Method for preparing a consumable electrode for melting TB14 titanium alloy

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Translation notes

Paragraph and claim identifiers are retained for comparison with the Chinese original. Diameter and mass designations embedded as images in the source examples have been checked visually. The term straightness is used for the source wording referring to straightness deviation.

Abstract

The invention relates to titanium processing and discloses a method for preparing a consumable electrode for melting TB14 titanium alloy. The method comprises: (1) using titanium sponge and niobium bars as raw materials, batching and weighing the titanium sponge according to the weight of the niobium bars and the nominal composition of TB14; (2) placing one half of the titanium sponge in the lower part of the press; (3) placing the niobium bars at the center of the press; (4) placing the remaining titanium sponge in the upper part of the press and compacting it to form an electrode block; and (5) repeating steps (1)-(4) to obtain multiple blocks and welding them into a vacuum consumable electrode for melting TB14. Weighing multiple custom-made niobium bars and batching the sponge accordingly reduces impurities introduced by cutting niobium bars. Dividing the niobium into multiple bars and positioning them at the electrode center during compaction makes the bars less likely to fall into the molten pool and helps improve ingot homogeneity.

Claims

1. A method for preparing a consumable electrode for melting TB14 titanium alloy, comprising: (1) using titanium sponge and multiple niobium bars as raw materials, weighing the niobium bars and then batching and weighing the titanium sponge according to the total weight of those bars and the nominal TB14 composition; (2) placing one half of the titanium sponge batched for TB14 in the lower part of the press; (3) placing the weighed niobium bars uniformly at the center of the press; (4) placing the remaining titanium sponge batched for TB14 in the upper part of the press and compacting it to obtain one electrode block; and (5) repeating steps (1)-(4) to obtain multiple blocks and welding them into a vacuum consumable electrode for melting TB14 titanium alloy.

2. The method of claim 1, wherein, in step (1), the titanium sponge is grade 0A titanium sponge; preferably its particle size is 0.83-12.7 mm.

3. The method of claim 1, wherein the niobium bars in step (1) are Nb1 niobium bars.

4. The method of claim 1, wherein each niobium bar in step (1) has a purity greater than 99.95%.

5. The method of claim 1 or 4, wherein each niobium bar in step (1) measures 16.2-18.6 mm x 16.2-18.6 mm x 300 mm.

6. The method of claim 1 or 4, wherein each niobium bar in step (1) has a straightness deviation no greater than 1 mm/m.

7. The method of claim 1, wherein titanium sponge and 6-8 niobium bars are used in step (1); after the bars are weighed, titanium sponge is batched and weighed according to their weight and the nominal TB14 composition.

8. The method of claim 1, wherein the niobium content of TB14 in step (1) is 42-47 mass %.

9. The method of claim 1, wherein a 1200 T titanium-sponge hydraulic press is used for compaction in step (4).

10. The method of claim 1, wherein steps (1)-(4) are repeated in step (5) to obtain 4-10 electrode blocks, which are welded into a vacuum consumable electrode for melting TB14 titanium alloy.

Description - Technical field

[0001] The invention relates to titanium processing, specifically a method for preparing a consumable electrode for melting TB14 titanium alloy.

Background

[0002] As a dedicated rivet material, TB14 (Ti-45Nb) alloy has been widely used in aerospace because of its excellent cold-workability, specific strength and high ductility.

[0003] TB14 is generally melted three times in a vacuum consumable-electrode furnace. Electrode preparation is a key determinant of ingot quality. The raw materials are titanium sponge and niobium bars. Niobium can generally be introduced directly as bars, as niobium powder or as titanium-niobium alloy powder. TB14 contains 42%-47% Nb. Powder additions would therefore be large, and the powder and sponge might not compact sufficiently. Niobium powder could fall into the molten pool early during melting and cause compositional segregation. High-purity niobium bars are therefore selected as the niobium raw material.

[0004] Commonly supplied niobium bars have dimensions of 13 x 13 x 300 mm or 17 x 17 x 450 mm. Using these sizes requires cutting to adjust the charge weight, which can introduce impurities and should be avoided in melting. The invention batches and weighs seven custom-sized bars and then batches titanium sponge to the nominal TB14 composition. This reduces cutting during charge-weight adjustment and strictly controls impurity introduction during electrode compaction.

Disclosure of the invention

[0005] The invention addresses insufficient compaction and segregation when niobium or titanium-niobium powders fall into the molten pool, as well as impurities introduced when niobium bars are cut to adjust weight. It provides a method in which custom-sized niobium bars are compacted at the exact electrode center, substantially reducing cost while improving ingot compositional homogeneity.

[0006] To achieve this objective, the invention provides the following method for preparing a consumable electrode for melting TB14 titanium alloy:

[0007] (1) Use titanium sponge and multiple niobium bars as raw materials. After weighing the bars, batch and weigh titanium sponge according to their weight and the nominal TB14 composition.

[0008] (2) Place one half of the titanium sponge batched for TB14 in the lower part of the press.

[0009] (3) Place the weighed niobium bars at the center of the press.

[0010] (4) Place the remaining titanium sponge batched for TB14 in the upper part of the press and compact it to obtain one electrode block.

[0011] (5) Repeat steps (1)-(4) to obtain multiple electrode blocks, then weld them into a vacuum consumable electrode for melting TB14 titanium alloy.

[0012] Preferably, the titanium sponge in step (1) is grade 0A.

[0013] Preferably, the particle size of the titanium sponge in step (1) is 0.83-12.7 mm.

[0014] Preferably, the niobium bars in step (1) are Nb1 bars.

[0015] Preferably, each niobium bar in step (1) has a purity greater than 99.95%.

[0016] Preferably, each niobium bar in step (1) measures 16.2-18.6 mm x 16.2-18.6 mm x 300 mm.

[0017] Preferably, each niobium bar in step (1) has a straightness deviation no greater than 1 mm/m.

[0018] Preferably, titanium sponge and 6-8 niobium bars are used in step (1); after weighing the bars, the sponge is batched and weighed according to their weight and the nominal TB14 composition.

[0019] Preferably, TB14 in step (1) contains 42-47 mass % niobium.

[0020] Preferably, compaction in step (4) uses a 1200 T titanium-sponge hydraulic press.

[0021] Preferably, steps (1)-(4) are repeated in step (5) to obtain 4-10 blocks, which are welded into a vacuum consumable electrode for melting TB14 titanium alloy.

[0022] The method weighs multiple custom-made high-purity niobium bars and batches and weighs titanium sponge to the nominal TB14 composition, reducing impurities introduced into the electrode by niobium-bar cutting. Centering the bars during compaction is simple and can reduce production cost. Compared with powder-form niobium material of other specifications, the bars are less likely to fall into the molten pool, helping improve titanium-alloy ingot homogeneity.

Description of the drawing

[0023] Figure 1 is a schematic cross-section of a consumable electrode block compacted according to the invention.

[0024] Explanation of drawing reference marks:

[0025] A is the titanium-sponge position in step (2); B is the niobium-bar position in step (3); C is the titanium-sponge position in step (4).

Detailed embodiments

[0026] Specific embodiments are described in detail below with reference to the drawing. They explain and illustrate the invention and do not limit it.

[0027] The endpoints and individual values disclosed here are not confined to the exact stated range or value, but include values close to them. Endpoints of different ranges, endpoints and individual values, and individual values may be combined to form one or more new numerical ranges, which are to be regarded as specifically disclosed herein.

[0028] The method for preparing a consumable electrode for melting TB14 titanium alloy comprises the following steps:

[0029] (1) Use titanium sponge and multiple niobium bars as raw materials. After weighing the bars, batch and weigh titanium sponge according to their weight and the nominal TB14 composition.

[0030] (2) Place one half of the titanium sponge batched for TB14 in the lower part of the press, as shown at A in Figure 1.

[0031] (3) Place the weighed niobium bars at the center of the press, as shown at B in Figure 1.

[0032] (4) Place the remaining titanium sponge batched for TB14 in the upper part of the press, as shown at C in Figure 1, and compact it to obtain one electrode block.

[0033] (5) Repeat steps (1)-(4) to obtain multiple electrode blocks, then weld them into a vacuum consumable electrode for melting TB14 titanium alloy.

[0034] The titanium sponge may be a conventional choice in the art. Preferably, grade 0A titanium sponge is used in step (1).

[0035] In step (1), the titanium-sponge particle size is 0.83-12.7 mm, for example 0.83, 0.88, 1, 1.2, 1.5, 1.8, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 or 12.7 mm. Preferably, it is 0.83-5 mm.

[0036] The niobium (Nb) bars may be a conventional choice in the art. In a preferred embodiment, Nb1 niobium bars are used in step (1).

[0037] High-purity niobium bars are used to avoid introducing impurities into the electrode. Each bar in step (1) has a purity greater than 99.95%, preferably greater than 99.99%.

[0038] Using custom-sized high-purity niobium bars and batching and weighing sponge to the nominal TB14 composition reduces impurities introduced into the electrode during bar cutting. Each bar in step (1) measures 16.2-18.6 mm x 16.2-18.6 mm x 300 mm; a preferred size is 17.3 x 17.3 x 300 mm.

[0039] Each niobium bar in step (1) has a straightness deviation no greater than 1 mm/m, preferably no greater than 0.9 mm/m and more preferably no greater than 0.8 mm/m.

[0040] Titanium sponge and 6-8 niobium bars are used in step (1). After weighing the bars, the sponge is batched and weighed according to their weight and the nominal TB14 composition. The number of bars may be 6, 7 or 8, preferably 7.

[0041] The titanium-sponge/niobium-bar proportions meet the TB14 composition requirement. The niobium content in step (1) is 42-47 mass %, for example 42, 43, 44, 45, 46 or 47 mass %, preferably 45 mass %.

[0042] Compaction equipment in step (4) may be a conventional choice in the art. Preferably, a 1200 T titanium-sponge hydraulic press is used.

[0043] Step (5) repeats steps (1)-(4) to obtain multiple electrode blocks and weld them into one vacuum consumable electrode for TB14 melting. The number welded may be chosen according to actual requirements for subsequent vacuum consumable-electrode melting. In a preferred embodiment, 4-10 blocks are produced and welded into one electrode.

[0044] In one preferred embodiment, the method comprises:

[0045] (1) Use titanium sponge and seven niobium bars. Weigh the bars, then batch and weigh titanium sponge according to their weight and the nominal TB14 composition.

[0046] (2) Place one half of the batched titanium sponge in the lower part of the press, at A in Figure 1.

[0047] (3) Place the weighed niobium bars at the center of the press, at B in Figure 1.

[0048] (4) Place the remaining batched titanium sponge in the upper part of the press, at C in Figure 1, and compact it to form one electrode block.

[0049] (5) Repeat steps (1)-(4) to obtain six electrode blocks, then weld the six blocks into a vacuum consumable electrode for TB14 melting.

[0050] Weighing multiple custom-sized high-purity niobium bars and batching the sponge to nominal TB14 composition reduces impurities introduced during bar cutting. Centering the bars during compaction is simple and can reduce production cost. Compared with powder-form niobium material of other specifications, the bars are less likely to fall into the molten pool, improving ingot homogeneity.

[0051] The following examples describe the invention in detail, but its scope of protection is not limited to them.

Working and comparative examples

[0052] Example 1.

[0053] This example illustrates electrode preparation for melting a TB14 (Ti-45Nb) ingot designated diameter 310 mm / 144 kg.

[0054] Use grade 0A titanium sponge and seven Nb1 niobium bars, each 17.3 x 17.3 x 300 mm, batched to nominal Ti-45%Nb. Place 3.3 kg of sponge in the lower part of the press (A, Figure 1), distribute the seven Nb bars uniformly at the electrode center (B), then place 3.3 kg of sponge in the upper part (C) and compact one electrode block. Weld six blocks into one consumable electrode designated diameter 130 mm / 72 kg. Compact 12 blocks in total and weld them into two consumable electrodes. After three vacuum consumable-electrode melts, obtain an ingot designated diameter 310 mm / 144 kg. Testing found uniform composition and no compositional segregation.

[0055] Example 2.

[0056] This example illustrates electrode preparation for melting a TB14 (Ti-45Nb) ingot designated diameter 310 mm / 144 kg.

[0057] Use grade 0A titanium sponge and eight Nb1 bars, each 16.2 x 16.2 x 300 mm, batched to nominal Ti-45%Nb. Place 3.3 kg of sponge in the lower press region (A), distribute eight Nb bars uniformly at the electrode center (B), then add 3.3 kg of sponge in the upper region (C) and compact one block. Weld six blocks into one consumable electrode designated diameter 130 mm / 72 kg. Make 12 blocks and weld them into two electrodes. After three vacuum consumable-electrode melts, obtain a diameter 310 mm / 144 kg ingot. Testing found uniform composition and no segregation.

[0058] Example 3.

[0059] This example illustrates electrode preparation for melting a TB14 (Ti-45Nb) ingot designated diameter 310 mm / 144 kg.

[0060] Use grade 0A titanium sponge and six Nb1 bars, each 18.6 x 18.6 x 300 mm, batched to nominal Ti-45%Nb. Place 3.3 kg of sponge in the lower press region (A), distribute six Nb bars uniformly at the electrode center (B), then add 3.3 kg of sponge in the upper region (C) and compact one block. Weld six blocks into one consumable electrode designated diameter 130 mm / 72 kg. Make 12 blocks and weld them into two electrodes. After three vacuum consumable-electrode melts, obtain a diameter 310 mm / 144 kg ingot. Testing found uniform composition and no segregation.

[0061] Comparative example 1.

[0062] Follow Example 1, except place 2 kg of grade 0A sponge in the lower press region, distribute seven Nb bars uniformly on it, then add 4.6 kg of sponge in the upper region and compact. Compositional segregation was found in the ingot.

[0063] Comparative example 2.

[0064] Follow Example 1, except use 17 x 17 x 450 mm Nb bars and cut them to obtain five 17 x 17 x 300 mm bars, four 17 x 17 x 150 mm bars and one 17 x 17 x 75 mm bar. Distribute them uniformly at the electrode center and compact. No significant compositional segregation was found, but a small amount of impurities introduced by cutting the Nb bars was observed.

[0065] Comparative example 3.

[0066] Follow Example 1, except use four 22.9 x 22.9 x 300 mm Nb bars, distribute them uniformly at the electrode center and compact. Because each bar was too heavy, a niobium bar fell directly into the molten pool during the first melting operation, causing melting to stop.

[0067] Preferred embodiments have been described in detail, but the invention is not limited to them. Within its technical concept, simple modifications may be made, including combining the technical features in other suitable ways. Such modifications and combinations are also considered disclosed and fall within the scope of protection.

Drawing

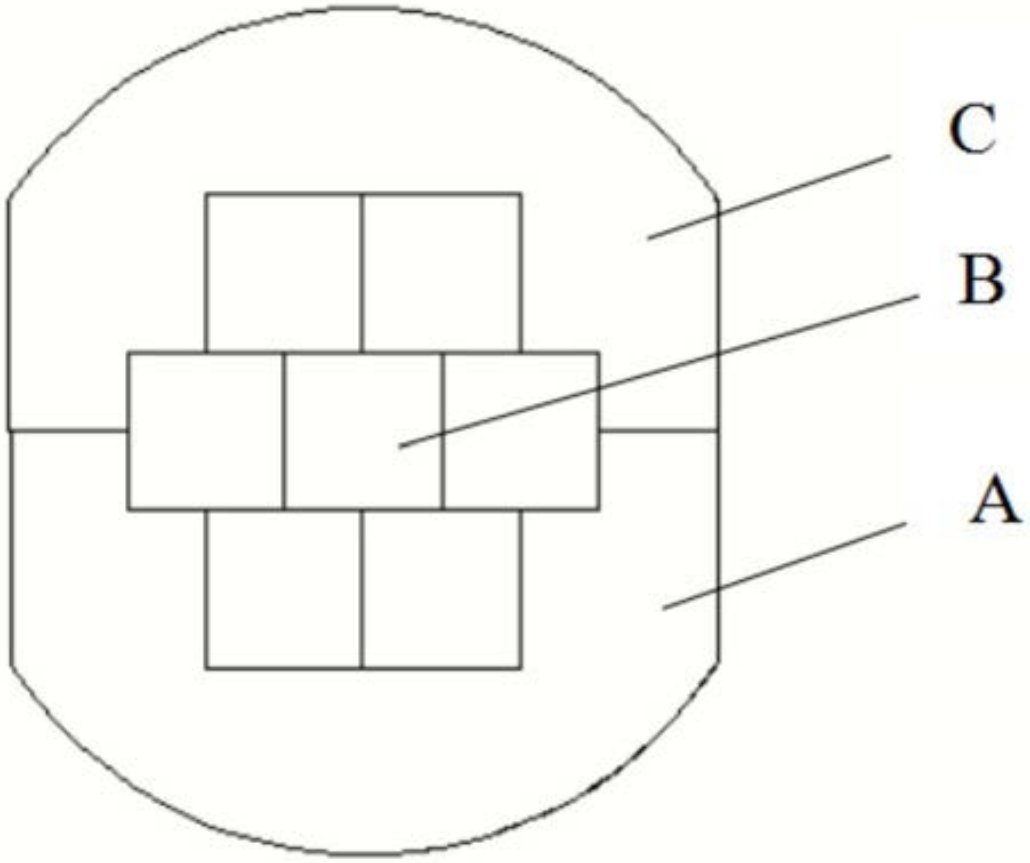


Figure 1. Cross-section of the compacted consumable electrode block. A: lower titanium-sponge region, step (2). B: central niobium-bar region, step (3). C: upper titanium-sponge region, step (4). Original drawing reproduced; reference letters are unchanged.