Pneumatics - introduction

Automation of apparel production

Advantages and Disadvantages of Pneumatic system

- Advantages:
  - **infinite source -** medium (atmospheric air) is available in the world around us in unlimited quantities at all times and places
  - **Clean** - the leakage of compressed air does not pollute the surroundings, the machine itself or the material being processed
  - **Safe** – the air is not flammable and does not short-circuit or explode
  - **Temperature is flexible** - Air can be used flexibly at various temperatures required (even in quite extreme conditions, the air was still able to work)
  - **Easy channelled – air is quickly passed or moved from one place to another through a small, long, and winding pipe**. Without feedback (back into the atmosphere)

- The possibility of using **central compressed air production** in the company
- The **transfer of power and speed** is very easy to set up and smooth
- A pneumatic system is **easy to maintain** and easy **to use**.
- possibility of **implementation into automatic work cycles**
- the compressor does not have to run continuously (**compressed air can be accumulated** in a pressure vessel and transported)

Disadvantages:

- high air compressibility - uniform piston movement and constant parameters cannot be achieved; therefore, it cannot be used for die cutting)
- Requires installation of **air-producing equipment** – compressed air should be **dry**, **clean** and contain the necessary **lubricant** for pneumatic equipment (against excessive wear and tear)
- **Easy to leak** - we need a seal so that air does not leak; Seal leakage can cause **energy loss**
- **Easy condenses** – before entering the system, must be processed first to dry, have enough pressure, and contain a small amount of lubricant to reduce friction in the valves and actuators

- **Potential noise** - Pneumatic using an open system, meaning that the air that has been used will be thrown out of the system; the air comes out loud and noisy so that it will cause noise, especially on the exhaust tract. The fix is to put a **silencer** on each dump line.
- Sensitive in **vibration**
- Compressed air is **more expensive** than electricity

After knowing the advantages and disadvantages of using compressed air, we can anticipate that these losses can be avoided.

IDEAL GAS LAW

- The **ideal gas law**, also called the **general gas equation**, is the equation of state of a hypothetical ideal gas:

$$\boldsymbol{p \cdot V = n \cdot R \cdot T}$$

where:

$$n = \frac{m[kg]}{M[kg \cdot mol^{-1}]}$$

- *p – **pressure** of the gas* [Pa]
- *V – **volume** of the gas* [m^3]
- *n – **amount of substance** of gas (number of moles)* [mol]
- *R – ideal or universal **gas constant*** [$J.mol^{-1}.K^{-1}$]
- *T – absolute **temperature** of gas* [K]

- It is a good approximation of the behaviour of many gases under many conditions, although it has several limitations.

IDEAL GAS LAWS

Many technically applicable processes take place in such a way that some of the thermodynamic quantities remain constant during the process

Constant quantity	**Name of the process**
Temperature	Isothermal process
Pressure	Isobaric process
Volume	Isochoric process
Heat	Adiabatic process
Entropy	Isentropic process
Enthalpy	Isenthalpic process

IDEAL GAS LAWS

- **BOYLE – MARIOTTE LAW**

  ISOTHERMAL PROCESS

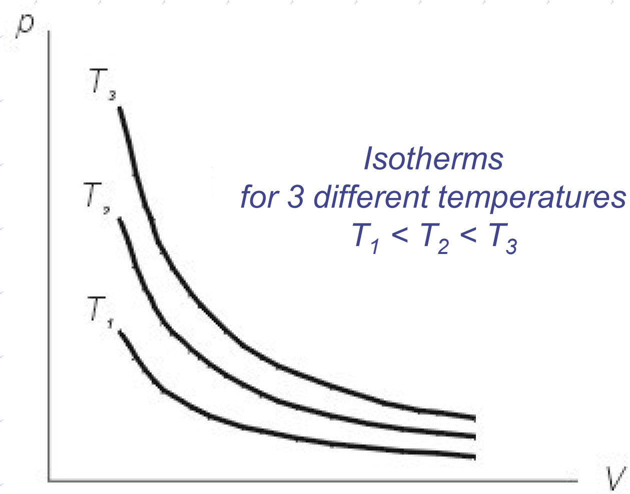
„The absolute pressure exerted by a given mass of an ideal gas is inversely proportional to the volume it occupies if the temperature and amount of gas remain unchanged within a closed system.“

- Law can be stated:

$$T_1 = T_2 = constant$$

$$p_1.V_1 = p_2.V_2 = p_3.V_3 = constatnt$$

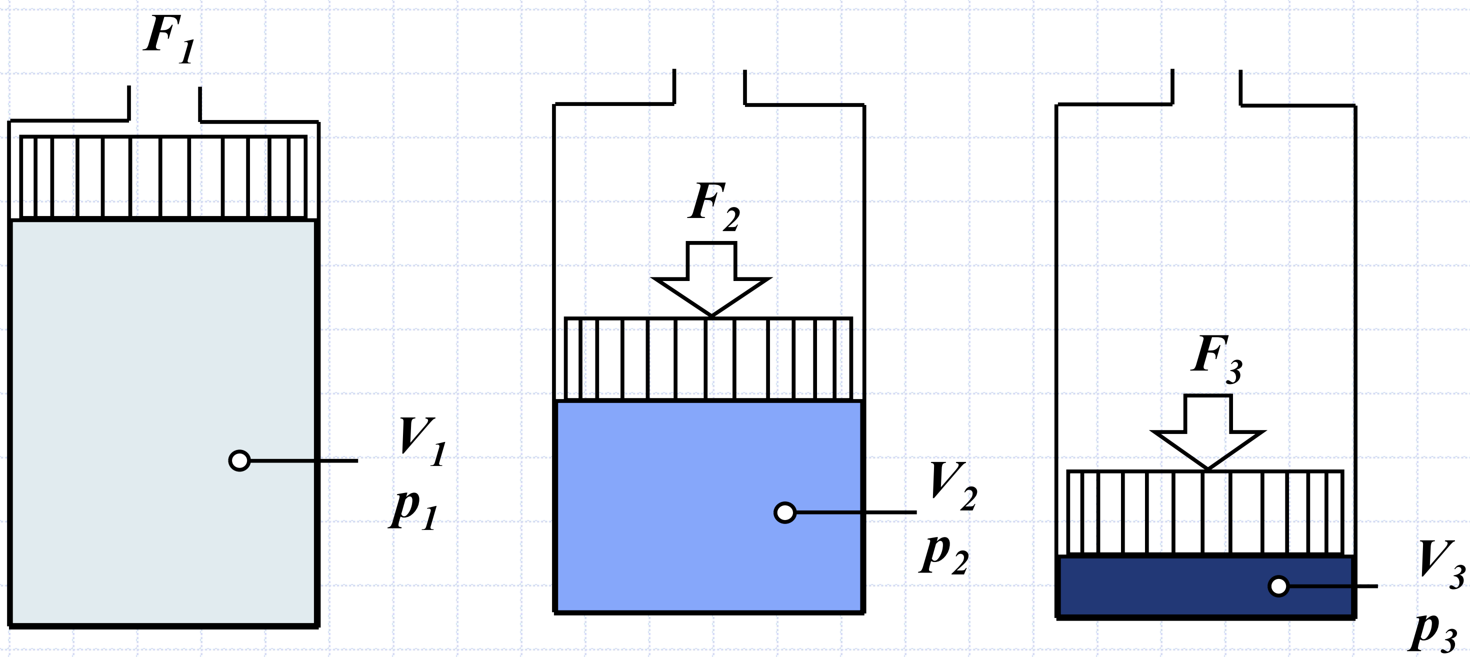
The dependence of pressure on gas volume is graphically expressed by the isotherm:



Isotherms for 3 different temperatures $T_1 < T_2 < T_3$

IDEAL GAS LAWS

- When the air is gradually compressed, the product of pressure and volume is the same in all cases. The volume decreases, and the pressure increases.



IDEAL GAS LAWS

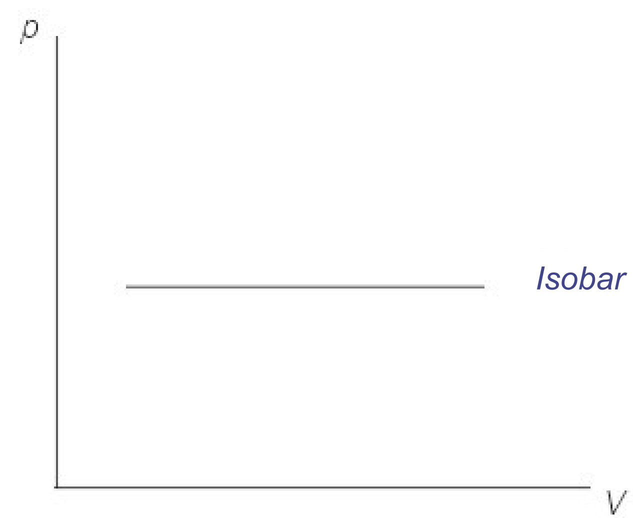
◆ GAY-LUSSAC´S LAW

ISOBARIC PROCESS

Gay-Lussac’s isobaric law states that by heating a gas at a constant pressure you cause an increase in its volume and this increase.

$$p_1 = p_2 = constant$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} = constant$$



The dependence of pressure on gas volume is graphically expressed by the **isobar**

IDEAL GAS LAWS

- **CHARLES´ LAW**

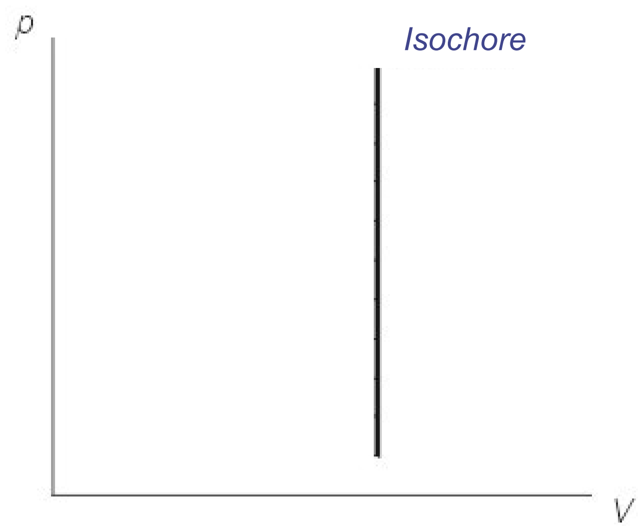
ISOCHORIC PROCESS

A thermodynamic process during which the volume of the closed system remains constant. According to the ideal gas law, pressure varies linearly with temperature.

$$V_1 = V_2 = constant$$

$$\frac{p_1}{T_1} = \frac{p_2}{T_2} = constant$$

The dependence of pressure on gas volume is graphically expressed by **isochore**



IDEAL GAS LAWS

- ADIABATIC PROCESS

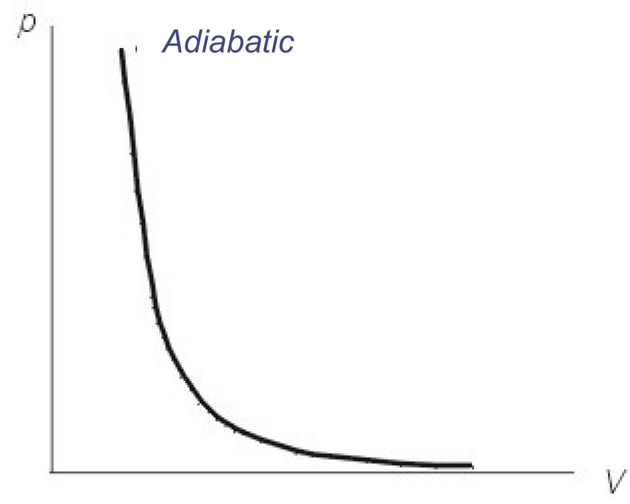
A type of thermodynamic process that occurs without transferring heat or mass between the thermodynamic system and its environment.

The adiabatic process is such a process that takes place so quickly that the exchange of heat with the environment is not enough.

However, both temperature and pressure, respectively volume, can change during a single run.

$$Q = 0$$

The dependence of pressure on gas volume is graphically expressed by the **adiabatic** curve:



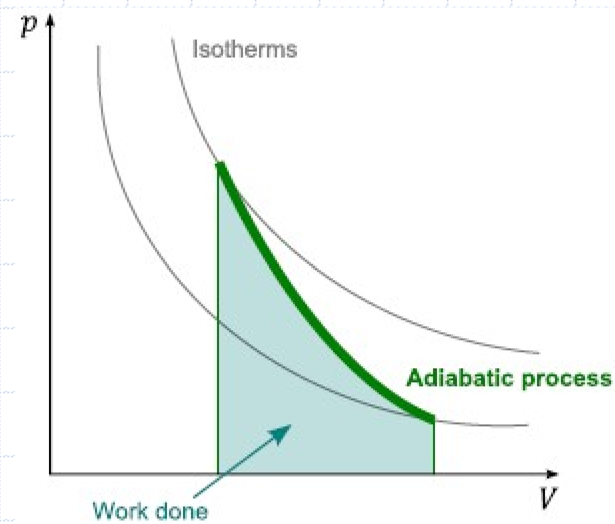
- **POISSON LAW**

$$p \, . \, V^{\kappa} = \text{konst.}$$

The exponent κ is called the **Poisson's constant** and its value is equal to:

$$\kappa = c_p / c_V,$$

where
c_p is the specific heat capacity at constant pressure,
c_V is the specific heat capacity at constant volume.



Examples of thermodynamic processes

- What air volume must we take from the atmosphere to obtain compressed air with a pressure of 2 bar with a volume of 0.5 cubic meters? Consider an isothermal process; atmospheric pressure is 1 bar.

- The closed container contains air with a temperature of 20 °C and a pressure of 3 bar. How does the pressure in the container change when the temperature rises by 20 °C?

- How does the volume of air in the piston change if it heats up from 20 °C to 50 °C? The current volume of air in the piston is 0.5 cubic meters.

AIR PRESSURE

- **Pressure** is the amount of force applied at right angles to the surface of an object per unit area:

$$p = \frac{F}{S}$$

where

p - **pressure** [Pa]

F – magnitude of normal **force** [N]

S - **area** of the surface on contact [m^2]

The SI unit for pressure is the **pascal** [Pa] (one newton per square metre)

$$Pa = \frac{N}{m^2}$$

AIR PRESSURE

Presently or formerly popular pressure units:

a) Atmosphere – absolute pressure in the technical system

$$1at = \frac{1kp}{cm^2} = 0{,}981bar$$

b) bar $$1bar = \frac{10^5 N}{m^2} = 10^5 Pa = 1{,}02at$$

c) Torr $$1Torr = \frac{1}{736} at \qquad 1Torr = \frac{1}{750} bar$$

Pressure Unit Conversion Table

	Pa	bar	PSI	at	atm	Torr
1 Pa =	1	1.10^{-5}	$1{,}45.10^{-4}$	$1{,}02.10^{-5}$	$9{,}87.10^{-6}$	$7{,}5.10^{-3}$
1bar =	10^{5}	1	14,5	1,02	0,987	750
1 PSI =	$6{,}89.10^{3}$	$6{,}89.10^{-2}$	1	$7{,}02.10^{-2}$	$6{,}8.10^{-2}$	51,71
1 at =	$9{,}81.10^{4}$	0,981	14,2	1	0,968	735,6
1 atm =	$1{,}01.10^{5}$	1,013	14,7	1,03	1	760
1 Torr =	133	$1{,}33.10^{-3}$	$1{,}93.10^{-2}$	$1{,}36.10^{-3}$	$1{,}32.10^{-3}$	1

1 Torr was originally the same as 1 mmHg.

AIR PRESSURE

For pneumatic circuits, there are:

Operating pressure - the pressure of air leaving the compressor or accumulator and located in the piping to the pneumatic motors.

Working pressure – the pressure required for the proper operation of pneumatic motors.

The maximum pressure is preferably **0.6 MPa**. This corresponds to the design of the pneumatic components.

Adherence to constant pressure is a prerequisite for the correct and reliable function of the pneumatic elements.

AIR PRESSURE

The following depend on the constant pressure value:

- speed
- forces
- time courses of pneumatic components functions

Pressure-regulating valves are used to maintain a constant pressure value.

Thermodynamic Processes - Examples

- What air volume must we take from the atmosphere to obtain compressed air with a pressure of 2 bar with a volume of 0.5 cubic meters? Consider an isothermal process; atmospheric pressure is 1 bar.
- The closed container contains air with a temperature of 20 °C and a pressure of 3 bar. How does the pressure in the container change when the temperature rises by 20 °C? (isochoric process)?
- How does the air volume in the piston change if it heats from 20 °C to 50 °C? The current volume of air in the piston is 0.5 cubic meters. (isobaric process).