5.2 Grippers

In robotics, an end effector is the device at the end of a robotic arm, designed to interact with the environment. The exact nature of this device depends on the application of the robot.In the strict definition, which originates from serial robotic manipulators, the end effector means the last link (or end) of the robot. At this endpoint the tools are attached. In a wider sense, an end effector can be seen as the part of a robot that interacts with the work environment. This does not refer to the wheels of a mobile robot or the feet of ahumanoid robot which are also not end effectors—they are part of the robot's mobility.

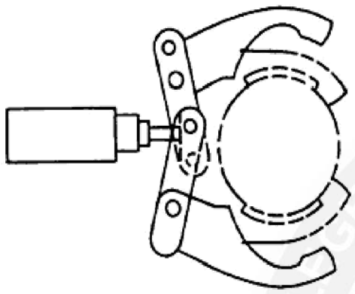


Figure 1 External gripper.

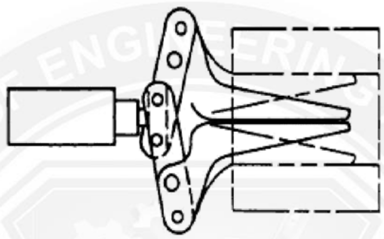


Figure 2 Internal gripper.

End effectors may consist of a gripper or a tool. When referring to robotic prehension there are four general categories of robot grippers, these are:

1. Impactive – jaws or claws which physically grasp by direct impact upon the object.
2. Ingressive – pins, needles or hackles which physically penetrate the surface of the object (used in textile, carbon and glass fibre handling).
3. Astrictive – suction[vague] forces applied to the objects surface (whether by vacuum, magneto- or electroadhesion).
4. Contigutive – requiring direct contact for adhesion to take place (such as glue, surface tension or freezing).

They are based on different physical effects used to guarantee a stable grasping between a gripper and the object to be grasped. Industrial grippers can be mechanical, the most diffused in industry, but also based on suction or on the magnetic force. Vacuum cups and electromagnets dominate the automotive field and in particular metal sheet handling. Bernoulli grippers exploit the airflow between the gripper and the part that causes a lifting force which brings the gripper and part close each other (i.e. the Bernoulli's principle). Bernoulli grippers are a type of contactless grippers, namely the object remains confined in the force filed generated by the gripper without coming into direct contact with it. Bernoulli gripper is adopted in Photovoltaic cell handling in silicon wafer handling but also in textile or leather industry. Other principles are less used at the macro scale (part size >5mm), but in the last ten years they demonstrated interesting applications in micro-handling.

A gripper is a motion device that mimics the movements of people, in the case of the gripper, it is the fingers. A gripper is a d evice that holds an object so it can be manipulated. It has the ability to hold and release an object while some action is being performed. The fingers are not part of the gripper, they are specialized custom tooling used to grip the object and are referred to as "jaws." Two main types of action are performed by grippers:

External: This is the most popular method of holding objects, it is the most simplistic and it requires the shortest stroke length. When the gripper jaws close, the closing force of the gripper holds that object.

Internal: In some applications, the object geometry or the need to access the exterior of the object will require that the object is held from the center. In this case the opening force of the gripper will be holding the object.

2.1 Magnetic Grippers

Magnetic grippers are most commonly used in a robot as an end effector for grasping the*ferrous* materials. It is another type of handling the work parts other than themechanical grippers and vacuum grippers.

Types of magnetic grippers:

The magnetic grippers can be classified into*two common types*, namely:
Magnetic grippers with

- Electromagnets
- Permanent magnets

Electromagnets:

Electromagnetic grippers include a *controller unit* and a *DC power* for handling the materials. This type of grippers is easy to control, and very effective in releasing the part at the end of the operation than the permanent magnets. If the work part gripped is to be released, the polarity level is minimized by the controller unit before the electromagnet is turned off. This process will certainly help in *removing the magnetism* on the work parts. As a result, a best way of releasing the materials is possible in this gripper.

Permanent magnets:

The permanent magnets do not require any sort of external power as like the electromagnets for handling the materials. After this gripper grasps a work part, an additional device called as*stripper push – off pin* will be required to separate the work part from the magnet. This device is incorporated at the sides of the gripper.

The advantage of this permanent magnet gripper is that it can be used in hazardous applications like *explosion-proof apparatus* because of no electrical circuit. Moreover,there is no possibility of *spark production* as well.

Benefits:

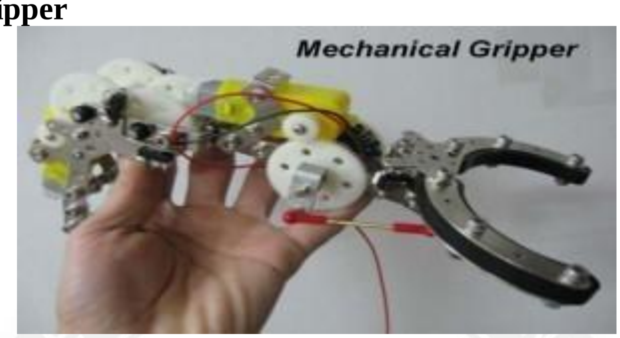
- This gripper only requires *one surface* to grasp the materials.
- The grasping of materials is done *very quickly*.
- It does not require *separate designs* for handling different size of materials.
- It is capable of grasping materials with *holes*, which is unfeasible in

the vacuum grippers.

Drawbacks:

- The gripped work part has the chance of *slipping out* when it is moving quickly.
- Sometimes *oil* in the surface can reduce the strength of the gripper.
- The *machining chips* may stick to the gripper during unloading.

2.2 Mechanical Gripper



A mechanical gripper is used as an *end effector* in a robot for grasping the objects with its *mechanically* operated fingers. In industries, two fingers are enough for holding purposes. More than three fingers can also be used based on the application. As most of the fingers are of *replaceable*type, it can be easily removed and replaced.

A robot requires either hydraulic, electric, or pneumatic drive system to create the input power. The power produced is sent to the gripper for making the fingers react. It also allows the fingers to perform open and close actions. Most importantly, a *sufficient force* must be given to hold the object.

In a mechanical gripper, the holding of an object can be done by *two different methods* such as:

- Using the finger pads as like the shape of the work part.
- Using soft material finger pads.

In the first method, the contact surfaces of the fingers are designed according to the work part for achieving the *estimated shape*. It will help the fingers to hold the work part for some extent.

In the second method, the fingers must be capable of supplying sufficient force to hold the work part. To avoid scratches on the work part, *soft type pads* are fabricated on the fingers. As a result, the contact surface of the finger and co – efficient of friction are improved. This method is very simple and as well as *less expensive*. It may cause slippage if the force applied against the work part is in the parallel direction. The slippage can be avoided bydesigning the gripper based on the force exerted.

$$\mu\ n_f F_g = w \qquad \text{…………………} \quad 1\mu$$

=> co – efficient of friction between the work part and fingers

n_f => no. of fingers contacting

F_g => Force of the gripper

w => weight of the grasped object

The equation 1 must be *changed* if the weight of a work part is more than the force applied to cause the slippage.

$$\mu\ n_f F_g = w\ g \qquad \text{…..……………..} \quad 2$$

g => g factor

During rapid grasping operation, the work part will get *twice* the weight. To get rid out of it, the modified equation 1 is put forward by *Engelberger*. The g factor in the equation

2 is used to calculate the acceleration and gravity.

The *values of g factor* for several operations are given below:

- g = 1 – acceleration supplied in the opposite direction.
- g = 2 – acceleration supplied in the horizontal direction.
- g = 3 – acceleration and gravity supplied in the same direction.

A pneumatic gripper is a specific type of pneumatic actuator that typically involves either parallel or angular motion of surfaces, A.K.A. “tooling jaws or fingers” that will grip an object. When combined with other pneumatic, electric, or hydraulic components, the gripper can be usedas part of a "pick and place" system that will allow a component to be picked up and placed somewhere else as part of a manufacturing system.

Some grippers act directly on the object they are gripping based on the force of the air pressure supplied to the gripper, while others will use a mechanism such as a gear or toggle to leverage the amount of force applied to the object being gripped. Grippers can also vary in terms of the opening size, the amount of force that can be applied, and the shape of the gripping surfaces—frequently called "tooling jaws or fingers". They can be used to pick up everything from very small items (a transistor or chip for a circuit board, for example) to very large items, such asan engine block for a car. Grippers are frequently added to industrial robots in order to allow the robot to interact with other objects.

Common industrial pneumatic components include:

- pneumatic direct operated solenoid valve
- pneumatic pilot operated solenoid valve
- pneumatic external piloted solenoid valve
- pneumatic manual valve
- pneumatic valve with air pilot actuator
- pneumatic filter
- pneumatic pressure regulator
- pneumatic lubricator

2.3 Hydraulic Grippers

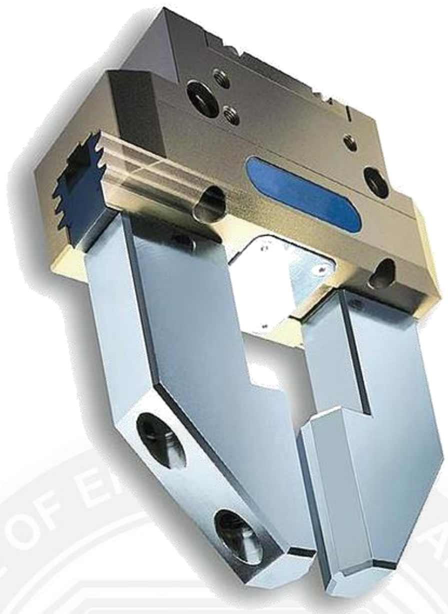
Posted by admin on Tuesday, September 24, 2013 · 1 Comment

Grippers are devices used with pick-and-place robotic systems to pick up or place an object on an assembly line, conveyor system, or other automated system. Fingered tooling—or jaws—is attached to the grippers to grip or hold the object.

They come in a variety of styles and powered designs. Three common types are parallel, three-finger, and angled designs. The most common are parallel designs, with two fingers that close on a workpiece to grip it or open it out by creating pressure on the inside. Three-finger designs hold the workpiece in the center, and have three fingers offset by 120°. Finally, angled designs feature jaws that work at a variety of different angle openings (for example, 30°, 40°, etc.).

In addition, three choices of power are available; the most common being pneumatic grippers; electromechanical grippers are second most common; and the least common being hydraulic grippers. Hydraulic grippers are most often used in conjunction with a piece of equipment that only has a hydraulic power source for actuators.

Most hydraulic grippers are designed for a hydraulic system where the cylinder diameter is made with less surface area, meaning that a hydraulic gripper would have the same force at 60 bar as a pneumatic gripper of the same size at 6 bar.

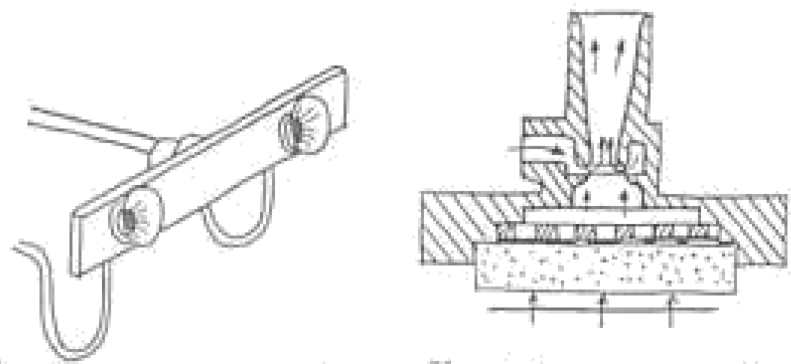


In general, hydraulic and pneumatic grippers have the same basic actuation principle. They include direct acting piston designs as well as piston wedge designs.
The direct acting piston design is used when a hydraulic force acts directly on a piston that is directly connected to the jaw or finger that is touching or gripping the part.
The piston wedge design features a hydraulic force acting on a piston while the piston itself is acting on a wedge. The wedge translates this force to the jaws or fingers, providing the grip force to grip the part. The wedge can give a mechanical advantage as it can increase grip force while keeping the piston diameter and pressure to the piston the same. This allows more grip force in a smaller package compared to the directing piston.

Unlike electromechanical grippers, which have motors on each actuator, onesingle motor powers the hydraulic fluid that supplies energy to multiple devices throughout a plant.When selecting a hydraulic gripper, it is important to consider the following:

- Part weight and size to be lifted
- Part material
- Clearance issues around the part that could interfere with the gripping part
- The environment the gripper will be used in (corrosive, food or beverage, etc.)
- The motion path of the robot or linear device that is moving the gripper
- The power supply that will be available and the pressure ratings available

2.4 Vacuum grippers



Suction cups vacuum gripper Venturi type vacuum gripper

Vacuum grippers are used in the robots for grasping the *non – ferrous objects*. It uses*vacuum cups* as the gripping device, which is also commonly known as *suction cups*. This type of grippers will provide good handling if the objects are *smooth, flat, and clean*. It has only one surface for gripping the objects. Most importantly, it is not best suitable for handling the objects with holes.

Vacuum cups:

Generally, the vacuum cups (suction cups) will be in the round shape. These cups will be developed by means of *rubber* or other elastic materials. Sometimes, it is also made of *soft plastics*. Moreover, the vacuum cups are prepared of hard materials for handling the soft material objects.

Two different devices are used in the suction cups for creating the vacuum. They are:

- Venturi
- Vacuum pump

Venturi device is operated with the help of *shop air pressure*, while the vacuum pump is driven either by means of *vane or piston* device. The vacuum pump has the ability to create the *high vacuum*. As the venturi is a simple device, it is more *reliable* and *inexpensive*. Both these devices are very well capable of providing high vacuum if there is a sufficient supply of air pressure.

Types of vacuum grippers:

- The *ball joint* type vacuum gripper is capable of changing into various contact angles automatically. Moreover, the bending moments in the vacuum cups are also decreased. It is used for carrying irregular materials, heavy objects, etc.
- A vacuum gripper with *level compensator* can be very helpful in balancing the objects with different levels. It also has the capability to absorb the shocks.

Applications of vacuum grippers:

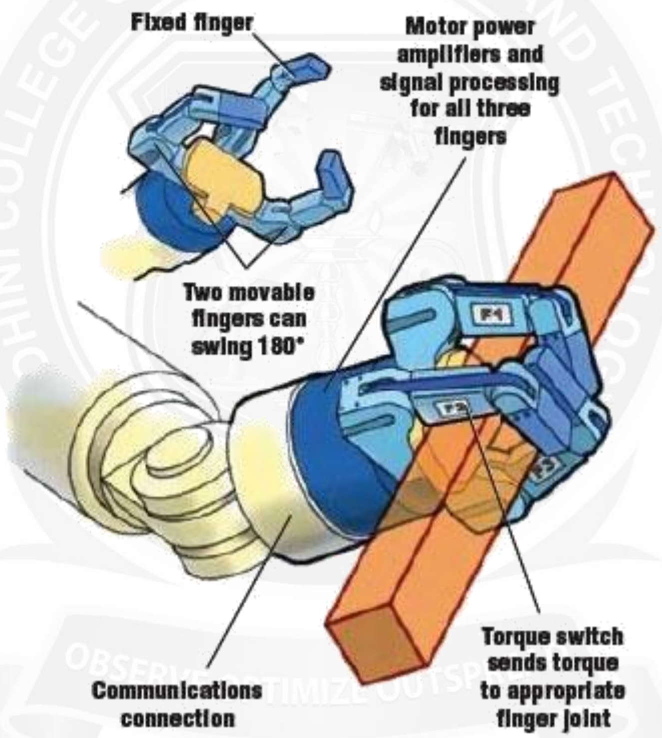
- Vacuum grippers are highly useful in the heavy industries, automobiles, compact disc manufacturing, and more for *material handling* purposes.
- It is also used in the tray & box manufacturing, labeling, sealing, bottling, and so on for *packaging* purposes.

2.5 Two and Three-fingered gripper

Three-fingered gripper

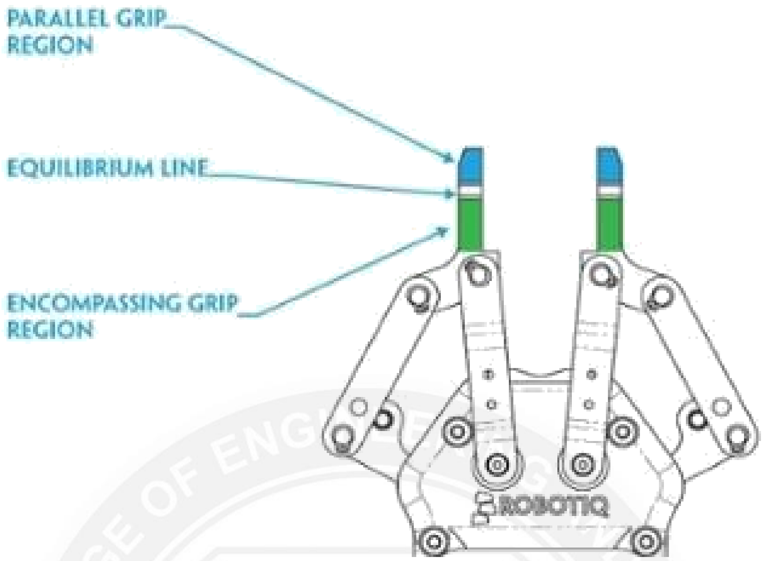
It's also costly to order custom-made handlers for special parts. To solve these problems, engineers at Barrett Technology Inc., Cambridge, Mass. (barrett.com), developed the Barrett Hand, a three-fingered gripper that can securely hold a wide variety of shapes and parts.

The device has three articulated fingers. The center finger is fixed, and the other two rotate up to 180˚ around the outside of the hand's palm. This gives the hand a wide variety of grips and configurations. Each finger has two sections which act in concert to grab objects. When the first section touches an object, the second section continues retracting until it is also in contact. With all the fingers in play, and including the palm, the hand can have a seven-point grip on the object. This lets it deal with objects of unknown or inconsistent shapes. The hand can lift about 1.2 kg.



The hand's eight joints are controlled by four brushless-dc motors, all in the wrist section. A torque switch lets four motors control eight axes of motion. The gripper's communications, five microprocessors, sensors, and signal processor are packed inside the palm body. A small umbilical cable connects the hand to an array of robotic arms from different manufacturers.

Two-fingered gripper



The mechanism driving the fingers of this Gripper is optimized to obtain two distinct contact regions. The first one, called the “encompassing grip region”, is located at the base of the fingers, while the second one, called the “pinch grip region”, is located at their end/tip. The boundary between these two adjacent regions is called the “equilibrium point”.

When the contact of the finger with the object to be grasped occurs in the encompassing grip region, the finger automatically adapts to the shape of the object and curls around it. On the other hand, when the contact is made in the pinch grip region, the finger maintains its parallel motion andthe object is pinched.

Since the finger keeps its parallel motion when a contact is made above the equilibrium point during a pinch grip, the same is true for a contact made below theequilibrium point during an inside grip, i.e. for a force applied at the back of the finger. This unique feature allows the Gripper to pick up objects from the inside, which proves to be very useful in many situations.

Coupling between the fingers

In addition to the mechanism used inside each of its fingers, the Gripper also relies on a special coupling architecture between the fingers. In fact, it is mechanically designed to ensure that the two fingers move in conjunction with each other in order to center the object grasped in the middle of the Gripper. This self-centering avoids the need to use expensive sensor sand is above all safer.

In the same vein to make this Robot Gripper as reliable as possible, a self-locking feature has been incorporated into it between the actuator and the fingers. By doing so, we are sure that the Gripper will never release the object and let it fall if the power is shut down. It is also economically interesting, as the actuator doesn’t need to apply torque continually when an object is grasped, thus in addition to the power saved, the lifespan of the Gripper is thereby maximized.

2.6 Selection and design considerations in robot gripper

The industrial robots use *grippers* as an end effector for picking up the raw and finished work parts. A robot can perform good grasping of objects only when it obtains a proper gripper selection and design. Therefore, *Joseph F. Engelberger*, who is referred as *Father of Robotics*has described several factors that are required to be considered in gripper selection and design.

- The gripper must have the ability to *reach* the surface of a work part.
- The change in work part size must be *accounted* for providing accurate positioning.
- During machining operations, there will be a change in the work part size. As a result, the gripper must be *designed* to hold a work part even when the size is *varied*.
- The gripper must not create any sort of *distort* and *scratch* in the fragile work parts.
- The gripper must hold the *larger area* of a work part if it has various dimensions, which will certainly increase *stability* and *control* in positioning.
- The gripper can be designed with *resilient pads* to provide more grasping contacts in the work part. The *replaceable fingers* can also be employed for holding different work part sizes by its *interchangeability* facility.

Moreover, it is difficult to find out the *magnitude of gripping force* that a gripper must apply to pick up a work part. The *following significant factors* must be considered to determine the necessary gripping force.

- Consideration must be taken to the *weight* of a work part.
- It must be capable of grasping the work parts constantly at its *centre of mass*.
- The *speed* of robot arm movement and the connection between the direction of movement and gripper position on the work part should be *considered*.
- It must determine either *friction* or *physical constriction* helps to grip the work part.

It must consider the *co-efficient of friction* between the gripper and work part.