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# METHOD OF FABRICATING AND TREATING TITANIUM-ALUMINUM ALLOY PARTS TO IMPROVE THEM FOR HIGH TEMPERATURE USE

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1 Claim. (Cl. 148—6.3)

This invention relates to titanium alloys for use in oxidizing atmospheres at high temperatures. The use of titanium alloys for many purposes has been limited by their absorption of oxygen at temperatures above 1200° F. I have found that alloys of titanium with 6–20% aluminum and more particularly those with 10–20% aluminum do not absorb oxygen at elevated temperatures except in a surface layer which does not affect the mechanical properties of the balance of the alloy. Unfortunately such alloys as made from conventional materials and by conventional techniques cannot be hot worked and do not have the necessary mechanical properties at temperatures around 1200° F.

In my copending application, Serial No. 668,770, filed June 28, 1957, I have disclosed that titanium-aluminum alloys containing from 6–20% aluminum can be hot worked in the absence of oxygen but that such oxygen-free alloys are not strengthened by increased aluminum. In that application, I have also disclosed that these alloys may be strengthened by adding up to 2% vanadium.

My present invention consists in forming such low oxygen alloys in the absence of oxygen then rendering them stable in oxidizing atmospheres at elevated temperatures by forming a high oxygen surface layer. This layer may be formed under conditions of use or by preforming under more severe conditions.

The relationship of aluminum content of the alloy to oxygen penetration is shown in the following table. All sample having been heated in air at 1400° F. for 24 hours.

TABLE

| Distance from Surface, Mils | Oxygen Content | | | | |
|---|---|---|---|---|---|
| | 2% Al | 4% Al | 6% Al | 10% Al | 20% Al |
| 0 | .3 | .5 | 2.0 | 2.5 | 4.0 |
| 2 | .2 | .4 | .5 | 0.8 | 1.1 |
| 4 | .1 | .3 | .10 | .025 | .02 |
| 6 | .08 | .2 | .030 | .02 | .015 |
| 8 | .06 | .1 | .025 | .015 | .015 |
| 10 | .05 | .08 | .02 | .015 | .015 |
| 15 | .04 | .05 | .015 | .015 | .015 |
| 20 | .03 | .03 | .015 | .015 | .015 |

It will be seen that a definite high oxygen layer is formed only in the 6, 10 and 20% aluminum alloys. In alloys lower in aluminum, the penetration of oxygen is not limited to a surface layer. If these oxidized alloys are now heated at 1200° F. in air for 2 weeks, additional oxygen will be absorbed by the 2 and 4% alloys but not by the 6, 10 and 20% alloys.

The oxygen absorption is not affected by adding up to 2% vanadium to the 6, 10 and 20% aluminum alloys, the strength of such alloys is, however, increased in proportion to the vanadium content as disclosed in my copending application above referred to.



Having now described my invention in its more general aspects, I will illustrate it by examples.

*Example I*

In this example I make an alloy of titanium with 10% Al, 1% V and .010 oxygen and substantially no other elements in order to prevent oxygen absorption in depth during exposure of said alloy to oxidizing atmospheres. I forge it into a rod ½" diameter after coating with titanium carbide, by first coating the ingot with graphite then making a cathode in a molten electrolyte composed of 65% $SrCl_2$—35% NaCl in which is dissolved 8% Ti as chloride, average valence 2.3 and at least one metal selected from the group of alkali and alkaline earth metals 1% as determined by gas evolution in ferric chloride solution. The rod is then annealed at 800° C.

The rod is turned in a lathe to remove .010 inch; one half is then heated for 2 weeks in air at 1200° F.; at the end of this time an additional .010 inch is turned off the heated portion of the rod.

The mechanical properties of the two halves are then determined with the following results:

| | UTS | YP | Elong., percent |
|---|---|---|---|
| Unoxidized Rod | 175,000 | 162,000 | 20.0 |
| Oxidized Rod | 174,000 | 163,000 | 21.0 |

It will be clear that the mechanical properties of the alloy have not been impaired by heating at 1200° F. in air for 2 weeks.

*Example II*

I take an alloy of 20% aluminum, 2% vanadium and .010% oxygen balance titanium and proceed as in Example I until the rod is turned and halved. I then take one half and heat in air to 1600° F. for 2 hours, and then in air at 1400° F. for 2 weeks. I then turn off .010" and compare the properties of the two halves. The results follow:

| | UTS | YP | Elong., percent |
|---|---|---|---|
| Unoxidized Rod | 275,000 | 250,000 | 10.0 |
| Oxidized Rod | 270,000 | 251,000 | 9.5 |

What is claimed is:

The method of making titanium aluminum alloy structural parts for service of at least several hours in oxidizing atmospheres at temperatures of 1000–1400° F., which consists in fabricating the part by a method which excludes oxygen from an alloy of titanium with 6–20% aluminum, up to 2% vanadium and less than .02% oxygen balance substantially titanium, then preforming on the part a high oxygen surface layer stable under surface conditions by exposure to oxidizing atmospheres at temperatures of 1000–1400° F.

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