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Research Article

THE STUDY OF HETEROGENEOUS SYSTEMS AND METHODS FOR THEIR SEPARATION

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ABSTRACT

The article shows the importance of methods for separating inhomogeneous systems, classified depending on the size of dispersed particles, the difference in densities of continuous and dispersed phases, as well as the viscosity of the continuous phase. The main methods of separation are considered: sedimentation, filtration, centrifugation, wet separation.

KEYWORDS

Sedimentation, filtration, centrifugation, wet separation.

INTRODUCTION

Heterogeneous systems- these are mixtures of at least two components that are in different phase states and are separated by clear boundaries. In such systems, two phases of a substance can be distinguished: a continuously distributed continuum of a phase called a dispersion medium, and fragmented particles of various sizes and shapes located in it - a dispersed phase. The particles of the dispersed phase have clear boundaries separating them from the dispersion medium. Heterogeneous systems are also called heterogeneous or dispersed. The disperse medium of inhomogeneous systems can be in three states of aggregation. The dispersed phase

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can also be in these states. Theoretically, the existence of 9 inhomogeneous systems is possible. However, according to this classification, an inhomogeneous gas-gas (G-G) system does not exist, since the mixture of gases is a homogeneous system. In the above classification of heterogeneous systems, it is also necessary to distinguish systems with solid phases S-L, S-G, S-S, which are not subject to separation and therefore cannot be considered heterogeneous. These systems include plastics and alloys.

Thus, dusts, fumes, mists, suspensions, emulsions, and foams should be classified as heterogeneous systems. The concept (term) "heterogeneous mixtures" combines compositions from components that are in a different state of aggregation - solid, liquid, gaseous. One of the components is necessarily present in the form of fine and/or tiny particles.

Suspended particles form a dispersed phase, and the rest form a common (continuous) phase of an inhomogeneous mixture. Based on the composition, they are classified as follows:

- Suspensions - a solid suspension in a liquid;
- Emulsions - two or more mutually insoluble and non-reactive liquids;
- Gas suspensions are solid particles in a gaseous medium.

To separate heterogeneous mixtures, depending on their type, mechanical, thermal and electrochemical methods are used that use the physical characteristics of the mixture components. Characteristics of liquid heterogeneous mixtures and the choice of separation method. The main characteristics of liquid heterogeneous mixtures include:

- Concentration (density) of the dispersed and total phase - expressed in mass and volume fractions or in%;
- Viscosity (depends on the concentration of the dispersed phase, the shape and size of its particles);
- Saturation, expressing the moisture content in the pores (capillaries) of the sediment.

For example, high viscosity or concentration of suspensions (30-40%) does not allow the use of hydrocyclones and centrifuges for their separation. Strong dispersion (too fine particles) requires additional equipment to conventional equipment or the use of special chemicals. The components collected as a result of separation of heterogeneous mixtures are disposed of or become secondary raw materials.

Dust- an inhomogeneous system consisting of a gas and solid particles distributed in it with a size of 5-50 microns. It is formed mainly during crushing and transportation of solid materials.

Smoke- an inhomogeneous system consisting of a gas and solid particles distributed in it with a size of 0.3-5 microns. It is formed during the combustion of substances.

Fog -an inhomogeneous system consisting of a gas and liquid droplets 0.3–3 μm in size distributed in it, which are formed as a result of condensation.

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Dusts, fumes, fogs are collectively called aerosols.

Suspension- an inhomogeneous system consisting of a liquid and solid particles suspended in it. Depending on the size of the particles, suspensions are distinguished: coarse ones with particles larger than 100 μm, fine ones with particles larger than 0.1-100 μm, and colloidal solutions containing particles smaller than 0.1 μm.

Emulsion- an inhomogeneous system consisting of a liquid and drops of another liquid distributed in it, which does not dissolve in the first one. The size of the particles of the dispersed phase varies within a fairly wide range.

Foam- an inhomogeneous system consisting of a liquid and gas bubbles distributed in it.

When the concentration of the dispersed phase changes, an inhomogeneous system can change its structure. This is accompanied by the so-called phase inversion. With inversion, the dispersion medium becomes a dispersed phase and vice versa. Thus, with an increase in the concentration of the solid phase in suspensions, a moment may come when the solid phase forms a continuous continuum - a continuous medium in which limited volumes of the liquid dispersed phase are distributed. In this case, it can be argued about the transition of the suspension into a plastic mass of class T-Zh.

Similar changes occur with foam if the liquid content in it increases; it passes into a supersaturated carbonated liquid, in which the dispersed phase of gas bubbles can be distinguished. Such a system is not sufficiently stable, although it can remain in this state for a relatively long time.

With an increase in the concentration of the solid dispersed phase, dust passes into a loose product with specific properties, i.e. both solid and liquid media. Such a system has some elasticity and plasticity (the ability to maintain its shape under relatively small loads), but takes the form of a container into which it is filled; when poured onto a plane, it forms a cone with an angle of repose.

To separate inhomogeneous systems, equipment and methods are used that are distinguished by a wide variety of physical phenomena. The choice of the optimal equipment is determined by the choice of a sign according to which the dispersion medium and the dispersed phase differ significantly in their properties and according to which they should be separated. Such features are: density, strength, magnetic and electronic properties, etc. It is by the use of one or more of these features that the methods of separating these systems differ. The sign, consisting in the difference in densities that make up a heterogeneous system, is used in the following separation methods: sedimentation due to gravity, settling centrifugation (separation) and cyclone process.

In conservative force fields (gravity, centrifugal forces, inertial forces), the particles of the dispersed phase acquire acceleration, which, according to Newton's second law, is proportional to the acting force and inversely proportional to the particle mass. In solution, the

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particles begin to move in the dispersion medium in the direction of the acting force vector. Their velocities eventually stabilize at a level corresponding to the balance of the driving force and the resistance forces of the medium. With a given speed, all "heavy" and denser than the dispersion medium particles settle on the hard surfaces of the equipment.

The sign, consisting in the difference in the magnetic properties that make up an inhomogeneous system, is used to isolate particles of metallomagnetic inclusions from a dispersion medium. In this case, under the action of magnetic forces, metal-magnetic particles are accelerated in the direction of their action, while the environment remains stationary. Due to this, phase separation occurs in space. A sign based on the difference in electrical properties that make up an inhomogeneous system is used in electrostatic precipitators. Under the action of a high electrical voltage, the particles of the dispersed phase can be ionized and move in space to the filter electrodes.

The feature, which consists in the retention of particles of the dispersed phase on solid partitions, is used in filtration processes (due to the pressure difference and centrifugal filtration). A feature associated with the association of dispersed particles into larger complexes is used in the processes of separation of dusty gas systems by a wet method. It is also possible to combine methods for separating heterogeneous systems.

Mechanical methods for separating heterogeneous mixtures. Wastewater is the most common slurry analogue. Using the example of the wastewater treatment process, one can get a complete picture of the existing mechanical methods for separating heterogeneous mixtures:

- settling;
- Filtration;
- Flotation;
- Dehydration.

As in the case of any other liquid heterogeneous mixtures, at the primary stage of purification, a mechanical separation method is used - sand traps, gratings and other devices that capture the largest and heaviest mixture fragments. The next stage is settling, which is often combined with filtration and/or flotation and consists in using the differences in the density of the solid and liquid components of a heterogeneous mixture. Heavier particles relative to water sink to the bottom of the sump, and lighter (floating or floating) particles are collected on the surface of the sump, from where they are removed. The clarified liquid is drained, and the remainder is actually a suspension. Over time, when the suspension becomes finer, the settling process slows down sharply, and coagulants, adsorbents, absorbents, and other chemical reagents can be used to speed it up.

Passive filtration of suspensions is the simplest method, but it requires large areas, so active belt, disk or drum vacuum filters are more often used. Centrifuges and hydrocyclones are another way

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of active mechanical separation of liquid suspensions.

These devices allow to achieve maximum dehydration of such mixtures. Thermal methods are used when the viscosity of the suspension does not allow the use of other separation methods. The main method for separating emulsions is the use of high speed centrifuges, including supercentrifuges for separating particularly stable emulsions. Gas suspensions are separated in high-speed cyclones, electrical and combined devices that collect (settle) solid particles on walls and/or electrodes. If heterogeneous mixtures contain radioactive components, sulfates and other hazardous substances, special technologies for their separation and disposal are used.

Methods that increase the efficiency and speed of the processes of separation of inhomogeneous systems. If dispersed particles are released slowly from the medium or it is necessary to pre-clarify an inhomogeneous system, methods such as flocculation, flotation, classification, coagulation, etc. are used.

Coagulation is the process of sticking together of particles in colloidal systems (emulsions or suspensions) with the formation of aggregates. Sticking occurs due to the collision of particles during Brownian motion. Coagulation refers to a spontaneous process that tends to move into a state that has a lower free energy. The coagulation threshold is the minimum concentration of an injected substance that causes coagulation. Artificial coagulation can be accelerated by adding special substances - coagulators to the colloidal system, as well as by applying an electric field to the system (electrocoagulation), mechanical action (vibration, mixing), etc. During coagulation, coagulant chemicals are often added to the heterogeneous mixture to be separated, which destroy the solvated shells, while reducing the diffusion part of the electrical double layer located near the surface of the particles. This facilitates the agglomeration of particles and the formation of aggregates. Thus, due to the formation of larger fractions of the dispersed phase, particle settling is accelerated. Salts of iron, aluminum or salts of other polyvalent metals are used as coagulants. Peptization is the reverse process of coagulation, which is the breakdown of aggregates into primary particles. Peptization is carried out by adding peptizing substances to the dispersion medium. This process contributes to the disaggregation of substances into primary particles. Peptizing agents can be surface-active substances (surfactants) or electrolytes such as humic acids or ferric chloride. The peptization process is used to obtain liquid dispersion systems from pastes or powders.

In turn, flocculation is a kind of coagulation. In this process, small particles that are suspended in gas or liquid media form flocculent aggregates called floccules. Soluble polymers, such as polyelectrolytes, are used as flocculants. Flocculating substances can be easily removed by filtration or settling. Flocculation is used for water treatment and the separation of valuable substances from wastewater, as well as for

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mineral processing. In the case of water treatment, flocculants are used in low concentrations (from 0.1 to 5 mg/l). In order to destroy aggregates in liquid systems, additives are used that induce charges on particles that prevent their convergence. This effect can also be achieved by changing the pH of the medium. This method is called deflocculation.

Flotation is the process of separating solid hydrophobic particles from a liquid continuous phase by selectively fixing them at the interface between the liquid and gaseous phases (the contact surface of liquid and gas or the surface of bubbles in the liquid phase). The resulting system of solid particles and gas inclusions is removed from the surface of the liquid phase. This process is used not only to remove particles of the dispersed phase, but also to separate different particles due to differences in their wettability. In this process, hydrophobic particles are fixed at the interface and separated from hydrophilic particles that settle to the bottom. The best flotation results occur when the particle size is between 0.1 and 0.04 mm. There are several types of flotation: foam, oil, film, etc. The most common is froth flotation. This process allows the particles treated with reagents to be carried to the surface of the water with the help of air bubbles. This allows the formation of a foam layer, the stability of which is controlled by a foaming agent.

The classification is used in devices of variable cross section. With its help, it is possible to separate a certain amount of small particles from the main product, consisting of large particles. Classification is carried out using centrifuges and hydrocyclones due to the effect of centrifugal force.

The separation of suspensions using magnetic processing systems is a very promising method. Water that has been treated in a magnetic field retains changed properties for a long time, for example, reduced wetting ability. This process makes it possible to intensify the separation of suspensions.

SEPARATION OF INHOMOGENEOUS SYSTEMS

To separate inhomogeneous systems, the processes of settling, filtering and centrifugation are most often used.

Settling

Settling - separation of heterogeneous systems under the action of gravity. Suspensions with large particles (mainly coarse suspensions) are subjected to settling. The concentration of precipitates obtained during settling depends on the size and structure of the particles and usually does not exceed 40-50%.

Sump performance

In batch settling tanks, the suspension is poured into the apparatus, and then, after a certain time required for the particles to settle, the clarified liquid layer is drained (decanted), and the sediment is unloaded from the apparatus. In continuous devices, the supply of the suspension and the removal of the sediment are carried out continuously.

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Single-tier row settling tanks continuous actions are low cylindrical tanks with a slightly conical bottom. Annular rectangular chutes are installed at the upper edge of the tanks to drain the clarified liquid. Inside the tanks there are rake mixers that rotate at a speed of 2.5-20 rpm.

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