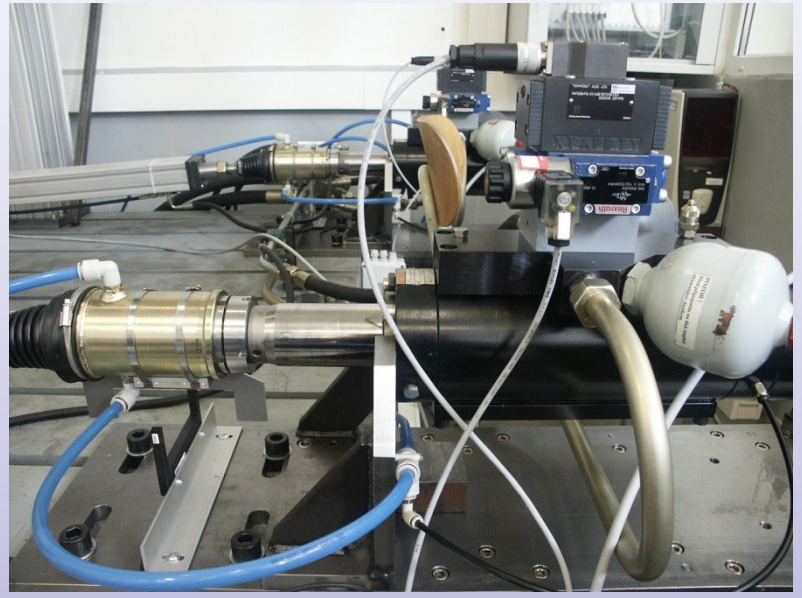
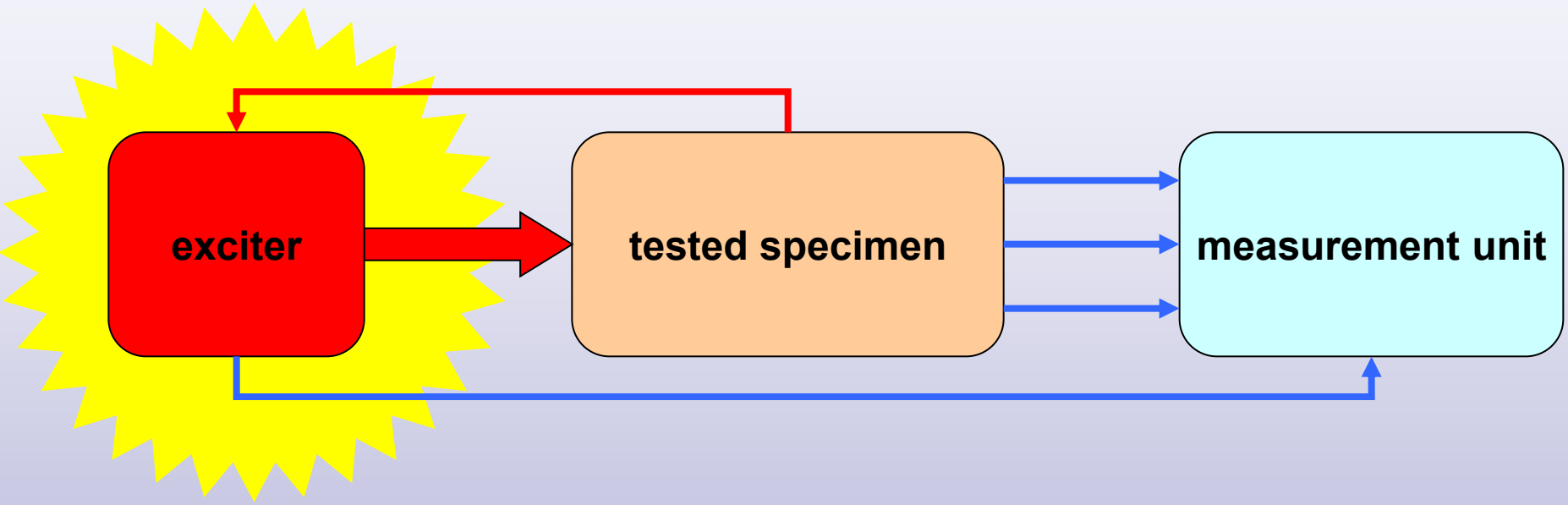
2. Exciters





exciter

- generates a load signal
- corrects load parameters by the feedback

1. CLASSIFICATION OF EXCITERS

- according to the deduced effect
  - linear loading
  - torque loading
  - vibrations
  - climatic effects

- according to the excitation duration
  - periodical excitation
  - one-off excitation

- according to the power supply of the exciter
  - mechanical
  - pneumatic
  - hydraulic
  - electric
  - operation of the tested subject

2. MECHANICAL EXCITERS

- to derive the load is used
  - gravity
  - springs
  - human strength

  or a combination thereof

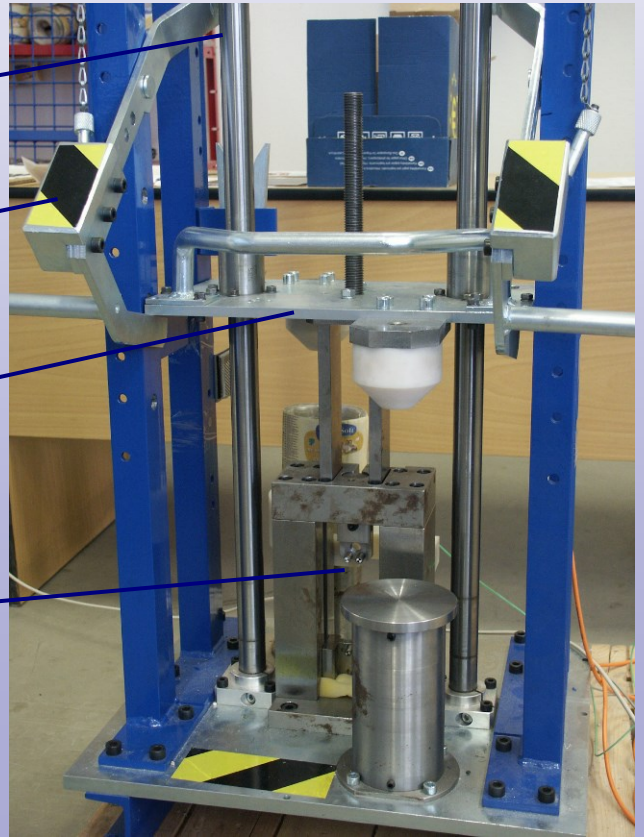
- fields of application
  - one-off tests
  - frequency (modal) analysis of the specimen

- advantages
  - simplicity
  - low price

- disadvantages
  - periodic excitation is not possible
  - human strength - poor repeatability and inaccuracy of load size

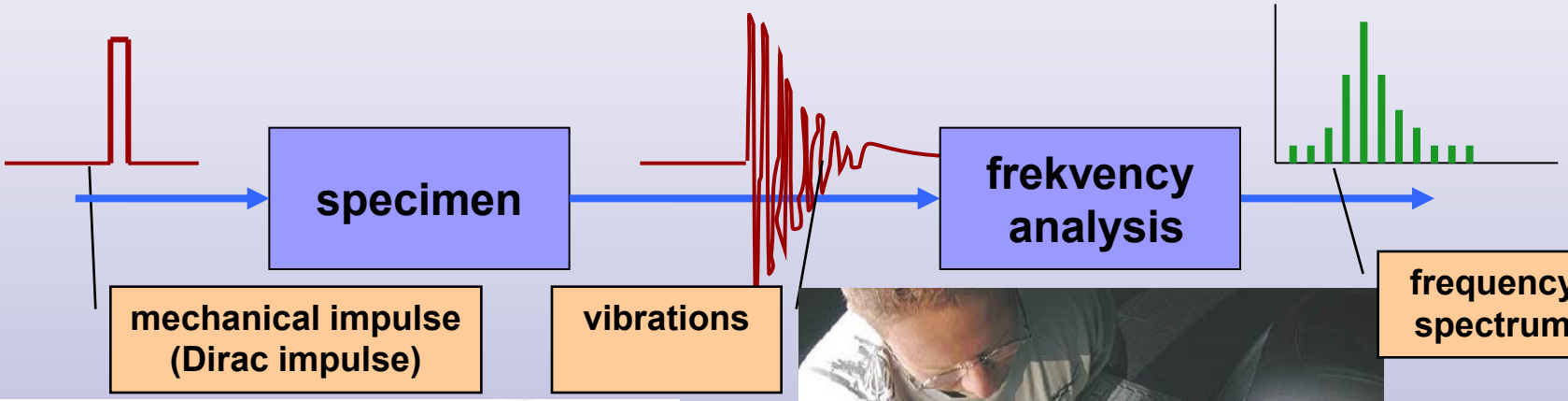
2. MECHANICAL EXCITERS

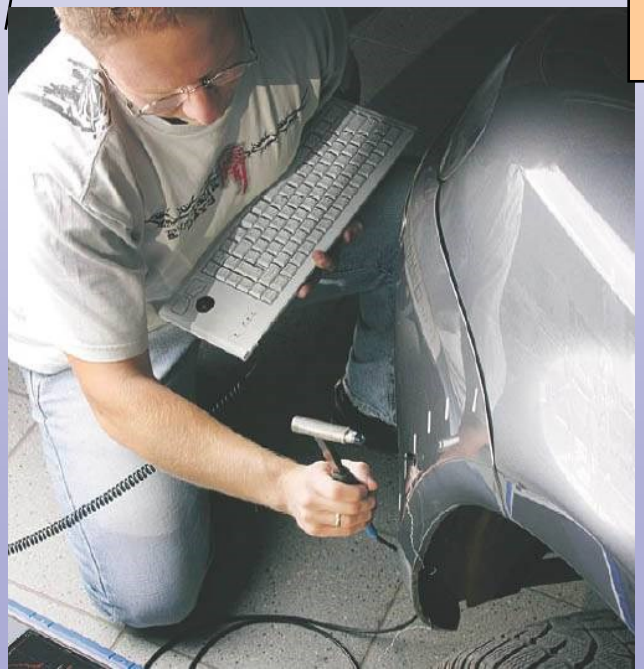
- gravity exciter:
  - one-off loading
  - the free fall of a matter is used
  - the speed is determined by the initial height
  - the impact energy is determined by the weight



2. MECHANICAL EXCITERS

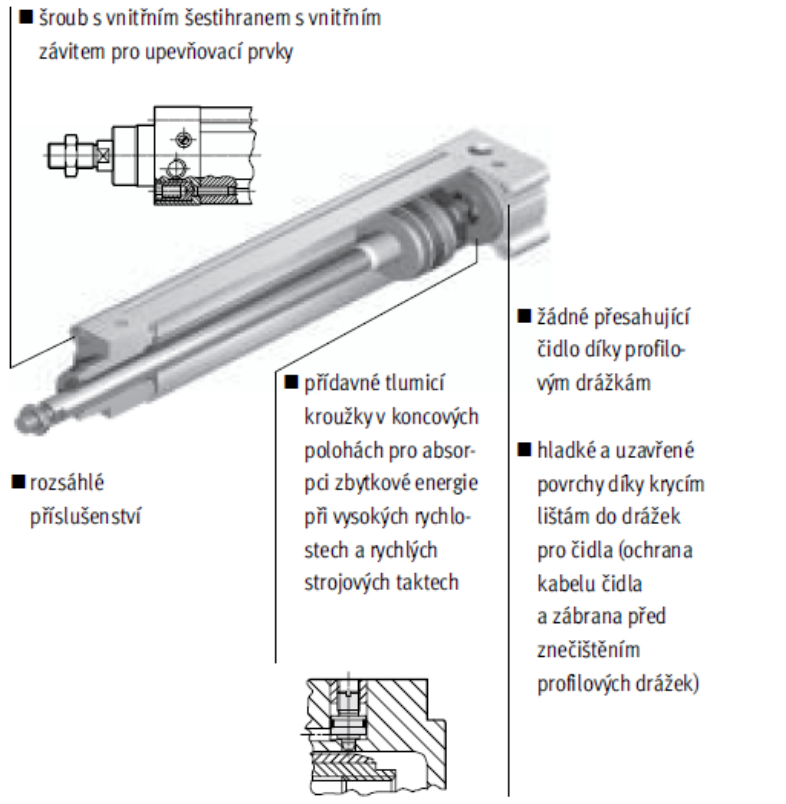
- frequency (modal) analysis of the specimen
  - impact hammer and human strength

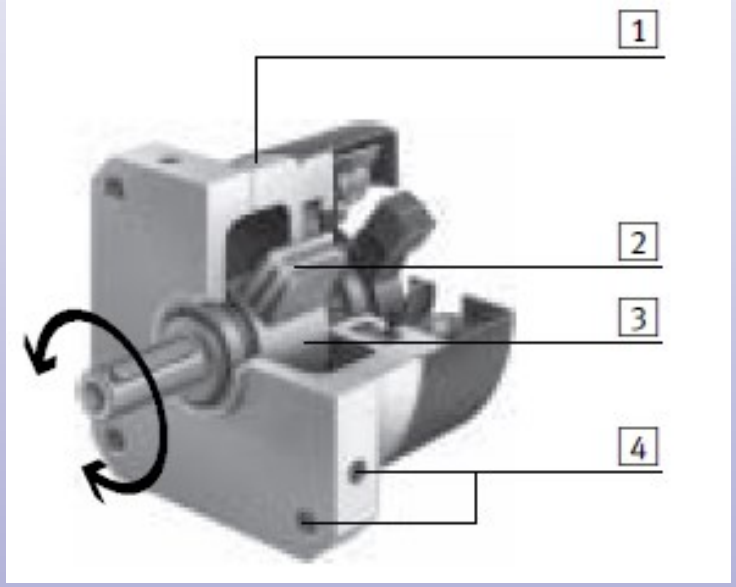




3. PNEUMATIC EXCITERS

- linear or rotary design = pneumatic cylinder or pneumatic engine
- the supply energy is a compressed air
  - force = air pressure x piston area
  - speed = air flow rate
  - big disadvantage - air is a compressible gas





3. PNEUMATIC EXCITERS

- **advantages:**
  - **low cost, many manufacturers and suppliers**
  - **linear or rotary design, wide range of types and designs**
  - **static loading is possible**
  - **environmentally friendly medium (air)**
  - **energy availability (compressed air is available in an industry)**
  - **simplicity of connection, easy installation (hoses, quick couplings)**
  - **suitable for use in the construction of single-purpose test equipments**

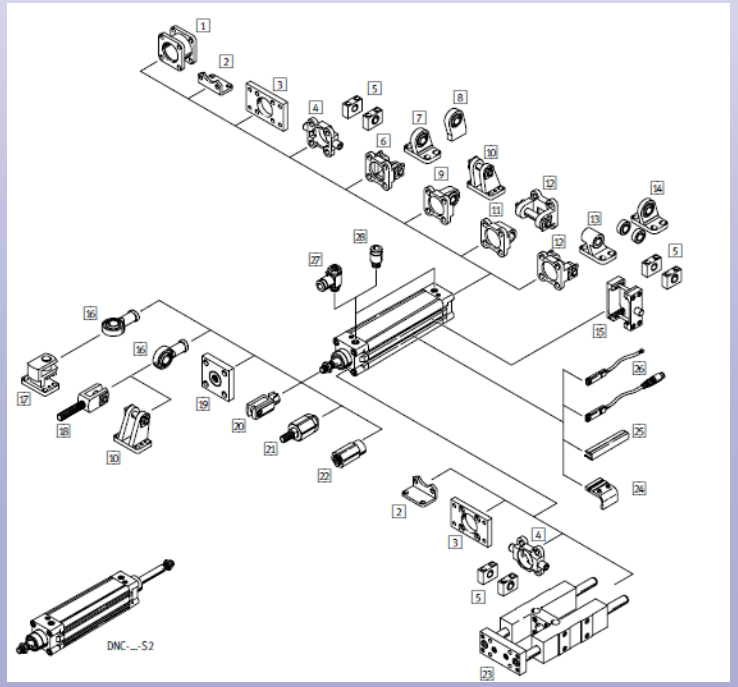
- **disadvantages:**
  - **air is a compressible gas - great influence of external load on position and speed**
  - **a large piston area is needed for large forces because air pressure is limited, the standard value is used in industry (6 or 10 atmospheres)**

3. PNEUMATIC EXCITERS

fields of application

- **single-purpose simple test equipment**
- **tests with a large number of cycles without the need to define the exact course**

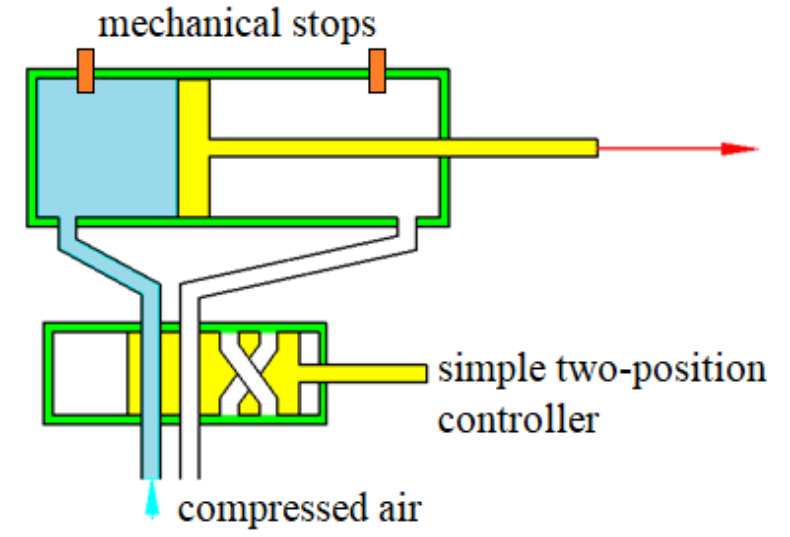
- **ease of use, wide range of components**
- **it's like a kit**



3. PNEUMATIC EXCITERS

- **control options**

  1) no automatic feedback

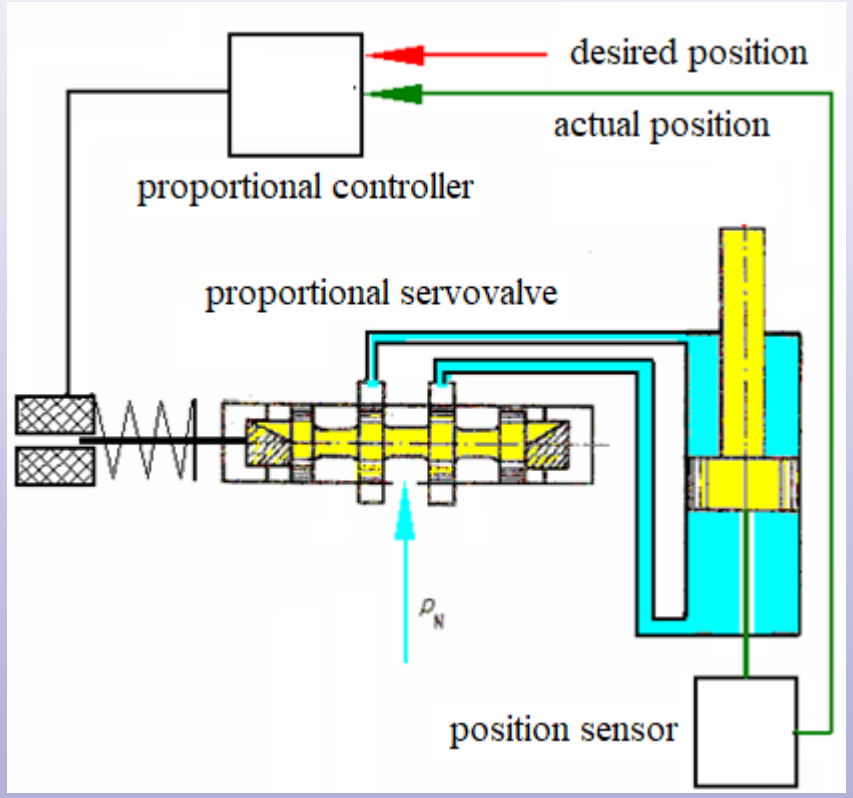


- **gas compressibility generates disadvantages:**
  - **impossible position control**
    end positions can be defined only by mechanical stops
  - **the exact speed of movement cannot be defined**
    the movement speed is affected by the action of external forces to the piston
  - **the end position can be changed by an external force**

3. PNEUMATIC EXCITERS

- control options

2) proportional feedback control

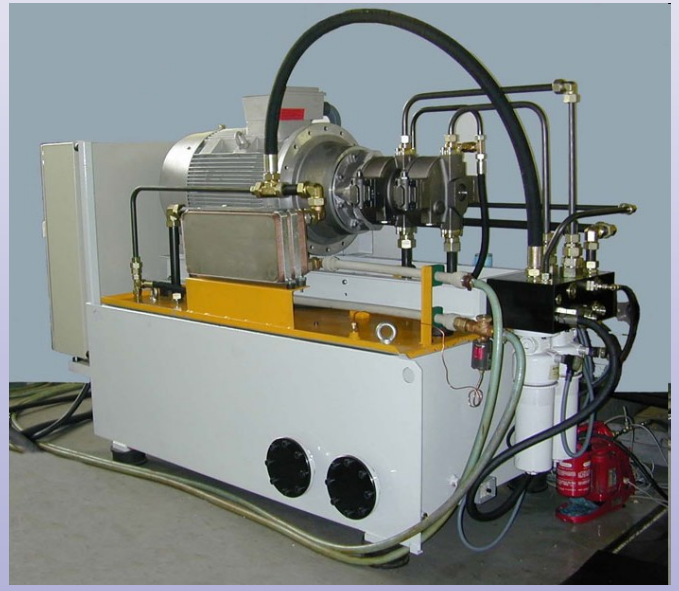


- not very widespread
- practically non-manufacturable very precise and very speed servovalve and the disadvantages of air compressibility prevent real use

- gas compressibility generates disadvantages:
  - difficult to maintain the desired position
    the position and the the movement coursecan be changed by an external force

4. HYDRAULIC EXCITERS

- linear or rotary design = hydraulic cylinder or hydraulic engine
- the supply energy is a hydraulic pressure fluid (oil)
  - force = fluid pressure x piston area
  - speed = fluid flow rate
  - big advantage - the fluid is practically incompressible



4. HYDRAULIC EXCITERS

- **advantages:**
  - **linear or rotary design**
  - **static loading is possible**
  - **high forces, high speed and great dynamics at small dimensions (high fluid pressure is used)**
  - **the fluid is practically incompressible precise control, any control signal waveforms can be used**

- **disadvantages:**
  - **high price, limited number of manufacturers and suppliers**
  - **environmentally unfriendly medium (oil)**
  - **a special source of pressure fluid (hydraulic aggregate) is needed (it is not commonly available in an industry)**
  - **the hydraulic aggregate consumes a lot of energy for its operation**
  - **difficult assembly and handling, high pressure components must be used**
  - **difficult piston rod sealing, possible oil leaks**

4. HYDRAULIC EXCITERS

fields of application

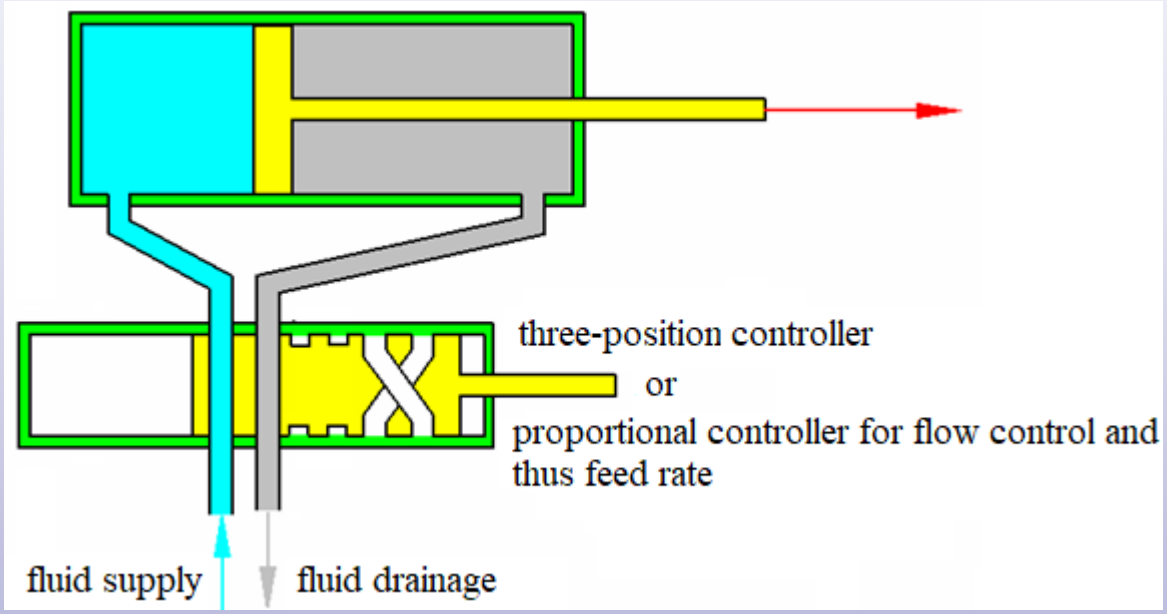
- **test equipments**
  - **with the possibility of deriving loads with any course**
  - **for high forces (hundreds of kN) and high speeds (tens of ms-1)**
  - **high load and high frequency (hundreds of Hz) shakers**

- **hydraulic aggregate power and limited oil flow through the piping define the maximum values**

4. HYDRAULIC EXCITERS

- **control options**

  1) no automatic feedback (feedback is on the operator's side)

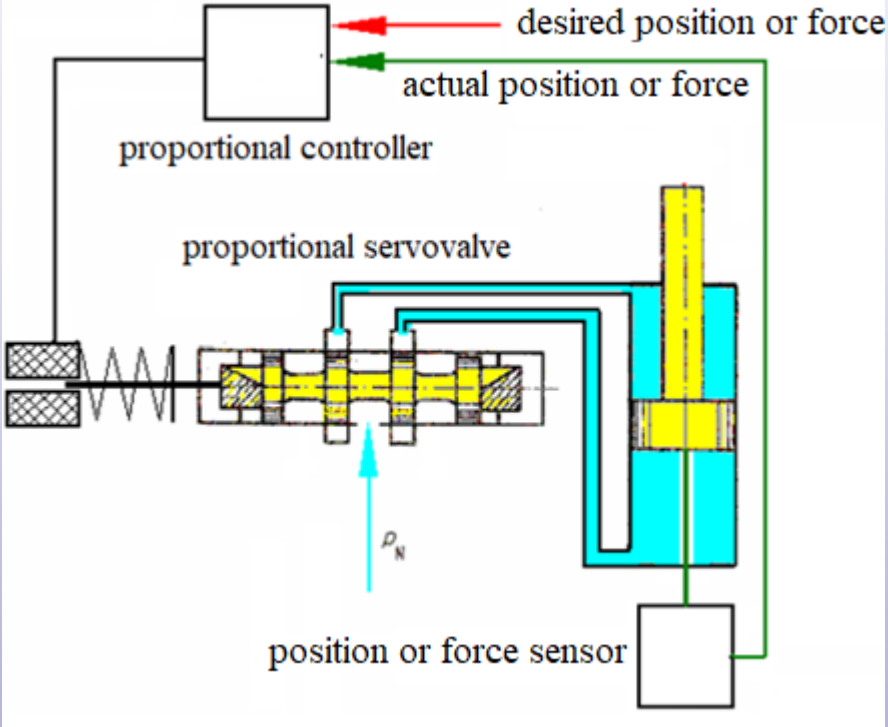


- **practically incompressible fluid:**
  - **precisely defined and stable position**
  - **the exact speed of movement can be defined by flow control**
  - **the position cannot be changed by external force**

4. HYDRAULIC EXCITERS

- control options

  2) proportional feedback control

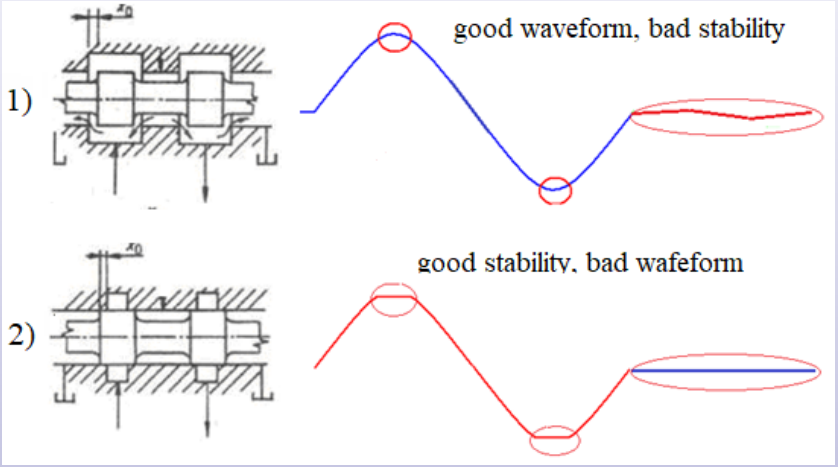


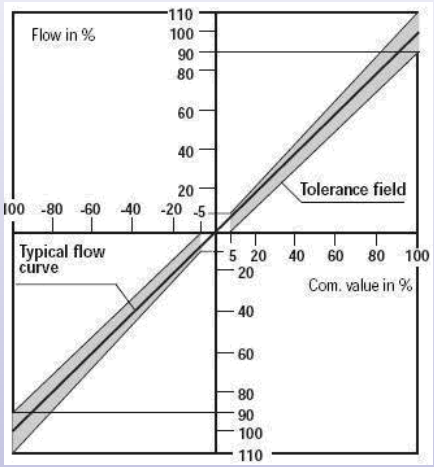
- commonly used control
- the proportional servovalve is the most important part of the control system, its properties (accuracy and speed) define the properties of the whole system
- the control can be in positional or force feedback

- practically incompressible fluid:
  - precisely defined signal waveform (position or force)
  - the position cannot be changed by external force

4. HYDRAULIC EXCITERS

- **servovalve properties**
  - **the accuracy of the servovalve piston edges affect the control accuracy and the stability of the desired value**





1) the servovalve with uncovered edges

there is no zero flow position

the hydraulic engine piston constant position is not possible without feedback operation

the engine piston moves uncontrollably in the event of a feedback control fault

2) the servovalve with overlaped edges

there is a position with zero flow, a constant position of the piston is well possible

the flow is stopped when the direction of movement is changed (the movement of the wide piston takes some time)

the waveform cannot be accurate

5. ELECTRIC EXCITERS

- types of electric exciters
  - electric motors
  - actuators
  - electrodynamic exciters

5. ELECTRIC EXCITERS

- electric motors
- advantages:
  - low cost, many manufacturers and suppliers
  - large number of types and designs (AC asynchronous, DC, stepper)
  - energy availability
  - high efficiency
  - simplicity of connection, easy installation
  - simple control, high control precision
  - suitable for use in the construction of single-purpose test devices

- disadvantages:
  - rotary motion only
  - torque characteristic depends on motor type and speed

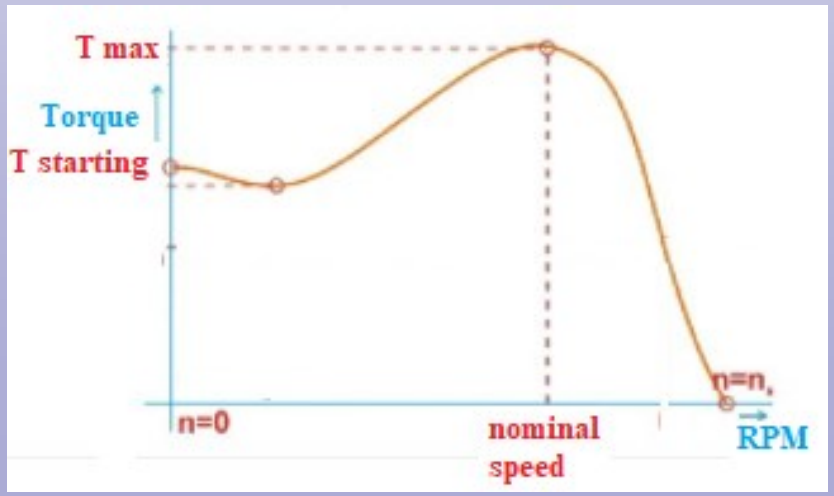
5. ELECTRIC EXCITERS

- electric motors

- AC asynchronous motors

  advantages
  - in the simplest case can be used without any control unit, can be connected directly to the mains
  - simple speed control by frequency converter
  - high dynamics

  disadvantages
  - low starting torque
  - rapid torque drop above nominal speed
  - cannot operate in static mode (without shaft rotation) or at very low speeds
  - precise positioning within one shaft revolution is not possible



5. ELECTRIC EXCITERS

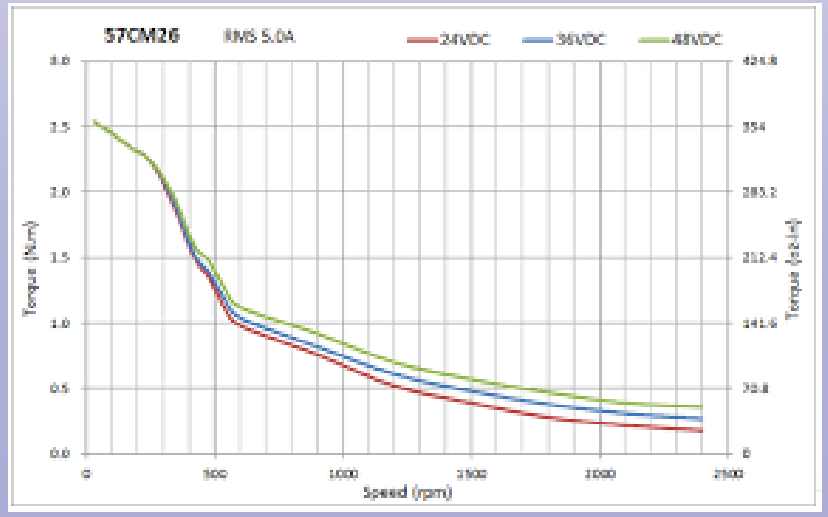
- electric motors
- Stepper motors

advantages

- simple speed control by electronic control unit
- can operate in static mode (without shaft rotation) or at very low speeds
- precise positioning within one shaft revolution is possible - each input pulse causes the shaft to rotate by a defined angle, i.e. a motor "step"

disadvantages

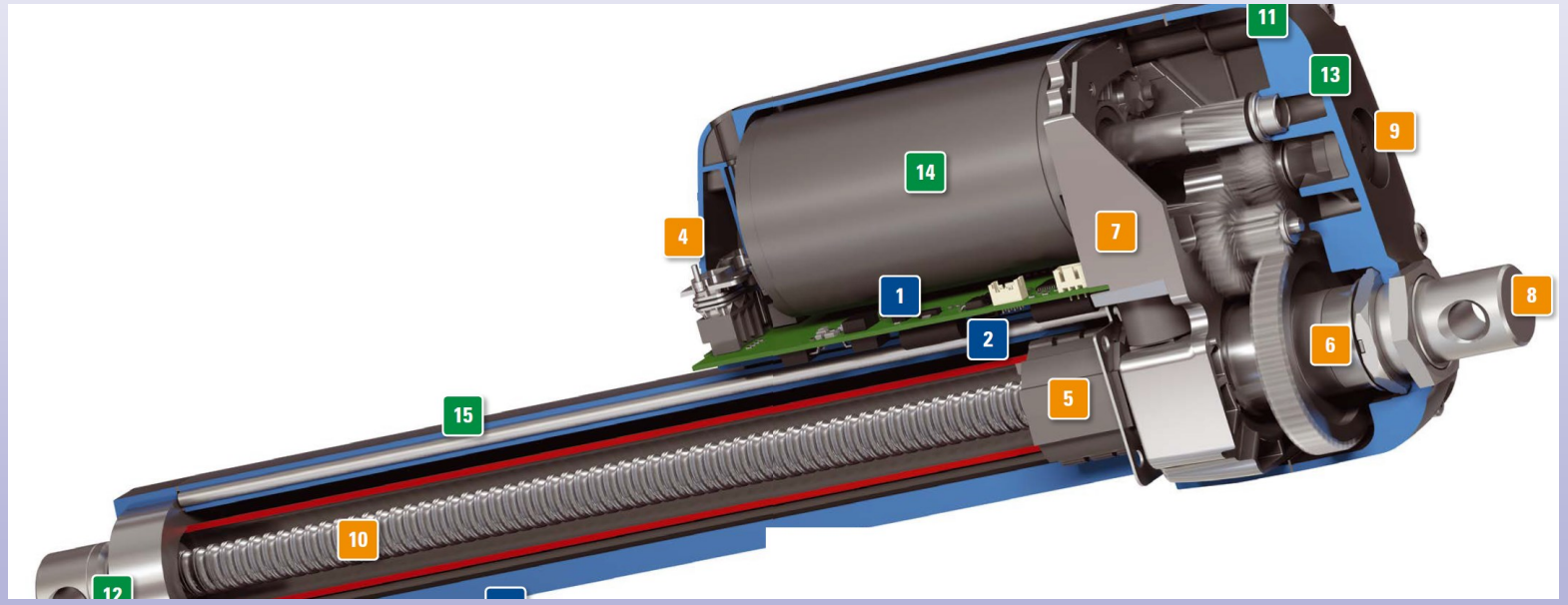
- torque decreases rapidly with speed
- lower dynamics, with rapid (step) speed changes the synchronization of shaft position and input pulses is broken - "loss of step"
- cannot operate without electronic control unit



5. ELECTRIC EXCITERS

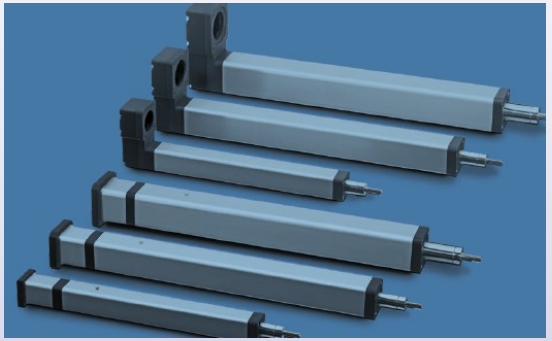
- actuators

- actuator = electric motor + gearbox + motion screw for linear motion



5. ELECTRIC EXCITERS

- actuators
- modern replacement for hydraulic exciters
  - strokes up to approximately 1 m
  - forces up to several tens of kN
  - speeds up to approximately 10 ms^{-1}



- advantages:
  - low cost, many manufacturers and suppliers
  - large number of types and designs (AC asynchronous, DC, stepper)
  - energy availability
  - high efficiency
  - simplicity of connection, easy installation
  - simple control, high control precision
  - they can be very resistant to external conditions and extreme temperatures
  - suitable for use in the construction of single-purpose devices

5. ELECTRIC EXCITERS

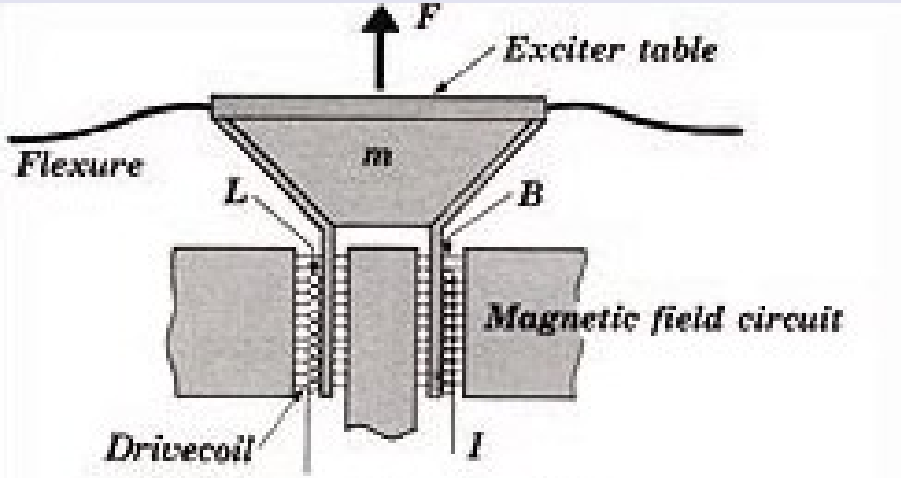
- actuators

- the characteristics of the actuator depend on the type of engine and gearbox used
- actuators with AC or DC motor
  - require a built-in position sensor and position feedback controller to achieve the desired position
- actuators with stepper motor
  - can be controlled without feedback
  - do not need a position sensor
  - the desired position is determined by the number of input pulses
  - there is a risk of positioning error if the motor loses steps
    - unauthorised large speed changes or exceeding the torque limit

- classic gearbox
  - failure to hold position after power or control switching off
- self-locking gearbox
  - holding position after switching off

5. ELECTRIC EXCITERS

- electrodynamic exciters
- single-purpose device - vibration exciter
  - basically it is a large speaker
  - the vibrating table is excited by a set of coils and permanent magnets



$F = BIL$ — F = force [N], B = magnetic flux intensity [T], I = current [A], L = length [m]

$F = ma$ — m = mass [kg], a = acceleration [m/s²]

5. ELECTRIC EXCITERS

- electrodynamic exciters

- Advantages:
  - high excitation frequencies even for high forces
  - compact device (exciter table and power and control system)
  - arbitrary excitation signals (harmonic, random, real)

- Disadvantages:
  - linear movement only
  - small deflections
  - limited number of suppliers, unfavourable price

9N, 2-18000 Hz

200kN, 5-2000Hz

6. CLIMATIC CHAMBERS

- adjustable conditions
  - temperature
  - humidity
  - ultraviolet radiation
  - most climate chambers allow combinations of these

- testing the effect of climatic conditions
  - on the service life of parts - corrosion, paint resistance, etc.
  - on mechanical properties of parts (plastics, composites) at extreme temperatures
  - to determine and compare the thermal expansion of parts made of different materials

- testing of parts directly in the climate chamber for smaller parts
- use of external boxes for large parts or when mechanical and climatic stresses are combined

6. CLIMATIC CHAMBERS

- the usual ranges
  - positive temperature up to 200 °C
  - negative temperature
    - compressor chambers (refrigerator principle) -40 °C for single compressor systems and -70 °C for twin compressor systems
      + only electricity is needed
      - lower temperature range
    - liquid nitrogen cooled chambers for very low temperatures (-195.76 °C)
      + very low temperatures
      - only smaller chambers for smaller specimens
        purchase of liquid nitrogen required - costly operation
  - humidity 10 - 98% for temperature range 10-95 °C
- control options
  - simple operation
    - setting and maintaining one temperature and humidity value
  - programming of temperature and humidity cycles
    - long-term automatic tests under changing climatic conditions

Exam questions

- classification of exciters
  - according to the deduced effect (p. 3)
  - according to the excitation duration (p. 3)
  - according to the power supply of the exciter (p. 3)
- mechanical exciters
  - operation principles, field of application, advantages and disadvantages (p. 4)
- pneumatic exciters
  - operation principles, field of application, advantages and disadvantages (p. 7, 8)
  - control options (p. 10, 11)
- hydraulic exciters
  - operation principles, field of application, advantages and disadvantages (p. 12, 13)
  - control options (p. 15, 16)
- electric exciters
  - types of electric exciters (p. 18)
  - electric motors, types, operation principles, advantages and disadvantages (p. 19 - 21)
  - actuators, what is it (p. 22), field of application, advantages, properties according to the type of engine and gearbox (p. 23, 24)
  - electrodynamic exciters, operation principles, advantages and disadvantages (p. 25, 26)
- climatic chambers
  - application possibilities, two cooling principles (p. 27, 28)