element, the rest being aluminum and incidental elements and impurities. Said 7xxx series aluminum alloy is overaged such that it should comply simultaneously with three conditions relating to yield strength, FSP performance and spall resistance. The chemistry of the 7xxx-series aluminum alloy claimed by US Patent No. 8,206,517 largely overlaps with that of alloy AA7085. U.S. military specification MIL-DTL-32375 (MR) covers 7085 wrought aluminum alloy armor plate for non-fusion welded applications in nominal thicknesses from 0.500 to 3.000 inch. According to this specification, 7085 alloy should only be used as unweldable appliqué armor.

[0010] It is generally difficult to achieve 7XXX alloys that have simultaneously high armor piercing resistance (AP) and fragment simulated particle (FSP) resistance. It is still more difficult to achieve 7XXX alloys that have also an acceptable behaviour after welding and may consequently be also used for manufacturing welded armor hull walls.

Summary

[0010a] In one aspect of the present disclosure, there is provided an armor component produced from a 7xxx series aluminum alloy, wherein the aluminum alloy consists of:

- 8.4 wt.% ≤ Zn ≤ 10.5 wt.%
- 1.75 wt.% ≤ Mg ≤ 2.04 wt.%,
- 1.2 wt.% ≤ Cu ≤ 2 wt.%
- at least one dispersoid forming element selected from Zr, Sc, V, Hf, Cr and Mn with a total dispersoid forming element content higher than 0.05 wt.% and a content less than 0.15 wt.% for Zr, lower than 0.3 wt.% for Sc, V; Hf, Cr and a maximum for Mn of 0.30 wt.%;
- the remainder aluminum, incidental elements and impurities;

wherein the 7XXX alloy is in the form of a plate having a thickness of 0.5 to 3 inches;

wherein the 7XXX alloy is aged to achieve:

(i) a fragment simulated particles V50 ballistic limit such that

$$V50\ (FSP\ 20mm) > 1633\ T^2 - 1479\ T + 1290$$

where T is the thickness plate (unit: inch) and the unit of V50 is feet/s.

(ii) an armor piercing V50 ballistic limit such that:

$$V50\ (0.30cal\ AP\ M2) > -282\ T^2 + 1850\ T + 610$$

where T is the thickness plate (unit: inch) and the unit of V50 is feet/s.

[0010b] In another aspect of the present disclosure, there is provided a method of producing an armour component disclosed herein, comprising:

a) casting said alloy into ingot form;
b) homogenising said ingot;
c) hot working said ingot to obtain a plate;
d) solution heat treating;
e) quenching;
f) optionally stretching to obtain a plastic deformation from 1 and 3 %;
g) aging at least in two steps, the aging treatment corresponding to the following 2-steps treatment: 4-8 hours at 110°C-130°C + 12-20 hours at 140°C-160°C.

[0010c] In a further aspect of the present disclosure, there is provided a method of producing an armour component disclosed herein, comprising:
a) casting said alloy into ingot form;
b) homogenising said ingot;
c) hot working said ingot to obtain a plate;
d) solution heat treating;
e) quenching;
f) optionally stretching to obtain a plastic deformation between 1 and 3 %;
g) aging, the total equivalent time at 150 °C of aging treatment not exceeding 25h, the total equivalent time t(eq) at 150 °C being defined by the formula :

$$t(eq) = \frac{\int \exp(-15683 / T)\, dt}{\exp(-15683 / T_{ref})}$$

where T is the instantaneous temperature in Kelvin of treatment which evolves with the time t (in hours), Tref is a reference temperature selected at 150 °C (423 K), and t(eq) is expressed in hours.

Description

[0011] A first object of the invention is an armor component produced from a 7xxx series aluminum alloy, wherein the aluminum alloy consists essentially of:
- 8.4 wt.% ≤ Zn ≤ 10.5 wt.%;
- 1.3 wt.% ≤ Mg ≤ 2 wt.%;
- 1.2 wt.% ≤ Cu ≤ 2 wt.%;
- at least one dispersoid forming element with a total dispersoid forming element content higher than 0.05 wt.%;
- the remainder substantially aluminum, incidental elements and impurities;
wherein the 7XXX alloy is in the form of a plate having a thickness of about 0.5 to about 3 inches, i.e. about 12.7 to about 76.2 mm;
wherein the 7XXX alloy is over-aged to achieve:
(i) a fragment simulated particles V50 ballistic limit such that:

$$V50\ (FSP\ 20mm) > 1633\ T^2 - 1479\ T + 1290$$

CLAIMS

1. An armor component produced from a 7xxx series aluminum alloy, wherein the aluminum alloy consists of:

- 8.4 wt.% ≤ Zn ≤ 10.5 wt.%
- 1.75 wt.% ≤ Mg ≤ 2.04 wt.%,
- 1.2 wt.% ≤ Cu ≤ 2 wt.%
- at least one dispersoid forming element selected from Zr, Sc, V, Hf, Cr and Mn with a total dispersoid forming element content higher than 0.05 wt.% and a content less than 0.15 wt.% for Zr, lower than 0.3 wt.% for Sc, V; Hf, Cr and a maximum for Mn of 0.30 wt.%,
- the remainder aluminum, incidental elements and impurities;

wherein the 7XXX alloy is in the form of a plate having a thickness of 0.5 to 3 inches;

wherein the 7XXX alloy is aged to achieve:

(i) a fragment simulated particles V50 ballistic limit such that

$$V50\ (FSP\ 20mm) > 1633\ T^2 - 1479\ T + 1290$$

where T is the thickness plate (unit: inch) and the unit of V50 is feet/s.

(ii) an armor piercing V50 ballistic limit such that:

$$V50\ (0.30cal\ AP\ M2) > -282\ T^2 + 1850\ T + 610$$

where T is the thickness plate (unit: inch) and the unit of V50 is feet/s.

2. An armor component according to claim 1, wherein Mg/Zn ≤ 0.20.

3. An armor component according to claim 1, wherein 0.9 ≤ Cu/Mg ≤ 1.1.

4. An armor component according to claim 1, wherein the dispersoid forming element is zirconium, whose content is from 0.05 wt.% and 0.15 wt.%.

5. An armor component according to claim 1, wherein Fe < 0.1 wt.% and Si < 0.1 wt.%.

6. An armor component according to claim 1, wherein said 7xxx alloy in the form of a plate is manufactured with following steps:

a) casting said alloy into ingot form;

b) homogenising said ingot;

c) hot working said ingot to obtain a plate;

d) solution heat treating;

e) quenching;

f) optionally stretching to obtain a plastic deformation from 1 and 3 %;

g) aging at least in two steps, the aging treatment corresponding to the following 2-steps treatment: 4-8 hours at 110°C-130°C + 12-20 hours at 140°C-160°C.

7. An armor component according to claim 1, wherein said 7xxx alloy in the form of a plate is manufactured with following steps:

a) casting said alloy into ingot form;

b) homogenising said ingot;

c) hot working said ingot to obtain a plate;

d) solution heat treating;

e) quenching;

f) optionally stretching to obtain a plastic deformation between 1 and 3 %;

g) aging, the total equivalent time at 150 °C of aging treatment not exceeding 25h, the total equivalent time t(eq) at 150 °C being defined by the formula :

$$t(eq) = \frac{\int \exp(-15683 / T)\, dt}{\exp(-15683 / T_{ref})}$$

where T is the instantaneous temperature in Kelvin of treatment which evolves with the time t (in hours), Tref is a reference temperature selected at 150 °C (423 K), and t(eq) is expressed in hours.

8. An armor component according to claim 1, wherein the 7xxx series aluminum alloy consists of:

8.5 wt.% ≤ Zn ≤ 9.5 wt.%;

1.75 wt.% ≤ Mg ≤ 2.04 wt.%,

1.4 wt.% ≤ Cu ≤ 1.8 wt.%;

Fe < 0.1 wt.%;

Si < 0.1 wt.%;

0.05 wt.% ≤ Zr ≤ 0.15 wt.%; balance aluminum and incidental elements and impurities.

9. An armor component according to claim 8, wherein 1.8 wt.% ≤ Mg ≤ 2 wt.%.

10. An armor component according to any of claims 1 to 9, wherein FSP V50 ballistics limit is such that:

$$V50\ (FSP\ 20mm) > 1633\ T^2 - 1479\ T + 1320 \qquad \text{(I-a)}$$

where T is the thickness plate (unit: inch) and the unit of V50 is feet/s.

11. An armor component according to any of claims 1 to 9, wherein FSP V50 ballistics limit is such that:

$$V50\ (FSP\ 20mm) > 1633\ T^2 - 1479\ T + 1350 \qquad (I\text{-}b)$$

where T is the thickness plate (unit: inch) and the unit of V50 is feet/s.

12. An armor component according to any of claims 1 to 9, wherein AP V50 ballistics limit is such that:

$$V50\ (0.30cal\ AP\ M2) > -282\ T2 + 1850\ T + 700 \qquad (II\text{-}a)$$

where T is the thickness plate (unit: inch) and the unit of V50 is feet/s.

13. An armor component according to any of claims 1 to 9, wherein AP V50 ballistics limit is such that:

$$V50\ (0.30cal\ AP\ M2) > -282\ T2 + 1850\ T + 790 \qquad (II\text{-}b)$$

where T is the thickness plate (unit: inch) and the unit of V50 is feet/s.

14. An armor component according to claim 1, wherein said plate is fusion welded and wherein the post-weld ultimate tensile strength is greater than 45%, preferably 50%, of the ultimate tensile strength before welding.

15. An armor component according to claim 1, wherein said plate is fusion welded and wherein the post-weld tensile strength is greater than 44 ksi, preferably 47 ksi.

16. A method of producing an armour component according to claim 1, comprising:

a) casting said alloy into ingot form;

b) homogenising said ingot;

c) hot working said ingot to obtain a plate;

d) solution heat treating;

e) quenching;

f) optionally stretching to obtain a plastic deformation from 1 and 3 %;

g) aging at least in two steps, the aging treatment corresponding to the following 2-steps treatment: 4-8 hours at 110°C-130°C + 12-20 hours at 140°C-160°C.

17. A method of producing an armour component according to claim 1, comprising:

a) casting said alloy into ingot form;

b) homogenising said ingot;

c) hot working said ingot to obtain a plate;

d) solution heat treating;

e) quenching;

f) optionally stretching to obtain a plastic deformation between 1 and 3 %;

g) aging, the total equivalent time at 150 °C of aging treatment not exceeding 25h, the total equivalent time t(eq) at 150 °C being defined by the formula :

$$t(eq) = \frac{\int \exp(-15683 / T)\, dt}{\exp(-15683 / T_{ref})}$$

where T is the instantaneous temperature in Kelvin of treatment which evolves with the time t (in hours), Tref is a reference temperature selected at 150 °C (423 K), and t(eq) is expressed in hours.