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МАТЕРИАЛОВЕДЕНИЕ И ТЕХНОЛОГИИ МАТЕРИАЛОВ (МАТЕРИАЛОВЕДЕНИЕ И ТЕХНОЛОГИИ НОВЫХ МАТЕРИАЛОВ)

Методические указания к практическим занятиям

для студентов специальности 22.03.01

MATERIALS SCIENCE AND MATERIALS TECHNOLOGIES (MATERIALS SCIENCE AND NEW MATERIALS TECHNOLOGIES)

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Материаловедение и технологии материалов (Материаловедение и технологии новых материалов): Методические указания к практическим занятиям. / Санкт-Петербургский горный университет. Сост. *Э.Р.Скорнякова*. СПб, 2023. 35 с.

Методические указания предназначены для студентов специальности 22.03.01 «Материаловедение и технологии материалов (Материаловедение и технологии новых материалов)». Предлагаемый материал направлен на совершенствование навыков профессионально ориентированного чтения студентов на английском языке. Методические указания к практическим занятиям включают тексты на языке оригинала, специально разработанные упражнения и задания, способствующие развитию речевой, языковой, социокультурной и информационной компетенций студентов, необходимых для общения в сфере профессиональных интересов. Методические указания также содержат грамматические упражнения, целью которых является подготовка к сдаче итоговой аттестации по дисциплине «Иностранный язык».

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ПРЕДИСЛОВИЕ

Данные методические указания предназначены для учебно-методического сопровождения курса английского языка для студентов неязыковых вузов, обучающихся по специальности 22.03.01 «Материаловедение и технологии материалов (Материаловедение и технологии новых материалов)». Методические указания составлены в соответствии с учебной программой по дисциплине «Иностранный язык» для формирования иноязычной профессиональной компетенции будущих специалистов. В методические указания включены аутентичные тексты, в которых освещаются следующие вопросы: «Строение и свойства материалов», «Структура и свойства железоуглеродистых сплавов», «Конструкционные и инструментальные стали и сплавы», «Цветные металлы и неметаллические материалы».

Изучение материала преследует цель развития навыков и умений просмотрового и изучающего чтения текстов по направлению подготовки, а также их перевода на русский язык с последующим использованием полученной информации для речевой практики; овладение студентами иноязычной коммуникативно-речевой компетенцией, позволяющей будущему специалисту осуществлять профессиональную коммуникацию; формирование активного словарного запаса, который включает наиболее употребительные английский термины и выражения по теме «Materials Sciences and materials Technologies».

UNIT 1. WHAT IS MATERIALS SCIENCE?

I. Read and translate the following text.

The field of materials science is the study of materials with a focus on their composition, structure, and properties. The interdisciplinary field combines physics, chemistry and engineering and encompasses all-natural and artificial materials. This includes metals, ceramics, glasses, polymers, semiconductors, and composites.

A «material» is a collection of many atoms or molecules, where the collection typically behaves differently than the individual parts. For example, when one or a few water molecules behave chemically similar to the molecules in a glass of water, but the few molecules are not a liquid, they don't flow, and they don't exhibit viscosity or surface tension. These are properties of large collections of molecules and are examples of properties of a material: properties that depend on the collective interaction of many molecules or atoms. Understanding and predicting material properties requires understanding the behavior of individual atoms and molecules and the behavior of large collections of these components. Materials scientists can use this understanding to develop new materials that follow a set list of desired properties.

Materials Science is a crucial discipline. Why do we care about materials? To put it simply, they are a foundation of our civilization. Look at how we name the ages of societal evolution after the materials they had to work with: the stone age, bronze age, iron age, and now the computer age (made possible by semiconductors, a distinct class of materials).

Humans only had materials like stone, wood, and leather in the stone age. The knowledge of metal processing led to huge leaps in civilization; imagine farming without an iron plow. The steady increase in food production through these advancements helped pave the way for more differentiation of labor and the growth of large towns and cities.

Technology has always been limited by the materials available to allow ideas to take physical form. The limit to technology has never been a lack of creative ideas for new designs. Instead, it's finding the right materials to make those ideas into a physical reality. Galileo's notebooks contained drawings of a lovely helicopter. What were the most advanced materials Galileo had to work with? Probably paper and rope, maybe iron. It would have been nearly impossible for Galileo to build a helicopter with the materials available to him at that time.

Fast forward to England in 1791 John Barber was granted a patent for the first jet engine. Limits on the properties of available materials meant the project had to wait until the 1930s, nearly a century and a half later, before metals of sufficient strength, temperature and wear resistance were available to build a practical jet engine.

Materials science is a crucial discipline because it lies at the nexus of chemistry, physics, and engineering. It empowers designers and engineers to realize their new ideas for electronics, medical devices, machines, and more [1].

II. Study the following words and expressions:

Composition, structure and properties – состав,структура и свойства, interdisciplinary field – междисциплинарная область, viscosity – вязкость, surface tension – поверхностное напряжение, crucial discipline – важная дисциплина, Stone Age – Каменный век, Bronze Age – Бронзовый век, Iron age – Железный век, leather – кожа, кожаные изделия, nexus – связь, переплетение, wear resistance – прочность на износ, износостойкость, engineering – инженерное дело, empower – уполномочить, дать возможность, electronics – электроника, электронная аппаратура

III. Complete the table and make 5 sentences with any of the words from the table.

verb	noun	adjective/participle
	foundation	
combine		
encompass		
		granted
	empowerment	

IV. Answer the following questions:

1. What is the field of Materials Science?
2. What disciplines does Materials Science combine?
3. What are the ages of societal evolution?
4. Why did the knowledge of metal processing lead to huge leaps in civilization?
5. What is John Barber famous for?
6. Why is Materials Science a crucial discipline?
7. What opportunities does Materials Science give to designers and engineers?

V. Insert the missing words and expressions:

Materials science, predetermined, metallurgy, interdisciplinary, subdisciplines, engineering, properties, researchers

(1) … and engineering is an (2) … and important branch of study that deals with designing and discovering new materials, particularly solids. Materials science is one of the oldest forms of (3) … and applied science. The material of choice in a given era is often a defining point (e.g., Stone Age, Bronze Age, Iron Age). The intellectual origins of materials science stemmed from the Enlightenment when (4) … began to use analytical thinking from chemistry, physics, and engineering to understand ancient, phenomenological observations in (5) … and mineralogy. Sometimes it is useful to subdivide materials science and engineering into materials science and materials engineering (6) ... The discipline of materials science involves investigating the relationships between the structures and (7) … of materials. In contrast, materials engineering is, based on these structure-property correlations, designing or engineering the structure of a material to produce a (8) … set of properties [2].

VI. Grammar task. Open the brackets.

1. Bob tried to avoid … (answer) my question.
2. I … (walk) home when I met David.

3. You … (*a modal verb of obligation*) wear a seatbelt in a car.
4. If you work hard, you … (pass) your exam.
5. I don't eat … (*many/ much/ a little/ a lot*) chocolate.
6. I feel a bit hungry. I think I … (have) something to eat.
7. What was ... (*a degree of comparison of* happy) day of your life?
8. Let's go out now. It … (not rain) anymore.
9. In summer John usually … (play) tennis once or twice a week.
10. The window was open and a bird … (flow) into the room.
11. Jim always puts … (*very few/ a little/ much/ a lot*) salt on his food.
12. I'd like to have a... (*a degree of comparison of* reliable) car. The one I've got keeps breaking down.
13. I … already … (see) this film twice. Can't we watch another one?
14. The college … (build) in the 16^{th} century.
15. I … (*a modal verb of ability*) speak five languages fluently.
16. Liam is saving money … (buy) a new car.
17. Kate's eyes are red. She … (cut) onions.
18. Look at those black clouds! It … (rain)!
19. If David … (speak) good English, he would get a job in that new hotel.
20. This castle … (not inhabit) for nearly a century [3; 4].

UNIT 2. MECHANICAL PROPERTIES OF MATERIALS

I. Read and translate the following text. Make up the plan of the text.

Compressive strength refers to the ability of a certain material or structural element to withstand loads that reduce the size of that material, or structural element when applied. A force is applied to the top and bottom of a test sample, until the sample fractures are deformed.

Materials such as concrete and rock are often evaluated using a compressive strength test and, in these cases, fracturing occurs.

Materials such as steel can also be tested for compressive strength, and in the case of ductile materials, deformation tends to occur. Initially, a ductile material will accommodate the applied load by adjusting its internal structure– a process referred to as plastic flow.

Once the deformation is concentrated in one area, the plastic flow stops, and the material breaks. For ductile metals, tensile strength is usually the preferred indicator for measurement and comparison. This is because tensile stress measures the forces needed to pull a material apart, which is better suited to the plastic flow phenomenon.

Durability is defined as the ability of a material to remain serviceable in the surrounding environment during the useful life without damage or unexpected maintenance, when faced with the challenges of normal operation over its design lifetime.

There are several measures of durability in use, including years of life, hours of use, and a number of operational cycles. In economics, goods with a long usable life are referred to as durable goods.

Durability should be understood as the ability of the constructive system and its materials not to exhibit significant deteriorations that imply loss of functionality for which they were designed.

In physics and materials science, elasticity is the ability of a body to resist a distorting influence and to return to its original size and shape when that influence or force is removed. Solid objects will deform when adequate loads are applied to them; if the material is elastic, the object will return to its initial shape and size after removal. This is in contrast to plasticity, in which the object fails to do so and instead remains in its deformed state.

The physical reasons for elastic behavior can be quite different for different materials. In metals, the atomic lattice changes size and shape when forces are applied (energy is added to the system). When forces are removed, the lattice goes back to the original lower energy state. For rubbers and other polymers, elasticity is caused by the stretching of polymer chains when forces are applied.

Malleability is a physical property of metals that defines their ability to be hammered, pressed, or rolled into thin sheets without breaking. In other words, it is the property of a metal to deform under compression and take on a new shape.

A metal’s malleability can be measured by how much pressure (compressive stress) it can withstand without breaking. Differences in malleability among different metals are due to variances in their crystal structures.

Malleable materials can be flattened into metal leaf. One well-known type of metal leaf is gold leaf. Many metals with high malleability also have high ductility. Some do not; for example lead has low ductility but high malleability.

Malleability is a physical property of matter, usually metals. The property usually applies to the family groups 1 to 12 on the modern periodic table of elements.

Malleability in metals is very important in the appliance and automotive industries. This property helps to construct refrigerators, microwaves and stoves, and also helps to construct flat and curved metal objects [5; 6; 7; 8].

Vocabulary

atomic lattice – атомная решетка;
compressive strength – предел прочности при сжатии;
compressive stress – сжимающее напряжение, давление сжатия;
concrete – бетон;
design lifetime – проектный срок службы;
deterioration – изношенность, ухудшение;
distorting influence - искажающее влияние;
ductile – вязкий, тягучий;
durability – срок службы (металлов), износоупорность;
elasticity – эластичность, упругость;
gold leaf – золотая фольга, листовое золото;
malleability – ковкость;
plastic flow – ползучесть, пластичное течение;
tensile strength – предел прочности на растяжение;
withstand loads – выдержать нагрузку

II. Answer the questions.

1. What property can be defined as the ability of a certain material or structural element to withstand loads that reduce the size of that material, or structural element when applied?
2. What is the plastic flow phenomenon?
3. Can you name several measures of durability?
4. Why are physical reasons for elastic behavior quite different for different materials?

5. Can you name the property of a metal to deform under compression and take on a new shape?
6. Why is malleability important in the appliance and automotive industries?

III. Insert the missing words and expressions:

Gold, malleable, allotrope, brittle, compression, nonmetals, ductility, malleability, melting points, heated

Metals are malleable because of their crystal structure. For example, (1) …, silver and magnesium are more malleable than vanadium or chromium. Atoms in close-packed structures are arranged like stacked flat sheets, so the planes can slip past each other under applied force. Meanwhile, body-centered structures are more like corrugated sheets that resist slipping.

Generally speaking, the elements that are (2) … are not malleable. However, there are a few exceptions. Certain allotropes are malleable. An example is the plastic (3) … of sulfur.

While nonmetallic elements are not malleable, some nonmetallic polymers are (4) ... . For example, some plastics display malleability.

While malleability is the property of a metal that allows it to deform under (5) … , ductility is the property of a metal that allows it to stretch without damage.

Copper is an example of a metal that has both good (6) … (it can be stretched into wires) and good (7) … (it can also be rolled into sheets).

While most malleable metals are also ductile, the two properties can be exclusive. Lead and tin, for example, are malleable and ductile when they are cold but become increasingly (8) … when temperatures start rising towards their (9) … .

Most metals, however, become more malleable when (10) … . This is due to the effect that temperature has on the crystal grains within metals [8].

IV. Find further information about mechanical properties of materials, make up presentations.

V. Translate the following text from Russian into English.

«Металлы в твердом состоянии обладают рядом характерных свойств: высокой тепло- и электропроводностью; положительным температурным коэффициентом электросопротивления; термоэлектронной эмиссией, т.е. способностью испускать электроны при нагреве; хорошей отражательной способностью; повышенной способностью к пластической деформации» [9: 9].

VI. Grammar task. Open the brackets.

1. If you … (not/keep) away from the edge, you'll fall down.
2. Bob has … (a little/many/few/little) knowledge of mechanics so he can check the car.
3. Most children strongly … (influence) by their parents.
4. Peter is usually rude but today he … (be) polite to his colleagues.
5. The longer I had to queue at the bank, the … (a degree of comparison of impatient) I became.
6. You … (a modal verb of absence of necessity) wear a tie to the interview.
7. You … (a modal verb of prohibition/not) smoke at petrol stations.
8. City life is too busy for me; I really miss … (live) in the country.
9. Tom was reading out the data while Sara … (write) it down.
10. The performances at our theatre … (start) at 7.30.
11. She … (go) to Madrid last year.
12. Lucy … (study) garden design for two years.
13. The sky is overcast with black clouds. It … (rain).
14. She was happy … (win) the prize.
15. The floor … (not/clean) yet.
16. If I ran round the park every morning, I … (keep) fit.
17. Oscar Wilde and Bernard Shaw … (be) the wittiest British writers.
18. Roger … (gain) a lot of weight recently.
19. There seem to be … (much/a lot/very few/little) people in this area.
20. I think … (a degree of comparison of good) way to learn English is to go to an English-speaking country [10; 11].

UNIT 3. ALLOYS

I. Read each word or word combination. Mind the stress. Find the meaning.

Solid state, soluble, subsequent solidification, an alloying element, solubility, insolubility, immiscible, microstructure, thermodynamic equilibrium, quenching, host lattice, lattice distortions, oversaturated state, crystal mixture, cooling curves, irrespective.

II. Read and translate the text. Make a plan of the text.

Depending on the extent to which the two components are soluble in each other in the solid state, different types of alloys result. In general, alloys are obtained by melting, mixturing and subsequent solidification. For this purpose, a certain amount of an alloying element (solute) is added to a host material (solvent) in the liquid state. In the liquid state, the atoms of the substances involved are only weakly bound to each other. In general, the substances can therefore be mixed relatively well.

A complete solubility or complete insolubility of the components of a binary alloy system are only special cases. In general, the components are neither completely immiscible nor completely miscible.

In reality, an alloying element B can always be dissolved to a certain degree in the host material A and vice versa. In general, therefore, a limited solubility of the components in the solid state is always obtained.

When the components of an alloy are partially soluble, the microstructure ultimately forms a mixture of solid solutions. Up to a certain percentage of B atoms can then be stored in the crystal of substance A. Conversely, this also applies to the crystal of substance B, in whose lattice atoms of type A can be dissolved to a certain degree.

The precipitation processes that occur through diffusion processes when the solubility limit is undershot always take certain time. However, this time can be taken away by rapid cooling (known as quenching). As a result, some of the normally insoluble alloying element atoms remain forcibly dissolved in the host lattice, as the time is taken for them to diffuse out. This leads to correspondingly strong lattice distortions and can lead to enormous increases in strength, as the dislocation movement is made more difficult by the lattice distortions and the forcely dissolved atoms.

The solid solutions are thus in an oversaturated state when rapidly cooled to room temperature and are not in thermodynamic equilibrium. In principle, however, each system strives for a thermodynamic equilibrium. For this reason, precipitates from the supersaturated solid solution will form over time, even at room temperature. However, due to the low diffusibility at such low temperatures, this process takes much longer. This can be a question of days, weeks, months or even years. By striving for a thermodynamic equilibrium state or the subsequent formation of precipitations, the original properties of the material naturally change over time. This process is also known as the aging.

If the two components of a binary alloy system are completely insoluble in one another in the solid state, one speaks of a crystal mixture. In this case, each of the two components forms its own crystal lattice structure. The individual crystals are only composed of the atoms of the corresponding substance, i.e. they are pure crystals.

The cooling curves of insoluble components (accounts only for the solid state, not in the liquid state) show a flattening during solidification as well as a thermal arrest. While the beginning of the flattening indicates the start of solidification, the solidification ends after the thermal arrest. Depending on the concentration of the alloying element, the solidification starts at different temperatures. The end of solidification, on the other hand, always takes place in a thermal arrest at the same temperature, irrespective of the alloy concentration [12; 13; 14; 15].

III. Match the left and the right.

1. Alloy	a) температурная остановка (на кривой нагрева или охлаждения)
2. Host lattice	b) растворенный компонент
3. Host material	c) растворяющее вещество
4. Cooling curve	d) сплав
5. Thermal arrest	e) кристаллическая решетка ос-

	новы; кристаллическая решетка основного вещества
6. Solvent	f) искажение решетки
7. Solute	g) состояние пересыщения
8. Lattice distortion	h) кривая охлаждения
9. Oversaturated state	i) материал основы; исходный материал
10. Precipitation process	j) осадительная плавка; процесс выпадения вторичных фаз

IV. Find in the text English equivalents of the following Russian words and expressions.

Растворимое вещество, твердое состояние, закалка, несмешивающийся, кристаллическая решетка, стареющий сплав, жидкое состояние, чистый кристалл, комнатная температура, диффузионная подвижность, термодинамическое равновесие, ограниченная растворимость.

V. Find 9 words from the unit:

P	**I**	**M**	**M**	**I**	**S**	**C**	**I**	**B**	**L**	**E**	**V**	**E**	**S**	**D**	**S**
A	**W**	**H**	**P**	**O**	**P**	**A**	**P**	**I**	**O**	**T**	**I**	**N**	**G**	**R**	**O**
L	**E**	**Q**	**L**	**A**	**T**	**T**	**I**	**C**	**E**	**K**	**J**	**E**	**A**	**I**	**L**
L	**C**	**D**	**R**	**A**	**S**	**O**	**L**	**V**	**E**	**N**	**T**	**H**	**R**	**L**	**U**
O	**U**	**P**	**R**	**E**	**S**	**P**	**L**	**I**	**T**	**T**	**I**	**N**	**G**	**L**	**N**
Y	**R**	**L**	**D**	**I**	**S**	**T**	**O**	**R**	**T**	**I**	**O**	**N**	**I**	**N**	**I**
G	**V**	**E**	**Q**	**U**	**E**	**N**	**C**	**H**	**I**	**N**	**G**	**A**	**B**	**E**	**O**
I	**N**	**S**	**O**	**L**	**U**	**B**	**I**	**L**	**I**	**T**	**Y**	**N**	**I**	**O**	**N**

VI. Grammar task. Open the brackets.

1. Every year students … (choose) a project on an environmental problem.
2. They have been talking on the phone since 9 o'clock this morning.
3. I have decided to sell this house. What you … (buy) instead?
4. My father … (teach) me how to drive when I was 18.
5. Stop … (talk) to each other, please!
6. You … (a modal verb of advice) drink more water.
7. The sinking of the Titanic is one of the most famous shipwreck stories of all time.
8. A miner's job is more dangerous than a fireman's job.
9. Last week a new leisure center was opened in the town of Halden.
10. I'm not wearing my black shoes today. They are being mended.
11. Martin isn't here. He … (go) to the library to get some books.
12. If he … (work) more slowly, he wouldn't make so many mistakes.
13. There isn't … (much/few/a few/a lot) space in this flat.
14. What time … the lecture (begin)?
15. Meg was lying in the sun while the children …(play) in the pool.
16. She … (a modal verb of absence of necessity) get up early. The lessons begin at 10.
17. Unless you … (leave) now, you'll miss the train.
18. I … (think) about visiting Jane this afternoon.
19. He is clever enough … (do) the crossword.
20. Will there be … (many/much/little/a little) guests at the party? [10; 11].

UNIT 4. IRON-CARBON ALLOYS: COMPOSITION AND PROPERTIES

I. Read, translate and retell the text.

Ferrous alloys, in which iron is the principal constituent, include steel and pig iron (with a carbon content of a few percent) and alloys of iron with other metals (such as stainless steel). Ferrous alloys are known for their strength. Alloys are usually stronger than pure metals, although they generally offer reduced electrical and thermal conductivity. The simplest ferrous alloys are known as steels, and they consist of iron (Fe) alloyed with carbon (C) (about 0.1% to 1%, depending on the type).

Steel is one of the most useful and common ferrous alloys in modern use. Their widespread use is accounted for by the following factors: iron-containing compounds exist in abundant quantities within the Earth's crust; metallic iron and steel alloys may be produced using relatively economical extraction, refining, alloying, and fabrication techniques; ferrous alloys are extremely versatile in that they may be tailored to have a wide range of mechanical and physical properties.

The principal disadvantage of many ferrous alloys is their susceptibility to corrosion. By adding chromium to steel, its resistance to corrosion can be enhanced, creating stainless steel, while adding silicon will alter its electrical characteristics, producing silicon steel.

Types of Ferrous Metals – Classification Based on Composition

Pig Iron. In general, pig iron is an intermediate product of the iron industry. Pig iron, also known as crude iron, is produced by the blast furnace process and contains up to 4–5% carbon, with small amounts of other impurities like sulfur, magnesium, phosphorus, and manganese. The high level of carbon makes it relatively weak and brittle.

Medium-carbon steel is mostly used to produce machine components, shafts, axles, gears, crankshafts, coupling, and forgings. It could also be used in rails, railway wheels, other machine parts, and high-strength structural components calling for a combination of high strength, wear resistance, and toughness.

Wrought Iron. Wrought iron is an iron alloy with very low carbon content (less than 0.08%) to cast iron (2.1% to 4%). The microstructure of wrought iron shows dark slag inclusions in ferrite. It is soft, ductile, magnetic, corrosion-resistant, and easily welded. It has high elasticity and tensile strength. It can be heated and reheated, and worked into various shapes. Wrought iron is no longer produced on a commercial scale. Many products described as wrought iron, such as guard rails, garden furniture, and gates, are made of mild steel. For example, the Eiffel Tower is a wrought iron lattice tower.

Steel. Steels are iron-carbon alloys that may contain appreciable concentrations of other alloying elements. Thousands of alloys have different compositions and/or heat treatments. The mechanical properties are sensitive to the content of carbon, which is normally less than 1.0 wt% (weight percentage). According to our AISI (American Institute of Steel and Iron) classification, carbon steel is broken down into four classes based on carbon content:

Low-carbon Steels. Low-carbon steel, also known as mild steel, is now the most common form of steel because its price is relatively low. At the same time, it provides material properties that are acceptable for many applications. Low-carbon steel contains approximately 0.05–0.25% carbon making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheap and easy to form; surface hardness can be increased through carburizing.

Medium-carbon Steels. Medium-carbon steel has approximately 0.3–0.6% carbon content, balances ductility and strength, and has good wear resistance.

High-carbon Steels. High-carbon steel has approximately 0.60 to 1.00% carbon content, and hardness is higher than in the other grades, but ductility decreases. High carbon steels could be used for springs, rope wires, hammers, screwdrivers, and wrenches.

Ultra-high-carbon Steels. Ultra-high-carbon steel has approximately 1.25–2.0% carbon content. Steels can be tempered to great hardness. This grade of steel could be used for hard steel products, such as truck springs, metal cutting tools, and other special purposes like (non-industrial-purpose) knives, axles, or punches. Most steels with more than 2.5% carbon content are made using powder metallurgy [16].

Vocabulary

blast furnace process – доменный процесс;
brittle – хрупкий, непрочный;
cast iron – чугун;
ferrous alloys – сплавы на железной основе;
high-carbon steel - высокоуглеродистая сталь, твердая сталь;

low-carbon steel - низкоуглеродистая сталь, мягкая нелегированная сталь;
magnesium – магний;
manganese – марганец;
medium-carbon steel – среднеуглеродистая сталь;
pig iron – чугунная чушка, литейный чугун;
silicon steel – кремнистая сталь;
stainless steel – нержавеющая сталь;
susceptibility – подверженность воздействию;
thermal conductivity – теплопроводность;
wrought iron – кованое железо

II. Match the left and the right.

1.principal	a) metals
2.physical	b) properties
3.blast	c) industry
4.iron	d) alloys
5.pure	e) steel
6.carbon	f) elements
7.steel	g) conductivity
8.electrical	h) constituent
9.alloying	i) products
10.high	j) content
11.stainless	k) elasticity
12.ferrous	l) furnace

III. Complete the text with the missing words.

Iron, fractures, conductivity, annealing, ductility, white, melting

Cast irons also comprise a large family of different types of (1) …, depending on how the carbon-rich phase forms during solidification. The microstructure of cast irons can be controlled to provide products with excellent (2) … , good machinability, excellent vibration damping, superb wear resistance, and good thermal (3) … . The most common cast iron types are:

Grey cast iron. Grey cast iron is the oldest and most common type of cast iron. Grey cast iron is characterized by its graphitic microstructure, which causes (4) … of the material to have a grey appearance.

White cast iron. White cast irons are brittle and unmachinable, while grey irons with softer graphite are reasonably strong and machinable. A fracture surface of this alloy has a white appearance, and thus it is termed (5) … cast iron.

Malleable cast iron. Malleable cast iron is white cast iron that has been annealed. An (6) … heat treatment transforms the brittle structure as the first cast into the malleable form.

Ductile cast iron. Ductile iron, also known as nodular iron, is similar to gray iron in composition. Ductile iron is stronger and more shock resistant than grey iron. Ductile iron has mechanical characteristics approaching steel, while it retains high fluidity when molten and lowers its (7) … point [17].

IV. Check your knowledge.

1. What is the most common ferrous alloy in modern use?
2. Why is steel so widespread?
3. Describe the classification of ferrous metals according to their composition.
4. Where is medium-carbon steel mostly used?
5. Describe four classes of steel based on carbon content.

V. Grammar task. Open the brackets.

1. The professor … (not/ start) speaking until everyone was quiet.
2. I’m sure you … (get) the tickets.
3. We … (be) out four times this week.
4. She … (stay) with a friend in London at present.
5. He had difficulty … (find) his way back.
6. If you finish work early, we’ll go for a walk.
7. I know old Mr. Hopper has … (many/few/a few/a lot) of money.
8. She heard footsteps; she thought she … (follow).
9. He is … (a degree of comparison of good) at football than his brother.

10. I have … (very little/many/few/a few) time for reading.
11. … (a modal verb of permission) I park my car in your garage?
12. He is too young … (have) his own car.
13. I saw Irene in the park. She … (sit) on the bench.
14. I'm sorry, I can't come. I … (meet) my sister at the station.
15. I … (work) on this problem for two months.
16. If I … (have) money, I would travel round the world.
17. Shakespeare is … (a degree of comparison of prominent) English poet and playwright of all the ages.
18. The Browns … (go) to the seaside every summer.
19. Look! There's nothing here. Everything … (take away).
20. You … (a modal verb of advice) book a hotel room [10; 11].

UNIT 5. STRUCTURAL AND TOOL STEEL

I. Read, translate and retell the text.

In today's world, we see and use steel structures everywhere. Thanks to its unique properties, all types of steel form a basis for our modern society.

Structural steel is a type of steel that is used as a construction material. It is designed to have a good strength/weight ratio (which is also called specific strength) and to be cost-effective in order to be benefited as a structural component in buildings, roads, bridges, etc.

There is not just one type of structural steel. There exist various different shapes and grades, depending on the needs for that specific application. Structural steels are classified by the shape of their cross-sections, such as the most frequently used I, T, C shapes. Besides their shape, the grade of the steel directly affects the mechanical properties. So, different grades of structural steel must be chosen according to different design requirements [18].

Tool steel refers to various carbon and alloy steels that are particularly well-suited to be made into tools.

Tool steel refers to a variety of carbon and alloy steels that are particularly well-suited to be made into tools (punches, dies, molds, tools for cutting, blanking, forming, drawing, steering, and slitting tools). Their suitability comes from their distinctive hardness, resistance to abrasion and deformation, and ability to hold a cutting edge at elevated temperatures. With a carbon content between 0.5% and 1.5%, tool steels are manufactured under carefully controlled conditions to produce the required quality. The presence of carbides in their matrix plays the dominant role in the qualities of tool steel.

They are generally grouped into two classes: plain carbon steels containing a high percentage of carbon, about 0.80-1.50%; alloy tool steels, in which other elements (chromium, molybdenum, vanadium, tungsten, and cobalt) are added to provide greater strength, toughness, corrosion, and heat resistance to steel.

One of the subgroups of tool steels is high-speed steels (HSS), which were named primarily for their ability to machine and cut materials at high speeds. It is often used in power-saw blades and drill bits.

Pure iron is too soft to be used for the purpose of a structure. Still, adding small quantities of other elements (carbon, manganese, or silicon, for instance) greatly increases its mechanical strength. The synergistic effect of alloying elements and heat treatment produces various microstructures and properties. The four major alloying elements that form carbides in tool and die steel are tungsten, chromium, vanadium, and molybdenum. These alloying elements combine with carbon to form hard and wear-resistant carbide compounds.

Tungsten produces stable carbides and refines grain size to increase hardness, particularly at high temperatures. Tungsten is used extensively in high-speed tool steels and has been proposed as a substitute for molybdenum in reduced-activation ferritic steels for nuclear applications.

Chromium increases hardness, strength, and corrosion resistance. The strengthening effect of forming stable metal carbides at the grain boundaries and the strong increase in corrosion resistance made chromium an important alloying material for steel. Chromium plays an important role in the hardening mechanism and is considered irreplaceable.

When added to tool steel, molybdenum (about 0.50-8.00%) makes it more resistant to high temperatures. Molybdenum increases harden ability and strength, particularly at high temperatures, due to the high melting point of molybdenum. Molybdenum is unique in the extent to which it increases steel’s high-temperature tensile and creeps strengths.

Vanadium is generally added to steel to inhibit grain growth during heat treatment. Controlling grain growth improves the strength and toughness of hardened and tempered steels. The size of the grain determines the properties of the metal. For example, smaller grain size increases tensile strength and tends to increase ductility. Larger grain size is preferred for improved high-temperature creep properties [19].

Vocabulary

abrasion – абразивное истирание, потертость, абразивный износ;
alloy tool steel – легированная инструментальная сталь;
blanking tools – инструменты для заготовительных операций ковки, вырубной инструмент;
carbide – твердосплавный инструмент;
cost-effective – экономичный в использовании;
creep properties – характеристика ползучести, предел ползучести;
die steel – штампованная сталь;
high-speed steel – быстрорежущая инструментальная сталь;
inhibit – замедлить, снижать вероятность;
grain growth – рост зерна металла;
plain carbon steel - углеродистая сталь, нелегированная сталь;
pure iron – чистое железо;
slitting tools – инструменты для резки давлением;
specific strength – коэффициент прочности;
structural steel – конструкционная сталь;

II. Find 9 words from the unit:

L	**T**	**P**	**R**	**O**	**P**	**E**	**R**	**T**	**I**	**E**	**S**	**Y**	**S**	**D**	**A**
C	**W**	**D**	**E**	**F**	**O**	**R**	**M**	**A**	**T**	**I**	**O**	**N**	**G**	**R**	**B**
A	**Q**	**O**	**I**	**N**	**I**	**T**	**I**	**A**	**T**	**I**	**O**	**N**	**A**	**I**	**R**
R	**U**	**C**	**O**	**R**	**R**	**O**	**S**	**I**	**O**	**N**	**S**	**H**	**R**	**L**	**A**

B	**A**	**M**	**A**	**N**	**G**	**A**	**N**	**E**	**S**	**E**	**R**	**R**	**G**	**L**	**S**
O	**R**	**S**	**I**	**L**	**I**	**C**	**O**	**N**	**T**	**Y**	**I**	**N**	**I**	**N**	**I**
N	**P**	**S**	**U**	**C**	**H**	**R**	**O**	**M**	**I**	**U**	**M**	**A**	**B**	**E**	**O**
G	**Y**	**A**	**V**	**A**	**N**	**A**	**D**	**I**	**U**	**M**	**S**	**L**	**I**	**T**	**N**

III. Read the text once again and answer the following questions.

1. What type of steel can be referred as structural steel?
2. What type of steel can be referred as tool steel?
3. Give examples of tool steel items.
4. Describe four major alloying elements that form carbides in tool and die steel.

IV. Grammar task. Open the brackets.

1. The warmer the weather, … (a degree of comparison of good) I feel.
2. We could still see the tracks where the car … (drag off) the road.
3. He needed a little peace so he went to a quiet island for … (a few/much/little/a lot) days.
4. The Earth … (rotate) round its axis.
5. I … (be) to New York several times, but I haven't been to Atlanta.
6. … your train… (arrive) at 7.00 or 7.30?
7. She took off her coat as soon as she … (enter) the house.
8. He was the last … (come) to work.
9. We tried hard but we couldn't persuade him.
10. I'm not sure where to go to my holiday. I may go to Italy.
11. John is usually careful but today he … (be) careless.
12. His brother is … (a degree of comparison of talented) person I have ever met.
13. A new metro station line … (construct) now.
14. … (Much/Few/A few/A lot) human labour was used in the building of the Pyramids.

15. I'm sure they will understand if you … (explain) your problem.
16. David Jones … (work) for the same company for 20 years.
17. Look at that little boy at the puddle. He … (fall into) it!
18. Jensa broke her leg when she … (ski) in Switzerland.
19. He spends his free time … (dig) the garden.
20. I could give you his address if I … (know) it [10; 11].

UNIT 6. NONFERROUS METALS AND NON-METALLIC MATERIALS

I. Read and translate the text. Make up the plan.

Nonferrous metal refers to any metal which does not contain iron as a component. It can be a pure metal or an alloy (a mixture of metals and other elements). Nonferrous metals are more expensive than ferrous metals due to their reduced supply.

The properties of nonferrous metals include low weight, corrosion resistance, a high degree of electrical conductivity, etc. These nonferrous metals are resistant to corrosion due to the absence of iron. Due to their low weight, nonferrous metals are used in making body parts of aircraft. The main advantage of nonferrous metals over ferrous metals is their malleability. Most nonferrous metals are non-magnetic. So they are used in wiring applications.

Types of Nonferrous Metals: aluminium – this exists as an alloy of aluminium, copper, and manganese. Due to its light weight, aluminium is used in aircraft manufacturing; copper – this is a very good electrical conductor, and is used in the production of wires; lead – this metal is heavy and malleable. It can avoid corrosion in moist environments; brass – Brass is mainly made of copper and zinc. But there can be other metal or non-metal components too. It is used for decorative purposes.

Difference between ferrous and nonferrous metals

Definition. Ferrous metals are metals that contain iron as one of their components. Nonferrous metals are metals that do not have iron in their composition.

Composition. Ferrous metals essentially contain iron and other metal or non-metal elements. Nonferrous metals essentially lack iron and are composed of other metal components.

Corrosion Resistance. Ferrous metals are always corrosive except for stainless steel. Nonferrous metals are non-corrosive.

Magnetic Properties. Ferrous metals show magnetic properties. Nonferrous metals do not have magnetic properties / they are non-magnetic.

Cost. Ferrous metals are not that much expensive due to higher supply. Nonferrous metals are expensive due to reduced supply.

Weight. Most of the ferrous metals are heavy weight metals. Nonferrous metals are low weight metals.

Conclusion. All metals can be grouped into two groups as ferrous metals and nonferrous metals based on their iron content. Thus, the main difference between ferrous metals and nonferrous metals is that ferrous metals contain iron as a component whereas nonferrous metals do not contain iron. These metals also have different properties based on this iron content, as well as, different uses based on these properties [20].

Non-metallic materials are used in engineering practice due to their low density, low cost, flexibility, and resistance to heat and electricity. Often, these materials provide solutions that traditional materials can not provide. For this reason, non-metallic materials have created their own space in engineering applications. A variety of products and resources that we use in our everyday life are made from non-metallic materials.

Non-metallic materials can be defined as any material that does not contain any metallic element in its composition. So, all non-metallic materials consist of non-metals. Because of the absence of metals, the properties of non-metallic materials are significantly different from metallic materials. Non-metals create the basic building block for all non-metallic materials. Some common non-metals are: solid non-metals: carbon, phosphorous, iodide, sulphur, selenium; liquid non-metals: bromine; gaseous non-metal: hydrogen, oxygen, nitrogen, helium, argon, krypton, fluorine, neon, chlorine, xenon, and radon.

A range of materials constitutes the group of non-metallic materials. The following is a list of common non-metallic materials that are found to be used widely: rubber, plastic, thermoset, thermoplastic, fiber, cork, ceramics, felt, lubricants, adhesives, clay, wood, bones, stone, leather, minerals.

Non-metallic substances possess chemical and physical properties that are quite different from metallic materials. Unlike metallic elements, non-metallic objects have little electrical and thermal conductivity, high resistance to chemical reactions, very good corrosion resistance, low heat resistance, lower strength, low density and lightweight, usually low melting and boiling point, etc.

The major advantages of non-metallic materials over their metallic counterparts are as follows: low cost: most non-metallic materials are cheaper as compared to metallic elements; easily available: the production of non-metallic products is usually easier and faster with very high efficiency; certain favorable properties: low conductivity, high corrosion resistance, etc. are favorable for some applications; non-metallic materials usually do not need post-production treatments like metallic elements [21].

Vocabulary

adhesive – клеевой подслой, вяжущее/адгезивное средство
aircraft manufacturing – самолетостроение
cork – пробковый слой
electrical conductor – электрический кабель
engineering application – техническое применение
fluorine - фтор
moist environment – влажная среда
non-corrosive – коррозионностойкий, коррозионноустойчивый
nonferrous metals – цветные металлы
non-magnetic – немагнитный
thermoplastic – термопластичная пластмасса
thermoset – термореактивный пластик

II. Answer the following questions.

1. Name the properties of nonferrous metals.
2. What are the main types of nonferrous metals?
3. What is the difference between ferrous and nonferrous metals?

4. Why are non-metallic materials mostly used in engineering practice?
5. Name the most common non-metals.
6. What are common non-metallic materials?
7. Why are non-metallic materials more advantageous than their metallic counterparts?

III. Match the left and the right.

1.corrosion	a) purposes
2.stainless	b) properties
3.metallic	c) element
4.decorative	d) point
5. solid	e) efficiency
6.boiling	f) counterparts
7.magnetic	g) point
8. metallic	h) non-metals
9.high	i) steel
10.melting	j) resistance

IV. Complete the text with the missing words.

Engineering, plastics, insulators, fuel, fiberglass, applications, industry, conditions, adhesives, automobile

Non-metallic materials are widely used in the (1) … world and for common uses. Some of the most common (2) … of non-metallic materials are:

- Due to their very low thermal and electrical conductivity, Non-metallic materials make good (3) … for electrical components.
- Carbon in the form of coal is widely used as a (4) … source.
- The lightweight and corrosion resistance property of nonmetallic materials allows them to be used as pipes and liners in the oil and gas (5) … .

- Non-metallic materials produce energy-efficient automotive parts and are widely used in the automobile and aerospace industries. Various plastic and (6) … can be found in building aircraft.
- Some Nonmetallic materials work as a very good sealing element as they are able to remain effective under a range of working (7) … .
- Foam and rubbers are widely used in various applications.
- The application of tapes and (8) … is well-known.
- A lot of useful household items are made from (9) … and ceramics.
- Leather is used in the (10) … industry, and fashion industry (clothing, shoes, belts, etc) [21]

V. Grammar task. Open the brackets.

1. I'll never forget … (go) to France for the first time.
2. Philip lost his camera when he … (walk) round the city.
3. It's unexpectedly hot today. What … you … (wear)?
4. She … (be) in Berlin for two years. She lives in Berlin now.
5. If we don't hurry, we … (be) late.
6. She speaks German quite well but only (a little/a few/much/many) French.
7. "King Lear" … (write) by Shakespeare.
8. She is … (a degree of comparison of graceful) gymnast of all.
9. You … (a modal verb of ability) run much faster when you were younger.
10. Sharon wants … (talk) to you.
11. I … (not/go) to the park yesterday because the weather wasn't very good.
12. Visit us next spring. You … (not/recognize) this place.
13. She has been practicing that song for hours.
14. I had an unpleasant feeling that I … (watch).
15. The weather forecast is not very good. It … (a modal verb of logical assumption) rain this afternoon.
16. What … you … (do) if the lift got stuck between two floors?
17. Last week there was so … (many/a lot/little/ much) rain that I was not able to go out.

18. He … (work) hard these days.
19. We … (write) two tests each term.
20. … (a degree of comparison of small) a flat is, the lower the rent is [10; 11].

UNIT 7. BEARING MATERIALS

I. Read, translate and retell the text.

There are different kinds of metals and metal alloys for different types of applications. Metals, especially steels are very good both for structural and dynamical applications. They withstand both dynamic loads and static loads. This is the biggest advantage of metals in bearing materials.

Carbon steels without chrome contents in them are one of the cheapest bearing materials. Carbon content in steels can be up to 2.1% and with the increasing amount of carbon, the hardness increases but the ductility decreases. Also with the increasing amount of carbon content, the bearing speed increases, and load-carrying capacity increases.

In general, carbon steel bearings are used in the bike wheels and wheels of shopping charts.

Chrome content in the steel provides very high resistance to chemical reactions and chemical attacks. High load-carrying capacity is one of the biggest advantages of chrome steel.

Stainless steels are also very common as a bearing material. They are very resistant to corrosion and chemical attacks.

The most important drawback of the steel applications is the very high requirement for lubrication and very heavy construction.

Tin-lead alloys are very common in bearing applications. In general, these alloys are used in lubricated bearings. Tin-lead alloys generally have low load-carrying capacities. But if there are good backing materials such as cast irons or steels, the load-carrying capacity of the tin-lead alloys will be better. The temperature has a significant effect on the mechanical characteristics of tin-lead alloys. Also, increasing or decreasing the alloying elements in tin-lead alloys may have significant effects. For example with the increasing alloying elements such as copper or antimony, the hardness and tensile strength of the tin-lead alloys increase but the ductility decreases.

So, the use of tin-lead alloys is very common because of these properties in bearing lining applications.

In the bearing applications, they use these materials in heavy-duty applications. Also, the fatigue resistances of copper-lead alloys are superior if we compare them to other materials. The lead content in the copper-lead alloys provides very good bearing surfaces. So, the frictions between the bearing surfaces are very low. But the corrosion resistance decreases with the increasing amount of lead.

Copper lead alloys are very common in the lining applications of steel-backed bearings. The general alloying elements in copper-lead alloys are tin, lead, and aluminum [22].

Vocabulary

antimony – сурьма;
bearing materials – конструкционные материалы;
chemical attack – химическая коррозия;
heavy-duty applications – тяжелый режим применения;
lining application – применение футеровки;
steel application – применение стали;
steel-backed application – вкладыш подшипника с антифрикционным слоем на стальной ленте;
tin-lead alloys – оловянно-свинцовый сплав

II. Match the left and the right.

1.structural	a) reactions
2.carbon	b) attack
3.chemical	c) steel
4.chrome	d) resistance
5. significant	e) elements
6.carbon	f) applications
7.fatigue	g) content
8. alloying	h) resistance
9.corrosion	i) effect

10.chemical	j) steels

III. Complete the text with the missing words.

Bearing, friction, mechanical, polymer, abrasion, creep

There are other types of materials in the (1) … applications. Among these materials, they use polymers, ceramics, and other materials.

The biggest advantage of (2) … materials in bearing applications is the very low frictions. Because of this property, there is no lubrication requirement for plastic bearings.

The most important polymers in bearing applications are; nylon and Teflon. They have very good low (3) … capabilities to use in bearing applications.

The most important drawback of polymers in bearing applications is the low (4) … properties compared with metals. We use polymer-based bearings in low loads. Because the mechanical strength of these materials is low. Also, they are suitable for low-speed bearing applications.

The main advantage of nylon is its good (5) … resistance which is very important for bearing applications. Also, a good wear rate and good embed abilities make the nylon polymer very useful material in bearing applications. In addition to these properties, nylon has a (6) … disadvantage under loads [22].

IV. Translate the following text from Russian into English.

«Пружины и рессоры являются важнейшими деталями различных машин и механизмов. Под действием нагрузки пружины и рессоры упруго деформируются, а после прекращения действия нагрузки восстанавливают свою первоначальную форму и размеры. Особенностью работы этих деталей является то, что при значительных ударных и статических нагрузках они должны испытывать только упругую деформацию, остаточная деформация не допускается. В связи с этим основным требованием, предъявляемым к сталям для пружин и рессор, является высокое сопротивление малым пластическим деформациям (высокий предел упругости) и стойкость к релаксации напряжений» [23: 30]

V. Grammar task. Open the brackets.

1. Skill … (come) with practice.
2. I … (not/see) Louise since Jeff's wedding. I wonder what's happened to her.
3. The train … (leave) at 10 tomorrow.
4. … you … (see) the Bruce Lee film on TV last night?
5. I'm sorry I forgot … (lock) the car.
6. He spends his free time … (dig) the garden.
7. You … (a modal verb of ability) run much faster when you were younger.
8. This new energy-saving washing machine is … (a degree of comparison of economical) model on the market.
9. The Pyramids … (build) by the Ancient Egyptians.
10. Jane has little knowledge of mechanics so she can't check the car.
11. Andrew … (read up) for his examinations these days.
12. Suzy is in her riding boots. She … (ride) all morning.
13. I promise I … (send) you those photographs.
14. Simon … (walk) home from work the other day when he noticed something shining on the pavement on the other side of the road.
15. I …(a modal verb of necessity) get up at 6 every day. My working day begins at 8.
16. His poems are … (a degree of comparison of popular) than his novels.
17. You can't go in. She … (interview) for the TV.
18. Was there … (a lot of/many/few/a few) opposition to your proposal?
19. If Paul …(enter) the competition, he would win.
20. She won't go to work unless she … (be) better [10; 11].

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