# L I S T A  D E  L U C R Ă R I

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1⁰ Tezele de doctorat

T1. *Contributions to the investigation of the dynamic behavior of the geared systems transmissions,* Co-direction: University POLITEHNICA of Bucharest and Auburn University, USA, Bucharest, October **2004**, Thesis in Mechanical Vibrations & Acoustics, Scientific Directors: Prof. Dr. Eng. Nicolae ENESCU( member of Romanian Academy of Technical Sciences), Prof. Dr. Eng. Malcolm CROCKER ( professor emeritus and executive director of The International Institute of Acoustics and Vibrations).With award MAGNA CUM LAUDE.

T2. *Contribuţii la studiul vibraţiilor parametrice al plăcilor plane subţiri*, Universitatea POLITEHNICA Bucureşti, Iulie **1997**, Conducător Ştiinţific: Acad. Radu P. VOINEA.

2⁰ Cărţi publicate (Ca, Cb, Cc), îndrumare publicate(I1, I2 etc.), capitole publicate în volume colective, capitole teoretice redactate, sisteme de laborator funcţionale etc. (D1, D2 etc.), după caz, prin care se aduc contribuţii la asigurarea şi perfecţionarea activităţilor didactice/profesionale.

Ca1. **Bugaru, M.** Mecanică Tehnică, Editura Bren, (CNCSIS,26), Bucureşti, ISBN 978-606-610-277-3, pg. 329, **2022.**
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Ca3. **Bugaru, M.,** Enescu, N. *MECANICA cu Aplicaţii în Inginerie,* Editura PRINTECH (recunoscută CNCSIS,137), Bucureşti, ISBN 973-718-325-8, 316 pg., 2005.
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Ca6. Simion, Fl. P., **Bugaru, M.,** ş.a., *Aplicaţii ale Mecanicii în Inginerie,* Editura PRINTECH(recunoscută CNCSIS,137),, Bucureşti, 302 pg., ISBN-973-98652-8-3, 1998.

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Cb3. Motomancea, A., **Bugaru, M.,** *Ordine şi Haos în Lagăre de alunecare,* Editura BREN(CNCSIS,26), Bucureşti, 165 pg., ISBN-973-99604-0-5, 2000.
Cb4. **Bugaru, M.,** Predoi, M.V. *Vibraţiile plăcilor plane rectangulare subţiri excitate parametric*, Editura BREN(recunoscută CNCSIS,26), Bucureşti, ISBN-973-9493-28-9, 143 pg., 1999.
Cb5. Predoi, M.V., **Bugaru, M.,** Motomancea, A. *Introducere în modelarea dinamicii plăcilor plane*, Editura BREN(CNCSIS,26), Bucureşti, ISBN-973-9493-29-7, 132 pg., 1999.

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I2. Stroe, I., **Bugaru, M.,** ş.a., *Probleme de Mecanică Analitică,* Editura PRINTECH(CNCSIS,137),, Bucureşti, ISBN 973-652-169-9, 211 pg., 2000.
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I4. Staicu, Şt., **Bugaru, M.,** ş.a., *Probleme de Dinamică,* Tipografia UPB, Bucureşti, 284 pg., 1996.
I5. Staicu, Şt., **Bugaru, M.,** ş.a., *Probleme de Cinematică,* Tipografia UPB, Bucureşti, 161 pg., 1995.

D1. ***Laborator Mobil de Măsurători Vibroacustice***:

**a. *Sistem portabil multicanal de achiziţie, prelucrare şi analiză a vibraţiilor şi semnalelor acustice cu softuri de prelucrare, procesare şi post-procesare a datelor achiziţionate pe 12 canale, rezultate în urma măsurării vibraţiilor si semnalelor acustice.*** Valoarea de achizitie: 331.415 Ron( approx. 92.000 Euro). Achizitionat din contract CEEX Modul 1 (31-06-05 nr. Intern ca responsabil contract A6761/2006). Utilizat la laboratoarele de MASTER (discipline: Bazele acusticii, Prelucrarea semnalelor, Proiectarea atenuatoarelor de zgomot şi vibraţii, Vibraţii neliniare, Stabilitatea dinamică a maşinilor şi structurilor) şi la contracte, **2008**,

**b. *Analizor PULSE 3560D Bruel&Kjaer***. Valoarea de achizitie: 70.000 Ron( cca. 20.000 Euro). Achizitionat din contract CEEX Modul 1 (31-06-05 nr. Intern ca responsabil contract A6761/2006). Utilizat la laboratoarele de MASTER (discipline: Bazele acusticii, Prelucrarea semnalelor, Proiectarea atenuatoarelor de zgomot şi vibraţii, Vibraţii neliniare, Stabilitatea dinamică a maşinilor şi structurilor) şi la contracte**, 2007**,

**c. Vibrometru Laser *Bruel&Kjaer* OMETRON model 8329**. Valoarea de achizitie: 200.000 Ron(cca. 55.000 Euro). Achizitionat din contract CEEX Modul 1 (31-06-05 nr. Intern ca responsabil contract A6761/2006). Utilizat la laboratoarele de MASTER (discipline: Bazele acusticii, Prelucrarea semnalelor, Proiectarea atenuatoarelor de zgomot şi vibraţii) şi la contracte**, 2008,**

**d. 2 Microfoane cu preamplificator ¼" B&K 4939** tip free-field cu gama de masurare in frecvenţă 4 Hz-100 kHz, **2008**,

**e. Accelerometru triaxial B&K 4506** (dotare **2009). Valoare totală investiţie 200.000 EURO.**

D2. ***Lanţ de măsurarea vibraţiilor fără contact*** *HOTTINGER-Baldwin Messtechnik inductive* (achizitionat pe baza GRANT ANSTI A.ad. 6001/2001 ca director tema B11), utilizat la laboratoarele de MASTER(discipline: Bazele acusticii, Prelucrarea semnalelor, Proiectarea atenuatoarelor de zgomot şi vibraţii) şi la contracte, 2001;
D3. ***Lanţ de măsuratori acustice Bruel&Kjaer*** ( achizitionat in 2001 din Contr. CNCSIS –Banca Mondiala nr.32/1998, tema 66) utilizat ulterior la: laboratoarele de MASTER (discipline: Bazele acusticii, Prelucrarea semnalelor) , GRANT nr. 5003/2001 pentru masurarea semnalelor acustice de scurta durata pentru amortizorule de zgomot ce echipeaza pistolul DRACULA MD 19,2001;
D4. ***Stand pentru cercetarea atenuării zgomotului propagat printr-un tub cu derivaţii laterale***, în cadrul Laboratorului de Acustică al Catedrei de Mecanică utilizat la laboratoarele de MASTER (discipline: Bazele acusticii, Prelucrarea semnalelor, Proiectarea atenuatoarelor de zgomot şi vibraţii),1999;
D5. ***Stand pentru cercetarea radiaţiei acustice a plăcilor rectangulare***, în cadrul Laboratorului de Acustică al Catedrei de Mecanică utilizat la laboratoarele de MASTER(discipline: Bazele acusticii, Prelucrarea semnalelor),1999;

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Obs. – Grupe distincte, în ordinea de mai sus.

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Ris21. **Bugaru M**., Chereches T., Rotariu A. , Gheorghian S., Cojocari V., The effect of geometric imperfections on the amplitude and the phase angle of the non-linear dynamic behavior of thin rectangular plates parametrically excited, *WSEAS Transactions on Mathematics*, Issue 4, Vol. 5, pp. 379-383, ISSN 1109-2769, **2006, Scopus Indexed,** https://www-scopus-com.am.e-nformation.ro/record/display.uri?eid=2-s2.0-33744537555&origin=resultslist&sort=plf-f&src=s&st1=BUGARU&st2=Mihai&nlo=1&nlr=20&nls=count-f&sid=373fb2727e9c5d2309f70d2b89c030ee&sot=anl&sdt=aut&sl=31&s=AU-ID%28%22Bugaru%2c+M.%22+13805674800%29&relpos=14&citeCnt=0&searchTerm=&featureToggles=FEATURE_NEW_DOC_DETAILS_EXPORT:1

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5⁰. BREVETE DE INVENŢIE / INOVAŢII (B,A)

B - Brevete de invenţie naţionale indexate OSIM.

B1. PANOU STRATIFICAT FONOIZOLANT ŞI FONOABSORBANT, înregistrată la OSIM cu nr. A/00750/2008 ( cerere-**2008**, finalizarea contractului 31-06-05)- prim inventator, 30-03-**2010(eliberare)**

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Obs. – Grupe distincte, în ordinea de mai sus.

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Valoare finanţare UPB : 800.000 Ron = 120.000 (2006-dotare 70.000 ), 382.000 (2007-dotare 331.500 ), 298.000 (2008-dotare 120.000)
**P2(Pn2).** CEEX, Modul I, 118/2006, A5187, 2006-2008, nr. int. 31-06-03, *Metodă inovativă de investigaţie noninvazivă a alterărilor morfofuncţionale în patologia articulară pe baza spectrelor vibroacustice şi termice*, CO: ATM, P1:UPB, P2: Universitatea Carol Davila, P3: Spitalul Militar Central Buc.,
Valoare finanţare UPB : 270.000 Ron = 61.300 (2006 ) , 51.250 (2007), 157.450 (2008-dotare 108.000 )
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Valoare finanţare UPB : 145.000 Ron = 145.000 (2008-dotare 58.000)
**P4(Pn4).** CEEX, Modul III, C251/2006, 2006-2008, nr.int. 31-06-06, *Pomovarea cercetării interdisciplinare de excelenţă în domeniul sistemelor multicorp şi racordarea la programul FP7,*
CO: Univ. Pitesti, P1: UPB, P2: Univ. Din Braşov,
Valoare finanţare UPB : 15.500 Ron = 15.500 (2007)
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P6(Pn5). *Modele hibride dinamice consistente pentru transmisiile cu roţi dinţate cilindrice,* Grant ANSTI nr. 6001/2001, B11, 5076-99, 2001.
P7(Pn6). *Cercetări experimentale ale transmisiilor cu roţi dinţate cilindrice,* Grant ANSTI nr. 6028/2000, A14, 5076-99, 2000-2001.
P8(Pn7). Modele ale rigidităţii în angrenare la transmisiile cu roţi dinţate, Grant ANSTI nr. 6028/2000, A6, 5076-99, 2000-2001.
P9(Pn8). *Modele dinamice de transmisii,* Grant ANSTI nr.1076/1999, B14, 1999.
P10(Pn9). *Sistem puls pentru corelaţia dinamică pneu-automobil,* Contract MCT nr. 429/1996, Orizont 2000, 1997.

P11(Pn10). *Determinarea experimentală a frecvenţelor şi modurilor proprii la pneuri,* Contract MCT nr. 428-8/1996, Orizont 2000, 1997.

Membru în echipa de cercetare
**P12(Pi2).** *Controlul poluării vibro-acustice a mediului ambient,* Grant CNSCU-Banca Mondială, nr. 36333/19.07.1999-43, 1999-2001.
P13(Pn11). *Cercetări privind variaţia rigidităţii la transmisiile cu roţi dinţate cu dantură înclinată*, Grant ANSTI nr. 1076/1999, B6, 1999.
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P15(Pn13). *Determinarea contactului real al angrenării cu roţi dinţate cilindrice cu dantură înclinată,* Contract MCT, nr. 711/1996, B10, 1996.

F1. *Proiectarea amortizorului de zgomot la pistoletul Dracula MD 19X9,* Contract Romtehnica, nr. 5003/2001.
F2. *Măsurarea nivelelor de emisii vibro-acutice induse de pompa GRUNDPHOS Cr16-50, element al sistemului HYDRO 1000-2CR16-50,* S.C. Corexim Trade SRL, Contr. Nr. 05/12.12.2000.2000-2001.
F3. *Măsurarea nivelelor de emisii vibro-acutice induse de pompa centrifugală GRUNDPHOS CH4-60/220V, element al sistemului HCH4-60R50,* S.C. Corexim Trade SRL, Contr. Nr. 31-20-01/18.07.2000. 2000-2001.

Data.25.07.2022

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# ADEVERINŢĂ

**Se adevereşte, prin prezenta, că dl. Prof. Univ. Dr. Ing. Mihai BUGARU, din departamentul de Mecanică al Facultăţii de Ingineria Sistemelor Biotehnice din cadrul Universităţii Politehnica din Bucureşti a avut calitatea de referent ştiinţific oficial în comisia de susţinere publică a tezei de doctorat din cadrul UPB a d-lui. Conf. dr. ing. Ovidiu Vasile intitulată "CONTRIBUŢII LA MODELAREA CONTROLULUI ZGOMOTULUI ŞI VIBRAŢIILOR" (2009) şi este membru în comisiile de îndrumare a doi doctoranzi, şi anume: Ing. Marian NEAGOE şi Ing. Andrei VASILE, din anul 2018.**

**S-a eliberat prezenta adeverinţă spre a ii servi la întocmirea dosarului de abilitare (conducere doctorat) conform Standardelor Suplimentare ale UPB.**

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# ADEVERINŢĂ

Se adevereşte prin prezenta că domnul prof. univ. dr. ing. **Mihai BUGARU** a desfăşurat activităţi în calitate de referent ştiinţific oficial, în următoarele comisii de susţinere a tezelor de doctorat:

1. Comisia de susţinere publică a tezei de doctorat „*Contribuţii la cercetarea şi realizarea minelor marine şi fluviale utilizate pentru apărarea comunicaţiilor navale*", elaborată de către domnul Gheorghe ICHIMOAIEI, având conducător de doctorat gl. bg (r). prof.univ.dr.ing. Tudor CHERECHEŞ, numită prin Decizia Rectorului Academiei Tehnice Militare nr. 124 din 27.06.2006;

2. Comisia de susţinere publică a tezei de doctorat „*Contribuţii la dezvoltarea mijloacelor antiteroristede neutralizare a dispozitivelor explozive artizanale*", elaborată de către domnul Vasile VOICU, având conducător de doctorat gl. bg (r). prof.univ.dr.ing. Tudor CHERECHEŞ, numită prin Decizia Rectorului Academiei Tehnice Militare nr. 227 din 20.11.2006;

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4. Comisia de susţinere publică a tezei de doctorat „*Contribuţii la studiul influenţei vibraţiilor ţevii sistemelor de armament de calibru mic asupra preciziei ochirii şi tragerii*", elaborată de către domnul Ioan-Liviu PITICARI, având

conducător de doctorat col.prof.univ.dr.ing. Ioan VEDINAŞ, numită prin Decizia Rectorului Academiei Tehnice Militare nr. 179 din 15.09.2015;

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| Recent Developments of Noise Attenuation Using Acoustic Barriers for a Specific Edge Geometry<br>Bugaru, Mihai ; Vasile, Ovidiu ; Neagoe, Marian<br>Published 2021 \| COMPUTATION | 0 Times Cited |
| A functional noninvasive method for early detection the damage of cartilage joint using vibroacoustic and thermic spectrums<br>Stanciu, S. ; Cirmaci, M. ; (...); Blaj, S.<br>Published 2007 \| ANNALS OF THE RHEUMATIC DISEASES | 0 Times Cited |
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| Johnson-Cook constitutive model for OL 37 steel<br>Trana, Eugen ; Zecheru, Teodora ; (...); Chereches, Tudor<br>Published 2007 \| ELECTRICAL AND COMPUTER ENGINEERING SERIES | 0 Times Cited |
| A Nonlinear Wave Propagation Model<br>Vasile, Ovidiu and Bugaru, Mihai<br>Published 2006 \| ROMANIAN JOURNAL OF ACOUSTICS AND VIBRATION | 0 Times Cited |
| Dynamic Behavior Of Helical Gear-Pair Systems Non-Linear Parametrically Excited<br>Bugaru, Mihai<br>Published 2005 \| ROMANIAN JOURNAL OF ACOUSTICS AND VIBRATION | 0 Times Cited |

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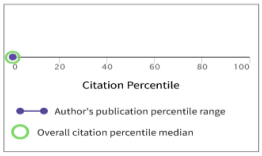


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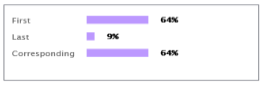

# A Nonlinear Wave Propagation Model

By: Vasile, O (Vasile, Ovidiu)[1]; Bugaru, M (Bugaru, Mihai)[1]
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ROMANIAN JOURNAL OF ACOUSTICS AND VIBRATION
Volume: 3 Issue: 1 Pages: 37-41
Published: 2006
Document Type: Article

## Abstract

The extended mild slope equation has been solved numerically to simulate wave propagation. Refraction, diffraction, shoaling, reflection, bottom friction, breaking energy dissipation and resonance with nonlinear wave celerity and group velocity have been considered. Mac Cormack Method and Point Gauss Seidel Method are applied together on an irregular mesh. In the predictor step, forward finite difference approximations are applied to first order derivatives and central finite difference approximations are applied to second order derivatives. In the corrector step, backward finite difference approximations are used for first order derivatives and central finite difference approximations are applied to second order derivatives. The developed numerical model has been applied to the Fethiye Bay located in the Mediterranen coast of Turkey.

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## Publisher

ROMANIAN SOC ACOUSTICS, 266 PANTELIMON ST, BUCHAREST, 021652, ROMANIA

## Categories / Classification

Research Areas: Acoustics

Web of Science Categories: Acoustics

## Document Information

Language: English

Accession Number: WOS:000415168000008

ISSN: 1584-7284

## Other Information

IDS Number: VB2SG

Cited References in Web of Science Core Collection: 18

Times Cited in Web of Science Core Collection: 0

# Dynamic Behavior Of Helical Gear-Pair Systems Non-Linear Parametrically Excited

By: Bugaru, M (Bugaru, Mihai)[1]
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ROMANIAN JOURNAL OF ACOUSTICS AND VIBRATION
**Volume:** 2 **Issue:** 1 **Pages:** 13-26
**Published:** 2005
**Document Type:** Article

## Abstract

The increased interest for improved gear design has led to extensive research into the field of non-linear dynamics of such systems. The paper reveals a complex dynamic model to study the behavior in a gear-pair system taking into consideration backlash and time-dependent mesh stiffness and mesh damping. In many applications including turbo machinery, machine tools and diesel engines non-linearity's are present due to tooth stiffness, damping and backlash that induced micro-vibrations of non-linear parametric type. In the mean time the input link of the driver ax and the output link of the driven ax induce non-linearity's. The paper presents the use of asymptotic method in order to compute the amplitude, the phase angle of steady state motion. In the mean time were determined the frontiers of instability. By this way the paper reveals the phenomena's characteristics of multiple jumps specific to the non-linear dynamic behavior of gear-pair due to: non-linearity's of the input-output linkages, backlash and self-induced parametric excitations, caused by the tooth stiffness and damping. It was highlighted the interaction between fundamental resonance and the principal parametric resonance.

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ROMANIAN SOC ACOUSTICS, 266 PANTELIMON ST, BUCHAREST, 021652, ROMANIA

## Categories / Classification

**Research Areas:** Acoustics
**Web of Science Categories:** Acoustics

## Document Information

**Language:** English
**Accession Number:** WOS:000415166900003
**ISSN:** 1584-7284

## Other Information

**IDS Number:** VB2SC
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**Times Cited in Web of Science Core Collection:** 0

# A functional noninvasive method for early detection the damage of cartilage joint using vibroacoustic and thermic spectrums

**By:** Stanciu, S (Stanciu, S.); Cirmaci, M (Cirmaci, M.); Berghea, F (Berghea, F.); Bugaru, M (Bugaru, M.); Ciobica, L (Ciobica, L.); Jurcut, C (Jurcut, C.); Chereches, T (Chereches, T.); Blaj, S (Blaj, S.)
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**ANNALS OF THE RHEUMATIC DISEASES**
**Volume:** 66 **Pages:** A34-A34 **Supplement:** 1 **Meeting Abstract:** 089
**Published:** MAR 1 2007
**Document Type:** Meeting Abstract

## Conference

**Conference:** 27th European Workshop for Rheumatology Research
**Location:** Florence, ITALY
**Date:** FEB 22-24, 2007

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## Publisher

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## Categories / Classification

**Research Areas:** Rheumatology
**Web of Science Categories:** Rheumatology

## Document Information

**Language:** English
**Accession Number:** WOS:000244337600105
**ISSN:** 0003-4967

## Other Information

**IDS Number:** 138BN
**Cited References in Web of Science Core Collection:** 0
**Times Cited in Web of Science Core Collection:** 0

# Nonuniformity of Isometric Properties of Automotive Driveshafts

By: Bugaru, M (Bugaru, Mihai)[1]; Vasile, A (Vasile, Andrei)[2]
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COMPUTATION
Volume: 9 Issue: 12
Article Number: 145
DOI: 10.3390/computation9120145
Published: DEC 2021
Document Type: Article

## Abstract

This paper presents an analysis of the CVJ (constant velocity joint) of automotive driveshafts from a point of view concerning the nonuniformity of isometric properties. In the automotive industry, driveshafts are considered to have constant velocity through its joints: free tripode joints and fixed ball joints, which has been proved by Mtzner's indirect method and Orain's direct method for tripod joint. Based on vectorial mechanics, the paper proved the quasi-isometry of velocity for polypod joints such as fixed ball joints. In the meantime, it was computed that the global nonuniformity of constant velocity joints for modern driveshafts based on the Dudita-Diaconescu homokinetic approach for the driveshafts. The nonuniformity of the velocity isometry of driveshafts was computed as a function of the input angular velocity of the driveshaft, angular inclination between the tripod-tulip axis and the midshaft axis and the angular inclination between the bowl axis and midshaft axis. The main aim of this article is how to improve the geometric and kinematic approach to add an important correction when designing the driveshaft dynamics prediction such as: forced torsional vibrations, forced bending-shearing vibrations, and coupled torsional-bending vibrations for the automotive driveshaft in the regions of specific resonances such as principal parametric resonance, internal resonance, combined resonance, and simultaneous resonances. By the way it is added, there are important corrections for the design of driveshafts, for the torsional dynamic behavior prediction, and for bending-shearing dynamic behavior of the driveshafts in the early stages of design. The results presented in the article represent a starting point for future research on dynamic phenomena in the area mentioned previously.

## Keywords

**Author Keywords:** homokinetic transmission; automotive driveshafts; isometry of driveshafts

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**Research Areas:** Mathematics

**Web of Science Categories:** Mathematics, Interdisciplinary Applications

## Document Information

**Language:** English

**Accession Number:** WOS:000735922400001

**eISSN:** 2079-3197

## Other Information

**IDS Number:** XW9IC

**Cited References in Web of Science Core Collection:** 20

**Times Cited in Web of Science Core Collection:** 0

# Recent Developments of Noise Attenuation Using Acoustic Barriers for a Specific Edge Geometry

By: Bugaru, M (Bugaru, Mihai)[1]; Vasile, O (Vasile, Ovidiu)[1]; Neagoe, M (Neagoe, Marian)[2]

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COMPUTATION
**Volume:** 9 **Issue:** 12
**Article Number:** 129
**DOI:** 10.3390/computation9120129
**Published:** DEC 2021
**Document Type:** Article

## Abstract

The aim of this research is to provide a better prediction for noise attenuation using thin rigid barriers. In particular, the paper presents an analysis on four methods of computing the noise attenuation using acoustic barriers: Maekawa-Tatge formulation, Kurze and Anderson algorithm, Menounou formulation, and the general prediction method (GPM-ISO 9613). Accordingly, to improve the GPM, the prediction computation of noise attenuation was optimized for an acoustic barrier by considering new effects, such as attenuation due to geometrical divergence, ground absorption-reflections, and atmospheric absorption. The new method, modified GPM (MGPM), was tested for the optimization of an y-shape edge geometry of the noise barrier and a closed agreement with the experimental data was found in the published literature. The specific y-shape edge geometry of the noise barrier contributes to the attenuation due to the diffraction phenomena. This aspect is based on the Kirchhoff diffraction theory that contains the Huygens-Fresnel theory, which is applied to a semi-infinite acoustic barrier. The new method MGPM of predicting the noise attenuation using acoustic barriers takes into consideration the next phenomena: The effect of the relative position of the receiver, the effect of the proximity of the source or receiver to the midplane of the barrier, the effect of the proximity of the receiver to the shadow boundary, the effect of ground absorption-reflections, the effect of atmospheric absorption, and the meteorological effect due to downwind. The conclusion of the paper reveals the optimization of the method for computing the noise attenuation using acoustic barriers, including the necessary corrections for ISO-9613 and the Sound PLAN software, as well as the optimization on a case study of a specific geometry of the edge barrier.

## Keywords

**Author Keywords:** noise barriers; noise attenuation; edge diffraction of acoustic barriers

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## Publisher

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**Research Areas:** Mathematics
**Web of Science Categories:** Mathematics, Interdisciplinary Applications

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**Accession Number:** WOS:000736262800001
**eISSN:** 2079-3197

## Other Information

**IDS Number:** XX4IZ
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# A Physically Consistent Model for Forced Torsional Vibrations of Automotive Driveshafts

By: Bugaru, M (Bugaru, Mihai) [1]; Vasile, A (Vasile, Andrei) [2]

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COMPUTATION

**Volume:** 10 **Issue:** 1

**Article Number:** 10

**DOI:** 10.3390/computation10010010

**Published:** JAN 2022

**Indexed:** 2022-02-03

**Document Type:** Article

Abstract

The aim of this research was to design a physically consistent model for the forced torsional vibrations of automotive driveshafts that considered aspects of the following phenomena: excitation due to the transmission of the combustion engine through the gearbox, excitation due to the road geometry, the quasi-isometry of the automotive driveshaft, the effect of nonuniformity of the inertial moment with respect to the longitudinal axis of the tulip-tripod joint and of the bowl-balls-inner race joint, the torsional rigidity, and the torsional damping of each joint. To resolve the equations of motion describing the forced torsional nonlinear parametric vibrations of automotive driveshafts, a variational approach that involves Hamilton's principle was used, which considers the isometric nonuniformity, where it is known that the joints of automotive driveshafts are quasi-isometric in terms of the twist angle, even if, in general, they are considered CVJs (constant velocity joints). This effect realizes the link between the terms for the torsional vibrations between the elements of the driveshaft: tripode-tulip, midshaft, and bowl-balls-inner race joint elements. The induced torsional loads (as gearbox torsional moments that enter the driveshaft through the tulip axis) can be of harmonic type, while the reactive torsional loads (as reactive torsional moments that enter the driveshaft through the bowl axis) are impulsive. These effects induce the resulting nonlinear dynamic behavior. Also considered was the effect of nonuniformity on the axial moment of inertia of the tripod-tulip element as well as on the axial moment of inertia of the bowl-balls-inner race joint element, that vary with the twist angle of each element. This effect induces parametric dynamic behavior. Moreover, the torsional rigidity was taken into consideration, as was the torsional damping for each joint of the driveshaft: tripod-joint and bowl-balls-inner race joint. This approach was used to obtain a system of equations of nonlinear partial derivatives that describes the torsional vibrations of the driveshaft as nonlinear parametric dynamic behavior. This model was used to compute variation in the natural frequencies of torsion in the global tulip (a given imposed geometry) using the angle between the tulip-midshaft for an automotive driveshaft designed for heavy-duty SUVs as well as the characteristic amplitude frequency in the region of principal parametric resonance together the method of harmonic balance for the steady-state forced torsional nonlinear vibration of the driveshaft. This model of dynamic behavior for the driveshaft can be used during the early stages of design as well in predicting the durability of automotive driveshafts. In addition, it is important that this model be added in the design algorithm for predicting the comfort elements of the automotive environment to adequately account for this kind of dynamic behavior that induces excitations in the car structure.

### Keywords

**Author Keywords:** homokinetic transmission; automotive driveshaft; quasi-isometry of driveshaft; nonlinear parametric torsional vibration; method of harmonic balance; nonlinear parametric dynamic behavior of automotive driveshaft; principal parametric resonance

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### Categories/Classification

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### Document Information

**Language:** English

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**eISSN:** 2079-3197

### Other Information

**IDS Number:** YO0HO

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COMPUTATION

**eISSN:** 2079-3197

**Current Publisher:** MDPI, ST ALBAN-ANLAGE 66, CH-4052 BASEL, SWITZERLAND

**Research Areas:** Mathematics

**Web of Science Categories:** Mathematics, Interdisciplinary Applications

# Modeling and Analysis of FBV Movements for Automotive Driveshafts in the PPR Region

**By:** Bugaru, Mihai (Bugaru, Mihai) ; Vasile, Ovidiu (Vasile, Ovidiu)

APPLIED SCIENCES-BASEL

**Volume:** 12 **Issue:** 7

**Article Number:** 3237

**DOI:** 10.3390/app12073237

**Published:** APR 2022

**Indexed:** 2022-04-24

**Document Type:** Article

Abstract

Featured Application The asymptotic method approach (AMA) is used to compute the amplitudes of forced bending vibrating (FBV) movements versus the excitation frequency in the region of principal parametric resonance (PPR) for multibody mechanical systems. An FBV movements model was designed for an automotive driveshaft to realize a powerful design tool for FBV movement control of the automotive transmission. This research's goal is to model and analyze the forced bending vibrating (FBV) movements for the elements of an automotive driveshaft using a perturbation technique, the asymptotic method approach (AMA), in the region of principal parametric resonance (PPR). The PPR region was chosen because the principal parametric resonance region is one of the essential resonance regions. The model of FBV movements for the automotive driveshaft (AD) considers the aspects of the following phenomena: geometric nonuniformity of the AD elements and shock excitation due to the road. To overcome the equations for the FBV movements of the AD elements, all inertia characteristics were reduced to the longitudinal ax of the midshaft using the variation of the geometric moments of inertia with the concurrent axis and Stener's theorem. The midshaft of the AD was considered a Timoshenko simply supported beam with a concentrated mass at both ends and springs and dampers for linear and rotational movements at both ends. To determine the equations describing the FBV movements of the AD elements, Hamilton's principle was used. After establishing the equations of motion for each AD element coupled with the specific boundary conditions, the amplitude and the phase angle were computed for stationary and nonstationary motion in the PPR region using the first order of the AMA, and the dynamic instability frontiers were determined based on the same equations. The dynamic behavior of the AD was investigated concerning the variation of the damping ratio and the variation of the parametric excitation coefficient. The AMA coupled with the model of FBV movements for the AD exhibits the future research directions for analyzing FBV movements for the AD in the regions of superharmonic resonances, subharmonic resonances, combination resonances, internal resonances, and simultaneous resonances. Additionally, the AMA can predict the endurance of the AD and design control of car damping systems.

Keywords

**Author Keywords:** multibody dynamics; automotive driveshafts; forced bending vibrations; asymptotic method; principal parametric resonance; dynamic stability frontiers

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Categories/Classification

**Research Areas:** Chemistry; Engineering; Materials Science; Physics

Document Information

**Language:** English

**Accession Number:** WOS:000781051300001

**eISSN:** 2076-3417

Other Information

**IDS Number:** 0K8PN

# A New Robust Method to Investigate Dynamic Instability of FTV for the Double Tripod Industrial Driveshafts in the Principal Parametric Resonance Region

**By:** Bugaru, Mihai (Bugaru, Mihai) ; Vasile, Ovidiu (Vasile, Ovidiu)

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APPLIED SCIENCES-BASEL

**Volume:** 12 **Issue:** 12

**Article Number:** 6182

**DOI:** 10.3390/app12126182

**Published:** JUN 2022

**Indexed:** 2022-07-06

**Document Type:** Article

**Abstract**

Featured Application Time-history analysis (THA), the Lyapunov Exponents Approach (LEA), and the Poincare Map (PM) are enhanced to investigate the dynamic instability of forced torsional vibrations (FTV) for a double tripod industrial driveshaft (DTID) in transition through the principal parametric resonance region (PPRR). Based on a modified designed model of FTV for an automotive driveshaft (AD), a robust method comprising THA, LEA, and PM (THA-LEA-PM) was created that certifies the existence of deterministic chaos or an ergodic process for the dynamic behavior of DTID's FTV in transition through PPRR. These methods represent a design tool for the DTID's FTV control of the homokinetic driveline transmission in the industry. The present work aims to design a robust method to detect and certify the deterministic chaos or ergodic process for the forced torsional vibrations (FTV) of a double tripod industrial driveshaft (DTID) in transition through the principal parametric resonance region (PPRR) which is considered by the researchers in the field as one of the most important resonance regions for the systems having parametric excitations. The DTID's model for FTV considers the following effects: nonuniformities of inertial characteristics of the DTID's elements, the harmonic torque excitation induced by the asynchronous electrical motor used for a heavy-duty grain mill, and the harmonic reaction torque generated by different granulation of the substance needed to be milled. Based on these aspects, a model of the FTV for the DTID was designed which was a modified, physically consistent model already used by the authors to investigate the FTV of automotive driveshafts (homokinetic transmission). For the DTID elements, the dynamic instability for nonstationary FTV in the PPRR using time-history analysis (THA) was analyzed-THA represents the phase portraits. Time-history analysis is a detection method for possible chaotic dynamic behavior for the nonstationary FTV (NFTV) in transition through PPRR. If this dynamic behavior was seen, a new robust method LEA-PM was created to certify and confirm the deterministic chaos for the NFTV of DTID. The new method, LEA-PM, is composed of the Lyapunov exponent's approach (LEA) coupled with the Poincare Map (PM) applied to the global system of differential equations that describe the FTV of DTID in the PPRR. This new robust method, which embeds LEA and PM, LEA-PM, establishes if the mechanical system has a deterministic chaotic dynamic behavior (strange attractor) or an ergodic dynamic process in this resonant region. LEA represents a new method that includes not only the maximal Lyapunov exponent method (MLEM) but also new mathematical criteria that is "the sum of all Lyapunov exponents has to be negative" which, coupled with MLEM, indicates the presence of deterministic chaos (strange attractors). THA-LEA-PM had been used for the NFTV of DTID computing the phase portraits, the Lyapunov exponents, and representing the Poincare Maps of the NFTV for the DTID's elements in transition through PPRR, founding deterministic chaos or ergodic dynamic behavior. Based on the obtained results, numerical simulations revealed the pitting manifestations of the DTID's elements, typical for the geared systems transmission, mentioned recently in experimental data research for the homokinetic transmissions.

Using the new robust method, THA-LEA-PM (time-history analysis coupled with LEA-PM) can be used in future research for chaotic dynamic analysis of DTID's NFTV transition through superharmonic resonances, subharmonic resonances, combination resonances, and internal resonances. Time-history analysis as a detection method for chaos and LEA-PM as a certifying method for deterministic chaos can be integrated as a design tool for DTID's FTV control of the homokinetic transmission.

## Keywords

**Author Keywords:** chaotic dynamic behavior; time-history analysis; Lyapunov exponents approach; Poincare Map; principal parametric resonance; multibody dynamics

**Keywords Plus:** TORSIONAL VIBRATIONS; SYSTEM; DRIVEN

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## Categories/Classification

**Research Areas:** Chemistry; Engineering; Materials Science; Physics

## Document Information

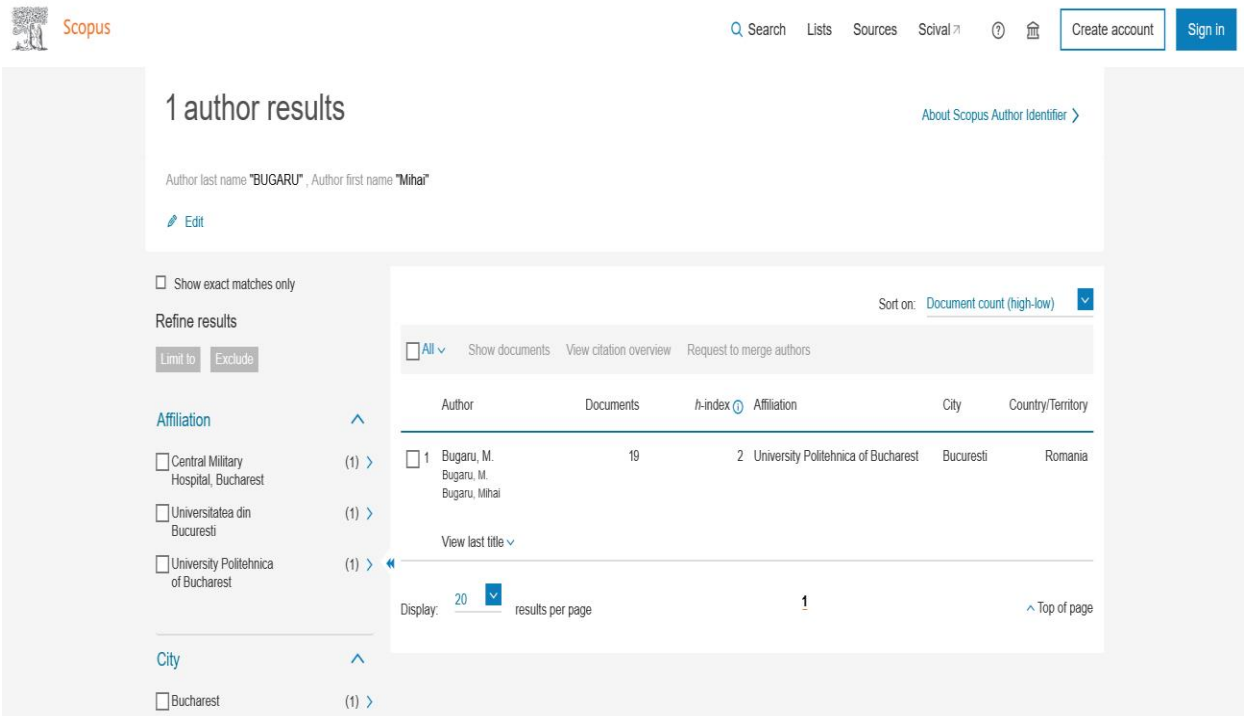
**Language:** English

**Accession Number:** WOS:000818408300001

**eISSN:** 2076-3417

## Other Information

**IDS Number:** 2N5GX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# ADEVERINȚĂ

Se adevereşte, prin prezenta, că dl. Prof. Dr. Ing. Mihai BUGARU, din departamentul de Mecanică al Facultății de Ingineria Sistemelor Biotehnice din cadrul Universității POLITEHNICA din Bucureşti este proiectantul şi realizatorul următorelor sisteme acustice cât şi a Laboratorului Mobil de Măsurători Vibroacustice, finanțând din contractele sale, în perioada 1998-2009, toate aceste sisteme precum şi dotarea integrală a acestui laborator din cadrul Departamentului de Mecanică

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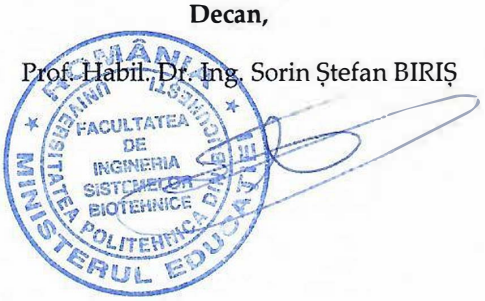

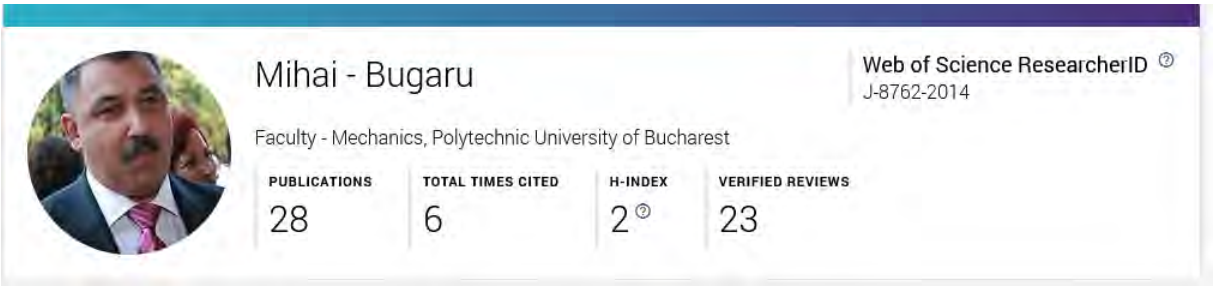

Mihai - Bugaru

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Web of Science ResearcherID
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| PUBLICATIONS | TOTAL TIMES CITED | H-INDEX | VERIFIED REVIEWS |
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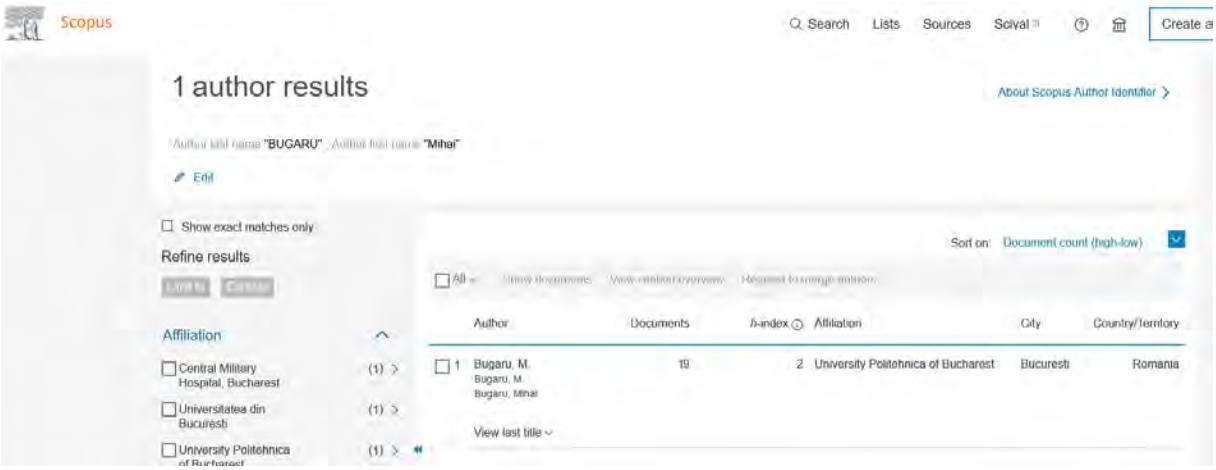


Mihai Bugaru

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Department of Mechanics, University POLITEHNICA of Bucharest
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Non-linear dynamics Mechanical engineering Vibrations Acoustics

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**Mihai BUGARU**

Universitatea Politehnica din Bucuresti, Facultatea de Ingineria Sistemelor Biotehnice, Departamentul Mecanica

Profesor

Mechanical Vibrations
Parametric vibrations of plates
Dynamic behaviour of thin plates
Coupled impulsive and harmonic excitations of mechanical systems
Nonlinear dynamic behaviour of gears and gearbox
Nonlinear Dynamic behaviour of automotive driveshafts
Acoustic barriers
Acoustic muffler design
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Vector Mechanics for Engineers

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|---|---|---|
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VIEWING 2 COMBINED AUTHOR RECORDS

# Bugaru, Mihai - *This is an algorithmically generated author record*

(Bugaru, Mihai)

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BUCHAREST, ROMANIA

Published names: Bugaru, Mihai; Mihai, Bugaru; Bugaru, M.

Organizations: 2005-2022 Polytechnic University of Bucharest; 2007-2007 Univ Politehn Bucuresti

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Publications | Author Impact Beamplot

## 11 Publications from the Web of Science Core Collection

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| | Times Cited |
|---|---|
| A New Robust Method to Investigate Dynamic Instability of FTV for the Double Tripod Industrial Driveshafts in the Principal Parametric Resonance Region<br>Bugaru, Mihai and Vasile, Ovidiu<br>Published 2022 \| APPLIED SCIENCES-BASEL | 0 |
| Modeling and Analysis of FBV Movements for Automotive Driveshafts in the PPR Region<br>Bugaru, Mihai and Vasile, Ovidiu<br>Published 2022 \| APPLIED SCIENCES-BASEL | 1 |
| A Physically Consistent Model for Forced Torsional Vibrations of Automotive Driveshafts<br>Bugaru, Mihai and Vasile, Andrei<br>Published 2022 \| COMPUTATION | 2 |
| Nonuniformity of Isometric Properties of Automotive Driveshafts<br>Bugaru, Mihai and Vasile, Andrei<br>Published 2021 \| COMPUTATION | 3 |
| Recent Developments of Noise Attenuation Using Acoustic Barriers for a Specific Edge Geometry<br>Bugaru, Mihai; Vasile, Ovidiu; Nastase, Marian<br>Published 2021 \| COMPUTATION | 0 |
| A functional noninvasive method for early detection the damage of cartilage joint using vibroacoustic and thermic spectrums<br>Stanciu, S.; Ciornei, M.; (...); Rusi, S.<br>Published 2007 \| ANNALS OF THE RHEUMATIC DISEASES | 0 |
| Transfer matrix method for a single-chamber mufflers<br>Bugaru, Mihai and Vasile, Ovidiu<br>Published 2007 \| | 0 |
| Finite elements method in Split Hopkinson Pressure Bar developing process<br>Adrian, Rotariu; Mihai, Bugaru; Tudor, Chereches<br>Published 2007 \| ELECTRICAL AND COMPUTER ENGINEERING SERIES | 0 |
| Johnson-Cook constitutive model for OL 37 steel<br>Trana, Eugen; Zecheru, Teodora; (...); Chereches, Tudor<br>Published 2007 \| ELECTRICAL AND COMPUTER ENGINEERING SERIES | 0 |
| A Nonlinear Wave Propagation Model<br>Vasile, Ovidiu and Bugaru, Mihai<br>Published 2006 \| ROMANIAN JOURNAL OF ACOUSTICS AND VIBRATION | 0 |
| Dynamic Behavior Of Helical Gear-Pair Systems Non-Linear Parametrically Excited<br>Bugaru, Mihai<br>Published 2006 \| ROMANIAN JOURNAL OF ACOUSTICS AND VIBRATION | 0 |

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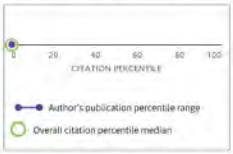


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### Author Position

# REVIEW CONFIRMATION CERTIFICATE

We are pleased to confirm that

*Mihai Bugaru*

has reviewed 13 papers for the following MDPI journals in the period 2021–2022:

*Machines, Micromachines, AppliedMath, Sensors, Applied Sciences*

Dr. Shu-Kun Lin, Publisher and President
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