UROP Report

Robotics Gripper Development for Warehouse Automation

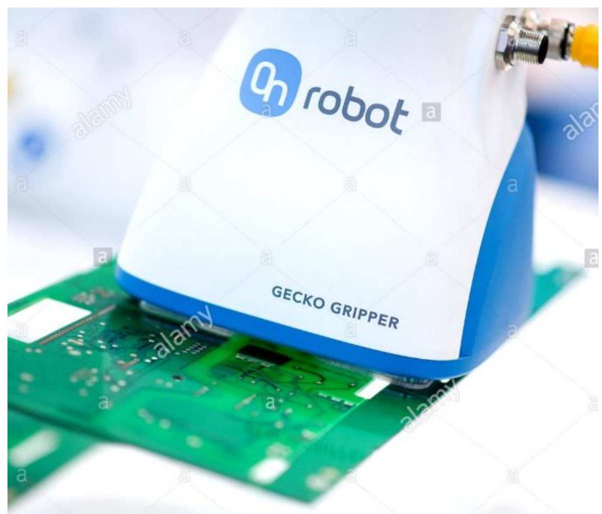
LIANG Yuchen Eric (20582717) | 2020.08

ABSTRACT

This UROP project is named as Robotics Gripper Development for Warehouse Automation. The naming involves Gripper and Automation which means the research focus on developing a gripper mechanism which can be applied to warehouse environment mainly for automation purpose. The gripper mentioned above is not the normal mechanical gripper we see in our daily life but another kind of special gripper that require special material design for the touching surface of the gripper and the object to be gripped. The material is a kind of gecko inspired dry adhesive which was inspired by the gecko's feet. For 2020 summer, the UROP research focus on mostly material design and fabrication and the mechanism mechanical design of the gripper.

INTRODUCTION

Gripping is a very easy action for man, our hands is biologically designed for gripping things. Gripping is also a very important action in our daily life. The action not only play a very important role in human lives, scientist and engineers have been research and develop robotics gripper for industrial use for decades. Several kinds of grippers have developed and largely used in the recent years [1] including, mechanical grippers which can be more specifically divided into pneumatic and hydraulic driven gripper, vacuum gripper, and servo-Electric Gripper.



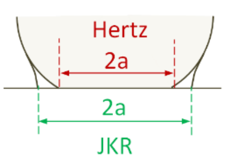
The kind of gripper that this UROP focus on is not the above kinds of gripper. This kind of gripper is a bionics mechanism/material. The gripper simulates the adhesion of gecko pads which allow itself to hold on any surface using chemical forces. The advantages of this kinds of gripper is it do not need too many spaces for mechanical structure and it do not need extra spaces beside the things to be gripped since it can provide lifting force by only attached itself to a single surface. The disadvantage of this gripper is it is difficult to manufacture and the force it provides is not big enough to withstand heavy things and adding the factors that it is expensive to be manufactured. To provide bigger force, engineers need to build dry adhesion with better performance, robustness, and durability [2].

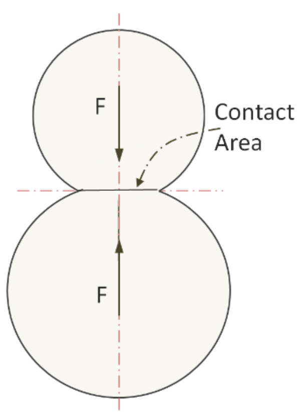
For this summer, this UROP focus on understanding the very basic physical principle of gecko adhesion, building of the gecko adhesive material, and designing the mechanism of the gripper.

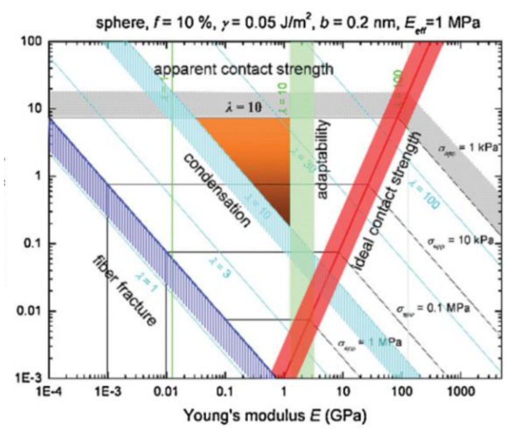
This report will mainly focus on summarizing the research of this area, the research and learning process of this UROP project.

PHYSICAL PRINCIPLE

The Johnson–Kendall–Roberts (JKR) theory [3] describes how two bodies adhere together and what deformation they undergo when in contact with each other. The deformation is the result of two opposing forces which results from surface tension and elastic deformation.

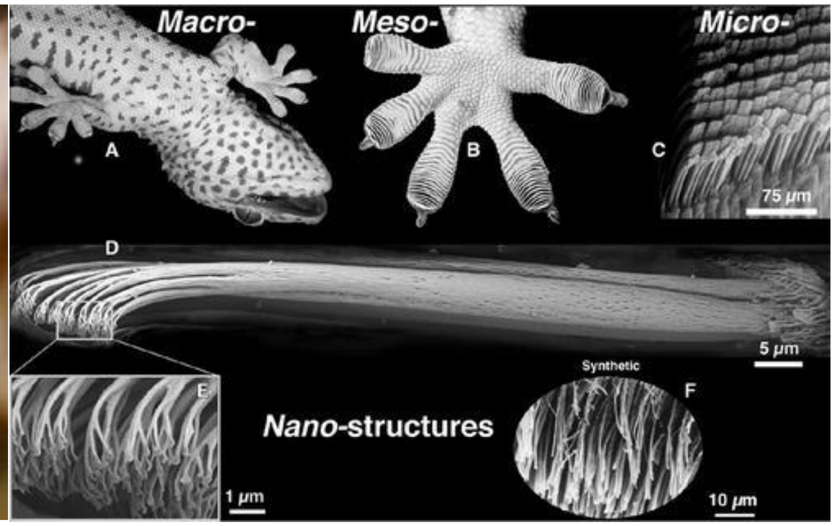






The theory can calculate the necessary force for producing a contact area with two different spherical solids of different radius.

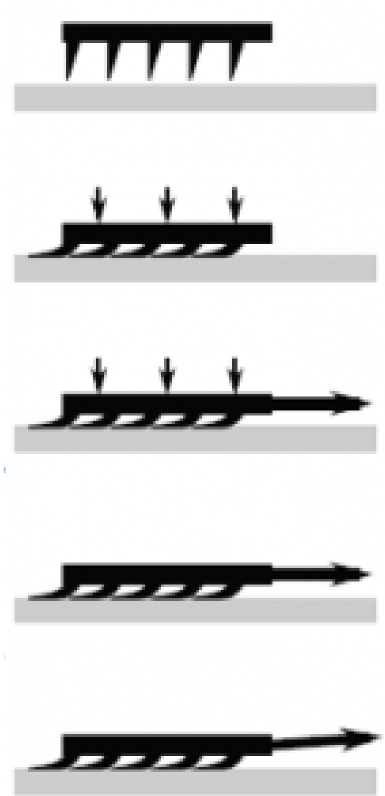
Though the JKP model does not contain any capillary contributions to the adhesion force, other research state that both contributions may be involved.



Gecko’s feet have a kind of special structure. On its feet there are three layers of setae. The first structure is at meso size, the second layer is microstructure and the third is at nano size. These three layers of setae will increase the actual contact area of the gecko feet with the surface, making the space between the feet and the surface is extremely small creating chemical forces between atom which is called can de Waals force. The feet of gecko are extremely fine structure and highly reversible. This allows gecko to climb up a vertical surface at a very high speed.

DESIGN AND FABRICATION

The purpose of the project is to simulate the gecko’s feet structure. But the manufacturing precision does not allow the parts to be as precise as a gecko foot. As a result, the structure needs to be simple and effective.

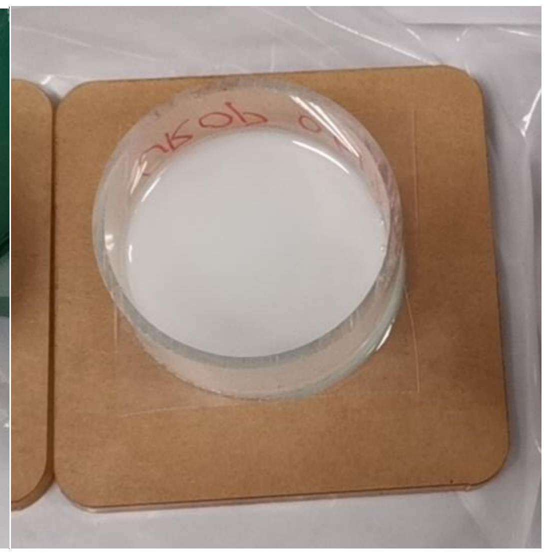


In this UROP project, the shape shown in the picture beside is used. Each spike looks like a right triangle. Technically, when providing a shear force and a normal force, the surface contact together will provide a relatively big van de Waals force. This force will drag the things to be gripped to the gripper.

To create this kind of structure, in this project, mold is used. The original mold is made of metal (Aluminum), the fabrication method is using CNC machine attached by a right triangle shape tool. By moving on the surface of a aluminum part, it can create the shape we want.

Since the Aluminum part is expensive, the next step is to do a turnover to avoid possible damage of the original mold. Using silica gel to create a functional part and use this part to do the turnover. The reason of choosing silica gel as the material is it is durable and uneasy to be damaged. This part’s structure can already be seen under the telescope. The turnover is done using a high-performance casting resin called Task 3 produced by Smooth-On company. By mixing the part A and part B together, the material will be solidify after filling the space around. The material can copy the touching surface in great details so it can copy the shape of the silica gel part, making itself into a turnover-mold. The mixed material needs to be put into suction pump to gather all the gas inside in order to avoid air inside to affect the flat surface of the material.

The material is contained in an acrylic tube with an acrylic board covering the bottom as shown in the picture below left.



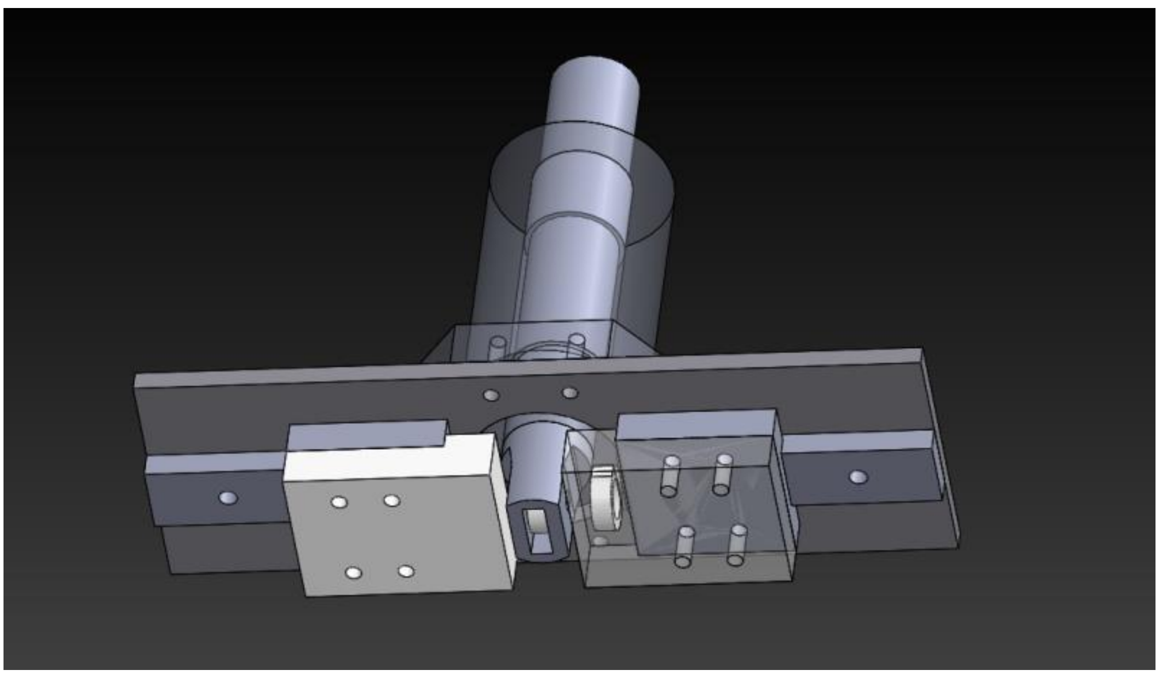
After creating the turnover mold, another kind of silica gel is used to make the actual part for application. The material is called Mold Star 15 Slow also produced by Smooth-On company. Simply mixing the part A and part B of the material and putting the turnover mold on to the material can create the parts we need as shown in the picture at the left.

Mold Star™ 15 SLOW

Mold Star™ rubbers are easy to use platinum silicones which are mixed 1A:1B by volume (no weighing scale necessary). **Mold Star™** silicones feature relatively low viscosities and vacuum degassing is not required for most applications. The pot life of **Mold Star™ 15** SLOW is 50 minutes and cure time is 4 hours at room temperature.

Features

Mold Star™ silicones cure to soft, strong rubbers which are tear resistant and exhibit very low long term shrinkage. Molds made with **Mold Star™** will last a long time in your mold library and are good for casting wax, gypsum, resins, concrete and other materials. Cured **Mold Star™** rubber is heat resistant up to 450°F (232°C) and is suitable for casting low-temperature melt metal alloys. ***Note: Mold Star™ rubbers are not intended for brush-on moldmaking.***



Despite the manufacture of the material, a mechanical gripper is also designed aimed to apply the material as a gripper. The mechanism is made of several parts, two separated mini rails is attached on a board and a rod pressed by the used is also attached on the same board. the two slider is hold with magnet. The magnets will always tend to drag the slider inside. When pressing the rod, it will push the two sliders aside creating a shear movement and a shear force, leading the spike on the material pad to lie down. This will enable the van de Waals force and stick the gripper on to a surface.

FUTURE OUTLOOK

The current state of the project is none of the gripper pad is successfully build since the fabrication need extremely high detailed operation. The prototype is not built because of the inaccessibility of manufacture equipment. The next step of the project should be focusing on improving the manufacturing method, increase the success rate and build the prototype of the designed mechanism. The mechanism now has a lot of problems already and it still need to be perfect.

References:

[1] "Grippers For Robots." [Online]. Available: https://www.robots.com/articles/grippers-for-robots. [Accessed: 23-Aug-2020].

[2] L. F. Boesel, C. Greiner, E. Arzt, and A. D. Campo, "Gecko-Inspired Surfaces: A Path to Strong and Reversible Dry Adhesives," *Advanced Materials*, vol. 22, no. 19, pp. 2125–2137, 2010.

[3] "Polymer Properties Database," *Energy of Adhesion*. [Online]. Available: http://polymerdatabase.com/polymer physics/Adhesion Contact Mechanics.html. [Accessed: 23-Aug-2020].