MODELING AND SIMULATION OF A NEW TYPE OF TORSION BENDING SOFT ACTUATOR

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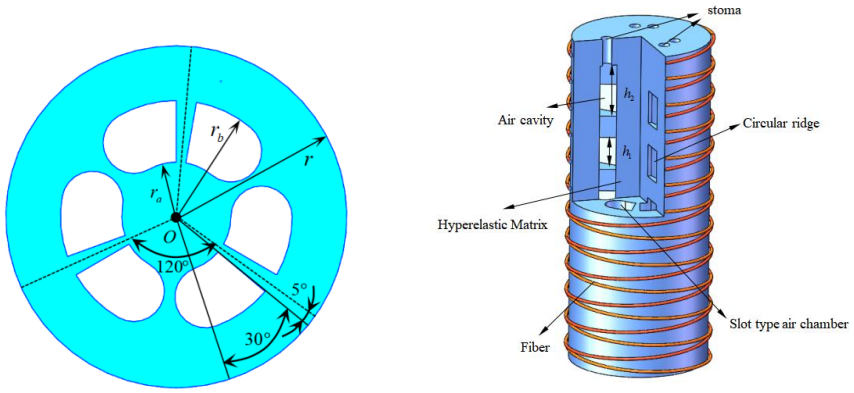
Summary. *In recent ten years, with the development of micro and nanometer machining technology, intelligent material driving and sensing, artificial intelligence and machine learning, 3D printing technology, soft robot has become one of the important research directions in the international robot academia. Soft robot has inherent high flexibility, excellent adaptability, good compliance and natural safety interaction. This also makes the soft robot in medical, education, service, rescue, detection, wearable devices and other fields more and more attention, and shows great development potential. The purpose of this paper is to introduce a three-dimensional soft actuator with multiple degrees of freedom. It can realize bending, torsion, swing, elongation and other functions. For the soft actuator, we use the virtual work principle and elastic strain energy to establish the kinematic relationship of torsional deformation. The software ABAQUS is used to simulate the soft actuator by finite element method. The results show that the deformation effect of the soft actuator and the relationship between the torsion performance and the filling pressure are verified.*

1. Structural design of Torsion Actuator

The main structure of the pneumatic torsion soft actuator studied in this paper is composed of a cylindrical matrix and six air chambers. Two sides of the three datum planes of the equidistant cylinder circle are symmetrically distributed with "groove" air chambers. The air chamber is divided into a semi cylindrical connected chamber and a circular ridge. The central angle of the circular ridge is 30 ° and the angle of the circumferential ridge relative to the reference plane is 5 °. It makes use of the isotropic expansion of the gas in the sealing chamber and the pressure difference between the two sides of the silica gel air chamber to generate circumferential pressure. The torque formed by the circumferential pressure pushes the actuator to produce torsional deformation. When the same pressure is input into the three symmetrical chambers, the actuator will produce torsional deformation in the opposite direction; if the same air pressure is applied to the air chambers on both sides of the reference plane, the bending deformation will occur. In order to prevent the "balloon effect" caused by excessive expansion of silica gel, Kessler fiber is wrapped around the periphery of the matrix symmetrically to enhance the stiffness of the actuator. The model of the software actuator is shown in the figure below.



2. Modeling of soft actuator

The soft actuator made of flexible materials has infinite degrees of freedom, large curvature bending and large deformation distortion, and the deformation is mostly nonlinear. So it is difficult

to describe its motion form by mathematical model. For the forward kinematics of existing soft robots, most researchers use the piecewise constant curvature method to simplify the simulation. For the torsion soft actuator, the virtual work principle and elastic strain energy are combined to establish the kinematic relationship of the torsion actuator. The principle of virtual work establishes the relationship between the work done by external force and the strain energy of elastic body. The elastic strain energy is solved by the large deformation theory of elastomer such as rubber, and the kinematic relationship between the air pressure and torsion angles can be established finally.

3. Finite element simulation

In this paper, ABAQUS software is used to simulate the soft actuator. Ecoflex 0030 is used as silicone rubber material, and the third-order Ogden model is used as its constitutive model. Then, the linear elastic material model is used to describe the fiber properties of the radial constrained soft actuator. The young's modulus of the fiber is 31067Mpa, Poisson's ratio is 0.36, the cross-section shape of the fiber is circular, and the radius is 0.0889mm.

This kind of soft actuator introduced in this paper has many functions, such as torsion, swing, elongation, bending and so on. If the same air pressure is injected into the circumferential distribution air chamber on one side of the reference plane, the torsion effect will appear; when the same air pressure is injected into the air chamber with circumferential distribution on the opposite side, it will twist in the opposite direction, and the torsion angles in the two directions are equal within the error range. When the same air pressure is injected into a single chamber or three connected chambers or five chambers, the swing effect will appear. If the same air pressure is injected into a pair or two pairs of air chambers on both sides of the reference plane, the elastic matrix will bend to the opposite side of the air chamber; if the same pressure is applied to the two chambers between the reference planes, the swing effect will also appear.

Reference

[1]Wen li,Wang Hesheng. Prospect of soft robot research: structure, drive and control.Robot ,2018,(5).

УДК 504.5; 621.9.02.07

ОЦЕНКА ТОКСИКОЛОГИЧЕСКОГО ДЕЙСТВИЯ СОЖ, ИСПОЛЬЗУЕМЫХ ПРИ РЕЗАНИИ МЕТАЛЛОВ

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Summary. *In this paper we consider the problem of the impact of waste lubricating technological means (LTT) on the human body. Particular attention is paid to the main paths of receipt of hazardous substances into the body LTT workers and has the effect of occupational diseases. It is proved that under the influence of oil on the body develop diseases such as lung cancer, throat, lips, men and women - lung cancer, colon, breast and genital organs.*

Современные машиностроительные предприятия потребляют СОЖ в объемах от нескольких десятков до десятков тысяч тонн в год, и эта цифра постоянно растет. Они используются для повышения стойкости режущего инструмента, улучшения качества обрабатываемой поверхности, снижения адгезионного схватывания инструментального и обрабатываемого материала. Это достигается направленным воздействием на физико-механические