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Mathematical Institute SANU, Belgrade, Department for Mechanics

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Program of Mechanics Colloquium – APRIL 2012

Start of each lecture is at each Wednesday at 18,00 h in room 301 F at Mathematical Institute SANU, street Knez Mihailova 36/III.

Sreda (Wednesday), 4 april (April 4) 2012 u 18 sati (18h) **Lecture No. 1185**

Nemanja Zorić, Teaching Assistant, Ph.D. Student,, Faculty of Mechanical Engineering, University of Belgrade

Lecture included in MechanicsColloquium Programm by recommendation of supervisor Professor **Zoran Mitrović**, Faculty of Mechanical Engineering, University of Belgrade

Vibration Analysis and Optimal Control of Smart Thin-walled Composite Structures using Self-tuning Fuzzy Logic Controller

Control performances of smart structures for active vibration control depend on location piezoelectric actuators and sensors as well as applied control algorithm [1, 2]. Conventional control methods have not been widely successful due to the dynamics complexity of flexible structures and stochastic nature of external disturbance excitation [3]. To avoid these problems, fuzzy logic controller (FLC) with on-line tuning of scaling factors [4, 5] is proposed for vibration control of thin-walled composite beams and plates. The problem is formulated using finite element method based on third-order shear deformation theory (TSDT). Membership functions of FLC are optimized using Particle swarm optimization (PSO) algorithm. Scaling factors of FLC are tuned online via peak observer. Several numerical examples are provided for composite beams and plates in cases of impulse, periodic and random excitation for both, single-input-single-output (SISO) and multi-input-multi-output (MIMO) configuration. In the case of MIMO configuration, optimal location of piezoelectric actuators is searched using PSO algorithm and large-scale system is decomposed into smaller subsystems in a parallel structure. In order to present efficient of proposed controller, obtained results are compared with corresponding results in the cases of conventional controllers and FLC with constant scaling factors.

References

[1] Gupta, V., Sharma M. and Thakur N. 2010. "Optimization Criteria for Optimal Placement of Piezoelectric Sensors and Actuators on a Smart Structure: A Technical Review," Journal of Intelligent Material Systems and Structures, 0:1-17.

[2] Wang, Y. and Inman, D. J. 2011. "Comparison of Control Laws for Vibration Suppression Based on Energy Consumption," Journal of Intelligent Material Systems and Structures, 22:795-809.

[3] Mat Darius, I. Z. and Tokhi, M. O. 2005. "Soft computing-based active vibration control of a flexible structure," Engineering Application of Artificial Intelligence, 18:93-114.

[4] Woo, Z-W, Chung H-Y and Lin J-J. 2000. "A PID type fuzzy controller with self-tuning scaling factors," Fuzzy Sets and Systems, 115:321-326.

[5] Bouallegue, S., Haggege, J., Ayadi, M. and Benrejeb, M. "PID-type fuzzy logic controller tuning based on particle swarm optimization," Engineering Application of Artificial Intelligence, Manuscript in press.

Sreda (Wednesday), 11 april (April 11) 2012 u 18 sati (18h) **Lecture No. 1186**

Major, assistant mr **Damir Jerkovic**, dipl.ing., Department of military mechanical engineering, Weapon section, Military academy of Serbia.

The influence of aerodynamic coefficient on the stability of the class axis-symmetrical profile

Overview. Aerodynamic coefficients and derivatives of projectile model were calculated with adopted models of calculation and were determined experimentally as function of Mach numbers and angle of attack of projectile model (three components of force and moment). The comparative analysis of experimental and calculated values of aerodynamic coefficients of projectile model was done.

Model of classic axis-symmetrical projectile. Presented model is projectile 40 mm. Stability of this unmanned projectile is described by parameters of stability (angle of attack, amplitude absorber coefficients and factors of dynamic stability and gyroscopic stability). These parameters were calculated on the basis of values of aerodynamic coefficients (determined by semi-empirical calculation - calc. and experimentally - exp. in three-sonic wind tunnel).

Aerodynamic forces and moments acting on the model were measured by ABLE 1.00 MKXXIIIA internal six-component strain gauge balance. Nominal load range of the balance was 2800 N for normal, 620 N for side forces, 134 N for axial force, 145 Nm for pitching, 26 Nm for yawing moment and 17 Nm for rolling moment.

Aerodynamic coefficients. During experiments in the wind tunnel T-38 the aerodynamic coefficients were measured in 14 different values of Mach number (Ma) and 21 different values of angle of attack (-10 - 10). The characteristic function of aerodynamic coefficients was represented on the figures and compared with calculated values.

Analysis of parameters of stability. Motion of projectile is simulated through six-degrees of freedom model. Comparative analysis of calculated and experimental parameters of stability is presented in figures as dependencies of angles of attack, amplitude absorber coefficients and factors of dynamic and gyroscopic stability on time and path.

Influence of aerodynamic coefficients on stability of projectile. Values of aerodynamic coefficients are changed from -15 % up to +15 % and values of parameters of stability of projectile is analyzed during the flight and presented on the following figures.

Axial AD coefficient affects on the damping coefficients, factors of stability and spin velocity. Dynamic derivatives of pitching moment show more effects on the damping coefficients and factors of stability. Static derivative of normal force shows effects on the dynamic stability factor. Most influenced are derivatives of Magnus moment (yawing moment) and force (side force) on the damping coefficients and dynamic stability factor.

Summary. The stability of classic axis-symmetrical projectile is affected by aerodynamic coefficients through a steady influence of the axial aerodynamic coefficient on the largest number of stability parameters and through the strongest influence of dynamic derivative of aerodynamic coefficient of pitching moment and derivative of aerodynamic coefficient of yawing (Magnus) moment and side (Magnus) force on amplitude coefficients and factor of dynamic stability.

Sreda (Wednesday), 18 april (April 18) 2012 u 18 sati (18h) **Lecture No. 1187**

Prof. dr **Dragomir N. Zeković,** University of Belgrade, Faculty of Mechanical Engineering, Beograd, Serbia (Project ON 174001)

Dynamics of mechanical systems with nonlinear nonholonomic constraints - III Part

Research results published in three papers* will be presented by lecturer.

* List of the published references

1. Dragomir N. Zeković, Dynamics of mechanical systems with nonlinear nonholonomic constraints – I The history of solving the problem of a material realization of a nonlinear nonholonomic constraint, ZAMM · Z. Angew. Math. Mech. 91, No. 11, 883 – 898 (2011) / DOI 10.1002/zamm.201000228
2. Dragomir N. Zeković, Dynamics of mechanical systems with nonlinear nonholonomic constraints – II Differential equations of motion, ZAMM · Z. Angew. Math. Mech. 91, No. 11, 899 – 922 (2011) / DOI 10.1002/zamm.201000229
3. Dragomir N. Zeković, On the motion of a nonholonomically constrained system in the nonresonance case, Mechanics Research Communications 38 (2011) 330–333

Abstract II. Depending on how the nonholonomic constraints have been introduced to the Lagrange-D'Alemberts's principle, there are several differential equations of motion in the mechanics of nonholonomic systems. In this work, the most general type of differential equations of motion (fundamental to all known forms

of the equations of motion for nonholonomic as well as holonomic systems) is derived. Here, the equations represent the generalization of Poincare's equation [1]. In published works [2, 3, 4, 5, 6], these have already taken into account nonlinear nonholonomic constraints and linear relations between real velocities and kinematic parameters. A method of dedication of the most generalized form of the equations of motion will be shown. It is followed by the analysis of particular cases. Then, it will be shown how to get form the generalized form to Maggi, Appell, Voronec, Chaplygin, Volterra, Ferrers, and Boltzmann-Hamel's equations appearing in nonholonomic systems. Further, a system of material points of variable mass, where the equations of motion are derived for the most general case of reactive forces and in case of constraints depending on mass variables will be considered. All theoretical
considerations are illustrated with the analysis of the relevant nonholonomic model.

Abstract III. The motion of a nonlinearly nonholonomically constrained system comprised of two material points connected by a "fork" is investigated in the nonresonance case. This leads to two equations of motion; one of which is nonlinear in the system velocities. The system is shown to be integrable in the nonresonance case, and the motion is described analytically and also computed numerically for several parameter values
yielding results that conform to the analytical predictions.

References

Kozlov, V.V., Kolesnikov, N.N., 1978. About the theorems in dynamics. Prikl. Mat.Mekh. 42 (1), 28–33 (in Russian).
Neimark, Yu.I., Fufayev, N.A., 1967. The Dynamics of Nonholonomic Systems. Nauka,Moscow (in Russian).
Zekovi´ c, D., 1984. Some problems of the dynamics of nonholonomic systems, PhD dissertation, Belgrade (in Serbian).
Zekovi´ c, D., 1992. On the motion of the integrable system with nonlinear nonholonomic constraint. Vestn. MGU Ser. 1 Mat. Mekh. 3, 64–66 (in Russian).
Zekovi´ c, D., 1993. On integrable system motion with nonholonomic bound. The case of resonant relations. Vestn. MGU Ser. 1 Mat. Mekh. 1, 104–108 (in Russian).

Sreda (Wednesday), 25 april (April 25) 2012 u 18 sati (18h) **Lecture No. 1188**

Professor **Tomislav Petrović,** Doctor of Technical Sciences, Mechanical Engineering Faculty, University of Niš.
(Project ON 174001)

The design of the new models of mechanisms for the transformation of motion with kinematic excitation

Two new models of mechanisms for the transformation of motion should be presented as follows:

* Screw mechanism for the transformation of one-way rotation into two-way linear motion with impulse control
* Gear mechanism for transforming the rotation into rotation with extremely high transmission ratio.

Both mechanisms are new construction solutions for which patent protection both in the country and abroad has been sought for . These mechanisms are based on the application of the differential gearbox with two degrees of freedom. They are characterized by the transformation of kinematic excitation at motion transformation of and the possibility of temporary or permanent changes in the structure by subtracting the redundant degrees of freedom. Thus the desired characteristic of the motion transformation is achieved. For each mechanism separately the principles of motion and transformation are described and the basic equations that describe the interdependence of geometric and kinematic parameters of the system are given. The basic principles of controlling new mechanisms for motion transformation have been pointed to and the basic constructional performances which may find practical application have been given. The new physical models of systems of motion transformation have been designed and their operation has been presented.

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Предавања ће се одржавати средом са почетком у 18.00 часова, у сали 301 F на трећем спрату зграде Математичког института САНУ, Кнез Михаилова 36/III, (зграда преко пута главне зграде САНУ).

Позив научницима и истраживачима да пријаве сцоја предавања
Пријава потенцијалног предавача треба да садржи апстракт предавања до једне странице на српском језику ћирилицом и превод на енглески jeѕik, као и CV обима до две странице. Пријаву послати на адресу управника Одељења за механику у виду Word DOC на адресу: khedrih@eunet.rs

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Announcement and Invitation

Start of each lecture is at each Wednesday at 18,00 h in room 301 F at Mathematical Institute SANU, street Knez Mihailova 36/III.

All scientists and researchers in area of Mechanics are invited to contribute to the Program of Mechanics Colloquium of Mathematical Institute of Serbian Academy of Sciences and Arts. One page Abstract of proposed Lecture with short CV is necessary to submit in world doc to Head of Department of Mechanics (address: khedrih@eunet.rs), one month before first day in the next moth.

Катица (Стевановић) Хедрих

Katica R. (Stevanovic) Hedrih
Head of Department of Mechanics