



Custom Fingertips for Adaptive Grippers

Library and Instructions

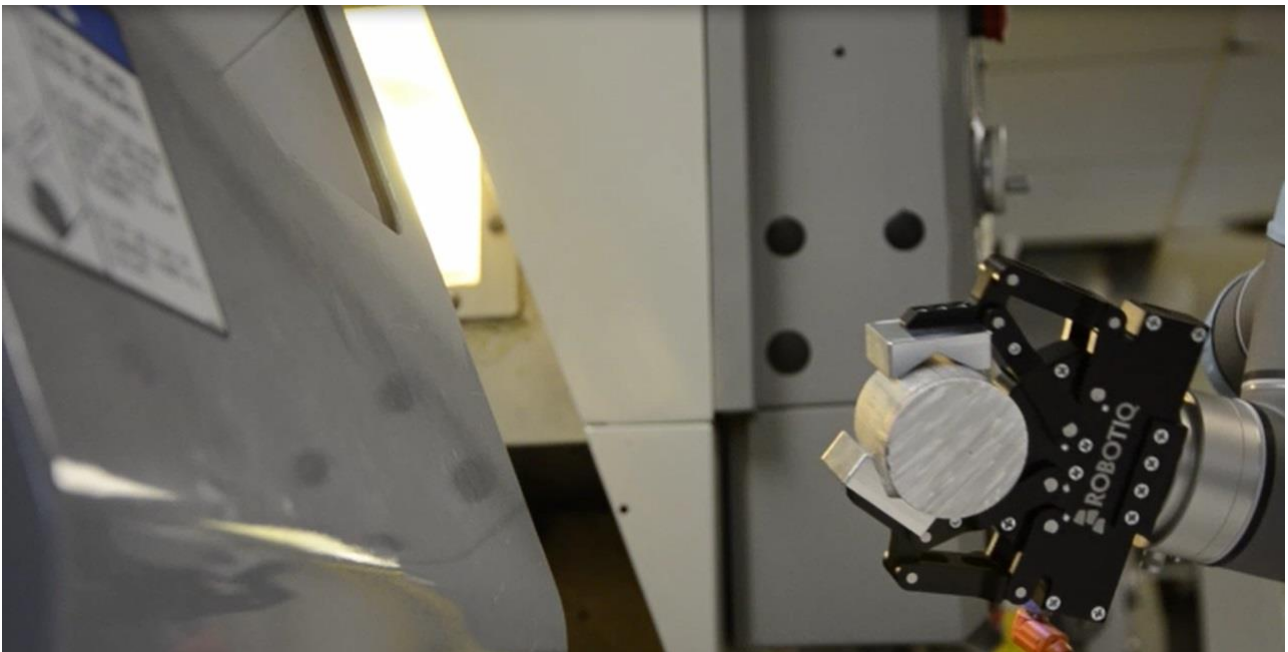


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INTRODUCTION

In a market where a wide variety of robot end-effectors are available, it may be hard to determine what is the best choice for your application. Most of the time, the choice of a gripper can be narrowed down to: Will this gripper work for my application? Even if the gripper has awesome specifications, if it cannot grasp your targeted object or execute the required task... it's not the right gripper for your application. This eBook will present strategies for grasping your parts using an adaptive gripper. It also discusses different ways to design fingertips for your applications. Included is a comparative chart of the different fingertips that have already been designed and how to use them properly.

1. END-EFFECTOR GRIPPING STRATEGIES

This section explains how to use the specifications of the Adaptive Grippers to enhance your gripping operation.

Use the Proper Fingertips

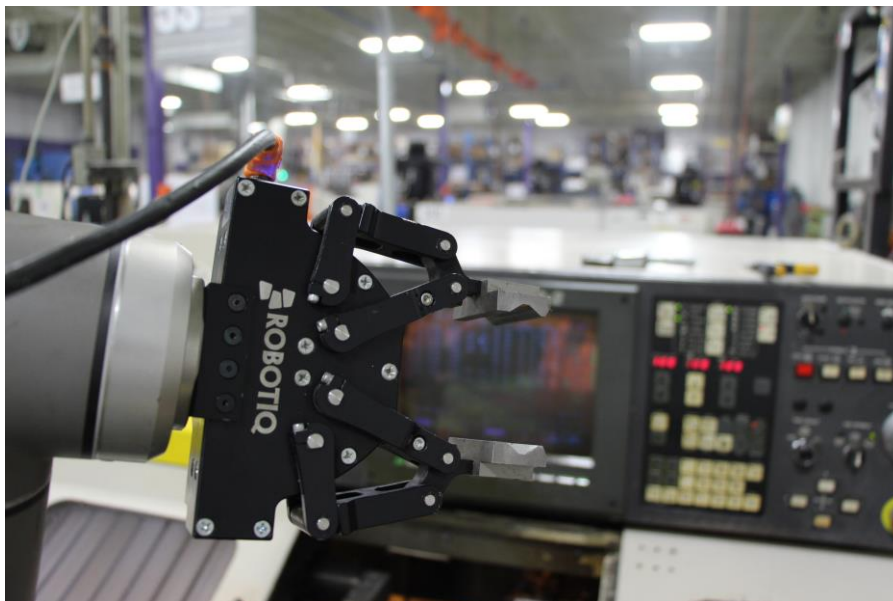
At the end of the day, the fingertips are the link between the gripper and the grasped object, right? So to optimize your gripping force or even your gripping strategy you might need to use a different fingertip. In fact, by using a customized fingertip, your grip on the object should get better and this will ensure a more reliable process.

Why not use the regular fingertips? It is not a question of good or bad functionality, it's more a question of what is best for your application. Most of the applications out there will be able to use the regular fingertips provided with your gripper and never have to worry about a proper grasp. Although, specific applications might have to use a fancier more dedicated fingertip to be able to reach their production goal or to ensure better gripping depending on the object or application.

Examples

- **Cylindrical Objects**

Most grippers out there (even ours) uses flat fingertips. Most of the time gripper manufacturers assume that the best way to grip something is by using flat tips. Although, when it's time to grip round parts, the flat fingertips create a force only on a thin region of the part. To enhance the grasping technique you may want to either increase the grasping force or enhance the amount of surface that touches the parts. Generally, you will want to have more than two contact points or pressure areas grasping the part. To achieve this, the part can be grasped using the [encompassing grip](#). This can also be achieved by using custom fingertips in a "V" shape.



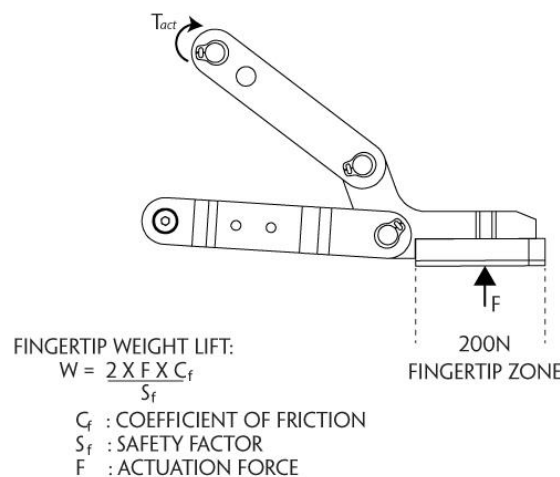
Example of "V" shaped fingertips for machine tending application.

By using this kind of fingertip, you get four pressure areas on your part. This means that the part is completely secure. By using the "V" shape instead of a round "C" shape it is possible to grasp a wider range of parts. The fingertips will be able to apply four pressure areas on everything from small diameters to wider ones.

- **Large Objects**

Big objects don't always mean heavy objects. Make sure to evaluate not only the geometry, but also the weight of the object that has to be grasped by the gripper to make sure it will work out. In fact, a large lightweight part can be grasped depending on its specific geometry even using a small gripper.

Although, if your big object is also heavy that's another thing. It is then important to consider the friction coefficient between the fingertips and the object. The more friction you have, the heavier the gripper can grasp. In fact, by using custom fingertips composed of a special rubber, for example, you can increase the friction coefficient and allow your gripper to carry a little extra part weight. A good post to review this in more detail can be found [here](#).



- **Small Objects**

Small objects often mean you also have a small picking or dropping area. You don't necessarily want to use big fingertips to place a small electronic chip onto a tiny electronic board especially with other fragile components around it. This is why we recommend creating customized fingertips with a narrow gripping area (which also means a reduced fingerprint on the pick and place layout). This would allow the gripper to get through small areas without touching other components around it. Thanks to the adjustable stroke of the [Robotiq Adaptive Grippers](#), this Gripper can open partially, thereby getting into and out of the small areas without occupying all the available space.

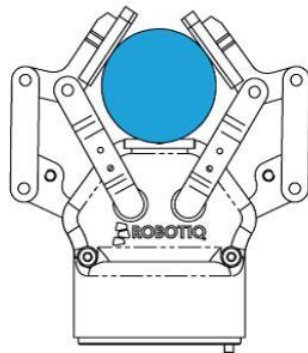
Small objects can also mean thin or fragile objects. To be able to grasp these kinds of objects without crushing them you can use the force and position settings of the [Adaptive Grippers](#). In fact, to grasp fragile objects, using a smaller force at a given position, means that the Gripper will stop once it reaches the programmed setting. By doing so, the risk of mangling the part is quite low.

Parallel Mechanism

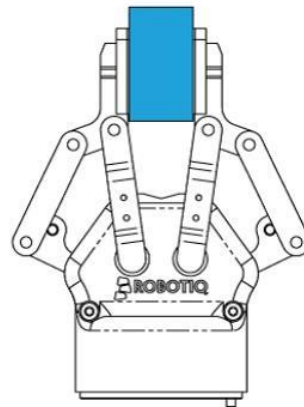
Robotiq Grippers are adapted to all types of industrial applications, because of its five linkage mechanism which allows our Grippers to adapt to the shape of the objects. Although, the specifications of our Gripper make it useful for applications that don't need the five linkage mechanism too. Those applications are

usually parallel gripping operations. This means that the five linkage mechanism has to become a four linkage mechanism to keep the fingers parallel to each other. Also, we do provide a locking pin mechanism for the [2-Finger Adaptive Grippers](#). Even if you don't use the locking pin, the parallel grip can still happen. The pin is only a supplementary security to ensure a constant parallel grip.

ENCOMPASSING GRIP



PARALLEL GRIP



Make it Faster

One of the advantages our Gripper as compared to other grippers is the ability to program our Gripper in a few clicks. By choosing the opening stroke, force and speed of the Gripper you can optimized your gripping operations with all the required settings you need. So, for example, to increase the rate of grasping you can either increase the closing speed or reduce the opening stroke. This second option, reducing the opening stroke, means that the Gripper can perform minimal movement before achieving a given position. The robot can then continue its motion when it receives the "open" signal. When you are automating your production, you don't want to lose a couple seconds per gripping operation when it's unnecessary.

These are just a few general tips but they can help you reduce your production time and achieve your required lead time and production targets. Makes sure to contact your Robotiq vendor or the [Robotiq support department](#) to get more information on how to optimize your production.

2. HOW TO DESIGN GRIPPER FINGERTIPS

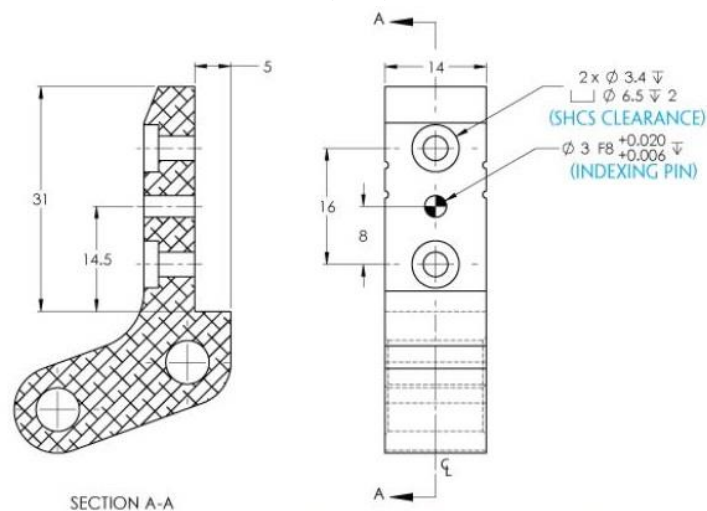
Designers of robotic grippers are always trying to enhance the gripping performance of their product. Some will increase force or precision to execute specific processes or applications. Some other companies will work on enhancing the flexibility of their grippers to make them ready for a wide range of situations. Although, if your robot application is only doing one task such as pick and place with a specific geometry, you may want to optimize your gripper and adapt it to your specific process. This is the main reason why custom fingertips might be a good solution for your applications.



If you are going to design custom fingertips you have 2 options. Either you can use your company's internal knowledge and design your own fingertips with the following information. Or you can take a look at section *4. Custom Fingertips Library* to have a better idea of the different options Robotiq is offering.

Phalanx Design

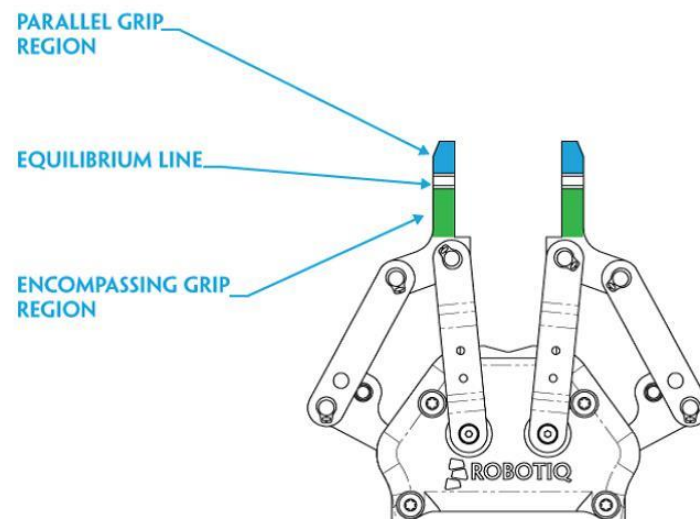
The design of your fingertips must be able to attach to the phalanx of the Gripper. The following drawing shows the main dimensions for fixation. The fingertips should use the two screws for fixation and an indexing pin should be installed for a maximum of precision when assembling (or disassembling) the fingertips. Notice that all measurement are in metric (mm).



Equilibrium Line

Since the robot Gripper is designed to perform an encompassing grip, the equilibrium point must be considered in the design of your custom fingertips. The equilibrium line is the region where the Gripper can switch from parallel gripping to encompassing mode. If a force is applied below the equilibrium line the phalanx rotates until it comes in contact with an object. If a force is applied above this line, the Gripper will

stay in parallel mode. Make sure to understand the significance of this mechanical concept before beginning your design. Remember, if your point of contact with the object is under the line, the Gripper will automatically go into encompassing mode, which might not be the best plan of action for certain applications.



3. HOW TO DESIGN CUSTOM FINGERTIPS

SPECIFIC TO YOUR APPLICATION?

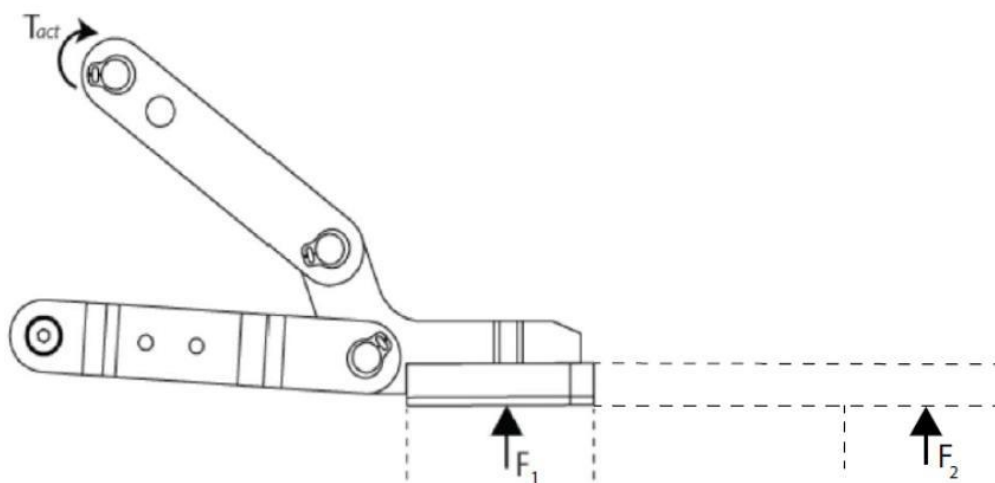
When designing any kind of mechanical device, you need to consider the context of where it will work. Designing custom fingertips for your grippers will, for sure, follow this rule. Even though some designs might be revolutionary, if they don't fit the application or correspond to the context, they are generally pretty useless. Here are a couple of tricks and tips that you should consider while designing custom fingertips for your gripper.

Handled Part

Part parameters such as weight, size and material must be considered in the first step of the design phase since it will limit some design options.

Part Weight

The weight of the part can be extremely limiting in some cases. You have probably looked to make sure that you have the correct payload for the weight of your part, you may also want to consider the torque applied on the finger base. In fact, even if your part is within the gripper's normal payload, grasping the part with the tip of a long finger will create a larger torque on the finger and can create damage or make the gripper run abnormally over the long run.



So as presented in the figure above, the torque at the finger base will increase if the force (F_1 vs F_2) is applied away from the rotating point (T_{act}). Since there is some mechanical limitation to the torque that can be applied at the finger base, the force (or part weight) should be considered in your design in order to respect the mechanical limitations of the robot gripper.

Part Geometry

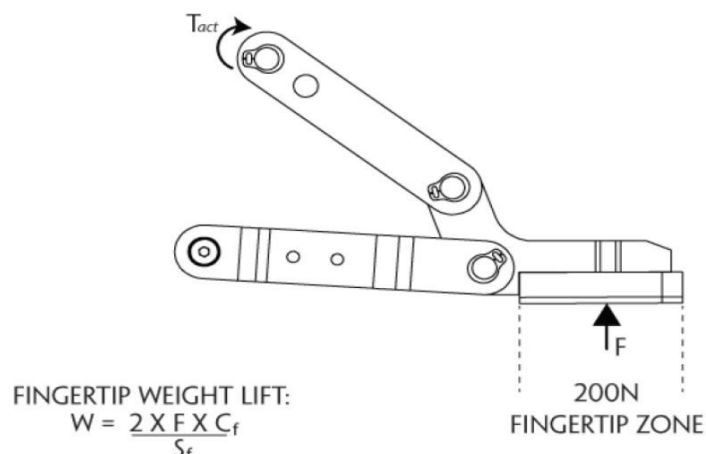
We have seen a lot of fingertip modifications or designs based on the geometrical properties of the objects being manipulated. In fact, to adapt the fingertips to the part that will be grasped, you want to know what this part will look like. If the part is round, for example, you may want to secure it using a v-shaped fingertip, as mentioned earlier.

In [machine tending](#) operations, customers often want to use the same gripper to do several operations. In this case, raw material will be placed in the CNC machine with a regular (round or square) shape and will come out in a totally different shape. This is one reason why some fingertips are designed to grasp different types of parts.

Part Material

Some applications out there will require a gentle prehension process because of the fragility of the part. In those particular cases, you may want to add rubber covers on the fingertips. Notice that our [3-Finger Adaptive Gripper](#) and [2-Finger 85 Adaptive Gripper](#) both have option of including rubber pads. This allows you to grab the part with a lower force and still be able to retain the part since the friction coefficient is higher than straight aluminum. Some of our customers have even increase the thickness of the finger silicone pads to add compliance to the gripper. In this situation, you can then grab the part with a little offset and the rubber will compensate for the positioning offset.

You may also want to consider the surface material texture of both the fingertip and the object in your design. You probably don't want to use rough fingertips if you are handling a super polished part.



Process

Robot motions are your biggest concern in the process analysis. If the robot program is using high acceleration/deceleration rates you may want to secure your part more firmly in your gripper. There are basically two different ways to do this. Either by increasing the force applied on the part by increasing the friction coefficient of the part against the pad or to mechanically secure the grasp.

So by increasing your fingertips friction coefficient (C_f), you can manipulate a bigger weight (W) for the same applied force (F). As told in the previous section, thicker rubber padding can be used to give more compliance and increase the friction coefficient.

The other way to do this is to mechanically retain the part in the gripper, you can use the encompassing grip for this. However not every part can use the encompassing gripping mode. This is why you may want to recreate this gripping method with the fingertips. Some customers have used this same principle in the design of their fingertips. In other words, the 4 minimum points of contact that are used to secure the part in an encompassing mode are replicated on the fingertips. So basically a v-shape or a rounded shape can surround the part and secure it. Note however that a v shape will allow for 4 contact points on more different sized circular shapes while a round shape would be specific to only one size object.

Part Presentation

This aspect is mostly limiting the outside geometry of the fingertips and gripper itself. As you might want to grab some parts from a given position you have to consider what is surrounding the part. Is this going to be a super packed cardboard? Does the part present itself in a narrow hole and do you need tiny fingertips to get to it? This is a really important aspect to observe. For example, clients who asked to design fingertips to grasp some specific part with a given gripper and as questions are asked to the customer, the engineer realize that the part wasn't even reachable in this particular configuration. This could be a big waste of time and energy and this is why part surroundings should be consider seriously. Don't forget to analyze the "dropping" area, too. If the gripper is doing packaging, what are the specifications for the material and area that will be used for the packaging.

These are some of the main aspects you might want to consider in the design of your fingertips. As told, this analysis is more oriented for Robotiq products, but these design tips can be transferred to other brands as well. Follow the link below to have more information on the Robotiq [2-Finger 85 Adaptive Gripper](#) for applications such as [machine tending](#), [assembly](#), and pick and place.

4. CUSTOM FINGERTIP LIBRARY

This section will cover the different finger options for the 2-Finger 85 Adaptive Gripper. These fingertips should be used in accordance with the parts that have to be grasped. Notice that these examples are only an indication. A wider range of applications can be made with the 2-Finger 85. However, the parts are representative of a wide array of applications that can be performed with Adaptive Grippers. All the fingertips configurations and related product numbers are displayed in Appendix 1 of this document.

Regular Geometry

Parts that have flat parallel geometry can be considered as regular parts. It is intuitive to grasp these parts. No questions asked: Flat fingertips should be used. At Robotiq we do offer two different types of flat fingertips. One model is for straight aluminum and the other has a silicone surface. The main difference between the two sets of fingertips is the friction coefficient. The one with the rubber pads is more useful for handling parts that are polished or that might have lubrication on them. Thanks to the adjustability of the grip force, the rubber pads can handle various regular parts even if they are a bit slippery.

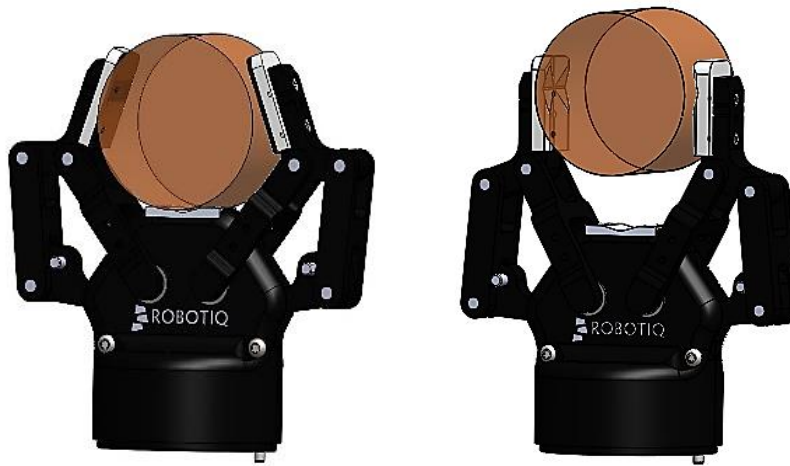


The difference between the two fingertip types is hard to visually distinguish. However once you use them, you will recognize a huge difference.

Cylindrical Geometry

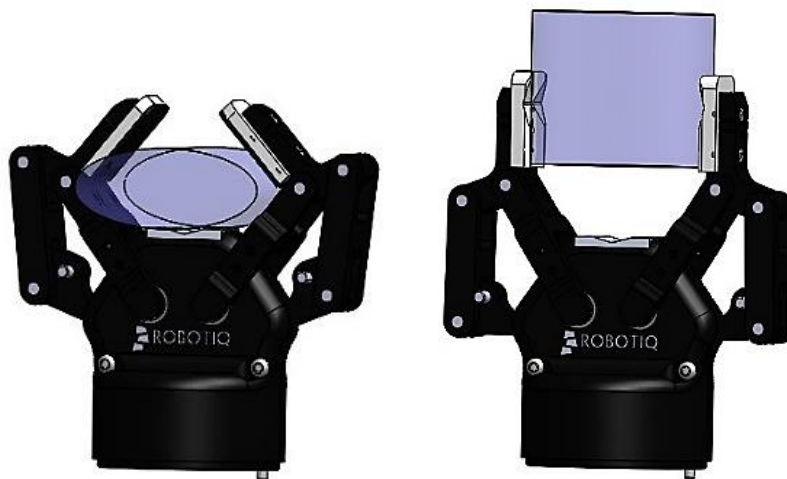
Cylindrical parts are tougher to handle. These parts can be found in CNC machine tending. For example, grasping a raw part with circular geometry can be a good representation. Since most standard grippers have flat fingertips, it is tougher to grab round parts. The flat pads create two small pressure lines that create instability in the grip. We have designed our Gripper to be able to handle these parts. In fact, the encompassing mode is able to close the fingers around the shape and lock its fingers around it. This encompassing grasping mode allows the part to be surrounded by five points of contact including the pads and the palm. You can see in the picture below that the pads are no longer parallel to each other, they encompass the part and secure it. No special fingertips are needed for this mode.

Even if the encompassing mode is useful for some applications, custom fingertips might still be useful. In fact, we have developed v-shaped fingertips to recreate the encompassing grip. By using these tips, the gripper can remain in parallel mode and still be able to grasp the part correctly. These fingertips touch the cylindrical parts with at least 4 points of contact.



Irregular Geometry

This is a very wide category. In fact, irregular parts are basically parts with particular geometries. Things such as tapered sections or non-symmetrical geometries can be considered irregular. There is a way to grasp them using the basic components of the gripper like the encompassing mode. However, not all irregular parts work well in encompassing mode. Using v-shaped fingertips can also be a good way to grasp them, however this might not allow you to grasp your object every single time. Most often if this is the case, we recommend that it is best to either find a regular geometry on the part where the gripper can be assured solid access or to design your own custom fingertips.



Minuscule Parts

Tiny parts are most of the time synonymous with limited space. Using straight pads can be inconvenient due to the space they require. Still, you should consider that using straight rubber pads will allow you to grasp fragile parts far more gently than with straight metal fingertips, because of the silicone's compliance capabilities. The other option available is to use tips with a longer reach and a smaller footprint. This will allow you to pick your part in a tiny space and to clear the space surrounding the part.



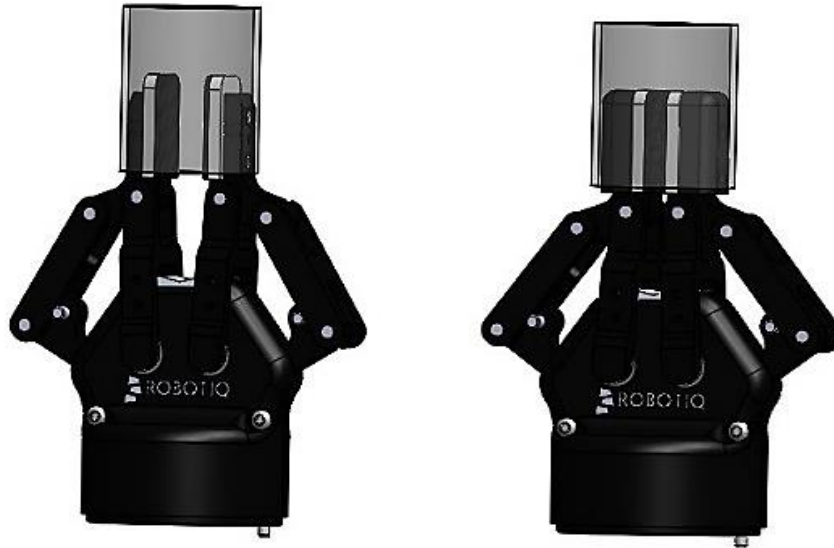
Large Parts

Our gripper is designed to fit all parts with at least one geometry smaller than 85 mm. But the thing is; a lot of parts are bigger than 85 mm. This is why we decided to do an enhanced gripper with a wider opening range. We still have the 85 mm opening range but we introduce the 120mm, 160mm and 200mm opening range. Those strokes will be available soon and will allow to grasp a wider range of parts. However, you should notice that the encompassing mode is limited and in some cases nonexistent. Make sure to contact our application engineer to have further information on those options. The picture below shows the gripper with the 120mm opening stroke holding a 100 mm part. You can notice the difference in the finger length.



Hollow Geometry

The 2-Finger 85 has been designed to grasp parts by their outer as well as their inner geometries. The finger force can be applied either by an internal or external grip. So if the only way to grab your part is by its internal geometry, the 2-Finger 85 Adaptive Gripper can be a good option for you.



In this case, regular fingertips can be used. The back side of the pads will apply the necessary force on the object and will be able to grasp it. However, it is in aluminum and the friction coefficient is quite low. We have also developed rubber pads for internal geometries. These pads allows the grasp to be done on a wider surface and with a greater friction coefficient. It is the best option when you want to grasp an internal geometry.

CONCLUSION

As you can see the choice of a gripper includes a lot of different features. You should consider every detail, from fingertips to opening stroke to make sure the gripper fits your application. By customizing or using special fingertips you insure that you will have the best grip possible for your parts. Notice that good grasping methods result in good robotic performance. In fact, if the grasping methods are right for your application, the grasping can be done faster and the robot motion can also be done with a greater acceleration. To have further information on the different grasping positions or fingertips available, consult Appendix 1 or contact one of our application engineers.

Ask...

You should definitively ask your gripper representative or application engineer if your applications are suited for certain types of grippers. Some gripper manufacturers can make customized grippers or gripper parts (customized fingertips, customized opening range) depending on your request. You should definitively tell the representative what your applications are and work around them instead of adapting your operations to the robot and gripper.

For further information, feel free to visit our website: www.robotiq.com

ABOUT ROBOTIQ

Robotiq designs and manufactures flexible robot grippers. We aim to give to industrial manufacturing – from large businesses to SMEs – flexible peripheral solutions to optimize automated processes by providing universal, agile and rugged robotic tools.

We work with robot manufacturers, system integrators and end-users to enable new applications and improve productivity.

We are Robotiq. We make tools for agile automation.

TO LEARN MORE

For any questions concerning robotics and automated handling or if you want to learn more about the advantages of using flexible electric handling tools, contact us.

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APPENDIX 1

Fingertips Library

APPENDIX 1: CUSTOM FINGER LIBRARY

		Rectangle	Cylinder	Oval	Small Part	Large Part (100 mm)	Hollow Cylinder	Hollow Rectangle
Product No.	Finger Option							
AGC-TIP-203-002						N/A		
AGC-TIP-204-002						N/A		
AGC-TIP-205-002					N/A	N/A		
AGC-TIP-206-002	 Not for encompassing		N/A	N/A		N/A	N/A	N/A
AGC-TIP-207-002		N/A	N/A	N/A	N/A	N/A		
AGC-FIN-120-002	 Not for encompassing		N/A	N/A				
AGC-TIP-202-002		Fully Customizable	Fully Customizable	Fully Customizable	Fully Customizable	Fully Customizable	Fully Customizable	Fully Customizable