S. T. Mileĭko. *Fibrous composites with metal and ceramic matrices*. For metal alloys the requirements of a high strength and a high crack resistance are generally contradictory. In contrast, fibrous composites present a unique opportunity for separating these requirements and achieving an elevated strength along with an improved crack resistance in the same system. High crack resistance in a structural material improves the structural reliability of the corresponding machines.

These possibilities are determined by a variety of mechanisms for the damage and deformation of fibrous composites and thus by a variety of means for controlling the overall strength and crack resistance of the material. The behavior of a macroscopic crack in a composite with a metal matrix is surprising at first glance.[1]

In the damage zone in front of the end of a crack, a system of stable microscopic cracks appears: breaks in brittle fibers (of inhomogeneous strength). This system spreads out, increases the volume of the zone of plastic deformation of the matrix metal. The result may be a significant increase in the crack resistance of a composite with brittle fibers and a metal matrix in comparison with the unreinforced matrix alone. A quantitative model which has been developed[2] shows that the dependence of the crack resistance of such composite materials on the concentration of the brittle fiber is strongly determined by the inhomogeneity of the strength of the fiber. A fiber which is ideal in the sense of having a homogeneous strength is not a suitable material for a composite with a high crack resistance.

The crack resistance of a composite which does not contain plastic components (e.g., metal components) is a property which requires more careful adjustment. However, recent results obtained at the Institute of Solid State Physics show that this adjustment is possible over a rather broad range. There is thus the hope not only for expanded capabilities of composites which are reinforced plastic materials but also for the development of ceramic-ceramic composites.

Composites can be used to solve three types of problems involving improvements in the effectiveness of structures: 1) reducing the weight of bearing structures, which is most important for transportation machines; 2) raising the working temperature of heat engines with the goal of raising the efficiency; 3) economizing on scarce metals, particularly dopants.

The weight-reduction possibilities are illustrated well by the example of a boron-aluminum composite, in whose development the Institute of Solid State Physics has pioneered. This material has a strength in the reinforcement direction of 100–150 kgf/mm^2, an elastic modulus $(20-25)\cdot 10^3$ kgf/mm^2, and a density of 2.7 g/cm^3. The material thus has the mechanical properties of a good steel but the density of aluminum. The weight reduction of, for example, structures used in space vehicles, is 20–30%, but an even greater weight reduction is possible in several new structural and technological problems involving, for example, structural joints. We might note that at present the design of structural joints for composite structures is largely based on the practice of "metal" designing.

As heat-resistant materials for load-bearing parts of heat engines and motors, fibrous composites have no competition at all. Ceramic-based fibrous structures already have a crushing energy an order of magnitude better than the corresponding values for the best homogeneous ceramics. The refractory and heat-resistance properties of oxide ceramics, for example, as a matrix raise the hope of producing heat-resistant light composites with working temperatures of 1600–2000 °C.

The possibility of economizing on scarce metals in structural materials is determined primarily by the circumstance that the crushing energy and the cracking resistance of composites are not limited by the brittleness of the components. Consequently, many high-strength and refractory but brittle compounds may find use as elements of structural materials. For example, composites with oxide fibers may replace nickel alloys in many applications in the very near future.

Fibrous structures have as yet found essentially no use as the basis for materials with special physical properties. At the same time, it is obvious that composite structures can be used extremely effectively in cases in which a high strength of elements is important (in piezoelectric and magnetostrictive transducers). Furthermore, there are obvious possibilities in combining an A–B transducer with a B–C transducer to produce an A–C transducer.

In general, research on composite structures indicates that it will be possible to produce some fundamentally new materials. At the same time, this research is raising several new and interesting problems in mechanics, physics, and technology.

[1] S. T. Mileĭko, Mekh. kompozit. materialov No. 2, 1979.
[2] S. T. Mileĭko, Mekh. kompozit. materialov No. 3, 1981.