Multilayer Engine for Microsurgery and Nano Biomedicine

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Abstract
In this paper, the structural circuit of the multilayer engine for microsurgery and nano biomedicine is received. We obtained the characteristics of the multilayer engine.

Keywords: Multilayer engine; Structural circuit

Introduction
The multilayer engine with the piezoelectric or electrostriction effects is used for microsurgery and nano biomedicine [1-9]. We received the structural circuit of the multilayer engine in contrast to Cady’s and Mason’s equivalent circuits [9-32]. We determined the mathematical model and the structural circuit of the multilayer engine with the equation of the electro elasticity and the matrix of the quadripole for the multilayer engine.

Structural Circuit of the Multilayer Engine
We received the structural circuit of the multilayer engine for microsurgery and nano biomedicine in difference from Cady’s and Mason’s equivalent circuits [1–14]. We have the matrix equation electro elasticity [7,8,14] in the form

\[ \Psi + \Psi \nu = \text{Ts} \]

In this equation we write the relative displacement, the coefficient of electro elasticity, the control parameter, the elastic compliance, the mechanical stress in the forms

\[ i, m, j, T \]

The causes force for the multilayer engine has the form

\[ F = \nu_m S_0 \Psi_m / s_i \]

where \( S_0 \) is the area of the multilayer engine.

The matrix of the quadripole for the multilayer engine [7, 29, 31] has the form

\[ [M] = \begin{bmatrix} \Psi & (\gamma) & \Psi \nu & (\gamma) \end{bmatrix} \]

In this equation we write \( l \) is the length of the multilayer engine and \( \gamma \) is the coefficient propagation.

We have the structural circuit of the multilayer engine for microsurgery and nano biomedicine on Figure 1 from its mathematical model in the form

\[ \Xi(p) = \left[ \begin{array}{c} \psi_1(p) \\ \psi_2(p) \end{array} \right] \]

where

\[ \psi_1 = \begin{pmatrix} d_1, d_1, d_1 \\ S, s, s \end{pmatrix}, \psi_2 = \begin{pmatrix} E_1, E_2 \\ D, D \end{pmatrix}, s_i = \begin{pmatrix} s_i, s_i, s_i \\ s_i, s_i, s_i \end{pmatrix}, l = \begin{pmatrix} l_i \\ l_i \end{pmatrix} \]

\[ \alpha = \gamma c_i, \beta = p/c_i + \alpha, \chi^v = s_i / S_0 \]

We have the matrix equation of the multilayer engine for microsurgery and nano biomedicine in the form

\[ \Xi(p) \Xi(p) = W(p)P(p) \]
In this equation we write the matrices \[ \begin{bmatrix} \Xi(p) \\ W(p) \\ P(p) \end{bmatrix} \].

In static for the multilayer engine with longitudinal piezo effect and one fixed end we received displacement in the form

\[ i_2 = \frac{d_s}{1 + C_s/C_s^E} n \]

where \( C_s, C_s^E \) are the rigidity of the load and the rigidity of the multilayer engine for \( E = \text{const} \). We received for the multilayer engine at \( d_3 = 4 \times 10^{-10} \text{m/V}, n = 12, U = 200 \text{V}, C_s^E = 2 \times 10^6 \text{N/m}, C_s = 0.4 \times 10^7 \text{N/m} \) the static displacement \( i_2 = 800 \text{nm} \).

We obtained the transfer function with lumped parameters of the multilayer engine with longitudinal piezo effect and one fixed end in the form

\[ W(p) = \frac{\Xi_2(p)}{U(p)} = \frac{d_s n}{(1 + C_s/C_s^E) \left( T_{3s}^2 + 2T_{3s}^0 + 1 \right)} \]

\[ T_{3s} = \sqrt{M_{3s}(C_s \cdot C_s^E)} \quad \xi_3 = \alpha(\delta_3) \xi_s^E \left( \frac{3c_s^E}{1} \sqrt{M_{3s}(C_s \cdot C_s^E)} \right) \]

where \( T_{3s}, \xi_3 \) are the time constant, the damping coefficient of the multilayer engine. Therefore, for the multilayer engine at \( d_3 = 4 \times 10^{-10} \text{m/V}, n = 12, U = 200 \text{V}, M_{3s} = 4 \text{kg}, C_s^E = 2 \times 10^6 \text{N/m}, C_s = 0.4 \times 10^7 \text{N/m} \) we have \( T_2 = 800 \text{nm} \) and \( T_{3s} = 0.4 \times 10^{-3} \text{s} \).

**Conclusion**

The structural circuit of the multilayer engine for microsurgery and nano biomedicine is obtained. The characteristics of the multilayer engine are received with using its structural circuit.

**References**


