

1) Compression, tension, fatigue and creep of metals

Engineers must know how materials respond to external forces, such as tension, compression, torsion, bending, and shear. All materials respond to these forces by elastic deformation. That is, the materials return their original size and form when the external force disappears. The materials may also have permanent deformation or they may fracture. The results of external forces are creep and fatigue.

Compression is a pressure causing a decrease in volume. When a material is subjected to a bending, shearing, or torsion (twisting) force, both tensile and compressive forces are simultaneously at work. When a metal bar is bent, one side of it is stretched and subjected to a tensional force, and the other side is compressed.

Tension is a pulling force; for example, the force in a cable holding a weight. Under tension, a material usually stretches, returning to its original length if the force does not exceed the material's elastic limit. Under larger tensions, the material does not return completely to its original condition, and under greater forces the material ruptures.

Fatigue is the growth of cracks under stress. It occurs when a mechanical part is subjected to a repeated or cyclic stress, such as vibration. Even when the maximum stress never exceeds the elastic limit, failure of the material can occur even after a short time. No deformation is seen during fatigue, but small localised cracks develop and propagate through the material until the remaining cross-sectional area cannot support the maximum stress of the cyclic force. Knowledge of tensile stress, elastic limits, and the resistance of materials to creep and fatigue are of basic importance in engineering.

Creep is a slow, permanent deformation that results from a steady force acting on a material. Materials at high temperatures usually suffer from this deformation. The gradual loosening of bolts and the deformation of components of machines and engines are all the examples of creep. In many cases the slow deformation stops because deformation eliminates the force

causing the creep. Creep extended over a long time finally leads to the rupture of the material.

I. Copy the underlined words and word-combinations, translate them into Ukrainian and learn them.

II. Find the following words and word-combinations in English in the text: ламатися; об'єм; первісний стан; тріщини; в багатьох випадках; перелом (розрив) матеріалу.

III. Answer the following questions.

1. What are the external forces causing the elastic deformation of materials? Describe those forces that change the form and size of material.
2. What are the results of external forces?
3. What kinds of deformation are the combinations of tension and compression?
4. What is the result of tension? What happens if the elastic limit of material is exceeded under tension?
5. What do we call fatigue? When does it occur? What are the results of fatigue?
6. What do we call creep? When does this type of permanent deformation take place? What are the results of creep?

2) Density, stiffness, strength, ductility, toughness and creep resistance of metals

Density (specific weight) is the amount of mass in a unit volume. It is measured in kilograms per cubic metre. The density of water is 1000 kg/ m³ but most materials have a higher density and sink in water. Aluminium alloys, with typical densities around 2800 kg/ m³ are considerably less dense than steels, which have typical densities around 7800 kg/ m³. Density is important in any application where the material must not be heavy.

Stiffness (rigidity) is a measure of the resistance to deformation such as stretching or bending. The Young modulus is a measure of the resistance to simple stretching or compression. It is the ratio of the applied force per unit area

(stress) to the fractional elastic deformation (strain). Stiffness is important when a rigid structure is to be made.

Strength is the force per unit area (stress) that a material can support without failing. The units are the same as those of stiffness, MN/m², but in this case the deformation is irreversible. The yield strength is the stress at which a material first deforms plastically. For a metal the yield strength may be less than the fracture strength, which is the stress at which it breaks. Many materials have a higher strength in compression than in tension.

Ductility is the ability of a material to deform without breaking. One of the great advantages of metals is their ability to be formed into the shape that is needed, such as ear body parts. Materials that are not ductile are brittle. Ductile materials can absorb energy by deformation but brittle materials cannot.

Toughness is the resistance of a material to breaking when there is a crack in it. For a material of given toughness, the stress at which it will fail is inversely proportional to the square root of the size of the largest defect present. Toughness is different from strength: the toughest steels, for example, are different from the ones with highest tensile strength. Brittle materials have low toughness: glass can be broken along a chosen line by first scratching it with a diamond. Composites can be designed to have considerably greater toughness than their constituent materials. The example of a very tough composite is fiberglass that is very flexible and strong.

Creep resistance is the resistance to a gradual permanent change of shape, and it becomes especially important at higher temperatures. A successful research has been made in materials for machine parts that operate at high temperatures and under high tensile forces, without gradually extending, for example the parts of plane engines.

I. Copy the underlined words and word-combinations, translate them into Ukrainian and learn them.

II. Find the following words and word combinations in English in the text: кількість маси; одиниця об'єму; важкий; співвідношення; сила, яка застосовується; переваги; квадратний корінь; вдале дослідження; двигуни літаків.

III. Answer the following questions.

1. What is density of materials?
2. What are the units of density? Where low density is needed?
3. What are the densities of water, aluminum and steel?
4. A measure of what properties is stiffness? When stiffness is important?
5. What is Young modulus?
6. What is strength?
7. What is yield strength? Why fracture strength is always greater than yield strength?
8. What is ductility? Give the examples of ductile materials. Give the examples of brittle materials.
9. What is toughness?
10. What properties of steel are necessary for the manufacturing of: a) springs, b) car body parts, c) bolts and nuts, d) cutting tools?
11. Where is aluminium mostly used because of its light weight?