US 20050271543A1

(19) United States

(12) Patent Application Publication

Pfannen-Mueller et al.

(10) Pub. No.: US 2005/0271543 A1

(43) Pub. Date: Dec. 8, 2005

(54) ALUMINUM-BASED ALLOY AND METHOD OF FABRICATION OF SEMIPRODUCTS THEREOF

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(21) Appl. No.: **10/343,712**

(22) PCT Filed: **Jul. 30, 2001**

(86) PCT No.: **PCT/EP01/08807**

(30) **Foreign Application Priority Data**

Aug. 1, 2000 (RU) 2000120272

Publication Classification

(51) **Int. Cl.**[7] **C22C 21/12**; C22F 1/04

(52) **U.S. Cl.** **420/532**; 420/535; 420/537; 148/694

(57) **ABSTRACT**

This invention relates to the field of metallurgy, in particular to high strength weldable alloy with low density, of aluminium-copper-lithium system. Said invention can be used in air- and spacecraft engineering.

The suggested alloy comprises copper, lithium, zirconium, scandium, silicon, iron, beryllium, and at least one element from the group including magnesium, zinc, manganese, germanium, cerium, yttrium, titanium.

Also there is suggested the method for fabrication of semiproducts' which method comprising heating the as-cast billet prior to rolling, hot rolling, solid solution treatment and water quenching, stretching and three-stage artificial ageing.

ALUMINUM-BASED ALLOY AND METHOD OF FABRICATION OF SEMIPRODUCTS THEREOF

[0001] This invention relates to the field of metallurgy, in particular to high strength weldable alloys with low density, of aluminium-copper-lithium system, said invention can be used in air- and spacecraft engineering.

[0002] Well-known is the aluminium-based alloy comprising (mass %):

copper	2.6–3.3
lithium	1.8–2.3
zirconium	0.09–0.14
magnesium	≦0.1
manganese	≦0.1
chromium	≦0.05
nickel	≦0.003
cerium	≦0.005
titanium	≦0.02–0.06
silicon	≦0.1
iron	≦0.15
beryllium	0.008–0.1
aluminium	balance

(OST 1-90048-77)

[0003] The disadvantage of this alloy is its low weldability, reduced resistance to impact loading and low stability of mechanical properties in case of prolonged low-temperature heating.

[0004] The aluminium-based alloy with the following composition has been chosen as a prototype: (mass %)

copper	1.4–6.0
lithium	1.0–4.0
zirconium	0.02–0.3
titanium	0.01–0.15
boron	0.0002–0.07
cerium	0.005–0.15
iron	0.03–0.25
at least one element from the group including:	
neodymium	0.0002–0.1
scandium	0.01–0.35
vanadium	0.01–0.15
manganese	0.05–0.6
magnesium	0.6–2.0
aluminium	balance

(RU patent 1584414, C22C21/12, 1988)

[0005] The disadvantage of this alloy is its reduced thermal stability, not high enough crack resistance, high anisotropy of properties, especially of elongation.

[0006] Well-known is the method of fabrication of semiproducts from alloys of Al—Cu—Li system, which method comprises heating of the billet at 470-537° C., hot rolling (temperature of the metal at the end of the rolling process is not specified), hardening from 549° C., stretching (ϵ=2-8%) and artificial ageing at 149° C. for 8-24 hours or at 162° C. for 36-72 hours, or at 190° C. for 18-36 hours.

U.S. Pat. No. 4,806,174, C22F Jan. 4, 1989

[0007] The shortcoming of this method is the low thermal stability of semiproducts' properties because of the residual supersaturation of the solid solution and its subsequent decomposition with precipitation of fine particles of hardening phases, and also the low elongation and crack resistance, all of which increases the danger of fracture in the course of service life.

[0008] The well-known method of fabrication of products from the alloy of Al—Cu—Li system is chosen as a prototype, which method comprising: heating the as-cast billet prior to deformation at 430-480° C., deformation at rolling finish temperature of not less than 375° C., hardening from $525^{\circ\pm5}$ C., stretching (ϵ=1.5-3.0%) and artificial ageing $150^{\circ\pm5}$ C. for 20-30 hours.

[0009] (Technological Recommendation for fabrication of plates from 1440 and 1450 alloys, TR 456-2/31-88, VILS, Moscow, 1988).

[0010] The disadvantage of this method is the wide range of mechanical properties' values due to wide interval of deformation temperatures and low thermal stability because of the residual supersaturation of solid solution after ageing.

[0011] The suggested aluminium-based alloy comprises (mass %):

copper	3.0–3.5
lithium	1.5–1.8
zirconium	0.05–0.12
scandium	0.06–0.12
silicon	0.02–0.15
iron	0.02–0.2
beryllium	0.0001–0.02
at least one element from the group including	
magnesium	0.1–0.6
zinc	0.01–1.0
manganese	0.05–0.5
germanium	0.02–0.2
cerium	0.05–0.2
yttrium	0.005–0.02
titanium	0.005–0.05
aluminium	balance

[0012] The Cu/Li ratio is in the range 1.9-2.3.

[0013] Also is suggested the method for fabrication of semiproducts, comprising heating of as-cast billet to 460-500° C., deformation at temperature ≧400° C., water quenching from 525° C., stretching (ϵ=1.5-3.0%), three-stage artificial ageing including:

[0014] I—155-165° C. for 10-12 hours,

[0015] II—180-190° C. for 2-5 hours,

[0016] III—155-165° C. for 8-10 hours,

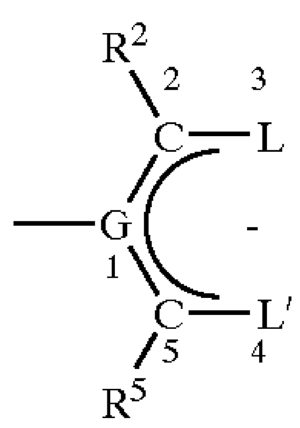
[0017] with subsequent cooling in a furnace to 90-100° C. with cooling rate 2-5° C./hours and air cooling to room temperature.

[0018] The suggested method differs from the prototype in that the billet prior to deformation process, is heated to 460-500° C., the deformation temperature is not less than 400° C., and the artificial ageing process is performed in three stages: first at 155-165° C. for 10-12 hours, then at 180-190° C. for 2-5 hours and lastly at 155-165° C. for 8-10 hours; then is performed cooling to 90-100° C. with cooling rate of 2-5° C./hour and subsequent air cooling to room temperature.

[0019] The task of the present invention is the weight reduction of aircraft structures, the increase in their reliability and service life.

[0020] The technical result of the invention is the increase in plasticity, crack resistance, including the impact loading resistance, and also the increase in stability of mechanical properties in case of prolonged low-temperature heating.

[0021] The suggested composition of the alloy and the method of fabrication of semiproducts from said alloy ensure the necessary and sufficient saturation of the solid solution, allowing to achieve the high hardening effect at the expense of mainly fine T_1-phase (Al_2CuLi) precipitates without residual supersaturation of the solid solution with Li, and that results in practically complete thermal stability of the alloy in case of prolonged low—temperature heating.



(V)

1-2. (canceled)

3. An aluminum-based alloy comprising, 3.0-3.5% copper, 1.5-1.8% lithium, 0.05-0.12% zirconium, 0.06-0.12% scandium, 0.02-0.15% silicon, 0.02-0.2% iron, 0.0001-0.02% beryllium; at least one element selected from the group consisting of 0.1-0.6% magnesium, 0.02-1.0% zinc, 0.05-0.5% manganese, 0.02-0.2% germanium, 0.05-0.2% cerium, 0.005-0.02% yttrium and 0.005-0.05% titanium; and aluminum which makes up the balance, wherein the ratio between copper/lithium (Cu/Li) is in the between about 1.9 and about 2.3.

4. The aluminum-based alloy of claim 3, wherein the Cu/Li is 2.26.

5. The aluminum-based alloy of claim 4, consisting of 3.4% Cu, 1.5% Li, 0.08% Zr, 0.09% Sc, 0.04% Si, 0.02% Fe, 0.07% Be, 0.3% Mg, 0.15% Mn, 0.001% Y and 94.349% Al.

6. The aluminum-based alloy of claim 3, wherein the Cu/Li is 1.98.

7. The aluminum-based alloy of claim 6, consisting of 3.48% Cu, 1.76% Li, 0.11% Zr, 0.069% Sc, 0.05% Si, 0.02% Fe, 0.06% Be, 0.28% Mg, 0.31% Mn, 0.02% Zn, 0.02% Ti, 0.001% Y and 93.82% Al.

8. The aluminum-based alloy of claim 3, wherein the Cu/Li is 1.90.

9. The aluminum-based alloy of claim 8, consisting of 3.1% Cu, 1.63% Li, 0.07% Zr, 0.1% Sc, 0.1% Si, 0.2% Fe, 0.0001% Be, 0.56% Mg, 0.3% Mn, 0.1% Ce, 0.02% Ti, and 93.8579% Al.

10. A method for producing a semi-product from the alloy of claim 3, the method comprising

heating a billet of the alloy to 460-500° C.,

deforming at a temperature of not less than 400° C.,

aging at 155-165° C. for 10-12 hours, aging at 180-190° C. for 2-5 hours and aging at 155-165° C. for 8-10 hours;

cooling the billet to 90-100° C. with cooling rate of 2-5° C./hour, and

air cooling to room temperature.

11. A method for fabricating a sheet of the alloy of claim 5, comprising heating a billet of the alloy to 490° C., rolling the billet such that the temperature of the alloy at rolling finish is 420° C., and aging the alloy at 160° C. for 10 hours, aging the alloy at 180° C. for 3 hours, and aging the alloy at 160° C. for 10 hours.

12. A method for fabricating a sheet of the alloy of claim 7, comprising heating a billet of the alloy to 460° C., rolling the billet such that the temperature of the alloy at rolling finish is 410° C., and aging the alloy at 160° C. for 12 hours, aging the alloy at 180° C. for 4 hours, and aging the alloy at 160° C. for 10 hours.

13. A method for fabricating a sheet of the alloy of claim 9, comprising heating a billet of the alloy to 460° C., rolling the billet such that the temperature of the alloy at rolling finish is 410° C., and aging the alloy at 160° C. for 10 hours, aging the alloy at 180° C. for 3 hours, and aging the alloy at 160° C. for 8 hours.

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