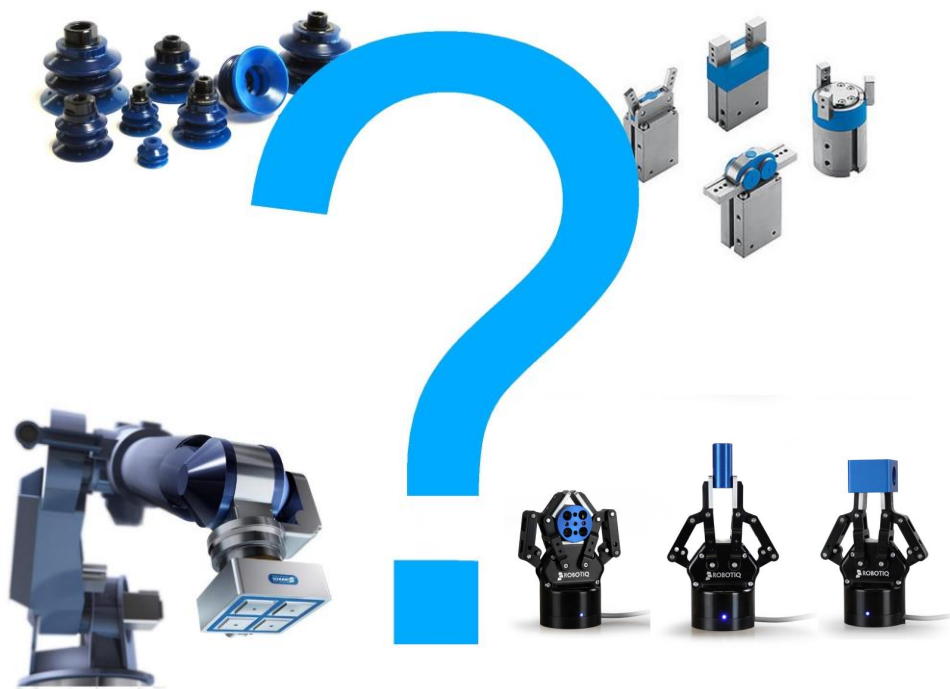




# How To Choose The Right End Effector For Your Application



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## INTRODUCTION

Nowadays, robots are part of many manufacturing processes and aspects of production are improved by using them. Their repeatability and consistency improve product quality by reducing scrap. Moreover, they help save money because they can work non-stop during long periods of time. Since they are fast, they also reduce cycle time. All these facts prove that robots are valuable assets for manufacturers.

However, a robot arm alone can hardly accomplish any job. This is why each manufacturing robot needs an end effector. By definition, an end effector is the device at the end of a robotic arm that allows it to interact with its environment.

In this eBook, you will find information on the different end effectors available on the market. There are different types of end effectors, but we can class them into two basic categories: Robot Grippers and Robotic Tools. Choosing among all these devices can be a hard task, so, in this eBook, you will find pertinent information to help you make your decision. Finally, you will be able to define your tooling costs by using a simple check list.

## DIFFERENT END EFFECTORS ON THE MARKET

### Robot Grippers

#### ELECTRIC GRIPPERS

With electric grippers, or servo-grippers, electric motors control the movement of the fingers using electric input from the robot controller. Adaptive electric end effectors are a good fit for many applications such as: bin picking, handling, machine tending and more. This kind of gripper is however often more expensive than other types.

These robot end-of-arm tools are appearing more and more in industrial markets. Below are the top 5 advantages of using electric grippers over other types of robotic grippers.



#### 1. Control the position of the gripper finger

Using encoded motors and the proper control scheme, the position of the jaw can be defined with an electric gripper. On the contrary, with conventional grippers, you typically have to use full stroke all the time. With electric grippers, you have the flexibility to use only the minimum necessary clearance to approach a part, then you can do a minimum stroke to pick it up. Partial opening and closing helps pick a wider range of part sizes without compromising the cycle time.

## 2. Detect grip

Using encoders, it is possible to determine if a part has been picked up by the gripper. Some electric grippers will relay this information back to the robot controller. For many applications, detecting the grip is mandatory for error-proofing. Doing it at the gripper level avoids putting other sensors in the loop, simplifies integration and can reduce overall cost.

## 3. Control the grip force and speed

As the electric motor current is directly proportional to the torque it applies, it is possible to control the grip force applied by the gripper. The same is true for the closing speed. This can be extremely important when handling fragile parts for example.

## 4. No air lines: save on power and maintenance

Many companies are making a move from pneumatic to electric to reduce operating costs. An important aspect of this shift is the cost reduction in eliminating pneumatic hardware, as well as the energy savings this provides.

## 5. Cleaner grippers

Some applications require a clean environment whereby air leakage could cause contamination. In these cases, electric grippers are the only viable solution to work with parts.

## PNEUMATIC GRIPPERS

Pneumatic grippers use air to make them work. Usually, compressed air is forced through a piston in order to make it move. This movement can be parallel or angular. These grippers are easily integrated into production lines. Because of their simple design, their cost is very low. In terms of grip force per dollar cost and grip force per unit size, pneumatic grippers highly appreciated. However, you need to pay attention to certain facts when you consider buying pneumatic grippers.



## 1. Gripper always at full stroke

With pneumatic grippers, it's either on or off, fully opened or fully closed. If you need to handle parts of different sizes with the same gripper, you will waste some time doing the full manipulation for some of the parts. This also means that your gripper will require a lot of space around small parts. In confined spaces, the gripper might interfere with its surroundings. Moreover, when it comes to customization of the gripper's jaws, the cost of this device can rapidly increase.

## 2. Limited gripper force control

You can control the force of the grip by controlling the pressure, but it's hardly programmable. Also, low forces are challenging to obtain, because friction will prevent the gripper jaw from moving at very low pressures. So, if you handle delicate parts and parts that require a strong grip force with the same robot, the pneumatic gripper will be difficult to adjust.

## 3. Limited gripper speed control

With most pneumatic grippers, you will hit the part at full speed. If the part is not fixed in place before the pick, there are chances that it will move to an unpredictable position.

## 4. The usual problems with compressed air

Pneumatic grippers can compromise air quality. For some applications, the air contaminants that come from the pneumatic system are not acceptable, think of the manufacturing of electronic components for instance. The electricity needed to run the compressor and the maintenance needs of pneumatic grippers can also represent significant costs.

## 5. No built-in grip detection

Detecting if you have picked a part can be useful, as this allows you to do online error-proofing. This feedback from the gripper can also be used to program the robot using grip events instead of timers for more efficient programs. With most pneumatic grippers, this feature is not built in and you need to add sensors if you want grip detection.

The speed and cost of pneumatic grippers are hard to beat. As long as you are automating low-mix, high volume production and looking for the best deal, you'll stick with them. But if you are using high-mix applications and looking for flexible automation, using programmable electric grippers present many advantages.

## SUCTION CUPS

Suction cups are simple devices that use vacuum to grab parts. They are low cost and give good flexibility for material handling. They can be used with many types of material, but cannot handle perforated parts. Vacuum grippers are a very widely used type of robotic gripper, but for some applications, they may present challenges. Here is what you need to pay attention to before choosing vacuum robot grippers.



### 1. Issues with varied surfaces

- Curved and sharp angled surfaces might not have sufficient flat surface contact to have enough of the cup exerting the required force.
- Porous or corrugated surface can prevent proper, repeatable suction.
- Dirty surfaces can clog the air lines.

## 2. Vacuum robot grippers can leave marks on some surfaces

In some cases (think glass or mirror), these marks will need an additional step in the manufacturing process, increasing cost and manufacturing time.

## 3. Vacuum robot grippers are compliant

This can prevent the robot from applying a sufficiently strong contact between the part being held and the work piece or decrease the repeatability.

## 4. Vacuum robot grippers need custom end-of-arm tooling to support them

To support different cups, you need to come up with a custom end effector, usually made of metal extrusion. If the part is complex, the design of the end effector can require a fair amount of trial and error. If you have different parts, or parts that evolve during the process (think bended sheet metal), the design of these end effectors can be costly and unpredictable.

## 5. The usual problems with compressed air

As we mentioned previously about pneumatic robot grippers, compressed air is energy inefficient and is being phased out wherever possible. Also, compressed air can introduce dirt into the environment that might not be suitable for some manufactured goods.

## MAGNETIC GRIPPERS

This kind of end effector is similar to suction cups, but can only be used with ferrous material. Moreover, they don't have an associated air cost and won't drop any material during air loss or power outages. They are also simple and require low maintenance. There exist 2 types of magnetic end effector.

### Electromagnets

Grippers using electromagnets are generally powered by DC power for handling material. This type of magnetic end effector is easy to control, because the attraction can be turned off by shutting down the current. This can also help to remove the magnetism of the handled part.

### Permanent Magnets

These kinds of end effectors do not need power to operate. They are always on. In order to separate the piece from the magnet, a push-off pin is included on the end effector. The permanent magnet offers an advantage when it comes to safety, since the gripper remains on even if a blackout occurs. Moreover, there is no possibility of generating sparks during production since no electric current is required.



### Top 5 advantages

- It only needs one surface to grab an object.
- The grasping speed is fast.
- It is flexible since it does not need different designs for different parts.

- It can grip parts with holes which is not possible with vacuum grippers.
- It requires minimal maintenance.

### Top 5 disadvantages

- When moved quickly, the part can slip out of the end effector.
- Just a little oil on the surface can reduce the strength of the end effector.
- Machining chips can stay on the gripper when unloading the piece.
- Handled parts can stay magnetized.
- It can only be used with ferromagnetic material.

## Robotic Tools

### ROBOTIC WELDING

A robot arm can also be used with a welding end effector. This kind of match is often seen in the automotive industry. A robot will give great results in a welding application, because of its consistency and precision. A lot of developments have been made in order to improve crossover implementation of these robots in more industries. New devices have been designed to help employees work with them. A great example is the Kinetiq



Teaching end effector by Robotiq. With this new device, teaching welding trajectories is simplified. No more need to have an in-depth knowledge of programming. Through this application, welders are able to hand guide a welding robot, record key points of the welding path and adjust welding parameters on-the-fly with the teach pendant.

### PAINTING

Painting is a hard task because the application has to be smooth and regular. Since contamination is a major issue, painting cells are often in a closed and controlled environment. Therefore, painting end effectors are a good asset for producing quality work and reducing contamination risks. Moreover, volatile paint is a health issue for human painters.



## CUSTOM TOOLS

The other group of end effectors can be called custom tools. Either for drilling, cutting or other applications, a personalized end effector can be designed.

There is an end effector for each application on the market. Since the robotic industry is constantly evolving, new designs are always being introduced to manufacturers.

## HOW TO CHOOSE?

We, at Robotiq, are interested by robotic grippers since we are a supplier. Grippers consisting of vacuum cups, pliers, or finger assembly are some of the most common EOATs (End-Of-Arm Tooling) to be used on industrial robots. To ensure economical and practical success in automation projects, choosing the right gripper is essential. After all, this is where the rubber hits the road. This chapter focuses on technical factors, from a process and parts perspective that must be taken into account when choosing the right gripper for your application.



## THE PROCESS

What will be done with your robot? Automation projects vary greatly from one to another.

- **The task itself:** The tasks to be done by a robot often determines the type of gripper that should be used. A very fast loading/unloading requirement will favor vacuum cups, but a slower process will favor pliers or fingers for accuracy.
- **Cycle time:** The speed needed for clamping and/or opening or closing the gripper will determine cycle time. The cycle time will also determine acceleration and resulting G force from the gripper, a heavier gripper will put more G stress on the robot and cause wear on its parts. You must remember that robot specifications for maximum acceleration are calculated by the sum of the gripper weight and the part, so more gripper weight means less weight available to the part you handle. In addition to this specification, reach and EOAT weight will determine the resulting torque at the robot base; again you will seek to minimize the gripper weight. This is why many modern grippers favor the use of hollow aluminum parts.
- **Precision need:** Some assembly work will require great precision, a mechanical gripper, activated by servo-electrical motors, would be ideal. Part sorting processes will require gripper adaptability to ensure parts can be sorted, especially those ranging in size or that are positioned differently from each other.
- **Environmental need:** Not all gripper types can be used in every process. In many clean room industries, vacuum and pneumatic grippers are not recommended since they can create a flow of particles in the air. Grippers used in less clean environments like foundries, machining and welding are exposed to dirt and particles so they must be protected. Corrosive or toxic environments in nuclear or chemical industries also create special considerations for protecting the gripper to ensure its stability and safe use. In most applications the gripper must be failsafe. Dropping a banana on the floor has no serious effect, but spilling chemicals or radioactive materials can be catastrophic and/or toxic in some cases.



## THE PART

Knowledge of the part to be manipulated is crucial in determining which gripper should be used. The main factors are:

- **Size:** Except for vacuum grippers, all other grippers need to grip parts with a parallel or angular closing mechanism. This means the bigger the part, the more reach gripper fingers will require. In all cases, the gripper must have enough reach to handle the part, but not in excess since longer fingers create more torque on the tool and the robot.
- **Shape:** The shape of an object will determine which kind of grasp can be done. Flat surfaces can be handled by vacuum or magnet types of grippers while other shapes can be handled by jaw, claws or multiple fingers. When using encompassing or fingertip grasps, calculating finger reach must be taken into account.
- **Weight:** To ensure grasping holds, a gripper must have enough force to meet the weight of the part and the acceleration it can withstand during the process. A designer cannot simply use maximum clamping force, since damage to the part or the gripper may occur.
- **Surface type:** The type of surface upon which a grasp will occur will also be an important factor when estimating friction.

Calculation of the clamping force must account for a part's weight, maximum acceleration during the process, surface friction and maximum stress the part and gripper can withstand.

## HOW MUCH DOES A ROBOT GRIPPER COST?

The decision has been made to automate a manual handling process. The automation concept has been chosen. Now is the time to look into the details on how we will pick, hold and place those parts. The cost of the gripping units itself is not a big part of an automation project. Suction cups can be as little as \$10 and an electric gripper can be over \$1,000; but these costs represent a small fraction of the whole project. That is why grippers are too often the last aspect to be analyzed in an automation project. But grippers have a direct impact on cell performance and throughput. When budgeting and choosing grippers, it is important to consider performance, purchase cost and even more importantly recurring costs that will come from using the gripper in production. This chapter explains how to compare the cost difference between robot gripper options for your automation project.

### DETERMINE YOUR ROBOTIC CELL DATA

The following numbers will come into play when comparing the costs of different robot grippers:

- Current number of geometrically different parts in production.
- Number of geometrically different parts handled in one cycle.
- Number of cycles per hour.
- Number of production hours per day.
- Number of production days per year.
- Number of changeovers on an average day.
- Number of new parts or products introduced every year.

- Average cell output value per hour.
- Number of identical cells to automate.

## **DEFINE YOUR ROBOT GRIPPER OPTIONS**

- What type of gripper will you be using: pneumatic gripper, electric gripper, magnetic gripper or suction cups?
- Will flexibility be required for a tool changer or a flexible robot gripper?
- Will you have to arrange off-the-shelf components on a custom made robot end effector?
- Will you have to machine your own custom made fingers?
- What will be the sequence in the cell needed to handle the different parts?
- What will happen when you change parts or products?
- Do you expect to introduce new parts on this cell in the future?
- Are you getting a price for the components that match the part and process requirements?

Estimate the custom work required. Make sure to get information on cycle time and maintenance required for the different options.

## **DEFINE THE ROBOT GRIPPERS PURCHASE COST**

For all the options in front of you, define what you will have to purchase initially:

- Cost of all gripping unit(s).
- Cost of tool changer(s).
- Cost of custom design and fabrication (end effector and/or fingers).
- Cost of robotic programming for grippers.
- Cost of spare parts.

## **OPERATION COST**

What will be the financial impact of the gripper choice once in production?

- Cost of tool changing - Will the tool changing time increase the cycle time?
- Cost of changeover - What is the loss in cell production caused by changing the tool between one product to the next?
- Cost of compressed air (electricity, maintenance).
- Cost of maintenance.

## **FLEXIBILITY COST**

What will be the financial impact of your gripper choice if you want to add new products on this line? This aspect is the most difficult to evaluate accurately. Still, it is worth considering as it can represent large hidden costs. The same costs that were considered at purchase need to be considered here. One difference though is that the programming time will most probably involve stopping the cell production, which can also be quite costly.

## CONCLUSION

This Ebook exposed you to different kinds of end effectors and more precisely grippers. You also learned how to choose the right gripper and to evaluate the cost for a possible integration of a robotic gripper. You now have all the tools you need to get started in robotic manipulation.

## ABOUT ROBOTIQ

Robotiq makes tools for agile automation; flexible robot grippers to handle a wide variety of parts and a robotic teaching device that makes robot programming easier.

Our goal is to enable all manufacturers — especially those dealing with a high mix of products — to take full advantage of robotics.

Robotiq has sold product in more than 30 countries, through our global network of partners.

## TO LEARN MORE

For any questions concerning robotic 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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