DSTA 2021 dys-ta.com
16th INTERNATIONAL CONFERENCE
Dynamical Systems – Theory and Applications
December 6-9, 2021, On-line

# Dynamics of impulse systems with friction

I.V. NIKIFOROVA[1*], V.S. METRIKIN[2], L.A. IGUMNOV[3]

1. National Research Lobachevsky State University of Nizhny Novgorod [0000-0002-6914-9845]
2. National Research Lobachevsky State University of Nizhny Novgorod [0000-0002-9749-5390]
3. National Research Lobachevsky State University of Nizhny Novgorod [0000-0003-3035-0119]

**Abstract:** The paper presents the results of a numerical-analytical study of the dynamics of a vibration-impulse mechanism with a crank-crank oscillator. Bifurcation diagrams and stability regions are given, which allow finding the main regularities in the reorganization of motion modes when changing the parameters of the mechanism.

**Keywords:** bifurcation, sustainability, vibration

## 1. Introduction

In the invention [1] and schemes of prototypes of mechanisms, a new scheme of a vibration-impulse mechanism with a crank-connecting rod vibration exciter for soil compaction in a closed production area is presented. The scheme contains several percussion pistons, which allows, as noted in [1], to more efficiently perform soil compaction, and small overall dimensions allow the mechanism to be used in difficult closed conditions. In [2], a mathematical model of a vibration-impulse mechanism with a crank-connecting rod oscillator is presented, together with formulas for finding the simplest periodic movements of the mechanism.

This work is a continuation of [2] and differs in that here we take into account the energy losses due to friction between the struts and the body. The results of numerical experiments are also presented, which made it possible to identify various types of movement of the mechanism, including stochastic ones, and to find the values of the parameters at which the known period doubling bifurcations are realized.

## 2. Results and Discussion

The scheme of the considered mechanism is shown on Fig. 1, where 1 is the mechanism's hull in which the bearings contain an axis 2 with a flywheel 3 and cranks 4 and 5 that have a stationary phase shift φ. The cranks have a joint connection to the piston rods 6; percussion pistons 7 and 8 are, in turn, connected to them with a joint. Under the percussion pistons we have anvils 9, 10 with heights $h_1$, $h_2$ respectively. The hull 1 has a joint connection to the racks 11 that are rigidly connected to the anvil block 12.

The rotation of the axis in the proposed scheme is transformed with a crank mechanism into a back-and-forth motion with respect to the anvil block. The percussion pistons may alternate their blows to the corresponding anvils, and the vibro-impulsive impact created here is transmitted through the anvil block to the material being compacted.

Taking into account the structure of the phase space and the behaviour of phase trajectories in it, the dynamics of the mechanism was studied using the method of point mappings [3].

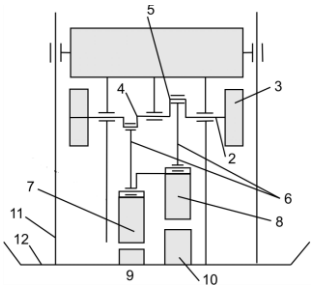


**Fig.2.** Vibro-impact mechanism diagram

The study of the complex dynamics of the two-piston mechanism was carried out using numerical experiments using a software package developed in the Borland C ++ Builder 6 environment. This software package was used to construct bifurcation diagrams and regions of existence of stable periodic motion modes.

## 3. Concluding Remarks

The proposed numerical-analytic method of study (based on the method of surface point maps) for the dynamics of new kinds of vibro-impulsive mechanisms has let us find regions in the space of parameters useful for successful tuning and control for the mechanism's motion, while our numerical computations imply the possibility for a specific choice of parameters and illustrate the basic reorganizations of the mechanism's motion modes depending on the changes in parameters. Using the peculiarities of the application of the method of point mappings in the study of the dynamics of systems with discontinuous nonlinearities [3], interesting results of a comparative analysis of the main modes of motion of the considered class of impulse systems with friction and without friction. were received.

**Acknowledgment:** This work was supported by the Ministry of Science and Higher Education of the Russian Federation, agreement No 0729-2020-0054.

## References

[1] SHILKOV V.A., SAVALYUK A.D., METRIKIN V.S., POLYAKOV A.A., SHABARDIN A.K., ALEKHIN A.I. AND OMENENKO I.YA.: *Vibrotrambovka (Vibrating Ramming),* USSR Inventor's Certificate no. 1020479, Byull. Izobret., 1983, no. 20, 3376593/29-33.

[2] IGUMNOV L. A., METRIKIN V. S., NIKIFOROVA I. V.: *The dynamics of eccentric vibration mechanism (Part 1):* JVE Journal of Vibroengineering 19, 4816-5656, 2017.

[3] FEIGIN M.I.: *Forced oscillations of systems with discontinuous nonlinearities*: M. Nauka, 1994. (in Russian)