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H. B. BOMBERGER, JR., ET AL

3,436,277

METHOD OF PROCESSING METASTABLE BETA TITANIUM ALLOY

Filed July 8, 1966

FIG. 1.

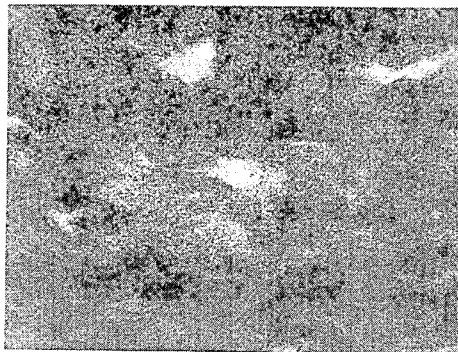
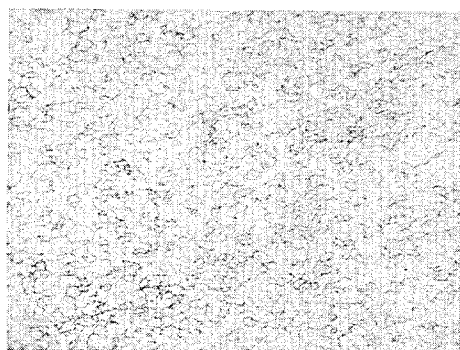


FIG. 2.



INVENTORS.

HOWARD B. BOMBERGER, JR. and

DONALD B. WARMUTH

By

Vincent G. Gioia

Attorney

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METHOD OF PROCESSING METASTABLE
BETA TITANIUM ALLOY

Howard B. Bomberger, Jr., East Liverpool, and Donald B.
Warmuth, Warren, Ohio, assignors to Reactive Metals,
Inc., a corporation of Delaware

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4 Claims

ABSTRACT OF THE DISCLOSURE

A method of processing a metastable beta titanium alloy which contains 0.8 to 1.8% aluminum, 7.5 to 8.5% vanadium, 4.5 to 5.5% iron and up to about 0.5% oxygen. The alloy is subject to a final hot-working at a temperature above its beta transus of about 1520° F. Thereafter it may be solution heat-treated, quenched, aged, or cold-worked and annealed. Method produces an improved microstructure and finer grain size over conventional practice of conducting the final hot-working at a temperature below the beta transus.

This invention relates to a method of processing metastable beta titanium alloy. More particularly, the invention relates to processing a titanium alloy containing 0.8 to 1.8% aluminum, 7.5 to 8.5% vanadium, 4.5 to 5.5% iron and up to about 0.5% oxygen to produce a product of uniform grain structure, of improved fabricability and which, in the solution heat treated and aged condition, has a yield strength of at least about 200,000 k.s.i.

The titanium alloy described above containing aluminum, vanadium and iron is normally referred to as the Ti-1Al-8V-5Fe alloy. It has been used with advantage as a fastener stock material in the aircraft industry. Unfortunately, however, this material when subjected to conventional processing has exhibited an undesirable microstructure which has a detrimental effect on mechanical properties.

the final hot working is accomplished entirely above the beta transus temperature and a uniform microstructure is obtained. Moreover, it has been found that the conventional hot working at below the beta transus in an effort to control grain structure is not necessary and that a sufficiently fine and uniform grain structure can be obtained by hot working above the beta transus temperature.

When the meta-stable beta alloy is worked below the transformation temperature, there results a rapid, localized strain-induced transformation of some of the unstable beta phase. This transformation is not uniform throughout the cross section of the alloy article. The result is that very distinct, generally symmetrical and highly objectionable work patterns are formed. The work patterns consist of variation in the alpha-beta distribution in the microstructure. It is believed that this variation in structure results in the undesirable variation in properties throughout the cross section which are observed and must be avoided. The undesirable microstructures can be avoided by practicing the invention and by performing all hot work above the transformation in the beta phase region.

The accompanying photomicrographs illustrate the different microstructure which result from the use of the conventional processing practices and processing according to the invention. The photomicrographs are of hot rolled and annealed specimens of Ti-1Al-8V-5Fe alloy taken at 100× magnification. As can be seen, the sample conventionally hot worked at 1450° F. shown in FIGURE 1 is darker due to the profusion of alpha phase transformation products. In contrast, the microstructure shown in FIGURE 2, of the alloy hot worked above the beta transus (at 1700° F.) reveals a desirable uniform grain structure without alloy segregation.

The improvement in mechanical properties obtained by practicing the invention is further shown in Table I which compares the tensile and yield strengths of samples hot worked below and above the beta transus temperature. It should be noted that the mechanical properties can be very significantly improved.

TABLE I

Annealing cycle		Hot worked above beta transus temp. at 1,700° F.			Hot worked below beta transus temp. at 1,450° F.		
Soln. ht. treat. and age cycle	Mechanical property	1,250° F./2 hrs. FC	1,300° F./2 hrs. AC	1,350° F./2 hrs. AC	1,250° F./2 hrs. FC	1,300° F./2 hrs. AC	1,350° F./2 hrs. AC
1,400° F./1 hr WQ.....	UTS, Ks.i.....	211.2-212.2	208.0-208.0	209.8-210.5	194.2-196.8	192.7-193.0	193.1-193.5
plus 950° F./2 hrs. AC.....	YS, Ks.i.....	204.0-205.0	199.9-200.9	202.0-203.1	188.1-191.0	186.8-187.4	186.7-186.9
1,425° F./1 hr. WQ.....	UTS.....	227.3-228.5	228.3	230.4	198.0-199.8		
plus 925° F./2 hrs. AC.....	YS.....	219.1-220.2	219.6	222.4	192.1-193.4		

The present invention involves an improvement in the processing of the aforementioned titanium alloy which avoids the above difficulties and provides a product of uniform grain structure. When treated in accordance with the invention, the alloy exhibits improved fabricability and a higher yield strength than obtained by conventional processing can be achieved. According to the invention, the final hot working of this meta-stable beta titanium alloy is conducted above the beta transition temperature of the alloy. In a preferred embodiment of the invention, the alloy is solution heat treated at 1350 to 1500° F., water quenched and aged at 900 to 1050° F., after the aforementioned final hot working above the beta transition temperature.

Conventional processing of the Ti-Al-V-Fe alloy has involved hot working the alloy at below the beta transus temperature, normally 50 to 100° F. lower than the transition temperature, to produce a fine-grained structure. The beta transus temperature for this titanium alloy is about 1520° F. In accordance with the present invention,

Material hot worked above the beta transition temperature, in accordance with the invention, may be subsequently processed in any desired manner so long as thermal treatments above the beta transus are avoided. A presently preferred embodiment involves solution heat treating and aging the hot worked alloy to develop high strength, i.e. yield strengths of at least about 20,000 k.s.i.

In practicing the preferred embodiment referred to above, it is important to conduct the solution heat treating and aging of the alloy under controlled conditions. It has been found that if the solution heat treatment is performed between 1350° F. and 1500° F., a maximum heat treatment response results, and maximum aged strengths can be obtained if aging is performed between 900° F. and 1050° F. Below 900° F., the aging response is negligible and above 1050° F. the aged strengths are significantly lower than the desired 200,000 k.s.i. minimum yield strength.

In addition to the basic procedure of hot working,

solution heat treating and aging as described above, it is possible to vary the fabrication practice in accordance with a particular desired result. Thus, for example, if it is advantageous to cold work the article following hot working, an intermediate annealing may be performed. Annealing, where used, is desirably conducted at between 1250 and 1500° F. The alloy article may be either furnace cooled or air cooled following annealing.

We claim:

1. In the processing of a metastable beta titanium alloy, which consists essentially of 0.8 to 1.8% aluminum, 7.5 to 8.5% vanadium, 4.5 to 5.5% iron, oxygen in an amount up to about 0.5%, and the balance substantially titanium, and which alloy has a beta transformation temperature of about 1520° F., an improved method of attaining a uniform grain structure in the alloy, said method comprising hot-working the alloy at a temperature above its beta transformation temperature and performing all hot work on the alloy above said transformation in the beta phase region, solution heat-treating the alloy at a temperature of 1350 to 1500° F., water-quenching the alloy, and aging the alloy at a temperature of 900 to 1050° F., said alloy in the solution heat-treated and aged condition having a yield strength of at least about 200,000 k.s.i. and a fine uniform grain microstructure without alloy segregation.

2. A method as defined in claim 1 in which the hot work is performed at a temperature of about 1700° F.

3. A method according to claim 1 wherein the alloy is cold worked and annealed after final hot working.

4. A method according to claim 3 wherein said annealing is performed at 1250° F. to 1500° F.

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CHARLES N. LOVELL, *Primary Examiner*.

U.S. Cl. X.R.

148—32.5, 133

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,436,277

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Howard B. Bomberger, Jr., et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 32, column 2, lines 60 and 70 and column 3, line 25, "k.s.i.", each occurrence, should read -- p.s.i. --. Column 2, line 59, "20,000" should read -- 200,000 --.

Signed and sealed this 14th day of April 1970.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM E. SCHUYLER, JR.

Commissioner of Patents