# ROBOTICS 1

End Effectors

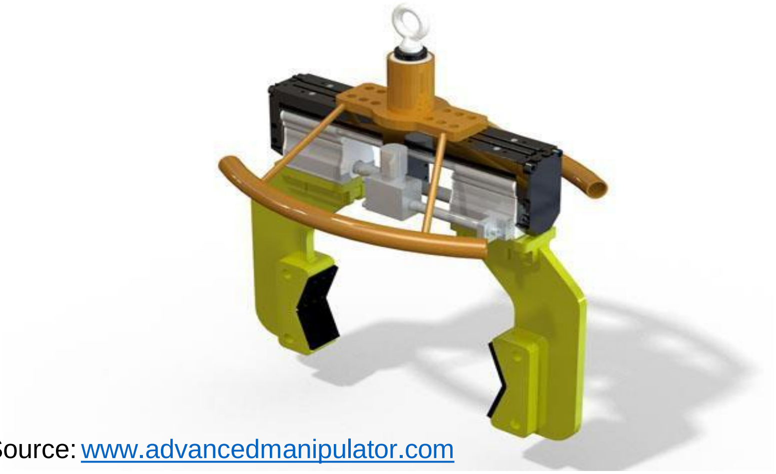
IMRAN KHAN

Resources: Text Book: Industrial Robotics ( Larry T. Ross)-GW Publisher

School of Applied Technology  Robotics and Automation

# End-Effectors

The last link of the robotic arm that interact with the environment through the tool is called an end-effector.



Source: www.advancedmanipulator.com

Source: wikipedia.org/wiki/File:Endeffector.png

# End Effectors Movement

- Prehensile Movement

  Use of thumb and  fingers to grasp an object.

- Non-prehensile Movement

  movements that do not dexterity or use of the thumb

# Prehensile Movements

- Five basic prehensile, or gripping, movements

Palmar Grip

Cylindrical Grip

Spherical Grip

Lateral Grip

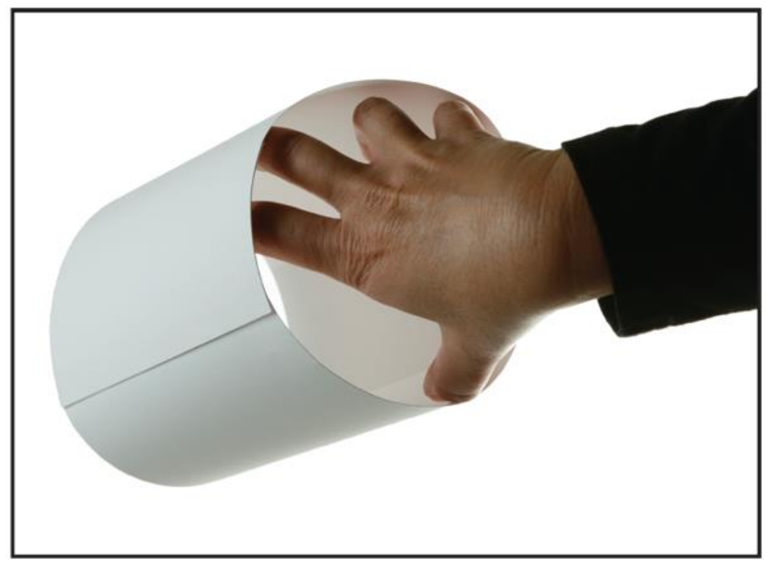
Oppositional Grip

*Goodheart-Willcox Publisher*

# Non prehensile Movements

- Do not require finger dexterity or use of opposable thumb

Hook



Spread

*Goodheart-Willcox Publisher*

# Classifications of End effector

- Two Major Classifications:

- Gripper
- Mechanical Grippers
- Collet Grippers
- Vacuum Grippers
- Electromechanical Grippers

- Tools
- Welding Tools
- Material Application Tools
- Machining and Assembly tools

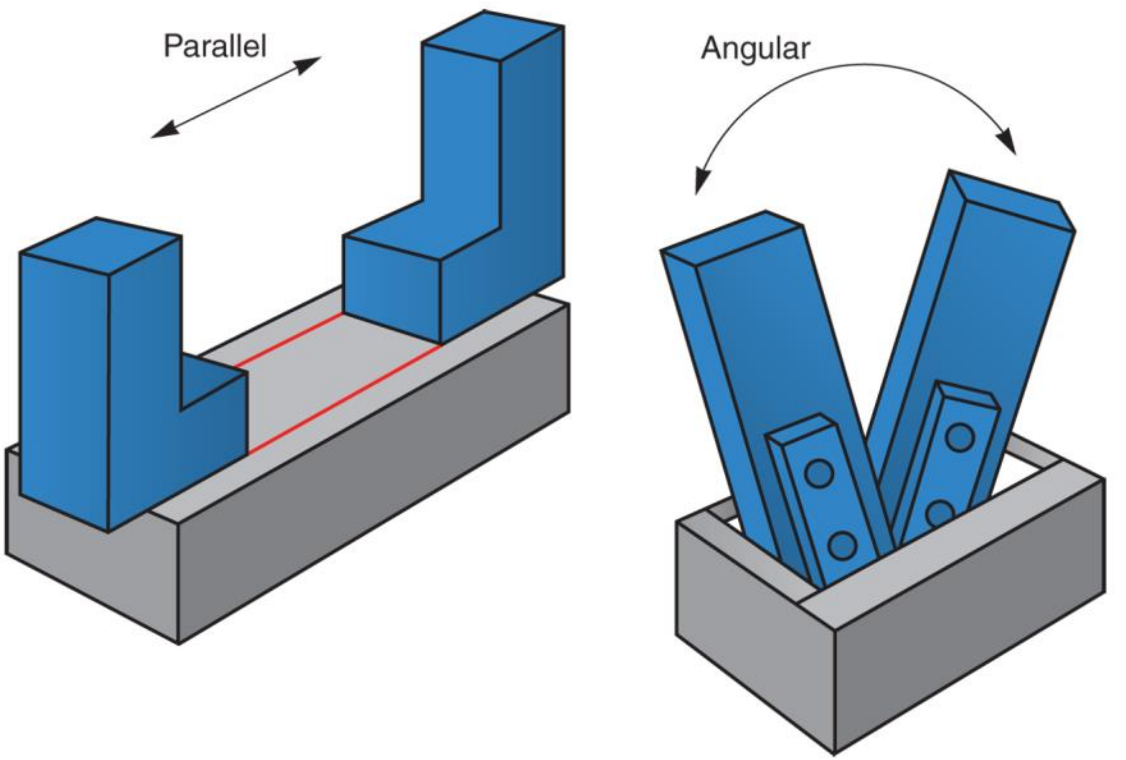
# Gripper Types

| Gripper End Effectors | | | |
|---|---|---|---|
| **Gripper Type** | **Gripper Configuration** | **Gripper Movement** | **Internal/External Gripping** |
| Mechanical finger | Two-finger<br>Three-finger<br>Four-finger | Parallel or angular | Internal and external |
| Collet | Round<br>Square<br>Hexagonal | 360° clamping contact | Internal and external |
| Vacuum | One or more suction cups | Vacuum/suction | External |
| Electromechanical | Permanent magnet<br>Electromagnet | Magnetic attraction | External |

*Goodheart-Willcox Publisher*

# Grippers

- *Mechanical finger grippers*
  Move in parallel or angular motion




*Goodheart-Willcox Publisher*

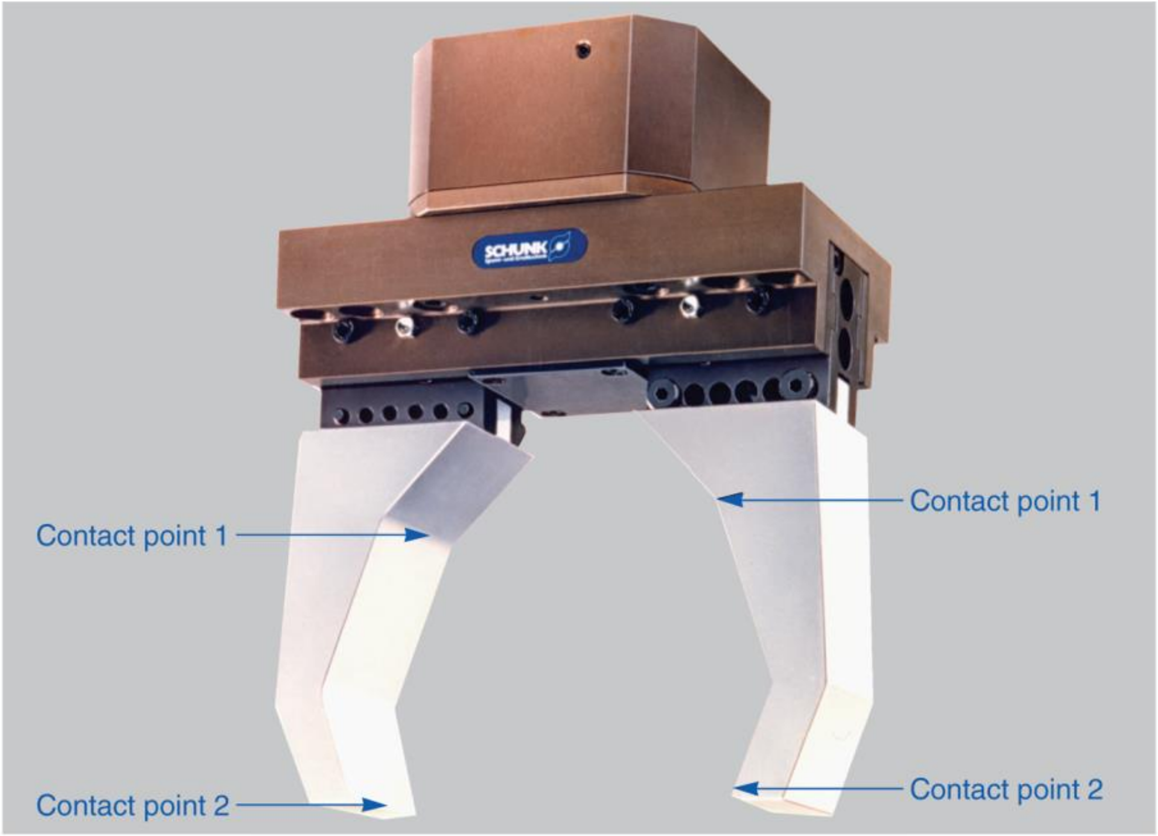
# Grippers

- Two-finger grippers
  Human thumb and index finger


*SCHUNK Intec Inc.*

# Grippers

- V-shaped fingers with two points of contact on each finger



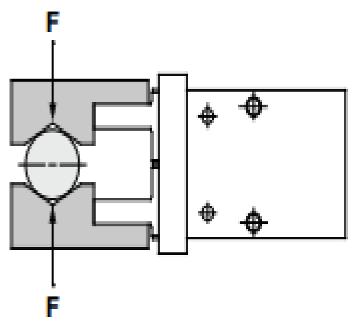

 *Schunk-USA*

# Grippers

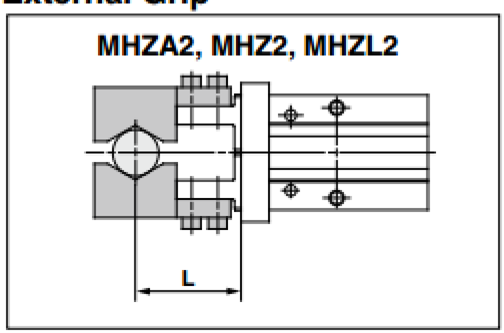
- Three-finger grippers
  - Human thumb, index finger, and third finger


SCHUNK GmbH & Co. KG

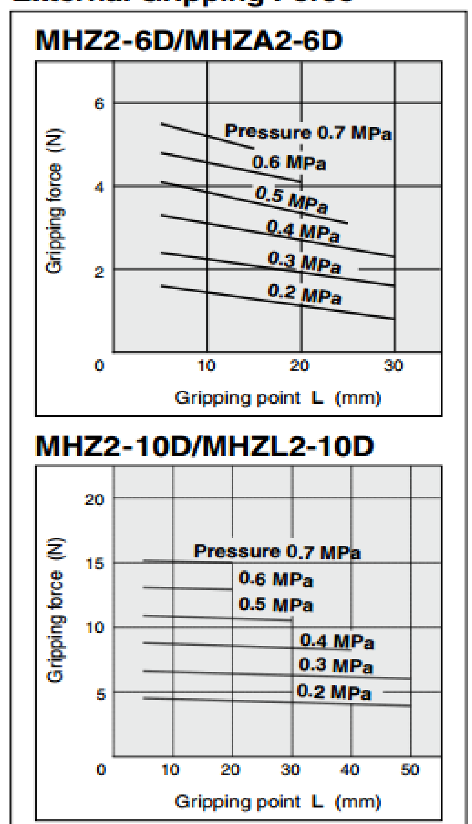
# GRIPPER FORCE



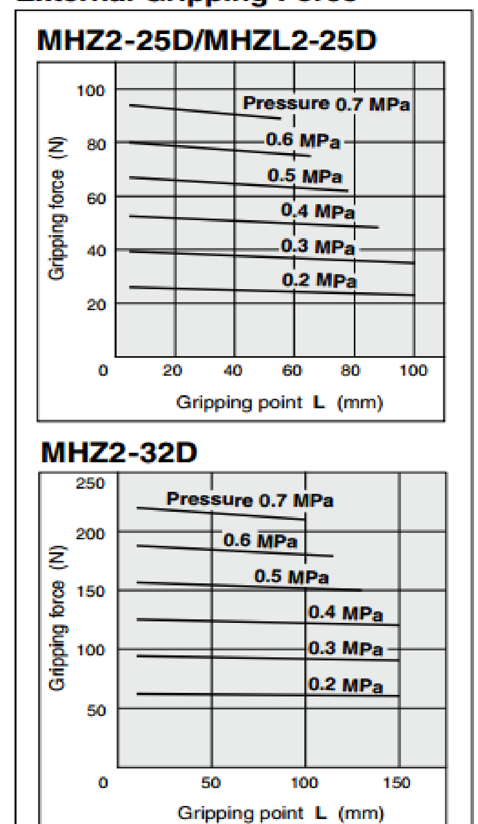

## External Grip




## External Gripping Force

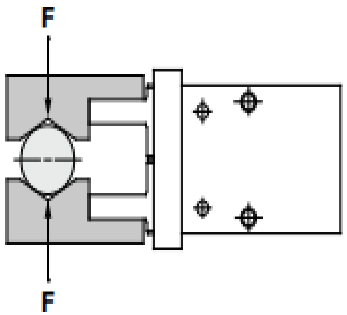



## External Gripping Force

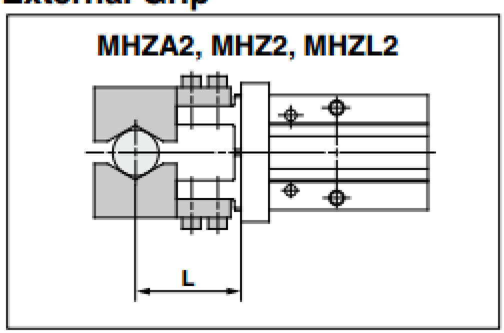


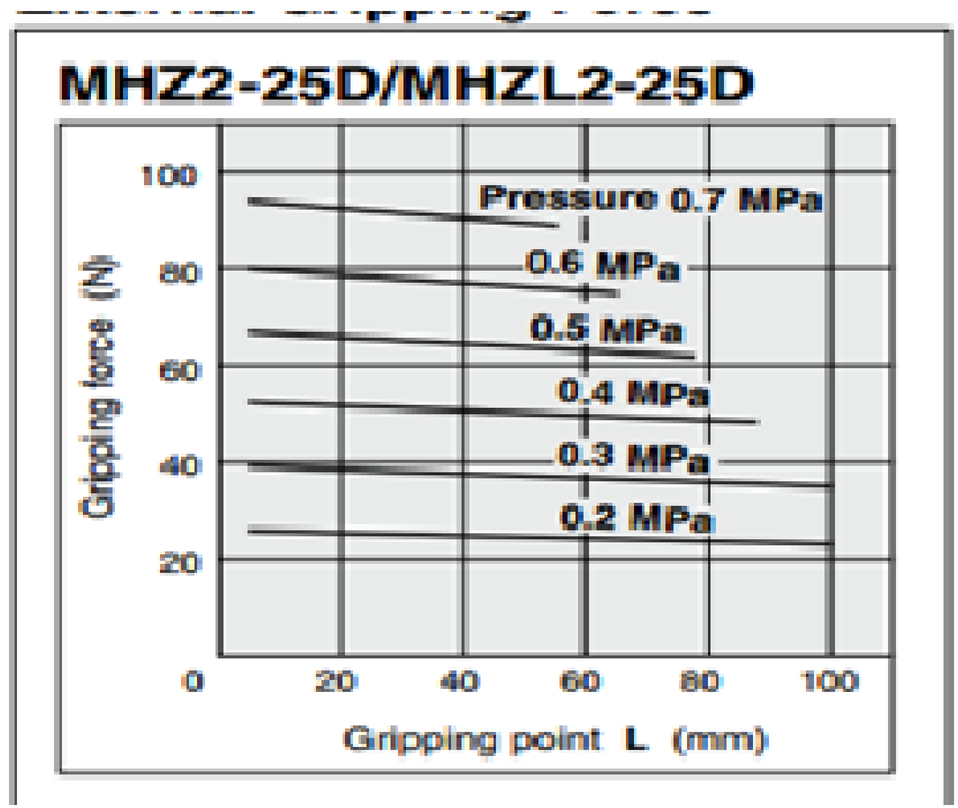
# GRIPPER FORCE

In LAB : From Round 02 onward, gripper force will be estimated based on the following graph (MHZ2-25D)  at 0.3 Mpa.



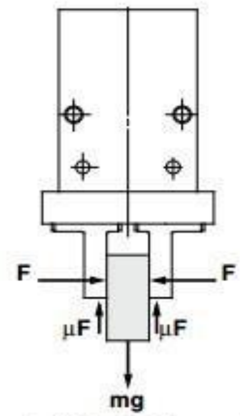

External Grip



# FORCE CALCULATION

**Model Selection Illustration**




**"Gripping force at least 10 to 20 times the workpiece weight"**

The "10 to 20 times or more of the workpiece weight" recommended by SMC is calculated with a safety margin of a = 4, which allows for impacts that occur during normal transportation, etc.

| When $\mu = 0.2$ | When $\mu = 0.1$ |
|---|---|
| $F = \frac{mg}{2 \times 0.2} \times 4$ $= 10 \times mg$ | $F = \frac{mg}{2 \times 0.1} \times 4$ $= 20 \times mg$ |
| 10 x Workpiece weight | 20 x Workpiece weight |

When gripping a workpiece as in the figure to the left, and with the following definitions,

**F:** Gripping force (N)
**μ:** Coefficient of friction between the attachments and the workpiece
**m:** Workpiece mass (kg)
**g:** Gravitational acceleration (= 9.8 m/s²)
**mg:** Workpiece weight (N)

the conditions under which the workpiece will not drop are

$$\underline{2} \times \mu F > mg$$

Number of fingers

and therefore,

$$F > \frac{mg}{2 \times \mu}$$

With **"a"** representing the extra margin, **"F"** is determined by the following formula:

$$F = \frac{mg}{2 \times \mu} \times a$$

# Example 1

Calculate the 2-finger gripper force required to hold the mass of 2 Kg.
Consider coefficient of friction μ=0.2 and factor of safety (fos=4)?

Solution :

$$F = \frac{mg}{n\mu} x \text{ (fos)}$$

$$F = \frac{(2)(9.8)}{(2)(0.2)} x (4)$$

Where,
m= mass in Kg
g= gravitational accelerations
n= number of fingers
$\mu$ = Coefficient of friction
fos = factor of safety

$$F = 196 \ N$$

# Example 2

Calculate the force of a 2-finger gripper. If the gripper is holding a block of 2Kg and moving with an acceleration of 3 m/s². Consider the coefficient of friction μ=0.2 and factor of safety (fos) is 4

Solution :

$$F = \frac{mg}{n\mu} x \text{ (fos)}$$

$$F = \frac{(2)(9.8+3)}{(2)(0.2)} x (4)$$

Where,
m= mass in Kg
g= gravitational accelerations
n= number of fingers
$\mu$ = Coefficient of friction
fos = factor of safety

$$F = 256 \ N$$

**Note:** If additional acceleration is given for moving the mass then
g = 9.8 + additional acceleration value

# Collets Gripper

- Use to pick and place cylindrical parts that are uniform in size. It provides 360° clamping contact.

# Vacuum Grippers

- Multi-cup vacuum grippers increase contact surface area

*Vacuum grippers*

Use

One or more

suction cups

Exact positioning

not as critical


*Pacific Robotics, Inc.*

# Electro-Mechanical Grippers

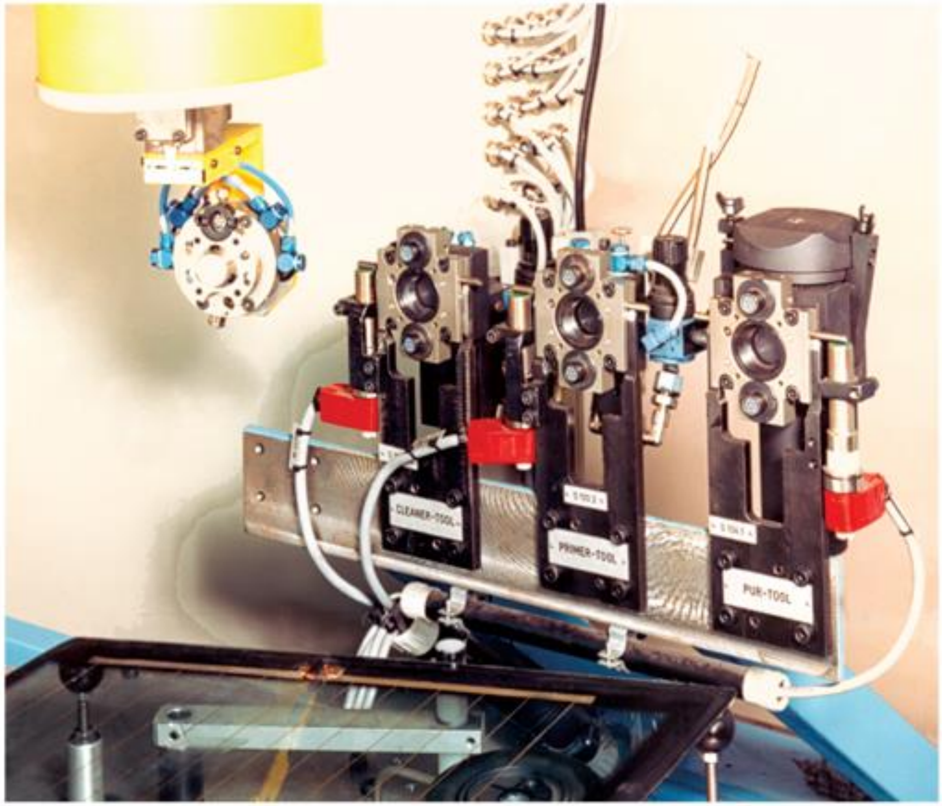
Electromechanical grippers, also called magnetic grippers, are end effectors that use a magnetic field created by a permanent magnet or an electromagnet to pick up an object. An electromagnetic gripper is energized by a DC power source.

# Tools

- Welding Tools
    - Arc welding
    - Spot welding
- Material Application Tools
    - Palletizing
    - Packaging
    - Handling Operations
- Machining and Assembly tools
    - Drilling
    - Cutting
    - Deburring

# Tools

- Typical automatic tool changer applications






*Schunk-USA*

# Changeable End Effectors

Robots for machining and assembly require different tools

Rapid tool changing critical to productivity

Material application for palletizing, packaging, and handling operations

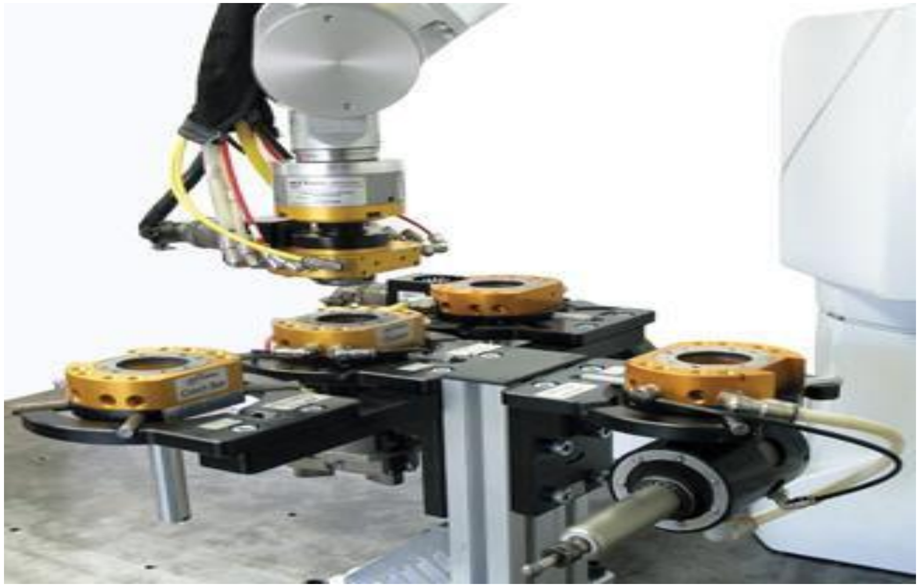
Rapid tool changing automates and improves process

# Automatic Tool Exchanger

An automatic tool exchanger is used that has more than one end effectors and can
change end effectors when needed to execute the operation.

We have ABB robot with automatic tool exchanger.

In Robotic II we will do automatic tool exchanger with ABB Robot.



Engineering 360°

# Consideration - Changeable End Effectors

- Quick-change tooling
- Interface adapters must be standardized
- Change end effectors with minimum downtime

# End Effectors Design characteristics

- Payload capacity
- Size and shape
- Type of materials
- Inertial
- Gripping force
- Gripper sensing capabilities
- Overload Sensor
- Compliance
- Part orientation
- Compensates for workpiece misalignment or irregularities (Remote Center Compliance)
- Guard against strain damage
- Strength to carry out tasks

# Custom-Designed End Effectors

- Can be designed for a particular application
- Broaden range of tasks that can be performed
- Can be designed to handle fragile or oddly shaped parts

# Custom-Designed End Effectors

- Dual end effector has internal and external gripping capabilities

Schunk-USA

# Custom-Designed End Effectors

Vision guidance system allows robot to find objects not placed symmetrically