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Questions and answers II.

Filters
Electrostatic separarors

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1. **What is the principle of filters and how is their operation controlled?**
2. **What are the main classe of filters and how do they differ?**
3. **What filter materials you know and what are their features?**
4. **How do you define the separability of filter materials?**
5. **What is the difference between absorption and porosity of filter?**
6. **What is the basic design of industrial filters and how are they regenerated?**
7. **What physical principle do use electrostatic separators?**
8. **What are the main components of electroseparator?**
9. **Draw, describe and explain the VA characteristic of electroseparator.**
10. **Explain the calculation of electrical separator size.**

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1.

The basis of filtration is the separation of particles in the filter layer. For filtration, fibrous layers are most often used, but also granular or porous masses. Waste gases pass most often through the fabric. Larger particles do not pass through the hole in the fabric and get caught on its surface. On the surface of the fabric, a filter cake is formed, which in itself forms a filter layer.

The flow rate of gas containing TZL through the filter material is controlled by:

- the sieve effect of a filter layer which does not pass through particles larger than the diameter of its pores;
- inertia and diffusion. Separation takes place on the surface and inside the filter layer;
- when the filter layer is thicker or the fabric is filled with dust, a layer of dust is formed on the front surface, which in itself forms a filter layer;

2.

Filters for the separation of solid particles from waste gases are divided into filters for atmospheric air filtration and industrial filtration. While atmospheric air filtration is used for ventilation, air conditioning and for dedusting of the working environment, where dust concentrations are small (of the order of $^{mg.m-3}$) and filter fabrics are not regenerated, dust concentrations in industrial filtration are in the order of tens of g.m-3. A layer of dust trapped on the filter is quickly formed and it must be regenerated. Several different principles are used for regeneration (reverse flow of purified gas, pressure surge of air, burring). The individual principles of regeneration correspond to the different design of the filters, especially the gas supply and the fabrics used.

3.

Filter materials are divided into three groups. These are filter cloths, granular layers and porous masses.

Most often, filter cloths are used, which are made either by weaving or by needle-punching. Most filter materials are produced by needle-punching. Woven fabrics are mainly used for separation at high temperatures.

Fabrics can be made of natural or synthetic fibers, porous fabrics made of plastics or metals, and granular fabrics. The most commonly used filter materials are wool and cotton, plastics are polyamides, polyesters, expanded polytetrafluoroethylene (e-PFTE), glass, etc. Filter cloths differ mainly in the environment in which they are applied, most often in temperature, as shown in Table 1:

Table 1: Examples of heat resistance of some filter materials

Materiál	**Temperature [°C]**
PVC	40 – 50
cotton	75 – 85
wool	80 – 90
polyamide, polypropylene	75 – 90
polyester	150
Teflon	200 – 280
glass fibres	250 –300
metal fibres	>300

The basic properties of filter materials are:

- structure
- porosity
- fineness
- strength;
- malleability;
- ductility
- resistance to temperature and chemical exposure to both dust and gas

The main operational characteristics of filter materials are:

- permeability
- specific load of the filter cloth
- separation
- poignancy

Breathability is a property by which the specific flow of textiles is expressed when the pressure drop Δp of 200 Pa is reached. For most needle-punched textiles, it reaches values of the order of hundreds of l.m-2 .$^{s-1}$. It is necessary to distinguish from breathability the concept of specific load of the filter fabric (expressed in m 3.m-2.s-1), which expresses the recommended value of the specific flow of gas through the fabric at steady state at normal pressure losses.

4.

These properties of filter materials are interrelated and change over time. The amount of dust collected on the unit area increases with time, thus increasing the pressure loss against the gas flow Δp and increasing separability. Separation (η) is defined as the difference between the input (x) and output concentration (y) in the waste gas related to the input concentration (x):

$$\eta = \frac{x - y}{x}.$$

5.

The absorption of the filter material is the amount of dust that the filter area unit holds at the maximum load-bearing pressure drop Δp.

Porosity means the volume of pores to the total volume of the filter mass. The separation of TZL on the filter can be increased:

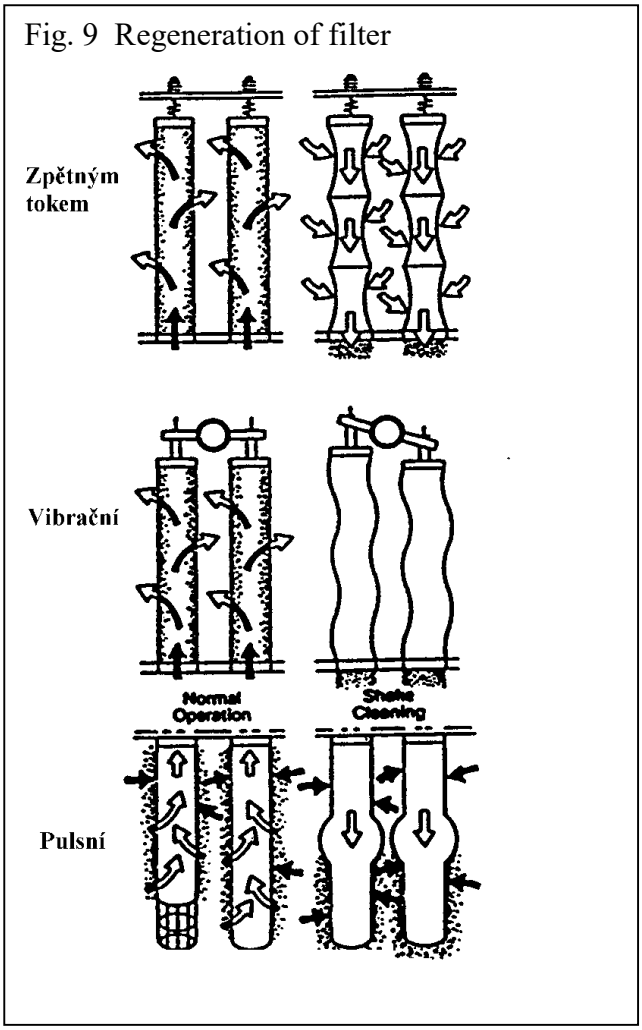
- by reducing the diameter of the fibers;
- by reducing porosity;
- by increasing the thickness of the filter mass on the filter.

6.

The design of industrial filters depends on the type of material used and the method of regeneration. The filter surfaces of fabric filters are arranged in the form of hoses or deep pockets. Accordingly, we distinguish filters into hose or pocket filters. Furthermore, when using granular materials, we are talking about filters with a granular or porous filter layer.

The basic methods of regeneration for hose or pocket filters are backwash or pulse blow. In the case of hose filters, backwash regeneration can also be combined with mechanical methods such as oscillating movement of hoses in the longitudinal direction or shaking in a plane perpendicular to the hose axis. Individual methods of regeneration of fabric filters are shown in Fig. 9. Regeneration is carried out only after a certain value of pressure loss has been reached, which is considered unacceptable.

Fig. 9 Regeneration of filter



7.

Electrostatic separation of dust from waste gases consists in the use of attractive forces between electrically charged dust particles and the oppositely charged precipitation (collecting) electrode. The charge of the particles is achieved in an electrostatic field, in which the charge carrier is the ions of ionized gas.

8.

The basic functional components of the electric separator are:

- a rechargeable (or hornet) electrode with a very small area;
- a precipitation electrode with a large area through which charged particles surrender their charge, settle on it and thus separate from the gas flow;
- and are stored in a common cabinet, most often made of structural steel.

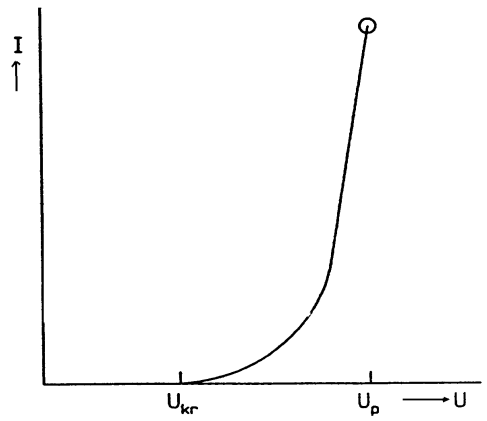
9.

By gradually increasing the voltage inserted on the charging electrode, an electric current (the so-called corona) begins to pass through the electrode at its critical value U_{kr}. This current increases up to a critical value (U_p) (see Fig. 10), at which a jump occurs and at which the corona can no longer be formed. The critical voltage that can be inserted on the electrodes depends:

- on the composition of the gas passing through the separator;
- radius of the ionization electrode;
- partly also at electrode distances.

To ensure reliable operation of the electro-separator, a stable corona is required, which is a source of ions. The higher the voltage inserted on the electrodes (55 – 75 kV), the better the separation efficiency. The stability of the corona is conditioned by the small surface area of the charging electrode and the negative voltage inserted on it.

Fig. 10: VAoltampérová characteristics



10.

The size of the separator depends on the required output concentration, which is most often taken into account as the separation efficiency. The dimensions of the separator are determined by the required separation area. The relationship between the efficiency of the electro-separator and its size is expressed by the Deutsch-Anderson equation:

$$\eta = 100\,\frac{C_p - C_k}{C_p}$$

$$1 - \eta = e^{\frac{-\omega A}{V}}$$

$$A = \ln\frac{1}{1-\eta} * \frac{V}{\omega},$$

kde: η je separation efficiency, [%]

ω migration rate, [$m.s^{-1}$]

A separating area, [m^2]

V gas flow, [m^3s^{-1}]