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DEVELOPMENT OF THE COMPLIANT MECHANISMS ON THE BASE FLEXIBLE ELASTIC THIN-WALLED ELEMENTS

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ABSTRACT

The mechanism is considered, in which as a working element the flexible elastic thin-walled element with the any form of an axis is used. The moving of an element is carried out at submission of pressure in a cavity of an element. The given task is nonlinear and are reduced to the second regional task Koshee. For the decision the method of discrete continuation on parameter in a combination to a method multisegment shooting is used. The technique allows to pick up under the given law of moving geometrical parameters of a flexible element.

Key words**:** a flexible elastic thin-walled element, working characteristic, discrete moving, working body.

INTRODUCTION

In modern technology vacuum technologies are widely used. Vacuum technology has its own characteristics [1, 7, 11]. In manipulators working in conditions of vacuum, it is necessary to reduce external friction negatively influencing on working environment. It is possible to apply to elimination of external friction mechanisms, in which the moving of the executive body is carried out thanking deformation of a flexible elastic thin-walled element at submission of pressure in a cavity of an element. The connection of elements among themselves allows to create mechanisms carrying out various functions: moving of the executive bodies or force influence them on object of processing [3]. Depending on parameters of an element and character loading the occurrence of effect bifurkation, allowing by jump to change the form of an element and, due to this is possible, to provide discrete moving of a working body. In connection with wide use of elastic thin-walled elements the research of elements with various geometrical parameters is necessary.

Definition of a task

Two types of flexible elements are considered:

Flexible element having a plane of symmetry;

Flexible element as a pneumatic spring bent on some radius of curvature.

The element of the first type can be simulated by the bent core, which form coincides with the form of cross section. Different variants of parities for flexible cores are known today. As permitting system the system of the nonlinear differential equations concerning basic unknown is used. Vector basic unknown in current section of a core enters the name as

$$X^T = \{X, Y, \psi, N, Q, M\}, \quad (1)$$

where X, Y - coordinates of the current point on an axis of a core; ψ - corner of an inclination toucher in a considered point; N, Q - longitudinal and cross force; M - bending moment.

The initial differential parities represent system of the nonlinear differential equations which have been written down in the standard form Koshee, are complemented by regional conditions [5, 8]. Thus, the problem of research of nonlinear behaviour of cores is reduced to a point-to-point regional task. The task is solved in a dimensionless kind.

The element of the second type represents thin axis-symmetrican cover of rotation open-ended in a district direction. As initial the basic parities of variant of the theory thin axis-symmetrican covers, modernized for the tubular manometerical elements [6]. At research two-dimensional the task is reduced to one-dimensional with the help of the generalized hypothesis of flat sections. A vector basic unknown in the current section of an cover:

$$X^T = \{u, v, \psi, U, V, M_1\}, \quad (2)$$

where U and V - horizontal and vertical making internal force; M_1 - bending moment working in meridional direction.

Is entered additional unknown χ - relative change of the central corner determined by the following expression:

$$\chi = \frac{\phi - \phi_0}{\phi_0}, \quad (3)$$

where ϕ and ϕ_0 - central corners of cover before and after deformation accordingly.

The additional equation closing system, is received from a condition of balance: the size of the equivalent moment of internal forces in cross section should be equal to the external moment enclosed to cut off part [2]. The system of the nonlinear differential equations enters the name in a dimensionless kind [4, 9]. Supplementing system by regional conditions, we reduce a problem of research of behaviour of an element to a regional task.

With use of a method multisegment shooting [10] the point-to-point regional task is replaced multidot (for rod and for cover models). The procedure of the step-by-step decision by a method of discrete continuation on parameter is used.

The practical interest represents reception of the working characteristic of a flexible element – to dependence of moving of a characteristic point on loading (internal pressure). The working characteristic allows to estimate quality and efficiency of work of an elastic element, and also to estimate possibilities of use of an elastic element in a design of the machine.

RESULTS

The rod model was used for the numerical decision of a practical task - analysis of process nonlinear deformation of the emergency switch shown in a figure 1.

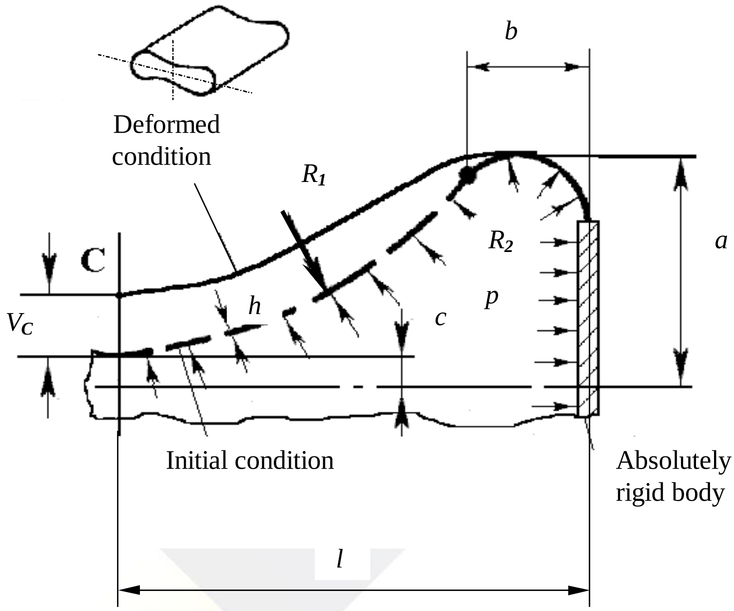

Figure 1 – The settlement circuit of the emergency switch

Using the technique described in the article, the researchers of the process of deformation of flexible elastic elements are carried out. Different cross-sectional shapes with different geometric parameters are researched. The basic geometrical parameters of initial settlement elements are given in the table 1. The results of account of a flexible element of variable thickness with the various form of cross section are given in a figure 2.

Table 1 – Geometrical parameters (mm) of cross section of the switch

№ of switch	*a*	*b*	R_1	R_2
1	2,0	2,56	4,65	1,5
2	2,5	1,71	6,85	1,0
3	3,0	1,28	8,81	0,75
4	4,0	0,80	3,76	0,4

Note. c =0,2 mm; h =0,1 mm; l =8,0 mm.

The results are the performance working characteristics of the elastic elements researched – dependence of vertical moving VC of a point C from internal pressure. The material is characterized by the module of elasticity of the first sort E=0,2 1012 Pa (Pascal) and coefficient of Poisson ν=0,3.

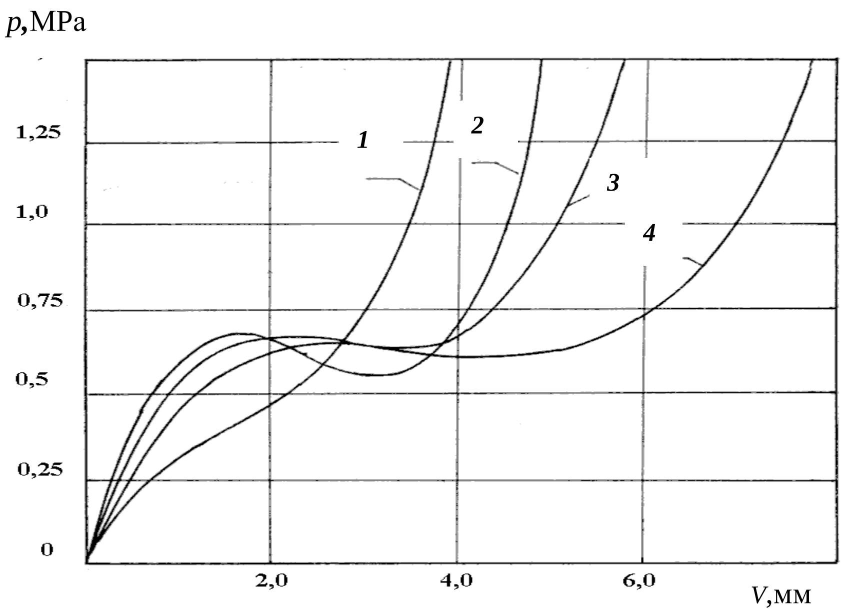

Figure 2 – Working characteristics of the switch

The analysis of the received working characteristics shows, that at various geometrical parameters of the switch it is possible to receive zones leaps. The area of spasmodic transition from one equilibrium situation in another provides discrete operation of the switch. There is a zone, in which the insignificant increase of internal pressure results in significant movings (curve 1). Depending on the showed requirements the similar elastic elements can be used as sensitive elements of devices. With the help of the developed algorithm the results of numerical research essentially of nonlinear process deformation of flexible tubular elements are received. The plane-oval manometerical tubular spring with half-axises a=8,55 mm and b =1,35 mm, radius and which thickness according c and h was considered. The material of considered springs is characterized by the module of elasticity of the first sort E=0,1 10^{12} Pa, internal superfluous pressure 0,1 10^{6} Pa (MPa). For reception of a flexible tubular element of discrete action it is offered to use internal membrane partition for creation of area of compression in tubular manometerical elements. The basic geometrical parameters of the considered models are given in the table 2. The results of numerical research as the working characteristics are given in a figure 3.

The carried out researches show, what not for all forms of cross section use of such constructive decision as membrane partition is lawful. For some elements the internal partition works on compression.

Table 2. Geometrical parameters (mm) of cross section manometerical of element

№ of element	c	H	R_2
1	121	0,6	∞
2	121	0,6	40
3	121	0,6	30
4	121	0,6	2,65
5	121	0,6	5
6	50	0,15	1

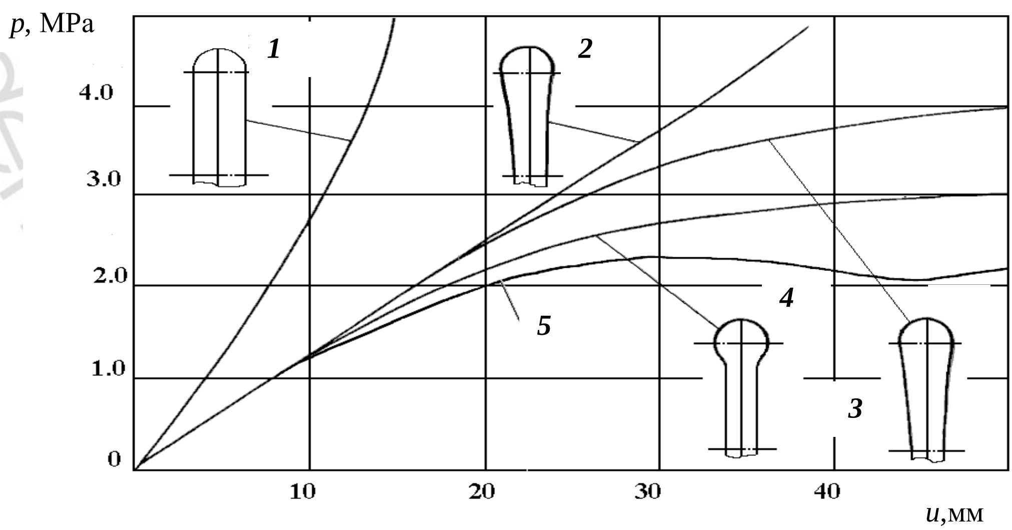

Figure 3 – Working characteristics of the manometerical elements

The developed technique has allowed to pick up the form of cross section tubular manometerical element with internal membrane partition of discrete action. The working characteristic of such element is shown in a figure 4. The carried out experimental researches confirm discrete operation of an element.

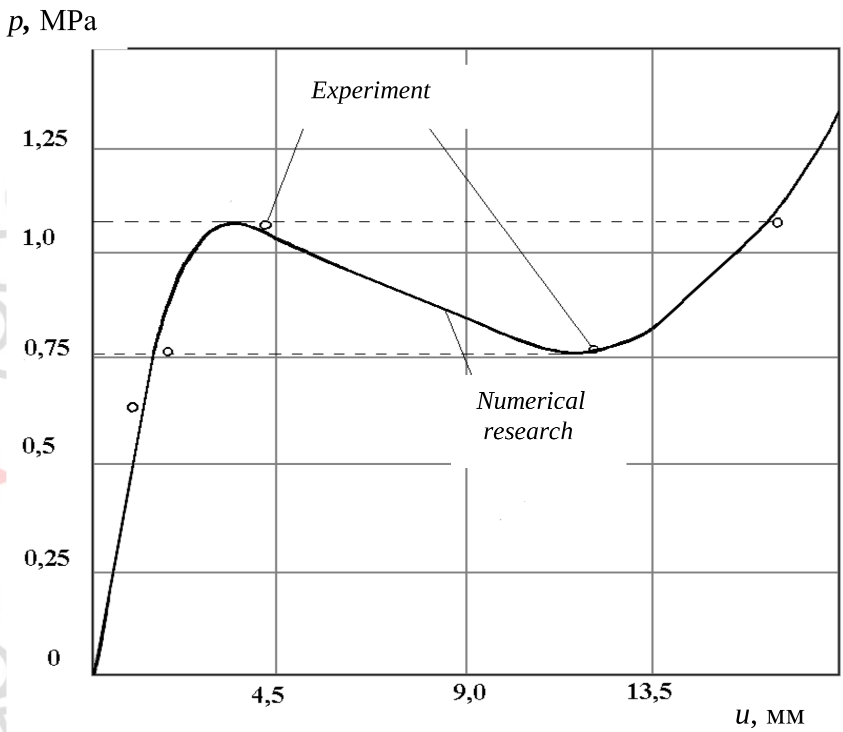

Figure 4 – Working characteristics of the tubular element with discrete action

At designing mechanisms, which working bodies realize the given moving, it is recommended to use the considered flexible elastic elements. Use of flexible elastic elements of discrete action allows to simplify a design of mechanisms realizing discrete moving of a working body; to increase speed; to lower power consumption.

CONCLUSION

The flexible elastic element of the emergency switch is considered. The geometrical parameters of elements of discrete action are received.

Is considered flexible elastic manometerical element. The geometrical parameters of a flexible tubular element realizing in process deformation discrete operation are received.

REFERENCES

Aleksandrova, A.T. and L'vov, B.G. (2002), "The vacuum mechanics devices and systems design for electronic machine building", Avtomatizatsiya i Sovremennye Tekhnologii, No. 7, pp.7-12.

Baryshnikova, O. O. (2012), "Designing mechanisms with flexible tubular elements", News of Universities, Mechanical Engineering branch, No. 12, pp 34-37.

Baryshnikova, O. O. and Boriskina, Z. M. (2014), "The design of advanced mechanisms on the basis of flexible tubular elements", News of Tula State University. Technical science, No. 11-1, pp. 468 – 473, http://publishing.tsu.tul…ru/TecnichNauki.html.

Baryshnikova, O. O. and Boriskina, Z. M. and Avdeeva, O. V. (2015), "Perspectives in Design of Mechanisms Based on Flexible Tubular Elements", Proceedings of the 14th IFToMM World Congress in Taipei, Taiwan, ISBN 978-986-04-6098; DOI 10.6567/IFToMM.14TH.WC.OS19.008.

Baryshnikova, O. O. and Boriskina, Z. M. and Shubin, A.A. (2015), "The use of flexible elastic elements of discrete action to ensure control and safety of technological processes of mechanical engineering", News of Tula State University. Technical science, Vol. 7, No. 2, pp. 32 – 42.

Clark, R.A. and Reissner E. (1951), Bending of curved tubes, Academic Press, New York.

Demihov, K.E. and Panfilov, Ju.V. and Nikulin, N.K. (2009), Vacuum technique, Mechanical Engineering, Moscow.

Gavryushin, S.S. and Baryshnikova, O. O., and Boriskin, O.F. (2014), Numerical analysis of structural elements of machines and devices, Publishing house of the Bauman Moscow State Technical University, Moscow.

Gavryushin, S.S. (2014), "Analysis and synthesis of thin-walled robot elements with the guided deformation law", Mechanisms and Machine Science, No. 22, pp. 411-418.

Gavryushin, S.S. and Nikolaeva, A.S. (2016), "Method of change of the subspace of control parameters and its application to problems of synthesis of nonlinearly deformable axisymmetric thin-walled structures", Mechanics of Solids, No. 51(3), pp. 339-348.

Goryunov, A.A. and Aleksandrova, A.T. (2002), "The vacuum machine building mechanisms based on drives for controllable elastic deformation", Avtomatizatsiya i Sovremennye Tekhnologii, No. 7, pp.13-18.