

ACTUATING SYSTEMS BASED ON TWO BELLOWS

PhD Stud. Eng. Vasile Sergiu JIȘA,

Technical University of Cluj-Napoca, e-mail: vasile_sergiu_jisa@yahoo.com

Assist. PhD Eng. Benjamin CHETLAN,

Technical University of Cluj-Napoca, e-mail: chetran_ben@yahoo.com

Lect. PhD Eng. Simona NOVEANU,

Technical University of Cluj-Napoca, e-mail: simona.noveanu@mdm.utcluj.ro

Prof. PhD Eng. Nour CRIȘAN,

Technical University of Cluj-Napoca, e-mail: nour.crisan@auto.utcluj.ro

***Abstract:** This paper propose a thorough theoretical and experimental research on bellows actuators in order to design and develop some actuating systems operated by two bellows actuators, with different options of corrugated items, the final scope being to establish a precise method of motion control. It is expected that most representative applications of actuators investigated will fit in field of mechanical engineering, robotics and biomedical engineering.*

Keywords: bellows, actuators, finite element method

1.INTRODUCTION

Bellows type elements called thin-walled corrugated tubes, are structural elements of mechanics frequently used as sensorial elements which falls into the category of the energy accumulation and translation signals. They are curved side surface and are elongate or compress under the action of an axial force or internal/external pressure, their function being based on the elastic deformation of the deformable elements [6]. Geometrical dimension, shape and materials of bellows determine a clear dependency between the installed pressure inside or outside, and deformation produced by this [5]

Paper treats aspects of corrugated tubes with pressure transducer role and travel compensation role also. Finally is performed their numerical calculation by finite element method (FEM) and are presented the analysis results. By this method is studying the effects of the internal or external pressure distribution on the bellow walls, subjected to various load cases. Is presented the mesh structures, the circumferential and radial stress distribution on the corrugations and then are imposed boundary conditions applied on axial charged corrugated tubes. Paper that treats aspects of bellows actuators by finite element methods are: [1] where authors presents a micro-pneumatic actuator driven by two micro bellows; in paper [4] bellows have the role to absorb the differential displacement between the turbine and the condenser shell in nuclear plants. Paper [3] describes a new method for manufacturing the metal bellows. The important parameters like initial length of the tube, internal pressure, axial feeding and velocity, mechanical properties and the type of the materials were investigated by finite element method. Paper [2] describes different comprehensive studies of the stresses and strains in the corrugated tubes subjected to different loads, and compares the numerical results with the analytic and experimental method analysis.

2.SYNTHESIS OF TWO BELLOWS ACTUATING SYSTEMS

The authors proposed several structural schemes of the corrugated tubes systems with two active elements in different configurations like are given in Fig. 1. The bellows can be actuated with internal pressure (a-f) and external pressure (g-j); they can be disposed in parallel for a greater force (b, c, e, h, i, j), in series for larger displacement (d) or in antagonist way (a, f, g), where relaxation can be done with bellows or elastic elements. Also the bellows can be reinforced from element is moved (b, h) or can be articulated (c, i).

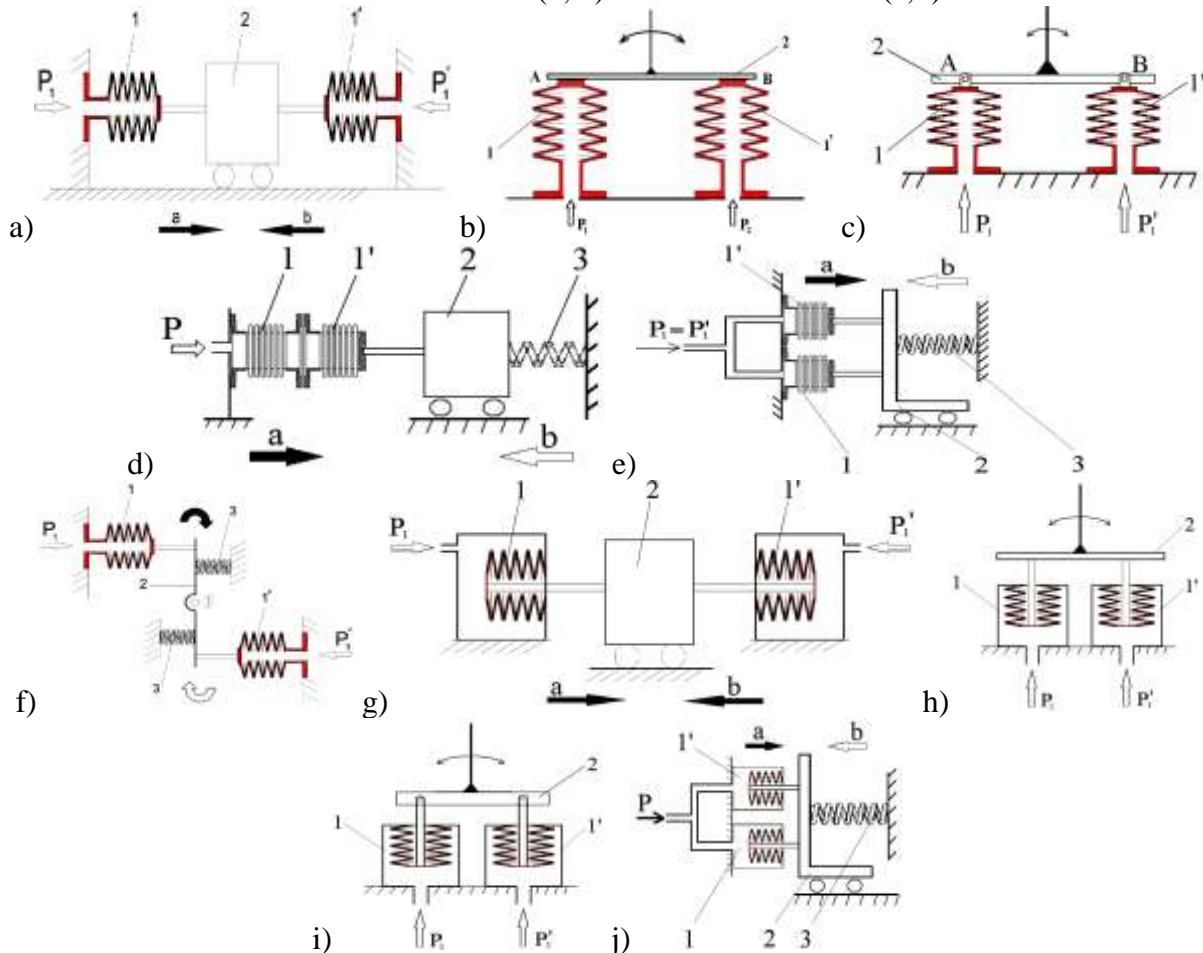


Fig.1 Structural schemes of bellows actuating systems

According to Fig.1 authors designed 3D models and developed some functional prototypes actuating systems based on two bellows actuators (Fig. 2).

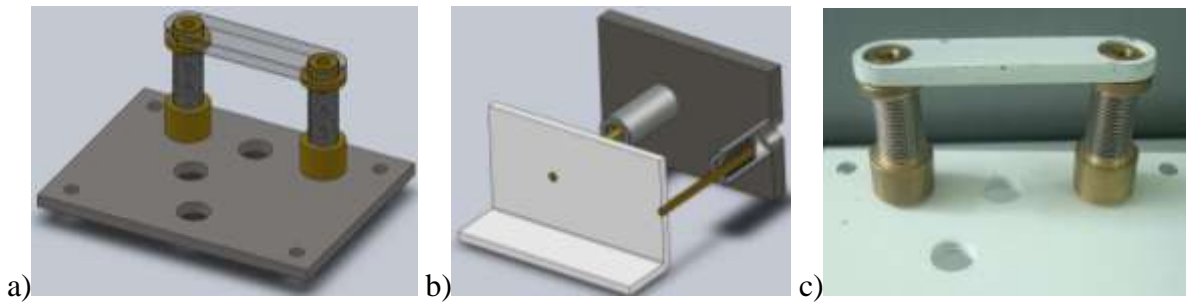


Fig. 2 3D models and bellows prototype actuator.

3.FINITE ELEMENT METHOD ANALYSIS

The numerical method is a technique for solving a practical problem using a finite number of arithmetic and logical operations implemented in a software that obtain approximate solutions to mathematic problems. These methods are necessary for evaluating optical, graphical or tabular to verify the functionality and operational safety, then the comparison with practical results.

First step in modelling with finite element method consisted in Design Modeler module of one of the configurations with internal pressure. It was attended automatic mesh structure where default program chose tetrahedral and hexahedral elements, from where result in a total of 327365 nodes and 165904 elements. Because the results are not satisfactory mesh was made by another method.

Authors perform finishing up discretization especially on bellows to get desired results such as those presented in Fig. 3, where are two elements on the whole wall thickness of the bellows.



Fig. 3 Bellows meshing

After several experiments with different inside pressure and constrains in fig 4 is presented total displacement of the structure when only one bellows is under pressure

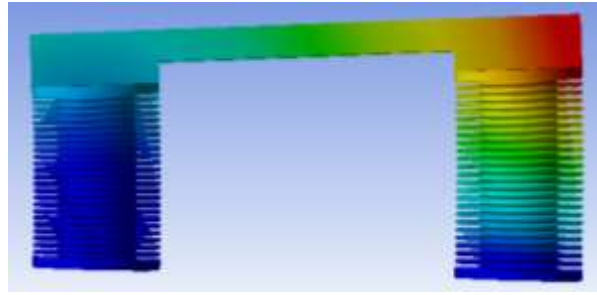


Fig. 4 Total displacement of the bellows at 0.1 MPa.

Also, the values for equivalent elastic strain and equivalent stress of the model is presented in fig. 5

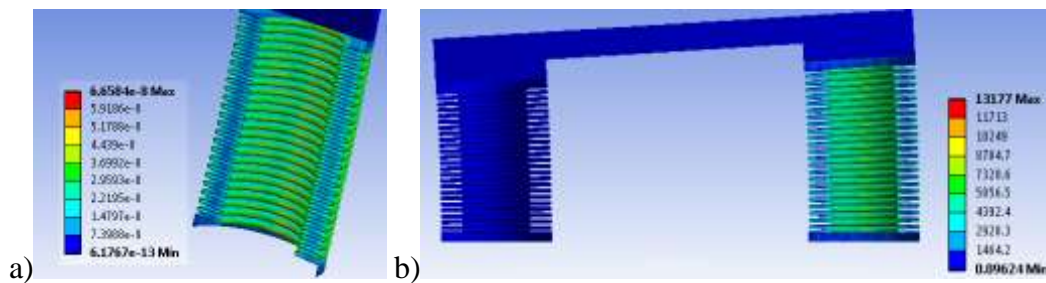


Fig. 5 Obtained values for: a) equivalent elastic strain; b) equivalent stress.

4.CONCLUSIONS

Bellows acts as connecting, sealing and achieving axial extension elements, the operating principle being based on elastic deformation of the undulations. They can be used in the structure of actuating systems, in parallel or antagonist way, presenting a higher interest for applications in oil industry, mechanical engineering, robotics, aerospace industry and biomedical industry. This paper describes a diversity of configurations arranged in series and parallel of two bellows which can be used as actuating systems for precise positioning, with internal and external pressure. Our goal is to see how bellows actuators behaves when are tensioned at different pressures and are consolidated or hinge jointed with the moved element. Until now, we performed the basic steps in meshing control and we extract preliminary results, project being in the development phase.

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