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Стручни извештај о учешћу на научном скупу

Поштовани,

У периоду од 17-20.02.2019. године учествовала сам у раду конференције "NODYCON 2019 – First International Nonlinear Dynamics Conference" у организацији „Sapienza University of Rome“, у Риму, Италија. Конференција је одржана на Факултету за грађевинарство и индустријско инжењерство (The Faculty of Civil and Industrial Engineering) у Риму.

У оквиру конференције учествовала сам са излагањем у секцији “Concepts and Methods in nonlinear dynamics“, са радом из дела истраживања у оквиру пројекта ОИ174001 координираног од стране Математичког института САНУ, под насловом:

Ivana D. Atanasovska, Katica R. (Stevanovic) Hedrih and Dejan B. Momcilovic

A theoretical model for vibro-impact dynamics of spur gears with tooth flanks wear

На конференцији је изложено више од 350 радова, а учесници су били из преко 20 земаља Света, са скоро свих континената. У оквиру Конференције отварање и пленарна предавања су одржана у ST. PETER IN CHAINS BASILICA, док су остала предавања организована кроз паралелене сесије одржана на „The Faculty of Civil and Industrial Engineering, Sapienza University of Rome“. Све сесије су биле веома посећене, а организација ове велике конференције је била веома успешна захваљујући организационом тиму са Факултету за грађевинарство и индустријско инжењерство у Риму, предвођеним Председником организационог одбора Prof. Walter Lacarbonara, Editor-in-Chief: Nonlinear Dynamics, Springer.

На конференцији сам била део малог али успешног тима са Пројекта ОИ174001, који смо чиниле Проф.Катица (Стевановић) Хедрих, ја и колега Степа Пауновић. Поред радног дела програма, конференција је садржала и прилике за неформалне разговоре, сусрете са колегама из других земаља, али и успостављање нових контаката и идеја за будућа заједничка истраживања. Боравак у Риму искористили смо и за посету Музеју посвећеном Леонарду да Винчију, који садржи велики број реконструкција механизама које је на својим цртежима приказао да Винчи.

Изложени радови са конференције објављени су у штампаној форми као проширени двостранични апстракти, а рецензије целих радова за зборник радова NODYCON 2019 Springer Proceedings је у току.

У прилогу Извештаја достављам: Обавештење о прихватању рада за усмено излагање, Копију Сертификата о учешћу на конференцији, Копију првих страна Књиге апстраката и Копију објављеног апстракта и неколико фотографија са одржане конференције.

С поштовањем,

У Београду, 01.04.2019.

др Ивана Атанасовска,
виши научни сарадник

Прилози:

^_NODYCON2019^_ notification for paper 89

From: NODYCON2019 (nodycon2019@easychair.org)

To: iviatanasov@yahoo.com

Date: Friday, October 5, 2018, 8:52 PM GMT+2

Dear Ivana Atanasovska,

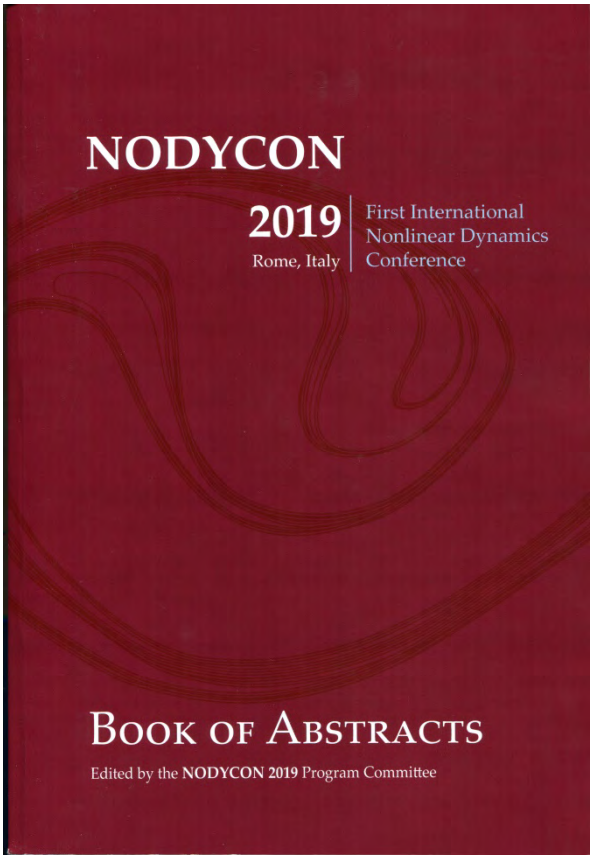
Thank you for submitting your two-page extended abstract ID # 89 titled "A theoretical model for vibro-impact dynamics of spur gears with tooth flanks wear" to NODYCON2019.
Based on the returned referee's report and overall evaluation of the Program Committee, we are glad to inform you that your work has been accepted for inclusion in the printed Book of Abstracts (short abstracts only) and online Proceedings of NODYCON2019 (two-page extended abstracts), both endowed with ISBN.

Please proceed with revising your work according to the comments provided in the attached review, if at all applicable, and uploading the revised two-page abstract using the webtool EasyChair.
The deadline for receiving the revised papers is October 22, 2018.

NODYCON is committed to high standards of peer review and quality of oral presentation and scientific discussion. We kindly ask you to revise your extended abstract with great care in compliance with the provided templates containing the instructions.

We look forward to receiving your final abstract in due course.

With best regards,
Walter Lacarbonara
NODYCON2019 Chair



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A theoretical model for vibro-impact dynamics of spur gears with tooth flanks wear

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Abstract: The main performances of involute gears operations lead to the appearance of nonlinear dynamic behaviour and impact. In this paper the influence of mild wear of the tooth flanks of gears without surface hardening on the vibro-impact behaviour is considered. For this purpose, a new theoretical model for vibro-impact dynamics of spur gears with mild wear of tooth flanks is developed and described. The developed theoretical model is based on the main postulates of a model of the central centric collision of two fictive rolling disks with radii equal to the radii of kinematic diameters of the pinion and the wheel, as well as on a combined analytical – Finite Element method for calculation the contact deformations, the contact pressure and wear on tooth flanks surfaces. A particular gear pair is used for presentation of the developed model.

Introduction

The wear is one of the most frequent types of gear tooth damages, which appears in different forms of wear, [1, 2]. In some specific cases of gear pairs with high value of transmission ratio and large diameter of the wheel, mainly designed for low angular velocities, the surface manufacturing of the tooth flanks of the pinion and the wheel are not the same. In such cases, the wheel tooth flanks are manufactured without final surface machining and surface hardening and therefore these surfaces are more susceptible to the mild wear process, which resulting in a vibro-impact excitation parameter.
The operation of spur gears with involute profile is characterized with total deformations variation particularly because of variable number of teeth pairs in contact. These variations, as well as all other sources of the tooth profile pitch deviations during operation (elastic deformations, profile deviations, wear, damages etc.) lead to the backlash, appearance of internal dynamic forces and impacts, [3]. Vibro-impact dynamics of spur gear pair caused by successive collisions of series of teeth pairs in forward-backward collision contacts are source of vibro-impact vibrations and noise in the geared transmission system. The spur gears with mild wear on the wheel teeth are analyzed in this paper and the new theoretical model of vibro-impact dynamics of spur gears with tooth flanks wear are developed as an extension of the model of vibro-impact dynamic of spur gears [3], which used the main postulates of a model of the central centric collision of two fictive rolling disks with radii equal to the radii of the kinematic diameters of pinion and wheel, and with the current rolling axes in collision coincided with the rotation axis of the pinion and the wheel [4].

Description of a vibro-impact model of spur gears with tooth flanks wear

The involute cylindrical gears are widely used primarily thanks to the approximately constant transmission ratio, which is defined as: $i=\omega_1/\omega_2$. Vibro-impact dynamics occurs when a disturbance of angular velocities ration appears. The disturbance angular velocity of pinion is defined as:

$$\Delta\omega_1 = \omega_1 - i\omega_2 > 0 \tag{1}$$

and could be considered as an excitation of vibro-impact vibrations when this phenomenon can appears. The mechanism of vibro-impact of spur gears is described in detail in the previous papers, [3].
The main part of the considered task of the vibro-impact oscillations of spur gears is the method for calculation of the disturbance pinion angular velocity. The starting point for developing of this procedure is a definition of tooth profile pitch deviation as a result of deformations, manufacturing deviations and wear, as:

$$b = K_b m_n + b_w \tag{2}$$

where: m_n - is a standard normal tooth profile module, while K_b -could be defined as error coefficient due to contact deformations and other sources of profile pitch deviations and b_w – is a profile pitch deviation due to wear.
The coefficient K_b can be very precisely determined by Finite Element method [3] with modeling the real contact geometry and working loads or by Hertz contact theory, and b_w can be determined by integrating the product of sliding distance and contact pressure during the time of contact on the base of the so-called generalized Archards wear equation, [5]:

$$\frac{dh_w}{dt} = k^w pv \tag{3}$$

where k^w is the wear coefficient, p is a local contact pressure obtained by Finite Element calculation and v is the sliding velocity which depends of the angular velocity and gears geometry.
The time which is required by a pinion tooth to pass the total tooth pitch deviation can be express as:

$$T(b) = \frac{K_b m_n + b_w}{\tau_1}\frac{1}{\omega_1} \tag{4}$$

The pinion disturbance angular velocity can be calculated in accordance with the postulate that the rotation

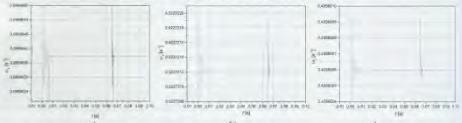
time of pinion gear will be the same in the cases with and without deviation b:

$$\frac{2\pi}{\omega_1} = \frac{2\pi+\frac{K_b m_n + b_w}{r_1}}{\omega_1+\Delta\omega_1}, \text{ ie } \Delta\omega_1 = \frac{K_b m_n + b_w}{2\pi r_1}\omega_1^2 \tag{5}$$

Then, in accordance with the relations which define the new model of the central centric collision of two fictive rolling disks [4], and with taking into consideration that the radii of these disks are equal to the radii of pitch diameters of the pinion and the wheel and that the instantaneous rolling axes of these disks in collision are coincided with the rotation axis of the pinion and the wheel [3], the vibro-impact dynamics of gears with mild wear are solved.

Results

The presented theoretical method has been used for calculation of the angular velocities of the pinion and the wheel before and after every collision, and before and after every successive collision-impact, [3, 4]. For a particular spur gear pair characterized with the possibility of vibro-impact occurrence and mild wear occurrence [3], the variations of the pinion angular velocity and the wheel angular velocity, as well as the kinetic energy of the pinion and the wheel and transmission ration during meshing period could be calculated. The results obtained for the wheel angular velocity are given in Figure 1.



a) b) c)

Figure 1: The results for the wheel angular velocity during two contact periods for different transmission ration: a) i=3; b) i=4 and c) i=4.8

Conclusions

The new model for analyzing the vibro-impact of spur gears presented in this paper has potential to include different sources of vibro-impact excitation (elastic deformations, profile deviations and roughness, wear, damages etc.). The results obtained for characteristic variables of vibro-impact gears dynamics show that this behavior is characterized with vibro-impact vibrations in teeth contact during a short period of time after every collision of pinion tooth and wheel tooth in points of changing of the number of tooth pairs in contact.
The comparative analysis of the influence of different wear level during gears operation could makes real benefits in selection the optimal working conditions for gear pairs which are the part of machines and other facilities within the important power plants, in accordance with the results of the periodical inspections. The presented research gives the possibility for separated consideration of vibro-impact phenomenon, while the existing models for gears dynamics investigate only the overall effects, [6, 7].

Acknowledgement.
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