Drive for Nanobiotechnology

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ABSTRACT

The structural model of the drive for nanobiotechnology is obtained. The structural scheme of the drive is constructed. In nanobiotechnology for the control systems with the drive its deformations are determined.

Keywords

Drive, Piezo drive, Structural model and scheme, Nanobiotechnology.

Introduction

Piezo drive on the reverse piezo effect is applied for conversion energy in the control systems for nanobiotechnology [1-8]. Drive on the piezoelectric or electrostriction effects are used for nanomovements. The energy conversion in the structural scheme of the drive is visibility and logical [7-14].

The structural model and scheme of the drive are constructed from it matrix equations and differential equation for the drive [8-28].

Piezo drives are used for atomic force microscopy, nanomanipulators, nanotechnology, biotechnology, astronomy, space research, metrology, laser resonator [16-35].

Two matrix equations [8, 11-19] for the piezo drive have the form

\[(d) = \begin{pmatrix} 0 & 0 & 0 & d_{15} & 0 \\ 0 & 0 & 0 & d_{15} & 0 \\ d_{31} & d_{31} & d_{33} & 0 & 0 \end{pmatrix}\]

\[(e^T) = \begin{pmatrix} \varepsilon_{11}^T & 0 & 0 \\ 0 & \varepsilon_{22}^T & 0 \\ 0 & 0 & \varepsilon_{33}^T \end{pmatrix}\]

\[(S^E) = \begin{pmatrix} s_{11}^E & s_{12}^E & s_{13}^E & 0 & 0 & 0 \\ s_{12}^E & s_{13}^E & s_{13}^E & 0 & 0 & 0 \\ s_{13}^E & s_{13}^E & s_{33}^E & 0 & 0 & 0 \\ 0 & 0 & 0 & s_{25}^E & 0 & 0 \\ 0 & 0 & 0 & 0 & s_{25}^E & 0 \\ 0 & 0 & 0 & 0 & 0 & 2(d_{11}^E - s_{12}^E) \end{pmatrix}\]

The equation of the reverse piezo effect [8,11-48] for piezo drive on Figure 1 has the form

\[S_i = d_{mi}E_m + s_{ij}^E T_j\]

where \(m, i, j\) are axises.

Differential equation for drive in nanobiotechnology has the form [11-38].

\[\frac{d^2 \Xi(x,s)}{dx^2} - \gamma^2 \Xi(x,s) = 0\]
\[ \gamma = s/c + \alpha \]

where \( x \) is coordinate, \( s \) is operator, \( \gamma, \alpha \) are coefficients, \( c \) is speed of sound.

The equations of structural model for the drive have the form

\[
\begin{align*}
\Xi_1(s) &= \left[ \frac{1}{(M_1 s^2)} \right] - F_1(s) + \left[ \frac{1}{[\gamma/sh(h)]} \right] \left[ d_m \Psi_w(s) - \left[ \frac{\gamma}{\gamma} \right] \right] \left[ \chi h(\gamma) \Xi_1(s) - \Xi_2(s) \right] \\
\Xi_2(s) &= \left[ \frac{1}{(M_2 s^2)} \right] - F_2(s) + \left[ \frac{1}{[\gamma/sh(h)]} \right] \left[ d_m \Psi_w(s) - \left[ \frac{\gamma}{\gamma} \right] \right] \left[ \chi h(\gamma) \Xi_2(s) - \Xi_1(s) \right]
\end{align*}
\]

where \( v_{uw} = \begin{bmatrix} d_{33} & d_{31} & d_{15} \\ g_{33} & g_{31} & g_{15} \end{bmatrix}, \Psi_w = \begin{bmatrix} E_3 & E_1 \\ D_3 & D_1 \end{bmatrix}, \chi_{uw} = \begin{bmatrix} s_{33} & s_{11} & s_{35} \\ s_{33} & s_{11} & s_{35} \end{bmatrix}, \chi_{uw} = s_{ij}/s_0 \), and \( \Xi = E, D \) is the control parameter on Figure 2, \( l \) is the length drive, \( M_1, M_2 \) are the masses.

The steady-states of deformations for the drive have the form

\[
\begin{align*}
\xi_1 &= d_m \Psi_m M_2/(M_1 + M_2) \\
\xi_2 &= d_m \Psi_m M_1/(M_1 + M_2)
\end{align*}
\]

The steady-states for its deformations for the transverse piezo drive have the form

\[
\begin{align*}
\xi_1 &= d_m \Psi_m h/\delta M_2/(M_1 + M_2) \\
\xi_2 &= d_m \Psi_m h/\delta M_1/(M_1 + M_2)
\end{align*}
\]

For the piezo drive from PZT \( d_{31} = 0.25 \text{ nm/V}, \ h/\delta = 10, \ M_1 = 0.5 \text{ kg}, \ M_2 = 2 \text{ kg} \) and \( U = 50 \text{ V} \) its steady-states deformations are determined in the form \( \xi_1 = 100 \text{ nm}, \ \xi_2 = 25 \text{ nm}, \ \xi_1 + \xi_2 = 125 \text{ nm} \) with an error of 10%.

**Conclusions**

The structural model of the drive for nanobiotechnology is determined from matrix equations and differential equation for the drive. The equations structural model and the structural scheme of the drive are obtained for the control system in nanobiotechnology.

The piezo drives for nanobiotechnology are widely used for atomic force microscopy, nanomanipulators of precision equipment. The energy conversion in the structural scheme of the drive is visibility and logical.

**References**


39. Afonin SM. Condition absolute stability of control system


42. Afonin SM. Multilayer piezo engine for nanomedicine research. MOJ Applied Bionics and Biomechanics. 2020; 4: 30-31.


