*technical / Processing of materials in mechanical engineering*

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**ANALYSIS OF PHYSICAL AND MECHANICAL PROPERTIES OF MATERIALS NONMETALLIC**

This paper analyzes the determination, dignity, non-metallic materials basis and classification of polymers. Also provides a method for producing polymers, which are divided into the polymerization and polycondensation. Describes the process of polymerization of the chemical compound and a large number of molecules of the monomer in a larger polymer molecule without changing the elemental composition of the monomer which leads to the various physical states of the polymer can be detected by a change in its deformation temperature. The paper presents the most popular non-metallic materials used as structural, high-molecular chemical compounds consisting of numerous elementary units, which represent the same group of atoms and interconnected chemical bonds. We study the different physical state of the polymer, can be detected by a change in its deformation temperature dependence of the deformation is considered graphic, developing over time at a given voltage, temperature. Considered thermal transitions, which are among the main characteristics of the polymers, the stress-strain for linear and cross-linked polymers. Substantiates the average temperature of the transition regions of not crystallization linear polymer associated with a change in distance between the material particles, which in turn, at a temperature below txr resin becomes brittle, which leads to destruction which is a result of chemical bond in the macromolecule. Crystalline polymers are considered below the melting temperature - crystallization tk, which are solid, but they have different stiffness due to the presence of the amorphous part, which can be in different states.

***Keywords*:** non-metallic materials, structural materials, physical and mechanical properties, rubber, polymers, plastics, stress, strain, of the physical state of the polymer temperature recrystallization.

**Introduction**

The use of non-metallic materials provides significant economic efficiency. To improve the physical and mechanical properties, various additives (ingredients). This material imparts improved physical and mechanical properties (in comparison with irregular polymers).

**Non-metallic materials** - are organic, inorganic and polymeric materials: different types of plastics, composite materials on the basis of non-metallic and rubber, adhesives, sealants, coatings, as well as graphite, glass, ceramics. As constructional materials they are an important addition to metals, in some cases advantageously replaces them and are themselves sometimes indispensable.

The advantage of non-metallic materials are such properties as sufficient strength, rigidity and elasticity at low density, light transmission, chemical resistance, dielectric properties, make these materials are often irreplaceable. Also of note is their adaptability and efficiency in use. The complexity in the manufacture of products from non-metallic materials in 5-6 times lower, they are 4-5 times cheaper than metal. In this connection, use is continuously increasing non-metallic materials in mechanical automotive, aviation, food, refrigeration and cryogenics et al. Engines of internal combustion ceramics dispense with cooling water, which is impossible in the manufacture of metal; fairings missiles made only from non-metallic materials. It is hard to household utensils, audio and video equipment, computers, sports equipment, cars and other equipment without non-metallic materials - plastics, laminates, ceramics, rubber, glass and others.

The basis of non-metallic materials are polymers, especially synthetic. Creator of the structural theory of chemical structure of organic compounds is A.M. Butlerov. Industrial production of the first plastmass - the result of work carried out by G.S. Petrov, S.V. Lebedev performed the world's first industrial synthesis of rubber, NN Semenov developed the theory of chain reactions and distributed on the mechanism of chain polymerization. The successful development of polymer chemistry and physics associated with the names of prominent scientists: P.P. Kobeko, V.A. Kargina, A.P. Alexandrov, S.S. Medvedev, S.N. Ushakov, V.V. Korshak et al. Development of heat-resistant polymers associated with the name K.A. Andrianov. In the field of polymeric materials contributed greatly to foreign scientists: K. Ziegler, D. Nutt et al. [1, 2].

Outlined in this article describes the most popular material non-metallic materials used as structural. Macromolecular polymers are called chemical compounds consisting of numerous elementary units are the same group of atoms linked by chemical bonds. Macromolecules are long chains of monomers, which determines their greater flexibility. Individual atoms in the monomers are connected together quite strong covalent chemical bonds. Between the macromolecules of polymers are much weaker physical connection. Their molecular weight ranges from 5,000 to 1,000,000 With such large amounts of macromolecules properties of materials depend not only on the chemical composition of these molecules, but also their mutual arrangement and structure.

**The theoretical calculations**

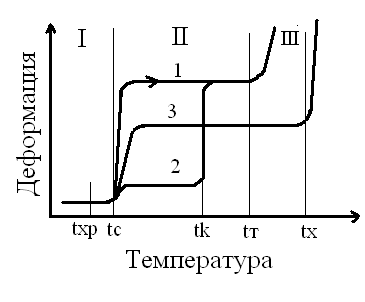
The equations for calculating the physical and mechanical properties of non-metallic materials have been used to study changes in materials under the influence of temperature - is a necessary condition for establishing the nature of many phenomena and theoretical calculation of stresses and cutting forces.

Polymers are classified according to various criteria: composition, form macromolecules, phase state, polarity, with respect to heat, etc. By nature, all of the polymers can be divided into two groups - natural and synthetic. Polymers found in nature - organic substances of plant and animal origin, as well as minerals. The synthetic polymers prepared from single substances by chemical synthesis. The main advantage of synthetic to natural polymers are unlimited supplies of raw materials and extensive synthesis of polymers with predetermined properties. Feedstock for synthetic polymers are the products of chemical processing of oil, natural gas and coal. The thus-obtained low-molecular weight substances are called monomers. They are processed into polymers during subsequent chemical processing.

As a method for producing polymers is divided by polycondensation and polymerization. Polymerization - process a large number of chemical compounds in the monomer molecules per polymer molecule without big changes the elemental composition of the monomer. In the polymerization process there is no release of reaction byproducts. The elemental composition of polymers and monomers are identical. Polycondensation - the formation of a polymer from monomers of different molecules in a chemical reaction with the release of reaction byproducts. Elementar composition different from the composition of the polymer participating in the polycondensation reaction of the monomers. Schematically, the formula of the polymer are recorded in the form of [M] n where M - the chemical structure of the monomer; n - index characterizing the degree of polymerization. On the composition of all polymers are divided into organic, organometallic, in organic. Organic polymers comprise the most extensive group of compounds. If the main molecular chain of such compounds formed only carbon atoms, they are called carbon-chain polymers. In heterochain polymers atoms of other elements present in the main chain, in addition to carbon significantly alter the properties of the polymer. Thus, oxygen atoms in macromolecules contribute to the flexibility of the chain, the phosphorus atoms and chlorine increase fire resistance, gas barrier sulfur atoms attach fluorine atoms, according polymer high chemical resistance, etc. Organic polymers are resins and rubbers. Organometallic compounds not found in nature. This class of materials is completely created artificially. They comprise a main chain composed of inorganic atoms (Si, Ti, A1) was combined with the organic radicals (CH3, C6H5, CH2). These radicals are attached to the material strength and elasticity, and inorganic atoms reported improved heat resistance. Their representatives are silicones. By inorganic polymers include silicate glass, ceramic, mica, asbestos. As part of the carbon skeleton of these compounds are not present. Basis materials are inorganic oxides of silicon, aluminum, magnesium, boron, phosphorus, calcium, and others. The organic radicals consisting of inorganic polymers are absent. By inorganic and include polymers, basic molecular unit which, as in the case of organic polymers, composed of carbon atoms, such as graphite and diamond, with graphite and contains a minor amount of hydrogen atoms. However, unlike organic polymers forming the basic molecular unit preferably in the form of linear chains, graphite and diamond form spatial structures. This gives them properties dramatically different from the properties of organic polymers. Graphite is the only material remaining in the solid state at a temperature above 4000 ° C and the diamond is the hardest substance [1, 2].

**Test data**

Various physical state of the polymer change detected by its deformation temperature. Graphic dependence of the strain that develops over time at a given voltage, the temperature is called thermomechanical curve (Figure 1) [3].



Deformation/Temperature

Figure 1 Thermomechanicalnoncrystalline linear curves (1), the crystalline (2) and rarely mesh (3) Polymer (tc, tk, ty, tx - Tg, crystallization began and the beginning of the viscous flow of the chemical decomposition, respectively), I-III - portions glassy, highly elastic and viscous state

On the curves are three sections corresponding to the three physical states. The average temperature of the transition regions are called transition temperatures. Linear nekristalliziruyuschegosya polymer (curve 1), the region I - Region of elastic deformations associated with the change in the distance between the particles of matter. At temperatures below thr polymer becomes brittle. Fracture occurs as a result of rupture of chemical bonds in the macromolecule. In region II, the small voltage causes movement of the individual segments of macromolecules and their orientation in the direction of the force. After removal of the load molecules as a result of intermolecular forces take the initial equilibrium shape.

Rubbery state is characterized by significant reversible deformations. Near the point ty except elastic and rubbery deformation occurs and plastic. Crystalline polymers below the melting temperature - crystallization tk - are solid, but have different stiffness (Figure 1, curve 2) due to the presence of the amorphous part, which can be in different states. When tk-crystalline portion melted and thermomechanical curve almost abruptly reaches 1 part of the curve corresponding to the rubbery deformation, as in non-crystalline polymer. Rarely mesh polymers have thermomechanical type curve 3. mesh nodes prevent relative movement of the polymer chains. In this connection, when raising the temperature of the viscous flow does not occur, and extended rubbery region becomes the upper limit temperature of the chemical decomposition of the polymer tx. Thermal transitions (tc and CT) are among the main characteristics of the polymers. The stress-strain for linear and cross-linked polymers are different. Linear polymers in the glassy state have a certain mobility of the segments, so the polymers are not so fragile as the inorganic substance. Under the action of large stresses in glassy polymers developed significant deformations, which by their nature are close to rubbery. These strains were named A.P. Alexandrov forced-elastic, and the phenomenon - forced elasticity. Arte-elastic deformations occur in the temperature range tc - txr, and when heated above tc they are reversible (Figure 2). The maximum in the curve is forced to limit flexibility. Polymers with a dense network structure under load there is elastic and highly elastic deformation, plastic deformation is usually absent. In comparison with linear polymers of the elastic deformation portion is a relatively large, highly elastic deformation is much lower. Nature rubbery deformation as a linear polymer, is a reversible change in the spatial shape of the polymer molecules, but the maximum tensile strain usually does not exceed 5-15%.

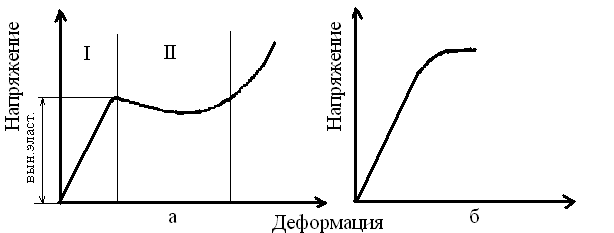


Figure 2. Diagram of stretching: a - a glassy polymer; b - a dense polymer network structure, I - elastic deformation region; II - rubbery deformation region

For crystalline polymers, the stress-strain line is expressed with clear transitions. In the first stage (part I) is proportional to the elongation of the acting force. Then the sample occurs suddenly "neck", whereupon the elongation increases at constant power up to a considerable amount. At this stage, the cervix (section II) is lengthened by a thicker part of the sample. After the entire sample turned into a neck, the process proceeds to the third stage (part III), ending rupture. The structure and properties of the material different from that of the neck and the properties of the original sample: the elements of the crystal structure are oriented in one direction (recrystallize) [3].

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