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Shape Memory Alloy

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Shape memory alloy is a material undergoing phase transformation under mechanical action or temperature change. When conditions become normal again, the alloy "remembers" its original shape and returns to it. Shape memory alloys have two crystalline modifications: austenite and martensite. At high temperatures, the alloy has the crystal structure of austenite, and at low temperatures – martensite. The transition from austenite to martensite and back is the cause of the phenomenon of "memory".

Shape Memory Effect. Mechanical twinning – reorientation of a crystal, as a mechanism of inelastic deformation, is in principle akin to sliding, although with some limitations. The reasons for spontaneous restoration of deformation when removing the force that caused the shift may arise if twinning occurs inside the medium: stresses will be generated in it due to the tightness of the deformation, striving to return the crystal to its original shape. Sometimes the formed doubles spontaneously disappear by means of bifurcation, that is, by shifts in the opposite direction.

Crystal deformations are initiated by three factors: temperature, magnetic and mechanical. It is known that heating a ferromagnet above a certain temperature, called the Curie temperature, eliminates the ferromagnetic state and cooling restores it again. The transition from low to high temperature and vice versa, in addition to deformation of thermal expansion or compression near Curie or Neel temperatures, causes additional deformations.

Another well-known example of deformation of a crystal lattice through the excitation of an electron-atomic subsystem relates to ferroelectrics and antiferroelectric. Thus, in addition to plastic deformation and mechanical twinning, there are other options for the implementation of deformations of an inelastic nature, primarily associated with a change in the crystal structure of a solid during phase transformation. A characteristic feature of such deformation is usually its complete reversibility. Now there are hundreds of substances that change their crystal structure during the so-called reversible martensitic transformations (named after the German metallurgist A. Martens).

The ability of shape memory alloys to exhibit the shape memory effect has contributed to the widespread popularity of this material for a wide range of applications. One of the first popular alloys consisted of a nickel-titanium alloy, commonly known as nitinol. Nitinol is an alloy of nickel and titanium in the proportions of 45% titanium and 55% nickel. The activation temperature of nitinol is about 40℃ [1].

Implementation. Due to the unique behavior of shape memory alloys in the production of products and components in a variety of industries, a choice is often made in their favor. In the aerospace industry, shape memory alloys are used to develop lightweight, quiet and efficient structures, and these are the three most important factors in the design of aircraft. Components such as fan nozzles with variable cross-section, vibration dampers and actuators are created from materials with shape memory. These devices are austenitic at their normal temperature and turn into martensitic (and take the required shape) when cooled due to a change in temperature under the influence of the air flow around the aircraft or even a change in ambient temperature during normal flight. Some passenger cars have an alloy valve with shape memory for pneumatic chambers in the seats. When pressed with a certain force, the lumbar support element takes the shape corresponding to the back of the driver or passenger. Shape memory alloys are also used to design actuators that make it easier to close the trunk of a car, as well as noise, vibration and stiffness control valves to control engine noise and vibration. Rods made of shape memory alloys in concrete beams provide prestressing of a bridge or building. Smaller products made of materials with shape memory can be used as reliable fittings of the pipeline network [2].

The use of shape memory alloys in the field of biomedicine can reduce the need for surgical intervention. For example, special stents can be implanted in the arteries, which is the least invasive way to improve blood flow in patients with heart disease. Microdrives and artificial muscles in robotic prostheses also consist of shape memory materials, which give amputee patients more freedom of movement.

References:
1. Likhachev, V. A. Shape memory effect / V.A. Likhachev [Electronic resource]. – Mode of access: https://text.ru/rd/aHR0cHM6Ly9iLW9rLmdsb2JhbC9ib29rLzgwNTg4NS84MTZlMjU%3D). Date of access: 17.03.2022.
2. Alloys examples of alloys: alloys | encyclopedia of circumnavigation [Electronic resource]. – Mode of access: https://text.ru/rd/aHR0cHM6Ly9zdGFua290ZWMucnUvcmF6bm9lLTIvc3BsYXZ5LXByaW1lcnktc3BsYXZvdi1zcGxhdnktZW5jemlrbG9wZWRpeWEta3J1Z29zdmV0Lmh0bWw%3D. – Date of access: 21.03.2022.