TA6 | ENGLISH TRANSLATION

High-dimensional-accuracy wide TA6 titanium alloy plate

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Full technical reference translation

This English edition includes the source abstract, description, claims, all examples, and all tables and drawings present in the technical disclosure. Machine-assisted source text has been reviewed and edited against the Chinese publication. English translation is for reference; the original Chinese publication controls. It is not a certified translation, purchase specification, material certificate, production licence or TiHubs performance guarantee. Original disclosure statements are retained as historical statements, not independently verified current claims.

Abstract

The invention provides a method for high-dimensional-accuracy wide TA6 medium-thickness plate. It comprises first heating of TA6 slab; first rolling to a first intermediate slab; cutting and second heating; second rolling to a second intermediate slab; shearing and third heating; third rolling to a third intermediate slab; and finish treatment to obtain wide TA6 plate. Quantitative control of heating temperature, rolling reduction and annealing produces low anisotropy, excellent mechanical properties and high thickness accuracy.

Description

Method for high-dimensional-accuracy wide TA6 medium-thickness plate

Technical field

The invention belongs to titanium alloy material processing technique fields, and in particular to a kind of processing of TA6 titanium alloys medium-thick plate Method.

Background technology

TA6, nominally Ti-5Al, is a medium-strength titanium alloy with good overall mechanical and processing properties. It is strengthened mainly by the alpha stabiliser Al. This high-aluminium-equivalent near-alpha alloy has the weldability and corrosion resistance of alpha titanium, relatively high creep strength, hot-deformation capability, no notch sensitivity under axial loading and good machinability. It can be used for parts and weldments operating below 400 degrees C.

In industrial production, TA6 has poor processing plasticity: the hot-working temperature window is narrow, cracking occurs readily and processing is difficult.

Conventional TA6 plate has large thickness variation and pronounced microstructural and mechanical anisotropy; longitudinal/transverse yield-strength differences commonly reach 50-100 MPa. It therefore no longer meets aviation-plate requirements for dimensional accuracy, uniform directional microstructure and small directional property differences.

The content of the invention

The invention addresses these deficiencies with a processing method for high-dimensional-accuracy wide TA6 plate. Combined control of rolling temperature, reduction per heat, reduction per pass, roll profile and rolling direction yields uniform longitudinal/transverse structure, low mechanical anisotropy and accurate thickness.

In order to solve the above technical problems, the technical solution adopted by the present invention is: A kind of high dimensional accuracy TA6 titanium alloy wides The processing method of medium-thick plate, which is characterized in that this method comprises the following steps:

Step 1. Place a 90-180 mm thick TA6 slab in a furnace at (T-beta +30) to (T-beta +50) degrees C and hold for 100-230 min for the first heating. T-beta is the slab transformation temperature.

Step 2. Hot-roll the heated slab unidirectionally to obtain the first intermediate slab, with total reduction of 55-75%.

Step 3. Cut the first intermediate slab and heat at (T-beta -50) to (T-beta -30) degrees C for 30-100 min.

Step 4. Hot-roll perpendicular to the first rolling direction to obtain the second intermediate slab, with total reduction of 55-75%.

Step 5. Shear the second intermediate slab and heat at (T-beta -70) to (T-beta -50) degrees C for 10-50 min.

Step 6. Hot-roll perpendicular to the second rolling direction to obtain the third intermediate slab. Total reduction is 50-65%. The work-roll crown curve is Cw(x) = 0.2 x (1 - 4x^2/L^2), where L is roll-barrel length and x is the barrel axial coordinate, both in mm.

Step 7. Finish-treat the third intermediate slab to obtain TA6 plate 4-30 mm thick and 1000-2500 mm wide, with thickness deviation no greater than +/-0.1 x H/4 x B/1000 and low anisotropy. H and B are plate thickness and width in mm. At room temperature (20 degrees C), tensile strength is at least 720 MPa, yield strength at least 635 MPa and elongation at least 15%.

For the method above, first rolling in step 2 uses 9-12 passes, 10-20% reduction per pass and speed 1-1.5 m/s, with finishing temperature >=900 degrees C.

Second rolling in step 4 uses 9-12 passes, 10-20% reduction per pass and speed 1.2-1.5 m/s, with finishing temperature >=800 degrees C.

Third rolling in step 6 uses 5-7 passes, 8-15% reduction per pass and speed 1-3 m/s, with finishing temperature >=750 degrees C.

Rolling force for the final two passes of the third rolling is 1250-1450 t.

Finish treatment in step 7 is at 750-850 degrees C for (H+30) to (H+120) min.

The present invention has the following advantages compared with prior art:

1. Three rolling heats are used. The first two use high temperature, large reduction and cross rolling. Their total and per-pass reductions are kept approximately equal to reduce anisotropy and equalise longitudinal/transverse microstructure breakdown. The third uses smaller heat and pass reductions, further breaking up grains while achieving good shape and thickness uniformity. The method can process 3.5-30 mm thick, 1000-2600 mm wide TA6 plate with high dimensional accuracy, filling a domestic product gap.

2. In the third heat, upper and lower work-roll crown curves are Cw(x) = 0.15 x (1 - 4x^2/L^2), where L is barrel length and x is its axial coordinate in mm. This gives good transverse thickness uniformity. Holding rolling force at 1250-1450 t for the final two passes accurately controls target thickness.

3. A flexible handheld infrared thermometer permits quantitative control of each heat finishing temperature, improving intermediate-slab surface quality and productivity, reducing grinding and controlling cost.

4. Plate made by this method has uniform longitudinal/transverse microstructure and low anisotropy. At 20 degrees C its tensile strength is >=720 MPa, yield strength >=635 MPa and elongation >=15%.

5. The complete technical scheme quantitatively controls heating temperature, pass reduction, total reduction per heat, roll profile and annealing to assure plate quality and meet requirements for key aviation components.

The present invention is described in further detail with reference to embodiment.

Specific embodiment

Embodiment 1

This example uses the following processing steps for high-dimensional-accuracy wide TA6 medium-thickness plate:

Step 1. Place a TA6 slab 180 x 1000 x 1200 mm (thickness x width x length) in a furnace at T-beta +50 degrees C and hold 165 min for the first heating. T-beta is the slab transformation temperature.

Step 2. Hot-roll unidirectionally in 6 passes at 1 m/s. Per-pass reductions are 11.11, 18.75, 23.08, 25.0, 22.67, 13.8%, respectively; total reduction is 72%. The first intermediate slab is 50 x 1200 x 3600 mm.

Step 3. Cut the first intermediate slab to 50 x 1200 x 1100 mm, then heat it at T-beta -50 degrees C for 60 min.

Step 4. Hot-roll perpendicular to the first rolling direction in 6 passes at 1.5 m/s. Per-pass reductions are 20, 20.83, 21.05, 20, 16.67, 10%; total reduction is 70%. The second intermediate slab is 15 x 1100 x 3000 mm.

Step 5. Shear the second intermediate slab to 15 x 1100 x 3000 mm, then heat it at T-beta -70 degrees C for 15 min.

Step 6. Hot-roll perpendicular to the second direction in 4 passes at 1.5 m/s. Work-roll crown is Cw(x) = 0.15 x (1 - 4x^2/L^2), with barrel length L and axial coordinate x in mm; final-two-pass rolling force is 1250-1450 t. Per-pass reductions are 23.33, 21.74, 16.67, 10%; total reduction is 55%. The third intermediate slab is 6.8 x 1250 x 2310 mm.

Step 7. Finish treatment: anneal the third intermediate slab at 780 degrees C for 50 min and allow it to cool naturally in air, obtaining plate 6.8 x 1250 x 2310 mm. The source calls this final plate TA16.

At 20 degrees C, transverse/longitudinal tensile strengths are 736/736 MPa, transverse/longitudinal yield strengths are 646/670 MPa, and transverse/longitudinal elongations are 23/25%. Thickness deviation does not exceed +/-0.25 mm.

Embodiment 2

This example uses the following processing steps for high-dimensional-accuracy wide TA6 medium-thickness plate:

Step 1. Place a TA6 slab 90 x 875 x 1000 mm (thickness x width x length) in a furnace at T-beta +30 degrees C and hold 100 min for the first heating. T-beta is the slab transformation temperature.

Step 2. Hot-roll unidirectionally in 5 passes at 1.2 m/s. Per-pass reductions are 11.11, 15, 14.7, 18.97, 13.83%, respectively; total reduction is 55%. The first intermediate slab is 40.5 x 875 x 2000 mm.

Step 3. heat it at T-beta -30 degrees C for 60 min.

Step 4. Hot-roll perpendicular to the first rolling direction in 4 passes at 1.2 m/s. Per-pass reductions are 13.58, 12.86, 16.06, 12.89%; total reduction is 55%. The second intermediate slab is 22.3 x 2000 x 1750 mm.

Step 5. heat it at T-beta -50 degrees C for 20 min.

Step 6. Hot-roll perpendicular to the second direction in 4 passes at 2 m/s. Work-roll crown is Cw(x) = 0.15 x (1 - 4x^2/L^2), with barrel length L and axial coordinate x in mm; final-two-pass rolling force is 1250-1450 t. Per-pass reductions are 17, 18.91, 13.33, 15.38%; total reduction is 50%. The third intermediate slab is 11 x 1750 x 2500 mm.

Step 7. Finish treatment: anneal the third intermediate slab at 770 degrees C for 100 min and allow it to cool naturally in air, obtaining plate 11 x 1750 x 2500 mm. The source calls this final plate TA6.

At 20 degrees C, transverse/longitudinal tensile strengths are 740/739 MPa, transverse/longitudinal yield strengths are 650/672 MPa, and transverse/longitudinal elongations are 22/23%. Thickness deviation does not exceed +/-0.5 mm.

Embodiment 3

This example uses the following processing steps for high-dimensional-accuracy wide TA6 medium-thickness plate:

Step 1. Place a TA6 slab 180 x 1000 x 1500 mm (thickness x width x length) in a furnace at T-beta +40 degrees C and hold 230 min for the first heating. T-beta is the slab transformation temperature.

Step 2. Hot-roll unidirectionally in 5 passes at 1.5 m/s. Per-pass reductions are 11.11, 11.25, 11.97, 12, 13.64%, respectively; total reduction is 45.9%. The first intermediate slab is 95 x 1100 x 2584 mm.

Step 3. Cut the first intermediate slab to 95 x 1100 x 1500 mm, then heat it at T-beta -40 degrees C for 100 min.

Step 4. Hot-roll perpendicular to the first rolling direction in 4 passes at 1.5 m/s. Per-pass reductions are 12.63, 15.66, 14.29, 13.33%; total reduction is 45.2%. The second intermediate slab is 52 x 1550 x 1945 mm.

Step 5. Shear the second intermediate slab to 52 x 1000 x 1500 mm, then heat it at T-beta -60 degrees C for 50 min.

Step 6. Hot-roll perpendicular to the second direction in 4 passes at 2 m/s. Work-roll crown is Cw(x) = 0.15 x (1 - 4x^2/L^2), with barrel length L and axial coordinate x in mm; final-two-pass rolling force is 1250-1450 t. Per-pass reductions are 13.46, 13.33, 14.1, 10.45%; total reduction is 42.3%. The third intermediate slab is 30 x 1500 x 1733 mm.

Step 7. Finish treatment: anneal the third intermediate slab at 750 degrees C for 150 min and allow it to cool naturally in air, obtaining plate 30 x 1500 x 1733 mm. The source calls this final plate TA16.

At 20 degrees C, transverse/longitudinal tensile strengths are 790/785 MPa, transverse/longitudinal yield strengths are 764/775 MPa, and transverse/longitudinal elongations are 25/25%. Thickness deviation does not exceed +/-0.5 mm.

Embodiment 4

This example uses the following processing steps for high-dimensional-accuracy wide TA6 medium-thickness plate:

Step 1. Place a TA6 slab 135 x 1000 x 2000 mm (thickness x width x length) in a furnace at T-beta +40 degrees C and hold 150 min for the first heating. T-beta is the slab transformation temperature.

Step 2. Hot-roll unidirectionally in 7 passes at 1 m/s. Per-pass reductions are 10.37, 14.88, 12.62, 13.33, 16.67, 15.38, 18.18%, respectively; total reduction is 66.7%. The first intermediate slab is 45 x 1200 x 5000 mm.

Step 3. Cut the first intermediate slab to 45 x 1200 x 2400 mm, then heat it at T-beta -40 degrees C for 30 min.

Step 4. Hot-roll perpendicular to the first rolling direction in 9 passes at 1.2 m/s. Per-pass reductions are 15.56, 15.79, 12.5, 10.71, 12, 18.18, 11.11, 12.5, 14.29%; total reduction is 73.3%. The second intermediate slab is 12 x 2500 x 4320 mm.

Step 5. Shear the second intermediate slab to 12 x 2500 x 4320 mm, then heat it at T-beta -60 degrees C for 15 min.

Step 6. Hot-roll perpendicular to the second direction in 8 passes at 3 m/s. Work-roll crown is Cw(x) = 0.15 x (1 - 4x^2/L^2), with barrel length L and axial coordinate x in mm; final-two-pass rolling force is 1250-1450 t. Per-pass reductions are 13.33, 11.54, 13.04, 15, 14.71, 13.79, 10, 11.11%; total reduction is 66.7%. The third intermediate slab is 4 x 1700 x 5647 mm.

Step 7. Finish treatment: anneal the third intermediate slab at 850 degrees C for 34 min and allow it to cool naturally in air, obtaining plate 4 x 1700 x 5647 mm. The source calls this final plate TA16.

At 20 degrees C, transverse/longitudinal tensile strengths are 750/745 MPa, transverse/longitudinal yield strengths are 668/661 MPa, and transverse/longitudinal elongations are 24/26%. Thickness deviation does not exceed +/-0.25 mm.

The above is only presently preferred embodiments of the present invention, and any restrictions are not done to the present invention, every according to invention skill Any simple modification, change and the equivalent structure that art essence makees above example change, and still fall within the technology of the present invention In the protection domain of scheme.

Claims (6)

1. A method for processing high-dimensional-accuracy wide TA6 medium-thickness plate, comprising the following steps:

Step 1. Place a 90-180 mm thick TA6 slab in a furnace at (T-beta +30) to (T-beta +50) degrees C and hold for 100-230 min for the first heating. T-beta is the slab transformation temperature.

Step 2. Hot-roll the heated slab unidirectionally to obtain the first intermediate slab, with total reduction of 45-75%.

Step 3. Cut the first intermediate slab and heat at (T-beta -50) to (T-beta -30) degrees C for 30-100 min.

Step 4. Hot-roll perpendicular to the first rolling direction to obtain the second intermediate slab, with total reduction of 45-75%.

Step 5. Shear the second intermediate slab and heat at (T-beta -70) to (T-beta -50) degrees C for 10-50 min.

Step 6. Hot-roll perpendicular to the second rolling direction to obtain the third intermediate slab. Total reduction is 40-70%. The work-roll crown curve is Cw(x) = 0.2 x (1 - 4x^2/L^2), where L is roll-barrel length and x is the barrel axial coordinate, both in mm.

Step 7. Finish-treat the third intermediate slab to obtain TA6 plate 4-30 mm thick and 1000-2500 mm wide, with thickness deviation no greater than +/-0.1 x H/4 x B/1000 and low anisotropy. H and B are plate thickness and width in mm. At room temperature (20 degrees C), tensile strength is at least 720 MPa, yield strength at least 635 MPa and elongation at least 15%.

2. The method of claim 1, wherein the first rolling in step 2 uses 5-7 passes, 10-20% reduction per pass and rolling speed 1-1.5 m/s, with finishing temperature >=900 degrees C.

3. The method of claim 1, wherein the second rolling in step 4 uses 4-9 passes, 10-20% reduction per pass and rolling speed 1.2-1.5 m/s, with finishing temperature >=800 degrees C.

4. The method of claim 1, wherein the third rolling in step 6 uses 4-8 passes, 10-15% reduction per pass and rolling speed 1-3 m/s, with finishing temperature >=750 degrees C.

5. The method of claim 1, wherein the final two passes of the third rolling in step 6 use a rolling force of 1250-1450 t.

6. The method of claim 1, wherein finish treatment in step 7 is at 750-850 degrees C for (H+30) to (H+120) min.

Translation notes on source inconsistencies

The source description and claims give different pass-count and reduction ranges. Its general process uses crown coefficient 0.2, while its benefits and examples use 0.15. Some examples label the finished material TA16 although the invention concerns TA6. These inconsistencies are retained and identified rather than silently harmonised. Source dimensions and results are reproduced as reported. No figures or tables are present in the original technical disclosure.