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Refractory Materials for Space Power Systems

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Refractory alloys and metals engage the attention of interrogator because of their great properties and promising practice usefulness. Properties of refractory metals, such as molybdenum, tantalum and tungsten, their strength, and resistance to high temperatures makes them suitable material for hot metal working and applications for vacuum furnace. Many special applications operate these properties: for example, tungsten filament lamps operate at temperatures up to 3073 K and molybdenum furnace windings can withstand up to 2273 K. However, poor low-temperature processability and extreme oxidation at elevated temperatures deficit the most refractory metals. Cooperation with the environment can significantly affect their high-temperature creep. The use of these metals require a protective atmosphere or coating. Refractory metal alloys of molybdenum, niobium, tantalum and tungsten are used in space nuclear power systems. These systems were designed to operate at temperatures from 1350 K to 1900 K. the environment does not have to cooperate with the material in question. Liquid alkali metals as coolants are used, as well as ultra-high vacuum. High temperature creep of alloys should be limited in their use. On creep should not exceed 1-2%. Additional complexity in the study of creep of refractory metals is the interaction with the environment, which can have a significant effect on the creep behavior [1].

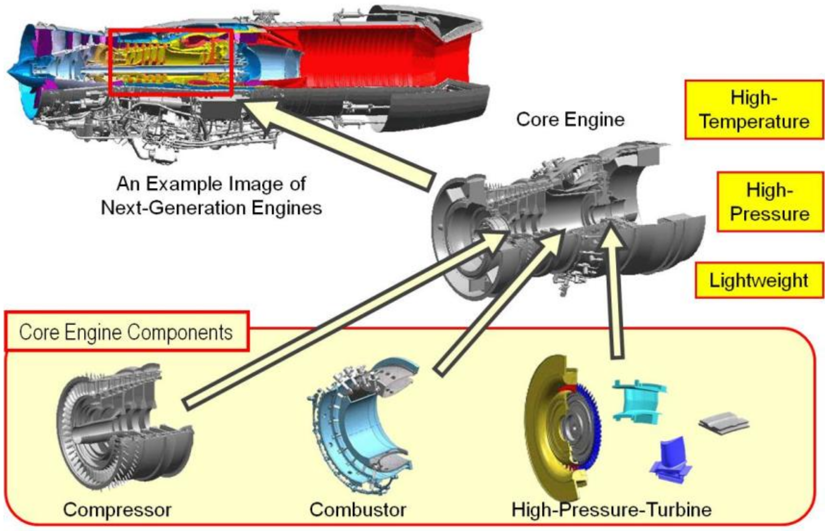

Figure 1 – Space power demonstrator engine

Refractory metals are a class of metals that are highly resistant to heat and wear. They include five elements: niobium, molybdenum, tantalum, tungsten and rhenium. They all have some properties, including melting point above 2000 °C and high temperature hardness. They are chemically inert and have a relatively high density. The high melting point make a powder metallurgy method for manufacturing parts made of these metals. Some of their applications include tools for machining of metals at high temperatures, wire, thread, mold, chemical reactions and vessels operating in aggressive environments. Partly because of its high melting point refractory metals resistant to creep at very high temperatures.

Refractory metals show a wide variety of chemical properties because they were members of three different groups in the periodic table. They are easily oxidized, but this reaction is slowed down in the bulk metal due to the formation of a stable oxide layer on the surface. However, poor low-temperature processability and extreme oxidation at elevated temperatures disadvantages of the most refractory metals. Interaction with the environment can significantly affect their high-temperature creep. The use of these metals require a protective atmosphere or coating.

Refractory metals are used in lighting, tools, lubricants, control rods of nuclear reactions, catalysts and chemical and electrical properties. Because of their high melting refractory metal components are never made by casting. The powder metallurgy process is used. Pure metal powders is compacted, heated by an electric current, and further fabricated by cold working with annealing steps. Refractory metals can be introduced wire, ingots, bars, sheets or foils. Refractory metal alloys of molybdenum, niobium, tantalum and tungsten are used in space nuclear power systems. These systems were designed to operate at temperatures from 1350 K to 1900 K. the environment should not interact with the material in question. Liquid alkali metals as coolants are used, as well as ultra-high vacuum [2].

- Molybdenum is used to make alloys. It is used in steel alloys to increase strength, hardness, electrical conductivity and resistance to corrosion and wear. These ‘moly steel’ alloys are used in parts of engines. Other alloys are used in heating elements, drills and saw blades [4].
- Tungsten has the highest melting point of all metals and is alloyed with other metals to strengthen them. Tungsten and its alloys are used in many high-temperature applications, such as arc-welding electrodes and heating elements in high-temperature furnaces [4].
- Niobium is used with iron and other elements in stainless steel alloys and also in alloys with a variety of nonferrous metals, such as zirconium, Niobium alloys are strong and are often used in pipeline construction. The metal is used in superalloys for jet engines and heat resistant equipment. Niobium is also used for jewelry. At cryogenic temperatures, niobium is a superconductor [5].

- Tantalum is used to make components for chemical plants, nuclear power plants, airplanes and missiles. Tantalum does not react with bodily fluids and is used to make surgical equipment. Tantalum also does not irritate the body and is used to make surgical sutures as well as implants, such as artificial joints and cranial plates. Tantalum is alloyed with steel to increase steel's ductility, strength and melting point [6].
- Rhenium is used as an important component in superalloys for blades in turbine engines and this is the major use today. Rhenium is an ideal metal for use at very high temperatures, which makes it suitable for rockets motors. Rhenium is added to tungsten and molybdenum to form alloys that are used as filaments for ovens and lamps. It is also used in thermocouples which can measure temperatures above 2000 C, and for electrical contacts which stand up well to electric arcs [7].

Refractory metal alloys of molybdenum, niobium, tantalum and tungsten are used in space nuclear power systems. These systems were designed to operate at temperatures from 1350 K to 1900 K. the environment should not interact with the material in question. Liquid alkali metals as coolants are used, as well as ultra-high vacuum. High temperature creep of alloys should be limited in their use. On creep should not exceed 1-2%. Additional complexity in the study of creep of refractory metals is the interaction with the environment, which can have a significant effect on the creep behavior.

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