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NUMERICAL AND EXPERIMENTAL STUDY OF REGULAR AND CHAOTIC BEHAVIOR OF TRIPLE PHYSICAL PENDULUM

Contact author:
J.A. (Jan) Awrejcewicz
Technical University of Łódź, Łódź, Poland
k16@p.lodz.pl

Co-author(s):
B. Supeł, G. Kudra, G. Wasilewski and P. Olejnik
Technical University of Łódź, Łódź, Poland

The aim of the work is experimental and numerical analysis of regular and chaotic dynamics exhibited by periodically excited plane three-degrees-of-freedom triple physical pendulum. The triple physical pendulum is a subject of numerical investigation of few papers [1, 2], where three joined externally excited links are analysed, and where the arbitrarily situated rigid limiters of motion are introduced additionally. In that work periodic, quasi-periodic and chaotic attractor are shown with their Lyapunov exponents spectra. The numerical analysis of the orbit stability, seeking for periodic orbits and following their branches as well as bifurcation of periodic orbits analysis are performed also in [1, 2]. The present work bases on those investigations and its aim is to provide experimental confirmation of those results.

The experimental setup is still in progress and now we investigate the system without impacts. The mathematical model for numerical simulation is a special case of the system investigated in works [1, 2] , where links are joined with viscous damping and where the first body is excited by periodic moment of force of rectangular shape.

The physical model consists of three links with adjustable lengths and masses suspended on the tripod and joined by the use of radial and axial needle bearings. The external forcing acting on the first body is implemented by the use of the direct-current motor of our own construction with optical commutation. The voltage conveyed to the engine inductors is controlled by the use of special digital system of our own construction in order to obtain desired amplitude and frequency of the forcing. The measurement of the angular position of three links is realized using the precise rotational potentiometers and the LabView measure-programming system including libraries of function and development tools designed especially for data acquisition.

The parameters of the physical model are identified minimizing the function being a sum of square of deviations between the measured signal from physical model and the corresponding signal obtained by simulation of the mathematical model. The frequency and amplitude of the external forcing serve as control parameters, which are changed in order to obtain different behavior of the system.

Then few attractors including periodic and chaotic ones are found in the experimental model fitting well the attractors obtained numerically from mathematical model for the same sets of parameters.

References:

[1] J. Awrejcewicz, G. Kudra, C.-H. Lamarque, Investigation of triple physical pendulum with impacts using fundamental solution matrices, International Journal of Bifurcation and Chaos 14(12), 2004, to appear.
[2] G. Kudra, Analysis of Bifurcations and Chaos in Triple Physical Pendulum with Impacts, Ph.D. Thesis, Technical University of Lodz, 2002.