Federal State Budgetary Educational Institution of Higher Education "Volgograd State Medical University" of the Ministry of Health of the Russian Federation

Department of Management and Economics of Pharmacy, Medical and Pharmaceutical Commodity Science

Fundamentals of materials science and manufacturing technology in terms of the formation of use value and product quality

Lecture № 4

Discipline: medical and pharmaceutical commodity science

3 course, 5 semester

Volgograd -2022

LECTURE PLAN

1. Materials Science. Basic concepts. Classification of materials. General characteristics of materials. Properties of materials for the manufacture of medical devices.
2. metal materials. General characteristics. Classification.
3. Alloys of iron with carbon. General characteristics. General characteristics and classification of steels. Steel marking. Cast iron. General characteristics, types.
4. Nonferrous metals.
5. non-metallic materials. Classification. General characteristics.
6. General characteristics of polymers. Plastics. Characteristics, classification, properties. Polymers in medicine.
7. Rubber, general characteristics, classification, properties. Latexes and products from them. Consumer properties of latexes. silicone rubbers.
8. Glass, general characteristics, classification, properties. Sitally. Ceramics.
9. The technological process of manufacturing products from metallic and non-metallic materials.
10. Processes for obtaining powder metallurgy.
11. Processes for obtaining products from polymers (plastic), rubber, latex, glass, composite materials .

Materials Science. Definition of the term

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 technology, **objective patterns of the dependence of their properties on the chemical composition, structure, processing methods and operating conditions, and develops ways to control properties.**

Material classification

Types of hard materials:

- composites
(materials belonging to two or three of the listed groups are combined)

- modern special (advanced) 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 .

METALS (1)

Materials belonging to the group of metals include one or more metals (such as iron, aluminium, copper, titanium, gold, nickel) and 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** .

METALS (2)

In metallic materials, there are many delocalized electrons , i.e. electrons not associated with certain atoms, **the presence of which explains many of the properties of metals** .

For example, metals are exceptionally **good conductors of electricity and heat.** They are **opaque to visible light** .

Polished metal surfaces **gleam** .

Some metals (such as iron, cobalt, and nickel) possess desirable **magnetic properties for their application** .

COMPOSITES (1)

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.

COMPOSITES (2)

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.**

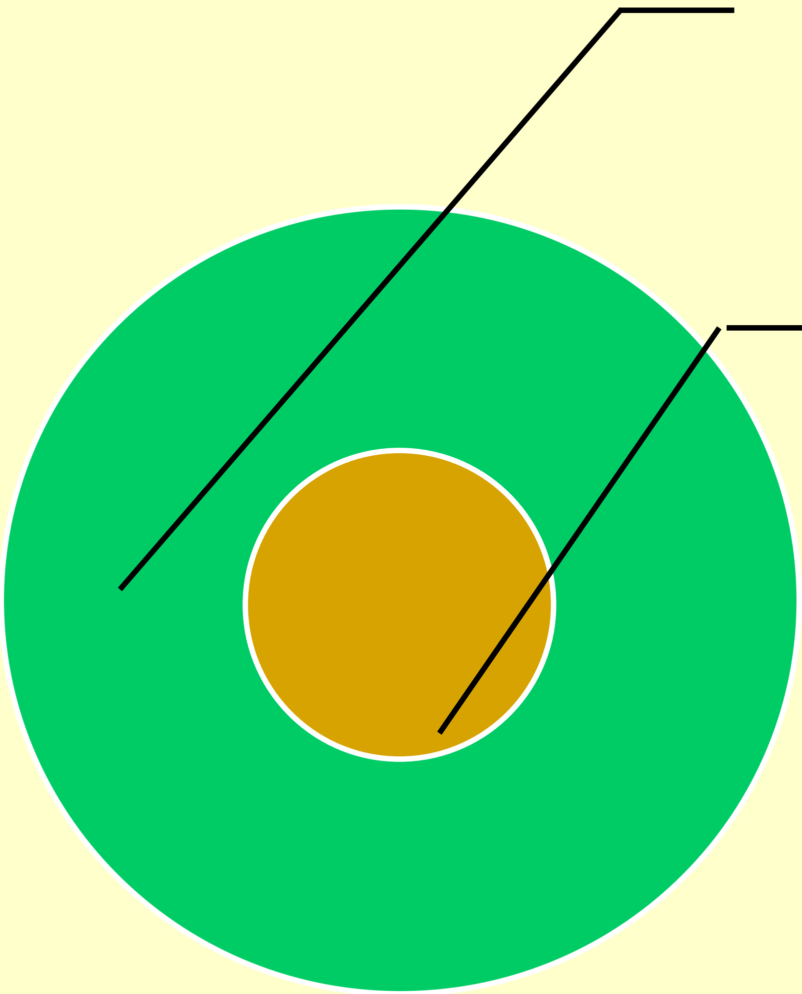
Types of modern special *(advanced)* materials:

- materials, destined for use in high-tech (high-tech) fields 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 nanotechnology products , which are intended, among other things, for the manufacture of lasers, integrated circuits, magnetic information storage devices, displays on liquid crystals and optical fibers).

PROGRESSIVE MATERIALS. BIOMATERIALS.

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).

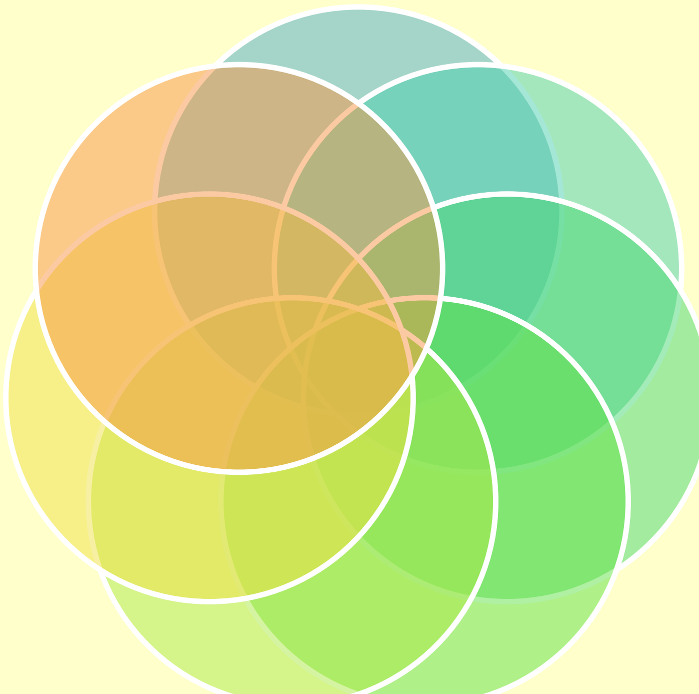
Metals, ceramics, polymers and semiconductors can be used as biomaterials .

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

Classification of materials by chemical composition and origin

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

- synthetic
- artificial
- natural



By origin, materials are divided into:

- inorganic
- organic.

INORGANIC MATERIALS:

metals and alloys based on them

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 (silica compounds with other oxides):

natural and **artificial** (glass, porcelain, faience).

Minerals

(including precious ones - diamond, etc.).

Organic substances and materials:

animal origin
(various protein substances) :

- **wool**
- **silk**
- **bones,** etc.

materials of vegetable 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.**

REQUIREMENTS FOR MATERIALS FOR MANUFACTURING MEDICAL DEVICES:

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 (not only metal, but also other materials of both organic and inorganic origin are subjected to corrosion - **microbiological corrosion, which** destroys many types of products under the influence of microorganisms, mold fungi and bacteria).

PROPERTIES OF MATERIALS

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

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.**

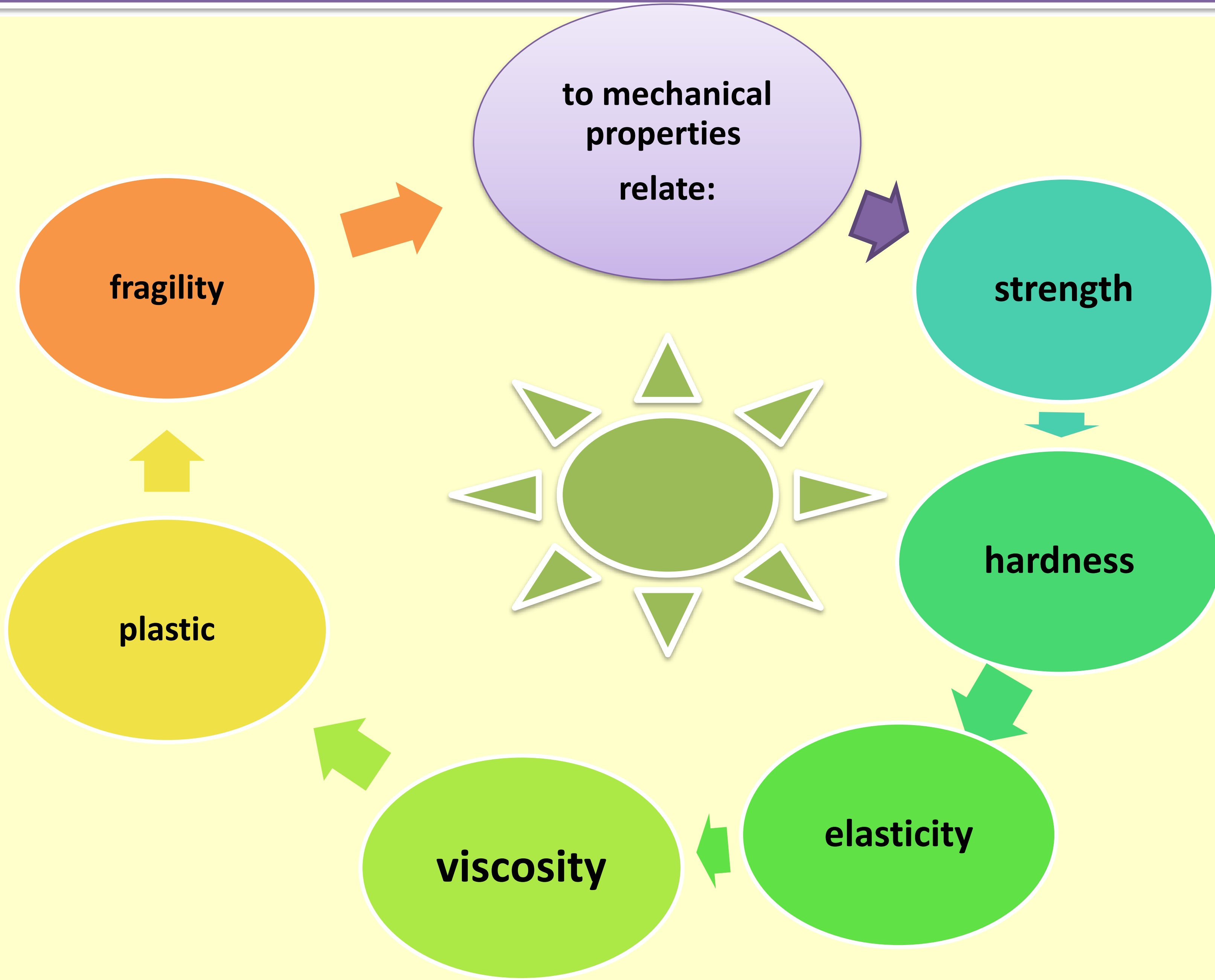
This applies primarily **to the mechanical and chemical** (anti-corrosion) properties that **determine the reliability and durability of the product.**

- mechanical

- technological

- chemical

MECHANICAL PROPERTIES OF MATERIALS



CHEMICAL PROPERTIES

Chemical properties determine the behavior of the material in relation to the action of environmental factors: its oxidizability, resistance to the action of 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 resistance of glass** is completely determined by **its composition** ;

- the chemical composition determines the grade of the material .

TECHNOLOGICAL PROPERTIES OF MATERIALS

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** .

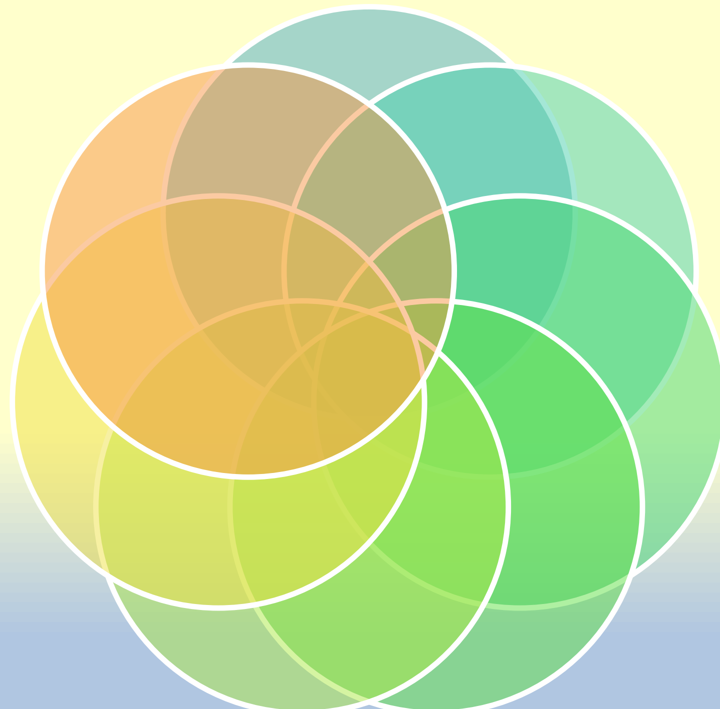
Often, as a result of casting and plastic deformation methods (forging, stamping, pressing, rolling, drawing), the internal structure of the material changes and its mechanical properties deteriorate. To improve the mechanical properties, the product is subjected to heat treatment, which, without changing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

OPTICAL PROPERTIES OF MATERIALS (1)

The optical properties of materials are properties that characterize their ability to quantitatively and qualitatively change the luminous flux.

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

When exposed to a light flux, the material exhibits such properties as



color,

shine,

transparency,

whiteness, etc.

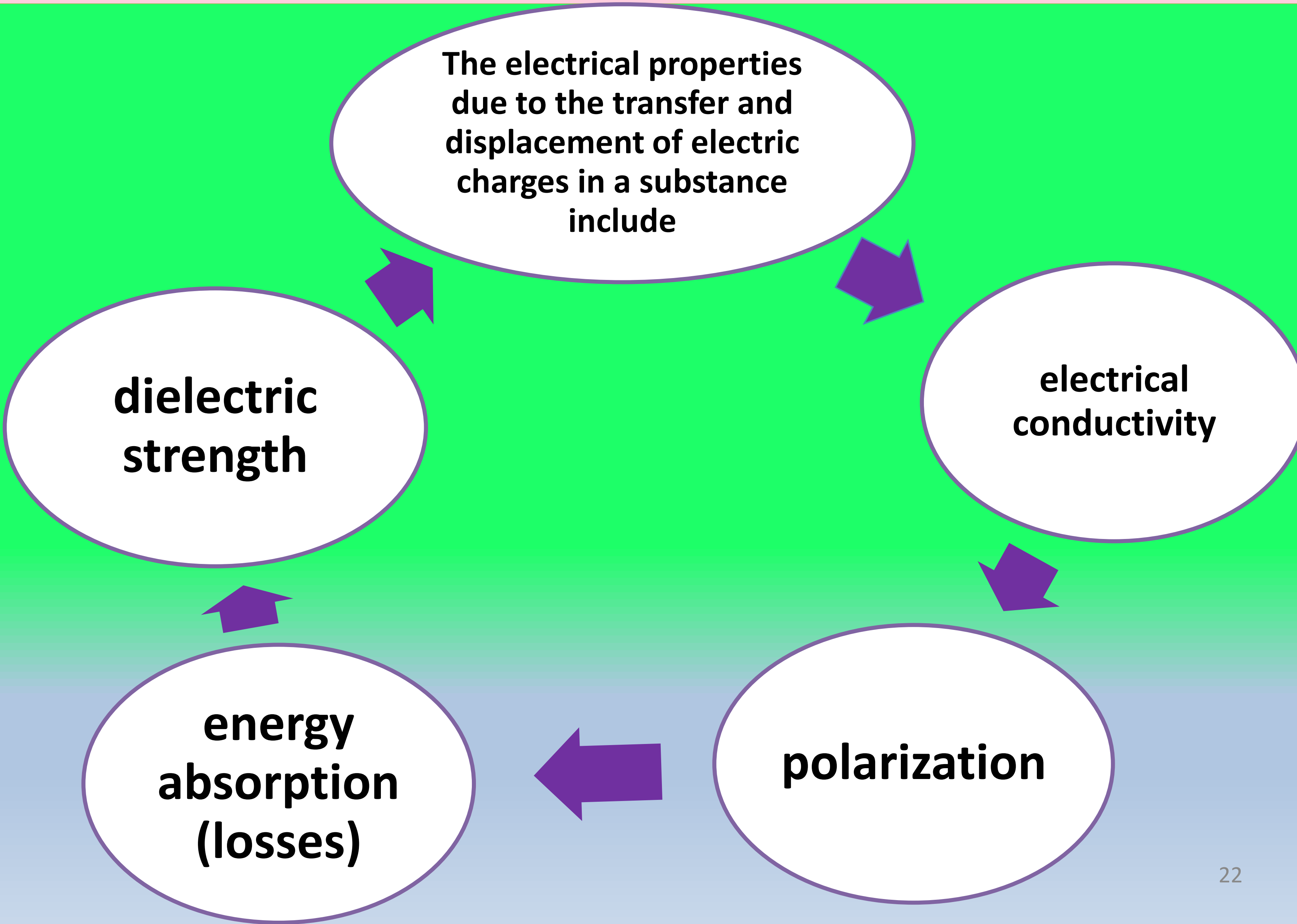
OPTICAL PROPERTIES OF MATERIALS (2)

The color difference is also revealed when assessing the color fastness of the material to various factors of influence: light, humidity, elevated temperatures, chemicals in the atmosphere, detergents, etc.

A change in color under the influence of these factors occurs as a result of a change in the state of the dye molecules and chemical processes leading to its destruction. The degree of occurrence of these processes depends on the intensity and duration of the factors, as well as the stability of the dye.

During the operation of products, the bond strength of the dye with the polymeric substance of the material is important, which can decrease under the influence of moisture, chemicals, and mechanical factors.

ELECTRICAL PROPERTIES OF MATERIALS (1)



ELECTRICAL PROPERTIES OF MATERIALS (2)

Electrical conductivity of solids

Differences in the electrical properties of solids are associated with the structure and degree of filling of energy bands with electrons. For high electrical conductivity of crystals, the presence of partially filled energy bands in their energy spectrum is necessary, to the free levels of which electrons could pass, increasing their energy under the action of an external electric field.

Crystals with partially filled energy bands are conductors of electric current.

All metals have an energy spectrum with partially filled energy bands.

ELECTRICAL PROPERTIES OF MATERIALS (3)

Electrical properties of metals and their alloys. Electrical conductors can be

solid bodies

liquids

gases (some rarely).

solid conductors are metals, metal alloys and some modifications of carbon.

Liquid conductors include molten metals and electrolytes. As a rule, the melting point of metals is high, with the exception of mercury, which has -39 ° C. Gallium has a melting point close to room temperature (29.8 °C). Other metals are liquid conductors only at elevated or high temperatures.

ELECTRICAL PROPERTIES OF MATERIALS (4)

The mechanism of the passage of current through metals in solid and liquid states is due to the movement of free electrons, as a result of which they are called conductors with electronic electrical conductivity.

The main characteristics of conductors include their **electrical resistivity and temperature coefficient of resistance.**

The specific electrical resistance of a conductor is the resistance of a wire 1 m long with a cross-sectional area of 1 mm2 and a temperature of 20 ° C.

The temperature coefficient of resistance is a coefficient equal to the relative change in resistance when the temperature changes by 1 degree.

METAL MATERIALS

METAL MATERIALS.
General characteristics.

Metals - (from the Greek.metallon - mine, mine) ***are simple substances that under normal conditions have characteristic metallic properties - high electrical conductivity and thermal conductivity, brilliance and plasticity.***

METALS, GENERAL CHARACTERISTICS.

Metals include:

- ***actual metals***
- ***their alloys.***

Alloys are macroscopic homogeneous systems consisting of two or more metals (less often metals and non-metals **), with characteristic metallic properties.**

METALS, GENERAL CHARACTERISTICS

Alloys are named based on the name of the chemical element that is included in them in the **largest amount.**

Example: iron alloys, aluminum alloys, copper alloys, etc.

Elements introduced into alloys to improve their properties are called **alloying elements,** and the **process itself is called alloying.**

METAL MATERIALS.
GENERAL CHARACTERISTICS. CLASSIFICATION

Alloys are divided into two groups:

non-ferrous metals - all other alloys

ferrous metals are alloys based on iron

ALLOYS OF IRON WITH CARBON. CLASSIFICATION

Alloys of iron with carbon:

- steels: alloys of iron with carbon containing up to 2.14% C , the crystallization of which ends with the formation of austenite, they have high ductility, are well deformed;

- cast irons: alloys of iron with carbon containing more than 2.14% C and the crystallization of which ends with the formation of a eutectic (ledeburite). Cast irons are less ductile and have good casting properties.

CLASSIFICATION OF STEEL

1. By chemical composition: carbonaceous and

doped .

2. By carbon content:

low-carbon , with a carbon content of up to *0.25%;*

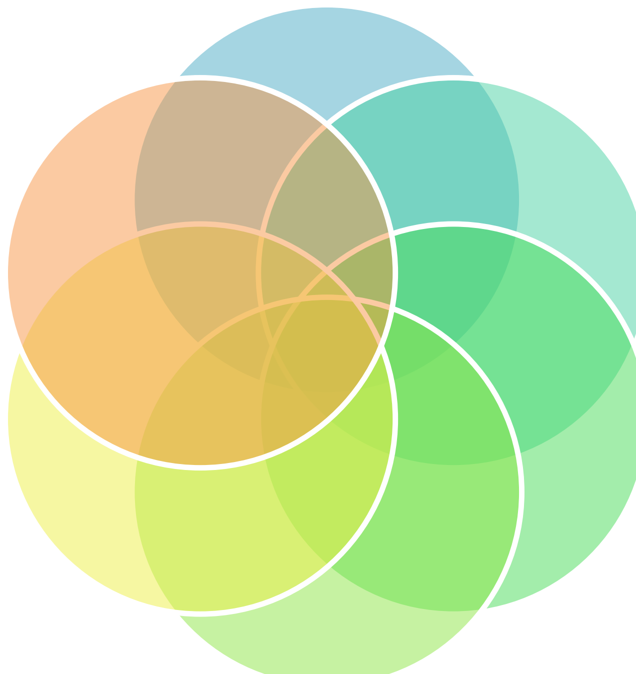
medium carbon, with a carbon content of *0.3 ... 0.6%;*

high carbon , with a carbon content above *0.7%.*

CLASSIFICATION OF STEEL (2)

3. According to the equilibrium structure :

- hypereutectoid , which contain **from 0.8 to 2.14% carbon** and have a **pearlite - cementite structure** (P + C)



- **hypoeutectoid ,** which contain **from 0.02 to 0.8% carbon** and have a **ferrite** (F) or **ferrite -pearlite** (F + P) structure

- eutectoid , which contain **0.8% carbon** and have a structure of **100% perlite**

CLASSIFICATION OF STEEL (4)

4. By quality

A quantitative indicator of the **quality of structural steels** is **the content of harmful impurities: sulfur and phosphorus:**

$0.04 \le S \le 0.06$; $0.04 \le P \le 0.08$ - **general purpose carbon steels;**

$0.03 \le P, S \le 0.04$ - high- **quality steels;**

$P, S \le 0.03$ - high- **quality steels** .

DEPENDENCE OF THE PROPERTIES OF CARBON STEELS ON THE Amount OF CARBON, STRUCTURE AND CONTENT OF IMPURITIES

Carbon steels are the main structural material, the properties of which depend on the amount of carbon, structure and impurity content.

As **the carbon content increases , the structure changes, the amount of ferrite decreases, the amount of perlite increases, and, accordingly, strength and hardness increase and plasticity decreases**

CLASSIFICATION OF STEEL BY SELTING METHOD

5. According to the method of smelting:

- in open- hearth furnaces ;
- in oxygen converters ;
- in electric furnaces: electric arc , induction , etc.

CLASSIFICATION OF STEEL BY PURPOSE

6. By appointment:

Structural (contains carbon up to 0.5%) - are used for the manufacture of machine parts and mechanisms;

Tool (contains carbon from 0.7% and above) - used for the manufacture of various tools;

Special - steels with special properties: electrical, with special magnetic properties etc. (stainless, corrosion-resistant, heat-resistant, heat-resistant, wear-resistant) .

PROPERTIES AND APPLICATIONS OF CARBON STEELS

The properties of carbon steels depend on their carbon content:

The **higher the percentage of carbon in steel, the higher its strength** . **The tensile strength of steel containing 0.15% carbon** is 32-40 kgf / mm ^{2} , and steel **containing 1% carbon** - up to 85-90 kgf / mm ^{2} , i.e., **the tensile strength more than doubles.**

In this regard, **low-carbon steels are used for less critical products** ,

and **more durable - instrumental - for the manufacture of surgical instruments that** play an important role in the process of surgical intervention.

Application examples of carbon steels (2)

Steel grades 15, 30, 45, containing 0.15, 0.30 and 0.45% carbon, respectively, are used for the manufacture of tool handles, screws, nuts.

Some dental instruments are made from steel 45 (round-nose pliers, pliers, etc.).

PROPERTIES AND APPLICATIONS OF CARBON STEELS (3)

Various types of tools **are produced from tool steel: cutting, measuring, including medical ones.**

For the manufacture of **medical devices, only high-quality carbon steels are used, which differ from ordinary steels in a lower content of harmful impurities—sulfur and phosphorus.** (no more than 0.02% sulfur and 0.03% phosphorus).

For example: tool steel U10A containing 1% carbon.

PROPERTIES AND APPLICATIONS OF CARBON STEELS (4)

Tool steels contain from 0.15 to 8.35% **manganese** and not more than 0.3% **silicon.**

For the manufacture of **surgical instruments, high-quality tool steel grades U7A, U8A, U10A and U12A are used.**

In the designation of these grades, the **number means the carbon content in tenths of a percent.**

*Sign **A distinguishes high-quality steel from ordinary*** and is affixed at the end of the designation of the steel grade.

PROPERTIES AND APPLICATIONS OF CARBON STEELS (5)

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

U7A - for the manufacture of **retractors , tweezers, forceps, clamps;**

U8A - for the manufacture of **saws, chisels, bone forceps, raspators, trocars;**

U10A - for the manufacture of **knives, scissors;**

U12A - for the manufacture **of eye knives** (U - carbon steel, 12 - carbon content, hundredths of a percent: 0.12%, A - high-quality steel).

ALLOY STEELS

When other components are added to steel in significant quantities (chromium, manganese, nickel), get **alloyed steel.**

Alloying is carried out in order to give steel the required properties.

Steel **with an alloy content of more than 10%** is referred **to as high-alloy steels, or steels with special properties.**

Thus, the addition of 13 to 18% chromium to steel sharply increases its corrosion resistance—such steels are referred to as stainless steels.

Classification of alloy steels

1. According to the structure after cooling in air, three main classes of steels are distinguished:

- pearlite;

- martensitic;

- austenitic .

Pearlitic steels are characterized by a **low content of alloying elements;**

martensitic - more significant content; **austenitic - high content of** alloying elements.

Alloy steel classification (2)

2. By the degree of doping (by the content of alloying elements):

low-alloyed - 2.5 ... 5%;

medium alloyed - up to 10%;

highly alloyed - more than 10%.

3. By the number of alloying elements:

three-component (iron, carbon, alloying element);

four-component (iron, carbon, two alloying elements) and so on.

Alloy steel classification (3)

4. By composition:

nickel, chromium, chromium-nickel, chromium-nickel -molybdenum and so on (a sign is the presence of certain alloying elements).

5. By appointment:

structural;

instrumental (cutting, measuring, stamping);

steels and alloys with special properties (pronounced properties **- stainless, heat-resistant and heat-resistant, wear-resistant, with special magnetic and electrical properties**).

ALLOYED STEELS. CLASSIFICATION OF STAINLESS STEELS

Stainless steels come in two grades:

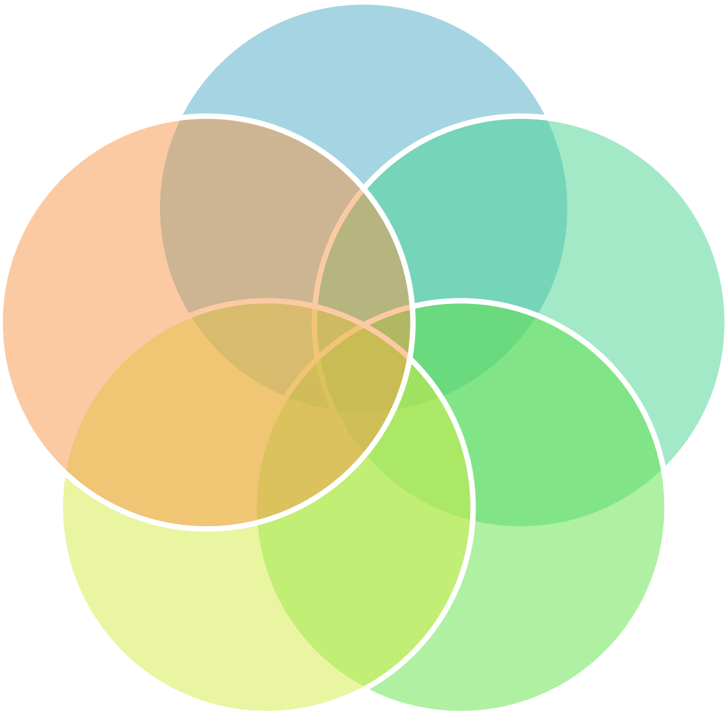
1) **hardenable, or martensitic class steels;**

2) non- **hardenable , or steel of the austenitic class.**

ALLOYED STEELS. CLASSIFICATION OF STAINLESS STEEL (2)

one) Hardenable, or martensitic steel
class:

In the manufacture of medical instruments, **hardenable stainless steels are used** for the manufacture of: **tweezers, hooks, needle holders, mirrors, chisels, forceps, raspators, scissors.**



20X13;

30X13;

40X13

(**40** is the **carbon content,**

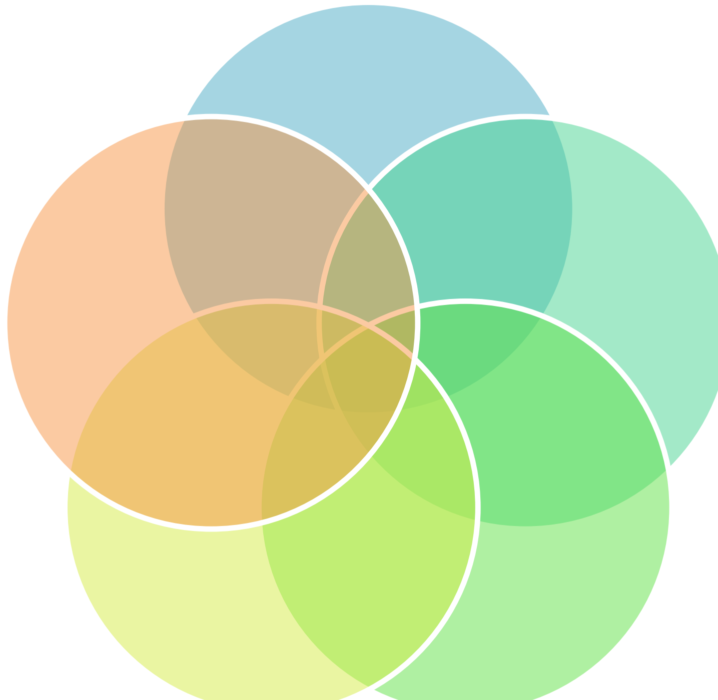
X - chrome ,

13 - percentage **of chromium**).

ALLOYED STEELS. CLASSIFICATION OF STAINLESS STEELS (3)

2) non- hardenable , or steel of the austenitic class:

From chromium-nickel steels, **dental crowns, sterilizer chambers, boiler bodies, etc. are made**
.



08X18H9

12X18H10

17X18H10T

(17 - carbon content,

X - chromium, 18 - percentage of chromium,

H - nickel, 10 - percentage of nickel,

T - titanium).

ALLOYING ELEMENTS (1)

The main alloying element is ***chromium*** *(0.8…1.2)%.*

It increases the **hardenability , contributes to obtaining a high and uniform hardness of steel.**

Cold brittleness threshold **chromium steels - (0 ... -100) *o* C.**

Additional alloying elements:

Boron - 0.003%. Increases hardenability and also increases cold brittleness threshold *(+20...-60 ^{o}C)* .

Manganese - increases hardenability , but promotes grain growth, and raises the cold brittleness threshold to *(+40 ... -60)*

Titanium *(~0.1%)* is introduced for grain refinement in chromium-manganese steel.

Introduction ***of molybdenum*** *(0.15 ... 0.46%)* in chromium steels **increases hardenability , reduces the cold brittleness threshold to -20 ... *-120 ^{o} C.***

Molybdenum increases the static, dynamic and fatigue strength of steel, eliminates the tendency to internal oxidation. In addition, molybdenum reduces the tendency for temper brittleness in steels containing nickel.

Additional alloying elements (2):

Vanadium in an amount of *(0.1 ... 0.3)%* in chromium steels refines the grain and increases strength and toughness.

nickel into chromium steels significantly increases strength and hardenability , lowers the cold brittleness threshold , but at the same time increases the tendency to temper brittleness (this disadvantage is compensated by the introduction of molybdenum into the steel). Chrome-nickel steels have the best set of properties. However, nickel is in short supply, and the use of such steels is limited. A significant amount of nickel can be replaced by copper, this does not lead to a decrease in toughness.

When alloying **chromium-manganese steels with** silicon, steels receive ***chromansil*** *(20HGS, 30HGSA)* . Steels have a good combination of strength and toughness, are well welded, stamped and machined. Silicon increases impact strength and thermal toughness.

Addition of lead, calcium - improves machinability. The use of hardening heat treatment improves the complex of mechanical properties.

Alloying elements have symbols:

High-quality and high-quality alloy steels have an alphanumeric designation.

Alloying elements have symbols . They are designated by the letters of the Russian alphabet.

Designations of alloying elements:
X - chromium, N - nickel, M - molybdenum, B - tungsten, K - cobalt, T - titanium, A - nitrogen (indicated in the middle of the brand), G - manganese, D - copper, F - vanadium, C - silicon, P - phosphorus, P - boron, B - niobium, C - zirconium, Yu - aluminum.

MARKING OF ALLOYED STRUCTURAL STEELS

Alloy structural steels:

At the beginning of the stamp, a two-digit number is indicated, showing the carbon content in hundredths of a percent.

alloying elements are listed below . The number following the symbol of the element shows its content as a percentage.

If the number does not stand, then the content of the element does not exceed 1.5%.

To designate high-quality alloy steels, the symbol A is indicated at the end of the grade.

MARKING OF ALLOYED STRUCTURAL STEELS(2)

The number after the letter indicates the content of the alloying element in tenths of a percent.

If the figure is not indicated, then the alloying element contains 0.8-1.5% , ***with the exception of molybdenum and vanadium*** (the content of which in salts is usually up to 0.2-0.3 ***%), as well as boron*** (in steel with the letter P it should be at least 0...0.010%).

In structural high-quality alloy steels, the first two digits show the carbon content in hundredths of a percent.

Example 1: **03Kh16N15M3B is a high-quality high-alloy steel that contains 0.03% C, 0.16% Cr , 0.15% Ni , up to 0.3% Mo , up to 1.0% Nb .**

Example 2: **steel 15Kh25N19VS2. The specified steel grade contains 0.15% carbon, 35% chromium, 19% nickel, up to 1.5% tungsten, up to 2% silicon.**

CAST IRON. General characteristics, types.

Cast iron is an alloy of iron and carbon, in which the carbon content is greater than 2.14%.

In addition to carbon and iron, impurities are present in the alloy : silicon, manganese, phosphorus, sulfur , **etc.** These impurities have a significant effect on the formation of the alloy structure and, consequently, on the mechanical, physical, and other properties of cast iron.

Depending on the form in which carbon is present in alloys, there are:

- white

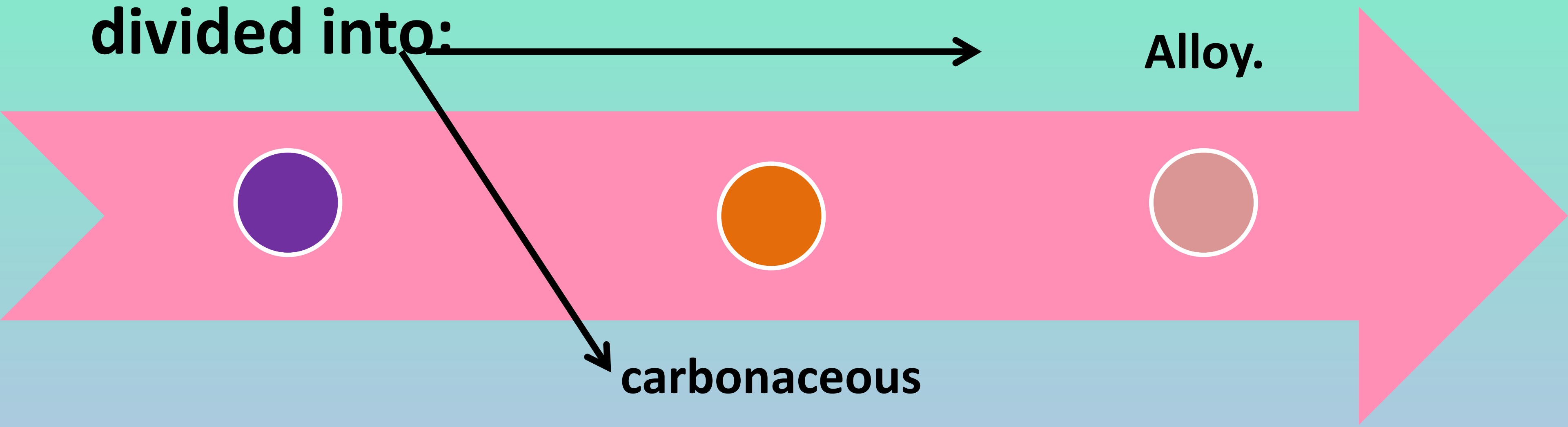
- gray

- malleable

- high-strength cast irons.

CAST IRON. General characteristics, types.

According to the chemical composition, cast iron is divided into:



The chemical composition of cast iron

The main elements in cast irons are Fe-C-Si

and permanent impurities - Mn , P, S.

Silicon - has a strong graphitising effect

Manganese - hinders graphitization .

Sulfur is a **harmful impurity that worsens the casting and mechanical properties of cast irons.**

Phosphorus is a **useful impurity in cast irons, as it improves fluidity** . Phosphide eutectic sites increase the hardness and wear resistance of cast iron. **Most often, the phosphorus content is in the range of 0.2 ... 0.5%.**

For castings that **require high wear resistance, the phosphorus content is allowed to be 0.7%, and for artistic casting - up to 1%.**

ALLOYED CAST IRON

Alloyed cast iron contains, **in addition to conventional elements, special additives to improve mechanical or special properties: wear resistance, heat resistance, corrosion resistance, etc.**

All **alloying elements change the graphitization process , and fine graphite and a more dispersed base are formed.**

High-alloy cast irons have, as a rule, an austenitic structure.

They are non-magnetic, have high heat resistance, corrosion resistance in alkalis, sulfuric, formic, acetic acids, caustic soda, in sea water, are less stable in hydrochloric acid and are quickly destroyed in nitric acid.

COLORED METALS

ALUMINUM AND ITS ALLOYS

As a structural material, aluminum alloys are much more often used. They are characterized by high specific strength, ability to resist inertial and dynamic loads, and good manufacturability . The ultimate strength reaches 500…700 MPa. Most have **high corrosion resistance (with the exception of alloys with copper.)**

The main alloying elements of aluminum alloys are Cu , Mg , Si , Mn , Zn , less often Li , Ni , Ti .

Many form with aluminum solid solutions of limited variable solubility and intermediate phases $CuAl_2$, Mg_2Si, etc. This makes it possible to subject alloys to hardening heat treatment. It consists of quenching to a supersaturated solid solution and natural or artificial aging.

On a technological basis, aluminum alloys are divided into two groups: **wrought, cast.**

WORKABLE ALUMINUM ALLOYS

Wrought alloys , **not hardened by heat treatment.**

These alloys **are characterized by high ductility, good weldability and high corrosion resistance** . Plastic deformation strengthens the alloys by almost a factor of 2.

This group of alloys includes **grades AMts (1.1 ... 1.6% Mn), AMg2, AMg3, AMg5, AMg6** (the number shows the magnesium content as a percentage).

WORKABLE ALUMINUM ALLOYS (2)

Deformable alloys hardened by heat treatment.

The most common representatives **of the group of aluminum alloys, used in a deformed form and hardened by heat treatment, are duralumins** (from the French dur - hard).

These include alloys of the Al - Cu - Mg - Mn system .

Typical duralumins are grades D1 and D16.

COPPER ALLOYS

In the manufacture of medical instruments and **equipment, copper alloys are most common (copper has high electrical and thermal conductivity, high corrosion resistance, and is well polished).**

***Copper Alloys: Brass* is an alloy of copper and zinc.** Most widely used in the medical industry **(sterilizers, bougies, catheters, probes** , etc.)

Bronzes : **tin** - if necessary, high corrosion resistance in combination with strength (sterilization -distillation equipment) and **tin -free** - have high mechanical, anti-corrosion and other properties.

***Nickel silver* is an alloy of copper with zinc, nickel and cobalt** (high corrosion resistance - cannulas, eye spoons, Voyachek probes).

ALLOYS OF TITANIUM, MAGNESIUM

Titanium and its alloys: contain **aluminum, molybdenum or vanadium** . **Material for medical instruments** (low specific gravity, high mechanical properties, corrosion resistance).

There is a good **germination of bone tissue in titanium implants, the instruments do not need to be coated.**

Magnesium and its alloys: have a low density with high mechanical properties.

High corrosion resistance and good workability by pressure.

They are used for the production of products for optical devices and electromedical equipment.

ALLOYS OF LEAD, ZINC

Lead : **has low permeability to X-ray and radioactive radiation, high plasticity.**

Used in chemical equipment for linings, tanks, bathtubs, gutters, pipelines.

Zinc: **has a low melting point, good casting properties, high resistance to air and fresh water.**

Used for anti-corrosion coatings and protectors of iron, steel, and other metals.

ALLOYS OF OTHER METALS (PRECIOUS)

Gold, silver, platinum:

used for the manufacture of **medical products (chemical glassware, thermocouples, solders, contacts** , etc.).

Silver is used in the production of certain types of ophthalmic and dental instruments .

Platinum is used to make the most **accurate resistance thermometers, as well as surgical needles** .

PRECISION ALLOYS

Precision alloys: - metal alloys with special physical properties (magnetic, electrical, thermal, elastic).

Created on the basis **of iron, nickel, cobalt, copper, niobium.**

They are indispensable in the manufacture of units of especially sensitive instruments and installations, experimental equipment, sensors.

CORROSION AND PROTECTIVE AND DECORATIVE COATINGS

Corrosion is understood as the destruction of a material due to exposure to the external environment.

Corrosion of metals and products from them has a **chemical or electrochemical nature.**

Corrosion of non-metallic materials (organic and synthetic **) is caused by microorganisms and is called microbiological corrosion, or biocorrosion** .

Corrosion is usually accompanied by changes in the appearance of products, since it begins with surfaces that are in direct contact with the external environment.

Chemical corrosion is the result of exposure to the metal of various chemicals with the formation of chemical compounds on its surface, i.e., corrosion products.

So, carbon steel products are covered with rust, which is iron hydroxide; products made of copper and its alloys turn green, covered with copper oxides and salts.

CORROSION AND PROTECTIVE AND DECORATIVE COATINGS (2)

All metallic materials undergo corrosion to some extent over time, but its degree depends on the **resistance of metals in certain environments.**

So, **aluminum and its alloys in the air are** covered with a thin **film of oxide** , which protects them from further damage, however, **under the action of alkaline solutions, the corrosion process is accelerated many times over.**

The need to protect medical products from corrosion is caused by the fact that these products undergo thermal or chemical sterilization or treatment with antiseptic solutions before use.

In addition, medical devices come into contact with aggressive corrosive media in the form of pus, blood, etc., which accelerate corrosion processes.

CORROSION AND PROTECTIVE AND DECORATIVE COATINGS (3)

To increase the service life of products, it is necessary to protect them from corrosion by one method or another, depending on the operating conditions.

Various coatings are used for this purpose.

No need for additional protective coating: **noble metals and some stainless steels, the surface of which must be well polished** to increase corrosion resistance .

CORROSION AND PROTECTIVE AND DECORATIVE COATINGS (4)

To protect medical products and their metal parts from corrosion, three types of coatings are used:

- metal

- non-metallic inorganic

- non-metallic coatings with paints and varnishes.

CORROSION AND PROTECTIVE AND DECORATIVE COATINGS (5)

Metallic coatings . In order to protect against corrosion , medical instruments made **of carbon steels and brass are usually coated with a layer of nickel or chromium, or both at the same time, using the galvanic method.**

At the same time, it is taken into account that the appearance of the coating must correspond to the functional purpose of the products.

CORROSION AND PROTECTIVE AND DECORATIVE COATINGS (6)

can be **glossy or matte** .

Matte **nickel plating is not used** , as it does not give the product a good decorative look.

Chrome plating is performed both shiny and matte. In recent years, matte black chrome has become quite widespread .

For metal coatings there is GOST:

- installing multilayer coatings for steel products (copper + nickel + chromium);

- **operating conditions for coated products** are divided into four groups: **light, medium, hard and very hard.**

CORROSION AND PROTECTIVE AND DECORATIVE COATINGS (7)

Medical devices are exposed to very aggressive substances during operation.

For products that have contact with body tissues, medicines, drugs and are subject to disinfection, pre-sterilization cleaning and sterilization **, a special group of operating conditions has been established: M-1.**

It includes **all surgical instruments** .

CORROSION AND PROTECTIVE AND DECORATIVE COATINGS (8)

The thickness of the coating for surgical instruments is prescribed taking into account the operating conditions:

- **surgical needles are coated with a minimum layer of chromium of 1-5** microns,

- **knives and scalpels - with a chromium layer of 3-6 microns ,**

- **the rest of the instruments are covered with a layer of nickel (12 μm) and chromium (3 μm).**

Nickel coatings are supplemented with chromium coatings due to the fact that it tends to tarnish, and also to reduce the porosity of the coating, since the pores of the nickel coating are blocked by a layer of chromium.

CORROSION AND PROTECTIVE AND DECORATIVE COATINGS (9)

Equipment parts that are **operated in a humid environment are coated with tin (tinned) or zinc** , and brass parts are coated with a layer, tin directly, and the rest are pre-coated with a layer of nickel (3 microns) and copper (10 microns).

Details of disinfection equipment exposed to steam-formalin and other mixtures used in disinfection chambers are **coated with a layer of zinc up to 42 microns.**

To protect **parts of medical equipment** , as a rule, **a three-layer coating (copper + nickel + chromium) with a total layer thickness of 24 to 40** microns, or a two-layer coating (nickel + chromium) - up to 18 microns is used.

To cover **some products (tracheotomy tubes, spectacle frames, etc.)** , **noble metals are used - silver and gold.**

CORROSION AND PROTECTIVE AND DECORATIVE COATINGS (10)

Metallic and non-metallic inorganic coatings

They consist of **inorganic metal compounds (oxide, oxide-phosphate, phosphate, etc.)** and are obtained **by chemical processing of products.**

Oxide films on steel products are **black in color and are used on instruments, including stainless steel, designed for operating under a microscope** (a set for operations on otosclerosis), as well as **on light-absorbing surfaces of parts of optical instruments** . These films are obtained by oxidation, i.e. processing in a boiling solution of alkalis (temperature 135-145 ° C): caustic soda NaOH , sodium nitrite Na_2NO_3 (or trisodium phosphate Na_2PO_3). **The oxide coating has low protective properties. These properties are enhanced when the coating is treated with neutral oils.**

Oxidation of non-ferrous metals (parts made of copper and its alloys, tools made of titanium). **Titanium alloy** tools are **electrochemically** oxidized **in an electrolyte** containing oxalic acid at normal temperature by applying direct current. The color of the resulting film depends on the grade of the alloy and can vary from light green with a reddish tint to dark gray with a greenish tint.

CORROSION AND PROTECTIVE AND DECORATIVE COATINGS (11)

Protective and decorative oxide films on aluminum and its alloys are obtained by anodizing , that is, by processing in an electrolytic bath containing a solution of sulfuric acid (180-200 g per 1 liter of water) at normal temperature. The oxide film obtained in this way can be dyed in various colors (black, blue, light green, red and yellow, as well as the color "gold"), as it easily adsorbs organic and inorganic dyes. **Anodizing provides protection for products operating in a water vapor environment, as well as against atmospheric corrosion.**

Wear-resistant anodic oxide coating , which is characterized by high hardness (770 kgf/mm ^{2}) and high **abrasion** resistance, especially when impregnated with lubricating oils , has found application for parts of medical products . Its color is dark gray to black.

CORROSION AND PROTECTIVE AND DECORATIVE COATINGS (12)

To improve the **corrosion resistance of parts coated with zinc and cadmium, especially for tropical conditions, these parts are subjected to phosphating** . Phosphate coatings are films of insoluble zinc phosphate salts firmly adhered to the metal surface. The film is painted in a gray-smoky color and has a fine-grained structure.

The disadvantages of this coating include the fact that fingerprints are stored on it.

CORROSION AND PROTECTIVE AND DECORATIVE COATINGS (13)

Surface treatment.

Electroplated coating obtained in electrolytes without special additives, as a rule, turns out to be matte. It does not have a good enough decorative appearance, it is easily soiled and poorly cleaned.

To give the coating a decorative look, it is polished.

A brilliant coating can be obtained mechanically, chemically or electrochemically, as well as in special electrolytes with the addition of brighteners .

NON-METALLIC MATERIALS

non-metallic materials. Classification. general characteristics

Non-metallic structural (and other) materials are a large group of materials made from organic and inorganic (mineral) raw materials .

Organic raw materials include wood and products from it, wool, fibers, bone, rubber, etc.,

to inorganic raw materials - gas, oil, air, water, diamond, clay, quartz, marble and various rocks.

Each type of raw material is used to produce a **large group of non-metallic structural materials used in various industries, agriculture, transport, medicine, culture, food industry, everyday life, etc** .: **plastics, laminates, glass, dyes, adhesives, varnishes, paper, cardboard, woolen and cotton threads and fabrics, building structures made of wood, blanks for furniture, plywood, art products made of bone and horn, etc.**

Classification of non-metallic materials

1. Inorganic materials:

1.1. Synthetic (artificial) : - minerals; - gases ; - inorganic chemicals.

1.2. Silicate materials: - glass; - ceramics (faience, porcelain).

1.3. Natural: - minerals; - gases .

2. Organic materials:

2.1. Natural: - animal materials (polymers, oligomers, monomers); - vegetable (polymers, oligomers, monomers).

2.2 Synthetic (artificial): - monomers; - oligomers; - macromolecular compounds.

POLYMERS. PLASTICS

GENERAL CHARACTERISTICS OF POLYMERS

By origin, polymers can be:

natural (proteins, polysaccharides, cellulose, starch, natural rubber, mica, asbestos, natural graphite)

synthetic (synthesized macromolecular substances obtained by polymerization or polycondensation (synthetic resins, fibers, rubbers, etc.).

GENERAL CHARACTERISTICS OF POLYMERS

The leading group of polymers used are synthetic polymers.

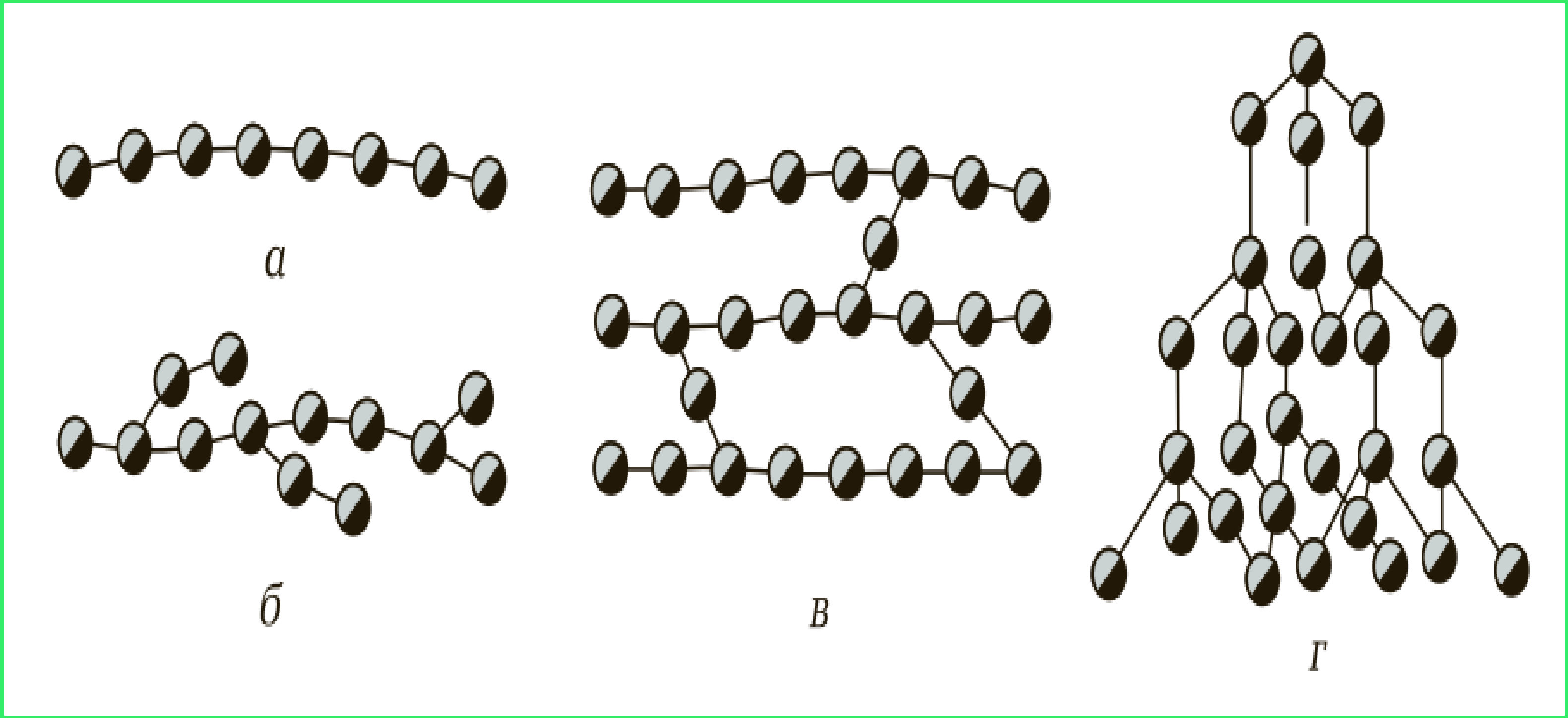
Because **macromolecules form chains** consisting of individual links and **extending in length over distances thousands of times greater than their transverse dimensions, macromolecules are characterized by flexibility** (which is limited by the size of segments - rigid sections consisting of several links).

The flexibility of macromolecules is one of the distinguishing features of polymers.

GENERAL CHARACTERISTICS OF POLYMERS

- **There are linear, linearly branched, network and spatial structure of polymer molecules.**

- **Rice. The structure of polymer molecules** : *a - linear;*
- *b - linearly branched;*
- *in - mesh; d - spatial*



GENERAL CHARACTERISTICS OF POLYMERS

According to the chemical structure of the main chain, homochain and heterochain polymers are distinguished.

Macromolecules of homochain polymers in the main chain contain the same atoms (carbon, silicon, sulfur, phosphorus, etc.). A characteristic representative of this group are *carbochain polymers, the main chain in the molecules of which consists of carbon atoms* .

In the macromolecules of heterochain polymers, the main chain contains various atoms.

Polymers can only exist in two states of aggregation (solid and liquid). The transfer of polymer macromolecules to a gaseous state without breaking the bonds of the main chain is impossible.

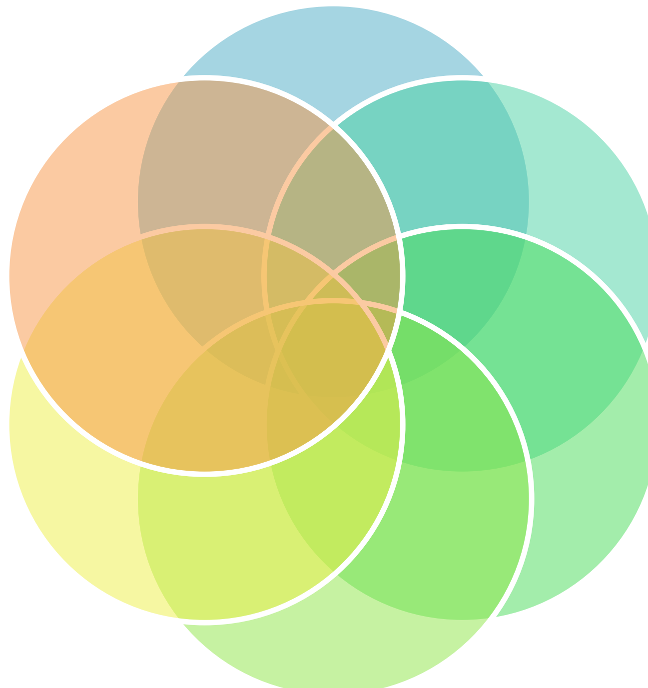
Classification of polymers

Classification of polymers (according to various criteria based on the relationship composition - structure - properties), according to:

- in relation to heating

and etc.

- composition



- polarity

- the shape of macromolecules

- phase state

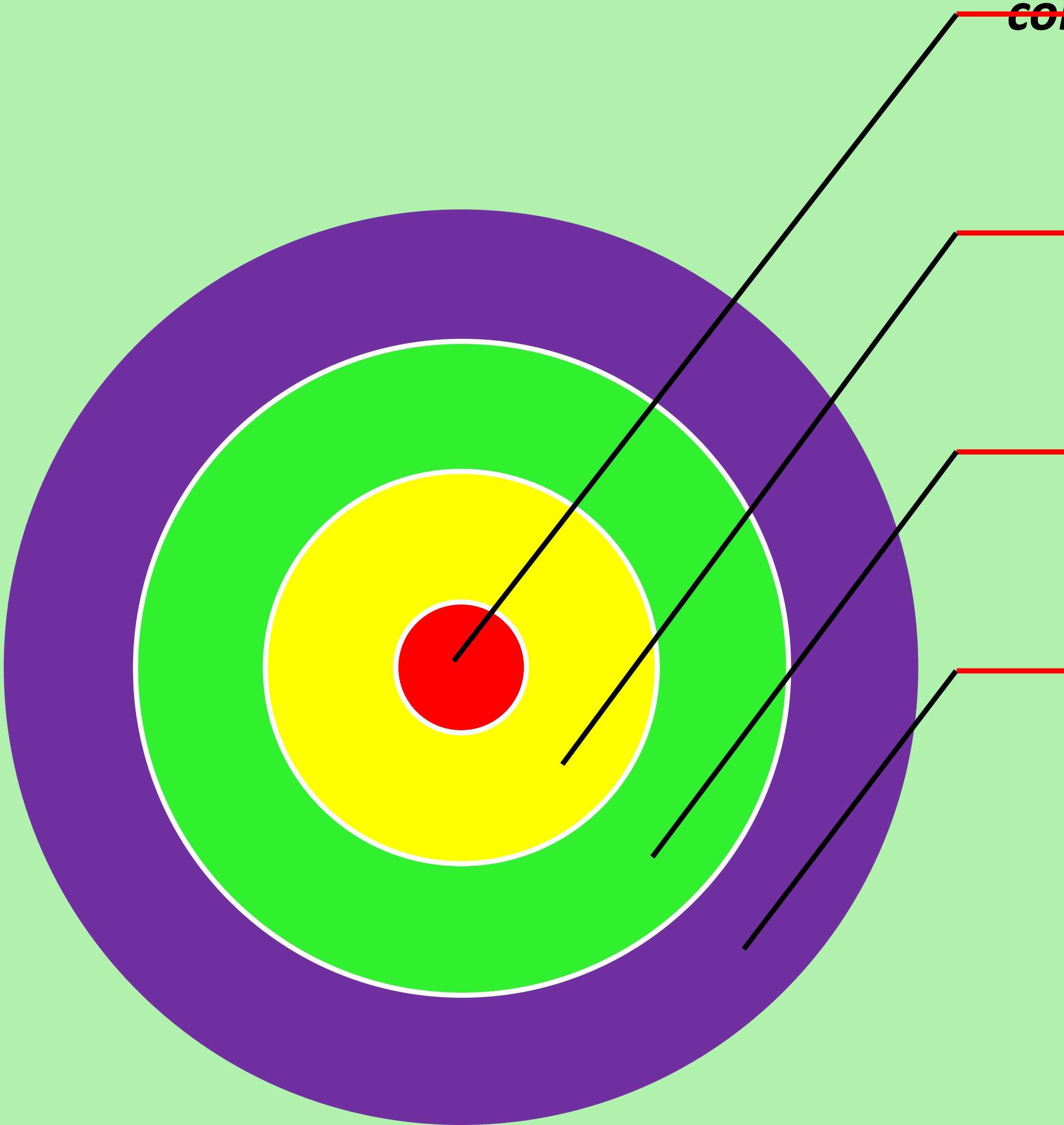
Classification of polymers

According to their composition, **polymers are divided into:**

- organic

- organoelement

- inorganic .



INORGANIC POLYMERS

Inorganic polymers:

Inorganic polymers ***include silicate ceramics, mica, asbestos*** . **These compounds lack a carbon skeleton.**

The basis of inorganic materials is oxides of silicon, aluminum, magnesium, calcium, etc.

There are two types of bonds in silicates: the atoms in the chain are connected by covalent bonds (Si –O), and the chains are connected by ionic bonds.

Inorganic polymers are characterized by high density and high long-term heat resistance. However, glasses and ceramics are brittle materials and do not withstand dynamic loads well. Inorganic polymers include graphite, which is a carbon chain polymer.

GENERAL CHARACTERISTICS OF PLASTICS

Plastics (plastics) are *polymer -based organic materials* that can soften when heated and take on a certain stable shape under pressure.

Polymer (**from the Greek words poly - many and meros - share, part) - a compound with a high molecular weight, the macromolecules of which consist of a very large number of simple, identical, repeating units (monomers) or repeating groups.**

The molecular weight of the polymer may be from 5,000 to 1,000,000 amu . With such large sizes of macromolecules **, the properties of substances are determined not only by the chemical composition of these molecules, but also by their mutual arrangement and structure.**

Classification of plastics according to the method of processing into products

According to the method of processing into plastic products subdivided into:

- casting

- pressing.

Injection moldings are processed into products by injection molding methods and are thermoplastic

Pressing materials are processed into products by hot pressing and are thermosetting

Classification of plastics by purpose

By purpose, plastics are divided into:

- structural *,*

- chemically resistant *,*

- gaskets and seals,

- friction and anti-friction,

- heat-insulating and heat-shielding,

- electrical insulating,

- optically transparent *,*

- facing and decorative and finishing .

Classification of polymers by phase state

According to the phase state, **polymers are divided into:**

- ***amorphous***

- *crystalline* .

Amorphous polymers are single-phase .

The structures in these polymers are fluctuating , thermodynamically unstable and characterized by a relatively short period of existence . The amorphous phase reduces the rigidity of the system and makes it elastic. This property is used in some technological processes to increase the elasticity of products by rapidly cooling (quenching) the polymer melt.

Classification of polymers (plastics) according to the state during heating and after cooling

All polymers, according to the state during heating and after cooling, are divided into ***thermoplastic*** and ***thermosetting*** .

Thermoplastic polymers (thermoplastics) are ***polymers that soften when heated, even melt, and harden when cooled, without undergoing any chemical transformations (this process is reversible).*** This behavior of polymers is explained by the fact that weak intermolecular bonds are destroyed during heating, while covalent bonds are preserved. This circumstance makes it possible to repeatedly process thermoplastics. Thermoplastics have increased plasticity, but low heat resistance, and are soluble in solvents.

Thermoset polymers (thermosets) are *polymers that, when heated, undergo irreversible chemical transformations, as a result of which they harden, losing solubility and the ability to change shape.* These polymers do not soften with increasing temperature, but break down when a sufficiently high temperature is reached. Thermoplastics are insoluble and can only swell in solvents.

Types of thermoplastics

Unfilled plastics are most often thermoplastic materials

.

Polyethylene (-CH2-CH2-) n is a colorless gas polymerization product - ethylene. One of the lightest materials (density 0.92 g / cm³), has high elasticity, chemical resistance, frost resistance. Disadvantages - susceptibility to aging and low heat resistance (up to 60 ° C). It is used for making film, wire insulation, making corrosion-resistant pipes, sealing parts. It ranks first in the total production of plastics.

Polypropylene (-CH2-CHS6H5-) n is a propylene gas polymerization product . By properties and application it is similar to polyethylene, but more heat-resistant (up to 150 °C) and less frost-resistant (up to 10 °C).

Types of thermoplastics(2)

Polyethylene is a white elastic material obtained from ethylene (a colorless gas) by a polymerization reaction. **Depending on the degree of pressure during the polymerization reaction, polyethylene of high, medium and low pressure is distinguished.**

High density polyethylene has low density, hardness, lower tensile strength and low heat resistance. At a temperature of 115 °C, the crystallinity decreases and polyethylene becomes amorphous. Shrinkage during cooling of high-density polyethylene is approximately 5%. Medium and low pressure polyethylene has high crystallinity, heat resistance, density, tensile strength, it is more resistant to acids and solvents and less gas permeable. During cooling, shrinkage is 1.0 ... 2.5%. Polyethylene has high dielectric properties.

Polyethylene is processed into products by extrusion, injection molding, pressing and stamping.

Types of thermoplastics (3)

Thermoplastics based on vinyl chloride polymers and copolymers have also found wide application.

Polyvinyl chloride (PVC) is obtained by polymerization of vinyl chloride. During heat treatment on rollers or floor presses, a solid material is obtained - sheet ***vinyl plastic*** . Extrusion of vinyl plastic produces pipes and sheet or block material.

Viniplast has high mechanical strength and high chemical resistance.

Plasticized PVC is called ***plastic compound*** , which is used to make abrasion-resistant linoleum and is used to make sheaths of electrical cables, haberdashery, etc.

Types of thermoplastics (4)

Polystyrene (-CH2-CHS6H5-) n is a hard, rigid, transparent polymer.

It has very good electrical insulating properties. Its disadvantages are low heat resistance, a tendency to aging and cracking.

Polystyrene is a synthetic polymer belonging to the class of thermoplastics. It is a polymerization product of vinylbenzene (styrene). It is a hard glassy material. **The general formula for polystyrene is as follows: [CH2CH(C6H5)]n. In an abbreviated version, it looks like this: (C8H8)n.**

LAYERED PLASTICS. GRP

Fiberglass - structural materials based on polymers on a fiberglass or fiberglass basis.

Depending on the type of binder and filler, technological regimes, properties and methods of processing the material into products, glass-reinforced plastics are divided into two groups:

- fiberglass based on phenol-formaldehyde, organosilicon, urea and other resins , requiring high temperatures (180 ° C and above) and pressure (250 ... 1,000 MPa (25 ... 100 kg / cm2) for processing into products).

- fiberglass based on unsaturated polyester and epoxy resins is obtained by "cold" curing at normal temperatures by contact method without pressure.

POLYMERS IN MEDICINE

Requirements for polymers in medicine

The main characteristics that play a decisive role in assessing the possibility of using polymers for medical devices:

- the presence of the necessary complex of physical, chemical and mechanical properties; high purity and homogeneity of the material;

- the possibility of processing into products without decomposition and isolation of low molecular weight products;

- the absence of irritating, toxic, carcinogenic effects on living organisms, both the polymers themselves and the products present in the material or formed during its storage and operation;

- the ability to withstand sterilizing treatment by various methods and means.

Requirements for polymers in medicine (2)

The polymer material, before being approved for use in medical practice by the Ministry of Health, undergoes a long and comprehensive test.

The defining and main property of such material is biological harmlessness (lack of toxicity, carcinogenicity, irritating effect on tissues in contact with it).

Polymeric materials must be biologically compatible with contact tissues and indifferent to the organism as a whole. Polymeric material and medicinal products made from it should not cause undesirable reactions (including allergic ones) on the part of the patient's skin.

The implant must also have chemical resistance, not break down or be subjected to minimal destruction in the environment of a living organism with the release of monomers and other degradation products. It is unacceptable that the implant contains toxic soluble components capable of migration (penetration) into the tissue fluid of the body.

Requirements for polymers in medicine (3)

Of particular importance is the toxicological evaluation of polymeric materials used in medicine in conditions of direct contact with a living organism. Products of thermal and thermal- oxidative degradation can be present in the material in adsorbed form and have a toxic effect on the body, which is not directly related to the chemical nature and structure of the original polymer.

The blastomatous effect (the occurrence of malignant tumors) of polyvinyl chloride , fluoroplastic, polyacrylates , polyamides, organosilicon rubber was observed only on small animals (rats, mice, hamsters, guinea pigs), in a similar way manifested themselves under these conditions such inert materials as glass, precious metals. It has also been established that the implantation of polymers in the form of powder or perforated plates does not cause tumors and has a weak blastomatous effect.

The blastomogenic effect of bioinert polymers is due not to their chemical nature, but to mechanical long-term irritation of the walls of the connective tissue capsule that occurs around the implanted material and disruption of normal metabolism in it.

Requirements for polymers in medicine (4)

The polymeric material should be easily processed into products in simple and relatively cheap ways.

Of great importance is the availability of the used polymeric materials and their cost, which affects the economic efficiency of the use of polymers in comparison with traditional materials.

The possibility of processing in order to comply with the rules of sanitation and hygiene without changing the properties and shape creates additional restrictions in the choice of materials.

Many plastics cannot be used to make syringes because they deform during high-temperature sterilization.

POLYMER APPLICATIONS IN MEDICINE (1)

High density polyethylene -

- parts of medical devices and instruments, parts of blood transfusion systems, patient care items, laboratory equipment, piston rods for single-use syringes, tips for bowel lavage devices, tracheotomy tubes.

Polyethylene of low density -

- soft containers for various purposes, connecting tubes and parts in blood transfusion equipment and in artificial organs, syringe tubes, material in the form of a film for packaging disposable products, intrauterine contraceptives, test tubes for microbiological research, parts of oxygen-respiratory equipment, prosthetic orthopedic products; catheters for various purposes.

POLYMER APPLICATIONS IN MEDICINE (2)

Polyamides

Brands: PA 6-110. PA 6-210/311, PA 6-210/310) - body parts of medical devices, tracheotomy tubes, funnels, spatulas, parts of oxygen-respiratory equipment, spectacle frames, transitional cannulas

Marks: PA-1210 - Details of syringes, cannulas for injection needles. Spatula for pushing the insides, clamps for electrocoagulation instruments.

Polymethyl methacrylate

Brands: ST-1, LSO-M. Dacria , LPT - 1 - droppers and parts of blood transfusion systems, tablets and chambers for immune responses, products for keratoprosthetics , lenses for corrective and protective glasses, contact lenses.

POLYMER APPLICATIONS IN MEDICINE (3)

Compounds based on polyvinyl chloride:

Brands: T-35, - Details of blood collection and transfusion systems, blood substitutes, lines to AIC and AIP, containers for washing erythrocytes, containers for storing blood and biological products;

PM - 1/42 - Catheters ureteral, urethral, otolaryngological, for hemodialysis, bougies, air ducts, sheaths of venoextractors , tubes and cannulas;

Grade L-172 - Details of blood transfusion systems, heads of intravenous catheters.

PVC plastisol:

Cuffs, liners, cannulas for anesthesia catheters, parts of an oxygen supply catheter.

POLYMER APPLICATIONS IN MEDICINE (4)

Polypropylene:

Marks: 01002, 01003, 01005, 01010, 01020 - Parts of medical devices and devices, handles, adapters, cannulas for needles and parts of disposable syringes, bougies and probes, handles of surgical instruments and gynecological devices, containers and packaging for sterile and non-sterile drugs funds.

TU6-05-1756-78: Bodies of valves, clamps, adapters, connecting sleeves, parts of roller pumps

Polystyrene:

Brands: PS MD, PSMM, PSS - Disposable injection syringes, laboratory glassware for biochemical research, containers and packaging for sterile and non-sterile medicines (except for liquid ones), details of oxygen-respiratory equipment.

Brands: NSM-111, PSM-115, PSM-118 - Tablets for immune responses, laboratory glassware

POLYMER APPLICATIONS IN MEDICINE (5)

Polystyrene (continued):

Brands: UPM-03l, UPM-0503, UPM-0508, UPM-0612l, UPS-0803l, UPS-1104 equipment, covers, cases for inhalers, phonendoscopes, instruments, containers and packaging for medicines (except for liquid ones)

Brand: PS - S - Disposable syringes, devices for taking liquids, glasses for sunglasses.

POLYMER APPLICATIONS IN MEDICINE (6)

Styrene copolymers:

- with impact-resistant methyl methacrylate - Marks: MPS-M - Parts for AIP, needles for puncturing plugs

- with butadiene with isoprene - Brands: DST-30 - Esophageal bougie; Catheter and drainage tubes , intestinal probes, endoscope sheaths (TU38-40-352-78).

Poly-4-methyl-pentene-1:

Brands: 202-02, 202-05, 203-02, 203-05, 205-05 - Disposable syringes, containers and packaging for medicines.

The use of polymers in medicine. Fluoroplastics

Ftoroplast-3 - Details of oxygen-respiratory equipment

Ftoroplast-4D, Ftoroplast-4 - Cannulas, shunts, containers for low-temperature preservation of the bone marrow, parts of oxygen-respiratory equipment, parts of heart valves, medical felt for endoprosthetics, bougie for probing the bile ducts, tubes for electrodes

Fluoroplast-4DM - Tubes for cytoresectoscope , catheters for stone extractors

Fluoroplast 6-30l - Containers for the preservation of tissues and organs, capping for medicines.

Fluoroplast-42 - Membranes for AIC

Bioinert polymers (1)

One of the first problems that surgeons and developers of polymeric materials **intended for endoprosthetics had to solve was the creation of bioinert polymers, i.e. polymers that do not have a toxic effect on the body and do not change their physical and chemical properties under the influence of the environment of the body.**

To date, there is considerable experience in studying this group of materials, which in some cases have already found practical application in reconstructive surgery (artificial blood vessels, heart valve prostheses, artificial joints).

Bioinert polymers (2)

As bioinert polymers that best meet operational requirements, the following are used:

polyolefins (polyethylene, polypropylene, poly4-methylpentene-1),

fluorinated polyolefins (fluoroplastics),

silicone polymers of the siloxane type ,

some polyesters (polyethylene terephthalate, polycarbonate).

Biocompatible polymers

so-called **"biocompatible" polymeric materials for reconstructive surgery, i.e. materials that provide a gradual combination with the tissues of the body and are placed in the body only for the period of restoration of the functions of tissues or organs.**

Such materials **, in contrast to bioinert ones, should be able to undergo destructive and metabolic transformations under the influence of biological media and be gradually replaced by body tissues.**

Ideally, **biocompatible polymeric materials should temporarily perform the functions of tissues lost as a result of surgical intervention, not interfere with their regeneration, and after completion of this process , be excreted from the body in the form of metabolic products.**

Biocompatible polymers (2)

In the process **of gradual combination of tissues with a polymeric material, neither the material itself nor the products of its biodegradation should have a negative effect on the surrounding tissues and the organism as a whole** , or, in any case, this effect should not go beyond acceptable limits.

from **biocompatible polymers for defective organ walls or entire hollow organs, such as trachea, esophagus.**

Biocompatible polymers (3)

The use **of elements in the form of sheets or thin films that can be gradually absorbed in the body** , applied to the resected areas of internal organs, **provides the necessary tightness of the wound surface, reduces or completely eliminates the risk of adhesions.**

Important **features of such connecting elements are minimal injury and deformation of the tissues adjacent to them,** which creates good prerequisites for the restoration of organ functions.

Biocompatible polymers (4)

In combination with a bioinert base, biocompatible polymers can be used to create artificial vessels.

From biocompatible polymers, various connecting elements have already been created and will be developed, allowing a fundamentally new way to solve the problem of connecting segments of hollow organs (vessels, intestines, esophagus) to each other, as well as connecting them to prostheses .

The use of foaming biocompatible materials for filling residual cavities in the body is promising in operations on the lungs, filling fistulas, cavities, empyema, cavities, and in a number of other cases.

Fibers from biocompatible polymers are used as absorbable sutures.

Biocompatible materials include polymer adhesives that are promising for use in surgery.

RUBBER

RUBBERS. GENERAL CHARACTERISTICS. CLASSIFICATION

Rubber is a product of special treatment (vulcanization) of a mixture of rubber and sulfur with various additives.

Rubbers are polymers with a linear structure and, during vulcanization, are converted into highly elastic rare- mesh materials - rubbers.

Vulcanization *is* the transformation of rubber into rubber, carried out with the participation of so-called vulcanizing agents and under the influence of ionizing radiation.

RUBBERS. GENERAL CHARACTERISTICS. CLASSIFICATION

Sulfur and other substances serve as vulcanizing additives. **With an increase in the content of the vulcanizer (sulfur), the network structure of the rubber becomes more frequent and less elastic.**

At maximum saturation with sulfur (30–50%) get **hard rubber (ebonite)** ,

when saturated with **sulfur 10-15% - semi-solid rubber.**

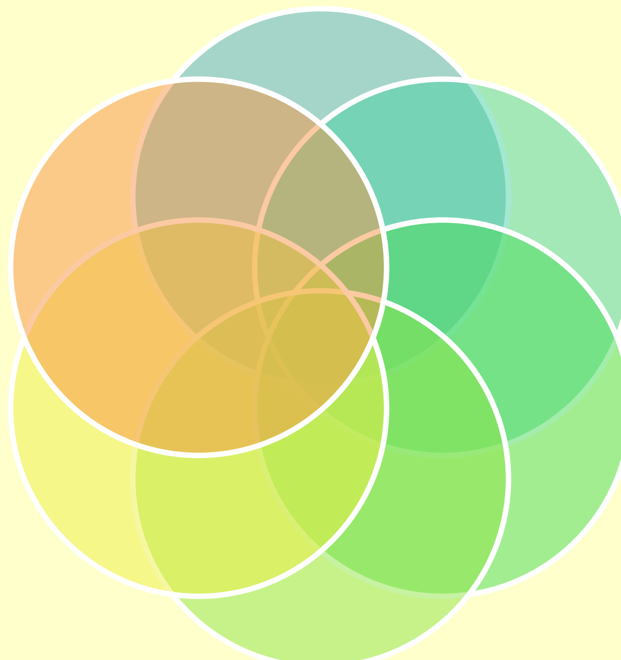
Typically **, rubber contains 5–8% sulfur.**

RUBBERS. GENERAL CHARACTERISTICS. CLASSIFICATION

Rubber materials are classified according to:

- types of thermal aging and volume change after exposure to petroleum fluid.

- type of raw material



- ecological methods of processing

- type of filler

- degree of ordering of macromolecules and porosity

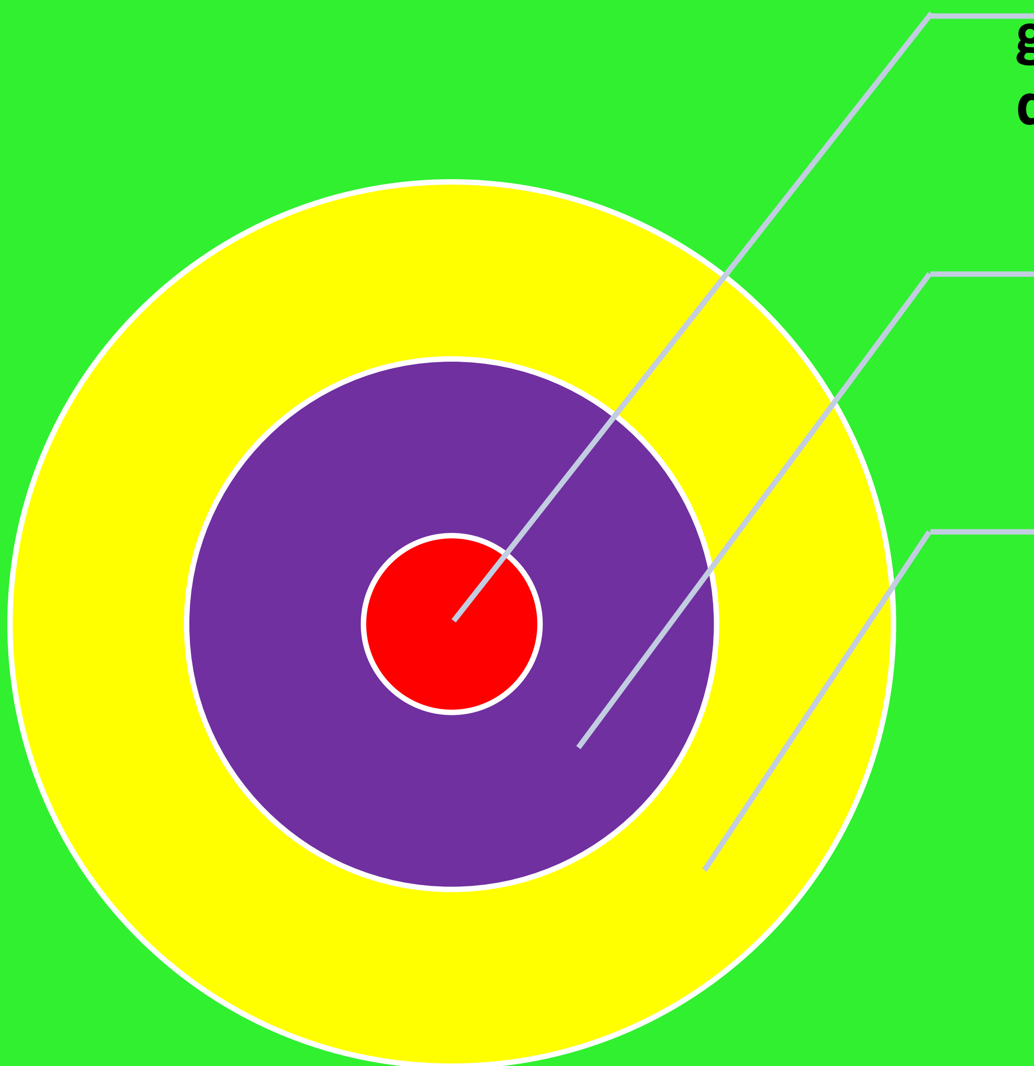
CLASSIFICATION OF RUBBERS BY TYPE OF TECHNOLOGICAL PROCESSING

Among the technological methods of processing for rubber materials are used:

- ***extrusion***
- ***pressing***
- ***casting.***

RUBBERS. CLASSIFICATION BY PURPOSE

By purpose, the main groups of rubber are distinguished:



- General purpose

- Special purpose

GENERAL PURPOSE RUBBERS

For general purpose rubbers, the main components are non-polar rubbers - NK, SKI, SKS and SCR.

Rubbers based on NC are distinguished by high elasticity, strength, water and gas impermeability, high electrical insulating properties : electrical resistivity $\rho_{ov} = 3\ 10^{14} – 23\ 10^{18}$ Ohm cm ; dielectric constant $\varepsilon = 2.5$.

Rubbers based on SCS (SKS-10, SKS-30, SKS-50) have received the greatest distribution in industry. These are the rubbers that work well with repeated deformations, have good aging resistance; in terms of gas impermeability and dielectric properties, they are equivalent to rubbers based on NK.

General-purpose rubber materials are used for the production of products operating in water, in air, in weak solutions of acids and alkalis at operating temperatures of -35–+ 130°C.

RUBBERS. GENERAL CHARACTERISTICS. CLASSIFICATION

RUBBERS* for special purposes *are divided into types:

- **heat resistant,**
- **frost-resistant,**
- **petrol resistant ,**
- **resistant to chemically aggressive environments,**
- **dielectric,**
- **conductive,**
- **magnetic,**
- **fire resistant,**
- **radiation resistant ,**
- **vacuum,**
- **friction (wear-resistant*),**
- **food and medical purposes,**
- **for tropical and other climate conditions**

RUBBERS. GENERAL CHARACTERISTICS. CLASSIFICATION

The types are distinguished:

- porous or sponge rubber
- transparent rubber
- colored rubber

Curing

The properties of rubbers resemble thermoplastic polymers . The presence of ***unsaturated bonds in rubber*** molecules makes it possible, under certain conditions, to transfer it to a thermostable state.

To do this, divalent sulfur (or another substance) is added at the place of the double bond, which forms in the transverse direction, as it were, "bridges" between the filamentous rubber molecules , resulting in a **spatial-network structure inherent in rubber (vulcanizate).**

The process of chemical interaction of rubbers with sulfur in technology is called **vulcanization** .

Properties of rubbers and rubbers

MECHANICAL PROPERTIES OF RUBBERS AND RUBBERS

The peculiarities of the mechanical properties of rubbers and rubbers include:

- highly elastic character of deformation of rubbers;

- **dependence of deformations on their speed and duration of the deforming force** , which manifests itself in relaxation processes and hysteresis phenomena;

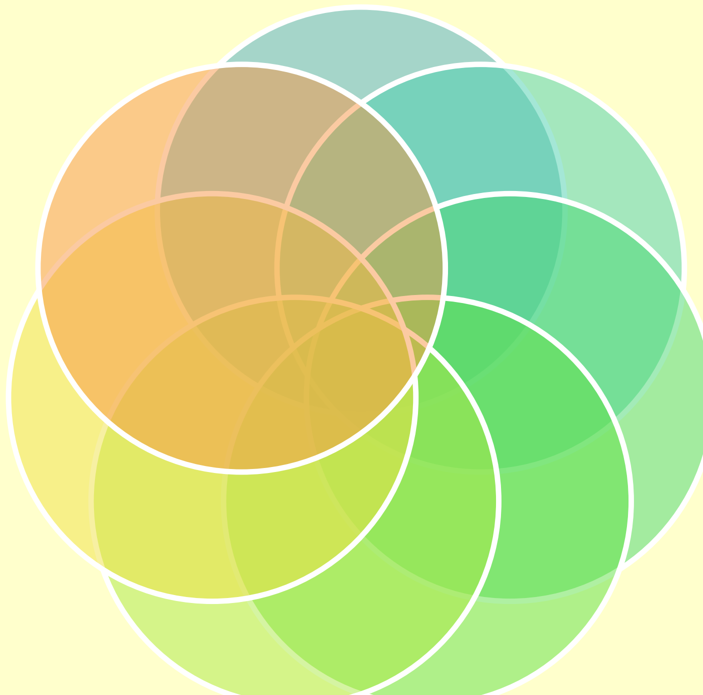
- **dependence of the mechanical properties of rubbers on their pre-treatment, temperature and the impact of various non-mechanical factors** (light, ozone, heat, etc.).

Properties of rubbers and rubbers

The main **deformation-strength properties** include:

- conditionally equilibrium modulus, modulus of elasticity, hysteresis loss, tear resistance , hardness.

- plastic and elastic properties,



- conditional stresses at a given elongation,

- tensile strength,

- residual elongation after rupture,

- relative elongation at break,

Resistance to aging and aggressive media

Aging is **an irreversible change in the properties of rubber or rubber under the influence of heat, light, oxygen, air, ozone or aggressive media, i.e. predominantly non-mechanical factors.**
Aging is activated if the rubber is simultaneously subjected to mechanical loads.

For atmospheric aging in open air or thermal aging in a hot air environment, the test result is evaluated by the aging coefficient. The smaller the change in properties during aging and the aging coefficient, the higher the resistance of rubber to aging.

Resistance to aging and aggressive media

Resistance to the action of various media (oils, alkalis, acids, etc.) is evaluated by changing properties - tensile strength and relative elongation at break in these media.

It is characterized by a coefficient representing the ratio of the indicator after exposure to an aggressive environment to the corresponding indicator before its impact.

Latexes and products from them. Consumer properties of latexes.

Latexes are colloidal systems, the dispersed phase of which consists of particles (globules) of a spherical shape.

The colloid-chemical characteristics of latex - the size of globules, viscosity, concentration, or the amount of dry residue, aggregation stability - significantly affect the technological behavior of latexes during their processing.

The stability of latexes is due to the protective layer adsorbed on the surface of the globules, which prevents spontaneous coagulation. This layer contains anionic, cationic or non- ionic surfactants (emulsifiers).

Latexes and products from them. Consumer properties of latexes.(2)

Types of latex:

1.Natural latex - milky juice of rubber plants . Synthetic latexes are aqueous dispersions of synthetic rubbers resulting from emulsion polymerization.

2. Artificial latexes (artificial dispersions) - products that are formed when "finished" polymers are dispersed in water.

The use of latexes makes it possible to obtain products that cannot be made from solid rubbers at all, for example, thin-walled seamless medical gloves. **Natural latex is mainly used for medical products.**

SILICONE RUBBERS

Silicone rubbers - ***organosilicon polymers with rubber -like properties,*** are a transparent, colorless , jelly-like mass, tasteless and odorless.

Silicone rubbers are characterized by high thermal- oxidative stability to ultraviolet radiation.

The physiological inertness of silicone rubbers allows them to be widely used in medicine, for example, in the production of tubes for blood transfusion, artificial heart valves, and implants in maxillofacial surgery.

SILICONE RUBBERS

Two types of silicone elastomers are most widely used:

1) rubbers vulcanizing at elevated temperature (hot curing);

2) rubbers vulcanizing at room temperature (cold curing).

Rubbers are used in medical practice:

hot and cold curing .

GLASS

Inorganic glass is a homogeneous amorphous substance obtained by solidification of an oxide melt . It does not have a specific melting or solidification point and, upon cooling, it passes from a molten, liquid state to a highly viscous state, and then to a solid one, while maintaining the disorder and heterogeneity of the internal structure.

Glass contains three types of oxides:

- glass formers

- modifying

- intermediate.

Glass-forming oxides are silicon, boron, phosphorus, germanium, arsenic .

The modifying oxides include oxides of alkali (Na , K) and alkaline earth (Ca , Mg , Ba) metals.

Modifying oxides are introduced during the glass melting process.

Alumina $A1_{2}0_{3}$ increases the mechanical strength, as well as the thermal and chemical resistance of glasses.

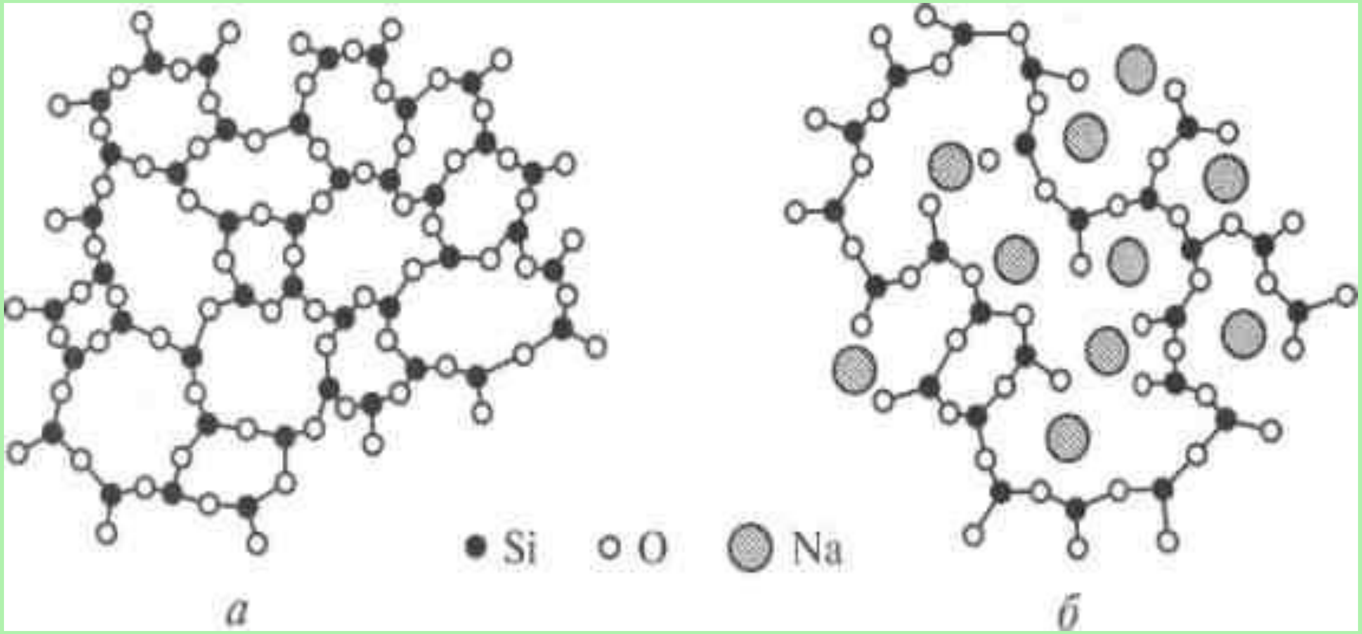
With the addition of $B_{2}0_{3}$, the rate of glass melting increases, clarification improves and the tendency to crystallization decreases.

Lead oxide PbO , introduced mainly in the manufacture of optical glass and crystal, increases the refractive index.

Zinc oxide ZnO lowers the temperature coefficient of linear expansion of glass, thereby increasing its thermal stability.

Intermediate are oxides of aluminium, lead, titanium, iron, which can replace part of the glass-forming oxides.

Glass-forming oxides (for example, SiO_2, $A1_20_3$, B_2O_3, P_20_3) form a spatial network of homogeneous polyhedral units, and modifying oxides, located inside the cells of the network, weaken or break bonds in glass-forming oxides and reduce clean, thermal and chemical resistance of glass, but allow you to control its softening temperature and other properties (Fig.).



- Rice. Scheme of a continuous structural glass grid:
- a - quartz; b - sodium silicate

GLASS CLASSIFICATION

The chemical composition of glass can be varied over a wide range, so the properties of glass can be different .

According to the chemical composition, depending on the nature of the glass-forming oxides, there are

- silicate

- aluminosilicate

- borosilicate

- aluminoborosilicate

and other types of glass.

GLASS CLASSIFICATION

Depending on the content of **modifiers** , glass can be:

- **alkaline**

- **alkali -free**

- **quartz inorganic glass.**

GLASS CLASSIFICATION

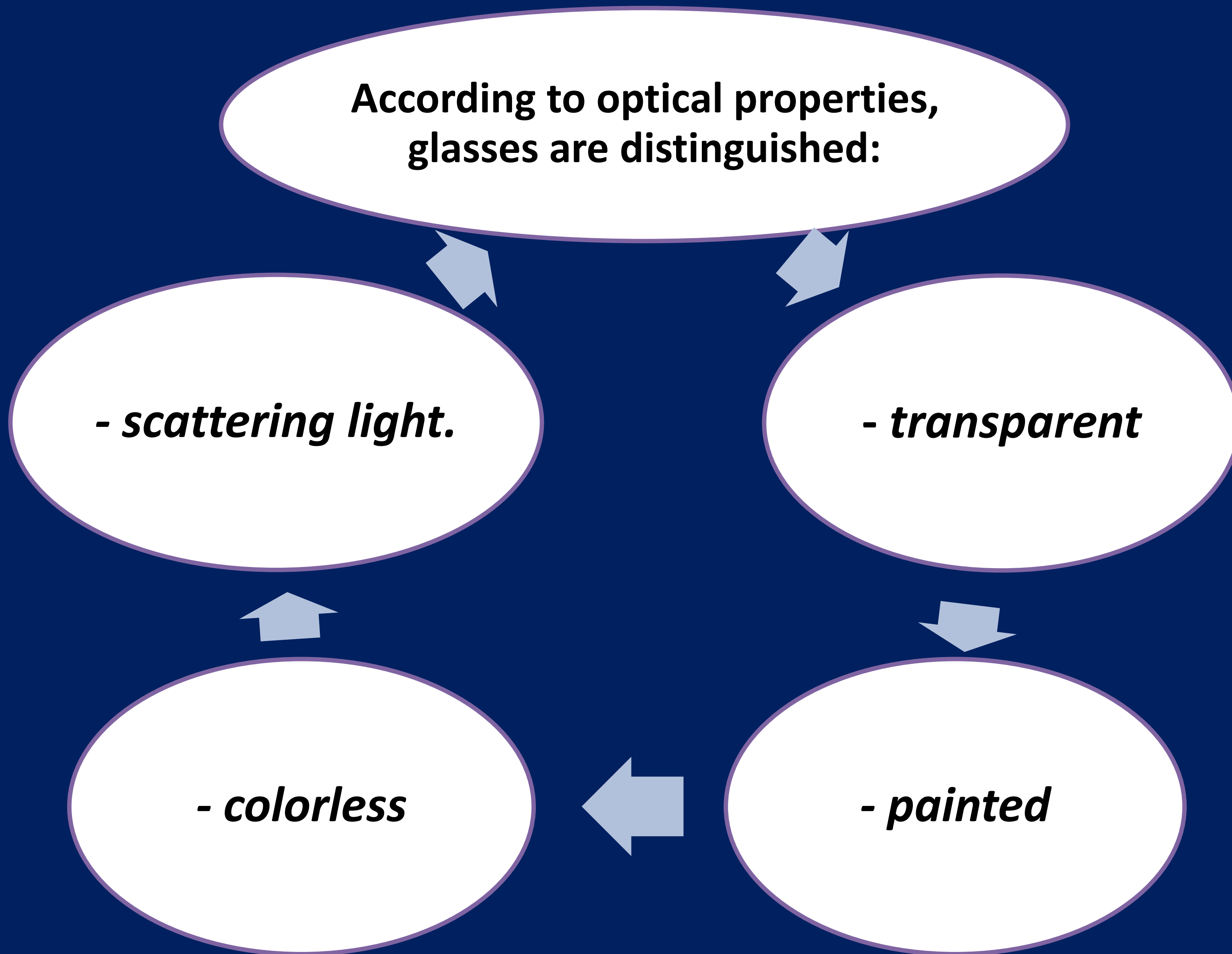
By purpose, glass is distinguished:

- construction (windows, glass blocks)

- household (glass containers, dishes)

- technical (optical, electrical, chemical, etc.).

Optical properties of glass



The main consumer properties of glass

Consumer properties of inorganic glasses include:

- transparency

- high weather resistance

- water and air tightness

- heat resistance.

Sitally
(glass-ceramic materials)

Sitally (glass-ceramic materials) - an artificial material based on inorganic glass, obtained by complete or partially controlled crystallization in them.

The term "sitalls" is derived from the words: "glass" and "crystals". According to the structure and production technology glass-ceramics occupy an intermediate position between ordinary glass and ceramics.

They differ from inorganic glass in their crystalline structure, and from ceramic materials in a finer-grained and homogeneous microcrystalline structure.

CERAMICS

Ceramics is a group of materials that are intermediate between metals and non-metals .

As a general rule **, the class of ceramics includes oxides, nitrides and carbides.** So, for example, some of the most popular types of ceramics consist **of aluminum oxide (Al_2O_3), silicon dioxide (SiO_2), silicon nitride (Si_3N_4).**

In addition, among those substances that many **refer to as traditional ceramic materials are various clays (in particular those used to make porcelain), as well as concrete and glass** .

CERAMICS (2)

The mechanical properties of ceramics are **relatively rigid and durable** materials comparable in these characteristics to metals.

Typical types of ceramics are very **hard.**

However, **ceramics is an exceptionally brittle material** (almost complete lack of ductility) and **does not resist fracture well.**

All typical types **of ceramics do not conduct heat and electricity (i.e. their electrical conductivity is very low).**

Methods for the production of products from metallic materials

BASIC PRODUCTION PROCESSES AND METHODS FOR OBTAINING BLANKS FROM METAL MATERIALS

In modern production, the following **main methods for obtaining blanks are used:**

- casting method,

- metal forming method,

- welding method,

- method of powder metallurgy.

BASIC PRODUCTION PROCESSES AND METHODS FOR OBTAINING BLANKS FROM METAL MATERIALS

casting get blanks of almost any size, both simple and very complex configuration. In this case, castings can have complex internal cavities and curved surfaces intersecting at different angles.

Dimensional accuracy and surface quality depend on the casting method.

Most often, blanks for body parts, machine beds, etc. are obtained by this method.

Machining of metals by pressure is used to obtain machine-building profiles, forged and stamped blanks.

BASIC PRODUCTION PROCESSES AND METHODS FOR OBTAINING BLANKS FROM METAL MATERIALS

Welded blanks are made by various welding methods. In some cases, welding simplifies the manufacture of a workpiece, especially of a complex configuration.

Powder metallurgy is the most promising method for obtaining blanks.

The raw materials for the production of blanks are polymer masses and powders of various materials.

The most characteristic feature of such blanks is that they can correspond in shape and size to the shape and size of finished parts and require only minor, most often finishing, finishing.

METAL SHAPING METHODS AND METHODS FOR PRODUCING BLANKS BY PLASTIC DEFORMATION

Metal shaping methods are:

- forging

- casting

- stamping.

METAL SHAPING METHODS AND METHODS FOR PRODUCING BLANKS BY PLASTIC DEFORMATION (2)

Methods for obtaining blanks by plastic deformation:

- pressing,

- mechanical restoration,

- drawing.

Welding (soldering) - the connection of several parts (when the product consists of several parts).

CASTING METHOD

Foundry technologies at the present stage make it possible to obtain products with high performance properties.

The casting method is understood as the process of obtaining workpieces by pouring molten metal of a given chemical composition into a mold, the cavity of which has the shape of a workpiece.

In modern foundry production, two main methods are most often used:

- casting in sand molds,

- special casting methods.

Technological process of manufacturing metal products

SHAPING

Enterprises supply metals in the form of:

- **bars, strips, sheets, tapes, wires, pipes (steel, brass, aluminium),**
- **ingots (cast iron, bronze).**

To obtain a product, it is necessary to carry out shaping - to give the product the desired shape and size.

Technological process of manufacturing metal products

SHAPING . Shaping methods:

- mechanical restoration.
- casting ,
- drawing ,
- forging,
- pressing ,
- stamping,

Technological process of manufacturing metal products

HEAT TREATMENT

Then the product is given the necessary properties, for example, strength, which is most often achieved by **heat treatment.**

Technological process of manufacturing metal products

SURFACE FINISH

After that, the surface of the product must be well finished in order to **provide the product with high performance properties** and give a beautiful appearance.
Surface finishing methods include:

- machining (grinding, polishing);

- electrochemical processing (electrogrinding , electropolishing).

PRODUCTION OF PRODUCTS CONSISTING OF SEVERAL PARTS

If the product consists of several parts, then they are connected using:

- welding or soldering.

Metals used to produce medical devices must be capable of being processed by one or more technological methods.

In this case, the **properties of metals often undergo significant changes, especially if the metal is heated to give the desired shape.** Often, as a result of such processing **, the internal structure of the metal changes and its mechanical properties deteriorate.**

TECHNOLOGICAL PROCESSES FOR PRODUCING BLANKS FROM NON-METALLIC MATERIALS

CLASSIFICATION OF NON-METALLIC MATERIALS BY METHOD OF PRODUCTION (PROCESSING)

According to the method of production (processing), non-metallic structural materials are divided into the following groups:

- materials obtained by chemical technology (polycondensation, polymerization, vulcanization, synthesis and other types of chemical processing);

- materials obtained by thermal and thermomechanical processing (casting, sintering, stamping, pressing, etc.);

- materials obtained by mechanical processing (sawing, planing, peeling, milling, drilling, stamping, etc.);

-materials obtained by combined technology, which consists in the use of two or more of the listed technologies (chemical and thermal, chemical and mechanical).

PROCESSES FOR OBTAINING PRODUCTS FROM POLYMERS (PLASTICS)

In most cases, parts are made from plastics that are in a viscous state.

In mechanical engineering, the following methods are used to obtain parts and blanks from plastics:

- pressing,
- injection molding ,
- extrusion (extrusion),
- stamping ,
- blowing,
- calendering .

INJECTION MOLDING

Injection molding is mainly used to produce products from thermoplastics.

Preheated to a viscous state, the thermoplastic is injected under pressure into a closed injection mold, after cooling, the mold opens and the product is pushed out.

Products made in this way do not undergo additional processing.

EXTRUSION (EXTRACTION)

Extrusion (extrusion) consists in the continuous extrusion of profiled products of great length on an extruder.

The heated plastic is fed by a screw to the mouthpiece, which gives the desired profile to the product.

In this way, thermoplastics (polyethylene, PVC, polyamide, etc.) are processed, from which pipes, rods, sheets, and films are made . On extruders, the wire is covered with insulation.

STAMPING

Stamping is used to produce products mainly from sheet thermoplastics.

This method produces various products (soap dishes, cases for toothbrushes, glasses, etc.), mainly from celluloid.

BLOWING

Blowing is done as follows:

two sheets of plastic are placed in a heated mold,

air or steam is passed between the sheets, which are pressed against the walls of the mold, forming a hollow product.

The blowing of hollow products from pipes consists in the fact that the thermoplastic is intermittently fed in the form of a pipe into a mold, where the pipe is blown to the desired size and shape . On products usually there are traces of the form. This method produces polyethylene bottles, canisters, vials, etc.

CALENDING

Calendering is used for the manufacture of plates, sheets of PVC , as well as artificial leather on a fabric, knitted or fibrous basis.

A heated mixture of polymer with filler, plasticizer and dye is applied to one side of the fabric using a calender.

Sometimes plastic compound or artificial leather is embossed at the same time .

WELDING METHOD (for some plastic products)

Some plastic products (thermoplastics) are produced by welding.

Welding can be:

- contact (with a heated tool),

- high frequency currents,

- ultrasound.

METHODS FOR OBTAINING LAYERED PLASTICS

Laminated plastics form a special group. **The technology for their production is significantly different from the production of other types of plastics.**

The process of obtaining a layered material is as follows:

Packages of sheet material and binder resins (in the form of impregnation or powder) are collected, then they are loaded onto tile floor presses and pressed at high pressure and temperature.

this way, laminates are obtained, in which the filler is fibrous materials.

Processes for obtaining blanks from rubber

Rubber is the vulcanization product of a mixture containing rubber, fillers, plasticizers, vulcanization activators, antioxidants and other ingredients.

The most important property of rubber is its high elasticity, i.e. the ability to large reversible deformations.

The manufacturing technology of products from rubber compounds consists of a number of operations performed in a certain sequence:

1 . Cutting rubber into pieces and plasticizing it by repeatedly passing it through rollers heated to 40-50 ° C in order to improve miscibility with other ingredients.

2. Mixing rubber with other components in a strictly defined sequence: anti -aging agents are first introduced , then vulcanizers. Mixing is carried out in rubber mixing or rolling machines.

The manufacturing technology of products from rubber compounds consists of a number of operations performed in a certain sequence:

3. Calendering the rubber mixture to obtain crude rubber by passing it through a three-byte stand of a sheet-rolling calender mill.

The rolls of the mill have different temperatures: the upper one is 90 °C, the lower one is 15 °C.

The rubber mass is heated and under the action of the rollers turns into a sheet or tape.

→

4. Manufacture of products from raw rubber by pressing in special molds under a pressure of 5–10 MPa or by injection molding by filling the mold with preheated raw rubber.

The manufacturing technology of products from rubber compounds consists of a number of operations performed in a certain sequence:

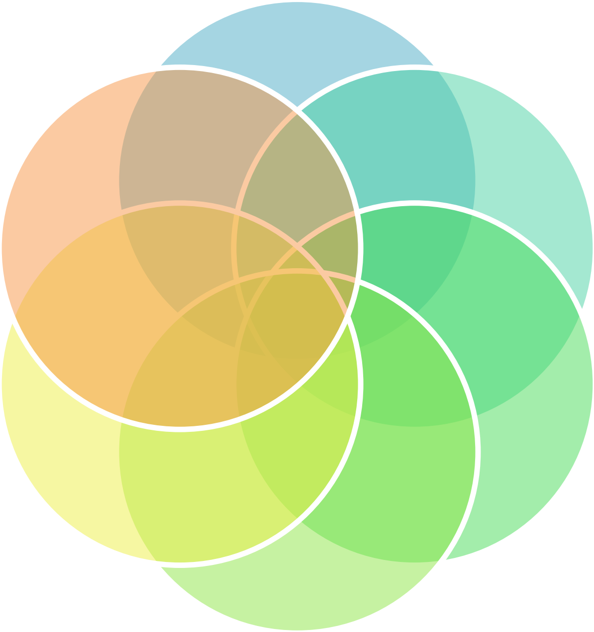
5. Vulcanization - the formation of the physical and mechanical properties of the product.

Hot vulcanization on vulcanizing machines at a temperature of 130–150 °C (heated steam, hot water, etc.).

During vulcanization, chemical interaction of rubber and vulcanizers takes place, as a result of which the linear molecular structure of rubber is transformed into a network.

Processes of shaping parts and blanks

Shaping parts and blanks. Various processes are used for this operation:



- Winding receive complex products (flexible armored hoses and sleeves).

- Calendering

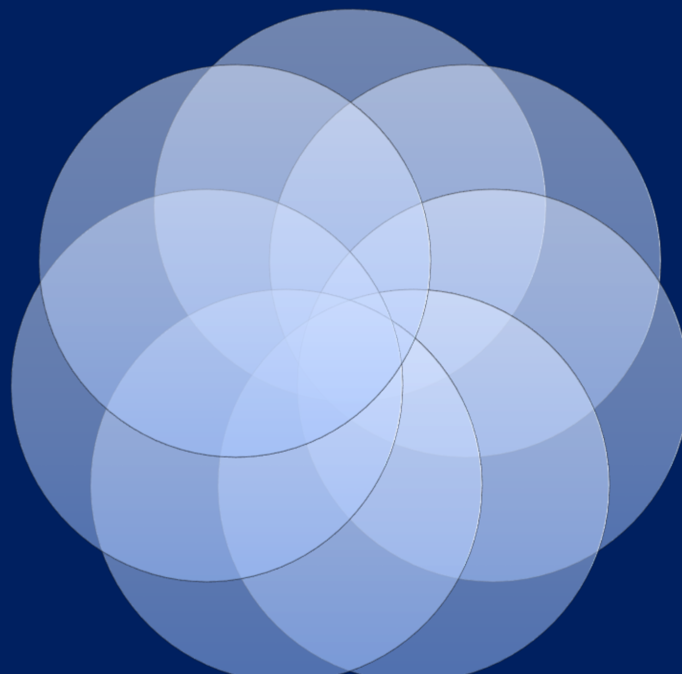
- Injection molding produces parts of complex shape.

- Continuous extrusion

- Pressing.

The process of obtaining products from latex

The technological process of obtaining products from latex includes the following processes:



1. latex preparation mixtures;
2. obtaining a semi-finished latex product;
3. gel seal;
4. drying of the finished product;
5. vulcanization of the finished product ;
6. quality control, packaging and labeling.

Processes for obtaining blanks from composite materials

The modern production of structural elements from CM is largely focused on the prepreg technology for manufacturing products.

- Prepregs are composite materials pre-impregnated with resin at high temperature and pressure. The resin in prepregs is in a semi-solid state. Its complete curing occurs during molding.

Prepregs are usually rolls or packs of tape sized material with a separating film between **the layers and are then flat or shaped molded** .

METHODS FOR MANUFACTURING PRODUCTS FROM COMPOSITE MATERIALS:

- **Contact molding with laying resin-impregnated fibrous canvas on a mold** (contact molding produces a wide range of products).
- **Spraying a fibrous-polymer composition onto the mold surface.** The method of spraying onto the mold surface is used for the manufacture of large-sized lightly loaded parts of complex configuration.
- **Molding in a closed mold.**
- **Winding resin-impregnated fiber onto a mould.** The winding technology is used primarily in the manufacture of bodies of revolution from fiberglass.

METHODS FOR OBTAINING FIBERGLASS

Fiberglass - structural materials based on polymers on a fiberglass or fiberglass basis.

Depending on the type of binder and filler, technological regimes, properties and methods of processing the material into products, glass-reinforced plastics are divided into two groups:

The first group is fiberglass based on phenol-formaldehyde, organosilicon, urea and other resins, requiring high temperatures (180 °C and above) and pressure (250 ... 1,000 MPa (25 ... 100 kg / cm2) for processing into products).

This type of fiberglass is produced mainly in the form of sheets, slates, parts with small overall dimensions, since complex equipment, large-sized presses and high pressure are required.

METHODS FOR OBTAINING FIBERGLASS (2)

Another group of glass-reinforced plastics based on unsaturated polyester and epoxy resins is obtained by "cold" curing at ordinary temperatures by the contact method without pressure.

The contact method for obtaining products from fiberglass is as follows .

First, a non-standard shape is made from wood, plaster or other material that can be easily molded into any shape, even a complex configuration.

This form is overlaid with a sheet of fiberglass, impregnated or filled with polyester or other "cold" curing resins, then the next layer of fabric is applied, etc.

By this method, it is possible to obtain a product of a given shape with any thickness, for example, small-sized pleasure boats, etc.

GLASS

The main raw materials for glass production are:

quartz sand;
nepheline;
magnesite (magnesium carbonate);
dolomite (magnesium and calcium carbonate);
sodium tetraborate ;

boric acid;
limestone (calcium carbonate);
potash (potassium carbonate);
soda ash (sodium carbonate);
sodium sulfate.

MEDICAL GLASS

Key quality indicators:

Medical glass is obtained by cooling a molten mixture of silicates, metal oxides, salts and is a solid solution.

Due to the fact that **medical glass is made from quartz glass, consisting of 95-98% silicon dioxide, it has a very high thermal and chemical resistance** . It is difficult to manufacture and seal ampoules from such glass because of the extremely high melting point (1550–1800°C).

Special modifiers (potassium and sodium oxides) are added to the composition of glass to lower the melting point. The introduction of these substances can reduce the chemical resistance to such an extent that it is possible to obtain liquid or soluble glass (potassium or sodium silicates).

METHODS OF GLASS PRODUCTION AND PRODUCTS PRODUCTION

The melting of medical glasses is carried out in continuous bath furnaces with a capacity of 5-25 tons of glass melt per day.

The cooking temperature is on average 1480-1520 °C, the production temperature is 1200-1250 °C.

Medical glasses are well boiled and clarified (with the exception of glasses of the HC- grades, due to the low content of alkaline oxides, they are poorly clarified).

METHODS OF GLASS PRODUCTION AND PRODUCTS PRODUCTION

During the melting of these glasses, the bubbling of the glass mass has an effective effect. When cooking **orange glasses, sodium sulfate is added to their mixture for coloring with an excess of a reducing agent (coal**). During the melting of such glasses, metal sulfides are formed in them, coloring the glass in an orange color.

The production of medical glass products is carried out on various machines.

A number of products are made from droit, which in these cases is a semi-finished product. These include ampoules and vials.

Getting glass

Medical products are produced mainly from neutral glasses (grades MS-1 and NS-2), from alkaline glass (grades NB-1, MT and OS) and from light-protective orange glass .

It is not allowed to introduce toxic oxides into the composition of glass, such as As_2O_3, Sb_2O_3, P_2O_5 and fluorine compounds.

Some brands of foreign glasses contain BaO and ZnO .

THANK YOU FOR ATTENTION!