Seminar No. 8

TOPIC "Fundamentals of materials science and manufacturing technology in terms of the formation of use value and quality of goods. [1] Materials science. Classification, properties, requirements for materials for medical products. [2]
metal materials. Metals and their alloys. [1] Types of alloys.»

The main questions to be discussed at the seminar:

1. Materials Science. Goal and tasks.
2. Classification of materials. General characteristics of materials.
3. Composites. Modern materials.
4. Material properties: mechanical, chemical, technological, optical, electrical.
5. Classification of the main types of raw materials for the production of medical and pharmaceutical products Requirements for materials for medical products.
6. metal materials. General characteristics. Classification.

Materials Science - a scientific discipline that studies the relationship between the composition, structure and properties of materials.

Materials science is a science that studies metallic and non-metallic materials used in engineering, objective patterns of the dependence of their properties on the chemical composition, structure, processing methods and operating conditions, and develops ways to control properties.

The purpose of the discipline is the knowledge of the properties of materials depending on the composition and processing, methods of their hardening for the most effective use in engineering, as well as the creation of materials with predetermined properties: high strength and ductility, high electrical conductivity or high resistance, special magnetic properties, a combination of various properties in one material (composite materials).

The main **tasks of materials science** :

- to reveal the physical essence of the phenomena occurring in materials when exposed to various factors in the conditions of production and operation;
- establish the relationship between the composition, structure and properties of materials;
- to study the theory and practice of various ways of hardening materials to increase the high reliability and durability of parts, tools and products;
- to study the main groups of modern materials, their properties and applications;
- to give an understanding of modern methods of studying the structure and predicting the performance properties of materials and products

Materials as raw materials for medical devices **must meet the** following **specific requirements**

- biological inertness and non-toxicity in relation to the tissues and environments of the body with which they come into contact;
- the possibility of aseptic processing without changing the properties and shape;
- corrosion resistance.

Each material has certain mechanical, chemical and technological properties. They are determined by GOSTs.

The mechanical properties of the material include strength, hardness, elasticity, viscosity, ductility, fatigue.

Chemical properties are determined by the chemical composition of the material, which affects its properties and attitude to various influences.

The technological properties of materials determine the various methods of their processing into products, in which significant changes in properties are possible.

Mechanical, chemical and technological properties of materials are closely interrelated; the quality of the product depends on them.

Among the factors affecting the quality of goods, an important place is given to the quality of raw materials, materials and components and the quality of technological processes during production.

Raw materials are various substances and materials used for the production of finished products. These substances and materials differ in chemical composition and origin. The classification of feedstock for the production of MFT is presented in

Classification of the main types of raw materials for production

According to the chemical composition, substances and materials are divided into inorganic and organic; by origin - into natural, artificial and synthetic.

From inorganic materials, metals and alloys based on them, silicate materials and minerals are widely used. The disadvantage of almost all metals and products made from them is that they are subject to corrosion and are difficult to process.

Silicate materials are compounds of silica with other oxides. They are natural and artificial (glass, porcelain, faience).

Inorganic raw materials also include various minerals, including precious ones (diamond, etc.).

Organic substances and materials of animal origin are various protein substances: wool, bones, etc. Materials of plant origin include wood, cotton, flax, medicinal plant materials. Synthetic organic substances and materials include rubber and rubber based on it, resins for producing synthetic fibers (nylon, lavsan), and plastics. In the course of the technological process of obtaining a product, raw materials and materials are subjected to mechanical, thermal, physicochemical and other types of influences, as a result of which (the quality of the finished product is formed. If the regimes of technological processes are violated, various defects may appear that reduce the quality of the product.

Steel is the main material widely used for the production of medical instruments, equipment and technology. It has a valuable set of mechanical, physicochemical and technological properties.

According to the chemical composition **, steels are** divided into **carbon and alloy steels** .

Carbon steels containing up to 0.25% carbon are called low carbon; from 0.25% to 0.6% - medium carbon; more than 0.6% - high carbon.

By purpose, steel is divided into:

a) structural (for machine parts, instruments);

b) instrumental (for instruments);

c) special purpose with special properties (stainless, corrosion-resistant, heat-resistant, heat-resistant, wear-resistant, etc.).

For the manufacture of medical instruments, different grades of carbon steels are used.

To give steel the required properties, various elements (chromium, manganese, nickel) are introduced into it, such steel is called alloyed.

High alloy steel contains more than 10% alloying elements. With the addition of 13-18% chromium, stainless steel is obtained.

Chromium-nickel steels are used to make dental crowns, sterilizer chambers, boiler bodies, etc.

Of the non-ferrous metals, the most common in the manufacture of medical instruments and equipment are the following:

1) copper and its alloys:

- with zinc: brass: JI-62 (62% copper and 38% zinc), LS 59-1 (59% copper, 1% lead, the rest is zinc) (catheters, probes, bougies, dilators, syringe fittings, needle heads injection);

- with zinc, nickel and cobalt: nickel silver (tracheotomy tubes, cannulas, eye instruments, ear and nasal probes);

2) aluminum and its alloy duralumin: with copper, manganese, magnesium, silicon, iron; used in the manufacture of parts and medical equipment;

3) noble metals - gold, silver, platinum; are used for the production of ophthalmic instruments, dental crowns in dentistry, spectacle frames;

4) tantalum and its alloys are used in the manufacture of brackets for staplers, wires for stitching bones;

5) vitalium - an alloy of complex composition, intended for the manufacture of special nails for connecting bone fragments.

Currently, chromium and chromium-nickel corrosion-resistant steels are used for the manufacture of rod and blade medical instruments for various purposes. In order to improve plastic deformation, they are alloyed with silicon, molybdenum, vanadium, and manganese. Metal products are protected from corrosion by coating with alloys based on nickel or titanium.

Classification of materials. Types of hard materials:

- Metals
- Non-metallic materials:
- ceramics
- polymers (rubber, ceramics, glass, plastics, glass-ceramics)

This division is based on the features of the chemical structure and atomic structure of matter. There are also modern special (advanced) materials composites (materials belonging to two or three of the listed groups are combined)

Materials belonging to the group of metals include one or more metals (such as iron, aluminium, copper, titanium, gold, nickel), as well as often some non-metallic elements (such as carbon, nitrogen or oxygen) in relatively small quantities . Atoms in metals and alloys are arranged in a very perfect order. Compared to ceramics and polymeric materials, the density of metals is relatively high.

Mechanical properties of metals :

- relatively rigid and durable;
- have a certain plasticity (i.e., the ability to large deformations without destruction), and fracture resistance .

Composites are a combination of two (or more) separate materials belonging to different classes of substances (metals, ceramics and polymers).

Composites combine the properties of different materials that cannot be obtained for individual components (materials), composites also provide an optimal combination of their characteristics.

A large number of different composites are known, which are obtained by combining metals, ceramics and polymers ; some natural materials are also composites (wood and bone).

Most composites are materials derived from synthetic materials.

Composite material fiberglass - is short glass fibers placed in a polymer matrix, usually epoxy or polyester resin . Glass fibers have high strength and stiffness, but they are brittle. At the same time, the polymer matrix is plastic, but its strength is low.

Fiberglass is a relatively rigid and high-strength material, which, nevertheless, has sufficient ductility and flexibility.

CFRPs are carbon fiber reinforced polymers (CFRP).

In these materials , carbon fibers are placed in a polymer matrix.

Materials of this type are stiffer and more durable than fiberglass, but at the same time more expensive.

Types of modern special *(advanced)* materials:

- materials intended for high-tech applications such as semiconductors
- biological materials
- "smart" (smart) materials and substances used in nanotechnology

progressive materials

- typical substances, but with improved properties (metals, ceramics or polymers - their cost is usually very high);
- new materials with outstanding characteristics (semiconductors, biomaterials and substances - "materials of the future" - the so-called "smart" materials and products of nanotechnology, which are intended, among other things, for the manufacture of lasers, integrated circuits, magnetic information storage, displays on liquid crystals and optical fibers).

Biomaterials

Biomaterials are used to create implants for the human body, which are designed to replace

diseased or destroyed organs or tissues.

Materials of this type must not emit toxic substances and must be compatible with human tissues (i.e. must not cause rejection reactions).

Metals, ceramics, polymers and semiconductors can be used as biomaterials .

An example is some of the biomaterials that are used to make artificial hip joints.

According to the chemical composition, substances and materials are divided into:

- inorganic
- organic.

By origin, materials are divided into:

- natural
- artificial
- synthetic
- animal origin *(various protein substances)* : wool, silk, - bones, etc.
- materials of plant origin : wood, cotton, linen, medicinal plant materials .

Synthetic organic substances and materials: rubber and rubber based on it, resins for synthetic fibers (nylon, lavsan), plastics.

All materials, regardless of their origin, method of production and processing, performance properties, etc. have three of the same properties:

- mechanical
- technological
- chemical

The main indicators that characterize the properties of the material and determine its choice for a given product are recorded in the standards and specifications for these products.

This applies primarily to the mechanical and chemical (anti-corrosion) properties that determine the reliability and durability of the product.

to mechanical properties relate:

- strength
- hardness
- elasticity
- viscosity
- plastic
- fragility

Chemical properties determine the behavior of the material in relation to the action of environmental factors: its oxidizability, resistance to various chemical agents and solvents, including corrosion resistance.

Chemical properties are determined by the chemical composition of the material.

Knowledge of the chemical composition makes it possible to judge a number of properties of the material and its relation to various influences.

Examples: a certain percentage of chromium in steel makes it stainless;

- high content of sulfur and phosphorus turns steel into brittle , unusable material;

the chemical stability of glass is completely determined by its composition ;

the chemical composition determines the grade of the material .

The technological properties of materials determine various technological methods for their processing into products (example: many metallic materials are well stamped, while others can only be shaped by casting).

Materials used to produce medical devices must be capable of being processed by one or more known economically viable technological methods .

Often, as a result of casting and plastic deformation methods (forging, stamping, pressing, rolling, drawing), the internal structure of the material changes and its mechanical properties deteriorate. To improve the mechanical properties, the product is subjected to heat treatment, which, without changing its shape, gives the product the necessary mechanical properties.

The optical properties of materials are properties that characterize their ability to quantitatively

and qualitatively change the luminous flux.

When exposed to light flux, the material exhibits properties such as color, gloss, transparency, whiteness, etc.

The optical properties of materials are essential in assessing the appearance, aesthetic perception of the product.

The **electrical properties** due to the transfer and displacement of electric charges in a substance include

- electrical conductivity
- polarization
- energy absorption (losses)
- dielectric strength