7. Space Radiation Shielding[Электронный ресурс] – Режим доступа: http://cygo.com/space-radiation-shielding/, свободный. – Загл. с экрана.

Antifriction Materials in Aerospace Instrument Making

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Rocket and space technique is very complex. There are many new and difficult problems in the process of space technique design which lead to emergence of the original structures and unusual technical solutions. Many of modern original inventions firstly were used in aerospace engineering, and then in everyday life.

One of the science tasks had to solve is spacecraft energy consumption reducing, heat losses and instruments and equipment durability increasing on spacecraft board.

Life-limiting parameters of aerospace systems include friction and wear in various devices along with extreme operating conditions including humidity variations with altitude changes and broad temperature ranges. Mechanical and endurance requirements of aerospace applications dictate new wear-reduction technologies demanding new materials and advanced technologies. Friction and wear requirements in aerospace systems are dictated by life limiting problems. One challenge is the broad range of contact stresses and sliding speeds for various movable devices. Another challenge is the extreme operation conditions; in particular an aircraft suffers periodical humidity changes depending on the altitude, broad temperature range, and abrasive wear by electrostatically attracted dust [1].

The solution of this problem was using antifriction materials in aerospace instrument making.

Antifriction materials are materials which operate with sliding friction and which under certain conditions have a low coefficient of friction. They are notable for low adhesion, good wear in, thermal conductivity, and stable characteristics. Under hydrodynamic lubrication conditions when are completely separated by a relatively thick layer of lubricant, the properties of the material from which the parts are made has no effect on the friction. The antifriction capability of materials becomes apparent under imperfect lubrication conditions and is a function of the physical and chemical properties of the material, including high thermal conductivity and heat capacity, the ability to form strong boundary layers that reduce friction, and the capability of being easily deformed or worn away so that the load can be uniformly distributed over the contacting surface. Also related to the antifriction capability are the microstructure of the surface and the ability of the material to “absorb” solid abrasion particles that fall on the friction surface, thereby protecting the associated part from wear. Antifriction capability is displayed under dry friction conditions by a material containing components that have a lubricating action and make for low friction by being present on the friction surface [2].

Antifriction materials are divided into metallic and nonmetallic types. The metallic bearing materials include alloys based on tin, lead, copper, zinc, aluminum, and also some cast irons [3,4].

The greatest single advance in the development of improved antifriction materials took place in 1839, when I. Babbitt obtained a United States patent for a bearing metal with a special alloy. This alloy, largely tin, contained small amounts of antimony, copper, and lead. This and similar materials have made excellent bearings. They have a silvery appearance and are generally described as white metals or as Babbitt metals [5]. Babbitt metal is most commonly used as a thin surface layer in a complex, multi-metal structure, but its original use was as a cast-in-place bulk bearing material. Babbitt metal is characterized by its resistance to galling. Babbitt metal is soft and easily damaged, which suggests that it might be unsuitable for a bearing surface. However, its structure is made up of small hard crystals dispersed in a softer metal, which makes it a metal matrix composite. As the bearing wears, the softer metal erodes somewhat, which creates paths for lubricant between the hard high spots that provide the actual bearing surface. When tin is used as the softer metal, friction causes the tin to melt and function as a lubricant, which protects the bearing from wear when other lubricants are absent. Another the most used metallic alloys are bronze and some types of cast iron.

One of the important properties of antifriction materials as a result of their antifriction capability under all friction conditions is their inability or poor ability to seize with the material of the associated part. The greatest tendency to seizure in friction is with ductile metals of the same composition in a pair having face-centered and body-centered cubical lattices. For steel the greatest tendency to seize in friction is with silver, tin, lead, copper, cadmium, antimony, bismuth, and alloys based on them [2].

The nonmetallic antifriction materials include certain kinds of plastics, materials based on wood, graphitic carbon materials, and rubber [2].

Antifriction materials based on polymers are intended to work with fluids having no lubricating properties as well as in non-lubricated environments, including under vacuum.

Tetrafluoroethylene (Teflon) is a great antifriction material with the lowest among all known available structural materials coefficient of sliding friction [6].

However, the major application of tetrafluoroethylene, consuming about 50% of production, is for wiring in aerospace and computer applications. This application exploits the fact that tetrafluoroethylene has excellent dielectric properties. This is especially true at high radio frequencies, making it suitable for use as an insulator in cables and connector assemblies and as a material for printed circuit boards used at microwave frequencies. Combined with its high melting temperature, this makes it the material of choice as a high-performance substitute for the weaker and lower-melting-point polyethylene commonly used in low-cost applications [7].

Some antifriction materials are a combination of metals and plastics for example, a porous layer formed by sintered bronze beads impregnated with tetrafluoroethylene or tetrafluoroethylene with fillers [2].

For application antifriction materials commonly used the Plasma Spray Process. This process is basically the spraying of molten or heat softened material onto a surface to provide a coating. Material in the form of powder is injected into a very high temperature plasma flame, where it is rapidly heated and accelerated to a high velocity. The hot material impacts on the substrate surface and rapidly cools forming a coating. Plasma spraying has the advantage that it can spray very high melting point materials such as refractory metals like tungsten and ceramics unlike combustion processes. Plasma sprayed coatings are generally much denser, stronger and cleaner than the other coating processes [8].

Thus, the problem of low durability of parts subjected to friction was solved by creation antifriction materials. Each of them has advantages and disadvantages. Metallic antifriction materials are the most cheap and simply in manufacturing. Nonmetallic materials are light-weight and more durable. Nonmetallic materials also have good physical (heat resistance and cold resistance) and chemical (chemical resistance) properties, the last one is of great importance in aerospace instrument making. However, the best antifriction properties have composite materials which include both metals and non-metals.

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Small Satellite

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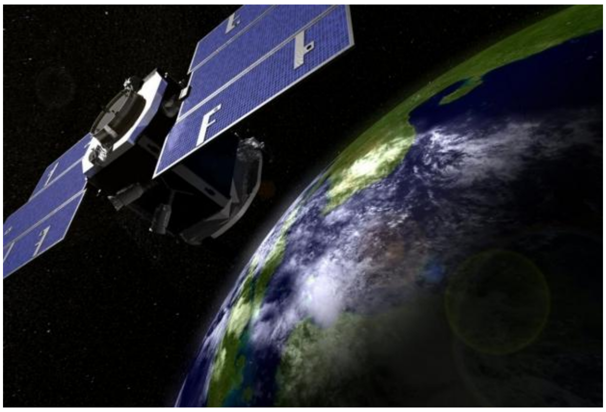

Figure 1 - Small satellites

Introduction

The first satellite, Sputnik-1, launched on October 4, 1957 was a small satellite. The success of launching a manmade object into earth orbit was a phenomenal achievement, even though its user performance of sending a few radio signals was minimal.

It took an equivalent large effort to develop a usable platform for lunar, planetary and earth observation with components assuring orbital performance, attitude control, sensor operation, telecommunication of signals and ground reception and ground processing of these.

While the U.S. lunar missions succeeded in building the Lunar Orbiter missions 1 to 5 to achieve this goal in preparation for the lunar landing in the years 1966 and 1967, it took until 1972 to launch a general earth observing platform in the Landsat program of the US [3].

Earth observation is a relatively minor application branch of satellite technology, and the use of satellites is primarily important for telecommunications, and to a lesser extent to scientific missions.

Large satellites have always been built by governments and large consortia, which had sufficient funding to assure reliable long range operation without severe mass and power restrictions. E.g. the communication satellite Intelsat 6 was built for 10 to 14 year operation with a mass of 6 x 4 x 12 meters dimension and 4600 kg producing 2600 W power by solar panels. A medium size small satellite of today has a mass of 50 kg, accommodating a space of 0.6 x 0.4 x 0.3 m producing only 30 W of power by batteries.