TA17 / TI-4AL-2V | ENGLISH TRANSLATION

Method for preparing TA17 titanium-alloy plate

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Scope of this reference

English translation of the published Chinese patent disclosure. This is not a certified translation, purchase specification, material certificate, qualified production procedure or guarantee of supplied properties. Results and benefits are statements of the original disclosure. The original Chinese publication controls.

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Source: https://patents.google.com/patent/CN106944492A/zh

Translation notes

This is a translation of the application publication, not a material standard. Source inconsistencies are retained: backing-plate dimensions in the examples use m where mm appears intended; Example 1 changes a width from 1100 to 1200 mm and repeats the final width; Example 2 changes 860 to 810 mm and repeats a final 1200 mm width; Example 3 states 1150°C in S2 and 1130°C in S4 while describing the temperatures as equal; Comparative Example 1 prints mmm once. The general >=950°C finish-temperature statement coexists with third-heat rolling at 840°C. These statements must not be used as a qualified production instruction without resolving the discrepancies. A rolling heat means a heating-and-rolling campaign, not one pass.

Bibliographic information

Application: 201610011005.3; filed 6 January 2016. Application publication: CN106944492A, 14 July 2017. This edition translates the abstract, complete technical description, all three examples, the comparative example and all six claims. No tables or drawings are included in the original publication.

Abstract

The invention discloses a method for preparing TA17 titanium-alloy plate. A TA17 slab is heated in a furnace, separated from upper and lower stainless-steel backing plates, and rolled in a first heat. It is then cut along its length according to the required finished-plate widths, rolled in a second heat and cut again along its length. The method uses the principle that inherited microstructure formed during high-temperature processing can be altered at the same temperature. Maintaining the breakdown-rolling temperature reduces cracking caused by temperature loss in conventional TA17 plate processing and reduces subsequent grinding. The backing plates can be reused to save cost.

Description - technical field

The invention relates to preparation of titanium and titanium-alloy plate, specifically a method for preparing TA17 titanium-alloy plate.

Background

The source describes TA17 as a near-alpha titanium alloy developed by the former Soviet Prometey Central Research Institute of Structural Materials, with nominal composition Ti-4Al-2V and an alpha/beta transformation temperature of approximately 890°C. A small Al addition, an alpha stabiliser, increases strength and heat resistance without an obvious effect on ductility; a small V addition, a beta stabiliser, refines grains and improves processing ductility. The source describes medium strength, good weldability, seawater-corrosion resistance and relatively high static and cyclic strength, and lists marine piping, valves, evaporators and condensers, and aero-engine compressor discs, blades and drums as applications.

The source then describes the plate as a single-phase titanium alloy and states that hot-rolling texture strongly affects the subsequent cold-rolling direction. Changing direction during hot rolling can cause breakage or spalling during cold rolling, potentially causing injury. The described domestic route is: (1) spread and change direction in the first heat, then retain that direction so hot and cold rolling agree; (2) use large deformation and multiple passes to exploit the first-heat breakdown temperature, with later hot rolling at lower temperature to preserve microstructure and properties; (3) complete hot rolling in three heats to approximately 4 mm, with smaller reductions in the second and third heats.

This route is unsuitable for producing multiple widths because the first heat establishes a fixed width and subsequent direction changes are disallowed. One slab therefore yields only one width, causing material accumulation and inventory. Cracking is also frequent: during the first heat the microstructure still resembles the coarse-grained slab, so even high-temperature, large-deformation rolling can produce severe surface and edge cracks, low yield and difficult surface treatment.

Disclosure of the invention

The method aims to produce several widths from one TA17 slab while avoiding the adverse effect of changed texture on cold rolling, reducing cracks and increasing yield. The process is as follows:

S1. Use a TA17 slab 130-180 mm thick, 800-1100 mm wide and 1000-1300 mm long. Clamp it between two steel plates and heat it in a furnace.

S2. Separate the heated titanium slab from the upper and lower stainless-steel backing plates.

S3. Roll in the first heat at a starting temperature >=1000°C and speed of 3-4 m/s, using 6-9 passes. Follow the small-large-small reduction sequence: small-pass reductions 3-5%, large-pass reductions 6-15%, total reduction 50-65%. Control rolled length as the sum of several required widths. Resulting dimensions: thickness 50-75 mm, width 800-1100 mm, length 2000-3800 mm.

S4. After the first heat, cut along the length to the required finished-plate widths. The resulting slab length equals the previous slab width, 800-1100 mm; the resulting width is 750-1500 mm.

S5. Roll the cut slabs in the second heat at a starting temperature >=1000°C, equal to the first-heat temperature, and speed of 3-4 m/s, using 6-9 passes. Use small-large-small reductions: small-pass reductions 4-7%, large-pass reductions 9-16%. Roll perpendicular to the preceding direction. Total reduction is 50-70%, with the difference from the previous heat controlled within 8%. Resulting dimensions: thickness 20-28 mm, width 750-1500 mm, length 3000-6000 mm.

S6. Cut along the length to 800-2000 mm. Roll in the third heat at 50-80°C below the phase-transformation temperature, at 3-4 m/s for 8-12 passes. Use large then small reductions: large-pass reductions 10-20%, small-pass reductions 5-8%, total reduction 60-80%. Resulting dimensions: thickness 4-8 mm, width 750-1500 mm, length 2000-4000 mm.

The steel plates in S1 are preferably 304 stainless steel. Each backing plate has an area at least equal to the titanium plate. The upper plate exceeds the titanium plate length and width by 0-10 mm; the lower plate exceeds its length and width by 20-100 mm.

The upper backing plate is preferably 3-5 mm thick and the lower plate 20-30 mm thick. Two pulling rings are welded to the upper plate to assist separation.

The S2 separation takes no more than 20 s. First, an overhead-crane clamp lifts the upper plate and titanium slab together from the lower plate in 6-10 s. Then an iron hook longer than 3 m engages the upper plate rings to separate it rapidly from the TA17 slab in 0-5 s.

The source specifies a TA17 slab starting rolling temperature >=1000°C and a finishing temperature >=950°C.

Before each rolling heat, coat the TA17 slab with a 1-2 mm thick glass-based high-temperature oxidation-resistant coating.

Reported technical effects and advantages

1. By using the same temperature in the first and second heats, cutting the first-heat slab along its length into required finished widths and changing rolling direction, several plate sizes can be made from one slab. The source attributes this to alteration of inherited high-temperature microstructure, avoiding breakage and cracks caused by strong texture after changing direction. Third-heat rolling below the phase-transformation temperature adjusts properties to the required level.

2. The operation is simple and rapid. Upper and lower backing plates protect the slab during heating and maintain its breakdown-rolling temperature, reducing temperature-loss-related cracking and subsequent grinding. The backing plates are reusable.

3. Producing several widths from one slab improves slab utilisation, speeds delivery and reduces the material inventory associated with making only one width from each slab.

4. The source uses the metallurgical principle that changing rolling direction at the same temperature and similar deformation can markedly alter texture and flow lines, enabling multiple widths while maintaining subsequent processability.

Detailed implementation

Other embodiments obtained by a person skilled in the art from these examples without inventive work are stated to fall within the protection scope of the invention.

Example 1

S1. Use a 180 × 1100 × 1300 mm TA17 slab (thickness × width × length). Clamp it between two steel plates during heating to retain heat and prevent cooling during transfer to the mill. The source gives the lower backing plate as 25 × 1300 × 1500 m and the upper as 4 × 1110 × 1310 m. Two pulling rings are welded on the upper plate.

S2. Heat to 1140°C for the first heat. Before rolling, separate the upper backing plate and slab together from the lower plate using an overhead-crane clamp in 6-10 s; then use an iron hook longer than 3 m engaging the pulling rings to remove the upper plate in 0-5 s.

S3. First-heat total reduction is 58%, producing a 75 × 1100 × 3120 mm slab. Cut along its length for required widths of 1100 and 810 mm, obtaining 75 × 1100 × 1100 mm and 75 × 810 × 1100 mm slabs.

S4. Second-heat temperature is also 1140°C. The two slab widths are 1100 and 810 mm. A total reduction of 63% gives 28 mm thickness, with stated dimensions 28 × 1200 × 2946 mm and 28 × 810 × 2946 mm. The reduction is close to the first heat (58%) and the temperature is equal; the source states that residual flow lines and texture are markedly removed, improving subsequent processing.

S5. Cut the two products into two 28 × 1200 × 1000 mm slabs and two 28 × 810 × 1000 mm slabs. Roll below the phase-transformation temperature at 840°C, with 76% total reduction, to 7 mm. The source states two 7 × 1200 × 4000 mm plates and another two 7 × 1200 × 4000 mm plates.

The reported microstructure is uniform, with mean grain size approximately 30-40 μm. Tensile strength is 876 MPa, yield strength 820 MPa and elongation after fracture 14.0%.

Example 2

S1. Use a 150 × 900 × 1200 mm TA17 slab. Clamp between steel plates during heating for temperature retention. The source states a lower backing plate of 20 × 1300 × 1500 m and an upper plate of 3 × 910 × 1210 m, with two pulling rings on the upper plate.

S2. Heat to 1130°C for the first heat. Separate the upper plate and slab together from the lower plate with an overhead-crane clamp in 6-10 s, then separate the upper plate with an iron hook longer than 3 m engaging the rings in 0-5 s.

S3. First-heat reduction is 57%, producing a 65 × 900 × 2769 mm slab. Cut for widths of 1100 and 860 mm, giving 65 × 1100 × 900 mm and 65 × 860 × 900 mm slabs.

S4. Second-heat temperature is also 1130°C. The widths are 1100 and 860 mm. Total reduction of 62% gives 25 mm thickness, with dimensions 25 × 1100 × 2340 mm and 25 × 860 × 2340 mm. Similar reduction to the first heat (57%) at the same temperature is stated to remove inherited flow lines and texture and improve further processing.

S5. Cut these plates into two 25 × 1100 × 800 mm slabs and two 25 × 810 × 800 mm slabs, as stated in the source. Roll at 840°C with 80% total reduction to 5 mm. The source gives the output as two 5 × 1200 × 4000 mm plates and another two 5 × 1200 × 4000 mm plates.

The reported microstructure is uniform, with mean grain size approximately 20-40 μm. Tensile strength is 866 MPa, yield strength 816 MPa and elongation after fracture 16.5%.

Example 3

S1. Use a 130 × 850 × 1300 mm TA17 slab. Clamp between steel plates during heating for temperature retention. The lower backing plate is given as 30 × 1000 × 1500 m and the upper as 4 × 850 × 1300 m, with two pulling rings on the upper plate.

S2. Heat to 1150°C for the first heat. Separate the upper plate and slab together from the lower plate using an overhead-crane clamp in 6-10 s, then remove the upper plate with an iron hook longer than 3 m engaging the rings in 0-5 s.

S3. First-heat reduction is 62%, producing a 50 × 850 × 3900 mm slab. Cut for widths of 1100, 860 and 810 mm, giving slabs of 50 × 1100 × 850 mm, 50 × 860 × 850 mm and 50 × 810 × 850 mm.

S4. The source says the second-heat temperature is likewise 1130°C. Roll the three slabs with 60% total reduction to 20 mm, producing 20 × 1100 × 2125 mm, 20 × 860 × 2125 mm and 20 × 810 × 2125 mm. It states that reduction is similar to the first heat (62%) and the temperature is equal, markedly removing residual flow lines and texture and improving further processing.

S5. Cut each plate into two slabs, respectively 20 × 1100 × 800 mm, 20 × 860 × 800 mm and 20 × 810 × 800 mm. Roll below the phase-transformation temperature at 840°C, with 80% reduction, to 4 mm. Obtain two plates of each size: 4 × 1100 × 4000 mm, 4 × 860 × 4000 mm and 4 × 810 × 4000 mm.

The reported microstructure is uniform, with mean grain size approximately 20-30 μm. Tensile strength is 838 MPa, yield strength 763 MPa and elongation after fracture 19.0%.

Comparative example 1

S1. Use a 180 × 1100 × 1300 mm TA17 slab clamped between steel plates during heating. The source gives the lower backing plate as 25 × 1300 × 1500 m and the upper as 4 × 1110 × 1310 m. Two pulling rings are welded on the upper plate.

S2. Heat to 1140°C for the first heat. Separate the upper backing plate and slab together from the lower plate using an overhead-crane clamp in 6-10 s, then remove the upper plate using an iron hook longer than 3 m engaging the rings in 0-5 s.

S3. First-heat reduction is 58%, giving 75 × 1100 × 3120 mm. Cut along the length into three 75 × 1100 × 1000 mm slabs.

S4. Second-heat temperature is also 1140°C. Continue rolling in the first-heat longitudinal direction. A reduction of 63% gives 28 mm thickness; the source prints the dimensions as 28 × 1100 × 2678 mmm.

S5. Cut the 28 × 1100 × 2678 mm plate into two 28 × 1100 × 1000 mm slabs. Roll at 840°C with 76% total reduction to 7 mm, giving two 7 × 1100 × 4000 mm TA17 plates.

The reported microstructural uniformity is ordinary, with mean grain size approximately 30-60 μm. Tensile strength is 863 MPa, yield strength 820 MPa and elongation after fracture 13.0%.

Comparison of Examples 1-3 with Comparative Example 1 is stated to show that direction-changing rolling produces multiple widths from one slab, with better microstructural uniformity and a more favourable combination of mechanical properties.

The examples are preferred embodiments and do not limit the invention. A person skilled in the art may modify their technical schemes or replace individual technical features with equivalents. Modifications, equivalent replacements and improvements within the spirit and principles of the invention are stated to be within its protection scope.

Claims

1. A method for preparing TA17 titanium-alloy plate, comprising the following steps:

S1. Use a TA17 slab 130-180 mm thick, 800-1100 mm wide and 1000-1300 mm long. Clamp it between two steel plates and heat it in a furnace.

S2. Separate the heated titanium slab from the upper and lower stainless-steel backing plates.

S3. Roll in the first heat at a starting temperature >=1000°C and speed of 3-4 m/s, using 6-9 passes. Follow the small-large-small reduction sequence: small-pass reductions 3-5%, large-pass reductions 6-15%, total reduction 50-65%. Control rolled length as the sum of several required widths. Resulting dimensions: thickness 50-75 mm, width 800-1100 mm, length 2000-3800 mm.

S4. After the first heat, cut along the length to the required finished-plate widths. The resulting slab length equals the previous slab width, 800-1100 mm; the resulting width is 750-1500 mm.

S5. Roll the cut slabs in the second heat at a starting temperature >=1000°C, equal to the first-heat temperature, and speed of 3-4 m/s, using 6-9 passes. Use small-large-small reductions: small-pass reductions 4-7%, large-pass reductions 9-16%. Roll perpendicular to the preceding direction. Total reduction is 50-70%, with the difference from the previous heat controlled within 8%. Resulting dimensions: thickness 20-28 mm, width 750-1500 mm, length 3000-6000 mm.

S6. Cut along the length to 800-2000 mm. Roll in the third heat at 50-80°C below the phase-transformation temperature, at 3-4 m/s for 8-12 passes. Use large then small reductions: large-pass reductions 10-20%, small-pass reductions 5-8%, total reduction 60-80%. Resulting dimensions: thickness 4-8 mm, width 750-1500 mm, length 2000-4000 mm.

2. The method of claim 1, wherein: The steel plates in S1 are 304 stainless steel. Each backing plate has an area at least equal to the titanium plate. The upper plate exceeds the titanium plate length and width by 0-10 mm; the lower plate exceeds its length and width by 20-100 mm.

3. The method of claim 2, wherein: The upper backing plate is 3-5 mm thick and the lower plate 20-30 mm thick. Two pulling rings are welded to the upper plate to assist separation.

4. The method of claim 1, wherein: The S2 separation takes no more than 20 s. First, an overhead-crane clamp lifts the upper plate and titanium slab together from the lower plate in 6-10 s. Then an iron hook longer than 3 m engages the upper plate rings to separate it rapidly from the TA17 slab in 0-5 s.

5. The method of claim 1, wherein: The source specifies a TA17 slab starting rolling temperature >=1000°C and a finishing temperature >=950°C.

6. The method of claim 1, wherein: Before each rolling heat, coat the TA17 slab with a 1-2 mm thick glass-based high-temperature oxidation-resistant coating.