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An Engine for Nanochemistry

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ABSTRACT
The structural model of an engine for nanochemistry is obtained. The structural scheme of an engine is constructed. For the control systems in nanochemistry with an elecro elastic engine its characteristics are determined.

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Introduction

An engine with piezoelectric or electrostrictive effect is used in precision control system for nanochemistry [1-6]. In structural schema of electro elastic engine its energy transformation is clearly [7-12]. The piezo engine is applied for precise adjustment for nanochemistry in adaptive optics and scanning microscopy [3-20].

Characteristics of an Engine

For an engine its equations in matrixes [8, 11-38] for nanochemistry have the form

$$[D]=[d][T]+[\varepsilon^T][E]$$

$$[S]=[s^E][T]+[d]^t[E]$$

where $[D]$, $[S]$, $[d]$, $[T]$, $[\varepsilon^T]$, $[E]$, $[s^E]$, $[d]^t$ are matrixes

electric induction, relative displacement, piezo coefficient, strength mechanical field, dielectric constant, strength electric field, elastic compliance, transposed piezo coefficient.

For piezo engine Figure 1 its relative displacement for 3 axis [8, 11-20] has the form

$$S_3 = d_{33}E_3 + s_{33}^E T_3$$

where d_{33} is piezo coefficient, E_3 is strength electric field on 3 axis, s^E_{33} is elastic compliance, T_3 is strength mechanical field on 3 axis.

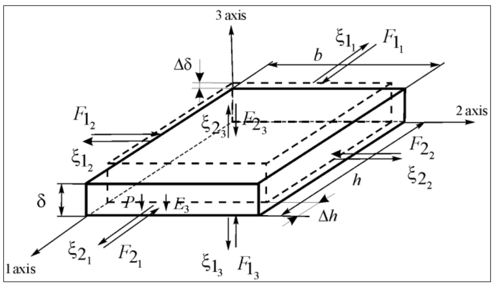

Figure 1: Piezo engine for nanochemistry

On the mechanical characteristic of longitudinal piezo engine its maximums values the force and the displacement are obtained in the form

$$F_{max} = d_{33}S_0E_3/s_{33}^E, \quad \Delta\delta_{max} = d_{33}\delta E_3 = d_{33}U$$

For $d_{33} = 4\cdot10^{-10}$ m/V, $S_0 = 1.5\cdot10^{-4}$ m², $\delta = 2.5\cdot10^{-3}$ m, $s_{33}^E = 15\cdot10^{-12}$ m²/N, $E_3 = 0.8\cdot10^5$ V/m the maximums values of the force and the displacement on Figure 2 are obtained $F_{max} = 320$ N and $\Delta\delta_{max} = 80$ nm with error 10%.

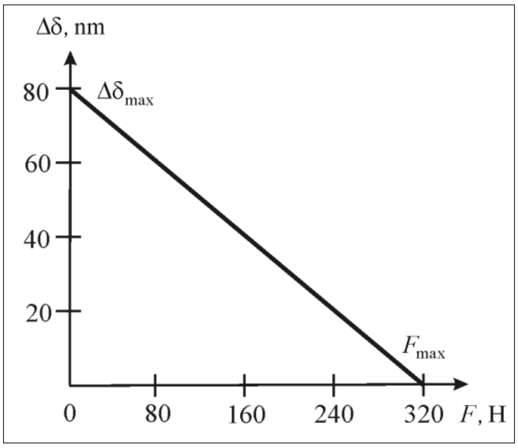

Figure 2: Mechanical characteristic of longitudinal piezo engine for nanochemistry

The differential equation of an electro elastic engine for nanochemistry has the form [11-45]

$$\frac{d^2\Xi(x,s)}{dx^2} - \gamma^2\Xi(x,s) = 0$$

$$\gamma = s/c^E + \alpha$$

here $\Xi(x,s)$ is the Laplace transform displacement, s is the parameter, x is the coordinate. The decision this differential equation is determined in the form

$$\Xi(x,s) = Ae^{-x\gamma} + Be^{x\gamma}$$

Using the expressions

$$\Xi(0,s) = \Xi_1(s) \text{ for } x = 0$$
$$\Xi(l,s) = \Xi_2(s) \text{ for } x = l$$

where l is length.

We have the coefficients A and B in the form

$$A = \left(\Xi_1 e^{l\gamma} - \Xi_2\right)/[2\text{sh}(l\gamma)]$$
$$B = \left(\Xi_2 - \Xi_1 e^{-l\gamma}\right)/[2\text{sh}(l\gamma)]$$

The solution equation has form

$$\Xi(x,s) = \{\Xi_1(s)\text{sh}[(l-x)\gamma] + \Xi_2(s)\text{sh}(x\gamma)\}/\text{sh}(l\gamma)$$

For an engine its system of the stresses has the form

$$T_j(0,s) = \left(s_{ij}^{\Psi}\right)^{-1} \left.\frac{d\Xi(x,s)}{dx}\right|_{x=0} - \nu_{mi}\left(s_{ij}^{\Psi}\right)^{-1}\Psi_m(s)$$
$$T_j(l,s) = \left(s_{ij}^{\Psi}\right)^{-1} \left.\frac{d\Xi(x,s)}{dx}\right|_{x=l} - \nu_{mi}\left(s_{ij}^{\Psi}\right)^{-1}\Psi_m(s)$$

where ν_{mi} is electro elastic coefficient.

Also the structural model of an engine for Figure 3 has the form

$$\Xi_1(s) = \left(M_2 s^2\right)^{-1}\left\{-F_1(s) + \left(\chi_{ij}^{\Psi}\right)^{-1}\begin{bmatrix}\nu_{mi}\Psi_m(s) - [\gamma/\text{sh}(l\gamma)] \\ \times[\text{ch}(l\gamma)\Xi_1(s) - \Xi_2(s)]\end{bmatrix}\right\}$$

$$\Xi_2(s) = \left(M_2 s^2\right)^{-1}\left\{-F_2(s) + \left(\chi_{ij}^{\Psi}\right)^{-1}\begin{bmatrix}\nu_{mi}\Psi_m(s) - [\gamma/\text{sh}(l\gamma)] \\ \times[\text{ch}(l\gamma)\Xi_2(s) - \Xi_1(s)]\end{bmatrix}\right\}$$

where $\nu_{mi} = \begin{cases} d_{33}, d_{31}, d_{15} \\ g_{33}, g_{31}, g_{15}\end{cases}$, $\Psi_m = \begin{cases} E_3, E_1 \\ D_3, D_1\end{cases}$, $s_{ij}^{\Psi} = \begin{cases} s_{33}^E, s_{11}^E, s_{55}^E \\ s_{33}^D, s_{11}^D, s_{55}^D\end{cases}$, $l = \{\delta, h, b$, $\gamma = \{\gamma^E, \gamma^D$, $c^{\Psi} = \{c^E, c^D$, $\chi_{ij}^{\Psi} = s_{ij}^{\Psi}/S_0$, and $\Psi = E$ or $\Psi = D$.

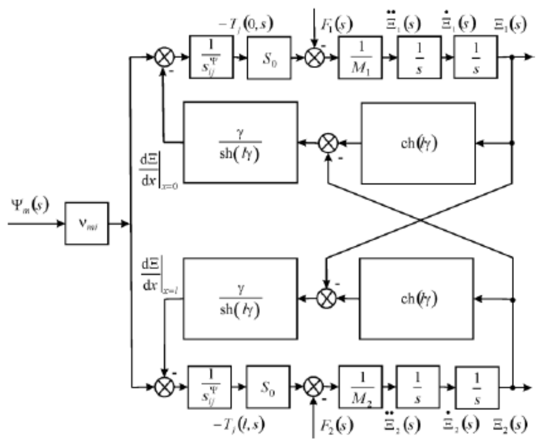

Figure 3: Structural scheme of an engine for nanochemistry

This structural scheme is used for calculation the deformations of the electro elastic engine in nanochemistry. From the structural model the matrix equation has the form

$$\begin{bmatrix}\Xi_1(s) \\ \Xi_2(s)\end{bmatrix} = \begin{bmatrix} W_{11}(s) & W_{12}(s) & W_{13}(s) \\ W_{21}(s) & W_{22}(s) & W_{23}(s)\end{bmatrix}\begin{bmatrix}\Psi_m(s) \\ F_1(s) \\ F_2(s)\end{bmatrix}$$

The steady-state movements of the faces 1 and 2 have the form

$$\xi_1 = d_{mi} M_2 l\Psi_m/(M_1 + M_2)$$
$$\xi_2 = d_{mi} M_1 l\Psi_m/(M_1 + M_2)$$

The steady-state movements of the longitudinal piezo engine have the form

$$\xi_1 = d_{33} M_2 U/(M_1 + M_2)$$
$$\xi_2 = d_{33} M_1 U/(M_1 + M_2)$$

For $U = 200$ V, $d_{33} = 4\cdot10^{-10}$ m/V, $M_1 = 0.5$ kg, $M_2 = 2$ kg the steady-state movements matter $\xi_1 = 64$ nm, $\xi_2 = 16$ nm, $\xi_1 + \xi_2 = 80$ nm and error 10%.

The steady-state movement of the transverse piezo engine with fixed one face and at elastic-inertial load has the form

$$\Delta h = \frac{d_{31}Uh/\delta}{1 + C_l/C_{11}^E}$$

For the transverse piezo engine at elastic-inertial load the expression has the form

$$W(s) = \frac{\Xi(s)}{U(s)} = \frac{d_{31}h/\delta}{\left(1 + C_l/C_{11}^E\right)\left(T_t^2 p^2 + 2T_t\xi_t p + 1\right)}$$
$$T_t = \sqrt{M/\left(C_l + C_{11}^E\right)}, \quad \omega_t = 1/T_t$$

where C_l, C^E_{11} are the stiffness of load and engine, T_t, ξ_t, ω_t are the time constant, the attenuation coefficient and the conjugate frequency of the engine. For $M = 2$ kg, $C_l = 0.2\cdot10^7$ N/m, $C^E_{11} = 1\cdot10^7$ N/m, we have the time constant $T_t = 0.4\cdot10^{-3}$ s and the conjugate frequency of the engine $\omega_t = 2.5\cdot10^3$ s^{-1} with error 10%.

Conclusions

For an engine its structural model for nanochemistry is determined. The structural scheme of an engine is constructed. The characteristics of an engine are obtained.

References

1. Schultz J, Ueda J, Asada H (2017) Cellular Actuators. Butterworth-Heinemann Publisher, Oxford, 382.
2. Afonin SM (2006) Absolute stability conditions for a system controlling the deformation of an elecromagnetoelastic transduser. Doklady Mathematics 74: 943-948.
3. Uchino K (1997) Piezoelectric actuator and ultrasonic motors. Boston, MA: Kluwer Academic Publisher 350 .
4. Afonin SM (2005) Generalized parametric structural model of a compound elecromagnetoelastic transduser. Doklady Physics 50: 77-82.
5. Afonin SM (2008) Structural parametric model of a piezoelectric nanodisplacement transducer. Doklady Physics 53: 137-143.

6. Afonin SM (2006) Solution of the wave equation for the control of an elecromagnetoelastic transduser. Doklady Mathematics 73: 307-313.
7. Cady WG (1946) Piezoelectricity: An introduction to the theory and applications of electromechancial phenomena in crystals. McGraw-Hill Book Company, New York, London, 806.
8. Mason W, editor (1964) Physical Acoustics: Principles and Methods. Vol.1. Part A. Methods and Devices. Academic Press, New York, 515.
9. Y Yang, L Tang (2009) Equivalent circuit modeling of piezoelectric energy harvesters. Journal of Intelligent Material Systems and Structures. 20: 2223-2235.
10. Zwillinger D (1989) Handbook of Differential Equations. Academic Press, Boston, 673.
11. Afonin SM (2006) A generalized structural-parametric model of an elecromagnetoelastic converter for nano- and micrometric movement control systems: III. Transformation parametric structural circuits of an elecromagnetoelastic converter for nano- and micrometric movement control systems, Journal of Computer and Systems Sciences International 45: 317-325.
12. Afonin SM (2016) Decision wave equation and block diagram of electromagnetoelastic actuator nano- and microdisplacement for communications systems. International Journal of Information and Communication Sciences 1: 22-29.
13. Afonin SM (2015) Structural-parametric model and transfer functions of electroelastic actuator for nano- and microdisplacement. Chapter 9 in Piezoelectrics and Nanomaterials: Fundamentals, Developments and Applications. Ed. Parinov IA. Nova Science, New York, 225-242.
14. Afonin SM (2017) A structural-parametric model of electroelastic actuator for nano- and microdisplacement of mechatronic system. Chapter 8 in Advances in Nanotechnology. Volume 19. Eds. Bartul Z, Trenor J, Nova Science, New York, 259-284.
15. Afonin SM (2018) Electromagnetoelastic nano- and microactuators for mechatronic systems. Russian Engineering Research 38: 938-944.
16. Afonin SM (2012) Nano- and micro-scale piezomotors. Russian Engineering Research 32: 519-522.
17. Afonin SM (2007) Elastic compliances and mechanical and adjusting characteristics of composite piezoelectric transducers, Mechanics of Solids 42: 43-49.
18. Afonin SM (2014) Stability of strain control systems of nano- and microdisplacement piezotransducers. Mechanics of Solids 49: 196-207.
19. Afonin SM (2017) Structural-parametric model electromagnetoelastic actuator nanodisplacement for mechatronics. International Journal of Physics 5: 9-15.
20. Afonin SM (2019) Structural-parametric model multilayer electromagnetoelastic actuator for nanomechatronics. International Journal of Physics 7: 50-57.
21. Afonin SM (2021) Calculation deformation of an engine for nano biomedical research. International Journal of Biomed Research 1: 1-4.
22. Afonin SM (2021) Precision engine for nanobiomedical research. Biomedical Research and Clinical Reviews. 3: 1-5.
23. Afonin SM (2016) Solution wave equation and parametric structural schematic diagrams of electromagnetoelastic actuators nano- and microdisplacement. International Journal of Mathematical Analysis and Applications 3: 31-38.
24. Afonin SM (2018) Structural-parametric model of electromagnetoelastic actuator for nanomechanics. Actuators 7: 1-9.
25. Afonin SM (2019) Structural-parametric model and diagram of a multilayer electromagnetoelastic actuator for nanomechanics. Actuators 8: 1-14.
26. Afonin SM (2016) Structural-parametric models and transfer functions of electromagnetoelastic actuators nano- and microdisplacement for mechatronic systems. International Journal of Theoretical and Applied Mathematics 2: 52-59.
27. Afonin SM (2010) Design static and dynamic characteristics of a piezoelectric nanomicrotransducers. Mechanics of Solids 45: 123-132.
28. Afonin SM (2018) Electromagnetoelastic Actuator for Nanomechanics. Global Journal of Research in Engineering: A Mechanical and Mechanics Engineering 18: 19-23.
29. Afonin SM (2018) Multilayer electromagnetoelastic actuator for robotics systems of nanotechnology, Proceedings of the 2018 IEEE Conference EIConRus, 1698-1701.
30. Afonin SM (2018) A block diagram of electromagnetoelastic actuator nanodisplacement for communications systems. Transactions on Networks and Communications 6: 1-9.
31. Afonin SM (2019) Decision matrix equation and block diagram of multilayer electromagnetoelastic actuator micro and nanodisplacement for communications systems, Transactions on Networks and Communications 7: 11-21.
32. Afonin SM (2020) Condition absolute stability control system of electromagnetoelastic actuator for communication equipment. Transactions on Networks and Communications 8: 8-15.
33. Afonin SM (2020) A Block diagram of electromagnetoelastic actuator for control systems in nanoscience and nanotechnology, Transactions on Machine Learning and Artificial Intelligence 8: 23-33.
34. Afonin SM (2020) Optimal control of a multilayer electroelastic engine with a longitudinal piezoeffect for nanomechatronics systems. Applied System Innovation 3: 1-7.
35. Afonin SM (2021) Coded control of a sectional electroelastic engine for nanomechatronics systems. Applied System Innovation 4: 1-11.
36. Afonin SM (2020) Structural scheme actuator for nano research. COJ Reviews and Research 2: 1-3.
37. Afonin SM (2018) Structural–parametric model electroelastic actuator nano- and microdisplacement of mechatronics systems for nanotechnology and ecology research. MOJ Ecology and Environmental Sciences 3: 306–309.
38. Afonin SM (2018) Electromagnetoelastic actuator for large telescopes. Aeronautics and Aerospace Open Access Journal 2: 270-272.
39. Afonin SM (2019) Condition absolute stability of control system with electro elastic actuator for nano bioengineering and microsurgery. Surgery & Case Studies Open Access Journal 3: 307–309.
40. Afonin SM (2019) Piezo actuators for nanomedicine research. MOJ Applied Bionics and Biomechanics 3: 56-57.
41. Afonin SM (2019) Frequency criterion absolute stability of electromagnetoelastic system for nano and micro displacement in biomechanics. MOJ Applied Bionics and Biomechanics 3: 137-140.
42. Afonin SM (2020) Multilayer piezo engine for nanomedicine research. MOJ Applied Bionics and Biomechanics 4: 30-31.
43. Afonin SM (2021) Rigidity of a multilayer piezoelectric actuator for the nano and micro range. Russian Engineering Research 41: 285-288.
44. Nalwa HS, editor (2004) Encyclopedia of Nanoscience and Nanotechnology. Los Angeles: American Scientific Publishers 10.

45. Bhushan B, editor (2004) Springer Handbook of Nanotechnology. New York: Springer, 1222.