FESTO

All About Robotic Grippers

Exploring current and future gripper trends and technologies in automated handling applications.

Introduction

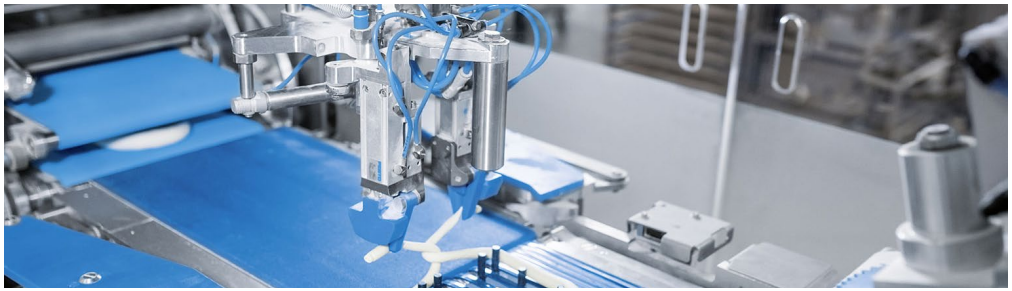
Grippers and robots go hand-in-hand — literally. A gripper is a pneumatic or electric actuator that holds, positions and moves a workpiece, representing the critical connection between the workpiece and industrial robot.

As robots continue to develop, taking on more difficult operations and handling increasingly complex workpieces, you have more grippers to choose from than ever. Some have multiple fingers, while others rely on suction. Some provide sturdy grips for machine tool applications, while others offer greater precision for handling delicate electronic components.

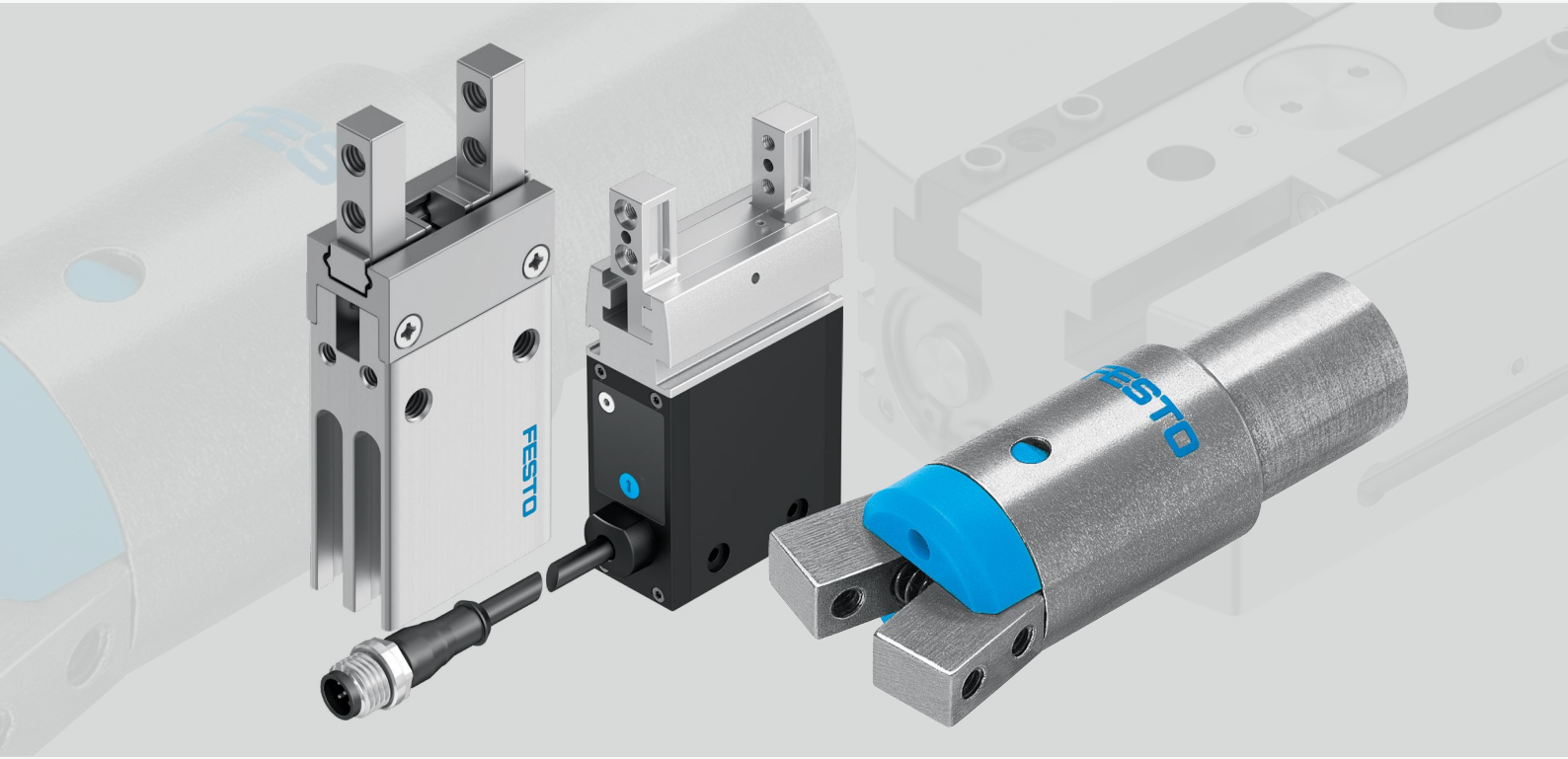
In addition to these general automation trends, workforce shortages are compelling many manufacturers to send robots into new applications, in turn creating the need for more diverse, capable gripper designs. Together, these factors have led to an explosion in gripper technology.

Besides traditional mechanical and vacuum grippers, bio-inspired “soft” grippers, which adapt to the unique contours of a workpiece, are on the rise. A step toward the universal gripper — the holy grail of robotics — many emerging grippers also use digital pneumatic technology, which provides the benefits of pneumatics and electric automation. These solutions use existing pneumatic infrastructure, offering an alternative to electric actuation, while combining innovative mechanics, electronics and software.

The following e-book will take you through the current state of the art in gripper technologies, discussing various designs and dispelling common misconceptions during the sizing and selection process. It will also cast an eye to the future, describing the latest technologies and innovations — from grippers that mimic the human hand, to end-of-arm tools based on the animal world.



Grippers 101



Grippers 101

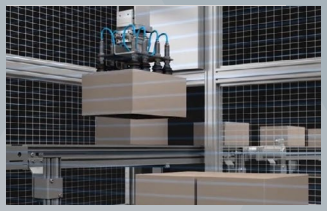
With all the gripper choices in front of you, it can be a challenge to figure out which one is best for your application. Selecting the right gripper depends on a number of factors, including the nature of the task, operating environment and size, mass and material of the workpiece. Other important factors to keep in mind include upfront, operating and maintenance costs, as well as energy consumption. Here's a quick rundown of some common gripper types:

Mechanical grippers make up the bulk of the market and fall into two categories: pneumatic and electric. Pneumatic grippers are lightweight, feature high grip forces and can handle fast cycle rates, while electric grippers offer greater precision, affording end-users with greater force and travel control. At the same time, electric grippers tend to increase upfront costs due to the presence of a motor and other internal components.

Whether electric or pneumatic, mechanical grippers fall into several design classes: parallel grippers, which have two- and three-finger designs; radial grippers, which open to 180 degrees; and angular grippers, which quickly open to an acute angle — e.g., 30 degrees.

Another common gripper technology is the **vacuum gripper**, which combines suction cups and vacuum generators. Vacuum grippers are typically more compact, lightweight, faster-acting and lower in cost compared to mechanical grippers. However, suction cups are prone to wear and commonly have to be replaced regularly. Venturi style vacuum generators consume high rates of compressed air — a fact that can be disadvantageous in applications requiring high pick rates. At the same time, the vacuum gripper's speed and weight make it a popular choice in many end-of-arm tooling applications.

Positioning and stacking of pre-packed goods.



Vacuum grippers are utilized to securely lift pre-packed goods onto pallets in a desired pattern, while ensuring the package is not damaged in transfer.

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Common Gripper Misconceptions

Common Gripper Misconceptions

The most important factors to consider when sizing your gripper are force and torque. Gripper force requirements depend on the jaw factor, or the style of jaw, and part weight — both from gravity and from acceleration. Jaw torque, the other critical sizing factor, has two sources: the torque generated by the gripper on itself, and the torque generated by the acceleration and weight of the part. Before sizing your gripper based on these parameters, however, it's important to dispel some common misconceptions about these robotic components.

Only One Jaw Supplies Gripper Force

When selecting robotic grippers, engineers tend to consider the force both grippers apply to the part. However, this value only tells half the story. The first misconception is this idea that a part experiences the combined forces from both jaws. In other words, 10 pounds of force per jaw applies 20 pounds of force to a part. In reality, however, the part only experiences 10 pounds of force. Why? The force provided by one jaw must counteract the force provided by the other.

This is the same phenomenon that happens when you lean against a wall. If you apply 50 pounds of force against the wall, the wall pushes back on you with 50 pounds of force — or else you would move it. Any object trapped between you and the wall subsequently experiences a 50-pound squeeze.

This same principle applies to grippers: force values pertain to only one jaw, not both.

Torque, Not Slide Efficiency, Is Important for Sizing

Charts that display jaw length versus force indicate a gripper's slide efficiency, or the amount of actual force provided by the gripper versus the theoretical force provided by the pneumatic or electrical system. In most cases, however, efficiency has little to do with sizing the gripper because the slide is equally efficient in both directions: if the part pushes back on the jaw due to weight or acceleration, then the slide will be just as efficient transmitting the force of the part to the gripper as it is in transmitting the force of the gripper to the part.

Common Gripper Misconceptions

Slide efficiency typically only matters when the jaws provide a friction grip — i.e., when the jaws squeeze a part to hold it in place. Slide efficiency charts provide only a rough measurement of a slide's torque capability, so while these charts are helpful, it's better to ask your gripper manufacturer for torque specifications for jaw pitch yaw and roll.

In short, always ask for a gripper's torque information during the sizing process instead of relying on slider efficiency charts.

Electric Vacuum Pumps Versus Pneumatic Venturi Vacuum Generators

Understanding how much energy your vacuum end-of-arm tooling requires isn't always as simple as comparing catalog data and pump ratings. For example, it's easy to assume the energy required to operate a continuously running mechanical vacuum pump will be constant, matching the rating listed on the machine. In reality, however, true energy consumption is application-specific — and it isn't enough to assume your pump's energy consumption will match the accompanying specifications.

If you compare the features and benefits of compressed air-driven generators versus those of the traditional mechanical pumps, you'll discover one option is superior. While mechanical pumps achieve high vacuum and suction rates, they tend to be heavy and large, requiring complex piping systems. Because they run continuously, they also consume a lot of current, generating heat. On the other hand, compressed air-driven generators — which consume energy only when suction is required at the cup — are cleaner, more compact, lighter in weight and easier to install. They also include simpler piping systems and incorporate no electrical connections, eliminating harmful heat buildup.

Advances in Gripping Technology

Advances in Gripping Technology

Digital Pneumatics: A Step Toward Universal Gripping

The universal gripper, the holy grail of robotics, is a one-size-fits-all component that can pick up anything, from a toothpick to a 20-pound case. Moving us in this direction is the advancement of digital pneumatic technology, which operates at the intersection of traditional pneumatics and electric automation. The development of universal grippers, based on digital pneumatics, is driven by industries like ecommerce — which requires robots to handle various materials and items, for example — as well as robotic operations for singulating and packing goods like bubble wrap, tubes, polythene (poly) bags, corrugated packages, envelopes and more.

At the forefront of these developments, Festo offers a universal foam gripper cup featuring a foam ring interface (See figures 1 and 2 below). Used in singulation applications, this gripper is ideal for apparel poly bags and other soft materials that can challenge traditional vacuum cups or mechanical grippers. These grippers also work well in agricultural applications — picking fruit off the vine, for example. The special foam-lipped gripper has a lightweight, rigid polymer body that provides high stiffness during lateral movements with heavy objects. This foam lip is a low-cost sealing surface that can form a vacuum seal on a wide range of product surfaces, textures and shapes. Thanks to the vacuum's simple operating principle, this gripper is a big step in the direction of universal gripping without sacrificing weight or speed.

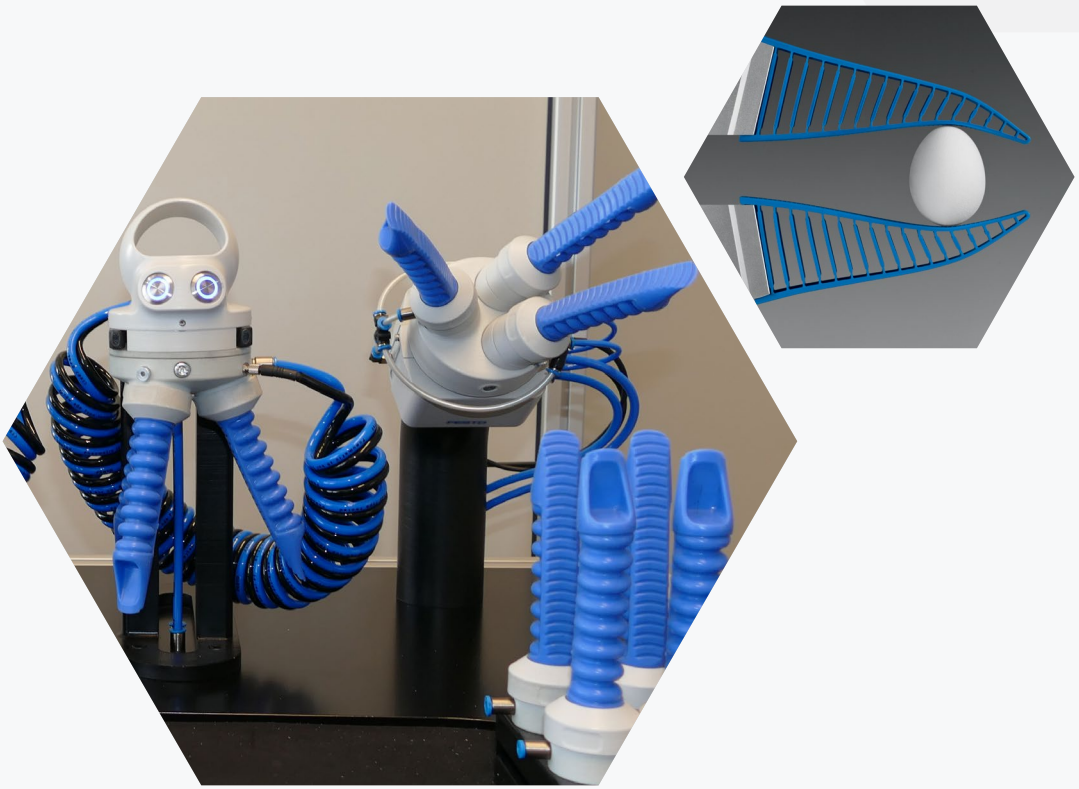
Figure 1

Figure 2

Advances in Gripping Technology

Emerging Soft Gripping Technologies

Many of the latest gripper innovations are moving away from traditional mechanical jaws and vacuum cups, instead incorporating soft designs that adapt to a part's unique shape and material. In many cases, these adaptive grippers are based on designs in the animal kingdom. One example is based on a fish tail fin, which, if pressed, curves around the pressure point instead of bending. The resulting FinRay Effect® gripper incorporates two flexible polyurethane structures connected to each other via intermediate webs. Whether arranged in parallel or centrically, the fingers adapt to the contour of a workpiece, enabling gentler, more secure gripping of sensitive objects. Thanks to its stiffness along the finger length, this gripper can even hold smaller objects using only the fingertips.



Degassing and sealing battery cells with flexible gripper.

Safely and reliably grip battery cells and load into the process chambers.
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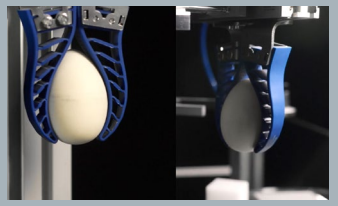
Gripper for every application.



Easy gripping, reliable motion and precise positioning of a wide variety of workpieces with the help of mechanical and electrical grippers or alternatively through a wide portfolio of suction cups.
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Advances in Gripping Technology

A second example of an adaptive gripper is based on a chameleon's tongue. This bionic gripper, called the FlexShapeGripper, consists of a double-acting cylinder, with one chamber filled with compressed air and the other filled with water. This second chamber features an elastic silicone cap, and the volume of the two chambers is designed to compensate for the cap's deformation. During the gripping process, an industrial robot guides the cap over an object. When the cap and object touch, the upper pressure chamber is vented, and the water-filled silicone cap pulls itself inwards. As the robot continues to guide the gripper over the object, the cap folds itself over the object, creating a tight and secure fit.

A third example of an adaptive gripper is a self-contouring "finger gripper" that utilizes the same technology as the BionicSoftHand. This component, which supports digital pneumatics, incorporates proportional piezo valves that precisely control the fingers.

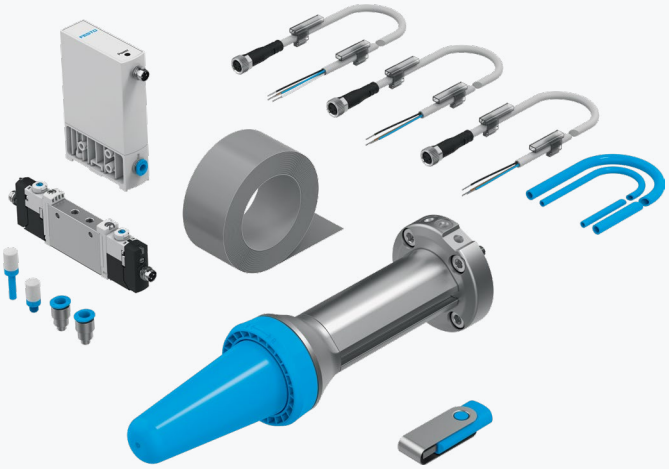
Gripper Kits For Universal Robotics

Gripper Kits for Universal Robotics

Many suppliers of automation and gripper technologies offer gripper kits that can interface directly with collaborative robots. A true plug-and-play solution, these kits come with sensors, accessories and software that facilitate the commissioning and programming processes. For example, gripper kits that are compatible with industrial robot arms by Universal Robots are available for gripping applications requiring clamping, adaptive contouring or vacuum suction.

These gripper kits offer the following advantages:

- Kits come with all the required mechanical and electric interfaces and software for Universal Robots, enabling you to start work immediately.
- Kits come with a Universal Robots software plug-in, facilitating commissioning, improving reliability during operation and making it quick and easy to program the robot with Festo grippers.



Many suppliers also offer product sizing and selection tools — all online. Simply enter in some basic information about your workpiece, including its weight and location, as well as details about your gripper design, motion requirements and mounting position. The software tool will then output various grippers that meet your requirements.

Gripper front-end unit on the robot arm.

This compact robotic solution is equipped with the most compact gripper on the market, offering impressive gripping force and gripping accuracy. This compact robot opens up new possibilities for positioning and alignment during depositing tasks, making it an invaluable asset in a wide range of applications.

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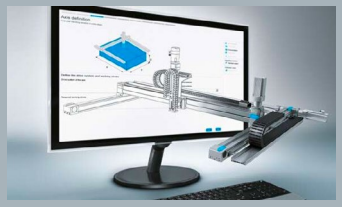
Festo Online Engineering Tools



Festo online engineering tools allow you to confidently design solutions, regardless of your level of expertise. Get more value from your industrial automation projects by leveraging Festo technology and expertise!

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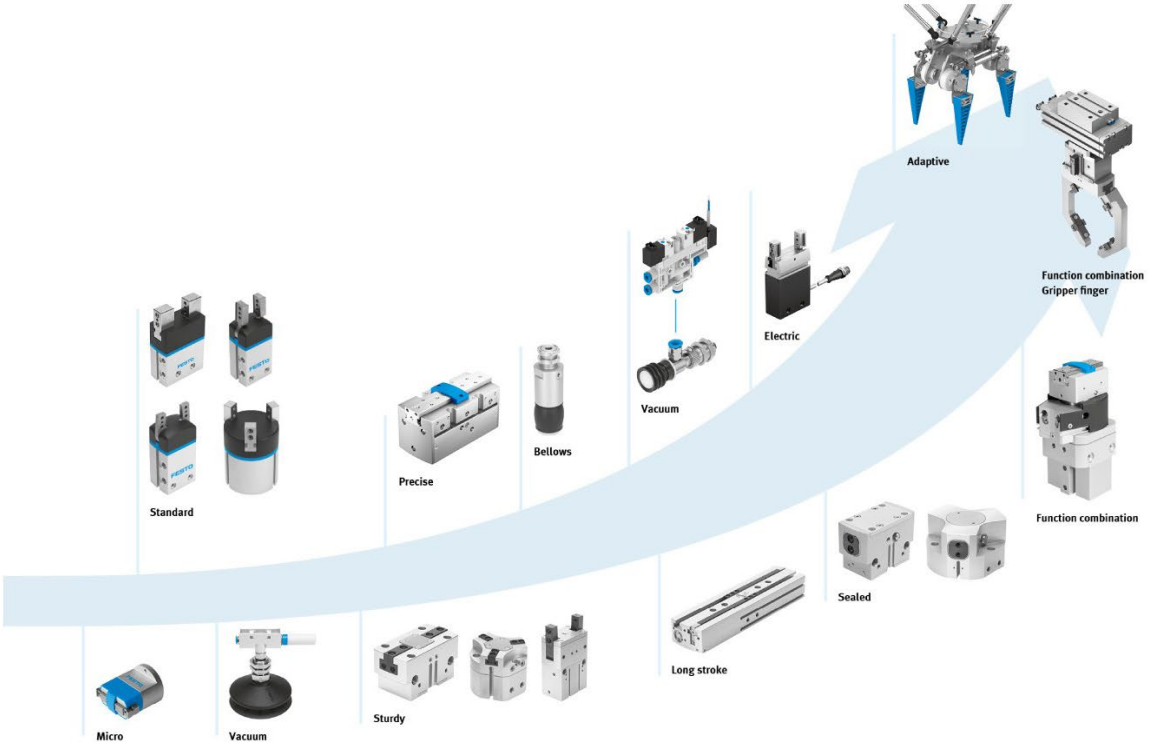
Festo Product Roundup



Festo Product Roundup

Mechanical Grippers	
DHPL Parallel Gripper	DHPC Parallel Gripper
DHPS Parallel Gripper	DHDS Three-Point Gripper
HGPD Parallel Gripper	HGDD Three-Point Gripper
HGPT Parallel Gripper	HGDT Three-Point Gripper
HGPL-B Parallel Gripper	DHWS Angle Gripper
HGPP Parallel Gripper	HGWM Angle Gripper
HGP Parallel Gripper	DHRS Radial Gripper
HGPM Parallel Gripper	HGRT Radial Gripper
HGDS Swivel/Gripper Unit	HPPF Flat Parallel
Vacuum Grippers	
OGVM Vacuum Suction Cup	ESS Vacuum Cups
OGGB Bernoulli Grippers	ESV Vacuum Cups
ESG Suction Grippers	VAS, VASB Vacuum Cups
Electric Grippers	
EHPS Parallel Grippers	HEPP Parallel Grippers
Adaptive Grippers	
DHEB Bellows Gripper	DHAS Adaptive Gripper Fingers
DHEF Adaptive Shape Gripper	HPSX Soft Grippers

Festo Product Roundup

Three-Point

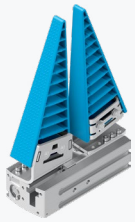
DHDS

- Heavy-duty, precision T-slot guide for gripper jaws
- High gripping force with compact size
- Max. repetition accuracy

HGDD

- Precise gripping with centric movements despite high torque loads
- Ideal for very harsh environments
- 5 sizes with up to 12 mm stroke/jaw

Parallel



HGPL

- Space-saving, high forces and torques
- Controlled, precise, and centered gripping
- Long stroke: long guide length for the gripper jaws

DHPC

- Resilient and precise ball guide
- High gripping force with compact size
- Max. repetition accuracy

Angle

DHWS

- Improved gripper jaw guide
- Internal fixed throttling, does away with the need for external throttling in 80% of applications
- Slotted guide

HGWM

- Micro gripper: compact, handy design
- Versatile thanks to externally adaptable gripper fingers
- Single-acting gripper, optionally with open (NO) or closed (NC) gripper jaws

Electric

DHPC

- Resilient and precise ball guide
- High gripping force with compact size
- Max. repetition accuracy

Adaptive

DHAS

- Self-adapting to different workpiece shapes
- Adaptive gripper fingers for gentle and flexible gripping, using the Fin Ray Effect® modelled on a fish tail fin
- For workpiece diameters from 6 to 120 mm

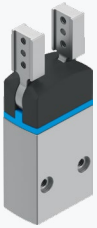
Festo Product Roundup

Bellows

DHEB

- 11 sizes for gripping diameter from 8 to 85 mm
- Direction of movement: bellows upwards or downwards
- Different bellows materials: EPDM or silicone

Radial



DHRS

- Lateral gripper jaw support for high torque loads
- Self-centering
- Internal fixed throttling

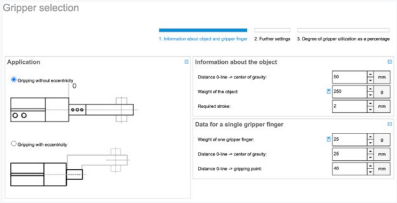
Swivel

HGDS

- Combination of parallel gripper and swivel module
- Swivel angle infinitely adjustable
- Precise end stop with elastic cushioning or integrated shock absorber

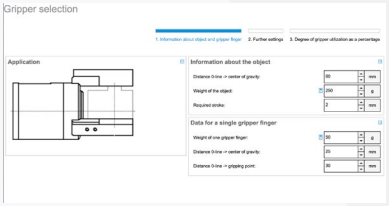
Online Support Tool

Our goal is to increase your productivity. Our software tools play an integral part in achieving this goal and are constantly being refined. They help you tap into productivity reserves and generate additional productivity along the entire value chain. In every phase of your project, from the initial contact to the modernization of your machine, you will come across a number of different tools which will be of use to you.



Parellel Grippers

The software tool tells you immediately which of the parallel grippers you need to use, and in which size.



Three-point Grippers

Tells you immediately which of the three-point grippers you need to use, and in which size.

Angle Grippers

Tells you immediately which of the angle grippers you need to use, and in which size.

Find more online tools here

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