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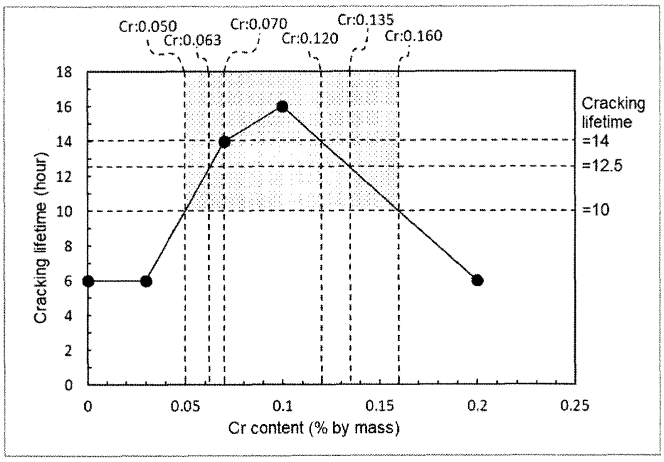
(54) ALUMINUM ALLOY EXTRUDED MATERIAL AND METHOD FOR MANUFACTURING SAME

(57) Disclosed is an aluminum alloy extruded material having a composition including: Zn: 3.0 to 6.0% by mass, Mg: 0.4 to 1.4% by mass, Fe: 0.05 to 0.2% by mass, Cu: 0.05 to 0.4% by mass, Ti: 0.005 to 0.2% by mass, Zr: 0.1 to 0.3% by mass, and Cr: 0.050 to 0.160% by mass, with the balance being Al and inevitable impurities, wherein a conductivity is 40.1 to 44.3%IACS.

FIG. 2



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Description

Technical Field

[0001] The present disclosure relates to an aluminum alloy extruded material, and a method for manufacturing the same.

Background Art

[0002] Conventionally, 6000-series aluminum alloy extruded materials with high strength have been mainly used for aluminum members used as frame members. However, the 6000-series aluminum alloy has high quenching sensitivity, and is liable to have strain due to quenching, so that it is difficult to use the 6000-series aluminum alloy for members requiring high accuracy. In view of the above, although 7000-series aluminum alloys have the problem of stress-corrosion cracking, an attempt has been made to use the 7000-series aluminum alloys with low quenching sensitivity for frame members.

[0003] Patent Document 1 discloses an Al-Zn-Mg-based alloy extruded material (that is, a 7000-series aluminum alloy extruded material) in which the composition and the like of the alloy are controlled to improve stress-corrosion cracking resistance and other characteristics of a T6 treated material. Specifically, Patent Document 1 discloses an alloy extruded material in which cracking does not occur even when a stress of 95% of yield strength is applied to the alloy extruded material by three-point bending and, thereafter, the alloy extruded material is held in a boiling chromic acid solution for 12 hours.

Conventional Art Document

Patent Document

[0004] Patent Document 1: JP H10-30147 A

Disclosure of the Invention

Problems to be Solved by the Invention

[0005] However, it was found that, in the conventional technique as disclosed in Patent Document 1, when a higher stress (100% of yield strength) is applied to the alloy extruded material by three-point bending and, thereafter, the alloy extruded material is held in a boiling chromic acid solution for 10 hours or more, cracking may occur. Accordingly, it was found that there is room for further improvement of stress-corrosion cracking resistance.

[0006] The present disclosure has been made in view of such circumstances and has an object to provide an aluminum alloy extruded material with improved stress-corrosion cracking resistance and to provide a method for manufacturing the same.

Means for Solving the Problems

[0007] A first aspect of the prevent invention is directed to an aluminum alloy extruded material having a composition including:

Zn: 3.0 to 6.0% by mass,

Mg: 0.4 to 1.4% by mass,

Fe: 0.05 to 0.2% by mass,

Cu: 0.05 to 0.4% by mass,

Ti: 0.005 to 0.2% by mass,

Zr: 0.1 to 0.3% by mass, and

Cr: 0.050 to 0.160% by mass,

with the balance being Al and inevitable impurities,

wherein a conductivity is 40.1 to 44.3%IACS.

[0008] A second aspect of the prevent invention is directed to the aluminum alloy extruded material according to the first aspect, wherein
the content of the Cr is 0.070 to 0.120% by mass.

[0009] A third aspect of the prevent invention is directed to a method for manufacturing the aluminum alloy extruded material according to the first aspect or the second aspect, the method including the steps of:

preparing a billet having a composition including:

Zn: 3.0 to 6.0% by mass,

Mg: 0.4 to 1.4% by mass,

Fe: 0.05 to 0.2% by mass,

Cu: 0.05 to 0.4% by mass,

Ti: 0.005 to 0.2% by mass,

Zr: 0.1 to 0.3% by mass, and

Cr: 0.05 to 0.15% by mass,

with the balance being Al and inevitable impurities;

heating the billet to 450 to 550°C;

cooling the heated billet to 300°C or lower at an average cooling rate of 90°C/hour or more;

reheating the cooled billet to 470°C or higher to perform extrusion; and

quenching the extruded billet.

Effects of the Invention

[0010] According to the embodiments of the present invention, it is possible to provide an aluminum alloy extruded material with improved stress-corrosion cracking resistance, and a method for manufacturing the same.

Brief Description of the Drawings

[0011]

FIG. 1 is a graph showing the relationship of conductivity to Cr content in the case where an aluminum alloy extruded material is manufactured by a manufacturing method which will be described later.

FIG. 2 is a graph showing the relationship of cracking lifetime in a stress-corrosion cracking resistance test to Cr content in the case where the aluminum alloy extruded material is manufactured by the manufacturing method which will be described later.

FIG. 3 is a graph schematically showing one example of temperature history in a method for manufacturing the aluminum alloy extruded material according to the embodiments of the present invention.

Mode for Carrying Out the Invention

[0012] The inventors have studied aluminum alloy extruded materials from various angles in order to realize an aluminum alloy extruded material with improved stress-corrosion cracking resistance. As a result, the inventors have found that the aluminum alloy extruded material with improved stress-corrosion cracking resistance can be realized by necessarily including Zn, Mg, Fe, Cu, Ti, Zr, and Cr, by controlling the contents of Zn, Mg, Fe, Cu, Ti, Zr, and Cr (particularly, the Cr content) to predetermined ranges, and by controlling conductivity to a predetermined range. The inventors have also simultaneously found that, in order to control conductivity to the predetermined range, it is necessary to control the composition (particularly, the Cr content), and it is also necessary to appropriately control manufacturing conditions (particularly, a billet heating temperature, a cooling rate, a reheating temperature, and the like).

[0013] Hereinafter, respective requirements specified in the embodiments of the present invention will be described in detail.

<1. Composition>

[0014] In an aluminum alloy extruded material according to the embodiments of the present invention, it is preferable that a composition include Zn: 3.0 to 6.0% by mass, Mg: 0.4 to 1.4% by mass, Fe: 0.05 to 0.2% by mass, Cu: 0.05 to 0.4% by mass, Ti: 0.005 to 0.2% by mass, Zr: 0.1 to 0.3% by mass, Cr: 0.050 to 0.160% by mass, with the balance being aluminum and inevitable impurities.

[0015] Hereinafter, respective elements will be described in detail.

(Zn: 3.0 to 6.0% by mass)

[0016] Zn is an element that increases strength of the aluminum alloy extruded material together with Mg. In order to sufficiently exhibit such an effect, the Zn content is set at 3.0% by mass or more. In contrast, when the Zn content is more than 6.0% by mass, stress-corrosion cracking resistance and general corrosion resistance are reduced. Thus, the Zn content is set at 3.0 to 6.0% by mass.

(Mg: 0.4 to 1.4% by mass)

[0017] Mg is an element that increases strength of the aluminum alloy extruded material together with Zn. To sufficiently exhibit such an effect, the Mg content is set at 0.4% by mass or more. In contrast, when the Mg content is more than 1.4% by mass, extrudability is reduced with an increase in extrusion pressure, and elongation is also reduced. Thus, the Mg content is set at 0.4 to 1.4% by mass.

(Fe: 0.05 to 0.2% by mass)

[0018] Fe is a main inevitable impurity of an aluminum alloy. In order to prevent a reduction in properties of the aluminum alloy extruded material, the Fe content is set at 0.2% by mass or less. In contrast, when the Fe content in the aluminum alloy extruded material is reduced to less than 0.05% by mass, a heavy burden is posed from the viewpoint of cost. Thus, the Fe content is set at 0.05 to 0.2% by mass.

(Cu: 0.05 to 0.4% by mass)

[0019] Cu is an element that increases strength of the aluminum alloy extruded material. When the Cu content is less than 0.05% by mass, a sufficient effect of increasing strength cannot be ensured. In contrast, the Cu content of more than 0.4% by mass leads to a reduction in extrudability. Thus, the Cu content is set at 0.05 to 0.4% by mass. From the viewpoint of extrudability, the upper limit value of the Cu content is preferably set at 0.2% by mass.

(Ti: 0.005 to 0.2% by mass)

[0020] Ti has the effect of increasing formability of an extruded material, so that Ti is added at a content of 0.005% by mass or more. However, when the Ti content is more than 0.2% by mass, such an effect saturates, and a coarse intermetallic compound is crystallized, thus forming an origin of fracture and hence, mechanical properties are reduced. Thus, the Ti content is set at 0.005 to 0.2% by mass, is preferably set at 0.005 to 0.1% by mass, and is more preferably set at 0.005 to 0.05% by mass.

(Zr: 0.1 to 0.3% by mass)

[0021] Zr has the effect of suppressing recrystallization of the aluminum alloy extruded material, thus increasing stress-corrosion cracking resistance. When the Zr content is less than 0.1% by mass, the above effect cannot be sufficiently ensured. In contrast, when the Zr content is more than 0.3% by mass, extrudability is reduced, and quenching sensitivity is increased, leading to a reduction in strength. Thus, the Zr content is set at 0.1 to 0.3% by mass.

(Cr: 0.050 to 0.160% by mass)

[0022] The inventors have found that, when the aluminum alloy extruded material is manufactured by a manufacturing method which will be described later, Cr content is closely correlated to stress-corrosion cracking resistance. When the Cr content is less than 0.050% by mass, stress-corrosion cracking resistance is reduced. The Cr content is preferably set at 0.063% by mass or more, and is more preferably set at 0.070% by mass or more. In contrast, when the Cr content is more than 0.160% by mass, an intermetallic compound of Cr starts to precipitate and hence, stress-corrosion cracking resistance is reduced. The Cr content is preferably set at 0.135% by mass or less, and is more preferably set at 0.120% by mass or less.

[0023] It is preferable that the aluminum alloy extruded material according to the embodiments of the present invention has the above-mentioned composition and, in one embodiment of the present invention, the balance being aluminum and inevitable impurities. As inevitable impurities, elements brought in due to conditions of raw materials, materials, manufacturing facilities, and the like are permitted to be mixed in the aluminum alloy extruded material. For example, there are elements, such as Fe, which are usually preferred in smaller contents and are therefore inevitable impurities, but whose composition range is separately specified above. For this reason, the term "inevitable impurities" herein is based on the concept that an element whose composition range is individually specified is excluded.

[0024] Examples of inevitable impurities include Mn and Si, and it is preferable that the content of each inevitable impurity be set at 0.05% by mass or less. Further, it is preferable to set the total amount of the inevitable impurities to 0.20% by mass or less.

[0025] In the aluminum alloy extruded material according to the embodiments of the present invention, it is preferable to set a ratio of the Zn content to the Mg content (hereinafter also referred to as "Zn/Mg mass ratio") to 2.92 to 9.12. This setting enables yield strength to be increased to 260 MPa or more. It is more preferable to set the Zn/Mg mass ratio to 3.15 to 8.32. This setting enables yield strength to be increased to 270 MPa or more.

<2. Conductivity>

[0026] By manufacturing the aluminum alloy extruded material according to the embodiments of the present invention in accordance with the manufacturing method which will be described later, it is possible to set conductivity to 40.1 to 44.3%IACS. Note that "%IACS" is an index calculated by setting the conductivity of soft copper in the international standards (resistivity 1.7241×10^{-8} Ωm) to be 100%. It is known that conductivity is reduced in this alloy system with an increase in the amount of solid solution Cr.

[0027] When conductivity is more than 44.3%IACS, stress-corrosion cracking resistance is reduced. Although a precise mechanism is not yet clear, it can be considered that, when the conductivity is more than 44.3%IACS, the amount of solid solution Cr is not sufficient, thus susceptibility to stress-corrosion cracking increases. The conductivity is preferably set at 43.7%IACS or less, and is more preferably set at 43.4%IACS or less.

[0028] In contrast, the lower limit of conductivity is not particularly limited. However, in order to set the Cr content to 0.160% by mass or less with the conductivity less than 40.1%IACS, it is necessary to control manufacturing conditions in more detail. From the viewpoint of productivity, it is preferable to set conductivity to 40.1%IACS or more. The conductivity is more preferably set at 40.9%IACS or more, and is further preferably set at 41.3%IACS or more.

[0029] In the embodiments of the present invention, resistivity can be measured by causing an eddy current to be induced in a specimen with using a sigma tester. Conductivity (IACS conductivity) is calculated as a percentage by dividing the resistivity of standard copper at 20°C by the resistivity of a measurement specimen.

<3. Manufacturing method>

[0030] FIG. 3 schematically shows one example of temperature history in a method for manufacturing the aluminum alloy extruded material according to the embodiments of the present invention. The method for manufacturing the aluminum alloy extruded material according to the embodiments of the present invention includes (a) a step of heating a billet having the above-mentioned composition to 450°C to 550°C, (b) a step of cooling the heated billet to 300°C or lower at an average cooling rate of 90°C/hour or more, (c) a step of reheating the cooled billet to 470°C or higher to perform extrusion, and (d) a step of quenching the extruded billet. In the latter half of the step (c) shown in FIG. 3, it is assumed that the temperature keeps increasing by taking into consideration the generation of heat during extrusion. However, it is not always necessary that the temperature keeps increasing. Hereinafter, respective steps will be described.

[(a) Step of heating billet to 450°C to 550°C]

[0031] In order to achieve homogenization, a billet having the above-mentioned composition is heated to 450°C to 550°C. With such an operation, for example, elements that increase strength, such as Zn and Mg, can be dispersed, and Cr can be solid-soluted in the Al matrix. When a heating temperature falls outside the above-mentioned range, for example, a sufficient yield strength cannot be ensured, and Cr cannot be solid-soluted in the Al matrix. The heating temperature is preferably set at 490°C or higher, is more preferably set at 500°C or higher, and is further preferably set at 510°C or higher. A heating temperature can be measured by attaching a thermocouple to a billet in a heating furnace. Although a heating time period is not particularly limited, for example, the heating time period may be set at 1 hour or more.

[(b) Step of cooling billet to 300°C or lower at average cooling rate of 90°C/hour or more]

[0032] After the step (a), the billet is cooled to 300°C or lower at an average cooling rate of 90°C/hour or more. When the average cooling rate is less than 90°C/hour, Cr that is solid-soluted in the billet precipitates, so that the amount of solid solution Cr is reduced, thus reducing stress-corrosion cracking resistance. The average cooling rate is preferably set at 200°C/hour or more, and is more preferably set at 400°C/hour or more. The average cooling rate can be calculated by dividing a difference between the above-mentioned billet heating temperature, which is measured by using a thermocouple, and 300°C after cooling by a time period required to cool the billet from the above-mentioned heating temperature to 300°C.

[(c) Step of reheating billet to 470°C or higher to perform extrusion]

[0033] After the step (b), the billet is reheated to 470°C or higher to perform extrusion. When a reheating temperature is less than 470°C, Cr that is solid-soluted in the billet precipitates, so that the amount of solid solution Cr is reduced, thus reducing stress-corrosion cracking resistance. A temperature during reheating can be measured by attaching a thermocouple to the billet. To allow the above-mentioned reheating temperature to be maintained during extrusion, it is preferable to set a die temperature and a container temperature to 400°C or higher during the extrusion. Although conditions for the extrusion are not particularly limited, for example, the extrusion ratio may be set at 10 or more and the extrusion speed may be set at 1 m/min or more. The shape and the like of an extruded material after the extrusion are not particularly limited.

[(d) Step of quenching billet]

[0034] After the step (c), the billet is quenched by a known method in order to ensure predetermined strength and to suppress precipitation of Cr. The billet can be quenched by air cooling, water cooling, mist cooling, or the like, for example.

[0035] To achieve the object of the present invention, the method for manufacturing the aluminum alloy extruded material according to the embodiments of the present invention may also include other steps (for example, a step of performing artificial aging treatment or the like that is performed after the step (d)).

[0036] The inventors have found that the above-mentioned manufacturing method allows Cr to be solid-soluted in the Al matrix and, in such a case, the Cr content, conductivity, and stress-corrosion cracking resistance are closely correlated to each other. FIG. 1 shows the relationship of conductivity to Cr content in the case where an aluminum alloy extruded material is manufactured by the above-mentioned manufacturing method. The hatched region in FIG. 1 shows the region in which conductivity is 40.1 to 44.3%IACS. It can be understood from FIG. 1 that conductivity is reduced with an increase in Cr content, and conductivity can be set at 40.1 to 44.3%IACS when the Cr content is set at 0.050 to 0.160% by mass.

[0037] FIG. 2 shows the relationship of cracking lifetime in a stress-corrosion cracking resistance test (specifically, the time period before cracking occurs in the case where a higher stress (100% of yield strength) is applied to an aluminum alloy extruded material by three-point bending and, thereafter, the aluminum alloy extruded material is held in a boiling chromic acid solution for 10 hours or more) to Cr content in the case where the aluminum alloy extruded material is manufactured by the above-mentioned manufacturing method. The hatched region in FIG. 2 shows the region in which cracking lifetime is 10 hours or more. It can be understood from FIG. 2 that, when the Cr content is 0.050% to 0.160% by mass, cracking lifetime is 10 hours or more, that is, stress-corrosion cracking resistance can be improved. It can be understood that, when the Cr content is less than 0.050% by mass, cracking lifetime is less than 10 hours. It can be considered that the reason for this is that a small amount of solid solution Cr increases susceptibility to stress-corrosion cracking. In addition to the above, it can be also understood that, when the Cr content is more than 0.160% by mass, cracking lifetime is less than 10 hours. The reason for this is that, when the Cr content is more than 0.160% by mass, (although conductivity is low and the amount of solid solution Cr is large,) the intermetallic compound of Cr starts to precipitate. It can also be understood from FIG. 2 that, when the Cr content is set at 0.063% to 0.135% by mass, cracking lifetime becomes 12.5 hours or more, that is, stress-corrosion cracking resistance can be further improved, and when the Cr content is set at 0.070% to 0.120% by mass, cracking lifetime becomes 14 hours or more, that is, stress-corrosion cracking resistance can be still further improved.

[0038] It is preferable that, by performing general artificial aging treatment, the yield strength of the aluminum alloy extruded material according to the embodiments of the present invention can be increased to 260 MPa or more. It is more preferable that yield strength can be increased to 270 MPa or more. Tensile strength after the general artificial aging treatment is preferably 330 MPa or more. Elongation after the general artificial aging treatment is preferably 10% or more, and is more preferably 11% or more.

[Example]

[0039] Hereinafter, the embodiments of the present invention will be described more specifically by way of Examples. The embodiments of the present invention are not limited by the following Examples, but they may also be implemented with modifications as appropriate to the extent that the modifications conform to the above-mentioned and following concepts, and all of these modifications are included in the technical scope of the embodiments of the present invention.

[0040] Aluminum alloy billets having compositions shown in table 1 were formed, and were heated to 470°C. A heating time period at 470°C was set at 6 hours. Then, the billets were air-cooled to a room temperature (approximately 25°C) at an average cooling rate of 90°C/hour or more. Thereafter, the billets were reheated to 480°C, and extrusion was then performed on the billets at a die temperature of 450°C, a container temperature of 450°C, an extrusion ratio of 60.9, and an extrusion speed of 4 m/min to form flat plates each having a cross-sectional shape with a thickness of 3 mm and a width of 110 mm. Thereafter, the flat plates were quenched by air cooling.

[0041] Thereafter, heat treatment of 70°C × 5 hours + 165°C × 6 hours, being a general condition T7for a 7000-series aluminum alloy, was performed as artificial aging treatment. A tensile test, a stress-corrosion cracking resistance test, and conductivity measurement mentioned below were performed on the obtained aluminum alloy extruded materials.

[0042] In table 1, "Tr.", being the abbreviation of "Trace", means a trace amount, and may be 0.01% by mass or less, for example.

[Table 1]

Test No.	Composition [% by mass] *Balance being aluminum and inevitable impurities (except for Si, Mn)								
	Zn	Mg	Fe	Cu	Ti	Zr	Cr	Si	Mn
1	5.47	0.73	0.14	0.13	0.03	0.15	0.10	0.04	Tr.
2	5.39	0.71	0.14	0.13	0.03	0.15	0.07	0.04	Tr.
3	5.36	0.71	0.13	0.12	0.03	0.16	Tr.	0.04	Tr.
4	5.43	0.71	0.13	0.12	0.03	0.17	0.03	0.04	Tr.
5	5.42	0.72	0.14	0.13	0.03	0.15	0.20	0.03	Tr.

<Tensile test>

[0043] Two test specimens specified in JIS13B were cut out from each aluminum alloy extruded material such that the tensile direction of the test specimen is parallel to the extrusion direction (L direction). A tensile test was performed in accordance with a method for testing a metal material specified in JISZ2241 in order to measure tensile strength, yield strength, and elongation.

<Stress-corrosion cracking resistance test (chromic acid acceleration test)>

[0044] A stress was applied to the aluminum alloy extruded materials by three-point bending. The direction along which the stress was applied was the lateral direction (LT direction), and the level of stress applied was set at 100% of the yield strength of each aluminum alloy extruded material after artificial aging treatment. Thereafter, two aluminum alloy extruded materials for each test No. were immersed into a boiling chromic acid solution, and were visually observed every two hours until 16 hours had elapsed. The longest time period during which neither of the two aluminum alloy extruded materials had cracking was taken as the cracking lifetime.

<Measurement of conductivity>

[0045] Conductivity (IACS conductivity) of each aluminum alloy extruded material was measured by using a sigma tester. Specifically, the conductivity of each aluminum alloy extruded material was measured three times in a room temperature environment, and the average value of the measurements was adopted.

[0046] Table 2 shows the results of the respective tests. For an aluminum alloy extruded material in which cracking was not observed even after the lapse of 16 hours in the stress-corrosion cracking resistance test, "16" was written in the column for cracking lifetime.

[Table 2]

Test No.	Cr content (% by mass)	Conductivity (%IACS)	Tensile strength (MPa)	Yield strength (MPa)	Elongation (%)	Cracking lifetime (hour)
1	0.10	42.1	337	284	12.7	16
2	0.07	43.4	336	283	13.0	14
3	Tr.	46.6	332	282	13.3	6
4	0.03	45.1	342	292	12.9	6
5	0.20	38.7	335	282	13.1	6

[0047] The following can be considered from the results from table 2. Each of test Nos. 1 and 2 in table 2 satisfies the requirements specified in the embodiments of the present invention, and the cracking lifetime was at least 10 hours or more, that is, stress-corrosion cracking resistance was improved.

[0048] In contrast, none of test Nos. 3 to 5 in table 2 satisfies the requirements specified in the embodiments of the present invention (Cr content being 0.050 to 0.160% by mass and conductivity being 40.1 to 44.3%IACS), and the cracking lifetime was less than 10 hours.

[0049] This application claims priority based on Japanese Patent Application 2021-106946 filed on June 28, 2021, the disclosure of which is incorporated by reference herein.

Claims

1. An aluminum alloy extruded material having a composition comprising:

   Zn: 3.0 to 6.0% by mass,
   Mg: 0.4 to 1.4% by mass,
   Fe: 0.05 to 0.2% by mass,
   Cu: 0.05 to 0.4% by mass,
   Ti: 0.005 to 0.2% by mass,
   Zr: 0.1 to 0.3% by mass, and
   Cr: 0.050 to 0.160% by mass,
   with the balance being Al and inevitable impurities,
   wherein a conductivity is 40.1 to 44.3%IACS.

2. The aluminum alloy extruded material according to claim 1, wherein the content of the Cr is 0.070 to 0.120% by mass.

3. A method for manufacturing the aluminum alloy extruded material according to claim 1 or 2, the method comprising the steps of:

   preparing a billet having a composition comprising:

      Zn: 3.0 to 6.0% by mass,
      Mg: 0.4 to 1.4% by mass,
      Fe: 0.05 to 0.2% by mass,
      Cu: 0.05 to 0.4% by mass,
      Ti: 0.005 to 0.2% by mass,
      Zr: 0.1 to 0.3% by mass, and
      Cr: 0.05 to 0.15% by mass,

with the balance being Al and inevitable impurities;

heating the billet to 450 to 550°C;
cooling the heated billet to 300°C or lower at an average cooling rate of 90°C/hour or more;
reheating the cooled billet to 470°C or higher to perform extrusion; and
quenching the extruded billet.

Amended claims under Art. 19.1 PCT

1. An aluminum alloy extruded material having a composition comprising:

Zn: 3.0 to 6.0% by mass,
Mg: 0.4 to 1.4% by mass,
Fe: 0.05 to 0.2% by mass,
Cu: 0.05 to 0.4% by mass,
Ti: 0.005 to 0.2% by mass,
Zr: 0.1 to 0.3% by mass, and
Cr: 0.050 to 0.160% by mass,
with the balance being Al and inevitable impurities,
wherein a conductivity is 40.1 to 44.3%IACS.

2. The aluminum alloy extruded material according to claim 1, wherein the content of the Cr is 0.070 to 0.120% by mass.

3. (Amended) A method for manufacturing the aluminum alloy extruded material according to claim 1 or 2, the method comprising the steps of:

preparing a billet having a composition comprising:

Zn: 3.0 to 6.0% by mass,
Mg: 0.4 to 1.4% by mass,
Fe: 0.05 to 0.2% by mass,
Cu: 0.05 to 0.4% by mass,
Ti: 0.005 to 0.2% by mass,
Zr: 0.1 to 0.3% by mass, and
Cr: 0.050 to 0.160% by mass,
with the balance being Al and inevitable impurities;

heating the billet to 450 to 550°C;
cooling the heated billet to 300°C or lower at an average cooling rate of 90°C/hour or more;
reheating the cooled billet to 470°C or higher to perform extrusion; and
quenching the extruded billet.

FIG. 1

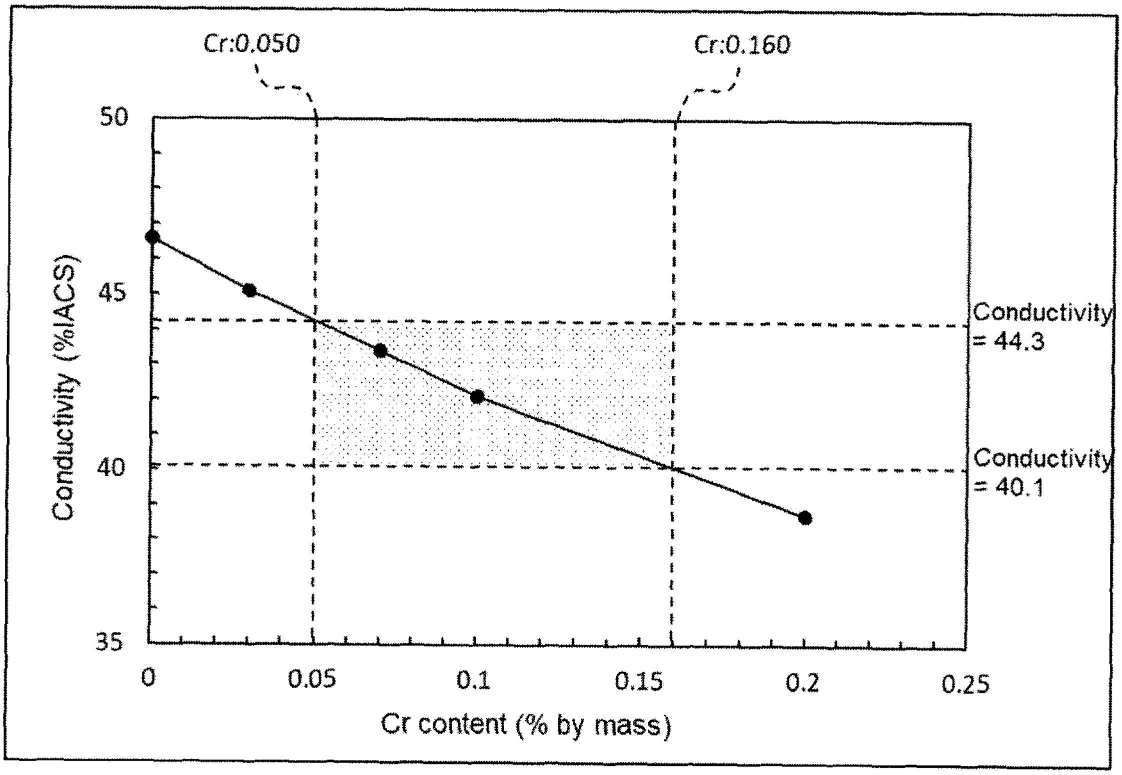

Cr:0.050
Cr:0.160
50
45
40
35
Conductivity (%IACS)
0
0.05
0.1
0.15
0.2
0.25
Cr content (% by mass)
Conductivity = 44.3
Conductivity = 40.1

FIG. 2

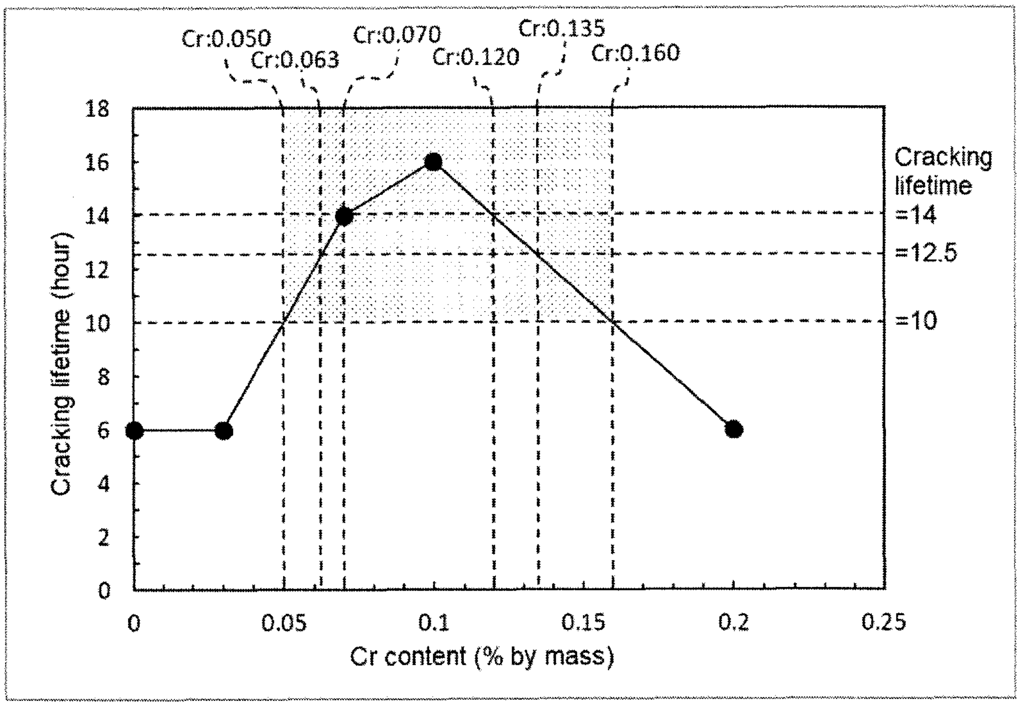
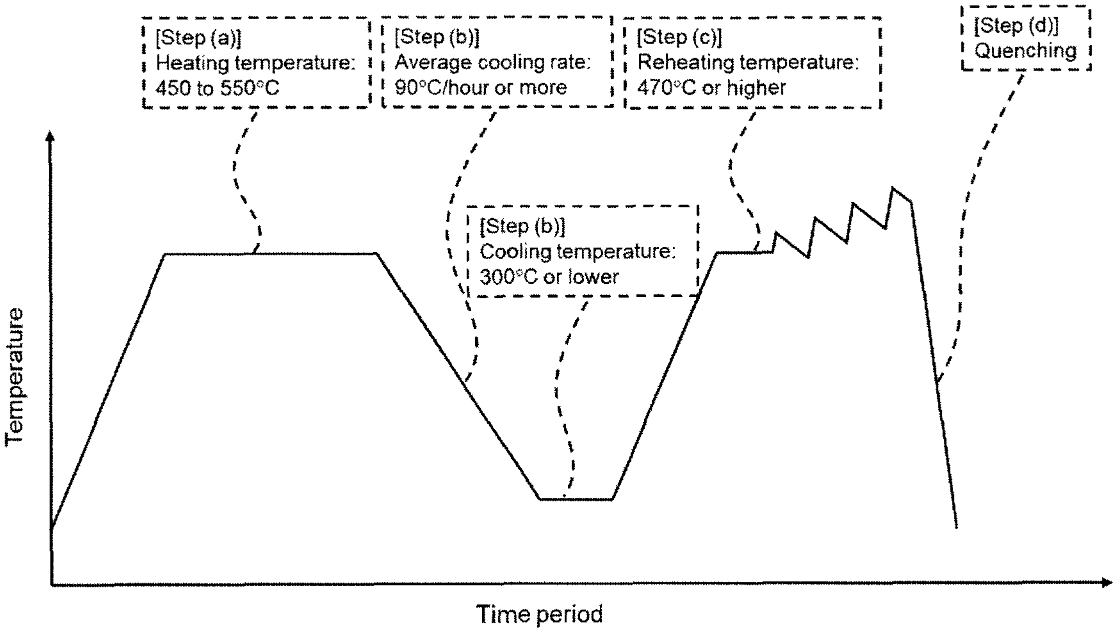

Cr:0.050
Cr:0.063
Cr:0.070
Cr:0.120
Cr:0.135
Cr:0.160
Cracking lifetime (hour)
0
2
4
6
8
10
12
14
16
18
Cracking lifetime
=14
=12.5
=10
0
0.05
0.1
0.15
0.2
0.25
Cr content (% by mass)

FIG. 3


[Step (a)]
Heating temperature:
450 to 550°C
[Step (b)]
Average cooling rate:
90°C/hour or more
[Step (c)]
Reheating temperature:
470°C or higher
[Step (d)]
Quenching
[Step (b)]
Cooling temperature:
300°C or lower
Temperature
Time period

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/021574

A. CLASSIFICATION OF SUBJECT MATTER

C22C 21/10(2006.01)i; ***C22F 1/00***(2006.01)i; ***C22F 1/053***(2006.01)i
FI: C22C21/10; C22F1/053; C22F1/00 612; C22F1/00 640A; C22F1/00 682; C22F1/00 691B; C22F1/00 691C; C22F1/00 692A; C22F1/00 692B; C22F1/00 694B; C22F1/00 683; C22F1/00 623; C22F1/00 630A; C22F1/00 630K; C22F1/00 660Z; C22F1/00 684C

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C22C21/10; C22F1/00; C22F1/053

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2009-221566 A (KOBE STEEL, LTD.) 01 October 2009 (2009-10-01) invention example 8, paragraphs [0023], [0024], [0038]	1-2 3
A	JP 2006-188730 A (FURUKAWA-SKY ALUMINUM CORP.) 20 July 2006 (2006-07-20) present invention examples	1-3
A	JP 2015-221924 A (KOBE STEEL, LTD.) 10 December 2015 (2015-12-10) paragraph [0024], table 1	1-3
A	JP 2006-505695 A (PECHINEY RHENALU SAS) 16 February 2006 (2006-02-16) table 2	1-3

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 June 2022	**12 July 2022**

Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)
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Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/021574

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2009-221566 A	01 October 2009	(Family: none)	
JP 2006-188730 A	20 July 2006	(Family: none)	
JP 2015-221924 A	10 December 2015	(Family: none)	
JP 2006-505695 A	16 February 2006	US 2006/0016523 A1 table 2 WO 2004/044256 A1 EP 1558778 B1 FR 2846669 A1 CA 2504931 A1 RU 2005117168 A AU 2003292348 A1	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP H1030147 A **[0004]**
- JP 2021106946 A **[0049]**