САМАРСКИЙ ГОСУДАРСТВЕННЫЙ АЭРОКОСМИЧЕСКИЙ
УНИВЕРСИТЕТ имени академика С.П.КОРОЛЕВА

МЕТАЛЛЫ И ХИМИЧЕСКИЕ ВЕЩЕСТВА

САМАРА 2001

МИНИСТЕРСТВО ОБЩЕГО И ПРОФЕССИОНАЛЬНОГО
ОБРАЗОВАНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ

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Учебные задания
по английскому языку

САМАРА 2001

Unit 1

1. Просмотрите следующие слова, они помогут вам в работе над текстом:

strength - прочность
toughness - вязкость
to recycle - перерабатывать
to dump - сваливать (складировать)
pure - чистый (без примеси)
treatment - обработка
melting point - точка плавления
hardening - закалка, затвердевание
tempering - отпуск, закалка с последующим отпуском
to withstand - выдерживать (противостоять)

2. Прочитайте текст, найдите ответы на следующие вопросы. Помните, что вам не нужно понимать каждое слово.

1) What is the main advantage of metals?
2) Can plastics be recycled?
3) Which type of heat treatment makes metal softer and less brittle?
4) Why are Concorde's engine surroundings made of titanium alloys?

Why does man use metals still so much today when there are other materials, especially plastics, which are available? A material is generally used because it offers the required strength, and other properties, at minimum cost. Appearance is also an important factor. The main advantage of metals is their strength and toughness. Concrete may be cheaper and is often used in building, but even concrete depends on its core of steel for strength.

Plastics are lighter and more corrosion-resistant, but they are not usually so strong. Another problem with plastics is what to do with them after use. Metal objects can often be broken down and the metals recycled; plastics can only be dumped or burned.

Not all metals are strong, however. Copper and aluminium, for example, are both fairly weak - but if they are mixed together, the result is an alloy called aluminium bronze, which is much stronger than either pure copper or pure aluminium. Alloying is an important method of obtaining whatever special properties are required: strength, toughness, resistance to wear, magnetic properties, high electric resistance or corrosion resistance.

The properties of a metal can be further improved by use of heat treatment. Heat treatment is the term given to a number of different procedures in which the properties of metals and alloys are changed. It usually consists of heating the metal or alloy to a selected temperature below its melting point and then coking it at a certain rate to obtain those

properties which are required. For example, hardening is used to make metal harder. Tempering makes them softer and less brittle. Annealing is carried out to make a metal soft so that it can be machined more easily. In this way, metallic materials can be produced to meet every kind of engineering specification and requirement.

When Concorde was built a material was needed which could withstand extreme aerodynamic conditions and would have a life of at least 45,000 flying hours. To achieve this, a special aluminium alloy was developed which is tough and lightweight and used in over 70% of Concord's structures. Another 16% is made of high-strength steel, and titanium alloys are used in the engine surroundings to withstand temperatures of 4000 degrees centigrade.

3. Пополните свой словарный запас.

a) свойства материалов:

strength - прочность; toughness - вязкость; corrosion resistant – сопротивление коррозии

Найдите в тексте еще девять слов, которые обозначают свойства металлов.

(b) Напишите значения следующих слов. Используйте словарь, если это необходимо.

Loosen; tighten; stiffen; brighten; cool.

c) Существительные и прилагательные. Дайте правильную форму недостающих слов:

Существ.	Прилагат.
strength	strong
resistance	-
-	tough
hardness	-

4. Переделайте следующие предложения, используя the Passive Voice вместо the Active Voice.

Model: We use hardening to make metals harder (The Active Voice).

Hardening is used to make metals harder (The Passive Voice).

1) We rarely find pure metals in nature.
2) We recover metallic ores from the earth in many ways.
3) We obtain lead from a mineral.
4) You need a lot of electrical energy to separate aluminium from the oxygen in aluminium ore.
5) If we add lead to molten tin and then cool the mixture, we find that the freezing point of the mixtures is lower than the freezing point of both lead and tin.

Unit 2

1. Просмотрите следующие слова, они помогут вам в работе над текстом:

1) brass - латунь, желтая медь
2) dilution - разжижение, растворение
3) rivet - заклепка
4) chip - стружка
5) forging - ковка
6) alloy - сплав
7) spring - пружина
8) application - применение

2. Какие слова образуют терминологические словосочетания

a) various	a) brass
b) increasing	b) pressing
c) free-cutting	c) operations
d) hot	d) range
e) machining	e) proportions
f) wide	f) speeds, amounts

3. Просмотрите текст.

Brass

Brass is an alloy of copper and zinc in various proportions. The colour of brasses varies widely with the composition. When increasing amounts of zinc are added to copper, the resulting brasses show a range of colour from copper red which persists for about 5 pct of zinc through a bronze colour at about 10 pct, a golden colour at about 15 pct and increasing dilution of colour to the typical brass yellow at 30 pct of zinc. With more than 38 pct of zinc (alloy obtainable only in rod form) the alloy again takes on a buff red cast. The question of colour is tremendously important in some applications, particularly costume jewelry, fuse boxes, architectural trim and so forth.

Red brass, containing 85 pct of copper, is the most important of the nonleaded brasses, being produced in very large quantities in all the common forms but particularly favoured for pipes for use in plumbing, because of its high resistance to corrosion.

A 90-10 mixture, commonly known as commercial bronze because of its colour, finds a wide field of application for such things as angles, channels, costume jewelry, screws, rivets, and many others.

The alloy that is used in greater quantity than all others in this group combined is free-cutting brass, containing 61.5 pct of copper, 3 of lead and 35.5 of zinc. It can be cut at high speeds with low tool pressure,

causing minimum rate of tool wear and with very short chips that clear the tool well. However, since free-cutting brass does not lend itself particularly well to cold-working procedures often required in addition to machining operations, a medium-leaded or high-leaded brass, might be used in preference.

Where hot pressing or hot forging is to be used as the principal shaping procedure, forging brass containing nominally 60 pct of copper, 2 of lead and 38 of zinc is the most suitable. This alloy, which is extruded readily, also can be forged into shapes over a wide range of temperature, and the 2 pct of lead facilitates extensive and ready machining there after.

The aluminium brass is more specifically used where high water velocities are encountered, as for instance in marine condensers, being highly resistant to so-called impingement attack.

The plain and leading naval brasses and manganese bronze are widely applied where a high-strength structural material resistant to salt-water corrosion is needed. In point of strength, the manganese bronze is distinctly superior to the naval brasses.

Phosphor bronzes containing 5,8, or 10 pct phosphorus are the preferred alloys for springs or other applications requiring high strength, great resilience, and corrosion resistance. The 1.25 pct phosphorous bronze finds its application in electrical contacts, flexible hoses.

Выберите правильный ответ в соответствии с содержанием текста.

1. The colour of brasses varies widely with the composition.
   a) It is right; b) It is wrong; c) It is not mentioned in the text.
2. Red brass, containing 85 pct of copper, is not important.
   a) b) c)
3. The silicon bronzes are general-purpose structural alloys of very wide applications where a combination of high strength, great toughness, resistance to corrosion, and other properties are essential.
   a) b) c)
4. Where hot pressing or hot forging is to be used as the principal shaping procedure, forging brass is the most suitable.
   a) b) c)
5. A 90-10 mixture, commonly known as commercial bronze, doesn't find a wide field of application for many things.
   a) b) c)

4. Просмотрите текст еще раз. Постарайтесь ответить на вопросы.

1) How many types of brass do you know?
2) What are they?
3) What alloy is used where high water velocities are encountered?
4) Why are phosphor bronzes the preferred alloys for springs?

5. Переведите следующий текст за 15 минут со словарем.

Tin, aluminium admiralty (Алюминиевая латунь) and aluminium brass are used almost exclusively for heat-exchanger tubes, primarily because of their high resistance to most conditions of corrosion encountered in such service. The admiralty alloy is now usually modified by the addition of a few hundredths of one per cent of an element from the group including antimony, arsenic, phosphorus, and silver, for the purpose of removal of zinc by corrosion, leaving spongy metal, which otherwise might occur under some conditions of operation. The aluminium brass is now currently made with an inhibitor, as the admiralty mixture is.

Unit 3

1. Просмотрите следующие слова, которые вам помогут понять текст ‘’Copper’’.

malleability - ковкость
ductility - эластичность, ковкость, тягучесть, вязкость
to roll - катать
annealing - отжиг
tenacity - твердость, вязкость, прочность
specific - удельный
solidification - затвердевание, схватывание, застывание
to volatilize - улетучиваться, испаряться, распылять
to surpass - превосходить, превышать, перегонять
impurity - примесь
atomic weight - атомный вес
moist - влажный

2. Просмотрите текст ‘’Copper’’ и найдите ответы на следующие вопросы.

1) What physical properties of copper do you know?
2) What is the melting point of copper?
3) What is the range of the specific gravity of copper?
4) What happens with copper when heated to near its melting point?
5) How do impurities influence the electric conductivity of copper?
6) Is copper an excellent conductor of heat?
7) What changes does copper undergo when heated to redness?

Copper

Physical properties. - Copper is distinguished by its red colour from all other metals. Malleability and Ductility. -It can be rolled into very thin sheets, beaten out into leaves and drawn into the wire, and thus possesses the properties of malleability and ductility in a high degree. By cold rolling or other mechanical treatment it becomes hard, but its malleability is regained by annealing. Tenacity. - Its tenacity when cast is 8 to 10 tons per s.i.; when rolled or drawn 16 to 23 tons or even more, according to the amount of mechanical treatment it has received.

Specific Gravity - The specific gravity of pure Cu, rolled, forged, or drawn, and afterwards annealed, may be taken as 8.89 at 20°C, but that of ordinary commercial copper usually ranges from 8.2 to 8.6.

Action of Heat. - The melting point of Cu lies somewhat about 1,083°C.

When molten it is rapidly oxidized with the formation of cuprous oxide (Cu_2O), which dissolves in the metal. It also absorbs hydrogen, carbon, monoxide, and sulphur dioxide, which are given off during solidification part, however, remains in the metal producing more or less

porosity. The metal is not volatilized at the temperature of ordinary furnaces, but readily in the electric furnace, its boiling point being about 2,100°C. When heated to near its melting point it becomes so brittle that it may be easily powdered.

Electric Conductivity - As a conductor copper is only surpassed by silver, and hence is largely used for electric wires and cables. Its electric conductivity is 976 if silver be taken as 1000. This is greatly reduced by the presence of impurities, especially by cuprous oxide, phosphorus, arsenic, antimony, and silicon.

Conductivity for heat. - Copper is an excellent conductor of heat, and in this property is about two and half times more efficient than iron. Atomic weight is 63.57.

Chemical Properties. -

Copper undergoes no change in dry air at ordinary temperatures, but in moist air a green coating of basic carbonate is formed. When heated to redness with access of air, as in annealing sheets, etc., a dark coloured scale is formed, which consists almost wholly of cuprous oxide. It is soluble in nitric acid, and in hot concentrated sulphuric acid.

3. Перечислите:
а) физические свойства меди
б) химические свойства меди

4. Вставьте нужные слова в следующие предложения из текста
1) By cold rolling or other mechanical ... it becomes hard.
2) The metal is not ... at the temperature of ordinary furnaces.
3) As a ... copper is only surpassed by silver.
4) The electric conductivity is greatly reduced by the presence of ... .

impurities; conductor; treatment; volatilized.

5. Переведите следующий текст письменно, пользуясь словарем.

Alloys of Copper

In addition to the extensive application of copper itself, it is largely used in the manufacture of alloys. Its alloys, especially those with zinc (the brasses) and with tin (the bronzes) are of vast importance for engineering and other purposes, while its alloys with other metals have numerous uses in many industries. When copper is cast in what is termed a closed mould - i.e., a mould with a small aperture or ‘’ingate’’ - unsound vesicular castings only can be produced. To obtain a sound casting the mould must be an open one, hence none but articles of simple forms can be cast of the metal. This is why alloys of copper have come into such extensive use.

Unit 4

1. Просмотрите слова, которые помогут вам понять текст ‘’Metal Adhesives’’.

1) justify - оправдывать, подтверждать
2) insulating film - изолирующая пленка
3) conventional - общепринятый, обусловленный, обычный
4) soldering - пайка
5) fatigue - усталость
6) adhesive - липкий, клейкий, связывающий
7) welding - сварка
8) bond - связь, соединение
9) area - площадь, район, зона

2. Переведите производные

to exist - existense - existing
to contribute - contribution
to join - jointly - joining
strong - strength
to apply - application
to simplify - simplification - simple
to produce - production - product - producer
to compare - comparable
able - ability
thick - thickness - to thicken
to limit - limitation

3. Прочтите текст ‘’Metal Adhesives’’

Metal Adhesives

Properties and advantages

Although metal adhesives have only existed for some years, they have already justified their existence by the contribution which they have made to the more outstanding products of the aircraft industry. Other industries are now utilizing the advantages conferred by using adhesives, notably the electrical industry, which for the first time is able to join together similar or dissimilar materials with a high-strength adhesive which is also an insulating film.

The conventional methods for joining metals are bolting, riveting, soldering, and welding, all of which are well-tried processes with which every engineer is familiar. There are, however, many applications, where none of these really meet the demands of the situation and in such cases adhesives with their rather different properties may be more suitable. The properties and advantages of adhesives usage may be summarized as follows:

1) Simplification of design.
2) Possible reduction of production time and consequently production cost.
3) Ability to join together dissimilar materials.
4) Increased strength over comparable riveted or sport - welded joints.
5) The ability to join together high-strength aluminium alloys without lowering the physical properties of the alloy.
6) Absence of distortion in a bonded structure, due to the avoidance of local heating and the lower temperatures used when compared with welding or brazing.
7) Even stress distribution over the whole of the bonded area and consequent avoidance of areas of high stress concentration, such as occur around rivet holes, spot welds or bolt holes.
8) Increased fatigue strength.
9) Adhesives do not cause corrosion.

In spite of these advantages, however, there are certain limitations controlling the use of adhesives, and one of these is the thickness of the parts being bonded. It is not the case that adhesives cannot be used for joining together materials greater than a certain thickness but rather that as the thickness of the material increases, so that advantages become fewer. It is therefore with sheet and strip materials that the greatest field for the application of adhesives is found.

4. Найдите в тексте предложения с модальными глаголами.
5. Переведите следующие предложения, обратив внимание на перевод конструкций модальный глагол + Passive Voice.

1) These methods of joining metals must be widely used nowadays.
2) The books may be given to the students.
3) The work can be done in time.
4) These things should be paid attention to.
5) He must be listened to attentively.

6. Укажите вопрос, на который вы не найдете ответ в тексте:

a) What conventional methods for joining metals are given in the text?
b) How is soldering done?
c) What properties and advantages of adhesive usage are summarized in the text?
d) Who suggested first to use metal adhesives?
e) What does the quality of metal adhesives depend on?
f) What types of adhesives do you know?

7. Переведите текст ‘’Types of adhesives’’.

Types of adhesives

There are many different types of adhesives used for joining metals, ranging from those which are applied and cured at room temperature to those which are applied hot and cured at elevated temperatures. Of those types which are available, however, the operating conditions rule out many for certain applications, as they will not retain their properties over the necessary range of operating conditions. Some, for instance, lose strength very rapidly as temperatures increase, some lose strength under conditions of high humidity whereas others lose strength when subjected to low temperatures.

Unit 5

1. Просмотрите следующие слова, они помогут вам при работе с текстом.

limestone - известняк
coke - кокс
hearth - под, горн (печи)
to contaminate - загрязнять
mould - литейная форма, матрица
ingot - слиток, болванка
treatment - обработка
to refine - очищать, рафинировать
intrinsic - внутренний, присущий, существенный

2. Просмотрите текст. Найдите ответы на следующие вопросы.

1) Where does the iron in the molten state collect?
2) In what process does the iron become contaminated?
3) What must be removed from pig iron to form steel?
4) What fundamental sciences is the science of metallurgy based on?
5) What does physical metallurgy deal with?
6) What does chemical metallurgy consider?

Relation of Metallurgy to Physics and Chemistry

In principle steelmaking involves only relative simple steps. Principle iron ores consist of combinations of iron with oxygen (iron oxides), mixed with varying percentages of useless earthy materials. In order to remove the oxygen and useless materials, the iron ore along with coke and limestone are charged into the blast furnace. Hot air blown into the blast furnace burns the coke to generate heat. The hot carbon of the coke, and the carbonbearing gases generated by its burning, combine with the oxygen of the iron oxide leaving the iron in metallic form. The iron in the molten state collects in the hearth at the bottom of the blast furnace. The limestone combines with the useless part of the ore to form molten slag that floats on the top of the pool of molten iron. In this process the iron becomes contaminated with some of the carbon from the coke used as fuel. The product of the blast furnace, pig iron, may contain somewhat over 4 per cent of carbon. To make steel from pig iron, some of the carbon must be removed, because most steels contain considerably less than 1 per cent of carbon. The unwanted excess of carbon is removed in the steelmaking processes, principally the Bessemer conventer and the open hearth furnace process, using controlled amounts of oxygen for its removal. The resulting final product, steel, is first poured into moulds to form ingots, which then are formed into useful shapes by rolling or other forming processes.

However formed, the final products, in many cases, are subjected to heat treatment to develop special properties.

The procedures simply outlined above become complex in practice because of a vast array of complicating circumstances. Actually, the problems in each step of manufacture are very complex. Their solution requires considerable technical knowledge and ability. Some previous knowledge of the fundamental sciences of chemistry and physics is essential to the study of these problems.

The science of metallurgy is based on the two fundamental sciences, physics and chemistry and is commonly subdivided into two major fields: namely, physical metallurgy which deals with the structure, fabrication and behaviour of metals, and chemical metallurgy which deals with the smelting of ores and minerals and, with the refining and furnace reactions of molten metals.

3. Переведите производные
to suit - suitable
pure - impure - impurity
to solve - to dissolve - solution
to react - reaction - reactivity
difficult - difficulty
success - successful - successfully
to conduct - conductor - conductivity

4. Составьте предложения, используя следующие слова:
1) metallurgy, based, physics, on, is, chemistry, and, the, of, science.
2) somewhat, pig iron, over, may, 4 per cent, carbon, contain.
3) iron, the, collects, at, bottom, the, of, hearth, in, the, blast furnace, the.
4) metallurgy, with, structure, of, the, deals, and, behaviour, fabrication, metals, physical.

5. Переведите на русский язык, обращая внимание на конструкцию ‘’in order to’’.
1) In order to remove the oxygen and useless materials, the iron ore along with coke and limestone are charged into the blast furnace.
2) In order to harden the steel through its cross-section the alloying elements, such as nickel, chromium, silicon and molybdenum, are used.
3) Iron ore is added as required in order to oxidize carbon, phosphorus, chromium, and manganese from the bath.
4) The ingots then pass through a mill and through various sizes and shapes of rolls in order to get desired shapes.

5) In order to keep an even composition and provide an adequate source of supply, the molten iron is often placed in a larger mixer.
6) Years of experience have taught him just when to turn down the vessel in order to get the desired composition.
7) In order to save his process in the face of opposition among steelmakers, Bessemer built a steel works at Sheffield.

6. Прочитайте и переведите текст:

Spectral analysis in our time is one of the most effective methods for determining the chemical composition of substances, and one of which science and industry are demanding more and more. They need more accurate and swifter methods of analysis of rapid technological processes which take place in conditions which make them inaccessible to man.

A group of physicists has evolved a method for using optical quantum generators for spectral analysis.

The research done by scientists has shown that it is possible, using the new method, to considerably increase accuracy and speed of analysis and even to make it automatic. With quantum generators it will be possible to carry out analyses of substances in unusual conditions, in particular, in pressurised vessels, where there is either an extremely rarefied atmosphere or high pressure.

It looks as though it will be possible to carry out analyses inside industrial apparatuses, in particular, in smelting furnaces during the smelting of metals. The method will make the control of technological processes more rapid than ever, so that there will be no danger of any essential ingredients in an alloy burning up.

Unit 6

1. Переведите следующие словосочетания:

1) since ancient times, glass-making, impure sodium, fewer extranuclear electrons; a number of differences; generally speaking, much alike; a metallic lustre; much more refractory; melting point; a pure form; high chemical reactivity, molten silicon; dielectric constant; electrical properties.

2. Просмотрите текст ‘’Silicon’’ и перечислите на английском языке

а) черты, общие для кремния и германия

б) свойства, различающие кремний и германий.

Silicon

Since ancient times, is has been known that siliceous materials were suitable for glass-making. The history of silicon began shortly after 1800 when Davy concluded that silicon was a compound not an element.

Crystalline silicon was prepared first by Denville in 1854 by electrolysis of impure sodium aluminium chloride. Shiny platelets of silicon were obtained by dissolving the aluminium from the granular melt which had contained about 10 per cent silicon.

Silicon like germanium, is a fourth-column element, and also has the diamond structure. However, the lattice constant is 5,430 A, smaller than that of germanium. The fact that silicon has a smaller atomic weight and fewer extranuclear electrons than germanium, leads to a number of differences in their properties. Generally speaking, however, the two substances are much alike.

Whereas germanium is bright silvery in appearance, silicon is darker in hue, although polished speciments still have a metallic lustre.

Silicon is much more refractory than germanium; its melting point of 1420°C is responsible for many of the difficulties of making it in pure form . The high chemical reactivity of the material at this temperature and the relative difficulty of preventing impurities from contaminating the molten silicon are typical of these problems. However, silicon has been prepared successfully in rather pure, single-crystalline form.

Silicon was studied much earlier than germanium, and was used in commercial rectifiers and diodes before germanium. However, as a result of the discovery of transistor action in germanium, much greater attention to germanium was given for several years. And it was only when the high band gap and low intrinsic conductivity of silicon gave promise of rectifiers and transistors which would operate well at higher temperatures that attention reverted to silicon and efforts developed to make the same time more research was devoted to silicon, which was now much purer and more perfect in crystalline properties than that available in previous research work.

Silicon has a smaller dielectric constant than germanium. This has a definite effect on the electrical properties. For instance, the ionization energy of silicon is larger than that of germanium. Third-and fifth column impurities in silicon have an ionization energy of about 0.045 eV whereas the values for germanium are about 0.01 eV.

Silicon exhibits impurity photoconductivity when the temperature is lowered to the point that most of the carriers are deionized. Since the ionization energies are greater in silicon than in germanium, this can be done at temperatures about liquid hydrogen.

3. Переведите следующие предложения на английский язык:

1) Кремний принадлежит к элементам четвертой группы периодической системы Менделеева.
2) Кремний, до некоторой степени, отличается от германия по своим свойствам.
3) Например, кремний имеет более высокую точку плавления, чем германий.
4) Кремний имеет высокую реактивность, когда он расплавлен.
5) Очищать кремний труднее, чем германий.
6) Только недавно стало возможным очищать кремний до той же степени чистоты, как и германий.
7) Германий может использоваться только при температурах ниже 60°C, а кремний применяется при температурах до 150°-200°C.

4. Переведите следующий текст без словаря.

Properties of Bombarded Silicon

Silicon, like germanium, shows marked changes in its properties when subjected to bombardment by electrons or nuclear particles. Perhaps the chief distinction is the tendency of silicon to go towards the intrinsic state after bombardment, rather than (а не; вместо того, чтобы) to go to p-type as often observed after bombardment of germanium. This effect is attributed to the formation in the silicon lattice of hole-and electron-trapping levels (уровни захвата электронов из дырок) very close to the middle of the forbidden band. With such levels being introduced, the material will tend to acquire a higher resistivity whether or not it was originally n-or p-type.

Unit 7
Tungsten

1. Tungsten, also known by its European name, wolfram, is a metal with unique properties that lead to its use in cutting and forming other metals and in important high-temperature applications. It has the highest melting point (3410°C) and the lowest vapour pressure of any metal. It has the highest tensile strength, yielding tensile of up to 600.000 psi in wire form. Its corrosion resistance is one of the highest. Its density is exceeded only by metals of platinum group. Properly worked, it is elastic and ductile. Its compound with carbon is the hardest known metallic substance.
2. The word ‘’tungsten’’ is an adaptation of Swedish tungsten (heavy stone) and was first applied to the mineral scheelite about 1758. The name wolfram of Germanium origin and from which the chemical symbol W is derived, probably has reference to the ‘’wolflike’’ characteristic of tungsten described by the early tin miners as ‘’devouring tin’’ and causing low recoveries in the tin smelting operations.

Tungsten is never found in the uncombined state in nature. The most important ores are wolframite, (FeMn) WO_4 and scheelite, $CaWO_4$. The mineral wolframite varies in composition and contains from 76.3 to 76.5 per cent tungsten trioxide. The mineral scheelite when pure, contains 80.6 per cent tungsten trioxide.

3. Tungsten concentrates are reduced to three commercial products: ferrotungsten, tungsten compounds, and pure tungsten.
4. Ferrotungsten. It is prepared by reduction of one of the tungsten minerals with carbon or silicon in the electric furnace or with aluminium and silicon in the thermit process.
5. Tungsten compounds. Most of the chemical compounds of commerce (tungstic oxide, tungstic acid, calcium tungstate) are obtained as intermediate products in the process of preparation of pure tungsten metal.
6. Tungsten metal. The high melting point of tungsten, its reactivity, and the nonavailability of refractories capable of containing molten tungsten, preclude the use of conventional smelting techniques. Consequently, tungsten is won from its ores by chemical decomposition of the ore, isolation of the purified trioxide, reduction of the oxide to metal powder and finally proceeding by powder metallurgical methods to the fabrication of metal products.
7. It is noteworthy that the physical properties possessed by finished tungsten products are materially affected by the chemical and physical characteristics of the powder from which they are produced. These, in turn, are dependent on the chemical and physical properties of the

oxide from which the metal is reduced, and the conditions prevailing during reduction. Obviously, then, control of the properties of the final product begins almost with the inception of ore decomposition and is necessary throughout the process to yield the desired properties of the finished product.

8. Tungsten carbide (WC) is made in powder form by the chemical combination of pure tungsten metal powder and finally divided lamp-black.

Notes:

1. ‘’wolflike’’ characteristic of tungsten ... as devouring tin’’ - ‘’волчья повадка’’ вольфрама ... как ‘’пожирателя’’ олова.

1. Просмотрите текст ‘’Tungsten’’, обращая внимание на значение следующих слов:

1) tensile strength - прочность на разрыв; временные сопротивления разрыву
2) psi - фунты на квадратный дюйм
3) rhenium - рений
4) ductile - пластичный, вязкий, тягучий
5) scheelite - шеелит (мин.)
6) to preclude - предотвращать, устранять, мешать
7) powder - порошок
8) inception - начало

2. Просмотрите 1 и 2 абзацы текста. Найдите предложения, содержащие Past Participle.

3. Переведите письменно раздел ‘’Tungsten metal’’.

4. Переведите следующие предложения на английский язык.

1) Элемент вольфрам был открыт в 1781 году шведским химиком К.Шееле при разложении кислотой минерала тунгтена ‘’тяжелый камень’’, который впоследствии был назван шеелитом.
2) Лишь через сто лет после того, как был открыт вольфрам, он получил большое промышленное применение.
3) Чтобы изменить свойства какого-нибудь материала, вводят специальные элементы или примеси.
4) Использование вольфрама для изготовления вольфрамовых нитей в электролампах было предложено и впервые осуществлено изобретателем Н.А.Ладыгиным в 1900 году.

5. Перескажите текст, используя следующий план.

1) Tungsten is a metal with unique properties.
2) Modern industry and communications would be impossible without it.

3) Tungsten is never found in the uncombined state in nature.
4) Wolframite and sheelite are the most important ores.
5) Tungsten concentrates are reduced to three commercial products: ferrotungsten, tungsten compounds, and pure tungsten.
6) The properties of the finished tungsten product depend upon the properties of the oxide and the powder.

6. Переведите следующий текст на русский язык, обращая внимание на пассивный залог.

Tungsten

Tungsten is one of the industrial minerals without which modern industry and communication would be imposible. It is used as an alloying element in steel, as an additional steel hardener in the form of tungsten carbide, and in its pure form in the radio and electronic industry light bulb filaments are made of pure tungsten for instance. It is also used in various chemical compounds.

The tungsten trioxide in terms of which ore content is usually measured, contains about 80 % of tungsten metal.

Unit 8

1. Просмотрите слова, которые помогут вам понять текст “Intermetallics”

face centered cubic lattice (fcc) – границентрированная кубическая решетка
body centered cubic (bcc) – объемноцентрированная кубическая решетка
hexagonal close-packed (hcp) – гексагональная (шестигранная) решетка с плотной упаковкой
pure – чистый (без примесей)
corner – угол
face – плоскость, грань
randomly – случайно, произвольно
ratio – отношение, соотношение
ordered structure – упорядоченная структура
predominate – преобладать
flow stress – напряжение потока
cleavage – спайность, расщепление, раскалывание
slide – скользить
slip –скользить, скольжение

2. Переведите производные.

Place – replace; alloy – alloying; occupy – occupation; require – required – requirement; brittle – brittleness; strength – strengthen; add – addition – additional; crystal – crystallization – crystallize; attract – attraction – attractive.

3. Найдите в тексте английские эквиваленты следующих словосочетаний:

Легирующий металл, чистый металл, первоначальные атомы, химическое соединение, приводит к…, плоскость скольжения, разрыв связей; для того, чтобы решить проблему; более вязкие структуры, граница зерна.

What are Intermetallics?

Most pure metals have crystal structures such as face centered cubic (fcc), body centered cubic (bcc), or hexagonal close-packed (hcp). In fcc structures, for example, an atom occupies each corner of the cubic structure and the center of each face.

As alloying metals with atoms of similar size are added, they randomly replace the original atoms. For example, as aluminium atoms are added to fcc nickel, they may occupy either corners or face positions.

In some alloys, as the alloying additions reach a critical number of atoms, they begin to occupy specific positions. For example, as the Ni/Al ratio approaches three to one, the nickel atoms occupy the face centered positions and the aluminium atoms occupy the corners. This is known as an ordered structure, and is described as the chemical compound Ni_3Al.

The reason for this order is the strong attraction between nickel and aluminium atoms, which is stronger than that between either two nickel atoms or two aluminium atoms. The requirement for the nearest neighbour of each aluminium to be a nickel atom results in the ordered structure. Because this order is maintained throughout the bulk of the material, intermetallics are called long-range ordered compounds.

Brittleness in intermetallics is due to several mechanisms, but three predominate. First, flow stress can be higher than cleavage stress in the slip planes. For example, the pressure required to cause one cube to slide past another can be higher than that required to break the bonds between the cubes. Although alloying has been attempted in order to solve this problem, so far it has not succeeded.

Second, some lattice structures are so large and complicated that they cannot deform without breaking. Alloying additions have helped in some cases where the original lattice is modified to more ductile structure.

Third, intermetallics have weak intergranular bonds that can break easily in multi-crystal structures even if the first two causes of brittleness do not apply. Micro-alloying additions that segregate to grain boundaries and strengthen them have been successful in some cases.

4. Прочтите текст и укажите вопрос, на который нельзя найти ответ в содержании текста:

1) What crystal structures have most metals?
2) What happens when alloying metals with atoms of similar size are added?
3) What is known as an ordered structure?
4) What is the reason of this order?
5) How are intermetallics called?
6) Was the initial development of intermetallics done?
7) What is the reason of brittleness in intermetallics?

5. Закончите данные предложения в соответствии с содержанием текста:

1) The atoms of alloying metals randomly replace … (the atoms of similar size; the original atoms, aluminium atoms).
2) Intermetallics have weak … (grain boundaries; intergranular bonds, lattice structures).

3) In some alloys, as the alloying additions reach the critical number of atoms, they begin to occupy … (each corner of the cubic structure; the center of each face; specific positions).

6. Назовите английские и русские термины, соответствиующие следующим определениям:
- Crystal structure in which each atom is surrounded by the nearest twelve atoms,
- Crystal structure in which each atom is surrounded by the nearest eight atoms.

7. Сгруппируйте слова - близкие по значению:

1. drawback	thanks to
2. advance	start
3. begin	limitation
4. approach	reach
5. due to	complicated
6. complex	improvement

- противоположные по значению

1. limited	different
2. advantage	weak
3. high	unlimited
4. similar	drawback
5. order	disorder
6. strong	low

8. Переведите предложения:
1) Большинство металлов кристаллизуется в одну из следующих трех структур: границентрированная кубическая решетка, объемноцентрированная и гексагональная решетка с плотной упаковкой.
2) В некоторых сплавах легирующие добавки достигают критической величины.
3) Причины упорядоченной структуры атомов Ni_3Al в сильном притяжении атомов никеля и алюминия.
4) Существует множество причин ломкости (хрупкости) металлов, но три из них преобладают.

9. Переведите текст со словарем.

Intermetallic compounds are well known as constituents of superalloys: Nickel-based superalloys derive much of their high-temperature strength from nickel aluminides and nickel silicides that

comprise as much as 60 % vol. of the superalloy. As monometallic materials, their advantages include high strength at high temperatures, high creep strength, high stiffness, low density, and high resistance to oxidation and sulfidation. They are also well known for their limitations: low room-temperature ductility and low fracture toughness. However, advances in alloy design and in processing technologies have improved these properties, and have brought several intermetallics to the brink of commercialization. These include aluminides of titanium, nickel, and iron, difficulties involved with overcoming their drawbacks did not seem worth the limited number of applications available at the time.

However, the National Aerospace Plane (NASP) and other advanced aerospace applications will require low-density, high-strengh materials including both monometallics, intermetallics and composites with intermetallic matrices. Applications in the petroleum and chemical industries are driving development of intermetallics for their high-temperature oxidation and sulfidation resistance, while automotive and truck applications take advantage of their low inertia and high creep strength.

Unit 9

1. Просмотрите слова, которые помогут вам понять текст “Sintering”.

sintering – агломерация, спекание, окускование
remedy – средство, v - исправлять
distortion – деформация, искажение, коробление
constituent – составная часть, составляющая
tin – олово
approximately – приблизительно
shrink – давать усадку, сморщиваться
furnace – печь, горн, топка
purge – очищать, продувать
jacket – кожух, обшивка
handling – управление, обращение (с чем-л.)
prevent – предотвращать
premix – заранее приготовленная смесь, предварительно перемешивать

2. Переведите производные:

to protect - protection – protective
to heat – heating
oxide – oxidation
crystal – crystallize – recrystallize – recrystallization
deform – deformed – deformation
heat – heating
to sinter – sintering
mix – premix – mixture – admixed
shrink – shrinkage

3. Найдите в тексте ответы на вопросы:

1. What operation is called sintering?
2. What are sintering temperature and time?
3. What happens with most cold-pressed metal powders during the sintering operation?
4. What are the factors influencing shrinkage?
5. What number of zones does the continuous type furnace usually contain?
6. What is the object of protective atmosphere?

4. Прочтите текст.

Heating of the pressed powder is called the sintering operation. The function of heat applied to the pressed powder is similar to the function of heat during a pressure operation of steel, in that it allows more freedom

for the atoms in the crystals; it gives them an opportunity to recrystallize and remedy the cold deformation or distortion within the cold-pressed part. The heating of any cold-worked or deformed metal will result in recrystallization and grain growth of the crystals, or grains, within the metal.

Aluminium and alloys of aluminium can be sintered at temperatures from 700º to 950º F. for periods up to 24 hours. Copper and copper alloys, such as brass and bronze, can be sintered at temperatures ranging from 1200 º F. to temperatures that may melt one of the constituent metals. Bronze powders of 90 per cent copper and 10 per cent tin can be sintered at approximately 1600 º F. or lower for periods up to 30 minutes. Compacts of iron powders are usually sintered at temperatures ranging from 1900 º F. to 2200 º F. for approximately 30 minutes. When a mixture of different powders is to be sintered after pressing and the individual metal powders in the compact have markedly different melting points, the sintering temperature used may be above the melting point of one of the component powders. The metal with a low melting point will become liquid.

Most cold-pressing metal powders shrink during the sintering operation. Factors influencing shrinkage include particle size, pressure used in cold pressing, sintering temperature, and time employed during the sintering operation. Powders that are hard to compress cold shrink less during sintering. It is possible to control the amount of shrinkage that occurs.

The most common type of furnace employed for the sintering of pressed powders is the continuous type. This type of furnace usually contains three zones. The first zone warms the pressed parts, and the protective atmosphere purges the work of any air or oxygen. This zone may be cooled by a water jacket surrounding the work. The second zone heats the work to the proper sintering temperature, the third zone cools the work to a temperature that allows handling. The third zone has a water jacket that allows for rapid cooling of the work, and the same protective atmosphere surrounds the work during the cooling cycle.

Protective atmospheres are essential to the successful sintering of pressed metal powders. The object of such an atmosphere is to protect the pressed powders from oxidation which would prevent the successful welding together of the particles of metal powder. A common atmosphere used for protection and reduction of oxides is hydrogen. The gas is premixed with air in a suitable gas converter or generator and then cooled and let into the furnace.

5. Закончите данные предложения в соответствии с содержанием текста:
   1. Heating of the pressed powder is called … (melting, welding, sintering).
   2. The heating of any cold-worked metal will result in …(deformation, recrystallization and grain growth of the crystals; shinkage).
   3. Factors influenting shrinkage include … (pressure used in cold pressing; time employed in cold pressing, volume of the furnace).
   4. The most common type of furnace employed for the sintering is the … (gas converter, generator, continuous type).

6. Назовите английские и русские термины, соответствующие следующим определениям:
   1. Heating of the pressed powder resulting in recrystallization and grain growth within the metal.
   2. The atmosphere surrounding the work during the cooling cycle.
   3. A process in which materials of a fine particle size are converted into coarse agglomerates.
   4. The point at which the metal becomes liquid.

7. Сгруппируйте слова, близкие по значению:

1. deformation	used
2. component	distortion
3. employed	important
4. essential	constituent
5. cold-pressed	various
6. approximately	over
7. different	nearly
8. above	cold-worked
9. usual	to handle
10. to work	common

8. Переведите предложение:

Металлические порошки можно отличить один от другого и классифицировать с учетом следующих характеристик: а) размера частиц, б) формы частиц, в) наличия примесей, г) давления, используемого при холодной штамповке, д) температуры и времени спекания.

9. Переведите текст со словарем.

Sintering

Almost all iron ores require concentration. The ore concentrate is a powdery material, unsuitable for blast-furnace smelting. Before charging into the blast-furnace it must be agglomerated into lumps. Two agglomeration methods are generally used: sintering and pelletizing.

Sintering is presently the predominant process. It may be defined as a process in which iron-bearing materials of a fine particle size are converted into coarse agglomerates by partial fusion. The product has a porous structure and its mineralogy may be substantially different from that of the original iron-bearing fines. Sintering, as we know it today, originated at the beginning of the 20th century after the invention in 1906 by Dewght-Lloyd, of the first continuous sintering machine. In sintering, a shallow bed of the fine particles is agglomerated by heat exchange and partial fusion of the quiescent mass. Heat is generated by combustion of a solid fuel admixed with the bed of fines being agglomerated. The combustion is initiated by igniting the fuel exposed at the surface of the bed, after which a narrow, high temperature zone is caused to move through the bed by an induced draft applied at the bottom of the bed. Within this narrow zone, the surfaces of adjacent particles reach fusion temperature, and constituents form a semi-liquid slag. The bonding is effected by a combination of fusion and grain growth. The incoming air quenches and solidifies the rear edge of the advancing fusion zone.

Five commonly observed zones are characterized as follows:

1. Zone of Sinter represents the product of the process.
2. Zone of Combustion and Fusion. It is within this zone that oxidation of carbon monoxide and carbon dioxide provides the large quantity of heat for slag formation and the fusion of the ore particles.
3. Zone of Calcination. At this level in the bed the gas stream is sufficiently hot as to calcinate the carbonates.
4. Dry and Preheat Zone. Within this zone the charge has been heated sufficiently to volatilize free moisture.
5. Wet Zone. The moisture level of the upper part of this zone may be raised by the condensation of moisture removed from the previous zones.

Notes:
ore concentrate – железорудный концентрат
quiescent – неподвижный (статический)
bed – слой шихты
zone of calcination – зона обжига
to volatilize – удалять
wet zone - зона сырой шихты

Unit 10

1. Просмотрите слова, которые помогут вам понять текст “New applications of Casting”

approach – подход
cross-section – поперечное сечение
integrity – единство, целостность
duplex steel – сталь “дуплекс” (изготовленная комбинированным процессом плавки в конвертере, а затем в мартеновской печи)
mold – мульда, литейная форма
binder – скоба для скрепления
die – литейная форма
cure – отвердение, сушка
to immerse – погружать, опускать
to insert – включать, вставлять, помещать
to invest – вкладывать
calcitrant – огнеупорный, тугоплавкий

2. Переведите производные:

to attract – attraction – attractive
to cast – casting – castability
solid – solidify – solidification
tough – toughness
sound – soundness
dimension – dimensional

3. Прочтите и догадайтесь о значении следующих слов:

Method, progress, traditional, hydraulics, pneumatics, chemically, vacuum, characteristics, section, combination, structure, uniform, complex, geometry, stability.

4. Найдите в тексте английские эквиваленты русских словосочетаний:

Приводят к…; кроме того; улучшенные свойства; цена, сопоставимая с…; нержавеющие стали; расплавленный сплав; температура затвердевания; зернистая структура; однородный химический состав; отливки сложной геометрической формы.

5. Дайте русские эквиваленты:

Sand casting, die casting, easier castability; vacuum casting, supercasting, precise process control, dimensional stability, recalcitrant metals; relatively low casting temperature; high metallurgical integrity.

6. Сгруппируйте слова, близкие по значению:

low	to insert
to use	die
improved	to apply
production	supply
to inject	advanced
to provide	fabrication
mold	reduced

7. Прочтите текст, найдите и переведите предложения, в которых содержатся ответы на вопросы:

What are the advantages of castings?
What causes rapid solidification of the molded part?
What are the dimensions of vacuum castings?

Because of its low cost casting has always been the most widely used metal fabrication process. New casting methods offering reduced costs, improved toughness, and closer tolerances in a wider range of alloys are making the process even more attractive.

New approaches such as vacuum, directional solidification, single-crystal casting allow parts to be cast that previously had to be forged or welded. Progress in traditional methods such as sand, and die casting result in products with improved soundness and closer tolerances. In addition, new alloys of aluminium, magnesium, iron, titanium, and zinc offer improved properties and easier castability.

Vacuum casting provides cross sections as thin as 1.75 mm and high metallurgical integrity at a cost competitive with sand casting and forging. A wide range of stainless steels, duplex steels, and superalloys are vacuum cast using a system of hydraulics, pneumatics, and sophisticated switching and sensing devices to assure precise process control.

In the process, sand molds with urethane binders are formed on metal dies, then chemically cured. The molds are immersed up to ¾ in. into the molten alloy while a vacuum is applied. The alloy, held at approximately 100º F above solidification temperature, is then drawn into the mold through gates in the bottom. Because of the drawing characteristics of the process, normally recalcitrant metals such as steels and superalloys can fill thin sections. The combination of relatively low casting temperature and thin sections causes rapid solidification of the molded part, resulting in finer grain structure, more uniform chemistry, and improved strength. The process produces castings with thin walls, complex geometries, and a high degree of dimensional stability.

8. Подберите определения к существительным:

casting	complex
steel	switching
device	precise
control	die
temperature	solidification
geometry	sensing
	duplex
	vacuum
	sand
	stainless

9. Переведите текст “Precision casting”.

Precision casting, has been used for thousands of years. In this process, the pattern is made by injecting wax or plastic into a die. If the part contains internal passages, a preformed core is inserted into the die cavity.

A mold is produced by investing the pattern assembly into a ceramic slurry, then coating it with coarse ceramic stucco to strengthen the shell. The shell is fired to burn out the pattern material, and to increase hardness and strength.

In the next step, metal is poured into the mold, cooled, and the part is removed from the mold. The resulting near-net-shape components, typically of superalloys or titanium, require only minor cleaning and finishing operations to obtain the final product.

Most of the advances in the casting technology over the last 15 to 20 years involve controlling formation of grain boundaries, because they reduce strength and operating temperatures. Directional solidification (DS) is a major part of this progress, and single-crystal casting is a specialized form of this technology.

In directional solidification, the section size gradually increases from one side of a casting to the other, so that as thin sections solidify, more-massive sections supply metal to compensate for volume shrinkage. Ideally, metal in the riser remains molten until the rest of the casting has fully solidified. The process produces aligned, axial grains rather than grains with random orientation.

Unit 11

1. Просмотрите следующие слова, они помогут вам в работе над текстом “Corrosion resistance”.

to protect – защищать, предохранять
base material – основной металл сплава
coat – покрывающий слой, покрытие
layer – слой
to prefer – предпочитать
to enclose – включать
gap – зазор
adhesion – сцепление, приставание
electrochemical series – ряд напряжений
tolerance – допуск, допустимое отклонение
preference – предпочтение, преимущество

2. Переведите производные:

to protect – protector – protection
nasty – nastiness
to corrode – corrosion
to prefer – preference
to know – knowledge – to acknowledge
to coat – coating
to resist – resistance
hard – hardness
to apply – application
to treat – treatment

3. Прочтите и догадайтесь о значении следующих слов:

base, material, electrochemical, technology, contact, zinc, aluminium, magnesium, typical, cadmium, hybrid, platinum, implantation, ion, ceramics.

4. Найдите в тексте английские эквиваленты русских словосочетаний:

Загрязненная окружающая среда; дырки, трещины; слой никеля; быстрая коррозия стали; предварительная обработка металлов; гальваническое покрытие; краски на металлической основе; ставить проблемы; допустимые отклонения размеров.

5. Дайте русские эквиваленты:

to resist the nastiness; in preference; rapid corrosion of the steel; excellent protection; good adhesion; good coating thickness; the commonest coating; envelope protection, to work well.

6. Сгруппируйте слова, близкие по значению:

to protect	gap
hole	quick
totally	to coat
rapid	important
vital	entirely
common	application
use	usual

7. Прочтите текст, найдите и переведите предложения, в которых содержатся ответы на вопросы:

What are the ways to protect the base material against a nasty environment?

What are low metals?

What are typical envelope protectors?

What is hybrid technology?

There are two ways to protect your base material against a nasty environment. Either you can coat it with a layer of something that will itself resist the nastiness. Or you can coat it with a metarial that will be corroded in preference to the base you are trying to protect.

To make this choice you need some knowledge of electrochemical series (any good basic chemistry book), and a little knowledge of corrosion technology. As a guide to the electrochemical series, any metal lower in the series will corrode in preference to any metal higher in the series when these metals are in contact. Low metals are zinc, aluminium and magnesium. Heigher metals are gold, silver and nickel.

If we take protection of steel as an example, and we coat it with nickel, then the layer of nickel must be entirely without holes or cracks, totally enclosing the steel. And gap in the nickel coating will lead to rapid corrosion of the steel. If we coat the steel with zinc, then it is the zinc which corrodes, and in so doing protects the steel against corrosion (this is known as sacrificial protection). This protection will last only as long as there is sufficient zinc left to be sacrificed.

Typical envelope protectors are paints and plastic coatings. These can give excellent protection, but good adhesion and good coating thickness are vital to achieve this protection, hence good pre-treatment of the metal is vital.

For steel there is a range of excellent sacrificial protectors, the commonest being cadmium, aluminium, zinc, tin/zinc, zinc/nickel, zinc/cobalt, zinc/iron, and aluminium/zinc. Cadmium is given first because it is acknowledged to be perhaps the very best, but environmental pressures will bring about its non-use, the alloy zinc coating and aluminium coatings look likely to replace it.

There is also a hybrid technology which involves metal filled paints. These give some level of both forms of protection. They are good, but pose problems where dimensional tolerances are important.

The commonest plated coatings for envelope protection are tin, nickel and electroless nickel, with small use of cobalt, and also nickel/iron and nickel/cobalt. Other metals will work well, such as platinum, but usually the high cost rules them out.

8. Закончите данные предложения в соответствии с содержанием текста:

1. Any metal lower in the series will control in preference to any metal higher in the series when these metals are … (to be sacrificed; in contact; likely to replace them).
2. Any gap in the protective coating will lead to … (excellent protection; good coating thickness; rapid corrosion of the base material).
3. Good pre-treatment of the metal is … (vital; acknowledged; common).
4. The commonest plated coatings for envelope protection are … (other metals; both forms of protection; tin, nickel and electrolyses nickel).

9. Найдите в тексте и переведите предложения, содержащие:

- оборот “it is … that”
- субъектный инфинитивный оборот

10. Переведите текст “Hard coatings and wear resistance”.

Metals can be given a hard surface by heat treatment of the metal itself. In this field there is case hardening, nitriding, and carburising. A newer development, Nitrotect, involves the use of nitriding coupled with post hardening treatments which gives a hard surface with outstanding corrosion resistance.

In plated finishes the hardest is chromium, available in several different forms these days – regular, crack-free and micro-cracked – but the main difference between these lies in their corrosion resistance. Not far behind in hardness is electrolyses nickel and electroplated nickel, and for high temperature applications cobalt.

With any wear resistant application the availability of lubrication is important. Electrolyses nickel, although hard, has poor wear resistance unless some level of lubrication can be provided.

The use of co-deposited particles to enhance hardness or wear resistance is one of the newer technologies, and a series of alloy coatings using cobalt and co-deposites has been developed.

The latest technology in this field is the physical and chemical vapour deposition of cermets such as titanium nitride. These have

incredible hardness and wear resistance, but can only be produced as very thin films.

Similar technology gives us iron implantation, particularly nitrogen implantation. This has been applied to steel and to chromium plated steel, giving improvements in wear resistance.

Finally in hard coatings come ceramics. Most are being applied by the plasma spray technique, but there are some applied in the form of a paste, then sintered on. The big attraction of these is a very high temperature resistance.

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