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ZIRCONIUM BASE ALLOY

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1 Claim. (Cl. 75—177)

The present invention relates to an improved zirconium base alloy. In particular it relates to a zirconium base alloy containing aluminum.

It has been heretofore proposed to alloy zirconium with suitable elements to provide an alloy having high mechanical strength and good corrosion resistance. These endeavors have been successful to a certain extent. However, it has been acknowledged by those skilled in the art that aluminum in appreciable quantities has a deleterious effect upon zirconium base alloys especially when employed in highly corrosive atmospheres.

It is an object of the present invention to provide a zirconium base alloy having predetermined proportions of aluminum, and molybdenum and beryllium and with or without boron, characterized by high mechanical strength, low corrosion rate, and low temperature coefficient of mechanical strength.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

In accordance with the present invention improved zirconium base alloys have been produced comprising from 3% to 10%, by weight, aluminum, and from 0.1% to 4%, by weight, molybdenum; in addition there may be present from .05% to 1%, by weight, of beryllium, and/or up to 1% boron, and the balance being zirconium, with incidental amounts of impurities. The alloys are characterized by good corrosion behavior, high mechanical strength, and low temperature coefficient of mechanical strength.

Aluminum in amounts of from 3% up to 10%, by weight, raises the range of stability of alpha-zirconium to a higher temperature, thus making it harder and stronger and more creep resistant than the alloy without aluminum at a given temperature. It also imparts to the zirconium base alloy a low temperature coefficient of mechanical strength. That is, an increase in temperature renders a relatively slight decrease in hardness as compared to the same alloy without the aluminum. Molybdenum, on the other hand, while only slightly soluble in alpha-zirconium causes a considerable increase in strength and hardness in amounts up to about 4%, by weight. Molybdenum in amounts materially above 4% results in alloys having a decreased hardness and considerable loss in ductility. Beryllium is a highly desirable constituent, especially when the zirconium base alloy is employed as a member in apparatus subjected to high temperature water and steam since it greatly improves the corrosion behavior of the alloy, in that, the alloy will deteriorate by oxidation less rapidly than similar zirconium alloys excluding beryllium in appreciable amounts.

The alloy may be employed as a structural member in high temperature boilers and other apparatus wherein its combination of properties renders it highly useful.

It is permissible to add boron in amounts up to 1%, by weight, depending on the proportions of the other components and it is found to be a highly effective strengthener when alloyed with the aforementioned elements in the zirconium base alloy.

The alloy should be melted by any one of several procedures which will ensure homogeneity and a minimum of contamination. For example, un-alloyed, high purity, sponge zirconium together with the proper amounts of aluminum, molybdenum and boron can be fed into a conventional arc melting furnace containing an inert atmosphere. A tungsten electrode may be used. A consumable electrode consisting of the un-alloyed sponge zirconium combined with pellets or wire or other shapes of the alloying elements may be compacted to form the electrode, and then vacuum arc melted. The resulting ingot should be vacuum arc remelted once or twice using it as a consumable electrode, to achieve homogeneity, then may be hot worked to the desired shape.

The following examples are illustrative of the present invention. In these examples, percentages given for the composition are by weight.

Example I

An alloy of the following composition was prepared by double vacuum arc melting; aluminum, 8.66%, molybdenum,1.89%, beryllium, .42%, and boron .15% and zirconium balance with incidental amounts of impurities. Specimens of the resulting ingot survived fourteen days in both standard corrosion environments (680° F. water and 750° F. steam) without developing cracks, fissures or a flaking corrosion product. Other specimens of the ingot survived 200 days under the same conditions showing only a slight weight loss. Better results would normally be expected since examination showed more than the usual segregation of the boron constituent. Hardness readings taken on section specimens from the tested ingot ranged from 45 to 50 Rockwell C.

Example II

An ingot was prepared by consumable arc-melting of an alloy composed of 96% zirconium, 1% molybdenum and 3% aluminum. Hardness readings taken on section specimens from the tested ingot ranged from 33 to 35 Rockwell C at 25° C. Other hardness tests were made up to 1000° C., using Vickers 2½ kg. hardness numbers:

Temperature, ° C	200	400	500	600	700	800	1,000
Hardness No.	270	223	192	141	62.6	28.8	2.7

Example III

An ingot was prepared by consumable arc-melting of an alloy composed of 95% zirconium, 2% molybdenum and 3% aluminum. Hardness readings taken on section specimens from the tested ingot ranged from 37–40 Rockwell C at 25° C. Other hardness tests were made up to 1000° C., using Vickers 2½ kg. hardness numbers:

Temperature, ° C	200	400	500	600	700	800	1.000
Hardness No.	345	299	236	120	56.2	27.4	3.8

Alloys composed of 3% to 10% aluminum and from 0.05 to 1% beryllium have properties similar to alloys containing molybdenum.

It will be understood that the above description is only exemplary and not in limitation of the invention.

We claim as our invention:

A zirconium base alloy comprising from 3% to 10% by weight aluminum, from 0.1% to 4% by weight molybdenum, from 0.05% to 1% by weight beryllium, up to 1% boron and the balance zirconium with incidental amounts of impurities.

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