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Design and Simulate the Finger of Soft Material Robot

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Abstract: *Soft material robot (Soft Robotics) is a type of gripper with mainly silicon material, Soft Robotics uses a special principle to be able to precisely control the "grab" and "drop" states. Besides, with the nature of soft materials, it has many advantages compared to traditional grippers such as: Good elasticity, durability, easy to replace, no damage. gripper deformation. Soft Robotics is increasingly popular even in industrial or civil industries because of the novelty of the product. In the robotic system, the soft material consists of two parts: the air supply system and the actuator. This paper describes the principle as well as the method to build a research on the actuator part of the soft material robot.*
Keywords: *Soft Robots, Silicon, Finite Element Calculus*

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I. INTRODUCE

The field of Robots is in the period of strong growth of technology development, they play a significant role in various fields. Since 1956 after the invention of the Servo motor, Robot has continuously positioned itself and developed science [3]. With the increasing intensity of work, humans require more features in the field of Robots.

In recent years, manufacturers have developed many controllers that have significantly improved by incorporating many elements such as motors, linkages, springs and gears. But that increases the complexity of the structure, even though the robot hands Traditionally, they have precision and quick response, but they can cause common problems that cannot be overcome, such as inability to contact or grip fragile objects, needing extremely high precision to avoid accidents. overexertion or overdrive [4].

Therefore, soft material robot is the solution to improve the ability of industrial robots in particular and the field of robots in general, due to soft materials, soft hand robots have the advantages of good toughness and elasticity. , temperature stability, environmental resistance, can be conductive or insulating modulation. Not only can it be grasped, but also can keep the durability of objects during work [2]. Some articles also show that the design of a robot with human-like finger shapes and the use of soft material robots in the limbs feels more like a real person than a device with mechanical structures. [5]

Figure 1. Pictures of the actuator [2]

II. DESIGN PRINCIPLES

The soft material robot operates on the principle of controlling pneumatic valves to supply and suck compressed air for the soft material picker, the soft material picker is activated due to the difference in density of the two surfaces. Soft material has a general shape that is one side with thinly spaced, thin-walled hollow chambers. The other side has a denser structure or can be made of other materials to achieve higher disparities [6].

Under normal conditions the fingers of the gripper are straightened. When supplied with compressed air, the compartments will stretch, depending on the number of compartments, the limbs can be bent according to the designer's wishes.

Here is a layered image of the finger 2:

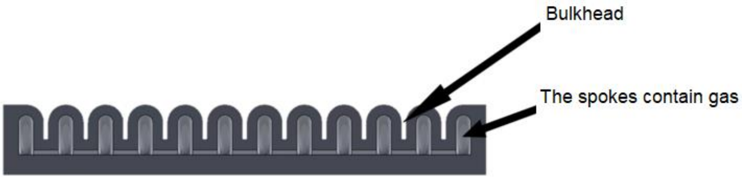


Figure 2. Finger layered photo

III. SIMULATE SOFT ROBOT FINGER DESIGN

3.1. Simulation of design operations

- Create designs and add simulations

First we need to build the idea and shape of the gripper's finger, can use Inventor or Solidwords software to design the desired shape, the reference size of the group with the finger is 20mm wide, 97mm long, 5mm high, with this size the group has researched to support the human hand in need of rehabilitation, but still must satisfy the conditions of the principle part mentioned in the previous part.

We add the design to the program by going to Parts and selecting the previously drawn file and selecting "Ok", to add the lower face we right-click on the Parts and select import and select the file as the initial step.

- Create material parameters

After adding the design to the simulation, the research continues to the stage of testing the force and curvature of the finger. With the help of Abaqus software, the software allows us to build properties of materials and apply force to the design. First of all we need to build parameters for the silicon material, after opening the drawing file on Abaqus we select the edit material section, name it Elastosil, the General section select Density, the resulting Material Bethaviors will appear the Density section, then let the mouse pointer go to Mechanical select Elasticity finally select Hyperelastic after this process the Material Bethaviors panel will appear with the Hyperelastic line.

Now continue to declare the stain energy potential item as Yeoh, we can understand that we use the quadratic Yeoh model for super material. elastic. After the parameter of elastosil, to increase the difference between the two sides of the material we create more parameters of the paper, again in the edit material section, set it to paper, in the General section to enter the specific gravity of 750e-12, then go to Mechianical, select Elasticity, finally choose Elastic, here enter data for Young's modulus and Poison't, the results we have in the Material Behaviors section will appear Density and Elastic.

Table 1. Material parameters

Elastosil material creation parameters	**Paper material creation parameters**
Name: Elastosil General: Density Data: Mass Density: 1130e-12 Mechanical => Elasticity => Hyperelastic stain energy potential: Yeoh Data: C10: 0.11 C20: 0.02	Name: paper General: Density Data Mass Density: 750e-12 Mechanical => Elasticity => Elastic Data: Young's Modulus: 65000 Poison's: 0.2

After the parameter creation process, we proceed to create a section, go to sections, create a section, name the section Sec-Elastosil, Category select Solid, Type select Homogeneous.

- Linking parts

We go to each part of the model and double-click Section Designments, scan the entire model, attach the Elastosil part.

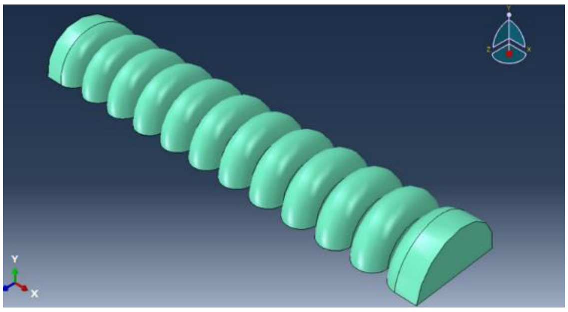


Figure 3: Simulation of a soft robot finger

- Assemble

We put the parts together. Go to the model tree find Instances in Assembly and select all 3 parts. Instance type must be set to “Dependent”. Now the parts must be properly positioned relative to each other. To do this requires a total of 2 constraints: 2 DOF translations for each part, involving a fixed number of parts. Use the face-to-face tool to create mate faces choose Create Constraint.
After selecting the desired constraint, click Ok to finish. Find the Merge/Cut instances button and select the information as Merge => Geometry, Original Instances => Supress, Geometry => Retain, then click continue and select the entire assembly and press "Done".

- Put pressure

Proceed to select the surface to put pressure on the model, In the Merged section select Surfaces and name it "Surf-Incavity". Find Tools => View cut => Manager => select the Z-Plane face. Select the force area as shown below and press “Done”

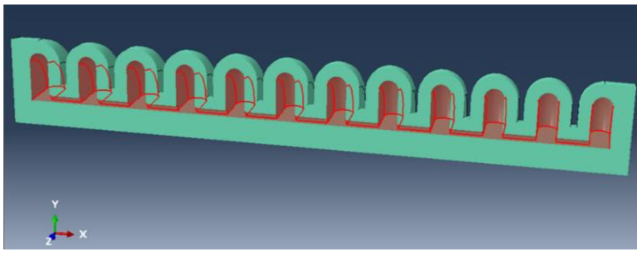


Figure 4: Simulation image of tomography

- Material meshing

To perform this step, we double click on the Mesh to create the parameters Approximate global size: 4.9 respectively, select Curvature control, Maximum deviation factor (0.0 < h/L < 1.0): 0.1, Minimum size control select By fraction of global size (0.0 < min < 1.0): 0.1, Item By absolute value (0.0 < min < global size): 0.49.
After the above step, select Assign Mesh Controls and then scan the entire design, select “Tet” => “Use default algorithm” => “Use mapped tri meshing on bounding faces where appropriate” and select “Ok”.

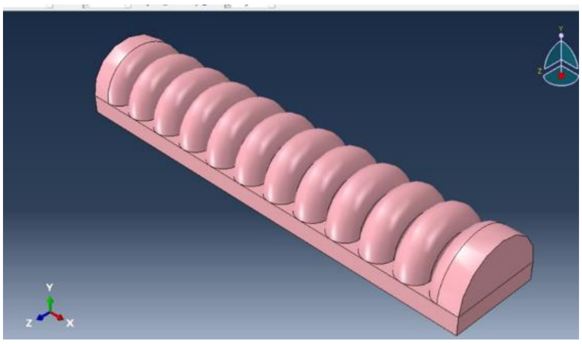


Figure 5: Mesh simulation image

Select the Mesh part in the tools section and click 'Yes'. We get the meshed shape. Select Assign Element Type, scan the entire surface, we get the Element Type table, select Hybrid formulation, click Ok and Done.

- Create a Step

- Find Steps and open Step-Gravity "Continue" => under "Nigeom" click "ON" then "Ok". Next to the Loads section to create Load-Gravity in the Types for Selected Step panel, click "Gravity" below and then click Continue. Then at Distribution: Uniform, Component 2: -9810, Amplitude:(Ramp).
- Find BCs, open Create Boundary Condition and name it Fixed, in the items set the following information: Step: “Step-Gravity”, Category Machanical, Types for Selected Step: Symmetry/ Antisymmetry/ Encastre, finally select continue and Done. Click on ENCASTER to see the results.

- Create a Step-Pressure section

- Go back to Step-Gravity, under “Insert new step after” select “Step-Gravity” and then click Continue => “OK”.
- The "Load" section of Step-Pressure creates more Load-Pressure, change "Gravity" to "Pressure" => "Continue" find "Surface" in the right corner and select it, select "Merged-1" => "Surf-incavity" ” and then click “Continue”. Finally, go to the Edit load table and fill in the parameters in the following positions: Distribution: Uniform, Magnitude: 0.03, Amplitude: (Ramp) => “Ok”

- Create a Job to run simulation

In the model tree on the left, open Analysis, select Jobs, name NewPenu and select Model-1, then select Job Manager tool => “Submit” wait for Running => “Monitor” and display the results.

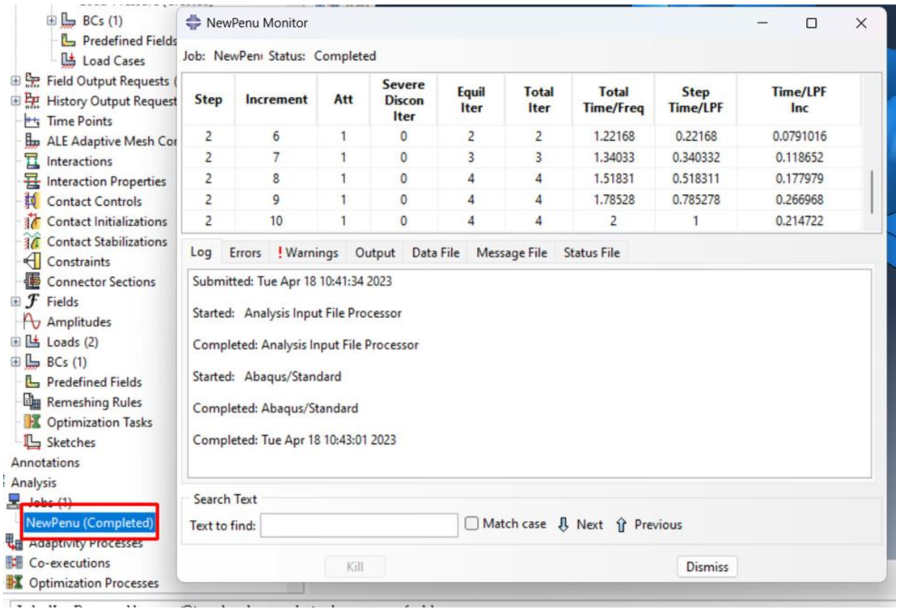


Figure 6: Simulation run parameter screen

- Run simulation test

On the toolbar, click on Job Manager -> click Result to run the simulation

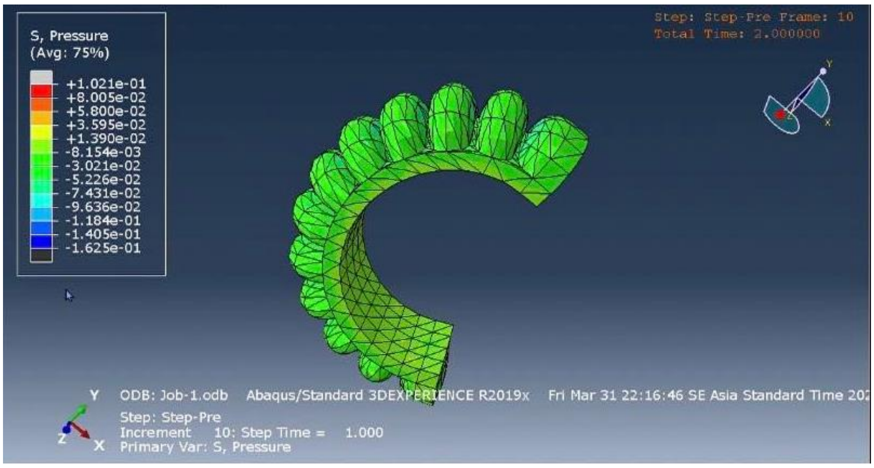


Figure 7: Simulation run results

3.2. Material Selection

In the design process, we have to determine the desired hardness of silicon, This study has conducted to find out the hardness scale of silicon materials and the results show that the recommended scale standard is the scale scale. Shore A, below is the reference content of the comparison table between the scales.

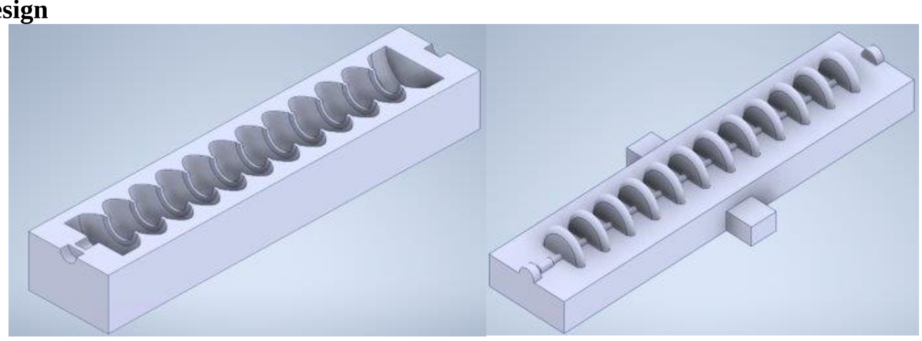
Table 2: Comparison between shore A and shore B scales [4]

Shore A	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
Shore D	6	7	8	10	12	14	16	19	22	25	29	33	39	46	58

Based on Table 2 we can see that the hardness of silicon shore A ranges from 40 shore A to 95 shore A, however we can adjust the shore of silcon the way we want, The team found 2 types of silicon with hardness are 40 shore A and Ecoflex silone 00-30 is equivalent to 00 shore A.

From the above two types of silicon, we can create the desired hardness of silicon at 30 Shore A with a phase ratio of 25% Ecoflex 00-30 and 75% silicon 40 Shore A.
Silicone hardening start time from 30-45 minutes, product forming time is 8 to 12 hours.

3.3. Mold design



A B

Figure 8: A female mold; B male mold

IV. INFERRED

Finally, after the desired simulation results, we proceed to design the mold, we use Inventor software, design the offset of the design, we get the shape of the mold, using a 3d printer. to create plastic molds that support mold reuse.
Because the structure of the finger is hollow to allow gas supply, and the material of the finger is made of liquid silicon that reacts with a catalyst to solidify, the die casting method is the optimal method for the design process. During the casting process, it is necessary to pay attention to the following contents:

– Need to carefully review the information of silicon
– While waiting for the finished silicon, do not move the mold,
– The mold should be exposed to the wind
– Avoid direct sunlight

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