347. A flat compound piezoelectric actuator of a type “a shaking beam”

P. Vasiljev[1]**, R. Bareikis**[2]**, L. Vasiljeva**[3]**, J. Tiškevičius**[4]**, A. Rotmanas**[5]
Vilnius Pedagogical University
Studentų 39, LT-08106 Vilnius, Lithuania
Phone: +370 5 2750992
E-mail: [1]*vasiljev@vpu.lt,* [2]*bare@vpu.lt,* [3] *vasiljev@cablenet.lt,* [4]*tdk@vpu.lt,* [5]*alrotman@vpu.lt*

(Received 19 February 2008; accepted 20 March 2008)

Abstract. It is investigated piezoelectric actuator, consisting of two flat converters of longitudinal fluctuations which ends are close by the hence – « a shaking beam ». Also is resulted the principle of work actuator in quality stator of the motor, and also as the ultrasonic concentrator of fluctuations. Additionally is made research of it actuator with the help of programs computer modeling. And is carried out optimization of the sizes driver hence actuator.

Theoretical researches are confirmed experimentally, with the help of the precision laser equipment.

Keywords: piezomotor, “shaking beam”, actuator, FEM

Introduction

After the publication of work «Actuator of type “Shaking beam”» [1] (Fig.1) has appeared a number of researches on creation actuators, not only for moving a body to one, linear or rotary direction [2,3], but also in two [4] or even three directions [5]. There is moving a body to planes or rotation of a sphere in three directions. In all mentioned variants for excitation actuator are used fluctuations of columns piezoelements in a direction of their polarization d_{33}. A source of electric fluctuations is one or several harmonious fluctuations of one resonant frequency with shift of a phase on ±90° or ±270°.

In works [6, 7] are resulted researches of linear motors with use d_{31} – actuator such as “a shaking beam”. However the detailed analysis such actuator is not present till now.

Aktuator for the linear motor with use "d_{31}" fluctuations.

Actuator (Fig.2) it is constructed on the basis of a flat symmetric two-side frame. Both sides of the basis form shoulders – resonators (1) longitudinal fluctuations, which end faces by means of T- figurative slit (2) pass in a cross-section beam (3) – “a shaking beam”. The middle of a

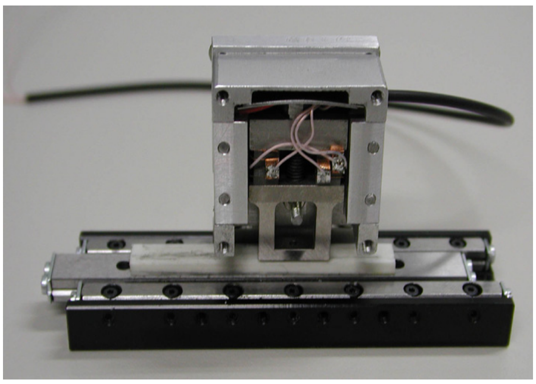

Fig. 1. Linear piezomotor on base of “Shaking beam” actuator

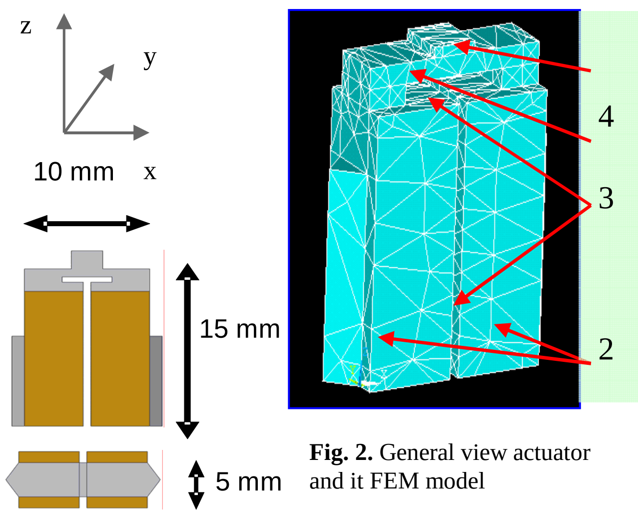

Fig. 2. General view actuator and it FEM model

shaking beam is executed with a lookout which is a drive element (4). Each resonator contains the flat piezoelectric plates polarized on thickness. Piezoplates are pasted on the basis so that at transformation fluctuations were excited d_{31} fluctuations and were absent flexural fluctuations.

In the present work it is investigated actuator in quality stator piezoelectric motor. This mode of fluctuations is supply on electrodes piezoplates opposite shoulders sin and cos – electric fluctuations. In this case [1] drive element forms an elliptic trajectory of movement.

It was researched actuator, made of phosphorits bronze the type БРОФ, with the sizes shown 10x15x5mm. The piezoelectric plates material - PI 181.

FEM Modeling and Analysis

It is natural to suppose about availability of optimum connection of the resonant length shoulders actuator (longitudinal fluctuations) with the cross-section size of "a shaking beam" (flexural fluctuations). For this purpose it is carried out FEM – the analysis of fluctuations actuator at different width horizontal "T" - a figurative slit.

On electrodes piezoplates are supplied the sine wave voltage of various amplitude. The criterion of an estimation actuator chooses the factor strengthening of amplitudes fluctuations.

$$K = \frac{\xi_1}{\xi_2}$$

where ξ_1 - amplitude of fluctuations a drive element (4) beams, ξ_2 - amplitude of fluctuations shoulders actuator.

On Table 1 is shown dependence of the strengthening factor actuator and values of its resonant frequency from width of a slip "b".

Table 1

B, mm	0,25	0,5	0,75	1,0	1,25	1,5	1,75
K	3,1	3,6	6,8	9,5	7,1	0,5	0,2
F, KHz	119	116	113	107	98	170	155

Resonant frequency 107 kHz is sin form to optimum cross-section section of a beam (b=1mm) at which the amplitude fluctuations of the middle of a beam is maximal (k=9.46).

On Fig. 3 amplitude frequency dependence actuator is shown at optimum cross-section section of a beam.

Fig. 4 is testifying to about manifestation of the resonant properties beam, as resonator flexural fluctuations.

For actuator with an optimum relation of length its shoulders, cross-section section of a beam and frequency and has been carried out calculation of elliptic trajectories drive element beam. This mode fluctuation is carried out at submission on electrodes piezoplates opposite shoulders – sin and cos – electric fluctuations.

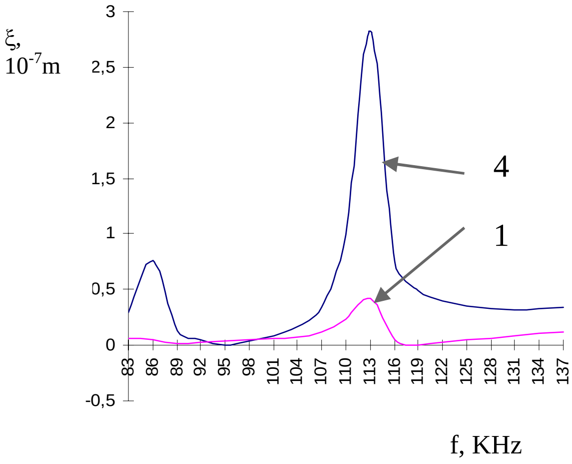

Fig. 3. Amplitude-frequency dependence actuator: 4- fluctuation drive element; 1- fluctuation shoulders.

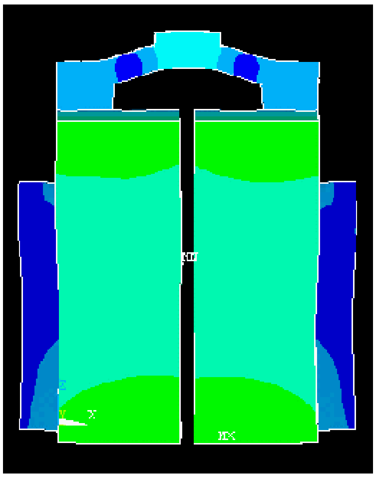

Fig. 4. Kind of optimum displacement of a beam.

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The analysis shows, that the form elliptic trajectories a little differs with change of the electric voltage (sin, cos), supplied on electrodes piezoelements shoulders actuator. Only amplitudes in directions x and z obviously are change.

On Fig. 5 are shown the elliptic trajectories fluctuations of the middle and the ends of "a shaking beam" at two values of an electric voltage (a - 20V, b - 150V).

Experimental Results

The experimental research was carried out in order to find distribution of oscillations amplitudes on the stator surfaces and trajectories of drive points. The experimental investigation must also sustain theoretical prerequisites on oscillations of the FEM model and the stator. Amplitude – frequency characteristics were determined using the impedance analyzer 4192A LF (Hewlett Packard). Surface oscillations of drive points and surfaces were controlled

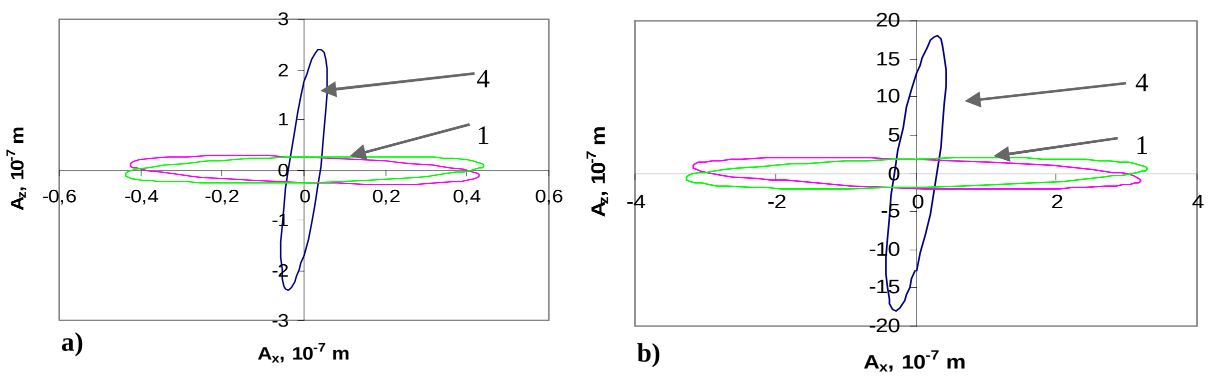

Fig. 5. The elliptic trajectories fluctuations of "a shaking beam" at electric voltage: *a* - 20V; *b* - 150V

using Doppler-laser (POLYTEC CLV 3D). Characteristic of the drive points of the stator surface oscillations was measured using Doppler-laser vibrometer.

On Fig.6 are shown experimentally established trajectories of movement drive element actuator (stator piezomotor) and its shoulders in planes x-z. Results show satisfactory concurrence of experiment to the theory. The closed trajectory movement drive element is more stretched in a direction "x", and, it is more, than the electric voltage is higher. On the ends of shoulders actuator also it is formed elliptic trajectories of movement.

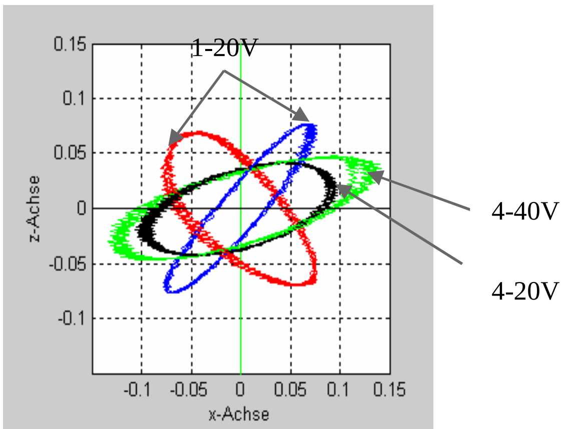

Fig.6. Trajectories of movement characteristic actuator-stator of piezomotor

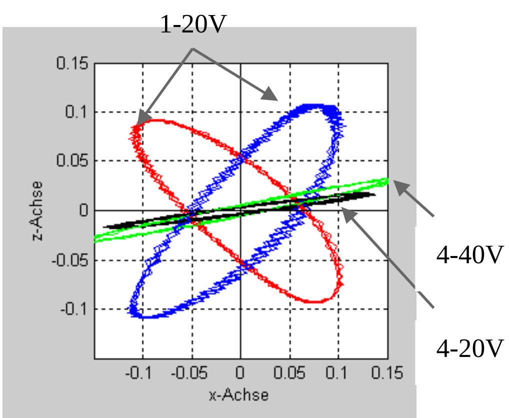

Fig. 7. Trajectories of movement characteristic the typical point's actuator in quality oscillator

Let's notice, that in some areas of technique it is necessary actuator with oscillatory – translational motion of its working surface. For example, it needs for scanning a beam laser, or for ultrasonic micro welding. Realization of such mode is reduced to submission on both shoulders actuator a sine wave voltage with shift of a phase on 180°. On Fig.7 are shown experimentally established trajectories of movement drive element above mentioned actuator. It is visible, that the trajectory of movement drive element is close to a line.

Conclusion

It is created flat actuator such as "a shaking beam" with use of longitudinal fluctuations in a direction d_{31}. The carried out researches show opportunities of its application not only in quality piezomotor stator, but also in quality oscillator for scanning a laser beam or for ultrasonic micro welding.

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