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PERSPECTIVES ON THE USE OF COMPOSITES

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Many natural materials may be referred to as composites. From the perspective of strength, the structure of wood, culms of cereals, and human and animal bones possesses an optimal combination of hard and soft, stiff and elastic components. Granite, many kinds of silica, and some meteorites have a composite structure.

Human started to reinforce materials and structures using elements of another, stronger material (reinforcement) in high antiquity. In Sumer and Babylon, ground stones, straw, and branches were introduced into clay bricks and pottery for reinforcement and decreasing shrinkage and cracking some 6 thousand years ago. In Egypt and Mesopotamia, ships were built of tarred cane in the third millennium A.D. In India and China, natural varnish, an excretion of some insects, was applied to sword handles and was used for manufacture of grind stones through mixing the varnish with sand. Asian nomadic peoples manufactured bows of several components (animal tendons, wood, and silk) bound using glue. The search for an optimal combination of materials continued at times not so distant from us.

Reinforced concrete is considered the prototype of modern composite materials. The first patent for manufacturing flower planters of a material which combined wire and cement was received by a Parisian gardener J. Monier in 1867. Glass fibre reinforced polyester materials were first used in airplane structure in 1942 and some time later industrial production of fibre glass plastics started. High-strength polymer– or metal-based composites reinforced with high-modulus fibres and filamentous monocrystals ("whiskers") of a perfect structure became widely used since the 1970-s.

Progress of technology was always based on, first of all, an increase in production and an expansion of the nomenclature of structural materials the main property of which is high strength. Successes of physical sciences and metal science and technology allowed to increase strength limit of aluminium alloys and steels up to 1200 and 2200 MPa respectively.

Reserves for a further economically feasible increase of strength characteristics of metals are considered to be almost exhausted. A significant increase in production of metal materials leads to a rise in their price and exhaust of the richest and the most available ore deposits.

Besides that, extraction, transportation, and processing of metal ores are connected with huge material expenses and environmental pollution.

Creation and use of composites is one of the most perspective ways to provide production with structural materials which enable an increase in operating parameters of new machines and resource saving.

Those engineering materials loosely referred to as composites include a wide range of products, ranging from those used in high-strength aircraft components to road-building tarmacadam and concrete.

Generally, composites are manufactured by mixing together two separate components, one of which forms a continuous matrix whilst the other, present either as particles or fibres, provides the strength or hardness required in the composite material.

Modern composites combine high strength and light weight. Their use in machinery, equipment, and buildings allows to decrease the construction weight by 25–50 %, man hours of their manufacture by 1,5–3 times, energy intensity of production by 8–10, and material consumption by 1,6–3,5 times. Technical life of machinery may be increased by 1,5–3 times and loss on corrosion and fuel flow etc. may be reduced to a minimum through the use of composites.

Of these materials, fibre-reinforced composites are the most significant in the modern engineering world.

The two areas of highly efficient use of composite materials have been identified: 1) as a substitute for the most scarce conventional materials – non-ferrous metals, metal profile materials, genuine leather, fabrics, and rare wood etc.; 2) as multi-purpose structural materials.

The first direction is realised through the use of waste products of industry and agriculture – sawdust, cuts of synthetic fibres, waste products of grain production, chemical industry and so on – as a raw material base for composite production. Composites of this type are used to manufacture:

– wood polymer and fibrous sheet materials for interior decoration of cabins of automobiles, tractors, harvesters, and other machines;

– long-length profile materials used as guideways of machine tools and handling equipment, for making windows and doors and indoor decoration of building sites;

– thermal insulating and sound and vibration absorbing panels and coatings;

– case products under light loads.

The second direction is development of a new generation of technical articles. Structural composites possessing special functional properties (low density, high thermal, wear, and corrosion resistance, resistance to influence of dynamic and impact loads) found their niche in aviation, spacecraft, automobile, and ship building, military technology, electrical and radio engineering, and electronics. The following facts prove this.

The composition of a modern transport airplane includes several tons of metal, ceramic, and polymer matrix composite materials. This allows to significantly decrease material consumption per article and fuel expenses during its operation and to increase technical life of an airplane. Wings and empennage of supersonic airliners of the XXI century are expected to be made of carbon composites, air intakes and engine inlets – of ceramic, chassis – of aluminium-carbon and magnesium-carbon composite materials.

World automotive industry has made stakes on composites too. Today the leading companies acknowledge that it is not feasible to increase power of an engine to move a steel automobile construction which weighs a ton. The optimal solution was to create a construction of an automobile body of the same strength of aluminium-based composites. The weight of such a body is twice as low as that of a steel one.

Though aluminium is a more expensive material than steel is, the cost difference is recouped quickly due to fuel saving and improvement of the ecological situation near highways.

Modern methods of road making were originated early in the nineteenth century by the Scottish engineer, John McAdam. The method he used – coating suitable hard aggregate material with tar – is roughly similar to the process used today, except that the tar (obtained from the gasworks where coal was destructively distilled) has been replaced largely by bitumen (residues from the refining of crude petroleum). Some asphalts also occur naturally, e.g. "Trinidad Lake".

The bituminous material is mixed with a suitable aggregate such as crushed blast-furnace slag for the coarse foundation work, or fine gravel for the finishing layers. The resultant mixture is tough and crack-resistant because of the bituminous matrix, whilst it is hard-wearing because of the exposed surface of hard aggregate material. Its structure and properties resemble very closely those of a bearing material in which hard, low-friction particles standing "proud" of the surface are held in a tough ductile shock-resistant matrix. However, whilst slip at a very low coefficient of friction is the objective in a bearing, the reverse is true in a road surface; the rubber tyre must be designed to provide maximum adhesion between tyre and road surface.

The use of composites in constructions of railway cars, ships, gasholders and other industrial containers, high pressure pipelines, and sports equipment has wide perspectives. All countries establish large-scale production of composite materials, special branches of materials science which elaborate scientific recommendations on construction of composites possessing a set complex of properties develop intensively.

In the developed countries of the world, many scientific groups work on creation of "smart" composites which not only are able to "adapt" to operating conditions, but also provide feedback with the help of which the degree of "adaptation" is adjusted. According to the NASA specialists (The National Aeronautics and Space Administration of the USA), the humanity moves towards the era of composite materials constructed with the help of computer. Components of these composites will be constructed at the molecular level so as to comply optimally with operating requirements which, first of all, concern material strength and density.

These structures outline contours of future spacecraft and samples of other modern machinery. Thus, basing on the estimates of materials science specialists the public opinion saying that future belongs to composite materials is being formed.

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IMPROVING THE PERFORMANCE OF TRANSMISSION OILS

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This article explores the ways of improving the performance properties of transmission oils. The operating conditions of the gears are characterized by high loads in the contact zone of the teeth, relatively high speeds of mutual movement of rubbing surfaces and significant temperatures in the contact zone. The anti-wear properties of oils should protect transmission parts from wear and the undesirable phenomenon of galling and abrasion of gear drives. In complex sulfur-chlorine additives, sulfide films prevent scuffing, while chloride films, due to their elasticity, reduce wear and energy consumption to overcome friction forces.

Transmission oil must provide reliable lubrication not only of the gear teeth themselves, but also of the plain bearings. Specific pressures and speeds of relative sliding in friction pairs of transmission units are important operational factors that necessitate the provision of high anti-wear properties of transmission oils.

This article proposes ways to improve the performance properties of transmission oils used for agricultural machinery. The operating conditions of gears are characterized by high loads in the contact zone of the teeth, relatively high speeds of mutual displacement of the rubbing surfaces and significant temperatures in the contact zone.

Energy losses in the transmission account for up to 20 % of the total power consumption of the vehicle. If 25 % of the so-called net engine power goes to the transmission without taking into account losses, then in the general system of transmission units due to its own losses in the units, this power transmitted to the drive wheels is already reduced to 12 %.

During the operation of gears, bearings and other transmission units, an increase in oil temperature is observed due to friction and mixing. This temperature can reach 150 ºC, and under extreme conditions and in units of heavy multi-axle machines and up to 200 ºC.

Transmission oils must, on the one hand, maintain a high viscosity at operating temperatures so that the film does not break and gaps are normally sealed, and, on the other hand, must not become too viscous, so that at the beginning of the operation of the mechanism, the cold oil in the unit would not interfere with the free rotation of the gears.

Wedge wear is the result of the combined action of mechanical wear with molecular forces. In this case, deep pulling out of the material occurs, local connection (setting) of two solids, metal transfer from one friction surface to another and the impact of the resulting irregularities on the mating surface.

At high temperatures, the oil must be sufficiently viscous to maintain the strength of the highly loaded oil film.

The temperature dependence of the viscosity of transmission oils is quite severe. Reducing the viscosity of transmission oils is one of the main ways to increase the efficiency of a vehicle. The viscous oil makes it difficult for the smooth movement of a cold car, it is more difficult to penetrate into narrow gaps between friction surfaces.

With an increase in viscosity, the thickness and resistance to mechanical stress of the oil layer between the rubbing surfaces increases. The viscosity of the transmission oil is the most important physical and chemical property that affects the friction force *F*:

$$F = \eta \frac{VS}{h},$$

where *V* – is the relative speed of movement of surfaces; *h* – is the thickness of the lubricant layer; *S* – is the sliding area.

The viscosity value affects the intensity of fatigue wear of transmission parts, which causes failures and breakdowns of transmission parts