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ALLOYS OF TITANIUM CONTAINING BETA STABILIZERS WITH MINOR AMOUNTS OF ALUMINUM

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This invention relates to fabricated alloys of titanium with beta stabilizing elements having from .01%–.03% oxygen and from .1–1% aluminum. In my copending application executed June 13, 1957, I have disclosed that alloys of titanium with 1–5% Fe, Cr, Mo, V and Mn with less than .03% oxygen having new and useful mechanical properties.

This invention relates to the modification of those properties by the addition of small amounts of aluminum. In my copending application referred to, I have disclosed that increasing the alpha stabilizing element oxygen above .03% rapidly brings the alloys of that invention into the range of conventional mechanical properties. The addition of substantial percentages of the alpha stabilizing element aluminum also brings the alloys of my previous invention into the range of mechanical properties of conventional alloys. I have found, however, that the addition of from 0.1–1% aluminum to the alloys of my earlier invention provides a heretofore unavailable combination of properties.

This may be conveniently illustrated by a specific example. An alloy of titanium with 4% vanadium made in accordance with my previous invention and fabricated to obtain a sheet containing .02% O_2 had the following properties when annealed at 800° C. and furnace cooled.

UTS, lbs./Sq. in.	YS, lbs./Sq. in., .2% offset	Elong., Percent, in 2"
225,000	208,000	10.2

I now make alloy sheet identical with the previous sheet except that it contains .5% aluminum. The properties are as follows when annealed at 800° C.

UTS, lbs./Sq. in.	YS, lbs./Sq. in., .2% offset	Elong., Percent, in 2"
148,000	130,000	38

It will be seen that 0.1% aluminum lowers the strength of the annealed material and increases its ductility. However, by quenching from 900° C., the strength of the alloy is greatly increased, the properties of the quenched alloy being:

UTS, lbs./Sq. in.	YS. lbs./sq. in. .2% offset	Elong., Percent, in 2"
220,000	200,000	11.6

It will be seen that the strength of the annealed alloy has been lowered to provide a cold workable alloy while

ductility remains at a far higher level than could be obtained with conventional alloys at the same strength level and also higher than with the substantially beta alloys of my previous invention. Quenching provides a hard strong alloy. I have found that the presence of aluminum in titanium alloys greatly increases the rate of oxygen absorption when heated in an atmosphere containing oxygen. In the practice of my invention, it is therefore necessary to avoid heating the alloy without protection from oxygen and nitrogen. This may be done by applying a suitable coating.

Example I

I take crystal intergrowths of pure titanium-manganese alloy containing 4% manganese, less than .01% oxygen and substantially no other impurities. Such crystal intergrowths can be conveniently prepared according to the method disclosed in my copending application of even date.

I mix these intergrowths with 1% pure aluminum and form the mass into a consumable electrode. I melt the alloy into an ingot in a vacuum arc furnace. I fabricate the resulting ingot without substantial addition of oxygen and obtain a fabricated alloy analyzing 3.95 Mn, .015 oxygen and 1% Al, balance substantially titanium. The alloy had the following properties:

	UTS, lbs./Sq. in.	YS, lbs./Sq. in., .2% offset	Elong., percent, in 2"
Annealed, 800° C.	135,000	115,000	36
Quenched, 900° C.	228,000	215,000	11

Example II

I take crystal intergrowths of titanium containing .5% iron. I form these into a consumable electrode with the addition of .25% Al and melt in a vacuum arc furnace. The resulting ingot is fabricated to produce sheet analyzing .51% Fe, .24% Al, .01% O_2, balance substantially titanium. This sheet had the following properties:

	UTS, lbs./Sq. in.	YS, lbs./Sq. in., .2% offset	Elong., percent, in 2"
Annealed, 800° C.	115,000	108,000	36
Quenched, 900° C.	195,000	180,000	15

Example III

In this example, I take pure chromium, substantially free from oxygen, crystal intergrowths of pure titanium and pure aluminum. I form these into a consumable electrode and melt in a vacuum. The resulting ingot is worked into sheet and the sheet analyzed:

	Percent
Cr	3.1
O_2	.005
Al	1

Balance substantially titanium.

This sheet had the following properties:

	UTS, lbs./Sq. in.	YS, lbs./Sq. in.	Elong., percent, in 2"
Annealed, 800° C.	120,000	110,000	30
Quenched, 900° C.	225,000	200,000	8

Example IV

In this example, I take crystal intergrowths of titanium with 2% molybdenum. I make these into a consumable

electrode with 0.25% pure aluminum. I work the resulting ingot into ¼ inch rod. The rod analyzes:

	Percent
Mo	1.9
O_2	.01
Al	.25

This rod had the following properties:

	UTS, lbs./ Sq. in.	YS, lbs./ Sq. in.,	Elong., percent, in 2"
Annealed, 800° C	105,000	90,000	30
Quenched, 900° C	185,000	160,000	15

What is claimed is:

1. Fabricated alloys of titanium with .1–5% of a metal selected from the group consisting of Fe, Cr, V, Mo and Mn, .01–.03% oxygen and .1—1% aluminum balance substantially titanium.

2. The method of heat treatment of alloys according to claim 1 which consists in heating at 800–900° C. and slow cooling whereby to soften the alloy mechanically working in the softened state, heating the alloy to 800–900° C. and cooling rapidly, whereby to harden and strengthen the alloy.

References Cited in the file of this patent

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