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TITANIUM FABRICATION

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ABSTRACT OF THE DISCLOSURE

Use of stainless steel envelopes in heating and forging titanium billets. Formation of scale and alpha case is reduced.

BACKGROUND OF THE INVENTION

This invention relates to fabrication of titanium. More particularly, it relates to protecting titanium billets in such a manner that when they are heated and forged, formation of scale and alpha case is minimized.

Titanium, that is, titanium and titanium base alloys, is prone to oxidize during heating in air to forging temperatures. This oxidation ordinarily takes the form of severe surface scaling and creation of a sub-surface formation called alpha-constituent or alpha case. Both scaling and alpha-constituent are detrimental to subsequent forging operations and therefore undesirable. Billets of unprotected titanium tend to scale at the rate of 0.0005" per minute when heated to forging temperatures in air. The term "billets" as used herein refers to unitary bodies made, for example, by casting, or by working such as extruding, rolling or the like. Use of an inert or non-oxidizing atmosphere is a rather elaborate and expensive way to reduce scale and alpha case formation, and glass coatings have thus far failed to reduce alpha case and scaling to the extent desired. Therefore, providing an improved method and economical alternative for minimizing scaling and alpha case formation during titanium billet heating and forging represents a highly desirable result.

STATEMENT OF THE INVENTION

It is accordingly an object of this invention to provide a method of minimizing scale formation and alpha-constituent formation during heating and forging cycles for titanium billets. Another object is to provide a method for improved fabrication of titanium billets by substantially eliminating scaling and alpha case formation. Other objects will be apparent hereinafter from the description and claims which follow.

My invention is predicated upon the discovery that scaling and formation of alpha case during heating and forging titanium billets is minimized by use of austenitic stainless steel envelopes or enclosures for said billets. I have found that the envelopes used according to my invention need be no thicker than foil, that is, no greater than about .006 inch thick. If desired, lubricants, for example, a conventional graphite-in-oil emulsion, may be used both on the dies used in the forging step and on the billets. Also, the titanium billets may be coated with glass frit, for example, in isopropyl alcohol, if desired, before wrapping in the stainless steel envelopes.

Sealing the envelopes after wrapping or encapsulating the titanium billets therein is desirable to minimize oxidation from contact with air. Sealing can be done in any convenient manner, for example, by pressing out most of the air which may be present by hand and folding over the open end of the envelope. Another way to wrap the titanium billets in the envelopes and to seal the envelopes around the wrapped or encased billets is to fold a strip of foil in half and then fold and clamp the two side edges, next folding over the end several times.

According to my invention, the encapsulated billets may be heated to at least 1600° F., for example, for up to an hour or longer, and then forged on dies which may be maintained at a temperature of about 500 to 800° F. The austenitic stainless steel envelopes contain by weight up to 0.1% carbon, 16–20% chromium, up to 2.5% manganese and 8–13% nickel. Illustrative of such austenitic stainless steels which may be used in the composition making up the envelopes useful according to my invention are those listed as austenitic steels in Table 1 on page 409 of The American Society for Metals "Metals Handbook," vol. 1, Properties and Selection of Metals, 8th Edition, copyright 1961.

One advantage of my invention is that the stainless steel envelopes do not have to be removed prior to forging. They may be removed during the machining operation which follows the forging or by mechanical means at any step during the fabrication process. When I refer to forging with respect to the invention of this application, I refer to die forging as well as to the upsetting operations.

A further understanding of my invention may be had from the examples in the table which follows. In these examples, the titanium contained 6% by weight aluminum and 4% by weight vanadium and the billets were about 1 inch in diameter by 1 inch in length. The stainless steel envelopes of Examples 1–4, which are illustrative of my invention, contained approximately .08% C, 2% Mn, 17–19% Cr and 9–12% Ni. The encased billets were placed in a furnace and heated for an hour at 1800° F. and then forged on flat platen dies maintained at 650° F. on a 35-ton press. In Example 5, which is for comparative purposes to illustrate how use of non-stainless steel foil envelopes (this example containing 0.2–0.5% C, 0.5–1% Mn and 0.35–0.8% Si) results in disintegration of the envelopes at heating and forging temperatures and formation of intolerable scale and alpha-constituent of greater than .006-inch thickness due to attack by oxygen. In Example 2, the billets were coated with glass frit prior to encasing with the austenitic stainless steel envelopes. In Examples 1 and 4 a graphite in oil lubricant was used on the dies. The envelopes used in the examples were made of foil .002 inch thick. In all instances in which austenitic stainless steel envelopes were used (Examples 1–4), there was substantially no scaling or scale formation and the alpha case formation, as indicated, amounted to less than about .006 inch in thickness.

TABLE

Example No.:	Alpha case thickness—inches
1	.0028
2	.0033
3	.0020
4	.0038
5	[1].0083

[1] Foil disintegrated in furnace.

From the preceding examples it is believed apparent that we have provided by use of austenitic stainless steel enclosures for titanium billets a way to substantially eliminate formation of scale and alpha case while the billets are in the furnace being heated to temperatures of at least 1600° F. and during subsequent forging.

While the invention has been described in terms of preferred embodiments, the claims appended hereto are intended to encompass all embodiments which fall within the spirit of the invention.

Having thus described my invention and certain embodiments thereof, I claim:

1. A method for fabrication of titanium which comprises enclosing titanium billets in austenitic stainless steel

envelopes containing up to 0.1% by weight carbon, 16 to 20% by weight chromium, up to 2.5% by weight manganese and 8 to 13% by weight nickel, removing air from within the envelopes, sealing the envelopes around the enclosed billets, heating the enclosed billets at a temperature of at least 1600° F. and then forging the enclosed billets thereby forming a product having an alpha case layer of less than about 0.006 inch in thickness.

2. The method of claim 1 wherein the envelopes sealed around the enclosed billets are of a foil thickness of not greater than 0.006 inch.

3. In a process for fabrication of titanium billets by heating and forging, the improvement which comprises encasing titanium billets in austenitic stainless steel envelopes containing up to 0.1% by weight carbon, 16 to 20% by weight chromium, up to 2.5% by weight manganese and 8–13% by weight nickel, removing air from said envelopes having said billets encased therein, sealing said envelopes around the encased billets, heating said encased billets to a temperature of at least about 1600° F., and without removing said envelopes from said billets forging said billets into shaped objects, thereby minimizing formation of scale on said billets and limiting alpha

case formation to a layer of less than about 0.006 inch in thickness.

4. The improvement of claim 3 wherein the austenitic stainless steel envelopes are of a foil thickness of not greater than about .006 inch.

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