ON THE STRENGTH AND FRACTURE RESISTANCE OF MATERIALS BASED ON REFRACTORY COMPOUNDS

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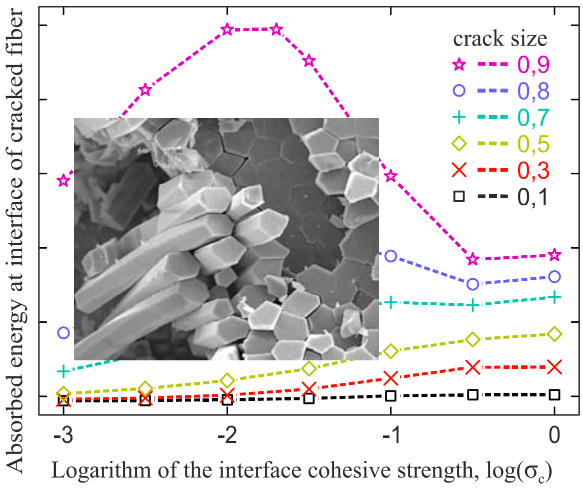
An interest in refractory compounds caused largely by possibility of development of high-temperature structural materials on their basis. However, even Samsonov noted [1] that the data on the mechanical properties of the refractory compounds are the least reliable. It is caused by low fracture toughness of known refractory compounds and the most materials on their basis. Strength is not a characteristic of the materials. It depends on a size of a defect in a particular sample of the material and its fracture toughness. Samples of the materials with nano-sized grains (defects) show the high strength, which it is almost impossible to reach for real products and, especially, to keep it during operation. Therefore, the most perspective direction of developing structural materials based on refractory compounds considered the increasing their fracture toughness.

In this regard, in recent decades, expanding study of regularities by which structural materials of biological origin are of the highest fracture resistance and are the best for conditions of existence of organisms. For example, the material of a nacre shell possess the fracture toughness, more than 3000 times the fracture toughness of calcite – the brittle component of which it is composed by 95%. A new generation of artificial structural materials, namely, one-component materials with a unidirectional fibrous structure are being developed. They are practically 100 percent content of load-bearing elements - of fibers - in the structure, and therefore have the highest potential of strength properties. The most striking example is the SA-Tyrannohex™ [2], which is almost 100% composed of SiC. Materials with such structure are obtained by hot pressing of bundles of fibers at their plastic deformation. During the obtaining of SA-Tyrannohex™, plastic deformation of fibers occurs at the step of their pressing when they are in a glassy state, i.e. before the Si-Al-C-O decomposition on SiC and CO. Similar materials with fibrous structure can be obtained by hot pressing of other fibers [3].

Analysis of biological structural materials shows that their main attribute that provides achievement of maximum fracture toughness is a presence in a representative volume of the material mechanisms of inelastic shear in direction only of maximum normal stress, that exist in the material before the fracture onset. Consequences of this feature are one-directional fibrous and layered structure of the materials and low stress of inelastic shear between the load-bearing elements (fibers, layers) of the structure.

A characteristic feature of biological structural materials is also fragmented load-bearing elements of the structure at different levels of the hierarchy.

The work established that there is an optimum cohesive strength of the interfaces between the load-bearing elements of the fibrous structure, at which the maximum energy absorbed during initial stages of the material fracture (see Fig.). It has been found an optimal distance between cracks along the fiber, at which the fibrous material absorbs maximum energy under deformation and fracture. Obviously, the unidirectional fragmented fibrous structure is the sole way to obtain the highest fracture resistance of structural materials based on refractory compounds.



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