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Bifurcations in a four degrees-of-freedom dynamical system with friction

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ABSTRACT

This work presents some numerical results obtained in the analysis of a four degrees-of-freedom dynamical system with a discontinuity of vector field introduced in a degenerated region of the investigated state space. Special attention has been paid on the analysis of bifurcation scenarios both of the system parameters and the sliding region. The region of dynamical unpredictability has been defined analytically as the part of four dimensional state space which has, in fact, crucial influence on the system dynamics and the bifurcation of stick-slip solutions as well. On the contrary, a stick-slip motion termed sliding-standard solution and occurring, in general, in piece-wise smooth dynamical systems is proposed in the form of block-on-belt model. The analysis of sliding solutions and conditions of their appearance is made on the basis of the theory of Filippov systems [2].

Since a discontinuity boundary is introduced as a function of velocity of the belt, the investigated system can be divided into the two subsystems, which are separately and continuously solved in two appropriate regions. From the mechanical point of view the system assumed in the work is two dimensional, but by virtue of scenarios of bifurcation the dynamical system includes, in addition, two differential equations of first order describing dynamical changes in some parameters of the block-on-belt model. The two of four equations derived are introduced to disturb some of system parameters which have decisive influence on the system behavior. A precise transition existing between solutions being defined in the adjacent regions has been found by means of an numerical procedure with the exact crossing set detection [1]. The method including detection of points being located exactly in the crossing region is introduced and then implemented as well.

[1] Awrejcewicz J., Olejnik P., Numerical analysis of self-excited by friction chaotic oscillations in two degrees-of-freedom system using exact Hénon method. *Machine Dynamics Problems,* 26(4), 2002, 9–20.
[2] Filippov A.F., *Differential Equations with Discontinuous Righthand Sides*. Kluwer Academic Publishers, Dordrecht, 1998.