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DESIGN, MODELING, AND COMPARATIVE ANALYSIS ON SILICONE RUBBER SOFT GRIPPER FOR FOOD INDUSTRY

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ABSTRACT

This paper works on the silicone rubber soft gripper in the field of the food industry, soft gripper grater improve in the field of material handling. This gripper is used in the different fields medical, food processing industry, house working, shop floor material handling, etc, but we focus on the Food Industry by using this gripper to hold the different material with help of two different modes, one is by applying the positive pressure gripper will bend hold the objects second one by applying the negative pressure to sucking the objects. This reaches us using two suction cups with different sizes one suction cup is placed in front of the gripper to hold the objects by applying the vacuum pressure to hold objects, the second suction cup is placed at the bottom of the gripper by using that cup to create the more holding capacity. And also in this gripper one more gripping process is there that is positive gripping process that means in gripper inside creating the number of hallow chambers by using that chambers when we apply the positive pressure that chambers will expand, the gripper will bend curve shape so that it will hold the objects. In this paper we using the 3 different designs with two different materials, in that three design we selecting the best design using the dragon skin 10 material based on different simulation test results again perform the simulation process on the best design with help of the dragon skin 10 & 30 materials with help of the simulation test results design3 with the dragon skin10 material it will generating the more bending angle at low pressure of 15kpa. After selecting the best design with best material, vacuum test is performed on the big suction air path why because in working process if any damage will occur it will effected total design so that it will tested with help of dragon skin10 material in our case it will produce the good simulation results so our design is safe which gives better results its suitable for food industry.

Keywords: Pressure, Material, Abaqus Software.

I. INTRODUCTION

in presents days innovation was more grown in the day by day in the field of the mechanical side, new model and a new age of robot are created this robot holding the objects need the gripper in the gripper having a distinctive plan and diverse reason however in the treatment of the delicate material we need delicate gripper. In this delicate gripper innovation likewise improved step by step and accessible distinctive material, the name demonstrating the delicate gripper implies smooth and delicate gripper in these grippers use to dealing with the delicate and exactness material that implies glass, surgical tools. The greater part of the examination is favoring this delicate gripper due to its ease to deal with, use, and simple to manufacturing [1, 2]. As indicated by a new audit [3], delicate mechanical grippers can be categorized into three groups based on the grasping principle (1) grasping by activation, (2) holding by controlled stiffness, and (3) grasping by controlled attachment. Most grippers in the first and second gatherings utilize static rubbing to lift objects, such as the grippers dependent on delicate pneumatic actuators [4, 5], the MR fluid gripper, and the sticking gripper [6] such cases, a large contact region is needed to create adequate grating, and it is regularly hard for them to get a handle on meager items. Conversely, grippers having a place with the third gathering are acceptable at picking up thin objects utilizing surface attachment and incorporate grippers that utilize pull [7], the electrostatic gripper [8], and grippers based on gecko bond [10]. As of late, the plan, manufacture, and activation of delicate mechanical technology have pulled in the creating consideration of analysts from different fields, for example, science [11], physical science [12], science [13], and mechanical designing [15]. Mechanical getting a handle on and control is tested in many applications, particularly those that include differing sizes, shapes, stances, and properties this has motivated the improvement of an assortment of hand-like robotic grippers with numerous fingers [16]. Delicate actuators are required to be delicate and consistent like regular muscles, which can't be given by customary actuators like electric engines this gripper are actuating need the actuation system three

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actuation systems are available1) pneumatic or air 2) Cable or wire 3) hydraulic by using these system physical control the robot gripper

We consider only the Air pressure because it is easy to available and operating cost is also low comparing the other two actuation methods first creating the design of the cad model in that design creating the Air chambers after that particular design upload to Abaqus in that software apply the material properties, coefficient values, gravitational force, and pressure value by using these value we perform simulation. The pressure is passed through the air chambers due to that pressure the gripper will bend at some angle if that gripper does not bend the required angle again changed the pressure and design dimensions. If we need more angle of bending the gripper's inner wall thickness and the gap between the two chambers are reduced and also the thickness of layers affects the angle of bending of the soft gripper [17]. In this simulation process using the soft material these materials are called soft silicone rubber material this material is best for soft silicone rubber so many materials are available but mostly used some materials those materials are Dragon Skin10 (DS10), DS20, DS30, Ecoflex10, Smooth-Sil 950, etc, but We used the Dragon Skin10 material are chosen because of this material generating the more bending properties. So that we choose these materials

But in this paper, we focus on the design and simulation part of the soft gripper by using simulation we work results choose the best design. By using this simulation to save time, money and physical damage of the objects the simulation process to be done using some software those are 1) hyper mesh 2) Analysis 3) Abaqus but most of the research are preferred for the “Abaqus” in Abaqus to getting better results and most effective working on the soft materials and in this software possible to creating the design also but some words difficult to designing as compare to Auto CAD. In the design of the gripper, some software’s available but we use the “AutoCAD 2017” because its user friendly by using this software we design the soft gripper

a. Background of simulation

Limited component displaying (FEM) gives a compelling arrangement to handling nonlinearities in delicate mechanical technology and dodges the need for an unequivocal logical model. Moreover, the FEM isn't limited to the slim constructions needed in the hypothesis of rods or the demonstrating of twisting movement utilizing the piecewise constant curvature presumption or Euler–Bernoulli pillar hypothesis. FEM has found numerous applications in delicate advanced mechanics because of the accompanying reasons The soft robotic gripper is simulation need some designs that design is designed to use some designing software’s those are 1) CAD or Auto CAD 2) Solid Works 3) CATIA and so on but most of the research and people prefer for the “Auto CAD” because of it user-friendly easy to operating and easy to design of the parts we design the particular dimension of the gripper after that we performed the simulation 1) FEM can adapt to the enormous disfigurements and material nonlinearities during the compression of SFAs. 2) FEM can be utilized to anticipate execution and assess the capabilities and restrictions of delicate actuator plans under various inputs. This quick and productive plan system lessens cost and advancement time because the creation of SFAs is very time-burning-through. 3) FEM can improve our comprehension of the stress focus and strain dissemination in delicate actuators. This includes prompts a superior comprehension of the impact of local strain on worldwide actuator execution and can be utilized, for example, to decide expected areas of exhaustion. 4) FEM can handle contact nonlinearities related to surfaces that come into contact upon twisting.

II. DESIGN OF GRIPPER

Designing of the soft gripper considering some points according to that make design ones is internal air chambers wall thickness, numbers of the air chambers in a fixed length, bottom layers thickness, the gap between the two air chambers and type of air chambers consider all according to design the gripper

a) Single Air chamber soft gripper

Single Air Chamber gripper in this gripper having the single air chambers will available in this Silicone rubbers with lower durometer (hardness) show very high levels of twisting at low pressing factors and lower Von-Mises stresses at the low pressure and also the thickness of the is reduced the bending capacity is increased, wall thickness reduced getting more bending capacity. Ideal power is obtained when the proportion of length to width of the inflatable.

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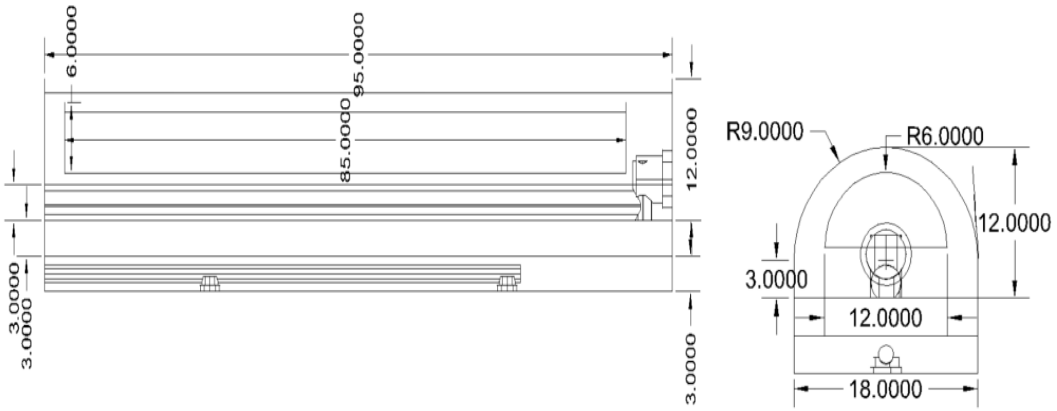
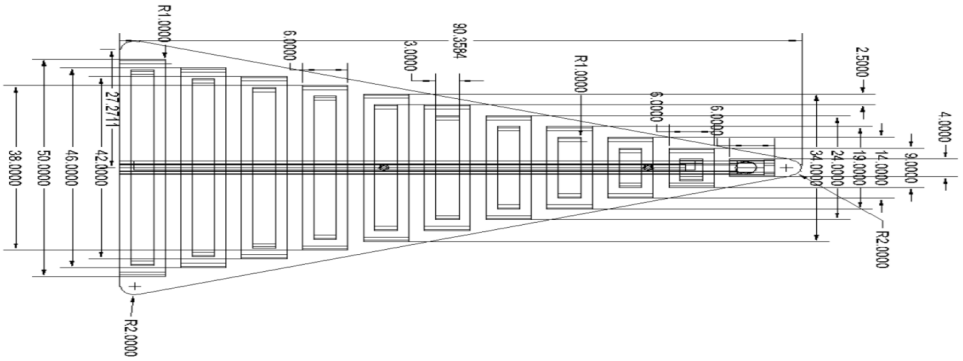
b) Multiple chamber soft grippers

A multi-chamber gripper has more air chambers so it can bend more as compared to a single chamber gripper this gripper angle of bending is based on the thickness of the internal walls and gap between the two chambers. The thickness of layers if reduced it will affect bending angles same time damage the air chambers because small thickness causes some damage on the air path so the design of multi-chambers to consider these all things. For a particular length, more chambers enable greater bowing at small pressures.

Designing is the main part of the gripper in this designing the grippers using some designing software 1) AutoCAD 2) CATIA 3) Solid Works and some other software but we using the AutoCAD because it is user-friendly easy to design the part so we choose this software by using this we crating the three different design of soft gripper. Each design has three layers each layer having different dimensions also providing the two types of the air chambers1) single internal air chambers in this inside of gripper creating the single air chambers in that apply the pressure the gripper bend to hold the objects 2) multi-internal air chambers, creating the more than one chamber apply the pressure it will bend some angle hold the object the design of the three shown in below figure1 and air chambers details shown in table1. Each design creates the suction cups by using those cups to suck the objects, two suction cups are creating 1) bigger suction cup it will show in figure 2a its fixed at the front of the gripper by using this we suck the more width of the objects 2) small suction cup is shown figure 2b placed at the bottom of the gripper and we are using the two small cups placed at each from 35mm distance this cups generating the more suction and gripping force two actuating these two different suction cups using the negative pressure. These two suction cup dimensions are the same for the three designs.



(a) Three designs have three different shapes from figure1a design 1 the shape of the design is semi-circular and it's a single air chamber in this single air chamber we test different designs but this semi-circular design generating good results so that choose this design and this having the three layers each layer have the same thickness. Figure 1b design 2 is triangular shape multi air chambers this design having the 11 internal and external air chambers the dimensions of each air chamber different and width is gradually decreed because its triangular shape so in width gradually changed and this design has three layers each layer have the same thickness. Figure 2c design 3 is rectangular shape this having the 18 internal and external air chambers each air chamber same dimension except first and last chambers this design having three layers each layer same thickness more internal air chambers getting the more angle of bending at fixed dimension.



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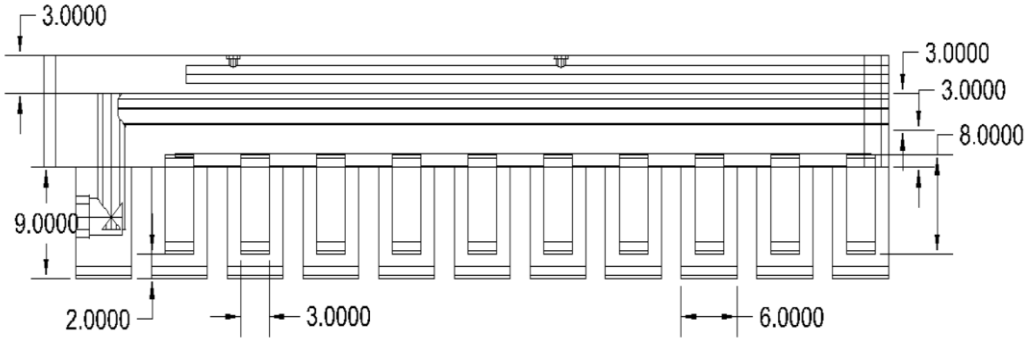
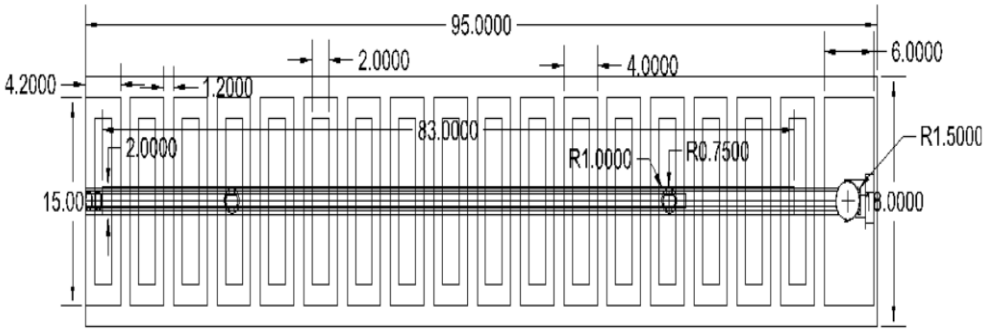
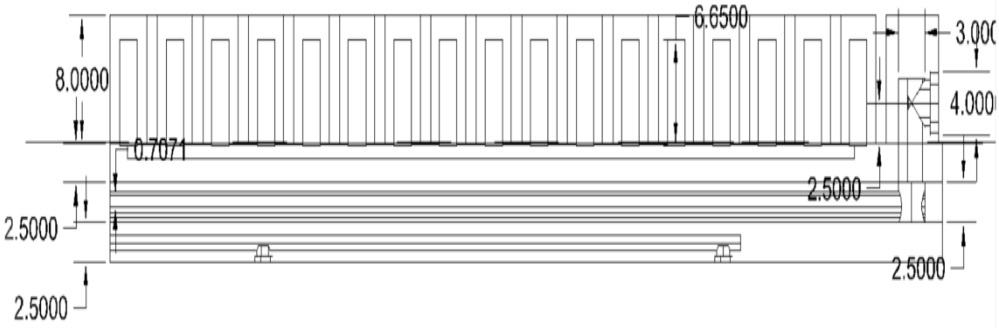


(a)



(b)



(c)

Figure 1: Details of different designs (a) design1 (b) design 2 (c) design 3

Table 1: Details of air chambers

Design Name	Air Chamber type	Number of internal and External Chambers
Design 1	Single internal air chambers	1
Design 2	Multi-air chamber	10
Design 3	Multi-air chamber	17

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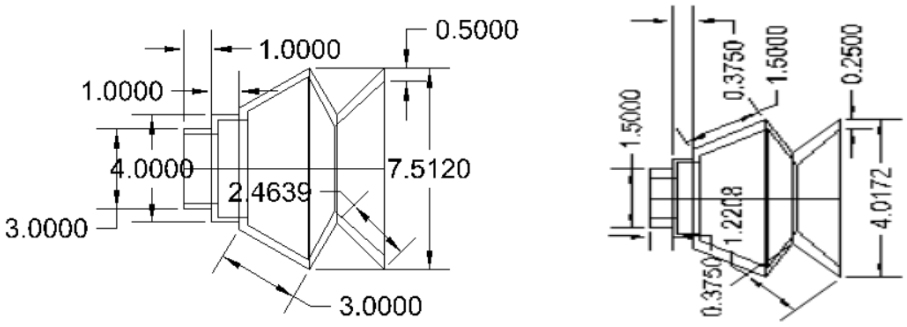


Figure 2: Design details of a suction cup (a) big suction cup, (b) small suction cup

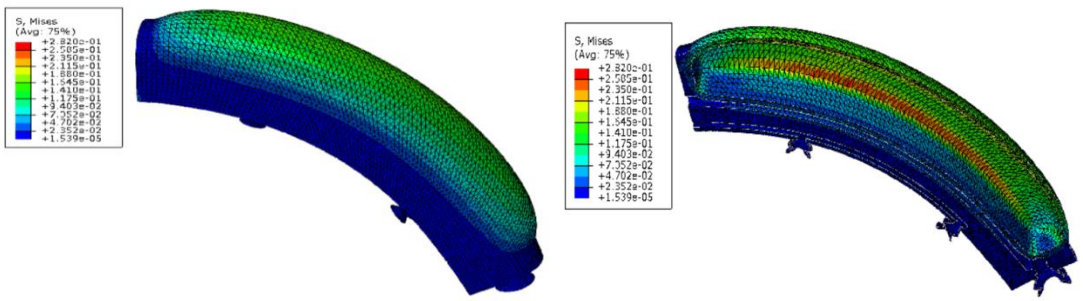
In this design, we introduce the new air path of the bottom suction cups this air path will be dimensioned the same for all three designs diameters and lengths are 1mm diameter and 72mm length because we tested so many dimensions but all finally selected these dimensions. Whenever we design the soft gripper we consider some main points 1) small thickness of the inner air chambers getting the more bending 2) gap between two outer chambers reduce it's affecting the bending angle 3) small thickness of layers generating the grater bending angle same time its damage the grippers considering these points design the these gentle gripper

III. SIMULATION WORK

Simulation is the process of testing our design before using the real-world application the testing process has some software's are available those are 1) Ansys 2) Solid works 3) Abaqus, but we are the Abaqus because it will be generating better results comparing the other simulation software's it is advanced and easy to use compare to other software. In simulation process need material, for this silicone rubbers available some materials are Dragon Skin 10, ecoflex30, Dragon Skin20, Dragon skin 30, etc but we choose the Dragon Skin 10 (DS10) the details will shown in table 2 this material having the low density and generating the more bending angle so that choose material, after setting the material details apply the pressure at inner air chambers and considering the gravitational force and apply the meshing in meshing Yeoh model is used because this model generating the more accurate results for hyperelastic materials in that Yeoh model use free meshing technique because in hyperelastic material suitable for the free meshing technique in this technique again consider the quadratic tetrahedron hybrid elements with the 10 node (C3D10H) and size of the global is 0.8 if we decrease the global size getting the best results getting good results global size between the 0.5 to 4, triangular type meshing used by default according this model only triangular type available.

Table 2: Material detail

Material Name	Software	Coefficient Values	Software Model	Density
Dragon Skin 10	Abaqus	C1=36kPa,C2=0.25 KPa,C3=0.023KPa	Yeoh	1070kg/m3
Dragon skin 30	Abaqus	C10=0.096Mpa,C20=0.0095Mpa	Yeoh	1080kg/m3



(a) Bending at an angle of 35kpa pressure Dragon Skin (b) Inner air chamber in presence of pressure

Figure 3: Simulation results for design 1

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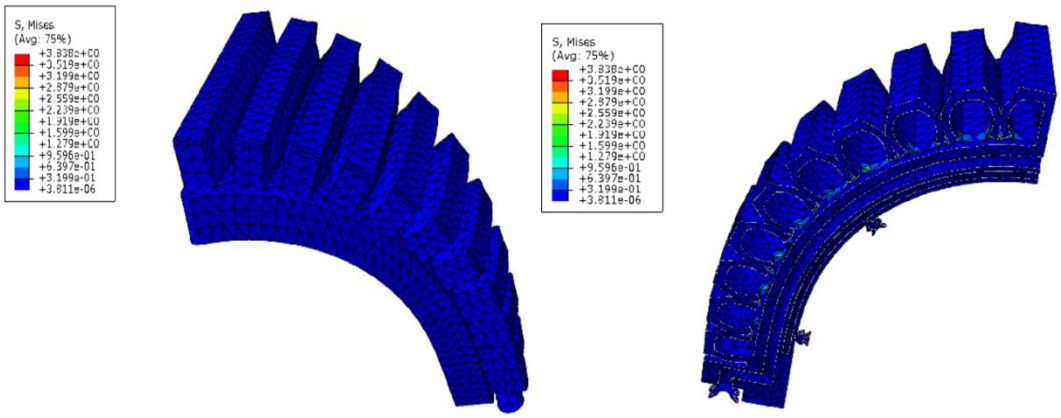
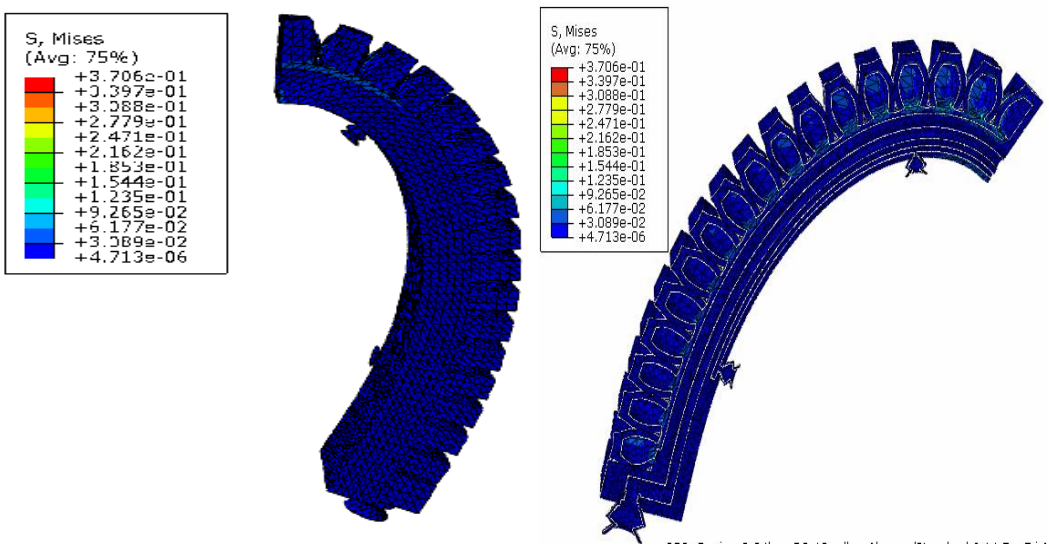


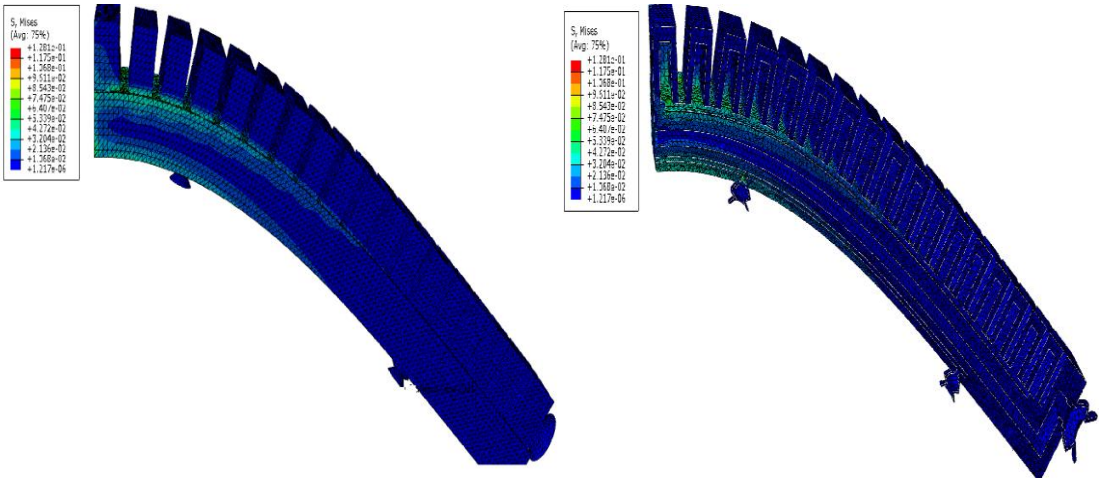
(a) Bending of gripper at 28kpa pressure (b) Inner air chamber section view

Figure 4: Simulation results for design 2



(a) Bending of the gripper at the 15kpa pressure (b) Section view of the inner air chamber

Figure 5: Simulation results for design



(a) Gripper bends at the pressure of 50kpa (b) Section view of the gripper

Figure 6: Simulation results of design3 with Dragon Skin 30

The simulation done on three designs from figure 3a is the semi-circular shape in this having the only single air chamber it will bend at the pressure of 35kpa and figure 3b showing the internal view of the inner air chamber in the presence of pressure. Figure 4a is a triangular shape bend at 28kpa pressure and 4b inner air chambers

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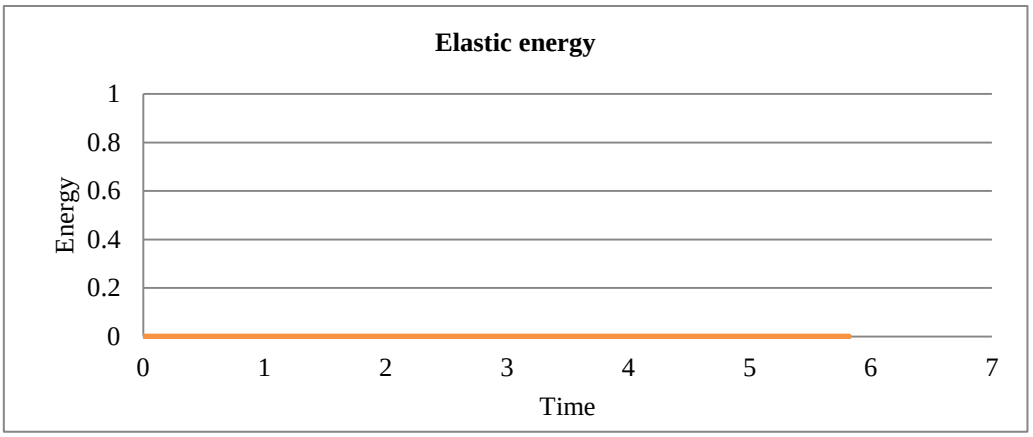
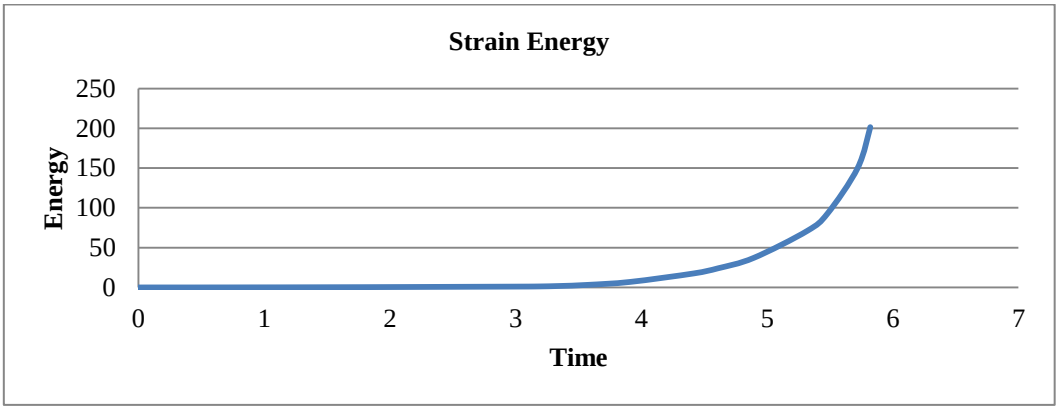
expanded in the presence of pressure figure 5a is the rectangular multi air chambers it will bend at 15kpa if more air chambers generate the more bending angle. Figure 6a shows the bending of the gripper with DS30 material and 6b shows the section view of the gripper

IV. RESULTS

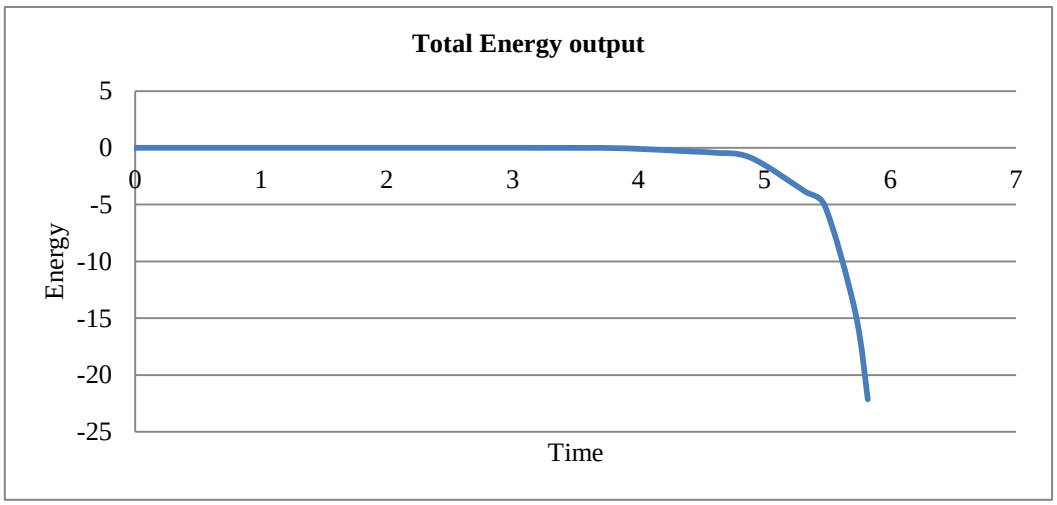
In this section presenting the final results of our work we simulate all three designs with help of the two different materials 1) Dragon Skin 10, 2) Dragon Skin30 with help of Dragon Skin 10 perform the simulation of all three designs selecting the best design below figures showing the output graph all three design of Dragon skin 10, and best design with Dragon skin30.



(a) Elastic Energy



(b) Strain Energy



(c) Total strain Energy

Figure 7: design 1 work output details in the graph at 35kpa pressure Dragon Skin 10

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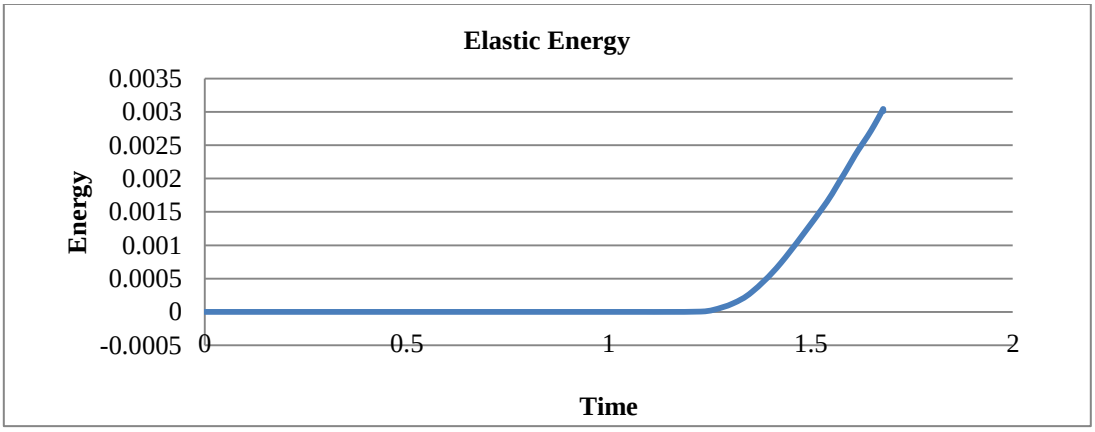
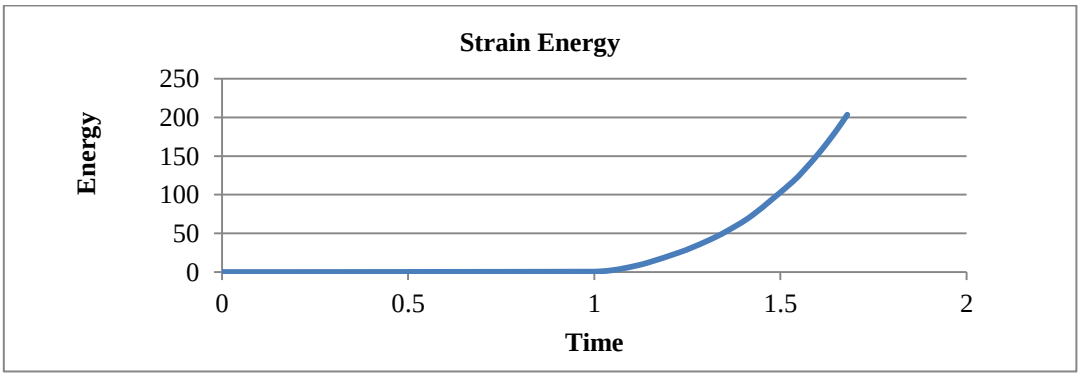
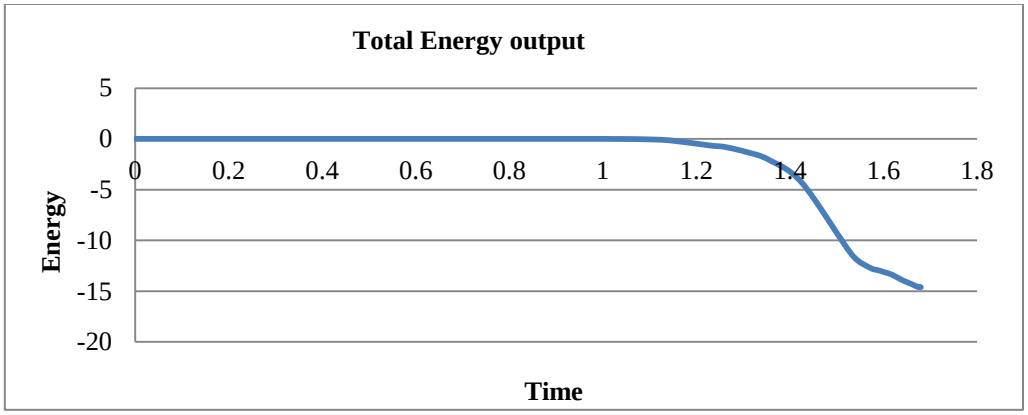
The above figure7 shows results of simulation figure 7a No elastic work because that design, not sufficient bending angle will be generated at the 35kpa pressure to produce the bending angle so that no elastic work also strain energy output is gradually increased and the total energy increased the after point 1 in the negative side because, till point 1 the gravitational force will be acting after point 1 the pressure force acting. From below figure 8a shows the elastic work in comparison to design 1 will generate the elastic work because the gripper will bend at a pressure of 28kpa so it will produce the elastic work figure 8b shows strain graph the more angle of bending will occur compared to design 1 strain graph up to point 3 the gravitational force will acting after that pressure force acting and figure 9a showing the more elastic work compare to remanding two designs because it will generate the more bending at low pressure of 15kpa and also figure 9c showing the more work output will be generating compare remanding two design finally considering the bending angle, simulation output of the three design choose the design3 is the best it will generating the more angle of bending at the pressure of 15kpa.



(a) Elastic Energy



(b) Strain Energy



(c) Total strain Energy

Figure 8: design 2 work output details in the graph at 28kpa pressure Dragon Skin 10

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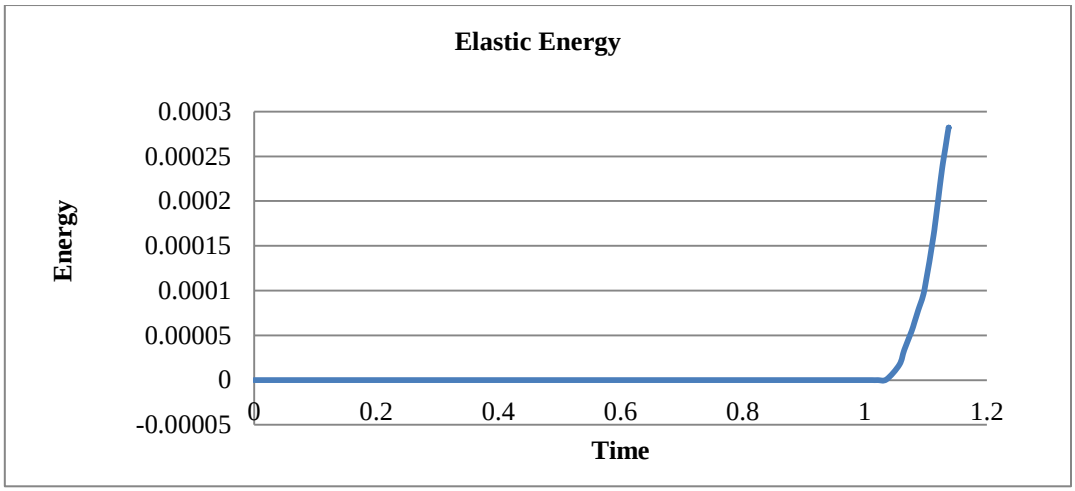
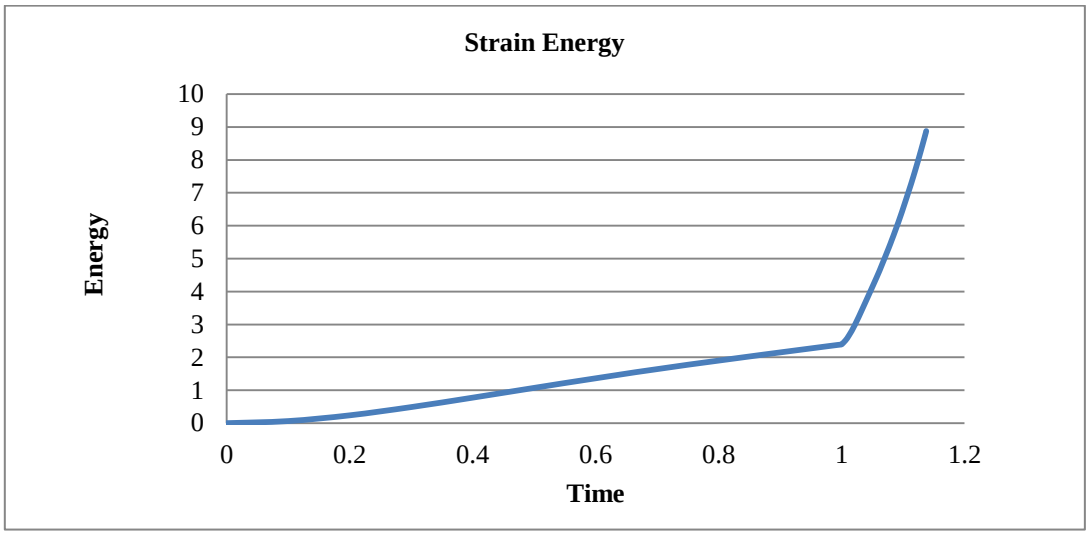
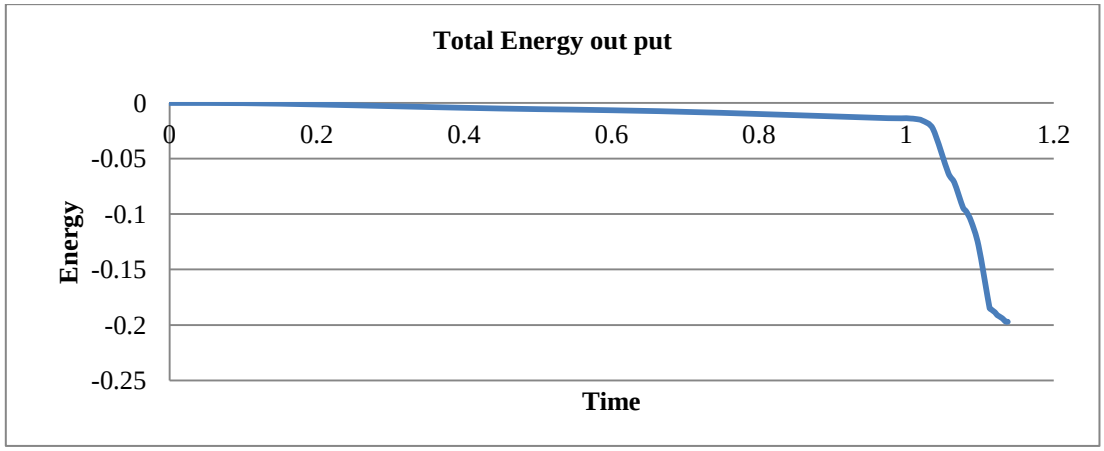


(a) Elastic energy



(b) Strain energy



(c) Total strain energy

Figure 9: design 3 work output graph at 15kpa pressure with Dragon Skin 10

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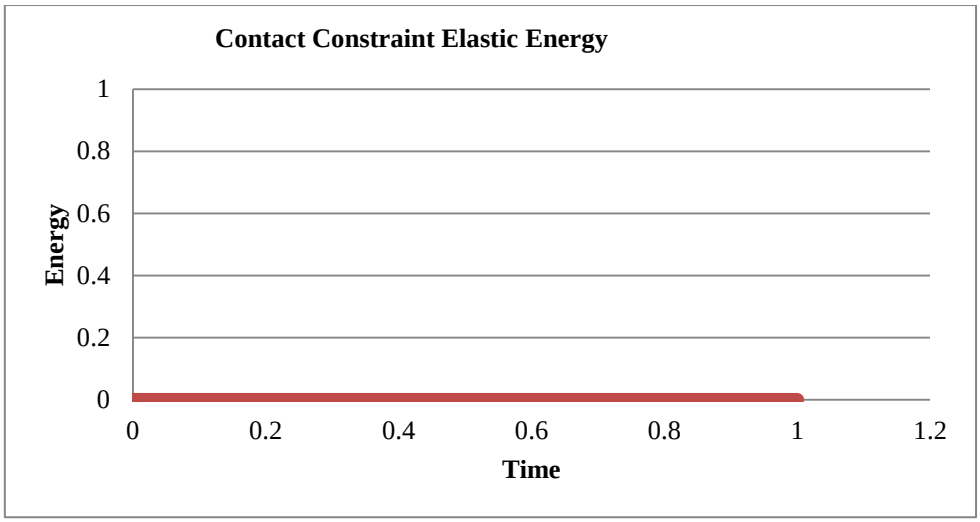
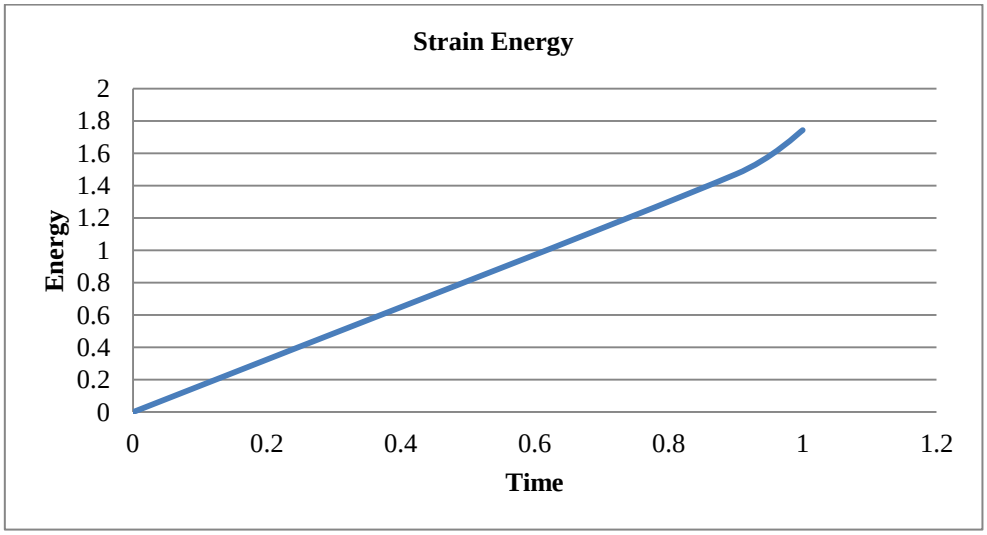
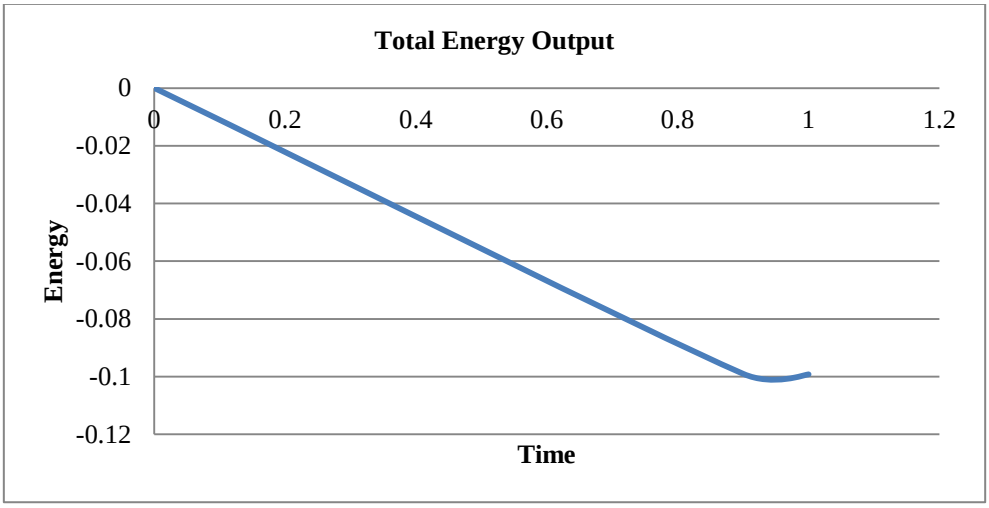


(a) Elastic energy



(b) Strain energy



(c) Total strain energy

Figure 10: Simulation output at the pressure of 50kpa results for Dragon Skin30 material

Below figure 11 shows the comparison of the strain energy of the Dragon skin10, thirty by perceptive the graph the blue line can step by step accrued and generating a lot of lines which means the gripper can step by step

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bending bends and a lot of bending angle can generating

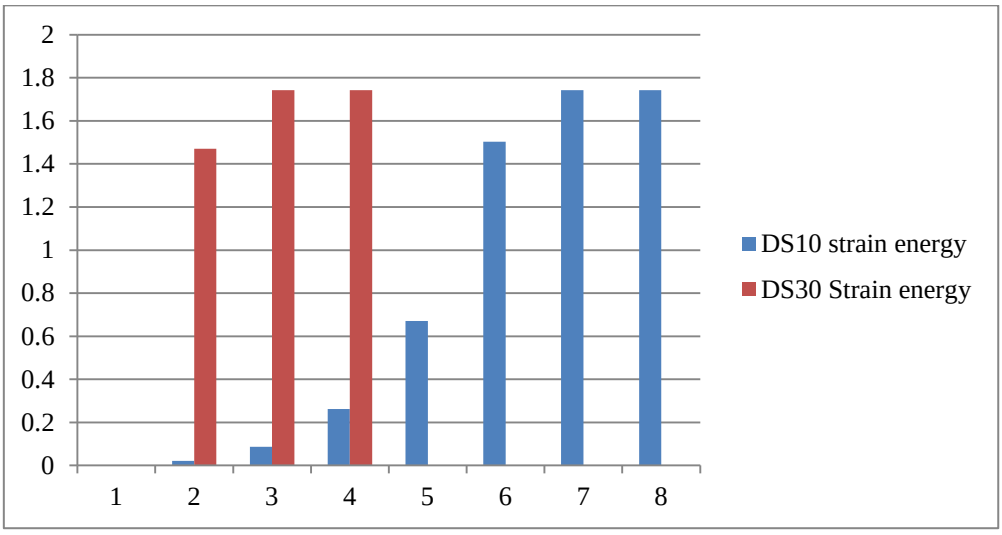

Figure 11: Comparison of strain energy

Belo figure 12 shows the overall energy output for the DS10, thirty materials however DS10 material having step by step accumulated meaning it is generating the additional work output

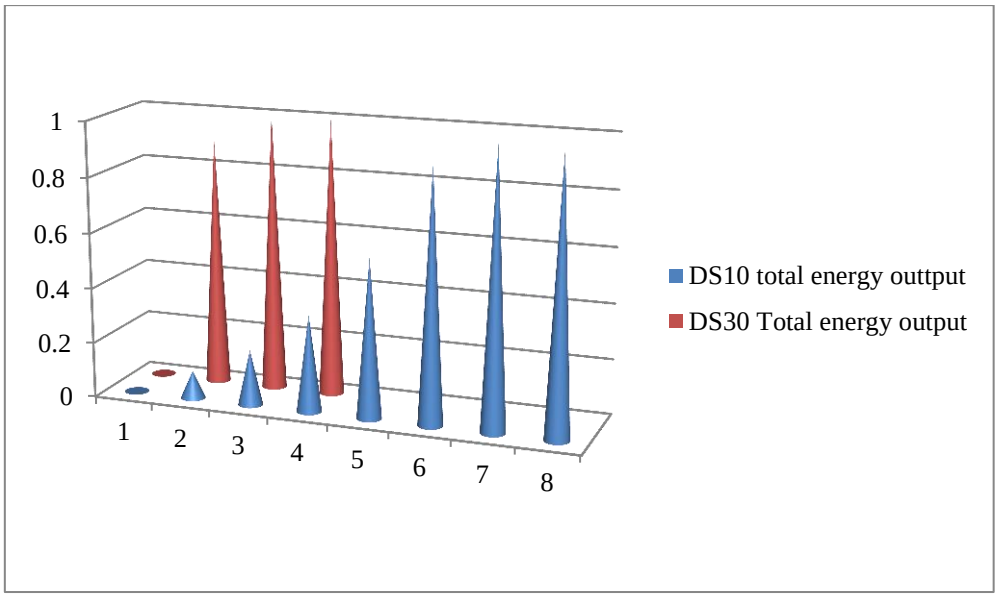

Figure 12: Comparison of Total energy

We observe all three design simulation results of bending we decide the “design 3” are going to be generating a lot of bending angle at the pressure of 15kpa figure “5” are going to be showing the bending of the gripper once choosing the best design once more simulating the pressure take a look at exploitation the Dragon Skin 30 material at the pressure of 50kpa higher, than figure 6 showing the bending results. And we observe the strain energy output comparison figure 11 shows, figure 12 shows the total energy output considering the all simulation output results we choose the design3 with Dragon Skin10 material after selecting design again simulating the big section air path because when we apply the vacuum pressure to sucking the objects on that time if the design is not good it may cusses leak the air it affected the suction process figure 13 shows the big suction air path this process top of the finger is fixed, apply the -20kpa vacuum pressure on inner air chambers after seeing the results output our design produces the good output finally our required needs satisfy the design 3 with their dimensions

Good for the food industry

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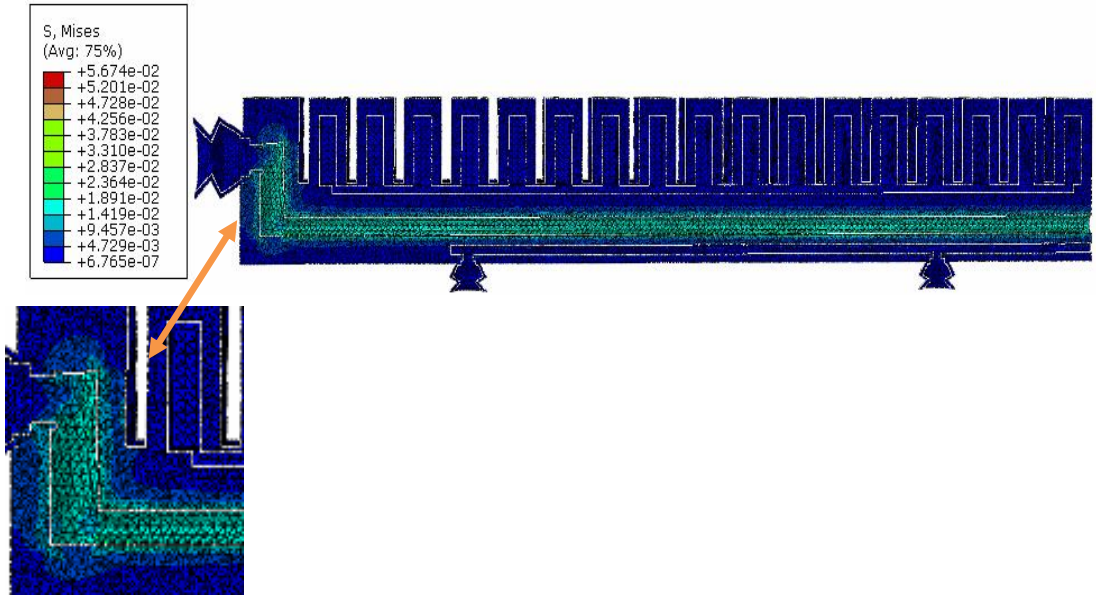

Figure 13: applying of vacuum pressure of big suction cup air path

So finally if you need more angle of bending us need more air chambers and small bottom layers thickness then we get more angle of bending by using that vacuum cup to suck the objects without bending so that our design is best for multi objects handling.

V. CONCLUSION

In modeling and comparative analysis of soft gripper for food business to handling need the gripper it having light weight, so polymer gripper is appropriate for the handling of fabric. During this work crating the three completely different styles with two different materials simulating all three designs look observantly of all simulation test results of potential energy, strain energy and total output work choosing the design3 with Dragon Skin 10 material is best for the soft gripper. Finally choosing the nice material for the desired style perform vacuum test at apply -20kpa negative pressure for the internal air path of the massive suction path see the however the negative pressure can touch the inner air path. If the vacuum take a look at the method the results made a lot of stress values the style the planning the look isn't smart again once a lot of modification the scale as a result of if more stress in the operating method could also be the air are going to be leaked however in our design generating the stable results at that pressure, therefore, our design7 with Dragon Skin10 glad the each condition. It will hold material with high accuracy as a result of the lowest facet of the gripper conjointly providing the suction cups by that improve the holding capability while not injury the merchandise and holding a lot of objects to activating a lot of those one pressure modes, therefore, we elect this synthetic rubber soft gripper

VI. FUTURE SCOPE

- Work can be performed with other materials also
- Physical test can be performed on the best design and comparison done with simulated worked

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