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TERNARY ZIRCONIUM BASE ALLOY CONTAINING Sn AND Ti

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1 Claim. (Cl. 75—177)

This invention deals with a zirconium-base alloy, and in particular with a ternary zirconium-tin alloy.

It is an object of this invention to provide an alloy which has high tensile strength at elevated temperature.

It is also an object of this invention to provide an alloy which is characterized by a high degree of ductility.

Alloys which have the above-mentioned properties are being used as construction material, for instance, for equipment which is subjected to high temperatures.

The objects of this invention are accomplished by providing zirconium-tin-titanium alloys. Although the desirable properties are obtained with practically all titanium contents, it is preferable to restrict the titanium content to a content of 6% by weight. The tin content should not exceed 4% if the alloys are to be fabricated. The alloy of this invention thus preferably contains from 0.5 to 4% by weight of tin and from 2 to 6% of titanium, the best alloy containing about 4% of either component.

The alloys may be produced by any method known to those skilled in the art. For the experiments described below the alloys were prepared by drilling holes into pieces of metallic zirconium, putting suitable quantities of tin and titanium thereinto, and then sealing the holes with zirconium chips. These zirconium pieces were then heated in a graphite crucible by high-frequency induction at an absolute pressure of less than 10 microns of mercury. A charge of about 200 grams was melted in each case; the crucible was first charged with about half of this quantity, and only after this first portion had melted was there added the remainder of the charge. The melted alloys were then allowed to cool slowly. The ingots obtained thereby weighed between 160 and 180 grams, part of the material having been taken up by the graphite of the crucible. In some instances, the alloys were produced in an arc melting furnace, and satisfactory results were then also obtained. It will be understood that, instead of melting the materials in two installments, the entire charge may be placed into a crucible at the beginning.

The alloys produced were tested as to hardness, tensile strength, and elongation, the characteristics primarily of interest for construction materials.

For the hardness tests, the ingots of the alloys were first upset-forged and then hot-rolled at 1000° C. to yield ⅛-inch thick slabs. Then about 0.01 inch of the slabs was shaved off from the surface on each side in order to remove any gaseous contaminants. These "scalped" slabs were then cold-rolled in reductions of approximately 0.002 inch per pass until a total reduction of from 20 to 30% had been obtained. The cold-rolled alloys were then annealed for one hour at 700° C. in a straightening press. The sheets resulting thereby were again "scalped" 0.01 inch on each side and cut into testing specimens. The hardness was determined at three stages of the alloys, namely, as cast, cold-rolled, and annealed. In addition to these, the hardness was also determined in some instances after the alloys had been heated to 955° C. and brine-quenched.

For the tensile strength tests, the specimens were taken parallel to the rolling direction. The specimens were 5 inches long and ⅝ inch wide; they had a 1½-inch long reduced section which was 0.5 inch wide and from 0.04 to 0.08 inch thick. The tensile strength was tested in an argon atmosphere at 500° C. with the head of the testing machine traveling at 0.02 inch per minute. The yield strength was determined as the 0.02% offset yield strength, which is the stress developed in tension producing an offset of 0.2% from the original modulus line.

Determination of the elongation was carried out by punching bench marks in the tensile specimens before testing. These bench marks were one inch apart before testing. After testing, the two halves of the broken specimen were placed together and the distance between the bench marks was measured. The increment in distance between the marks was an indication of the elongation of the specimen.

In the following table the properties of some of the alloys of this invention are summarized.

Components of Zirconium Alloy	0.68% Sn, 3.3% Ti, 0.43% C	2% Sn, 4.5% Ti	3.9% Sn, 1.2% Ti	3.9% Sn, 1.6% Ti	3.9% Sn, 4.2% Ti
0.2% offset yield strength at 500° C., p. s. i.	24,000	25,600	25,400	28,100	32,000
Ultimate strength at 500° C., p. s. i.	44,000	42,400	38,800	42,600	50,000
Elongation in 1" at 500° C., percent	22	28	29	35	18
Reduction of area at 500° C., percent	28	34	35	34	22
Hardness as cast, Rockwell "A"	54	45	52	53	56
Hardness, cold-rolled, Rockwell "A"	60	62	60	60	63
Hardness, cold-rolled and annealed 1 hr. 700° C., Rockwell "A"	[1] 56	58	58	57	60
Hardness after brine-quenched from 955° C., Rockwell "A"		63	54	55	68

[1] This alloy was annealed for 3 hours at 700° C.

These results show that titanium increases the yield strength of a zirconium-tin alloy and also that a tin content improves the yield strength of a zirconium-titanium alloy. The 0.2% offset yield strength for pure zirconium was found to range between 4000 and 11,000 p. s. i., which is considerably less than that found with the alloys. Stainless steel 347, which is a steel containing from 17 to 19% chromium and from 9 to 12% nickel, has a yield strength of 31,000 p. s. i. at 500° C.

The microstructure of these alloys was determined on sections of the alloys, which had been annealed for three hours at 700° C.; these sections were polished by hand to 4/0 paper and etched with a 2% ammonium bifluoride-2% ammonium persulfate solution. The alloys were found to consist of one single phase with the exception of minor carbide particles which were formed from a low contaminating carbon content.

The alloys of this invention are used advantageously as construction materials in the chemical industry where the equipment has to undergo temperature increases.

It will be understood that this invention is not to be limited to the details given herein but that it may be modified within the scope of the appended claim.

What is claimed is:

A ternary zirconium-base alloy containing about 4% by weight of tin and about 4% by weight of titanium.

References Cited in the file of this patent

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