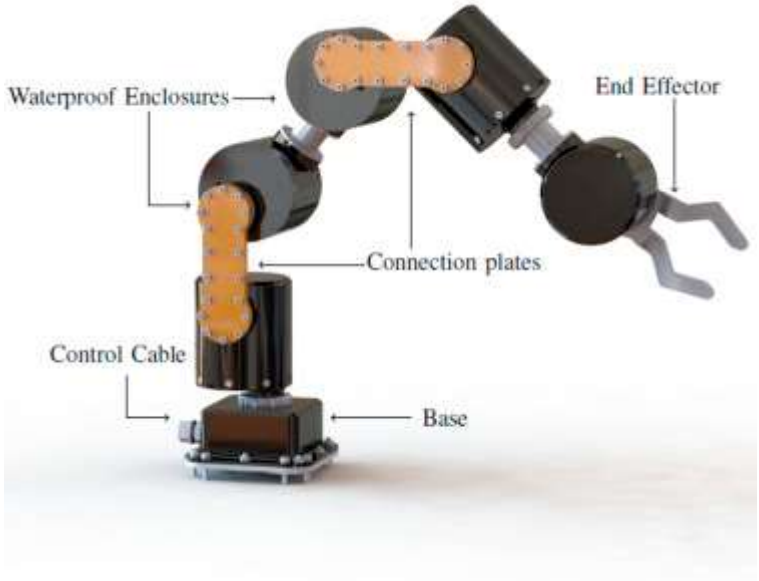
END EFECTORS

End Effector

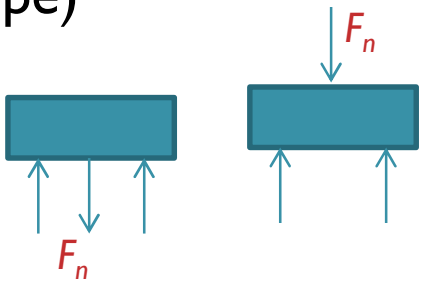
- End effector is a device or tool that's connected to the end of a robot arm where the hand would be
- End effector gives a functionality to the industrial robot
- The end effector is the part of the robot that interacts with the environment



Haugaløkken, B. O. A.; Jørgensen, E. K.; Schjølberg, I. Experimental validation of end-effector stabilization for underwater vehicle-manipulator systems in subsea operations, Robotics and Autonomous Systems, Volume 109, 2018, P pp 1-12, ISSN 0921-8890, https://doi.org/10.1016/j.robot.2018.08.007.

End Effector Types

- Grippers (the most common type)
  - Mechanic
    - With one-sided contact
    - With two-way contact
  - To Pick Up
    - Vacuum
    - Magnetic
- Tools (depending on the application)
  - Welding
  - Polishing
  - Screwing…
- Sensors



Grippers

- Active
  - it can change the gripping force by which the object is gripped
- Passive
  - the gripping force cannot be regulated

Special grippers for gripping textile materials

Sewing machine ⇒ utilisation is only for 30%; the rest is handling and other activities

- ➔ the need to reduce handling times
- ➔ the importance of automation of textile material handling
- ➔ use of handling equipment with special gripping heads (End effectors)

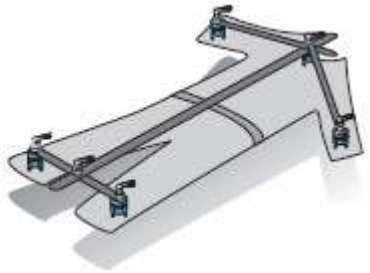
Disadvantages of textile material from the point of view of handling

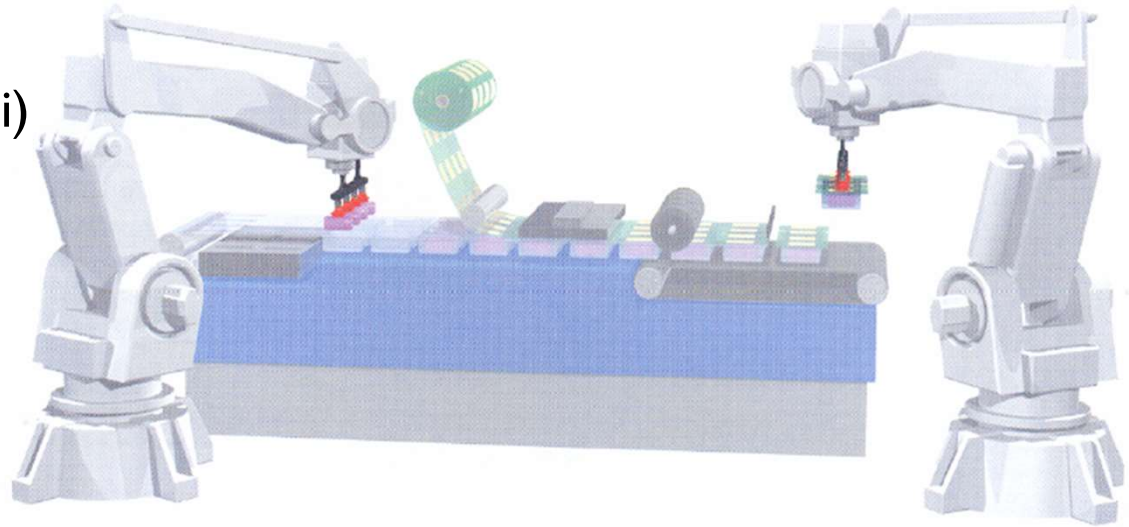
1) The **soft** material does not grip very well
2) **Small thickness -** the material has two dimensions prevailing over the third
3) **Low stiffness** – the material is flowing
4) **Breathability**
5) The material retains an **electrostatic charge -** gluing of individual layers of material
6) The material has a **low weight**, it hardly falls off the gripper
7) **Elasticity**

Suzhou Rochu Robotics Co.,Ltd. *Fabric micro gripper GC-Beak in Row* [online]. Available from: https://www.directindustry.com/prod/suzhou-rochu-robotics-co-ltd/product-217255-2260204.html

Typical grippers for textile semi-finished products

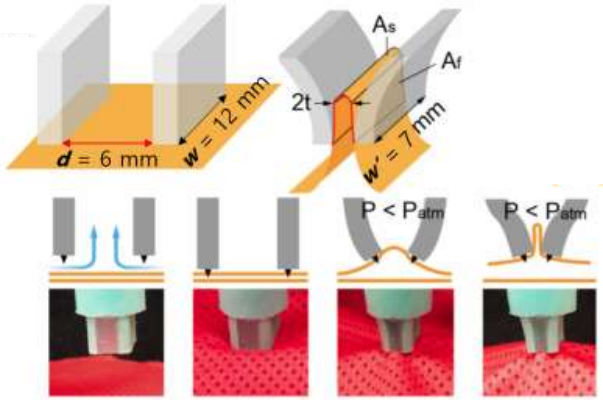
- **Mechanical**
  - Needles
  - Collets
- **Pneumatic**
  - Low-pressure
  - Rubber sucker
  - Ejector (Bernoulli)
- **Adhesive**
  - Adhesive tape
- **Electrostatic**
- **Frictional**
  - Tape
  - Roller
- **Combined**





Mechanical grippers

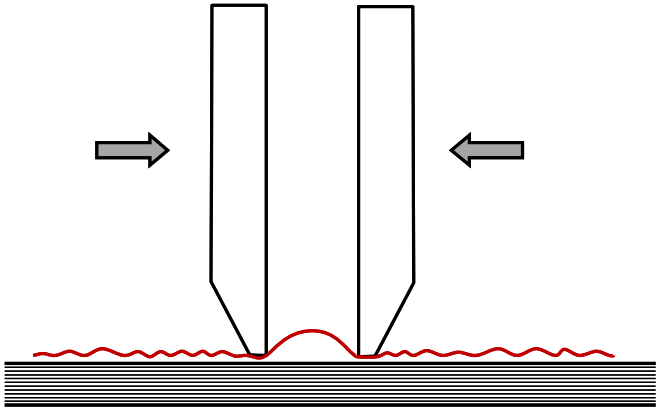
VIDEO: https://www.youtube.com/watch?v=FuB2qF0krU0

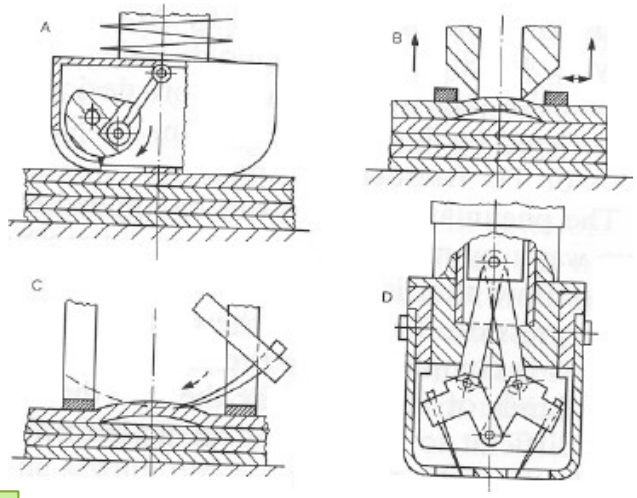


S. Ku, J. Myeong, H. Kim, and Y. Park. *Delicate Fabric Handling using A Soft Robotic Gripper with Embedded Microneedles*.
IEEE Robotics and Automation Letters 2020, IEEE/RSJ International Conference on Intelligent Robots and Systems)

- **Needles**
  - Basic – MOST USED
  - They stab into the material and grab it
  - Most common, so-called „cat-claw“
- **Collets**
  - When pressed, the textile material curls and that's enough to grip

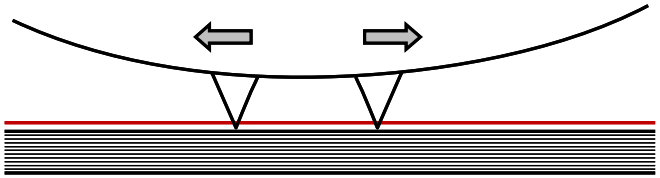
VIDEO: https://www.youtube.com/watch?v=zWR7V_tdbgY



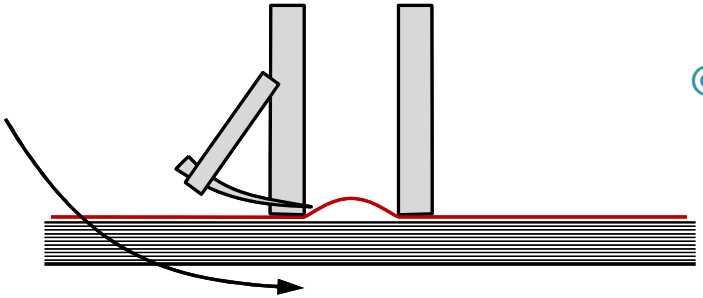


VIDEO: https://www.youtube.com/watch?v=RVTyvGO5LSE

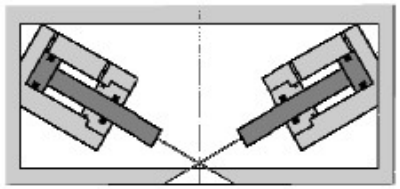
Mechanical grippers - Needles

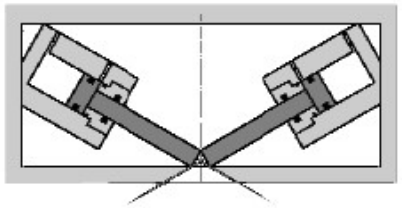


- They stab almost perpendicular to the fabric ⇒ then they move away from each other and the fabric is stretched



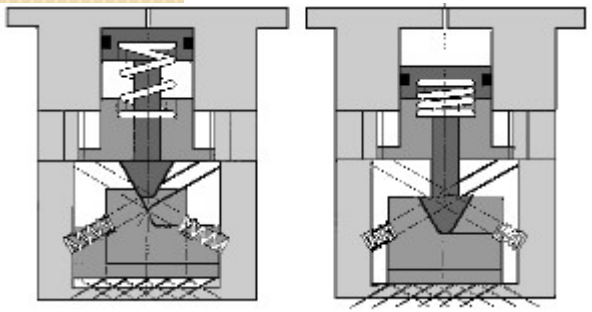
- The needle is inserted almost tangentially into the fabric ⇒ it reaches the top of the material and it is enough to grip

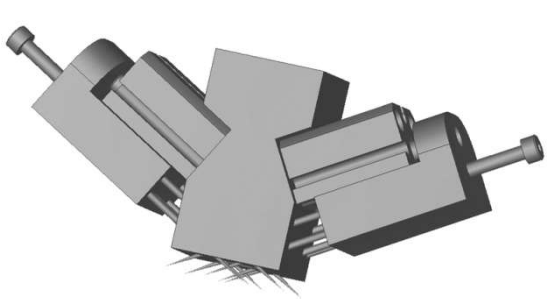


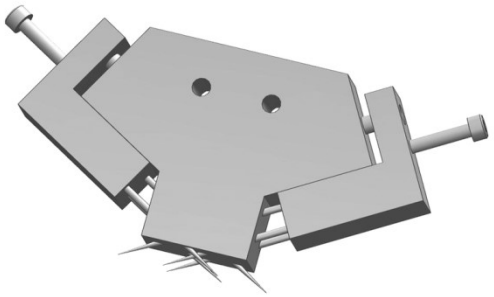


- The needles cross and both rise

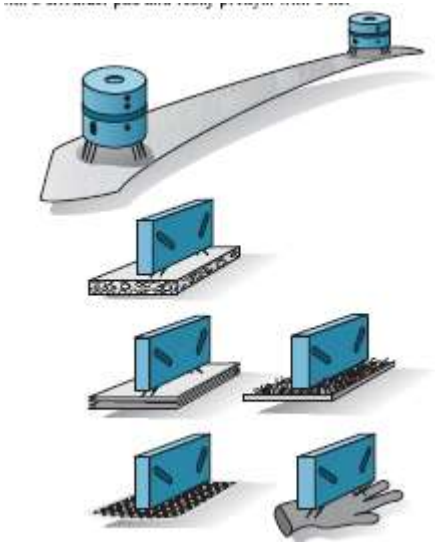
VIDEO: https://www.youtube.com/watch?v=5_QPiWrBN4E

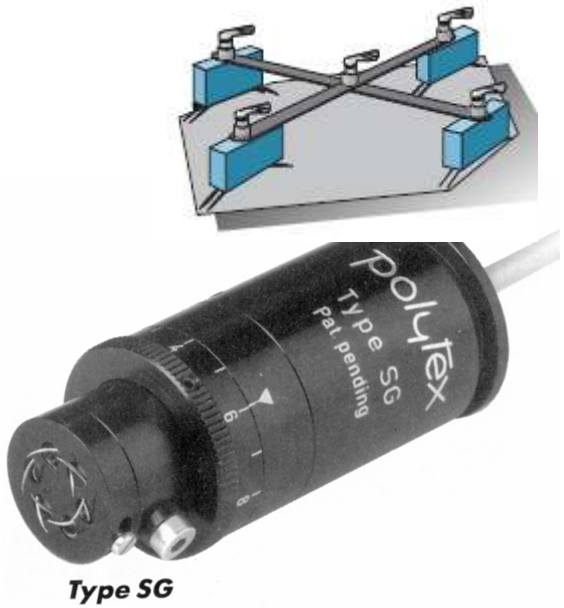






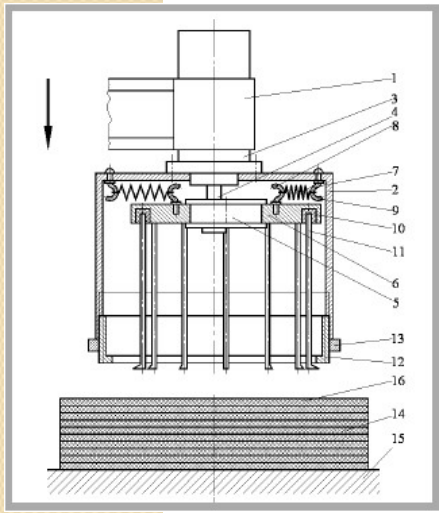
Mechanical grippers - Needles

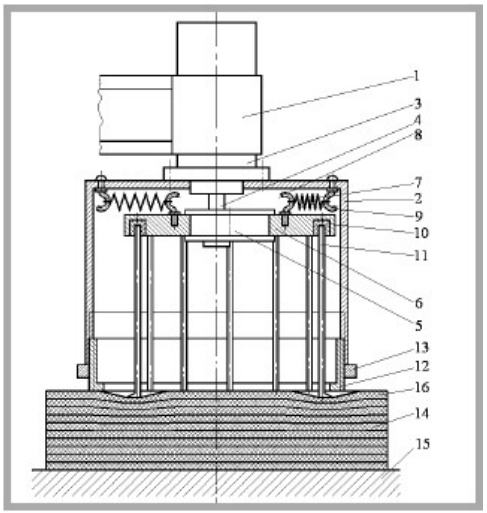


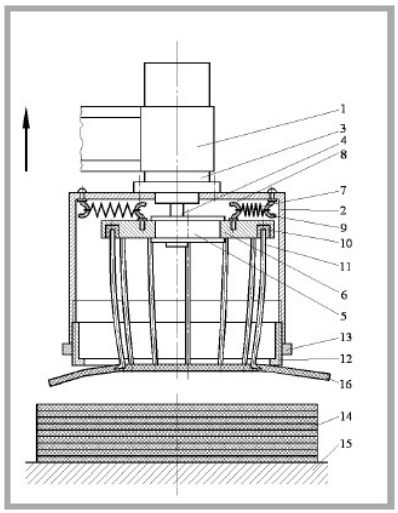


Type SG

http://www.techno-sommer.com





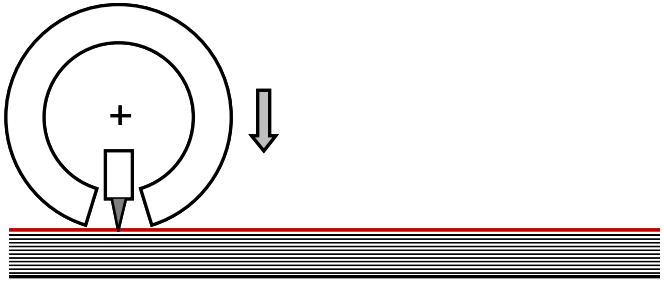


- Flexible needles

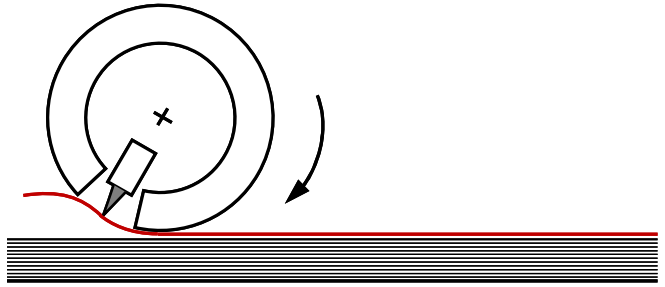
Kondratas A. *Robotic Gripping Device for Garment Handling Operations and Its Adaptive Control*.
FIBRES & TEXTILES in Eastern Europe October / December 2005, Vol. 13, No. 4 (52)

Mechanical grippers - Needles

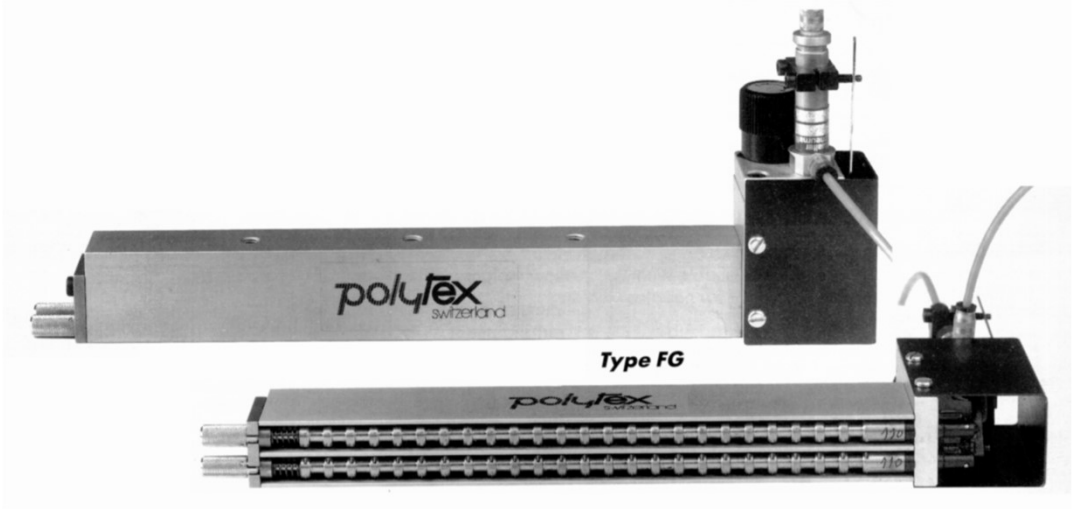
- **Roller principle**



The cylinder is hollow, inside there is a bar with needles



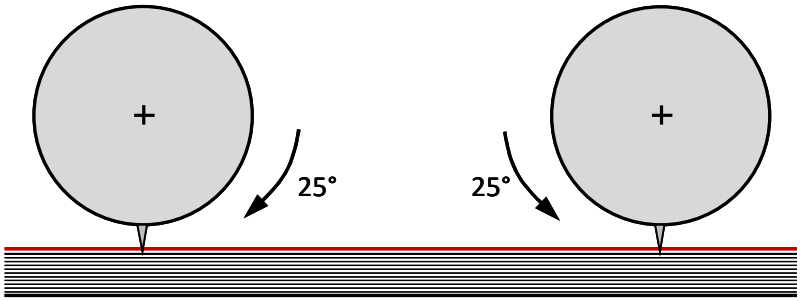
Rolling, in which the top layer of material is "picked up"



http://www.polytex.ch/pages/px_start.html

Mechanical grippers - Needles

- **Two - roller principle**

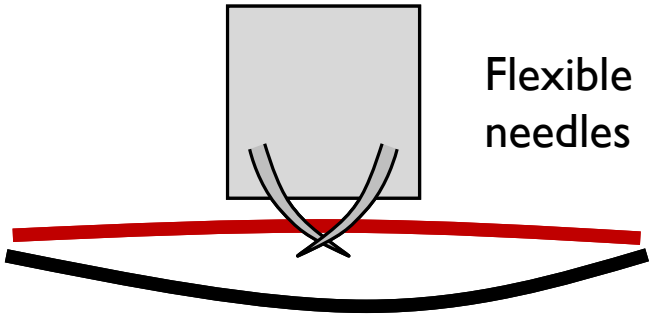


Rollers with needles

the needles are inserted into the top layer of material

Rollers rotate by 25 °

and lift

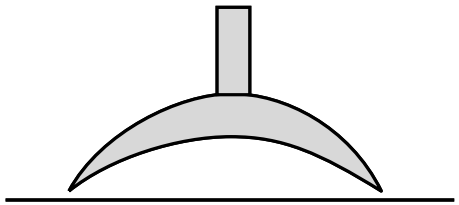


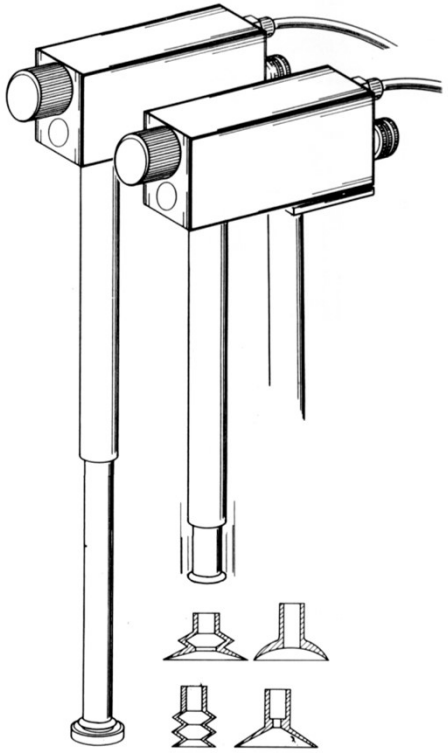
Compressed air is supplied, which blows off the bottom layer of material

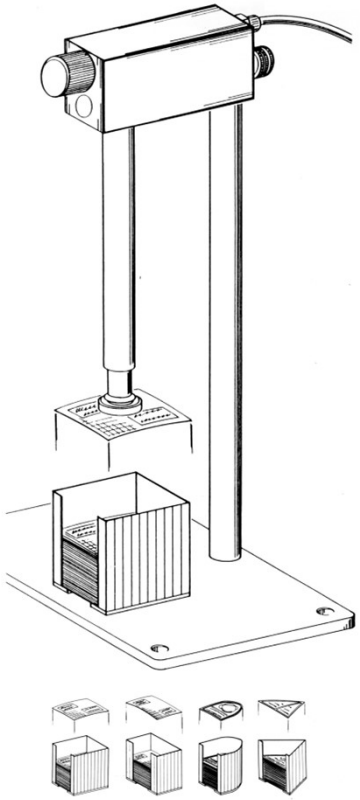
Pneumatic grippers

Very easy to use

- **Rubber sucker**
  - Limitation given by material permeability
  - Use on airtight materials (leatherette, tent tents, rubberized materials, etc.)
  - Rubber – simple
  - Pneumatic - cheap
  - Passive head
    – constant gripping force

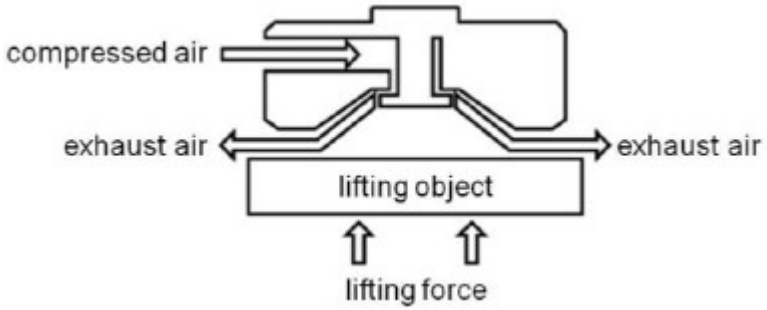






Pneumatic grippers

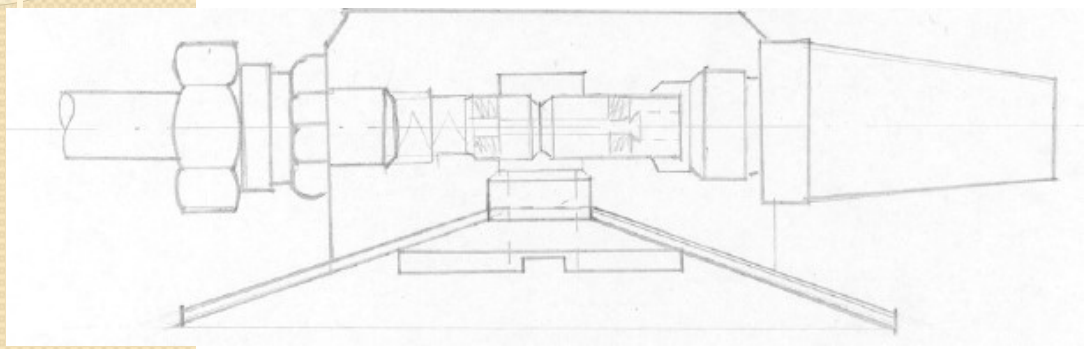
- **Ejectors**
  - Active effectors
  - Easy control of gripping force
  - Also used as a group of warheads
  - The basic principle of operation - the flow of compressed air through the ejector
  - Venturi tube ⇒ Bernoulli's equation principle

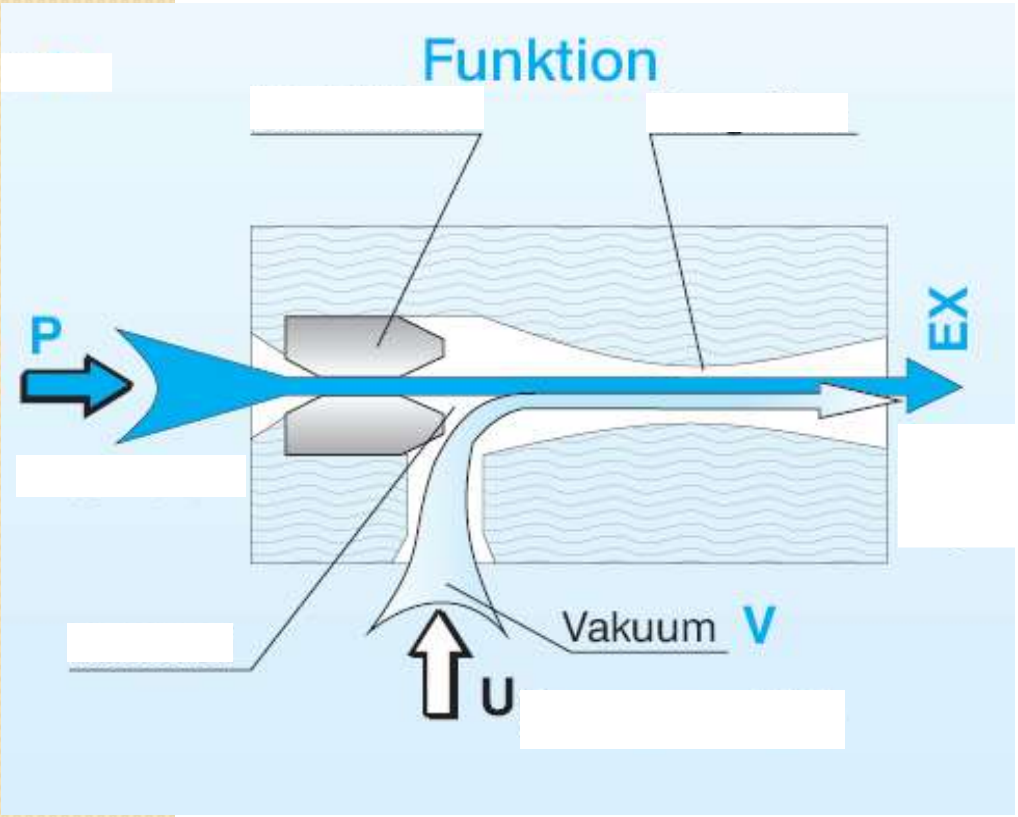


Stühm, K. & others. (2014). A Novel *Gripper for Battery Electrodes based on the Bernoulli-principle with Integrated Exhaust Air Compensation*. Procedia CIRP. 23. 10.1016/j.procir.2014.10.065.

Rossella. *Taking fabrics, felts or paddings. Bernoulli!* [online]. VacuumDaily.net. Available from: https://www.vacuumdaily.net/2015/09/taking-fabrics-felts-or-paddings-bernoulli/

Ejector principle



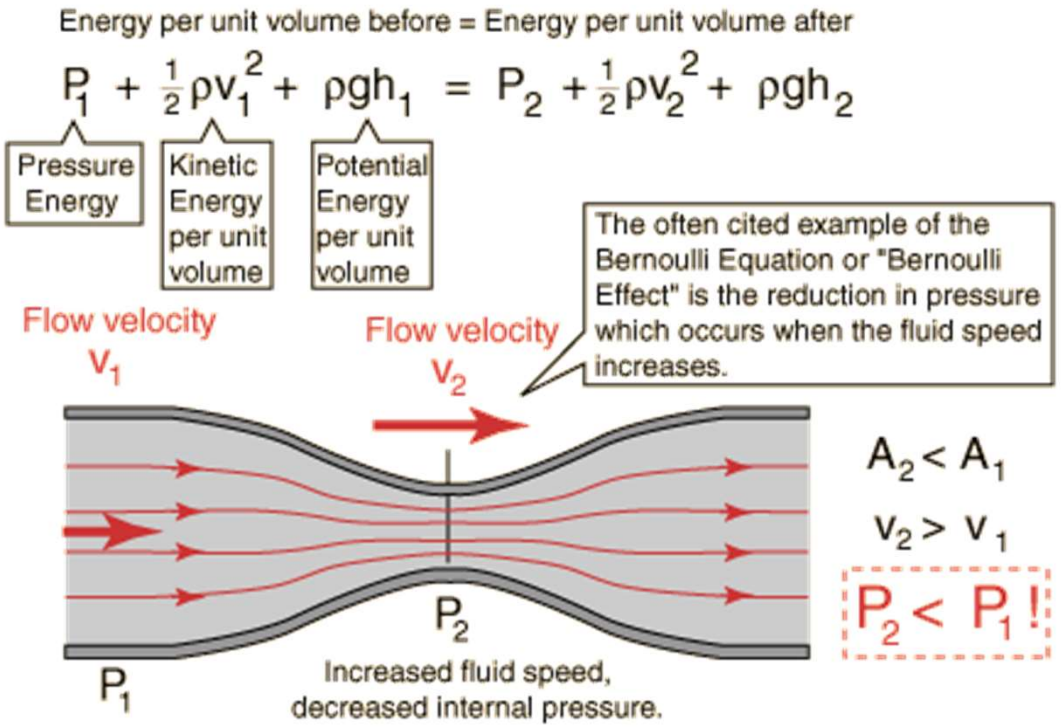


- **The Venturi tube** works on the basis of **Bernoulli´s equation** (expresses the **law of conservation of energy** for the flow of an ideal fluid in a horizontal pipe.)

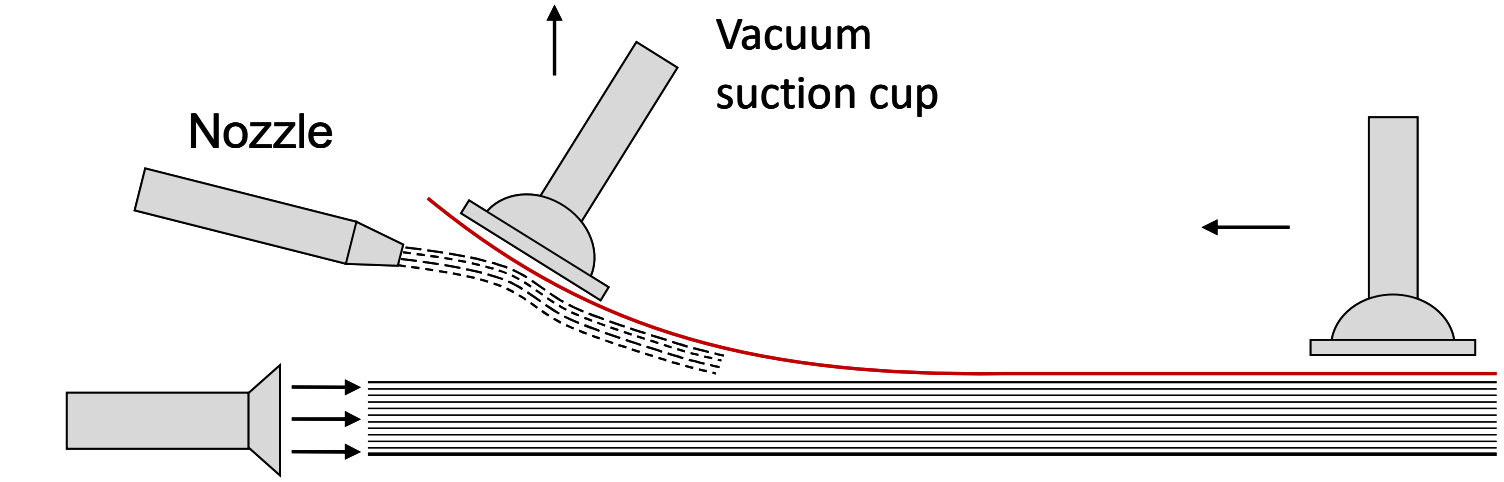
- the pressure of the flowing fluid decreases with increasing speed
- *The expression of the Bernoulli equation for gases is more complicated, because for gases their density changes very significantly with the change of pressure.*
- If the gas flows through the tube at a sufficient speed, the pressure at that point is reduced so much that it can be used, for example, **for suction**.
  This phenomenon is called **the hydrodynamic paradox**

Related concept → continuity equation

Ejector principle – Bernoulli´s equation

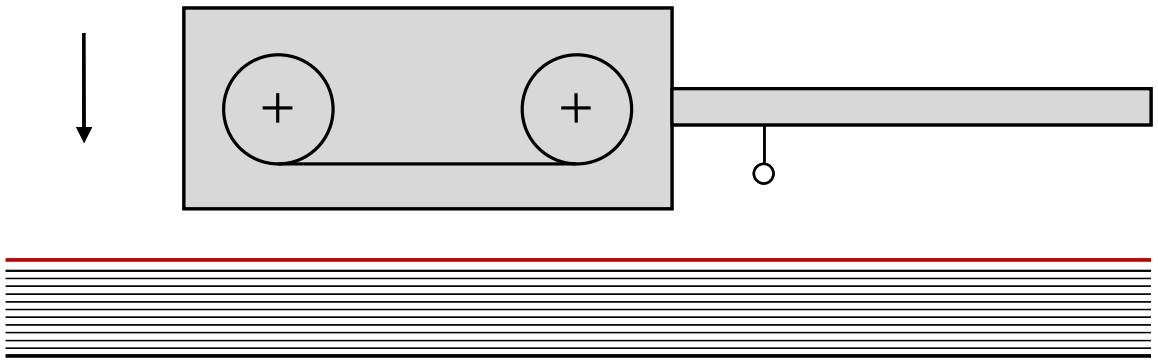


Pneumatic grippers



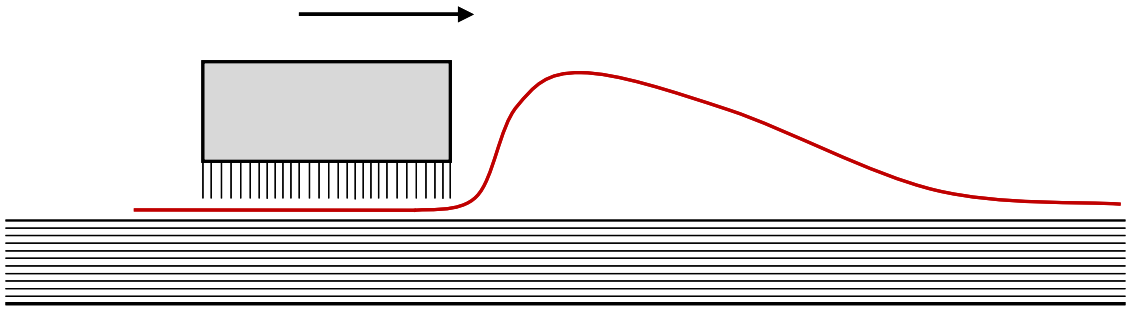
Adhesive grippers

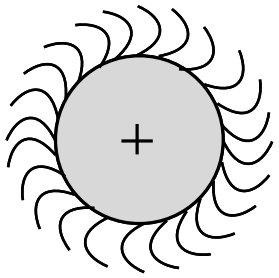
- The material is glued with adhesive tape
- Dropping is problematic, more strength is needed
- Advantage: very simple system
- Disadvantage: the gripping force cannot be removed at once
- Possibility to use adhesive rubber instead of adhesive tape



Frictional grippers

- The material is removed from the gripper with a brush
- Use specially alone or in combination with other heads





Electrostatic grippers

- Principle - The head charges the material for a short time and then drops it
- Efficiency - 100% of needle gripper
- They work - 100%
- PROBLÉM – (re)moving only one layer of material
- Measures:
  - Brushes on the sides
  - Small electromagnet
  - Steel pressure plate

VIDEO: https://www.youtube.com/watch?v=6jo13FCglXw

VIDEO: https://www.youtube.com/watch?v=I-MPrumjrRw