assessments, the uncertainty must be determined and reported in the measurement report according to the requirements of the third edition of ISO 1996 series. This paper aims to provide a detailed procedure for assessing the uncertainty of total environmental noise measurements for individual noise in the context of Serbian legislation and the third edition of ISO 1996 series. The presented procedure can also be applied in other countries where noise limit values refer to total noise.*

Key words: *environmental noise measurement, short-term measurement, measurement uncertainty*

Rezime - *Treće izdanje serije ISO 1996 opisuje metode za merenje i ocenu buke u životnoj sredini koja potiče iz različitih tipova izvora buke (drumski, železnički i vazdušni saobraćaj i industrijska postrojenja). Pored toga, ovi standardi daju smernice za procenu nesigurnosti kratkotrajnih i dugotrajnih merenja buke u životnoj sredini, s obzirom na uticaj različitih izvora nesigurnosti. Opisani postupak za procenu merne nesigurnosti se odnosi na specifičnu buku pojedinačnih izvora buke (drumski, železnički i vazdušni saobraćaj i industrijska postrojenja) i ne može se direktno primeniti kada se razmatra ukupna buka kojoj doprinose višestruki, različiti, bliski i daleki izvori u svakoj situaciji u određeno vreme, zajedno sa odgovarajućom mernom nesigurnošću. Granične vrednosti indikatora buke propisane propisima Srbije se odnose na ukupnu buku, pa je za ocenu buke u životnoj sredini u svakoj situaciji i u datom trenutku neophodno odrediti indikatore buke za ukupnu buku. Iako srpsko zakonodavstvo ne zahteva korišćenje merne nesigurnosti u oceni buke u životnoj sredini, nesigurnost se mora utvrditi i dati u izveštaju o merenju u skladu sa zahtevima trećeg izdanja serije ISO 1996. Ovaj rad ima za cilj da prikaže detaljan postupak za procenu nesigurnosti merenja ukupne buke u životnoj sredini za pojedinačnu buku u kontekstu srpskog zakonodavstva i trećeg izdanja serije ISO 1996. Prikazani postupak može se primeniti i u drugim zemljama gde se granične vrednosti buke odnose na ukupnu buku.*

Ključne reči: *merenje buke u životnoj sredini, kratkotrajna merenja, merna nesigurnost*

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APPLICATION OF INDICATORS IN NOISE CONTROL

PRIMENA INDIKATORA U KONTROLI BUKE

Abstract - *Indicators provide a foundational basis for offering essential data and describing changes in the environment at national, regional, or local levels. An indicator created to highlight the cause of change, the consequences of changes, the state of the environment, or the significance of implementing protective measures may be considered relevant for research. An adopted indicator, as part of the National List of Indicators, forms the basis for developing strategies, creating national policies, and establishing legal norms. Serbia's National List of Environmental Indicators includes two noise indicators, which belong to the sixth thematic section and are classified as indicators of state. The overall noise indicator, designated as 6.40 and part of the sixth thematic section entitled "State", describes noise disturbance over a 24-hour period, including the day-evening-night segments. According to the regulation, the day period lasts from 6 AM to 6 PM, the evening period from 6 PM to 10 PM, and the night period from 10 PM to 6 AM. The night noise indicator, also under the "State" category, with the designation 6.41, specifically describes noise disturbance during the night period (10 PM to 6 AM). This paper analyzes the use of indicators in noise control at both local and national levels. The use of indicators in noise control is a significant prerequisite for systematically and internationally accepted determination of the state of the environment, and for creating conditions to compare noise level values on an international level. Indicators are based on highly reliable data, which must be monitored in accordance with statistical correctness and internationally recognized methodology. The value of these indicators, published in the Report on the State of the Environment, becomes publicly available and is subject to comparative analysis.*

Key words: *indicators, control, measurement range, environment*

Rezime - *Indikatori predstavljaju početnu osnovu za pružanje osnovnih podataka i opisivanje promena u životnoj sredini, na nacionalnom, regionalnom ili lokalnom nivou. Indikator kreiran da ukazuje na uzrok promene, posledice promena, stanje životne sredine ili značaj primene zaštitnih mera, može da se smatra relevantnim za istraživanja. Usvojen indikator, kao deo Nacionalne liste indikatora, predstavlja osnovu za izradu strategija, kreiranje nacionalne politike i donošenje zakonskih normativa. Nacionalna lista indikatora životne sredine Srbije sadrži dva indikatora buke, koji pripadaju šestoj tematskoj celini i klasifikovani su u indikatore stanja. Ukupni indikator buke, kao deo šeste tematske celine, ima oznaku 6.40 i pripada tematskom području "Stanje". Po definiciji iz pomenutog pravilnika opisuje ometanje bukom za vremenski period od 24h, za dan-veče-noć. Period koji se odnosi na dan traje od 6-18h, veče je u terminu od 18-22h, dok se noćni termin računa od 22-6h. Indikator noćne buke pripada istoj tematskoj celini i indikatorima „stanja", ali nosi oznaku 6.41. Prema definiciji iz pomenutog pravilnika opisuje ometanje bukom u toku noći, odnosno u terminu od 22-6h. U radu je izvršena analiza primene indikatora u kontroli buke, na lokalnom i nacionalnom nivou. Primena indikatora u kontroli buke predstavlja značajan preduslov da se na sistematski i međunarodno prihvatljiv način utvrdi stanje i stvore uslovi za poređenje vrednosti nivoa buke na međunarodnom nivou. Indikatori se baziraju na podacima visokog nivoa pouzdanosti, koje treba pratiti u skladu s statističkom ispravnošću i međunarodno priznatom metodologijom. Vrednost indikatora, objavljena u Izveštaju o stanju životne sredine, postaje javno dostupna i predmet uporednih analiza.*

Ključne reči: *indikatori, kontrola, opseg merenja, životna sredina*

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ENVIRONMENTAL NOISE IN VICINITY OF THE BREWERY - A CASE STUDY

BUKA U ŽIVOTNOJ SREDINI U BLIZINI PIVARE – STUDIJA SLUČAJA

Abstract - *Industrial plants can noticeably affect environmental noise pollution. In addition to the noise generated by industrial processes, vehicles used for transporting raw materials and finished products represent a significant noise source. As production capacity increases, particularly in the case of modern factories developed from traditional family manufactories, the problem becomes more pronounced within existing infrastructure. This paper specifically analyzes environmental noise in the immediate vicinity of the brewery, located in the central part of one city in Serbia. Through analysis of noise monitoring results, certain machines and processes within the brewery that significantly impact environmental noise indicator's values were identified. Accordingly, recommendations were provided for implementing appropriate measures within the brewery aimed at enhancing acoustic comfort in the surrounding environment near the brewery. Environmental noise measurements were repeated after the acoustic treatment of the dominant noise source in the brewery, after which the effect of the measures taken in terms of reducing the noise levels in the immediate vicinity of the source was examined.*

Key words: *industrial noise, environmental noise monitoring, environmental noise, indicators, environmental noise limit values*

Rezime - *Industrijska postrojenja mogu primetno da utiču na zagađenje životne sredine bukom. Pored buke industrijskih procesa, značajan izvor buke predstavljaju i vozila za transport sirovina i gotovih proizvoda. U postojećoj infrastrukturi, problem postaje veći sa povećanjem proizvodnih kapaciteta, naročito u slučaju modernih fabrika koje se razvijaju na osnovama tradicionalnih porodičnih manufaktura. Rad se upravo odnosi na analizu stanja buke u životnoj sredini u neposrednoj blizini pivare koja se nalazi u centralnom delu jednog grada u Srbiji. Na osnovu analize rezultata monitoringa buke, izvršena je identifikacija pojedinih mašina i procesa u pivari koji bitno utiču na vrednosti indikatora buke u životnoj sredini. U tom smislu su date preporuke za preduzimanje odgovarajućih mera u pivari, koje bi doprinele poboljšanju akustičkog komfora u životnoj sredini u neposrednoj okolini pivare. Merenja buke u životnoj sredini su ponovljena nakon akustičkog tretmana dominantnog izvora buke u pivari, nakon čega je ispitan efekat preduzetih mera u smislu redukcije nivoa buke u neposrednoj okolini izvora.*

Ključne reči: *industrijska buka, monitoring buke u životnoj sredini, indikatori buke u životnoj sredini, granične vrednosti buke u životnoj sredini*

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NOISE LEVEL MEASUREMENTS OF ROAD TRAFFIC AT DIFFERENT HEIGHTS IN RELATION TO THE NOISE SOURCE

MERENJE NIVOA BUKE DRUMSKOG SAOBRAĆAJA NA RAZLIČITIM VISINAMA U ODNOSU NA IZVOR BUKE

Abstract - *The paper provides an analysis of the results of noise levels originating from road traffic measured at different heights on the example of an eighteen-storey solitaire in the Dušanovac, which is located along the city road Bulevar Franše d'Eperea in Belgrade (the former section of the E-75 Belgrade-Niš highway). Measurements were made simultaneously at three measuring points, on the second, tenth and eighteenth (last floor) of the solitaire.*

Key words: *noise, road traffic, heights, levels*

Rezime - *U radu je predstavljena analiza rezultata merenja nivoa buke sa gradske saobraćajnice na različitim visana, na primeru osamnaestospratnice u naselju Dušanovac, koji se nalazi duž gradske saobraćajnice Bulevar Franše d'Eperea u Beogradu (bivša deonica auto-puta E-75 Beograd-Niš). Merenja su urađena istovremeno na tri merna mesta, na II, X i XVIII (poslednji sprat) spratovima solitera.*

Ključne reči: *buka, drumski saobraćaj, visina, nivo*

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MEASUREMENT OF NOISE LEVELS IN THE ENVIRONMENT AROUND THE „STANARI“ MINE

MERENJE NIVOA BUKE U ŽIVOTNOJ SREDINI U OKOLINI RUDNIKA „STANARI“

Abstract - *Sound is an integral part of every person's life. However, in some situations, sound in the form of noise can be a nuisance or threaten the normal functioning of a person. Noise is defined as any unwanted sound, which has physical characteristics but also harmful psychophysical effects and influences. Noise in humans causes a subjective feeling of discomfort in the form of a nuisance, disturbance and endangerment. There are various workplaces where noise is present as a harmful factor in the working environment (industrial noise), and which leads to hearing damage due to long-term exposure to it. For this reason, it is necessary to focus on prevention in the form of using personal protective equipment and regular measurement of the noise level in the working environment. In the continuation of the work, the results of the measurement of the noise level in the environment in the vicinity of the „Stanari“ mine were listed. The goal of measuring the noise level is to obtain results on the possible impact of the noise generated in the mine on residential buildings and the population living in the vicinity.*

Key words: *noise, noise measurement, mine „Stanari“, environment*

Rezime - *Zvuk je sastavni deo života svakog čoveka, međutim,u nekim situacijama zvuk u vidu buke može da predstavlja smetnju ili da ugrožava normalnno funkcionisanje čoveka. Buka se definiše kao svaki neželjeni zvuk, koji poseduje fizičke karakteristike ali i štetna psihofizička dejstva i uticaje. Buka kod čoveka izaziva subjektivni osećaj neprijatnosti u vidu smetnje, uznemiravanja i ugrožavanja. Postoje različita radna mesta gde je buka prisutna kao štetni faktor radne sredine (industrijska buka), i koja dovodi usled dugotrajne ekspozicije istoj do oštećenja sluha. Iz tog razloga potrebno je fokusirati se na prevenciju u vidu korišćenja lične zaštitne opreme i redovnog merenja nivoa buke u radnoj sredini. U nastavku rada predstavljeni su rezultati merenja nivoa buke u životnoj sredini u okolini rudnika „Stanari“. Cilj merenja nivoa buke jeste dobijanje rezultata o mogućem uticaju buke koja nastaje u okolini rudnika, na stambene objekte i stanovništvo koje stanuje u okolini.*

Key words: *buka, merenje buke, rudnik “Stanari”, životna sredina*

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EXAMINATION OF THE NOISE LEVEL IN THE ENVIRONMENT IN THE AREA OF THE STANARI MUNICIPALITY THERMAL POWER PLANT

ISPITIVANJE NIVOA BUKE U ŽIVOTNOJ SREDINI U OPŠTINI STANARI U OKOLINI TERMOELEKTRANE

Abstract - *Noise is described as sound without an acceptable musical quality or as an undesirable sound. Exposure to noise can lead to hearing damage, it can affect speech communication, which causes a weakening of a person's attention. Also, noise can cause a decrease in the volume and efficiency of work, as well as the appearance of fatigue in people. The paper itself presents the results of the noise level examination in the environment in the vicinity of the Stanari municipality thermal power plant. The goal of the noise level examination is to obtain results on the possible impact of the total noise during the operation of the power plant, on residential buildings and the population living in the vicinity of the Stanari municipality thermal power plant.*

Key words: *noise; noise measurement; thermal power plant; environment*

Rezime - *Buka se opisuje kao zvuk bez prihvatljivog muzičkog kvaliteta ili kao nepoželjan zvuk. Izlaganje buci može dovesti do oštećenja sluha, može uticati na govornu komunikaciju što prouzrokuje slabljenje pažnje čoveka. Takođe, buka može da izazove pad obima i efikasnost rada, kao i pojavu umora i zamora kod ljudi. U samom radu predstavljeni su rezultati ispitivanja nivoa buke u životnoj sredini u okolini termoelektrane, u opštini Stanari. Cilj ispitivanja nivoa buke jeste dobijanje rezultata o mogućem uticaju ukupne buke u toku rada elektrane na stambene objekte i stanovništvo koje boravi u okolini termoelektrane „Stanari“.*

Ključne reči: *merenje buke, termoelektrana, životna sredina*

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MEASURING THE NOISE LEVEL OF MUNICIPAL VEHICLES DURING WASTE DISPOSAL AT THE NIŠ LANDFILL

MERENJE NIVOA BUKE KOMUNALNIH RADNIH MAŠINA PRILIKOM DEPONOVANJA OTPADA NA NIŠKOJ DEPONIJI

Abstract - *The main sources of noise that are encountered daily in the human environment include: sources of noise in open spaces, and sources of noise in closed spaces. One of the divisions of noise sources in the open space is traffic (road), machines and vehicles for communal maintenance. When providing the services of the Public Utility Company "Mediana" Niš, and performing the basic activities of collecting, transporting and depositing waste road traffic is the dominant source of noise. o Outdated utility equipment within the existing transport infrastructure creates an environment where noise is a potential problem. The paper presents measurements of the daily noise level caused by the use of machinery at the location of the "Bubanj" landfill, Niš. The results obtained in this work showed a higher degree of reliability. The program is used to monitor the noise level, an indicator that describes the disturbance by noise for a period of 24 hours, for day-evening-night, at measuring points M1, M2 and M3, with a relatively constant flow of vehicles throughout the day, at the landfill (Environmental Noise Monitoring Program in the city landfill). The conclusion is reached that the noise level in the measuring points does not exceed the limit values of noise in the environment, and that there is no impact on the safe and healthy work of the employee.*

Key words: *landfill, communal equipment, noise source, sound pressure*

Rezime - *Glavni izvori buke koji se svakodnevno sreću u čovekovom okruženju, uključuju: izvore buke na otvorenom prostoru, i izvore buke u zatvorenom prostoru. Jedna od podela izvora buke na otvorenom prostoru jeste saobraćaj (drumski), mašine i radne mašine za komunalno održavanje. Prilikom pružanja usluge Javnog komunalnog preduzeća "Mediana" Niš i obavljanja osnovne delatnosti sakupljanja, transporta i deponovanja otpada, drumski saobraćaj je dominantni izvor buke. Zastarela komunalna oprema u okviru postojeće transportne infrastrukture stvara okruženje u kojem buka predstavlja potencijalni problem. U radu su prikazana merenja dnevnog nivoa buke koja nastaje upotrebom mašina, na lokaciji deponija "Bubanj", Niš. Rezultati dobijeni u ovom radu pokazali su viši stepen pouzdanosti. Program se koristi za praćenje nivoa buke kao indikator koji opisuje ometanje bukom za vremenski period od 24 časa, za dan-veče-noć, na tačkastim izvorima M1, M2 i M3, sa relativno stalnim protokom vozila tokom celog dana, na deponiji (Program monitoringa buke u životnoj sredini na gradskoj deponiji). Dolazi se do zaključka da nivoi buke u mernim tačkama ne prelaze granične vrednosti buke u životnoj sredini i da nema uticaja na bezbedan i zdrav rad zaposlenog.*

Ključne reči: *deponija, komunalna oprema, izvor buke, zvučni pritisak*

Jovan Miočinović

TEHPRO d.o.o., Belgrade, Serbia

CASE STUDY: PREDICTION OF THE EFFECT OF PERFORMED ACOUSTIC INSULATION ON MACHINE PARTS ON REDUCING OCCUPATIONAL NOISE EXPOSURE

PREDLOG PRAVILA ZA VREDNOVANJE IZLOŽENOSTI INDUSTRIJSKOJ IMPULSIVNOJ BUCI U POGLEDU RIZIKA OD OŠTEĆENJA SLUHA

Abstract - *Since publishing of ISO 1999:2013 and ISO 9612:2009, core standards for determination of occupational noise exposure, in rating noise levels in workplace the corrections for noise types that until then considered possible additional damaging effects of noise uneven in time and frequency domain are being omitted. Recent literature as well as models of the effect of noise on hearing indicate a particularly damaging effect of impulsive noise. At the same time, regulations require considering the type of noise, including exposure to impulse noise. Here a proposal of the rule for rating is given that would reduce the risk of hearing damage due to disregarding the impulsive character of noise.*

Key words: *industrial noise, impulsive noise, rating levels*

Rezime - *Od stupanja na snagu standarda ISO 1999:2013 i ISO 9612:2009 koji su u osnovi postupka određivanja izloženosti buci u radnoj okolini iz postupka vrednovanja izloženosti buci na radnom mestu pri određivanju merodavnih nivoa izostavljene su korekcije za tipove buke koje su do tada uzimale u obzir moguće dodatne oštećujuće efekte vremenski i frekventno neujednačene buke. Novija literatura, kao i modeli delovanja buke na sluh, ukazuju na posebno oštećujuće dejstvo impulsivne buke. Istovremeno, propisi nalažu uzimanje u obzir vrstu buke uključujući izloženost impulsnoj buci. Ovde je dat predlog pravila vrednovanja primenom kojeg bi se smanjio rizik od oštećenja sluha zanemarivanjem impulsnog karaktera buke.*

Ključne reči: *industrijska buka, impulsna buka, merodavni nivo*

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25. 10. 2024.

10:00 – 12:00

Room 7 - Sala 7

3rd SESSION – 3. SEKCIJA

Chairman / *Predsedavajući*:

Nicolae Herisanu, Ph. D.

Nicolae Herisanu[1,2], Bogdan Marinca[1], Vasile Marinca[1,2]

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NONLINEAR VIBRATION OF A BEAM SUBJECTED TO MECHANICAL IMPACT AND WINKLER-PASTERNAK FOUNDATION

NELINEARNE VIBRACIJE GREDE USLED DEJSTVA MEHANIČKOG UDARA I WINKLER-PASTERNAKOVOG OSLONCA

Abstract - *The simultaneous effects of mechanical impact and Winkler-Pasternak foundation on dynamic response of a Euler-Bernoulli beam are studied. By means of Galerkin-Bubnov procedure, the governing equation with partial derivatives is reduced to an ordinary differential equation. This nonlinear equation is solved by mens of Optimal Homotpy Asymptotic Method (OHAM).*

Key words: *nonlinear vibration, OHAM, mechanical impact, Winkler-Pasternak foundation*

Rezime - *Proučavani su istovremeni efekti mehaničkog udara i Winkler-Pasternakovog oslonca na dinamički odgovor Euler-Bernoullijeve grede. Osnovna jednačina sa parcijalnim izvodima je redukovana na običnu diferencijalnu jednačinu pomoću Galerkin-Bubnov postupka. Ova nelinearna jednačina je rešena metodom optimalne homotopijske asimptotske metode (OHAM).*

Ključne reči: *nelinearne vibracije, OHAM, mehanički udar, Winkler-Pasternakov oslonac*

Bogdan Marinca[1], Nicolae Herisanu[1,2], Vasile Marinca[1,2]

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DYNAMIC ANALYSIS OF A NANOBEAM UNDER THE INFLUENCE OF AN ELECTROMAGNETIC ACTUATOR AND A MECHANICAL IMPACT

DINAMIČKA ANALIZA NANOGREDE POD UTICAJEM ELEKTROMAGNETNOG AKTUATORA I MEHANIČKOG UDARA

Abstract - *The Optimal Auxiliary Functions Method (OAFM) is applied in the study of nonlinear vibration of a nanobeam, considering the curvature of the beam, the presence of an electromagnetic actuator and a mechanical impact. Our procedure is based on the existence of some auxiliary functions which assure a fast convergence of the approximate solution. The convergence-control parameters present in the auxiliary functions are evaluated by rigorous mathematical procedures.*

Key words: *OAFM, electromagnetic actuator, mechanical impact, nonlinear forced vibration*

Rezime - *Metoda optimalnih pomoćnih funkcija (OAFM) se primenjuje u proučavanju nelinearnih vibracija nanogrede, uzimajući u obzir zakrivljenost grede, prisustvo elektromagnetnog aktuatora i mehaničkog udara. Naš postupak se zasniva na postojanju određenih pomoćnih funkcija koje obezbeđuju brzu konvergenciju aproksimativnog rešenja. Parametri za kontrolu konvergencije prisutni u pomoćnim funkcijama se procenjuju rigoroznim matematičkim postupcima.*

Ključne reči: *OAFM, elektromagnetni actuator, mehanički udar, nelinearne prinudne vibracije*

Milena Mančić[1], Dragan Jovanović[2], Miomir Raos[1], Marko Mančić[2]

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VIBRATIONS MEASUREMENTS IN INDUSTRIAL PLANTS AND THEIR INFLUENCE ON MACHINES

MERENJE VIBRACIJA U INDUSTRIJSKIM POSTROJENJIMA I NJIHOV UTICAJ NA MAŠINE

Abstract - *In the field of industrial machinery condition monitoring, vibration analysis is a vital technique that helps engineers and maintenance specialists identify possible problems in intricate systems before they become expensive failures. Ensuring the best performance and longevity of industrial gear is crucial, especially in sectors that largely depend on intricate machinery. The proper selection and application of measurement tools and methodologies is one of the most important components of an efficient vibration analysis. This research analyzes the impact of vibrations on the performance of two distinct machines, as well as the different methods employed by the machine manufacturers in interpreting the vibration measurements.*

Key words: *Vibration measurements, industrial machines, vibration impact*

Rezime - *U oblasti praćenja stanja industrijskih mašina, analiza vibracija je značajna tehnika koja pomaže inženjerima i stručnjacima za održavanje, da identifikuju moguće probleme u složenim sistemima pre nego što dodje do velikih oštećenja i troškova. Obezbeđivanje najboljih performansi i dugovečnosti industrijske opreme je ključno, posebno u sektorima koji u velikoj meri zavise od složenih mašina. Odgovarajući izbor i primena mernih alata i metodologija je jedna od najvažnijih komponenti efikasne analize vibracija. Ovo istraživanje analizira uticaj vibracija na performanse dve različite mašine, kao i različite metode koje koriste proizvođači mašina u tumačenju merenja vibracija.*

Ključne reči: *merenja vibracija, industrijske mašine, uticaj vibracija*

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ADVANTAGES AND DISADVANTAGES OF VECTOR SENSORS COMPARED TO CLASSICAL ACOUSTIC SENSORS AND ACOUSTIC ANTENNAS

PREDNOSTI I NEDOSTACI VEKTORSKIH SENZORA U ODNOSU NA KLASIČNE AKUSTIČKE SENZORE I AKUSTIČKE ANTENE

Abstract - *The report examines the characteristics, advantages and disadvantages of vector acoustic sensors used in recent years in civil and military information systems for detection, localization and classification of various types of targets and noise sources with high dynamics of emitted signals. A comparison with classical acoustic sensors and discrete acoustic antennas is given. Conclusions and recommendations are made. They are based on a review of publications and experiments.*

Key words: *acoustic sensors, weapon systems, battlefield detection*

Rezime - *U radu se ispituju karakteristike, prednosti i nedostaci vektorskih akustičkih senzora koji se poslednjih godina koriste u civilnim i vojnim informacionim sistemima za detekciju, lokalizaciju i klasifikaciju različitih tipova ciljeva i izvora buke sa visokom dinamikom emitovanih signala. Dato je poređenje sa klasičnim akustičnim senzorima i diskretnim akustičnim antenama. Donose se zaključci i preporuke koji su zasnovani na pregledu publikacija i eksperimenata.*

Ključne reči: *akustički senzori, sistemi naoružanja, detekcija na bojnom polju*

Mladena Lukić[1], Katarina Đorđević[2], Žarko Ćojbašić[3], Dragan Markushev[4]

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SENSING WITH SOUND: FURTHERING GASES AND SOLID ANALYSIS BY PHOTOACOUSTIC SPECTROSCOPY

DETEKTOVANJE ZVUKOM: UNAPREĐENJE ANALIZE GASOVA I ČVRSTIH MATERIJALA FOTOAKUSTIČKOM SPEKTROSKOPIJOM

Abstract - *The development of photoacoustic spectroscopy is being driven by the growing demand for precise, efficient, and reliable detection methods that can be used for in situ measurements and real-time monitoring. Along with rapid technological progresses, photoacoustic spectroscopy became ultra-sensitive, selective, cost-effective technique that can meet the demanding requirements for environmental monitoring, industrial safety, and medical diagnostics. This paper highlights how continuous improvements in photoacoustic technologies, including the use of appropriate laser sources as well as sensing elements, and machine learning methods, are pushing the limits of gases and solid analysis and, providing critical tools for addressing modern scientific and industrial challenges.*

Key words: *photoacoustic spectroscopy, trace gases analysis, material characterization, photoacoustic imaging, machine learning.*

Rezime - *Rastuća potreba za preciznim, efikasnim i pouzdanim tehnikama detekcije, koje omogućavaju merenja na terenu i u realnom vremenu, podstakla je razvoj fotoakustičke spektroskopije. Zahvaljujući ubrzanom razvoju tehnologije, fotoakustička spektroskopija je postala visoko osetljiva, selektivna i efikasna tehnika, koja ispunjava stroge zahteve u oblastima: monitoringa životne sredine, zaštite na radu i medicinske dijagnostike. U radu je istaknuto, kako kontinuirana poboljšanja metoda fotoakustičke spektroskopije, uključujući upotrebu odgovarajućih laserskih izvora, senzora i metoda mašinskog učenja, pomeraju granice analize gasova i čvrstih materijala, pružajući ključne alate za suočavanje sa savremenim izazovima u nauci i industriji.*

Ključne reči: *fotoakustička spektroskopija, analiza gasova u tragovima, karakterizacija materijala, fotoakustičko snimanje, mašinsko učenje*

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ENSURING AN ACOUSTICALLY UNPOLLUTED LIVING ENVIRONMENT

OBEZBEĐIVANJE AKUSTIČKI NEZAGAĐENE ŽIVOTNE SREDINE

Abstract - *Human beings are always concerned with living in an unpolluted environment. One of the pollutions that can occur is noise pollution. In order to manage this pollution, the acoustic behavior of the environment is investigated. This is done through periodic measurements, identifying the sources of pollution at the same time. Based on the measurements made, the way in which the environment is affected is assessed. Based on this, pollution reduction measures are established. The paper presents research undertaken by authors in this field. The way of working, the implementation of measurements, the establishment of reduction methods, and their efficiency are detailed.*

Key words: *environmental pollution, noise reduction*

Rezime - *Ljudi su uvek zainteresovani za život u nezagađenoj životnoj sredini. Jedno od zagađenja koje može nastati je zagađenje bukom. Da bi se upravljalo ovim zagađenjem, istražuje se akustičko ponašanje životne sredine. Ovo se radi kroz periodična merenja, istovremeno identifikujući izvore zagađenja. Na osnovu izvršenih merenja se procenjuje stepen uticaja buke na životnu sredinu. Na osnovu toga se utvrđuju mere za smanjenje zagađenja. U radu su prikazana istraživanja autora u ovoj oblasti. Detaljno je opisan način rada, sprovođenje merenja, uspostavljanje metoda redukcije i njihova efikasnost.*

Ključne reči: *zagađenje životne sredine, smanjenje buke*

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A STUDY OF THE HEARING HEALTH OF AMBULANCE DRIVERS

PROUČAVANJE SLUHA VOZAČA VOZILA HITNE POMOĆI

Abstract - *Partial hearing loss has been reported among ambulance workers (doctors, paramedics and drivers) caused by the noise produced by car sirens. The noise levels inside the ambulance (the driver's cabin and the inside of the car, where the patient is placed) were analyzed. This study was conducted over a period of 15 months (February 2023 – April 2024) and on 18 drivers aged 32-61. During the use of sirens, the average noise level in the driver's cabin is 105-111 dB, and inside the ambulance it is 99-102 dB. These values far exceed legal limits; for the ambulance drivers, by the fact that they work 8h+, but also for the transported patients, who, in addition to being sick, are forced to endure particularly loud noise. Following the audiograms performed by the drivers under study, it was found that their average hearing thresholds decreased by 8-15 dB (compared to drivers driving cars without sirens).*

Key words: *siren noise, ambulance drivers, hearing loss*

Rezime - *Prijavljen je delimičan gubitak sluha među zaposlenima u hitnoj pomoći (lekarima, medicinskim tehničarima i vozačima) uzrokovan bukom koju proizvode sirene vozila. Nivoi buke unutar vozila hitne pomoći (vozačeva kabina i unutrašnjost gde se nalazi pacijent) su analizirani. Ova studija je sprovedena tokom perioda od 15 meseci (februar 2023 – april 2024) i obuhvatila je 18 vozača starosti između 32 i 61 godine. Tokom korišćenja sirena, prosečan nivo buke u vozačevoj kabini iznosi između 105 i 111 dB, dok je unutar sam vozila između 99 i 102 dB. Ove vrednosti znatno premašuju granične vrednosti; kako za vozače hitne pomoći, koji rade više od 8 sati dnevno, tako i za pacijente, koji pored svojih zdravstvenih problema moraju da trpe izuzetno visoke nivoe buke. Na osnovu audiograma urađenih na vozačima obuhvaćenim studijom, utvrđeno je da se njihovi prosečni pragovi sluha smanjuju za 8-15 dB (u poređenju sa vozačima koji voze vozila bez sirena).*

Ključne reči: *buka sirene, vozači u hitnoj pomoći, gubitak sluha*

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APPLICATION OF ULTRASOUND IN DIFFERENT PURPORSES WITH EXAMPLES

UPOTREBA ULTRAZVUKA U RAZLIČITE SVRHE SA PRIMERIMA

Abstract - *In the last decade application of ultrasound is increasing. Reason of that is because huge range of frequency can be used in different purposes. Different scientific field describe ultrasound in its own way, and looking from engineering point of view use of ultrasound is quite interesting. Topic of this paper is to give review how ultrasound can be used in the field of diagnostics and in the field of welding with some practical examples. Also, during this research dependency between measured echo of ultrasound wave and depth of founded irregularity is given.*

Key words: *ultrasound, ultrasound diagnostics, ultrasound welding, echo, depth, wires and welded joint*

Rezime - *U poslednjoj deceniji upotreba ultrazvuka je sve veća. Razlog tome je taj što širok opseg frekvencija može da se koristi u različite svrhe. Različite naučne oblasti opisuju ultrazvuk na sebi svojstven načинин, posmatrajući sa inženjerske tačke gledišta upotreba ultrazvuka je izuzetno zanimljiva. Tema ovog rada je da se pokaže kako ultrazvuk može da se koristi u oblasti dijagnostike i u oblasti zavarivanja sa prikazom praktičnih primera. Takođe, tokom ovog istraživanja zavisnost između izmerenog eha ultrazvučnog talasa i dubine detektovane nepravilnosti je prikazana.*

Ključne reči: *ultrazvuk, ultrazvučna dijagnostika, ultrazvučno zavarivanje, eho, dubina, provodnici i zavareni spojevi*

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VIBRATION PHENOMENA INDUCED BY PULSED LASER HEATING OF MICROMECHANICAL STRUCTURES

VIBRACIONI FENOMENI INDUKOVANI IMPULSNIM LASERSKIM ZAGREVANJEM MIKRO-MEHANICKIH STRUKTURA

Abstract - *Illumination generated vibrational phenomena could significantly affect the mechanical behavior of micro-mechanical structures (MEMS) and consequently to performance of pressure detectors based on that sensors. In this paper, we study evolution of thermoelastic deflection induced by pulsed laser heating of solid micro-mechanical structures. An analytical-numerical technique based on Laplace transform is used to calculate the vibration deflection. The results indicated that the laser-induced vibration is scale-dependent: as the sample thickness decreases, the peak deflection increases indicating possibility of size-dependent engineering of properties of pressure detectors that used micromechanical structures.*

Key words: *vibration, micro-mechanical structures, pulsed laser, deflection*

Rezime - *Vibracioni fenomeni koje generiše osvetljavanje mikro-mehaničkih struktura mogu značajno da utiču na njihovo mehaničko ponašanje a zbog toga i na performance detektora pritiska baziranih na ovim strukturama. U ovom radu, mi proučavamo vremensksu zavisnost termoelastične defleksije indukavane impulsnim laserskim zagrevanjem mikro-mehaničkih struktura. Za izračunavanje vibracione defleksije su korišćene analitičko-numeričke tehnike zasnovane na Laplasovoj transformaciji. Dobijeni rezultati pokazuju da laserski indukovane vibracije zavise od dimenzija uzorka: defleksioni pik raste kada se debljina uzorka smanjuje. Ovo ukazuje na mogućnost inženjeringa osobina detektora pritiska zasnovanih na mikro-mehaničkim strukturama jednostavnom promenom dimenzija strukture.*

Ključne reči: *vibracije, mikro-mehaničke strukture, impulsni laser, defleksija*

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