11th International DAAAM Baltic Conference
"INDUSTRIAL ENGINEERING -
20-22 April 2016, Tallinn, Estonia

IMPROVING RELIABILITY ELEMENT BASE OF CONTROL SYSTEM AND AUTOMATION

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Abstract: *In order to increase the durability and efficiency functioning of the automatics devices at the magnetically-controlled contacts exercised dismantling a number of modifications contact systems of reed switches and micro-sensor pressures (DMD). Proposed by the authors of article engineering and design solution of the membrane mercurial reed switches, which requires bringing modern technology, will increase the sensitivity, increase switching currents, reducing bounce, improve manufacturability, as well as increased durability of the membrane contacts.*
Key words: elastic sensor, reed switch, membrane, regular microrelief, control system.

1. INTRODUCTION

Reed switches are the switching elements of the circuits of automation and are widely used in relays based on them. The latter are widely used in software and logic schemes of automation and remote control, alarms and protection, weighing and control, automatic control valves in radio, telephone, and electric appliances, and other mouth-discrete devices operation [1,2].
The tendency of risk mitigation in maintenance of control systems constantly forces to pay attention to the improvement of existing designs of switching elements and methods of calculating static and dynamic characteristics for the purpose of increasing sensitivity, increasing switching currents, reducing the bounce, improve manufacturability, and increase the lifetime of the membrane contacts. Mathematical modelling of the dynamics of the switching elements reduces the amount of costly experiments at the design stage [3].
Important role in the establishment and development of methods for the analysis of elastic sensing elements have made such scientists as: Andreeva A. N., Korsunov V. P., as well as some foreign scientists: Reissner E., M. Hamada, K., etc.
The authors analysed the stiffness and frequencies of the membrane elements of the reed switch and proposed a several modifications.
It shall contain and be structured in the following way: problem statements, application area, research course, method used, status, results, further research, references.

2. ANALYSIS OF STIFFNESS AND FREQUENCIES OF MEMBRANE ELEMENTS

In modern switching elements of reed switches can be used with both round and rectangular membrane [1]. On the example of square membranes consider the characteristics that are most important for use as a sensitive element of the contact group [1,2].
Clamped along the contour of a square membrane with size A×A and thickness c_n loaded by evenly distributed differential pressure Δp (Fig.1).
If the frequency of the intensity change Δp is much less than the oscillation frequency of the main (lowest) tone, move the points of the membrane has the form

$$\delta(x,z)=\Lambda\left(1-\cos\frac{2\pi x}{A}\right)\left(1-\cos\frac{2\pi z}{A}\right), \quad (1)$$

where $\Lambda=\dfrac{\Delta pA^4}{32\pi^4 D}$, $D=\dfrac{Ec_i^3}{12\left(1-v^2\right)}$ – cylindrical stiffness of the plate (v – Poisson's ratio).

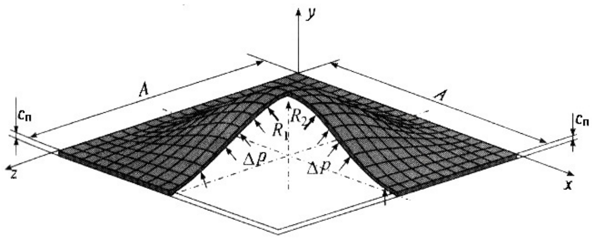

Fig. 1. The deformation of the square membrane

Obviously, the maximum displacement corresponds to the centre of the membrane with coordinates *x = A/2*; *z = A*:

$$\delta_{\max}=\frac{\Delta pA^4}{8\pi^4 D}$$

Define the stiffness of the membrane in the direction of the y axis

$$G_y=\frac{\Delta pS}{\delta_{\max}}=\frac{\Delta pA^2}{\delta_{\max}}=\frac{8\pi^4 D}{A^2}, \ (S=A^2)$$

and the pitch frequency of the membrane:

$$f=\sqrt{\frac{G_y}{m}}=\frac{\pi^2}{A^2}=\sqrt{\frac{8D}{\rho c_n}},$$

where $m=Sc_n\rho$ – mass of membrane (ρ – density of the membrane material).

Elongation of the membrane in the direction of axes x and z;

$$\left.\begin{aligned} e_x&=\frac{x}{R_1}=-y\frac{\Delta pS}{8\pi^2 D}\cos\frac{2\pi x}{A}\left(1-\cos\frac{2\pi z}{A}\right);\\ e_z&=\frac{z}{R_2}=-y\frac{\Delta pS}{8\pi^2 D}\cos\frac{2\pi z}{A}\left(1-\cos\frac{2\pi x}{A}\right).\end{aligned}\right\}(2)$$

Expressions (2) allow to determine the location of the resistors R_1, R_2 (topology) on the membrane. If, for example, the plane of their location is defined by *y=0*, the points with coordinates *x*=0, *z=A/2* and *x=A*, *z=A/2* and *z=0*, *x=A*/2 and *z=A*, *x=A*/2 maximum deformation defined by the formula:

$$e_{\max}=\frac{\Delta pc_n S}{8\pi^2 D}.$$

At the points with the maximum relative deformation of the membrane should be placed (implanted) resistors included, usually in bridge schemes. At points with coordinates *x=A/4*, *z=A/2* and *x=A/2*, *z=A/4* and *z=A/2*, *x=3A/4* and z=*3A/4*, *x=A/2* deformation zero, and ethics in the field should be placed resistors for temperature compensation.

The point with zero relative deformation correspond to points of inflection of lines, the resulting cross-sections of the deformed middle plane of the membrane planes passing through the point with coordinates *x= A/2*, *z=A/2* and perpendicular to the *xz* plane.

Substitute any of the coordinates of points with zero relative deformation in the expression (1) and get moving inflection points:

$$\delta(x,z)=\frac{\Delta pA^4}{16\pi^4 D}.$$

4. CONCLUSION

The mathematical expression allowed the authors to analyze the characteristics of the most important when estimating sensitivity, bounce and service life of the membrane contact [4].

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