16th INTERNATIONAL CONFERENCE
Dynamical Systems – Theory and Applications
December 6-9, 2021, On-line

Control algorithm of a vibrating robot with a flywheel and unbalance with limited angular acceleration.

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Abstract: When developing a robot for moving on the surface of small planets, in addition to low gravity, it is necessary to take into account the influence of an aggressive environment. The design of a vibrating robot, which is an isolated capsule, and moves due to the movement of internal masses and friction of various natures against the planet's surface, is considered. The robot is equipped with one unbalance and one flywheel. The unbalance angular acceleration control algorithm is built on the assumption that the robot can lift off the surface and perform a translational motion. It is shown that if the limitation on the maximum value of the unbalance acceleration is not considered for the selected algorithm, then the average speed of the body can also grow indefinitely. In this case, the standing time of the robot body is reduced, and its horizontal "flight" speed increases. An algorithm for controlling the robot is constructed, taking into account the limits on the angular acceleration of the unbalance and the flywheel.

Keywords: vibration robot; dry friction; mathematical model; control algorithm.

1. Introduction

A vibrating robot (an inertioid) is considered [1]. The robot consists of the body 1, the balanced flywheel 2, and the unbalance (eccentric) 3 (Fig. 1). The plane-parallel motion of the body on a rough surface is considered. The flywheel is driven by the motor around point *A*. The unbalance is rotated by another motor around point *B*. The center of mass of the unbalance is located at point *C*.

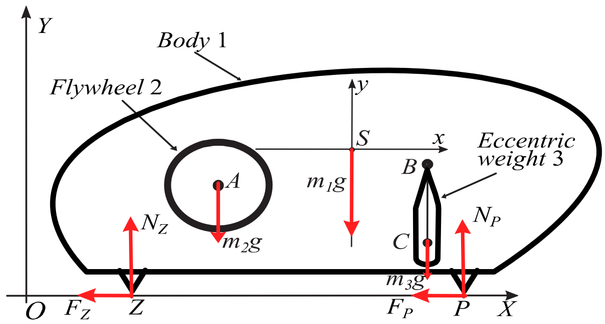

Fig. 1. Vibration robot with the balanced flywheel and the unbalance.

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The relative position of the centers of the robot body, flywheel and unbalance is arbitrary. We assume that the robot body is equipped with an accelerometer that measures the acceleration of its certain point, and the unbalance motor rotor is equipped with sensors for its angle of rotation and angular velocity, and the flywheel rotor is equipped with an angular velocity sensor. The angular accelerations of rotating structural links are used as control functions.

2. Estimation of the value of the unbalance speed when implementing the control algorithm

An algorithm for controlling the motion of the robot body in the desired direction is proposed. When the algorithm is implemented, with each new revolution of the eccentric, the time of the stages during which the body moves increases. The maximum body speed at each such subsequent stage also increases.

The proposed algorithm provides for sequential relay switching of the unbalance control angular acceleration φ''. In this case, on the phase plane, the representative point passes from the curve corresponding to the phase of acceleration of the rotating parts and the rest of the robot body (dashed green curve) to another, corresponding to the phase of "flight" and displacement of the robot body (solid red curve) and back. Let us consider the sequence φ_k of angle φ of unbalance rotation, at which the *k*-th odd switching of the angular acceleration occurs. It is shown that if we do not consider the limitation on the maximum value of acceleration, then the speed of rotation of the unbalance at $k \to \infty$ grows to infinity.

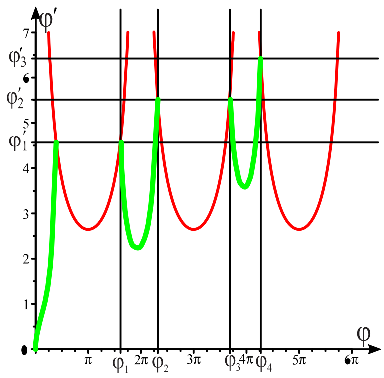

Fig. 2. Switching points on the phase plane.

3. Implementation of the new algorithm

An algorithm for controlling the robot is constructed taking into account the limits on the angular accelerations of the unbalance and flywheel. The impact of these accelerations on the average speed of the robot body is estimated.

References

[1] Dosaev M, Samsonov V, Hwang SS: Construction of control algorithm in the problem of the planar motion of a friction-powered robot with a flywheel and an eccentric weight. *Applied Mathematical Modelling.* 2021, **89** (2):1517-1527.