A REVIEW ON SILICONE RUBBER SOFT GRIPPER

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ABSTRACT

This appraisal paper is introducing a survey of the silicone elastic delicate gripper, we study more than 50 papers noticing the all finding and examination subtleties of the papers concurring their outcomes and their conversation we set up this paper, we compose the all-out audit of this silicone elastic delicate gripper. We are including this paper creation, distinctive incitation strategies, and reproduction subtleties of the diverse plan with various models and various materials utilized for the manufacture of this delicate gripper, in the wake of noticing all paper choosing the Dragon Skin10 (DS10) material with multi air chambers gripper is best for the creation of the delicate gripper.

Keywords: fabrication, actuation, material, simulation

1) INTRODUCTION

A recent year's technology was developed in the field of robotic the robot having the gripper that is very important to hold the objects Soft robotics is a new member of the robotic household that has several promising features, such as lightweight, inexpensive, easily fabricated, honestly to manipulate, etc[1, 2]. The design, fabrication, and actuation of tender robotics have attracted the developing attention of researchers from multiple fields such as chemistry [3, 4], physics [5], biology [6, 7], and mechanical engineering [8, 9]. To holding the objects gripper are many types available to handling the objects but soft and precision material we need soft gripper. This gripper also having different types to hold different objects so research is proposed as the soft silicone rubber soft gripper. This soft gripper used in different industry and general-purpose application those are food processing, pick and place purpose for precision objects, underwater gripper, surgery tool, shop floor dusk, but in medical still facing challenges for holding the precision surgical tools because of lack of modeling and manage algorithm [10]Different soft gentle actuator is developed that ought to produce the bending motion by themselves or by the mechanism used that bend, due to the actuation [11, 12]. This gripper to actuation three types is available 1) pneumatic 2) Cable 3) hydraulic, is used for actuation the gentle gripper but out these three mostly used pneumatic actuation. Because Fabrication of this gripper is easy and pneumatic air available free of cost used to fabricating this gripper used material is silicone rubber in this silicone rubber available in two parts that are part A&B by mixing these two parts in the same percentage prepare the soft gripper. At the present different type of silicone rubbers are available Dragon skin10 (DS10), Dragon Skin20, Dragon Skin30, Ecoflex 10 Ecoflex 30, smooth sil 950 these are the material used for this gripper but mostly used the Dragon Skin10, 20, 30 because it less density and generating better work output the soft gripper can be fabricated by several approaches including multi-material 3D printing [13, 14], shape deposition manufacturing (SDM)[15], soft lithography [16, 17], or integrate multiple manufacturing approaches to create composite materials [18, 19] considering the cost, fabrication time, holding of material used this silicone rubber soft gripper method. The fabrication of this silicone rubber soft gripper preparing the two parts, first part is preparing by using 3d for die printing the die also different shapes according to our design requirement the shape and design will change, the second part is preparing the silicone rubber mixture this silicone rubber available in two parts that is part A&B to mixing these two parts in the same ratio after preparing the mixture pouring into die to wait for 30min to 2.5 hr in presence of room temperature and vacuum cooling based on the material

Actuation is the work for holding the objects according to the actuation the gripper material and model will be changed. To actuating the soft gripper having the different types that are pneumatic, cable type, vacuum, hydraulic but in this silicone gripper two methods are mostly used 1) pneumatic technique 2) cable operation because this gripper is soft made of silicone rubber that why use only these two actuation techniques the remanding techniques also used. By using these grippers to operating the gently the precision and smooth objects easily

2) DESIGN AND FABRICATION

2.1) Designing and printing of die

Design the gripper to considering the distribution of stress throughout the adhesives must be as uniform as allow load sharing [20] and the layers had been used as a structural asymmetry to convert growth of the chambers of elastomer actuators into bending [21- 23]. In designing the soft gripper, we consider some points 1) wall thickness of the internal chambers 2) in a multi-chamber gap between two chambers must be small so it can generate the more bending angle 3) thickness of the layers it will also be affecting the bending angle consider these points design the gripper. This gripper fabricating having two processes 1) printing of die 2) preparing the soft gripper.

1) Printing process using the 3D printer for printing the required shape of gripper die in this printing process mostly used FDM (fused deposition machine) because low cost easily available. Before printing the die to design the required shape of gripper die so that design required several parts so in designing purpose use some design software that is Auto CAD, Solid Work, CATIA, by using these software design the required shape of the gripper dies. To complete the design to convert the design into 3d printing file that means an STL file that STL data giving to the 3d printer according to the data 3D printer is printing the gripper die. The design for the different gripper to supplied the different pressure ranges according to that range to use different pressure levels that are 7 psi, 0.5atm, 50kPa [24] that pressure to control using some microcontrollers and processors

2.2) Fabrication of gripper

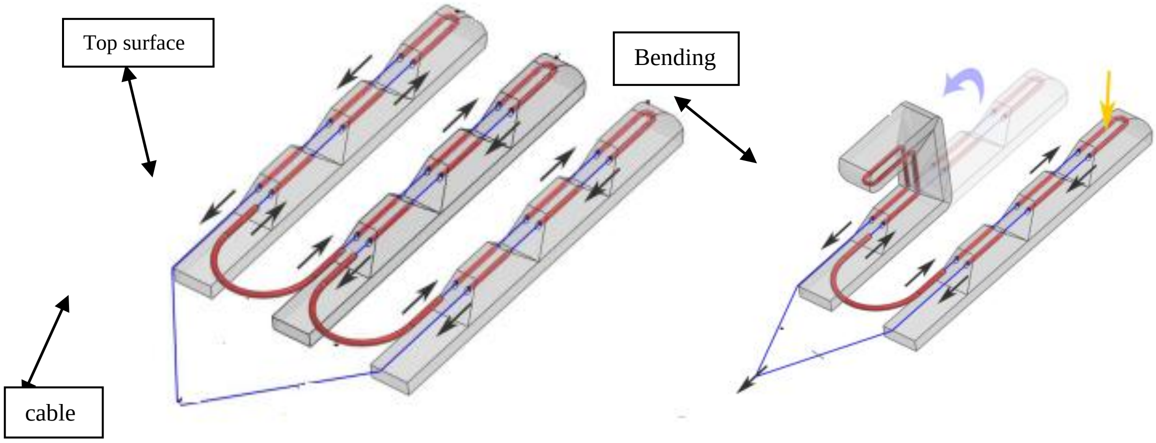
Fabrication is the process of preparing the soft material, pouring and solidification processes in this fabrication we used the different types of mold, the model used is based on the analysis by Gafford [25]. Some gripper their need the 3D printing parts those parts attached directly using the mold star30 material because of it having the good mechanical strength so it can protect the joints. Prepare the required material in this material available in two parts part A&B by mixing these two parts in 1A:1B ratio after pour into die in this pouring process some time air bubbles will form it damage the gripper so carefully pour the material in to die. After the pouring process completed to solidified the die in different ways 1) room temperature in this cool the die at normal room temperature it will take 30min to 2.5 hr based on the type of the material used these type cooling mostly used dragon skin 10, 20, 30 type material 2) vacuum cooling in this type material placed in the vacuum chamber and set the temperature at 60℃ to 100℃ based on the type of the material in this system mostly used Mooth-Sil 950, Elastosil M4601 type material after complete solidification process to remove the gripper from dying to actuate to test the gripper

3) ACTUATION

Actuation means some amount of work done the gripper with help of some actuation process in soft gripper mainly used the three actuation models 1) pneumatic 2) cable actuation 3) hydraulic

1) Pneumatic actuation is done with help of the air pressure in this actuation high compressed or pressurized air passed through the internal chambers air chambers of the gripper in that pressure the gripper bends some angle to hold the objects, first pneumatic operating system used in the soft grippers are Deimel and Brock [26] with help of the pump and Alternatively, do this process piston-cylinder arrangement [27]. Operating different grippers needs different pressures in the "Asymmetric Bellow Flexible Pneumatic Actuator for Miniature Robotic Soft Gripper" 0.3MPa of internal steady-state pressure, 5and 6kpa gauge pressure used to actuate the gentle gripper [28], to measure the pressure using the one-touch (KQ2UD04, SMC, Japan), the pressure changed the based on the material for Dragon Skin10, 20 to 50kpa sufficient to generating near to 270℃ of bending angle because the density of the material is low compare to other, Dragon Skin30 50 to 150kpa It will generating the near to 360℃ of the bending angle. Pneumatic actuation is the best actuation technique for the soft gripper because the cost of the system is low and the cost of the fabrication process low and easy to operate so mostly prefer this actuation

2) Cable actuation to actuating the gripper cables placed in the die center of the gripper its placed before pouring the rubber, below figure 1 show the details to actuating process used 1331T006SR [29], model its very power full motor to place the motor at motor housing the details show below figure 2 by this motor to hold and pickup up to 3kg in this system suitable for hard material. The top part of the gripper used Dragon Skin materials for gripping purpose



a) Pacing of the cable at center b) actuation of the gripper

Figure 1: Details of the actuation

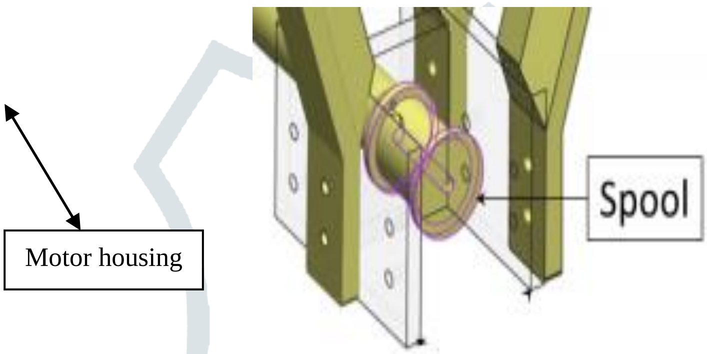


Figure 2: motor housing details

The cable-type of actuation is suitable for the easy operating and operating required less space holding and pick up the objects gently, suitable for the hard type of objects to be grasping as comparing the pneumatic but the main problem is not suitable for all the objects this type of actuation because it made as different mixing of silicone rubbers it may hard but is giving the better output

3) Hydraulic actuation is also similar to pneumatic in this system using the hydraulic oil or fluid if we need more grasping power that time using this system to actuating using a hydraulic motor with help of valve operating system solenoid valves are used mostly this system is pressurized fluid passed through the gripper finger due to that force fingers will be expanded to graph the object to getting this pressure using the hydraulic motor and piston-cylinder both are using them according to the needs this hydraulic

Pressure will be different from the different shape of the gripper that pressures are 6kpa, 0.5kpa, etc the cable-type of actuation is suitable for the easy operating, operating required less space holding and pick up the objects gently, suitable for the hard type of objects to be grasping as comparing the pneumatic but the main problem is not suitable for all the objects this type of actuation because it made as different mixing of silicone rubbers it may hard but is giving the better output

4) FINITE ELEMENT ANALYSIS OF FINGER

FEM approaches are used to analysis of gripper with different tests simulation process using the different software's 1) Abaqus 2) Ansys 3) solid works etc. but Abaqus is best software because its new type software in the simulation fields and it's generating the better results. In soft gripper used some material the details show below table1. In this simulation of the gripper two model of design available

Table 1: Material details

Material	Software	Model	Coefficients	Density
Dragon Skin10 (DS10)	Abaqus	Yeoh	C10=36Kpa,C20=0.25Kpa, C30=0.025Kpa [30]	1070kg/m3
		Ogden	μ1=180.2,μ2=553.8,μ3=409.9Kpa [31]	
		Neo-	C1=42.5 Kpa, μ1=-85 Kpa [32]	

		Hookean		
Dragon Skin 20	Solid works	Hooke's law	E=0.120 Mpa [33]	1075kg/m3
	Abaqus	Ogden	µ10=1307.7,µ20=2349.7,µ30=1207.5 Kpa α1=1.1087,α2=-0.0317,α3=-1.6291 [31] D1=490.0,D2=0,D3=0 Kpa	
Dragon Skin 30	N/A	Mooney–Rivlin	C10=0.001190KPa,C20=0.023028 Mpa [34]	1080kg/m3
	Abaqus	Yeoh	C10=0.096Mpa,C20=0.0095 Mpa [31]	
		Ogden	µ1=1180.6,µ2=874.3,µ3=1939.6Kpa α1=1.0698,α2=-1.2370,α3=0.1347 [31] D1=702.9,D2=0,D3=0 Kpa	
	Ansys	Yeoh	C1=0.11488 kPa,C2=0.001262 Mpa [35]	
Ecoflex 10	COMSOL	Generalized	C10=-7.48,C01=0.19610 Kpa [36]	
		Rivlin	C20=-19.81,C02=-53.9 Kpa [36]	
Ecoflex 30	Abaqus	Yeoh	C1=110,C2=20 Kpa [37]	
		Ogden	µ10=1.887,µ20=0.02225,µ30=3.574 Kpa α1=-3.848,α2=0.663,α3=4.225 [38] D1=2930, D2=0, D3=0 Kpa	1130kg/m3
	COMSOL	Yeoh	C10=0.0127,C20=0.423,C3=0.00146 Mpa [39]	
Mooth-Sil 950	Abaqus	Neo-Hookean	C10=340 Kpa [40]	

1) single air chamber in this bending angle is depend on the thickness of the internal wall if small thickness of internal air chamber produces more bending angle below figure 3 show bending of gripper at different pressure ranges [41]. This single chamber gripper required more pressure to multi chamber its suitable for holding the hard and 3 to kg 6 of weight

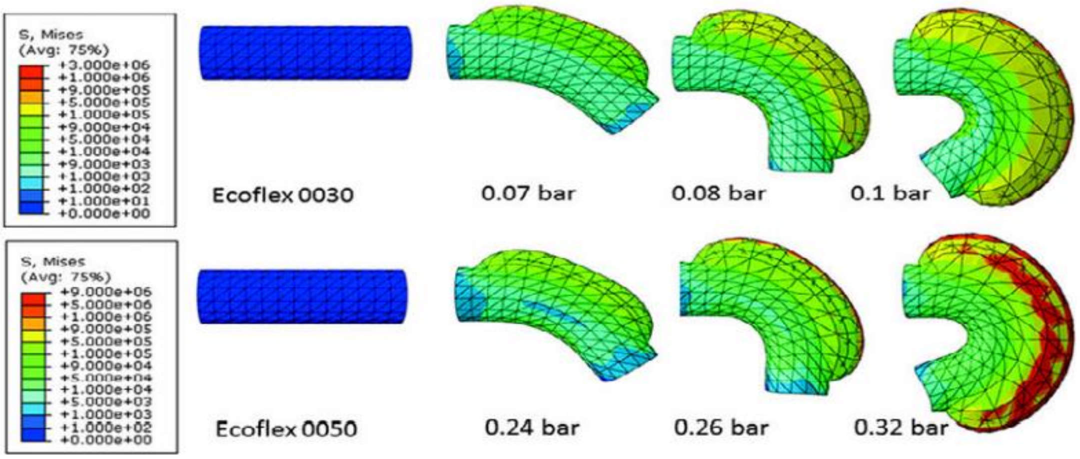
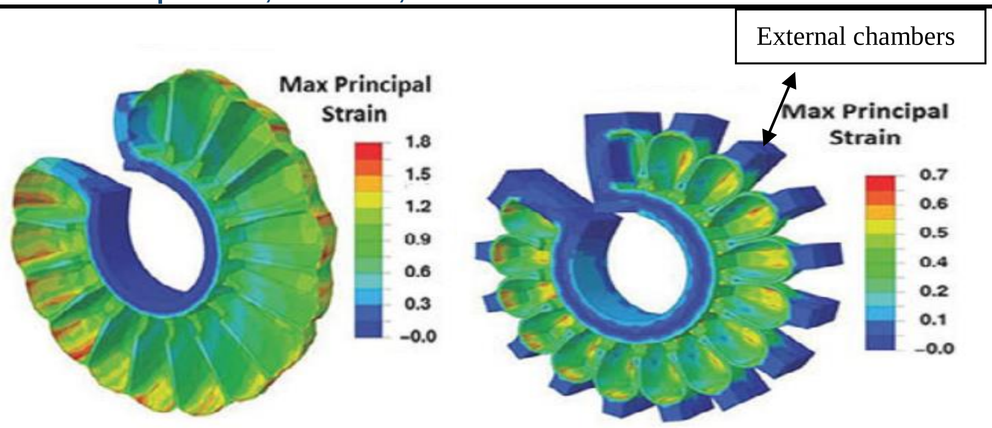


Figure 3: single air chamber gripper bending at different pressure with different material

2) Multi air chamber gripper these grippers having the more than one internal air chambers so it can generate the more bending angle at low pressure the angle of bending is depended on some points a) thickness of the internal walls b) gap between the two chambers c) thickness of the bottom layer d) if increase the numbers of air chambers in fixed length is generating the more bending angle, this multi air chamber having two types [41]1) only internal air chambers in this chambers generating the more bending angle comparing with single air chambers figure 4a show the bending of gripper at 45kpa pressure 2) internal and external chambers in this type gripper generating the more bending angle compare with the only internal chambers at low pressure figure 4b show the bending angle with pressure of 40kpa



a) Internal air chambers at 45kpa b) internal and external chambers at 40kpa

Figure 4: multi air chamber gripper

Different model of design needed different pressure below figure 5 [42] show the bending half circle using the Dragon Skin20 material at 30 kpa pressure. By using the above material detail performed the simulation but mostly used the Dragon Skin 10, Dragon Skin 20, Dragon Skin 30, these materials used mostly for soft gripper because it produced the more bending angle at low pressure

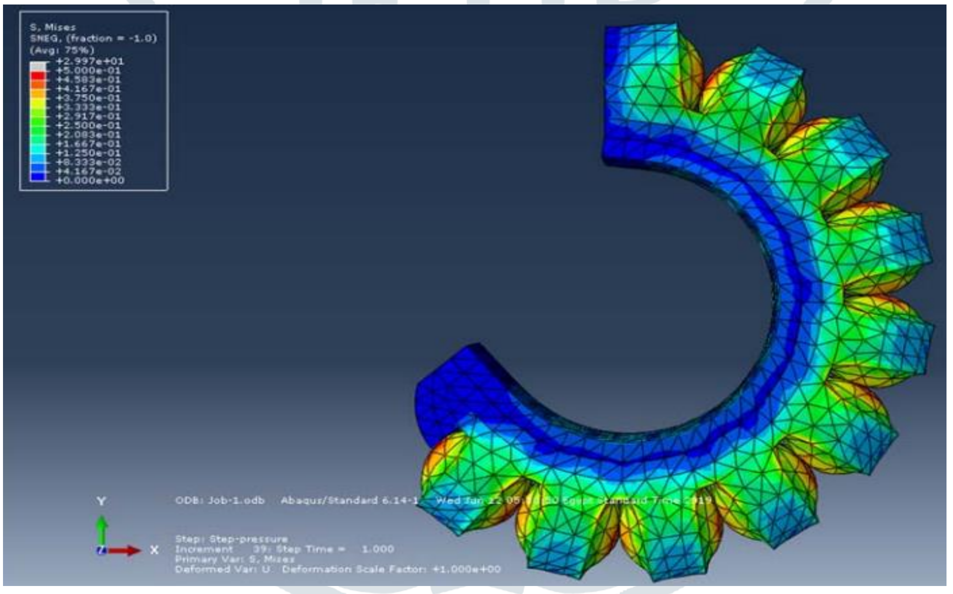


Figure 5: bending at 30kpa pressure

Defecting of the multi chamber gripper with respective to pressure those angles are 27∘, 30∘, 43∘, and 48∘ as in opposition to the 35∘, 37∘, 48∘, and 56∘ as bought via the manufactured actuator at inner pressures of ninety 90kPa, one hundred twenty 120kPa, a hundred and fifty 150kPa, and a hundred and eighty 180kPa [43]. The FEM approach is an incredibly correct way to reproducing the deformation conducting the deformable objects and has been regularly utilizing to the mannequin and simulates tender gripper [44-48] the below figure 6 showing the simulation details of the two different material figure6a is the Dragon Skin 10 and figure6b is the dragon skin 30 material[49]. Below figure7 showing the Down scale simulation of the pressure and curvature of the gripper under pressure [50]

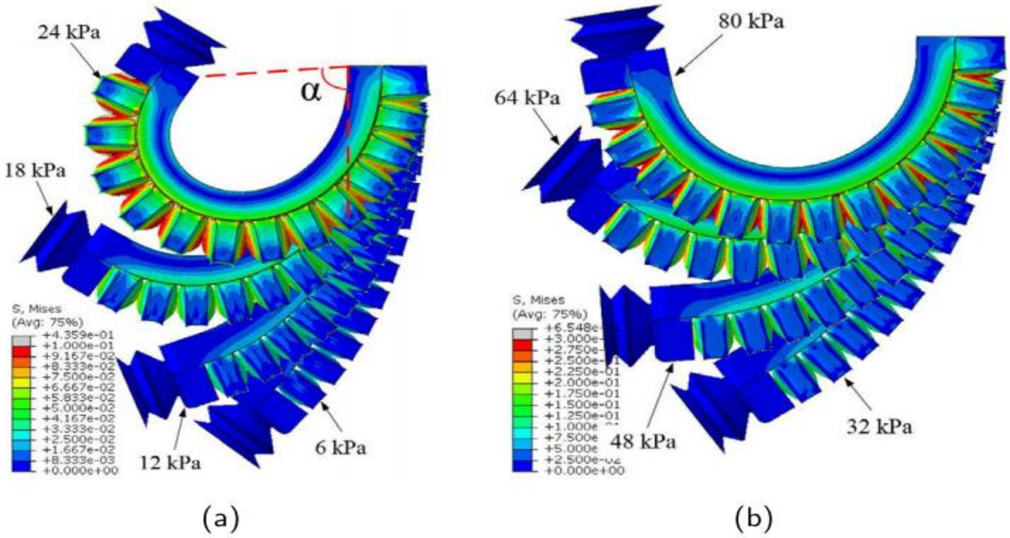


Figure 6: Simulation of the multi- air chamber gripper a) Dragon Skin 10 material b) Dragon Skin 30 material

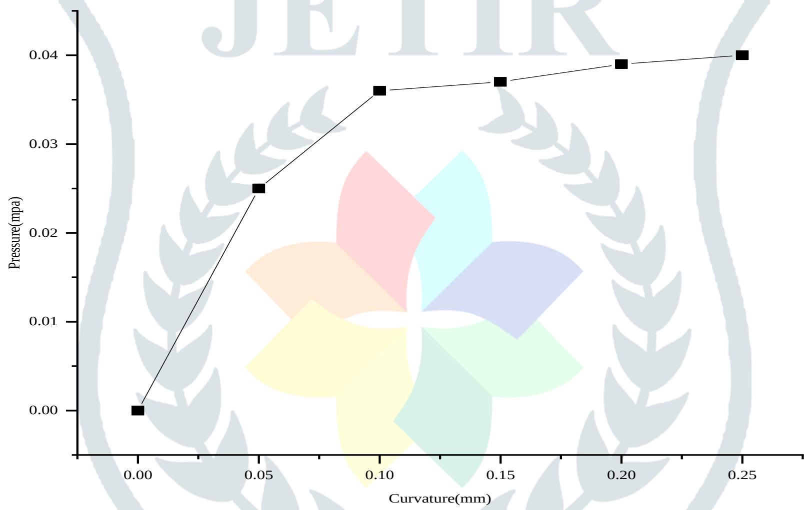


Figure7: the curvature of the gripper concerning pressure

5) RESULT

Our result describing the how to working and grasping the different gripper the final output of adapting and different load condition of the soft gripper show the grasping of objects change the displacement at different force if the gripper having the one chamber is easy to control of the more than two chambers comparing to a conventional actuator of more than two chambers [51-54] the detail of each finger of the gripper when applying the load how to reacting each finger of the gripper and the gripper 1 maximum average grasping load 0.68N and gripper two 15.12N under the tension [55]. To recording the readings using the force gauge Mark-10 M5-10 the angles of joints is zero degrees [56], output toque with two noted points; nonlinearity was not captured by the model, measure torque exceeds the predicted torque If the gripper getting stable in the grasping of more than 3kg of weights the gripper weight is 156 gram [57] and some gripper reacting very fast ensuing actuator bends 270◦ at 17kPa with an enter of 15.7mJ of power takes less than 0.4s [58]

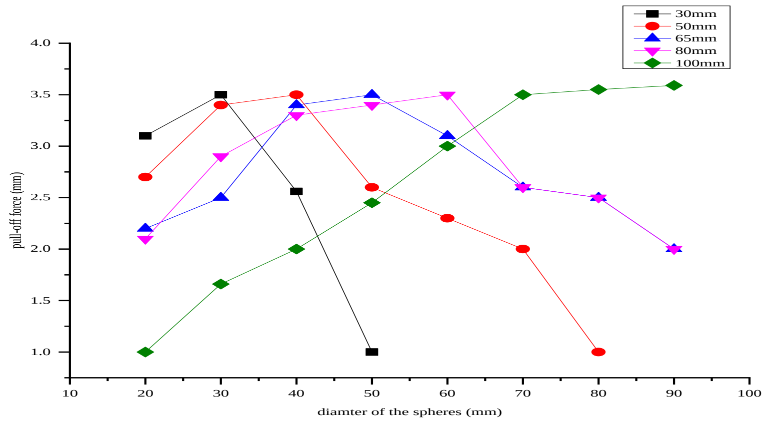


Figure8: Detail of the different size of the spheres with respected to force

The above figure8 explains the detail of the different spheres is grasping at the different forces "Universal soft pneumatic robotic gripper with variable effective length"[59] the gripper's most common greedy pressure price is 1.02N in the corresponding of 25.12N of tension. The below figure9 is showing the experimental and theoretical difference between the force and pressure relation of "Asymmetric Bellow Flexible Pneumatic Actuator for Miniature Robotic Soft Gripper"[60]

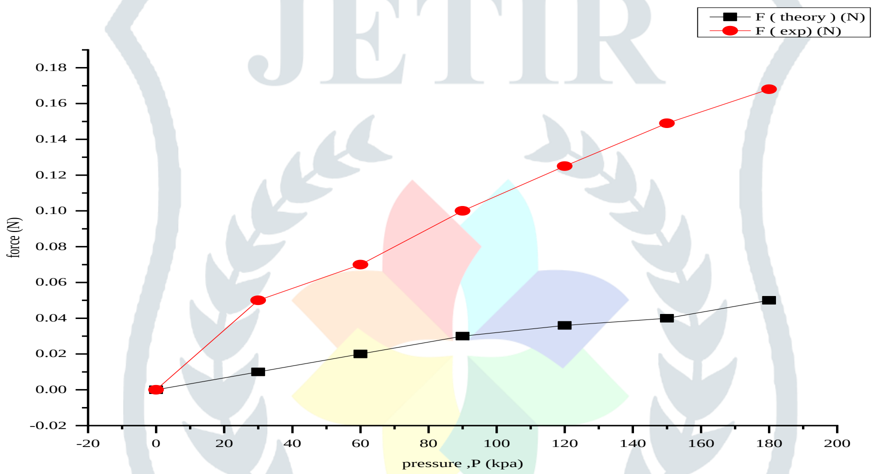
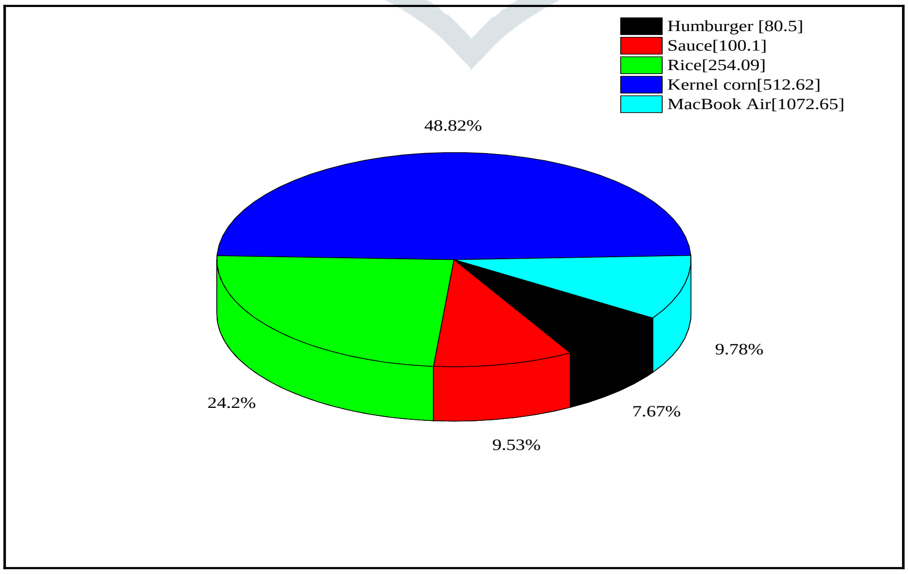


Figure 9: show the difference of the theoretical and experimental

The below figure10 is showing the suction test results of the different type of items concerning the weight how much percentage of the suction required to lift those item [61]



Figur10: detail of suction pressure requirement

Different gripper exhibits the different load characteristics at different force or pressure levels the below figure 11 showing the resistive forces of two different object [62]

Figure11: gripper forces for different object

6) CONCLUSION

In the field of robotic different gripper are available but handling the soft material a smaller number of the gripper are available, the best one is silicone rubber soft gripper. Our systematic review of the design, fabrication, and simulation of the soft grippers used to hold the soft materials and precision parts in the field of food processing industries, medical, home application, pick, and place purpose. By using this gripper to do the work at low cost and less time, this soft gripper is easy to fabricating compare the all-other types of the grippers because of the process of fabrication is casting solidification at room temperature and vacuum.

In simulation process different design are observing and finally chose the multi- air chamber is best if increase the more chambers in fixed length it will generating the more bending angle with help of the Dragon Skin 10 material is best for this soft gripper because low density it will generating the more bending angle

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