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(54) Aluminium piping material for automobile heat exchanger

(57) An aluminum piping material for an automobile heat exchanger, containing 0.05 to 0.4 mass% of Si, 0.05 to 0.4 mass% of Fe, 0.6 mass% or lower of Cu, 0.15 to 1.5 mass% of Mn, 0.05 to 0.3 mass% of Ti, and 0.05 to 0.3 mass% of V, with the balance being Al and inevitable impurities, wherein the aluminum piping material is excellent in corrosion resistance.

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to an aluminum piping material excellent in corrosion resistance suitable for piping of heat exchangers, such as automobile air-conditioners, oil coolers, radiators, and heaters.

BACKGROUND OF THE INVENTION

[0002] Heretofore, as piping materials for such heat exchangers, JIS 1000-series alloys, JIS 3000-series alloys, JIS 6000-series alloys, or the like, are used in many cases. For example, known as a JIS 6000-series alloy is an aluminum alloy excellent in intergranular corrosion resistance and pitting corrosion resistance, which comprises 0.35 to 1.5 mass% (hereafter simply referred to as %) of Mg, 0.2 to 0.8% of Si, and 0.1 to 0.3% of Zn, further comprises 0.02 to 0.1% of Sn, and 0.15 to 0.4% of Cu (e.g. see JP-B-61-36577 ("JP-B" means examined Japanese patent publication)).

[0003] With respect to a JIS 3000-series alloy, there is a disclosure of a method for producing a tube material for a heat exchanger excellent in tube formability, which comprises 0.5 to 2.0% of Mn, 0.25 to 0.75% of Cu, and further comprises one or more elements of 0.05 to 0.2% of Mg, 0.05 to 1.0% of Si, 0.5 to 1.2% of Fe, 0.05 to 0.2% of Ti, 0.05 to 0.2% of Zr, 0.05 to 0.15% of Cr, and 0.05 to 0.15% of V (e.g. JP-A-2001-26850 ("JP-A" means unexamined published Japanese patent application)). However, this material has a sheet shape, and is a type that is to be subjected to electric resistance welding (ERW or seam welding) or the like for formation of a pipe.

[0004] For an aluminum brazing sheet to be used as a tube material, there is a proposal of a material, in which an Al-Si-based alloy filler alloy is clad on one side of a core alloy, and in which a sacrificial anode alloy, such as an Al-Zn-based alloy or an Al-Zn-Mg-based alloy, is clad on the other side (e.g. JP-A-06-073480). However, sheet-shaped tube materials and piping materials are utterly different in the casting methods and production processes.

[0005] Thus, for example, JIS 3003-series alloys excellent in mechanical strength, workability, weldability, and corrosion resistance are heretofore used for automobile piping materials, but the corrosion resistance is insufficient under severe conditions. For example, perforation corrosion may occur when the alloy is used in an automobile engine room of harsh environment, or when used at high-temperature and high-humidity environments, such as in Southeast Asia. When perforation corrosion occurs even in one spot in allocated piping, the refrigerant (cooling water) in the piping will leak, resulting in that the cooling function is lost in the case of the piping in an air conditioner or that an engine is burned in the case of the piping in a radiator. Thus, from the viewpoint of corrosion resistance, not single layer materials as described above but materials in which both or either of inner and outer surfaces of a core alloy, such as a JIS 3003-based alloy, are clad with a JIS 7072-based alloy or the like are commonly used, but such materials pose a problem of high manufacturing cost.

SUMMARY OF THE INVENTION

[0006] The present invention resides in an aluminum piping material for an automobile heat exchanger, which comprises 0.05 to 0.4 mass% of Si, 0.05 to 0.4 mass% of Fe, 0.6 mass% or lower of Cu, 0.15 to 1.5 mass% of Mn, 0.05 to 0.3 mass% of Ti, and 0.05 to 0.3 mass% of V, with the balance being Al and inevitable impurities, wherein the aluminum piping material is excellent in corrosion resistance.

[0007] Further, the present invention resides in an aluminum piping material for an automobile heat exchanger, which comprises 0.05 to 0.4 mass% of Si, 0.05 to 0.4 mass% of Fe, 0.6 mass% or lower of Cu, 0.15 to 1.5 mass% of Mn, 0.05 to 0.3 mass% of Ti, 0.05 to 0.3 mass% of V, and at least one selected from the group consisting of 0.05 to 0.4 mass% of Mg, 0.05 to 0.2 mass% of Cr, and 0.05 to 0.2 mass% of Zr, with the balance being Al and inevitable impurities, wherein the aluminum piping material is excellent in corrosion resistance.

[0008] Further, the present invention resides in an aluminum piping material for an automobile heat exchanger, which is produced by: subjecting an aluminum alloy ingot having any one of the above-mentioned compositions to hot extrusion, to form a raw pipe for extrusion; and subjecting the resultant raw pipe to drawbench drawing or continuous drawing, to form said aluminum piping material, wherein the aluminum piping material is excellent in corrosion resistance.

[0009] Other and further features and advantages of the invention will appear more fully from the following description.

DETAILED DESCRIPTION OF THE INVENTION

[0010] The inventors of the present invention, having conducted intensive study to solve the above-mentioned problems in the conventional technique, found that corrosion resistance is remarkably improved by adding both of Ti and V to an Al-Mn-based alloy. The present invention has been attained based on this finding.

[0011] According to the present invention, there is provided the following means:

(1) An aluminum piping material for an automobile heat exchanger, comprising 0.05 to 0.4 mass% of Si, 0.05 to 0.4 mass% of Fe, 0.6 mass% or lower of Cu, 0.15 to 1.5 mass% of Mn, 0.05 to 0.3 mass% of Ti, and 0.05 to 0.3 mass% of V, with the balance being Al and inevitable impurities, wherein the aluminum piping material is excellent in corrosion resistance;

(2) An aluminum piping material for an automobile heat exchanger, comprising 0.05 to 0.4 mass% of Si, 0.05 to 0.4 mass% of Fe, 0.6 mass% or lower of Cu, 0.15 to 1.5 mass% of Mn, 0.05 to 0.3 mass% of Ti, 0.05 to 0.3 mass% of V, and at least one selected from the group consisting of 0.05 to 0.4 mass% of Mg, 0.05 to 0.2 mass% of Cr, and 0.05 to 0.2 mass% of Zr, with the balance being Al and inevitable impurities, wherein the aluminum piping material is excellent in corrosion resistance;

(3) The aluminum piping material for an automobile heat exchanger according to Item (1) or (2), wherein the Cu content is 0.05 mass% or lower; and

(4) An aluminum piping material for an automobile heat exchanger, which is produced by: subjecting an aluminum alloy ingot having a composition according to any one of Items (1) to (3) to hot extrusion, to form a raw pipe for extrusion; and subjecting the resultant raw pipe to drawbench drawing or continuous drawing, to form said aluminum piping material, wherein the aluminum piping material is excellent in corrosion resistance.

[0012] Hereinafter, the present invention will be described in detail.

[0013] First, alloying elements of an aluminum alloy forming the aluminum piping material of the present invention will be described.

[0014] In the present invention, Si is an essential alloying element, and the Si content is 0.05 to 0.4 mass% (hereinafter simply referred to as %). Si has an effect of enhancing the mechanical strength after brazing, by forming a solid solution in a matrix of the aluminum alloy structure and/or by forming an Al-Mn-Si-series compound, and thus Si is an essential alloying element. To achieve this effect, the Si content needs to be 0.05% or more. When the content exceeds the upper limit, corrosion resistance and extrusion property (the life of a dice to be used) will be lowered. Thus, the upper limit of the Si content is set to 0.4%. The Si content is more preferably 0.05 to 0.2%.

[0015] In the present invention, Fe is an essential alloying element, and the Fe content is 0.05 to 0.4%. Fe has an effect of enhancing the mechanical strength, by being crystallized or precipitated as an Al-Fe-series intermetallic compound. To achieve this effect, the Fe content needs to be 0.05% or more. However, when Fe is excessively contained, the excessive Fe or compound therefrom is crystallized on the surface, to increase a corrosion speed. Thus, the upper limit of the Fe content is set to 0.4%. The Fe content is more preferably 0.05 to 0.2%.

[0016] In the present invention, the Cu content is 0.6% or lower, and Cu is an optional element that may not be added (i.e. the Cu content may be 0%) or may be added, if required. Cu has an effect of enhancing the mechanical strength, by forming a solid solution. To achieve this effect, Cu may be added up to the upper limit of 0.06%, as needed. However, when the Cu content exceeds the upper limit, the corrosion resistance is conspicuously lowered. When corrosion resistance is regarded as the most important property among various properties, it is more preferable to adjust the Cu content to 0.05% or lower.

[0017] The Mn content is 0.15 to 1.5%, and Mn is an essential alloying element in the present invention. Mn is added in an amount of 0.15 to 1.5% so as to enhance the mechanical strength. When the Mn content is 0.15% or lower, the effect is not sufficiently exhibited, and when the Mn content exceeds 1.5%, extrusion property and drawing workability are lowered. The Mn content is more preferably 0.8 to 1.2%.

[0018] Each of the Ti and V contents is 0.05 to 0.3%, and Ti and V are essential alloying elements in the present invention. Ti and V have an effect of further improving the corrosion resistance. More specifically, Ti and V each are separated into a high concentration region and a low concentration region, to alternately disperse those regions in the direction of the sheet thickness to form layers. Then, the region having low Ti and V concentrations preferentially corrodes as compared with the region having high Ti and V concentrations, to form a layered corrosion state. This prevents corrosion from progressing in the thickness direction, to thereby improve the resistance to pitting corrosion. By adding both of Ti and V, this effect is exhibited more notably.

[0019] Further, Ti and V can also contribute to enhancement of the mechanical strength, and further higher effects can be obtained by adding a combination of Ti and V. To sufficiently obtain these effects, Ti and V each need to be contained in an amount of 0.05% or more. When each content exceeds 0.3% (upper limit), a giant or coarse intermetallic compound is generated at the time of casting, which may adversely affect the extrusion property and/or drawing workability. The Ti and V contents each are more preferably 0.1 to 0.2%.

[0020] In the present invention, addition may be optionally made of at least one element selected from 0.05 to 0.4% of Mg, 0.05 to 0.2% of Cr, and 0.05 to 0.2% of Zr. These alloying elements contribute to improvement in the mechanical strength of the alloy, by forming a solid solution or a dispersion as minute intermetallic compounds upon homogenization. Therefore, at least one alloying element is contained, if desired. To sufficiently obtain the above-mentioned functions, the content of each element is preferably 0.05% or more. When the alloying elements are excessively contained, the extrusion property and/or drawing workability are lowered. Thus, the upper limit of each alloying element is defined as mentioned above. It is more preferable that the Mg content be 0.15 to 0.3%, and that the Cr and Zr contents each be 0.05 to 0.15%.

[0021] The aluminum alloy piping materials of the present invention for automobile heat exchangers can be produced, by processing the aluminum alloy having the aforementioned composition, according to the following procedure.

[0022] The aluminum alloy for use in the present invention can be produced by melting (to give an ingot) in a usual manner in which the target is set to have the above-mentioned alloying elements, and there is no particular limitation on the production method for the aluminum alloy. When a raw pipe for extrusion is produced using the thus-obtained alloy, it is preferable to subject the aluminum alloy (ingot) to homogenization.

[0023] The homogenization is conducted, by maintaining the aluminum alloy under the conditions in a usual manner of, for example, at 550 to 620°C, preferably 590 to 620°C, for 1 to 10 hours, preferably 2 to 4 hours, in a process of precipitating dispersed particles composed of Si, Mn, or the like, into a matrix uniformly with a high density. Then, the resultant alloy is heated to 450 to 550°C at least before extrusion, and subjected to soaking, followed by hot extrusion. There is no particular limitation on heating methods, heating furnaces, etc., for use in the above-mentioned homogenization and soaking processes.

[0024] The thus-obtained raw pipe for extrusion is then drawn by drawbench drawing or continuous drawing, followed by working to a product size. Then, the resultant is annealed, for example, by maintaining it at 300 to 520°C for 1 to 10 hours, to give a final product.

[0025] The above-mentioned extruded materials are to be used as heat exchanger materials, and may be usually used for piping materials for circulating a heating medium and/or piping materials for circulating water in a radiator, a heater core, or the like. Further, the heat exchangers may be used at any places or sites, without particular limitation.

[0026] According to the present invention, there can be developed an aluminum alloy material whose corrosion resistance is higher than that of JIS 3003 alloy in a single layered form, without cladding, and can be provided an excellent aluminum piping material for an automobile heat exchanger.

[0027] Further, according to the present invention, heat exchanger piping materials having excellent corrosion resistance can be obtained, even if the aluminum alloy piping materials for automobile heat exchangers are not clad materials but single-layer bear materials. Furthermore, according to the present invention, it is possible to eliminate the necessity of forming pipes from a sheet material with electric resistance welding or the like; to provide aluminum alloy piping materials capable of being worked by simple extrusion and drawing; and to reduce the production cost of the resultant heat exchangers. Thus, the present invention exhibits industrially remarkable effects.

[0028] The present invention will be described in more detail based on the following examples, but the invention is not intended to be limited thereto.

EXAMPLES

(Example 1)

[0029] An Al alloy having the composition, of a number shown in Table 1 (numeric values represent mass%), was molten, and cast, to produce a billet of diameter 219 mm. This billet was maintained at 610°C for 4 hours for homogenization. The resultant billet was cut to a length of 300 mm, to give a billet for extrusion. This billet for extrusion was heated again at 450 to 500°C. Then, the thus-heated billet was extruded with a mandrel dice, to give a raw pipe of outer diameter ϕ 36 mm and thickness 3 mm. Then, cold-continuous drawing was conducted to the raw pipe at plurality times, to attain the final size of outer diameter ϕ 17 mm and thickness 1 mm, to thereby obtain a pipe material. Then, the pipe material was maintained at 360°C for 2 hours for annealing, and allowed to cool, to obtain a sample of the number shown in Table 1.

[0030] The conventional example No. 1 is JIS 3003 alloy.

[0031] To evaluate the internal corrosion resistance of these samples, the piping of any one of samples was connected to a commercially available aqueous coolant using a cyclic tester. Then, a cycle test in which the samples were maintained at 88°C for 8 hours and then at room temperature for 16 hours was performed for one year. Surface corrosion products of each sample were removed, and the corrosion state of each sample was evaluated. Evaluation was made, by measuring the maximum pitting corrosion depth by a method using depth of focus with an optical microscope. The results are shown in Table 1.

[0032] Tensile strength was evaluated, by cutting the piping of each sample to form a JIS No. 11 test piece while keeping a circular shape, and a test was conducted at tensile speed 10 mm/min, according to JIS H4080.

Table 1

Categories	No	Si	Fe	Cu	Mn	Ti	V	Mg	Cr	Zr	Al	Tensile strength (MPa)	Maximum pitting corrosion depth after internal cyclic test (μm)	Extrusion property and drawing property
This invention	1	0.05	0.05	0.4	0.15	0.05	0.05	-	-	-	Balance	94	245	Good
	2	0.05	0.05	0.02	0.15	0.3	0.3	-	-	-	Balance	100	102	Good
	3	0.05	0.05	0.02	1.1	0.3	0.3	-	-	-	Balance	133	109	Good
	4	0.05	0.05	0.02	1.1	0.05	0.05	-	-	-	Balance	120	144	Good
	5	0.05	0.05	0.02	1.1	0.05	0.3	-	-	-	Balance	124	129	Good
	6	0.05	0.05	0.02	1.1	0.3	0.05	-	-	-	Balance	115	131	Good
	7	0.05	0.05	0.02	0.7	0.15	0.15	-	-	-	Balance	110	184	Good
	8	0.05	0.05	0.02	0.7	0.15	0.05	-	-	-	Balance	106	141	Good
	9	0.05	0.2	0.2	0.7	0.2	0.2	-	-	-	Balance	119	180	Good
	10	0.05	0.4	0.6	1.5	0.2	0.2	-	-	-	Balance	150	327	Good
	11	0.2	0.05	0.01	0.5	0.15	0.15	-	-	-	Balance	108	118	Good
	12	0.2	0.2	0.1	1.1	0.2	0.2	-	-	-	Balance	124	148	Good
	13	0.2	0.3	0.2	1.1	0.05	0.3	-	-	-	Balance	129	155	Good
	14	0.2	0.3	0.2	0.5	0.3	0.05	-	-	-	Balance	119	147	Good
	15	0.2	0.3	0.2	0.7	0.3	0.3	-	-	-	Balance	150	137	Good
	16	0.4	0.05	0.02	0.15	0.15	0.15	-	-	-	Balance	90	114	Good
	17	0.4	0.2	0.3	1.1	0.25	0.05	-	-	-	Balance	138	265	Good
	18	0.4	0.2	0.6	1.1	0.3	0.3	-	-	-	Balance	159	271	Good
	19	0.4	0.4	0.6	1.5	0.3	0.3	-	-	-	Balance	168	286	Good
	20	0.2	0.2	0.1	1.1	0.2	0.2	0.2	-	-	Balance	139	182	Good
	21	0.2	0.2	0.1	1.1	0.2	0.2	-	0.2	-	Balance	135	140	Good
	22	0.2	0.2	0.1	1.1	0.2	0.2	-	-	0.2	Balance	131	164	Good

(continued)

Categories	No	Si	Fe	Cu	Mn	Ti	V	Mg	Cr	Zr	Al	Tensile strength (MPa)	Maximum pitting corrosion depth after internal cyclic test (μm)	Extrusion property and drawing property
Comparative example	1	0.2	0.2	0.2	1.1	0.35	0.35	-	-	-	Balance	-	-	Impossible to extrude and draw
	2	0.2	0.2	0.2	1.6	0.05	0.05	-	-	-	Balance	-	-	Impossible to extrude and draw
	3	0.5	0.5	0.2	1.1	0.04	0.04	-	-	-	Balance	123	617	Good
	4	0.2	0.2	0.7	1.1	0.05	0.05	-	-	-	Balance	149	727	Good
	5	0.2	0.5	0.2	1.1	0.05	0.05	-	-	-	Balance	121	596	Good
	6	0.5	0.2	0.3	1.1	0.05	0.05	-	-	-	Balance	130	592	Poor extrusion property
Conventional example	1	0.1	0.45	0.1	1.0	-	-	-	-	-	Balance	110	580	Good

[0033] As is apparent from the results shown in Table 1, the Ti, V, and Mn alloying elements of the samples of Comparative examples 1 and 2 each were outside the range defined in the present invention, and it was impossible to subject those samples for comparison to extrusion and/or drawing, and no product was obtained. The Ti and V contents of the sample of Comparative example 3 were less than the range defined in the present invention, and the corrosion resistance of the sample for comparison was not improved and was inferior to that of the conventional example. The Cu and Fe contents of the samples of Comparative examples 4 and 5 each exceeded the range defined in the present invention, and the corrosion resistance of the samples for comparison was inferior to that of the conventional example. The Si content of the sample of Comparative example 6 exceeded the range defined in the present invention, and the corrosion resistance of the sample for comparison was inferior to that of the conventional example and the extrusion property was poor.

[0034] Contrary to the above, it is found that the examples according to the present invention were extremely excellent in the corrosion resistance inside the piping, as compared with that of the comparative examples and conventional example.

[0035] Further, it is also found that the tensile strength of each example according to the present invention was at least substantially equivalent to or much higher than that of the conventional example.

(Example 2)

[0036] An Al alloy having the composition, of a number shown in Table 2 (numeric values represent mass%), was molten, and cast, to produce a billet of diameter 219 mm. This billet was maintained at 610°C for 4 hours for homogenization. The resultant billet was cut to a length of 300 mm, to give a billet for extrusion. This billet for extrusion was heated again at 450 to 500°C. Then, the thus-heated billet was extruded with a mandrel dice, to give a raw pipe of outer diameter ϕ 36 mm and thickness 3 mm. Then, cold-continuous drawing was conducted to the raw pipe at plurality times, to attain the final size of outer diameter ϕ 17 mm and thickness 1 mm, to thereby obtain a pipe material. Then, the pipe material was maintained at 360°C for 2 hours for annealing, and allowed to cool, to obtain a sample of the number shown in Table 2.

[0037] To evaluate the external corrosion resistance of these samples, each sample was subjected to a CASS test, according to JIS H8601, for 1,500 hours. After the test, surface corrosion products of each sample were removed, and the corrosion state of each sample was evaluated. Evaluation was made, by measuring the maximum pitting corrosion depth by a method using depth of focus with an optical microscope. The results are shown in Table 2.

[0038] Tensile strength was evaluated, by producing test samples in the same manner as in Example 1, and examining under the same conditions as in Example 1, according to JIS H4080.

Table 2

Categories	No	Si	Fe	Cu	Mn	Ti	V	Mg	Cr	Zr	Al	Tensile strength (MPa)	Maximum pitting corrosion depth after CASS test (μm)	Extrusion property and drawing property
This invention	1	0.05	0.05	0.4	0.15	0.05	0.05	-	-	-	Balance	94	300	Good
	2	0.05	0.05	0.02	0.15	0.3	0.3	-	-	-	Balance	100	125	Good
	3	0.05	0.05	0.02	1.1	0.3	0.3	-	-	-	Balance	133	133	Good
	4	0.05	0.05	0.02	1.1	0.05	0.05	-	-	-	Balance	120	176	Good
	5	0.05	0.05	0.02	1.1	0.05	0.3	-	-	-	Balance	124	158	Good
	6	0.05	0.05	0.02	1.1	0.3	0.05	-	-	-	Balance	115	160	Good
	7	0.05	0.05	0.02	0.7	0.15	0.15	-	-	-	Balance	110	150	Good
	8	0.05	0.05	0.02	0.7	0.15	0.05	-	-	-	Balance	106	172	Good
	9	0.05	0.2	0.2	0.7	0.2	0.2	-	-	-	Balance	119	220	Good
	10	0.05	0.4	0.6	1.5	0.2	0.2	-	-	-	Balance	150	400	Good
	11	0.2	0.05	0.01	0.5	0.15	0.15	-	-	-	Balance	108	145	Good
	12	0.2	0.2	0.1	1.1	0.2	0.2	-	-	-	Balance	124	181	Good
	13	0.2	0.3	0.2	1.1	0.05	0.3	-	-	-	Balance	129	190	Good
	14	0.2	0.3	0.2	0.5	0.3	0.05	-	-	-	Balance	119	180	Good
	15	0.2	0.3	0.2	0.7	0.3	0.3	-	-	-	Balance	150	168	Good
	16	0.4	0.05	0.02	0.15	0.15	0.15	-	-	-	Balance	90	140	Good
	17	0.4	0.2	0.3	1.1	0.25	0.05	-	-	-	Balance	138	325	Good
	18	0.4	0.2	0.6	1.1	0.3	0.3	-	-	-	Balance	159	332	Good
	19	0.4	0.4	0.6	1.5	0.3	0.3	-	-	-	Balance	168	350	Good
	20	0.2	0.2	0.1	1.1	0.2	0.2	0.2	-	-	Balance	139	223	Good
	21	0.2	0.2	0.1	1.1	0.2	0.2	-	0.2	-	Balance	135	171	Good
	22	0.2	0.2	0.1	1.1	0.2	0.2	-	-	0.2	Balance	131	201	Good

(continued)

Categories	No	Si	Fe	Cu	Mn	Ti	V	Mg	Cr	Zr	Al	Tensile strength (MPa)	Maximum pitting corrosion depth after CASS test (μm)	Extrusion property and drawing property
Comparative example	1	0.2	0.2	0.2	1.1	0.35	0.35	-	-	-	Balance	-	-	Impossible to extrude and draw
	2	0.2	0.2	0.2	1.6	0.05	0.05	-	-	-	Balance	-	-	Impossible to extrude and draw
	3	0.5	0.5	0.2	1.1	0.04	0.04	-	-	-	Balance	123	755	Good
	4	0.2	0.2	0.7	1.1	0.05	0.05	-	-	-	Balance	149	890	Good
	5	0.2	0.5	0.2	1.1	0.05	0.05	-	-	-	Balance	121	730	Good
	6	0.5	0.2	0.3	1.1	0.05	0.05	-	-	-	Balance	130	725	Poor extrusion property
Conventional example	1	0.1	0.45	0.1	1.0	-	-	-	-	-	Balance	110	710	Good

[0039] As is apparent from the results shown in Table 2, the Ti, V, and Mn alloying elements of the samples of Comparative examples 1 and 2 each were outside the range defined in the present invention, and it was impossible to subject those samples for comparison to extrusion and/or drawing, and no product was obtained. The Ti and V contents of the sample of Comparative example 3 were less than the range defined in the present invention, and the corrosion resistance of the sample for comparison was not improved and was inferior to that of the conventional example. The Cu and Fe contents of the samples of Comparative examples 4 and 5 each exceeded the range defined in the present invention, and the corrosion resistance of the samples for comparison was inferior to that of the conventional example. The Si content of the sample of Comparative example 6 exceeded the range defined in the present invention, and the corrosion resistance of the sample for comparison was inferior to that of the conventional example and the extrusion property was poor.

[0040] Contrary to the above, it is found that the examples according to the present invention were extremely excellent in the corrosion resistance outside the piping, as compared with that of the comparative examples and conventional example. Further, it is also found that the tensile strength of each example according to the present invention was at least substantially equivalent to or much higher than that of the conventional example.

[0041] Having described our invention as related to the present embodiments, it is our intention that the invention not be limited by any of the details of the description, unless otherwise specified, but rather be construed broadly within its spirit and scope as set out in the accompanying claims.

[0042] This non-provisional application claims priority under 35 U.S.C. § 119 (a) on Patent Application No. 2006-228383 filed in Japan on August 24, 2006, which is entirely herein incorporated by reference.

Claims

1. An aluminum piping material for an automobile heat exchanger, comprising 0.05 to 0.4 mass% of Si, 0.05 to 0.4 mass% of Fe, 0.6 mass% or lower of Cu, 0.15 to 1.5 mass% of Mn, 0.05 to 0.3 mass% of Ti, and 0.05 to 0.3 mass% of V, with the balance being Al and inevitable impurities,
wherein the aluminum piping material is excellent in corrosion resistance.

2. An aluminum piping material for an automobile heat exchanger, comprising 0.05 to 0.4 mass% of Si, 0.05 to 0.4 mass% of Fe, 0.6 mass% or lower of Cu, 0.15 to 1.5 mass% of Mn, 0.05 to 0.3 mass% of Ti, 0.05 to 0.3 mass% of V, and at least one selected from the group consisting of 0.05 to 0.4 mass% of Mg, 0.05 to 0.2 mass% of Cr, and 0.05 to 0.2 mass% of Zr, with the balance being Al and inevitable impurities,
wherein the aluminum piping material is excellent in corrosion resistance.

3. The aluminum piping material for an automobile heat exchanger according to Claim 1 or 2, wherein the Cu content is 0.05 mass% or lower.

4. An aluminum piping material for an automobile heat exchanger, which is produced by:

subjecting an aluminum alloy ingot having a composition according to any one of Claims 1 to 3 to hot extrusion, to form a raw pipe for extrusion; and
subjecting the resultant raw pipe to drawbench drawing or continuous drawing, to form said aluminum piping material,

wherein the aluminum piping material is excellent in corrosion resistance.

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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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