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ANTI-SEIZING SURFACES

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3 Claims

ABSTRACT OF THE DISCLOSURE

A coating and a process for preparing the coating for an alloy of aluminum and a transition metal such as either iron or vanadium in which the aluminum is in solid solution. The coating is formed by heating the alloy in an oxidizing atmosphere of helium containing steam.

BACKGROUND OF THE INVENTION

Considerable difficulty is often experienced with seizing of rotating pump shafts in bearings or sticking of valve seats situated in hot alkali metal systems and self-welding of stainless steel in a hot sodium environment, in particular. For example, in a recent series of tests, balls of chromium stainless steel in contact with each other were tested in flowing sodium at 700° C. with an external load of 11.6 pounds on each ball support point. The balls were thereafter examined and it was found that extensive sintering at the points of contact took place. This demonstrated that stainless steels of the usual type for this purpose are unsuitable in such applications where seizing is to be avoided.

SUMMARY OF THE INVENTION

The invention described herein was made in the course of, or under a contract with the U.S. Atomic Energy Commission.

This invention relates to alloys consisting of solid solutions of aluminum in certain transition metals that form surface films which eliminate self-welding at points of contact in such an environment as that of bearings in molten sodium systems.

It is therefore a principal object of this invention to provide coatings which are suitable for use on bearings in liquid sodium environments to prevent sintering taking place at points of contact.

Other objects and advantages of this invention will hereinafter become readily apparent from the following description of preferred embodiments of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention provides a type of alloy and a bearing construction which avoids the problems mentioned above. In accordance with the principles of this invention, an alloy consisting of a solid solution of aluminum in a transition metal is treated to generate a barrier or surface film which is impervious to and is stable in molten sodium.

A principal requirement of an alloy made in accordance with the principles of this invention is the use of a transition metal with the aluminum in which the aluminum has an appreciable solid solubility. In one embodiment the presence of sufficient aluminum in the alloy is provided to form a barrier layer consisting principally of Al_2O_3 . This barrier layer, insoluble in and impervious to the metal matrix and at least partially adherent to the alloy, provides the principal barrier to sintering or adhesion of one loaded unit to another. In an alloy system such as Cr-Al, for example, where a mutual solid solubility exists, a barrier layer of Al_2O_3 must be present to

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an appreciable extent in the resulting solid solution oxide, $Cr_2O_3-Al_2O_3$, for the alloy to be useful as a bearing alloy in a hot alkali metal system. In addition, the use of such an alloy, as a barrier layer for separating liquid sodium from its containment, will reduce or eliminate mass transfer between the liquid metal and the container material.

The presence of additional minor elements in the solid solution alloy does not alter the results or contribute significantly to improvement of the anti-seizing properties of the alloys but may, on the other hand, result in poorer anti-seizing properties or barrier properties for the binary Al-transition metal solid solution.

Examples of alloys prepared in accordance with this invention are as follows:

EXAMPLE 1

The iron-aluminum binary shows extensive solid solubility of aluminum in iron (approximately 50 a/o). In this system, because of embrittling effects of high aluminum additions and the possible formation of Fe_3Al ordered solid solutions, the anticipated useful high aluminum limit is somewhat lower. By a/o is meant atom percent.

A typical binary alloy near the useful upper aluminum limit was prepared as follows:

High purity Al (20.45 g.) was arc melted 5 times in an inert atmosphere copper cold hearth furnace with 193 grams of high purity iron without measurable weight loss. The resulting alloy corresponded to 17.97 a/o Al and 82.03 a/o Fe. The alloy was then cut into fragments weighing 0.93 ± 0.05 g. to yield $\frac{1}{4}$ in. fragments which were then placed into hemispheric cavities in a copper block and melted to yield nearly spherical alloy pellets.

The samples were then removed and heated at 1000° C. in an Al_2O_3 boat for $3\frac{1}{2}$ hours under an atmosphere of H_2+He saturated with water at 0° C. by bubbling through the water and rapidly cooled in dry H_2+He . This resulted in a relatively adherent film of Al_2O_3 on the balls and a weight gain of .0001 g./93 g. sphere or approximately .0001 g./cm.² alloy surface as a result of oxidation.

The spheres were tested under 11.6 lbs. load in flowing 700° C. sodium and examination afterwards showed that they did not adhere to each other.

EXAMPLE 2

A second group of Re-Al alloy spheres was prepared and oxidized as in the preceding example except with the composition 10 a/o Al-90 a/o Fe. The resulting spheres were similarly tested under an 11.6 lb. load flowing 700° C. sodium and these spheres also did not stick to each other.

EXAMPLE 3

Another group of Fe-Al alloy spheres was prepared as in the previous example, but were oxidized by pretreating for 8 hours at 1000° C. in an H_2+He atmosphere saturated with water at 0° C. followed by flushing with dry H_2+He at 1000° C. before rapid cooling to produce a protective film containing Al_2O_3 over the surfaces. Tests showed that the resulting spheres were not sintered together in the sodium alkali environment mentioned previously. However, it is believed that if the protective film were to be removed by abrasion in a hot sodium system, it would take longer to heal by reaction with trace oxygen (i.e. 10 to 500 p.p.m.) in the sodium than would a 15 or 20 a/o aluminum alloy. It is thought that to obtain the protective coating or barrier layer which is self-healing it is desirable to have an alloy containing aluminum approaching the maximum amount consistent with acceptable mechanical properties for the particular alloy application.

EXAMPLE 4

A group of Al-V alloy spheres was prepared as in the preceding examples with the composition of 9.5 a/o Al and 90.5 a/o V from pure elements by arc melting and then oxidized for one hour in an atmosphere of He+H₂ saturated with water at 0° C. at about 1000° C. and cooled in dry helium to avoid hydriding of the vanadium, to give a uniformly gray surface. These spheres were tested in 700° C. sodium as in the preceding examples and it was noted that the spheres did not stick to each other.

The upper limit for aluminum content of these alloys is taken as the maximum solubility of aluminum in the major element at 600° C. or above. Because of poor workability (brittleness) of saturated solid solutions of aluminum in these elements, less than the maximum aluminum content is generally desirable.

Representative composition limits for a variety of aluminum alloys which may be suitable for hot sodium applications are given in the following table.

System:	Atom Percent-Al
Al-Fe -----	3-35
Al-V -----	3-40
Al-Cr -----	3-15
Al-Ni -----	3-10
Al-Cu -----	3-15
Al-Mo -----	2-4
Al-W -----	2-8

It is thus seen that there has been prepared alloys having the ability of functioning in a hot sodium environment. These alloys may be used to form the articles such as bearings having the anti-seizing surfaces, or the alloys may be used as cladding materials on other materials on the articles before coating, if desired and feasible for the particular application.

What I claim is:

1. An article of manufacture having an anti-seizing surface layer thereon for use in a liquid sodium system, said surface layer comprising an alloy of a solid solution

of aluminum in vanadium, the aluminum being present in the range of 3 to 40 atom percent, said layer having an in situ oxidized barrier impervious to and stable in liquid sodium, the barrier consisting principally of Al₂O₃.

2. A method of preparing an anti-seizing surface layer for an article of manufacture for use in molten sodium comprising depositing a surface layer of an alloy of a solid solution of aluminum in vanadium, the aluminum being present in the range of 3 to 40 atom percent, upon the article of manufacture, and simultaneously heat treating and oxidizing the surface layer at a temperature of at least 900° C. whereby an oxidized surface barrier is formed on the surface layer.

3. The method of claim 2 in which the heat treatment of the article is conducted in an atmosphere of hydrogen and helium previously saturated with water vapor at 0° C.

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