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(54) TITANIUM ALLOY FOR CORROSION-RESISTANT MATERIAL

TITANLEGIERUNG FÜR KORROSIONSBESTÄNDIGES MATERIAL

ALLIAGE DE TITANE POUR MATERIAU RESISTANT A LA CORROSION

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(73) Proprietor: **Nippon Steel & Sumitomo Metal Corporation**
Tokyo 100-8071 (JP)

(72) Inventors:
- **MATSUMOTO, Satoshi**
  Osaka-shi, Osaka 541-0041 (JP)
- **NAGASHIMA, Keisuke**
  Osaka-shi, Osaka 541-0041 (JP)
- **MAEDA, Takashi**
  Osaka-shi, Osaka 541-0041 (JP)

(74) Representative: **Jackson, Martin Peter et al**
J A Kemp
14 South Square
Gray's Inn
London WC1R 5JJ (GB)

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a titanium alloy for corrosion-resistant materials.

BACKGROUND OF THE INVENTION

[0002] Titanium forms thereon an oxidized film and therefore is not easily corroded as compared with general metals, so that it is widely used in a place requiring corrosion resistance. However, in this intended use, there is a demand for titanium having more excellent corrosion resistance, and in order to deal with it, corrosion resistance is improved hitherto by adding another element to titanium.

[0003] For example, as titanium having improved corrosion resistance, Ti-Pd alloys, which are also prescribed in JIS 11 type, 12 type and 13type, are known. These are alloys containing 0.12-0.25% by mass of Pd in pure titanium. Also, it is conventional to contain therein Co, Ni or the like other than Pd (cf. Patent Documents 1 and 2).

[0004] Meanwhile, titanium has excellent characteristics as compared with general metals, and specifically it has not only excellent corrosion resistance but also a light weight and a high strength, and therefore various alloys are used in various applications, such as sports goods such as golf clubs and bicycles. However, titanium alloys are expensive compared with general metals, and in these days, utilization of low cost, recycled titanium alloys, which are obtained by recycling not only sponge titanium produced from titanium ores, but also titanium alloys, which were once introduced into markets and had become out of use, are now being studied.

[0005] However, when even a small amount of another element is mixed in titanium for which corrosion resistance is required as mentioned above, corrosion may occur starting at such an element, and therefore recycled titanium alloys are not used for titanium alloys for corrosion-resistant materials. Furthermore, platinum group elements, such as Pd, are generally expensive compared with titanium and therefore titanium alloys for corrosion-resistant materials have been very expensive in the past.

[0006] The published japanese application JP S62 199744 A discloses a titanium alloy that contains a Pt-group metal for improved crevice corrosion resistance.

[0007] In other words, conventional titanium alloys for corrosion-resistant materials have a problem in that they cannot be produced at low cost while maintaining the capability to suppress the deterioration of corrosion resistance.

Patent Document 1: Japanese Patent No. 2132925
Patent Document 2: Japanese Patent Application Publication No. Hei-4-57735

[0008] JP-S62-199744-A discloses alloying Ti with specified amounts of a Pt group element and Nb, Zr, Hf, Ta or Bi or further adding Ni or Co and/or Mo, W or V so that the Ti alloy contains, by weight, 0.01-0.12% in total of one or more kinds of Pt group elements such as Ru, Rh, Pd, Os, Ir and Pt and 0.05-2.00% in total of one or more among Nb, Zr, Hf, Ta and Bi, or further contains 0.05-2.00% in total of Ni and/or Co and/or 0.05-1.00% in total of one or more among Mo, W and V.

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0009] In consideration of the above problems, it is an object of the present invention to provide a titanium alloy for corrosion-resistant materials that is capable of being produced at low cost while maintaining the capability to suppress the deterioration of corrosion resistance.

[0010] The present inventors intensively studied in order to solve the above problems, consequently found that it is possible to suppress the deterioration of corrosion resistance when a certain amount or less of at least one of Al, Cr, Zr, Nb, Si, Sn and Mn is contained in a titanium alloy, and thus achieved the present invention.

[0011] Specifically, according to the present invention, there is provided a titanium alloy for corrosion-resistant materials as defined in claim 1, which is characterized in that it contains 0.01-0.12% by mass in total of at least one of platinum group elements, at least one of Al, Cr, Zr, Nb, Si, Sn and Mn, with at least one of Sn or Mn being present, and the residue comprising Ti and impurities, in which the total content of Al, Cr, Zr, Nb, Si, Sn and Mn is 5% by mass or less.

[0012] By containing Al, Cr, Zr, Nb, Si, Sn and Mn in a titanium alloy is meant that Al, Cr, Zr, Nb, Si, Sn and Mn each are present in the titanium alloy in an amount exceeding the unavoidable level. The content of each of these elements can be measured by using a conventionally used analytic instrument. Usually, the contents, as the unavoidable levels, of these elements present in a titanium alloy are, at maximum, Al: 0.007% by mass, Cr: 0.007% by mass, Zr: 0.001%

by mass, Nb: 0.001% by mass, Si: 0.004% by mass, Sn: 0.001% by mass and Mn: 0.001% by mass, respectively. Accordingly, by containing Al, Cr, Zr, Nb, Si, Sn and Mn in a titanium alloy is meant in the specification of this application that these elements each are present in the titanium alloy in an amount exceeding the corresponding amount.

ADVANTAGES OF THE INVENTION

[0013] According to the present invention, Al, Cr, Zr, Nb, Si, Sn or Mn is contained in a titanium alloy for corrosion-resistant materials, so that it is possible to reuse recycled titanium alloys coming from products in which at least one of Al, Cr, Zr, Nb, Si, Sn, with at least one of Sn and Mn being present, is used. In addition, according to the present invention, 0.01-0.12% by mass in total of at least one of platinum group elements is contained in the titanium alloy for corrosion-resistant materials, and the total content of Al, Cr, Zr, Nb, Si, Sn and Mn is 5% by mass or less. Whereby, it is possible to suppress the deterioration of corrosion resistance.

[0014] In other words, it is possible to provide a titanium alloy for corrosion-resistant materials that is capable of being produced at low cost while maintaining the capability to suppress the deterioration of corrosion resistance.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0015] Now, the description will be made for a preferred embodiment of a titanium alloy for corrosion-resistant materials. First, the description will be made for the amount of each element contained in a titanium alloy for corrosion-resistant materials and the reason for determining the amount thereof.

[0016] A titanium alloy for corrosion-resistant materials of this embodiment usually contains a platinum group element, any one or both of Co and Ni, at least one of Al, Cr, Zr, Nb, Si, Sn and Mn, in which at least one of Sn and Mn is included, and the residue comprising Ti and impurities.

[0017] The platinum group element is an essential component of a titanium alloy for corrosion-resistant materials, and the content thereof is 0.01-0.12% by mass. The content of the platinum group element is 0.01-0.12% for the reason that when the platinum group element is less than 0.01% by mass, the corrosion resistance of the titanium alloy for corrosion-resistant materials does not reach a satisfactory level, which may cause corrosion, and on the other hand, even when the content thereof exceeds 0.12% by mass, it cannot be expected to have the corrosion resistance improved as the increase of the content thereof, and in addition, there is a possibility of increasing the cost of a titanium alloy for corrosion-resistant materials.

[0018] As this platinum group element, it is possible to use Ru, Rh, Pd, Os, Ir and Pt, and preferably use Pd.

[0019] Co and Ni are optional components, and the content thereof is 0.05-2.00% by mass. These may be contained in the titanium alloy for corrosion-resistant materials, in place of Ti contained in the titanium alloy as a residue of the essential components, such as the platinum group element and at least one of hereinafter described Al, Cr, Zr, Nb, Si, Sn and Mn. They are contained in the amount of 0.05-2.00% by mass, thereby producing an advantage of further improving the corrosion resistance while increasing the strength of the titanium alloy for corrosion-resistant materials. When the total amount of Co and Ni is less than 0.05% by mass, it is difficult to produce the advantage of further improving the corrosion resistance while increasing the strength of the titanium alloy.

[0020] The at least one of Al, Cr, Zr, Nb, Si, Sn and Mn, in which at least one of Sn and Mn is included, is an essential component of a titanium alloy for corrosion-resistant materials, and the total content of Al, Cr, Zr, Nb, Si, Sn and Mn is 5% by mass or less. These elements are contained in such a range for the reason that when the total content of Al, Cr, Zr, Nb, Si, Sn and Mn exceeds 5%, the corrosion resistance of the titanium alloy for corrosion-resistant materials is deteriorated, which causes corrosion. From these points of view, the total content of them is preferably 3% or less, and more preferably 2% or less.

[0021] Examples of impurities include unavoidable impurities such as C, O, H and Fe, and a small amount of another element may be contained in the titanium alloy for corrosion-resistant materials to such an extent as not to deteriorate the advantages of the present invention. Especially, V, Mo and W are known as the elements causing less influences on the corrosion resistance, and can be contained in a titanium alloy for corrosion-resistant materials as long as the total content thereof is about 5% by mass or less.

[0022] The titanium alloy for corrosion-resistant materials mentioned above is preferably used for conduits, heat exchangers, electrolysis vessels and the like of such as a nickel refining plant, which are used in environments, in which they are exposed to concentrated sulfuric acid, nickel sulfate or nickel chloride at about 250°C.

EXAMPLES

[0023] Now, the description will be made for the present invention in more detail with reference to examples without intention to limit the present invention thereto.

(Preparation of samples)

(Examples 1 to 8, Comparative Examples 1 to 11, and Reference Examples 1-21)

[0024] Titanium alloys for corrosion-resistant materials are prepared by adjusting samples for evaluation on corrosion resistance of the respective Examples, Comparative Examples and Reference Examples, using pure titanium and the respective components so as to have the components of Tables 1 and 2 contained in the amounts of Tables 1 and 2. For Comparative Example 1, pure titanium is used.

[0025] First, the titanium alloy of each composition is produced with a size having a thickness of 20 mm, a width of 70 mm and a length of 90 mm by melting through button arc melting.

[0026] Then, the thus produced pieces each are hot rolled into 3 mm thickness, and then acid-washed, thereby removing scale from the surface, and cut into a test piece having a width of 50 mm and a length of 100 mm. Then, one side of this test piece is polished with a #200 polishing sheet, while the lateral and rear sides thereof were sealed with a sealing agent, thereby allowing only the polished surface to be exposed to the surface. Thus, each sample for evaluation of corrosion resistance is prepared.

[0027] As a conventional titanium alloy for corrosion-resistant materials produced from sponge titanium or the like, a titanium alloy for corrosion resistance (Conventional Examples 1-4) containing the components shown in Table 3 are prepared and evaluated in the same manner as in Examples and Comparative Examples.

[TABLE 1]

	Components (%)*										Total **
	Pd	Co	Ni	Mn	Sn	Al	Cr	Zr	Nb	Si	
Example 1	0.05			3							3
Example 2	0.05	0.35		4							4
Example 3	0.05				3						3
Reference Example 1	0.02					3					3
Reference Example 2	0.1					3					3
Example 4	0.05	0.35		1	1						2
Example 5	0.05	0.1	0.15	3							3
Reference Example 3	0.05					0.01		0.01			0.02
Reference Example 4	0.05	0.35				0.01	0.01				0.02
Reference Example 5	0.05		0.35			0.01				0.01	0.02
Example 6	0.05	0.2	0.15		0.01	0.01					0.02
Reference Example 6	0.05					4					4
Reference Example 7	0.05						3.5				3.5
Reference Example 8	0.05	0.1	0.15					3			3
Reference Example 9	0.05					2			2		4
Reference Example 10	0.05									2	2
Reference Example 11	0.05					0.1		0.2	0.2		0.5
Reference Example 12	0.05					1					1
Example 7	0.05			1							1
Reference Example 13	0.05					0.5		0.5			1
Example 8	0.05				1	1					2
Reference Example 14	0.05						1		1		2
Reference Example 15	0.05						0.1				0.1
Reference Example 16	0.05					0.1					0.1

(continued)

	Components (%)*										Total **
	Pd	Co	Ni	Mn	Sn	Al	Cr	Zr	Nb	Si	
Reference Example 17	0.05					0.4					0.4
Reference Example 18	0.05						1				1
Reference Example 19	0.05							1			1
Reference Example 20	0.05								1.5		1.5
Reference Example 21	0.05					1			0.6		1.6
* The numerals in Table are given in percent by mass. ** The total content of Mn, Sn, Al, Cr, Zr, Nb and Si is represented.											

[TABLE2]

	Components (%)*										Total **
	Pd	Co	Ni	Mn	Sn	Al	Cr	Zr	Nb	Si	
Comparative Example 1	-										0
Comparative Example 2	0.05			6							6
Comparative Example 3	0.05		0.35	6							6
Comparative Example 4	0.05				6						6
Comparative Example 5	0.05					3			3		6
Comparative Example 6	0.05	0.1	0.2	6							6
Comparative Example 7	0.05					6			7		13
Comparative Example 8	0.05					2	5				7
Comparative Example 9	0.05							6			6
Comparative Example 10	0.05								5.5		5.5
Comparative Example 11	0.05									6	6
* The numerals in Table are given in percent by mass. ** The total content of Mn, Sn, Al, Cr, Zr, Nb and Si is represented.											

[TABLE 3]

	Components (%)*										Total **
	Pd	Co	Ni	Mn	Sn	Al	Cr	Zr	Nb	Si	
Conventional Example 1	0.05										0
Conventional Example 2	0.05	0.35									0
Conventional Example 3	0.05		0.35								0
Conventional Example 4	0.02	0.2	0.15								0
* The numerals in Table are given in percent by mass. ** The total content of Mn, Sn, Al, Cr, Zr, Nb and Si is represented.											

(Nickel-chloride-resistance test)

[0028] The samples of Examples, Comparative Examples, Reference Examples and Conventional Examples for eval-

uation on corrosion resistance each are immersed in 20% nickel chloride solution at 100°C for 100 hours, and the surface of each of the samples are observed by eyes and an optical microscope. Thus, the surface texture is evaluated. According to the result of the evaluation, it is determined as "○" for a sample in which no change is confirmed between its initial surface condition and its surface condition after the immersion in the nickel chloride solution, as "Δ" for a sample in which increase of unevenness or the like is slightly confirmed therebetween, and as "×" for a sample in which increase of unevenness or the like is apparently confirmed therebetween. The results are shown in Table 4.

[0029] The weight of each sample for evaluation of corrosion resistance is measured before and after the immersion in the nickel chloride solution by using an electronic balance that is capable of measuring the weight with the unit of 0.1 mg, and the difference thereof is calculated as a weight reduction (ΔM). The reduced amount is calculated by the following expression based on the surface area (S) of each sample for evaluation of corrosion resistance before the immersion.

$$\text{Reduced amount } (g/m^2) = \Delta M(g)/S(m^2)$$

[0030] The results are shown in Table 4.

(Heated-sulfuric-acid-resistance test)

[0031] The samples of Examples, Comparative Examples, Reference Examples_ and Conventional Examples for evaluation on corrosion resistance each are immersed in 5% sulfuric acid solution at 240°C for 1 hour, and the reduced amount is determined by calculation in the same manner as in the nickel-chloride-resistance test. The results are shown in Table 4.

(Heated-hydrochloric-acid-resistance test)

[0032] The samples of Examples, Comparative Examples, Reference Examples_ and Conventional Examples for evaluation on corrosion resistance each are immersed in boiled 10% hydrochloric acid solution for 1 hour, and the reduced amount is determined by calculation in the same manner as in the nickel-chloride-resistance test. The results are shown in Table 4.

(Clearance-corrosion-resistance test)

[0033] Two samples of each of Examples, Comparative Examples, Reference Examples and Conventional Examples are overlapped each other with the surfaces thereof facing each other, and are immersed in 20% NaCl solution at 90°C, adjusted to a pH value of 1 by hydrochloric acid, for 100 hours. Thus, the clearance-corrosion-resistance test is performed. In the same manner as in the nickel-chloride-resistance test, it is determined as "○" for a sample in which no change is confirmed between its surface conditions before and after the test, as "Δ " for a sample in which increase of unevenness or the like is slightly confirmed therebetween, and as "×" for a sample in which increase of unevenness or the like is apparently confirmed therebetween. The results are shown in Table 4.

[TABLE 4]

	Nickel-Chloride-Resistance		Heated-Sulfuric-Acid-Resistance	Heated-Hydrochloric-Acid Resistance	Clearance-Corrosion-Resistance			Nickel-Chloride-Resistance		Heated-Sulfuric-Acid-Resistance	Heated-Hydrochloric-Acid Resistance	Clearance-Corrosion-Resistance
	Surface Texture	Reduced Amount	Reduced Amount	Reduced Amount	Surface Texture			Surface Texture	Reduced Amount	Reduced Amount	Reduced Amount	Surface Texture
Ex. 1	○	<0.10	0.76	1.5	○	Com. Ex. 1		×	0.26	13.5	41.2	×
Ex. 2	○	<0.10	0.61	1.8	○	Com. Ex. 2 Ex. 2		Δ	0.14	1.01	2.5	Δ
Ex. 3	○	<0.10	0.65	1.7	○	Com. Ex. 3		Δ	0.15	1.25	3.5	Δ
Ret Ex. 1	○	0.1	0.86	1.9	○	Com. Ex. 4		Δ	0.13	1.13	3.7	Δ
Ref. Ex. 2	○	<0.10	0.35	1.1	○	Com. Ex. 5		Δ	0.14	1.01	2.5	Δ
Ex. 4	○	<0.10	0.58	1.7	○	Com. Ex. 6		Δ	0.15	1.21	3.4	Δ
Ex. 6	○	<0.10	0.58	1.6	○	Com. Ex. 7		Δ	0.25	1.81	4.2	Δ
Ref. Ex. 3	○	<0.10	0.36	1.2	○	Com. Ex. 8		Δ	0.16	1.22	2.4	Δ
Ref. Ex. 4	○	<0.10	0.42	1.3	○	Com. Ex. 9		Δ	0.15	1.1	2.2	Δ
Ref. Ex. 5	○	<0.10	0.46	1.4	○	Com. Ex. 10		Δ	0.13	1.05	2.1	Δ

(continued)

	Nickel-Chloride-Resistance		Heated-Sulfuric-Acid-Resistance	Heated-Hydrochloric-Acid Resistance	Clearance-Corrosion-Resistance		Nickel-Chloride-Resistance		Heated-Sulfuric-Acid-Resistance	Heated-Hydrochloric-Acid Resistance	Clearance-Corrosion-Resistance
	Surface Texture	Reduced Amount	Reduced Amount	Reduced Amount	Surface Texture		Surface Texture	Reduced Amount	Reduced Amount	Reduced Amount	Surface Texture
Ex. 6	○	<0.10	0.57	1.4	○	Com. Ex. 11	Δ	0.14	1.11	2.2	Δ
Ref. Ex. 6	○	<0.10	0.61	1.8	○						
Ref. Ex. 7	○	<0.10	0.62	1.7	○	Conv. Ex. 1	○	<0.10	0.36	1.2	○
Ref. Ex. 8	○	<0.10	0.54	1.3	○	Conv. Ex. 2	○	<0.10	0.42	1.3	○
Ref. Ex. 9	○	<0.10	0.7	1.8	○	Conv. Ex. 3	○	<0.10	0.46	1.4	○
Ref. Ex. 10	○	<0.10	0.51	1.5	○	Conv. Ex. 4	○	<0.10	0.57	1.4	○
Ref. Ex. 11	○	<0.10	0.58	1.3	○						
Ref. Ex. 12	○	<0.10	0.6	1.4	○						
Ex. 7	○	<0.10	0.63	1.4	○						

(continued)

	Nickel-Chloride-Resistance		Heated-Sulfuric-Acid-Resistance	Heated-Hydrochloric-Acid Resistance	Clearance-Corrosion-Resistance							
	Surface Texture	Reduced Amount	Reduced Amount	Reduced Amount	Surface Texture	Nickel-Chloride-Resistance		Heated-Sulfuric-Acid-Resistance	Heated-Hydrochloric-Acid Resistance	Clearance-Corrosion-Resistance		
						Surface Texture	Reduced Amount	Reduced Amount	Reduced Amount	Surface Texture		
Ref. Ex. 13	○	<0.10	0.65	1.4	○							
Ex. 8	○	<0.10	0.7	1.5	○							
Ref. Ex. 14	○	<0.10	0.68	1.5	○							
Ref. Ex. 15	○	<0.10	0.63	1.3	○							
Ref. Ex. 16	○	<0.10	0.63	1.3	○							
Ret Ex. 17	○	<0.10	0.65	1.3	○							
Ref. Ex. 18	○	<0.10	0.68	1.4	○							
Ref. Ex. 19	○	<0.10	0.68	1.4	○							
Ref. Ex. 20	○	<0.10	0.72	1.4	○							

(continued)

	Nickel-Chloride-Resistance		Heated-Sulfuric-Acid-Resistance	Heated-Hydrochloric-Acid Resistance	Clearance-Corrosion-Resistance		Nickel-Chloride-Resistance		Heated-Sulfuric-Acid-Resistance	Heated-Hydrochloric-Acid Resistance	Clearance-Corrosion-Resistance
	Surface Texture	Reduced Amount	Reduced Amount	Reduced Amount	Surface Texture		Surface Texture	Reduced Amount	Reduced Amount	Reduced Amount	Surface Texture
Ref. Ex. 21	○	<0.10	0.72	1.4	○						

*The "reduced amount" in each test is given in g/m^2. The "<0.10" is meant that the reduced amount is less than 0.10 g/m^2.

[0034] From Table 4, it is also appreciated that a titanium alloy for corrosion-resistant materials containing 0.01-0.12% by mass in total of at least one of platinum group elements, at least one of Al, Cr, Zr, Nb, Si, Sn and Mn, in which at least one of Sn and Mn is included, and the residue comprising Ti and impurities, in which the total content of Al, Cr, Zr, Nb, Si, Sn and Mn is 5% by mass or less, or a titanium alloy for corrosion-resistant materials containing 0.01-0.12% by mass in total of at least one of platinum group elements, 0.05-2.00% by mass in total of any one or both of Co and Ni, at least one of Al, Cr, Zr, Nb, Si, Sn and Mn, in which at least one of Sn and Mn is included, and the residue comprising Ti and impurities, in which the total content of Al, Cr, Zr, Nb, Si, Sn and Mn is 5% by mass or less, is excellent in corrosion resistance compared with the respective Comparative Examples, and has corrosion resistance equivalent to that of a conventional titanium alloy for corrosion-resistant materials using sponge titanium.

[0035] In other words, it is appreciated that the titanium alloy for corrosion-resistant materials of the present invention is capable of suppressing deterioration of corrosion resistance even though it uses recycled titanium alloys or the like, and thus being produced at low cost while maintaining the capability to suppress the deterioration of corrosion resistance.

Claims

1. A titanium alloy for corrosion-resistant materials, which is **characterized in that** it consists of 0.01-0.12% by mass in total of at least one of platinum group elements and in percent by mass at least one of Al: more than 0.007% but not more than 5%, Cr: more than 0.007% but not more than 5%, Zr: more than 0.001% but not more than 5%, Nb: more than 0.001% but not more than 5%, Si: more than 0.004% but not more than 5%, Sn: more than 0.001% but not more than 5%, Mn: more than 0.001% but not more than 5%, in which at least one of Sn and Mn is included, wherein the total content of Al, Cr, Zr, Nb, Si, Sn and Mn is 5% by mass or less, and optionally contains 0.05-2.00% by mass in total of any one or both of Co and Ni, and optionally contains one or more of V, Mo and W, wherein the total content of V, Mo and W is 5% by mass or less, and the residue consisting of Ti and impurities.

Patentansprüche

1. Titanlegierung für korrosionsbeständige Materialien, **dadurch gekennzeichnet, dass** sie insgesamt aus 0,01 - 0,12 Massenprozent von mindestens einem von Platingruppenelementen und in Massenprozent aus mindestens einem der Folgenden besteht: Al: mehr als 0,007 %, aber nicht mehr als 5 %, Cr: mehr als 0,007 %, aber nicht mehr als 5 %, Zr: mehr als 0,001 %, aber nicht mehr als 5 %, Nb: mehr als 0,001 %, aber nicht mehr als 5 %, Si: mehr als 0,004 %, aber nicht mehr als 5 %, Sn: mehr als 0,001 %, aber nicht mehr als 5 %, Mn: mehr als 0,001 %, aber nicht mehr als 5 %, wobei mindestens eines von Sn und Mn enthalten ist, wobei der Gesamtinhalt von Al, Cr, Zr, Nb, Si, Sn und Mn 5 Massenprozent oder weniger ist und optional insgesamt 0,05 - 2,00 Massenprozent von einem oder beiden von Co und Ni enthält, und optional eines oder mehrere von V, Mo und W enthält, wobei der Gesamtinhalt von V, Mo und W 5 Massenprozent oder weniger ist und der Rest aus Ti und Unreinheiten besteht.

Revendications

1. Alliage de titane pour matériaux résistants à la corrosion **caractérisé en ce qu'**il se compose de 0,01 à 0,12 % en masse au total d'au moins un élément du groupe du platine et, en pourcentage en masse, d'au moins un élément parmi Al : plus de 0,007 % sans dépasser 5 %, Cr : plus de 0,007 % sans dépasser 5 %, Zr : plus de 0,001 % sans dépasser 5 %, Nb : plus de 0,001 % sans dépasser 5 %, Si : plus de 0,004 % sans dépasser 5 %, Sn : plus de 0,001 % sans dépasser 5 %, Mn : plus de 0,001 % sans dépasser 5 %, en sachant qu'au moins un élément parmi Sn et Mn est inclus, la teneur totale en Al, Cr, Zr, Nb, Si, Sn et Mn étant de 5 % en masse ou moins, l'alliage contenant éventuellement de 0,05 à 2,00 % en masse au total de Co et/ou de Ni, et contenant éventuellement au moins un élément parmi V, Mo et W, la teneur totale en V, Mo et W étant de 5 % en masse ou moins, et le reste se composant de Ti et d'impuretés.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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