Ceramics Material in Space

Frolov R.A.
Scientific advisor: Ivanova V.S., Ph.D., Associate Professor
Tomsk Polytechnic University, 30, Lenin Avenue, Tomsk, 634050, Russia
E-mail: frolov07121994@mail.ru

Introduction

Development of mechanical engineering requires new materials with high mechanical and thermal properties. So, in the world people began to use ceramics material (fig.1). The leading place in the world takes the use of ceramic materials in the industry of Japan and the USA.

Advanced ceramic materials make applications possible today that were almost unthinkable just yesterday. Due to their unique material properties, technical ceramics are considered to be one of the most used materials of our time [1].

Figure 1 - Different examples of ceramic materials

Structure and Properties of Ceramics

Ceramics usually have a combination of stronger bonds called ionic and covalent. These types of bonds result in high elastic modulus and hardness, high melting points, low thermal expansion, and good chemical resistance. On the other hand, ceramics are also hard and often brittle which leads to fracture [2].

Ceramic materials are directly related to the nature of their structure, formed during roasting. Allocate material with porous and dense crock. Most of ceramic materials are porous. The strength of ceramic materials is also related to the porosity of the structure.

Metals have weaker bonds than ceramics, which allows the electrons to move freely between atoms. This is saying about ductility of metals, where the metal can be easily bent without breaking, allowing it to be drawn into wire [3]. So, at a high speed of loading, for example in case of explosive blow when this speed exceeds the speed of the movement of dislocations in metal, plastic properties of metals won't play any role and metal will be same brittle, as well as ceramics. In this concrete case the ceramics is significantly stronger than metal.

Mechanical properties are important in structural and building materials as well as textile fabrics. They include the many properties used to describe the strength of materials such as: elasticity, tensile strength, compressive strength, ductility (low in brittle materials), and indentation hardness [4].

Important properties of ceramic materials are the high hardness, the elasticity module, melting temperature by 2 – 3 times of low density. Retentions of strength when heating allows to use ceramics as strong armor.

Materials based on boron carbide have highest protection properties. But they are rarely used due to their high cost by pressing. Therefore, tiles made of boron carbide are used only to reduce the weight of armor protection, for example to protect the seats and automatic control systems for helicopters, crew and troops. Ceramics, which have the highest hardness and elastic modulus, are used for protection from heavy armor-piercing tank shells.

For mass production of ceramics is the most promising comparatively cheap oxide of aluminum. The ceramics on its basis is used for protection of overland and sea military equipment.

To increase the strength, surface reflectivity of the outer shielding materials is coated with a layer of enamel a thickness of about 300 microns. Plates of coated used in most hot places spacecraft, ballistic missiles and hypersonic aircraft. They can withstand up to 500 minutes of heating in an electric arc plasma at a temperature of 1670 K. Facing layer protects heat insulating layer of ablation and erosion damage and takes the basic thermal load.

The principal disadvantages of ceramics are its brittleness and complexity of processing. Ceramic materials do not work in conditions of mechanical or thermal shocks, and also under cyclic loading conditions. They are characterized by high sensitivity to incision. At the same time, ceramic materials have high heat resistance, excellent corrosion resistance and low thermal conductivity, which allow them to be used successfully as a elements of thermal protection. Ceramics is a very durable material. It is durable than any of the alloys at temperatures above 1000 ° C, and it's the heat and creep resistance above [4].

Ceramics in the aerospace engineering

During the flight in the dense layers of the atmosphere head of the rocket, spacecraft, shuttles, heated to a high temperature (fig.2). Materials for heat protection should have high heat resistance and toughness in combination with the minimal values of the coefficient of thermal expansion. Technical ceramics is the material, which best meets these requirements. The body of the Space Shuttle Also covered with ceramic plates and exposed to extreme thermal loads during launch and in space.

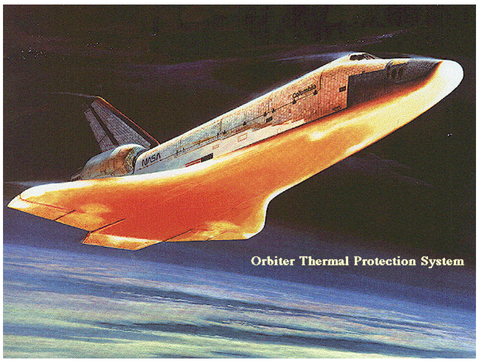

Figure 2 - Using ceramic plates

High fire resistance, heat resistance, low thermal conductivity make ceramic materials indispensable for the manufacture of refractories, heat pipes, lining high temperature reactors, heat exchangers and heat protection.

In the aviation and aerospace industry has successfully developed the technical possibilities for the application of ceramic bearings. Leading projects in these sectors is the U.S. Space Shuttle Project. Made especially for him hybrid bearings for the three main engines ultimately provide a reliable and efficient operation of the system in extreme conditions.

Currently, hybrid and ceramic bearings found their application in jet engines, gearboxes, drives in aviation, power drives for satellites and other similar applications.

Engineered ceramics are increasingly being used in commercial and military aircraft, and have been used in the space shuttle and its equipment for many years. Ceramic applications include thermal protection systems in rocket exhaust cones, insulating tiles for the space shuttle, engine components, and ceramic coatings that are embedded into the windshield glass of many airplanes.

These coatings are transparent and conduct electricity for keeping the glass clear from fog and ice [5].

Ceramic fibers are used as heat shields for fire protection and thermal insulation in aircraft and space shuttles because they resist heat, are lightweight and do not corrode. Other significant characteristics include high melting temperatures, resiliency, tensile strength and chemical inertness [5].

A non-oxide ceramic called silicon nitride has excellent high temperature strength, excellent fracture toughness, high hardness and unique tribological properties. Silicon nitride aerospace applications result in superior mechanical reliability and wear resistance allowing components to be used under minimal lubrication without wear. These include jet engine igniters, bearings, bushings, and other wear components [5].

Conclusion

The advantage of using ceramic materials as structural material is low density, resulting in lower material costs and saves rare materials.

The disadvantages of ceramic materials are the complexity processing and, in consequence - and the high cost of the finished product. Processing of Ceramics and control are the main components of the balance cost of ceramic products.

References:

1. CeramTec International: Technical ceramics from the ceramic Experts [Электронный ресурс]. – Режим доступа: https://www.ceramtec.com/ceramic-materials/, свободный;
2. Ceramic Properties. [Электронный ресурс]. – Режим доступа: http://depts.washington.edu/matseed/mse_resources/Webpage/Ceramics/ceramicproperty.htm, свободный;
3. The American ceramic society: Structure and Properties of ceramics. [Электронный ресурс]. – Режим доступа: http://ceramics.org/learn-about-ceramics/structure-and-properties-of-ceramics, свободный;
4. Ceramic materials [Электронный ресурс]. – Режим доступа: http://en.wikipedia.org/wiki/Ceramic_materials, свободный;
5. The American ceramic society: Ceramic Engineering in Aerospace. [Электронный ресурс]. – Режим доступа: http://ceramics.org/learn-about-ceramics/ceramic-engineering-in-aerospace, свободный.

Die Nanosatelliten

Galkina P.V., Tarasova L.V.

Wissenschaftliche Betreuerin: Tarasova L. V. Doktor der Pädagogik, Dozentin

Polytechnische Universität Tomsk, 634050, Russland, Tomsk, Lenin-Pr., 30

E-mail: polina.galkina.2015@mail.ru

Die winzigen Flugkörpercharakterisieren sich dadurch, dass sie einen kurzen Entwicklungszyklus besitzen. Sie sind einfach in der Instandhaltung, benötigen weniger stattliche Finanzaufwände, um sie in die Erdumlaufbahn zu bringen. Der Fokus von Nanosatelliten liegt in der Zuverlässigkeit und der hohen Wirtschaftlichkeit der Systeme. Sie werden folgender Weise klassifiziert: die große Satelliten - mehr als 1000 kg; die kleine Satelliten (Midi) - 500 – 1000 kg; die Minisatelliten - 100 – 500 kg; die Mikrosatelliten 10 – 100 kg; die Nanosatelliten - 1 – 10 kg; die Pikosatelliten - weniger 1 kg.

Die Bestimmung der Nanosatelliten:

1. Die Optimierung der neuesten Technologien, der Methoden und der Hardware-