United States Patent Office

2,985,530

Patented May 23, 1961

2,985,530

METALLURGY

Maurice C. Fetzer and John D. Sprowl, Spokane, Wash., and Stanley L. Channon, Riverside, Calif., assignors to Kaiser Aluminum & Chemical Corporation, Oakland, Calif., a corporation of Delaware

No Drawing. Filed Mar. 11, 1959, Ser. No. 798,601

9 Claims. (Cl. 75—146)

This invention relates to alloys, and particularly to aluminum base alloys suitable for fabricating and welding articles in which substantially high mechanical properties are required in the as-welded condition.

It has long been recognized that there is a need for an aluminum alloy which after welding possesses higher mechanical properties than obtained with present day aluminum alloys. In the design of welded parts, it must be taken into consideration that the metal would be heat-affected or annealed for a short distance from the weld and that the weld has a cast structure having about the same strength as the annealed metal. Unless the metal in the weld zone is strain hardened after the welding operation or heat treated in the case of heat treatable alloys, the properties of the weld and/or the adjacent annealed section will in many instances determine the strength of the fabricated part.

This invention relates to aluminum base alloys consisting essentially of from about 0.20 to 0.90% manganese, 4.50 to 6.00% magnesium, 0.05 to 0.20% chromium, 1.50 to 3.00% zinc, 0.02 to 0.15% titanium, the balance aluminum and impurities in normal amounts. Such alloys possess a combination of qualities that makes them desirable for the fabrication of many welded structures, such as irrigation tubing, rocket bodies, vessels, boats, etc. These alloys possess the desirable characteristics of moderate cost, good mechanical properties, adaptability to ordinary methods of working and excellent resistance to corrosion and stress corrosion.

The alloys normally contain nominal amounts of copper, beryllium, silicon and iron as impurities. The amount of copper present should not be in excess of about 0.10%. Silicon should be kept below 0.40% maximum since it combines with the magnesium to form magnesium silicide thereby reducing the magnesium in solid solution. Iron should be kept below 0.40% maximum. Iron is not appreciably soluble (less than 0.01%) in solid aluminum at any temperature and too great an amount of iron will result in the formation of insoluble compounds wihich have a detrimental effect on the corrosion resistance of the alloys. Furthermore, the iron may have the effect of reducing the ductility of the alloy although the hardness and tensile strength will be increased. Other impurity elements should be limited to a maximum of 0.05% each and a total of 0.15%.

The primary function of the magnesium addition is to improve the strength of this alloy. It has been found that magnesium additions of less than 6.00% produce excellent corrosion and stress corrosion resistance. In alloys having a magnesium content above about 6.00%, the stress corrosion cracking resistance of the alloy is decreased. The combination of manganese, chromium and zinc are essential constituents for purpose of improving the strength of the alloy. More specifically, manganese increases the strength and the recrystallization temperature, chromium increases the strength and corrosion resistance, while titanium produces grain refinement. The maximum amounts of these elements are

respectively 0.90%, 0.20% and 0.15%. Where greater amounts of these elements are present, there is a tendency for formation of primary compounds which adversely affects formability. The zinc is added to effect natural age hardening of the alloy.

When employing the processes that are now used for welding aluminum, rapid cooling of the weld metal and adjacent parent metal is generally achieved. In accordance with the invention, advantage is taken of this rapid cooling to effect solution treatment of an age hardenable constituent which precipitates upon natural ambient temperature aging whereby the strength of the weld is improved. Zinc has been found to be the most promising addition element for this purpose since it has the required age hardening characteristics, reduces susceptibility to stress corrosion, provides higher strength in the parent metal and prevents weld cracking. It has been found that a minimum of 1.50% zinc is required to produce the natural age hardening necessary for the improved tensile properties of this alloy.

The alloy composition hereinbefore set forth includes alloys especially suited as the metal of the base or parent metal member to be welded as well as alloys especially suited as the metal of the filler rod for use in welding, e.g. inert gas arc welding using a consumable or non-consumable electrode.

The base or parent metal alloys of this invention consist essentially of from about 0.20 to 0.90% manganese, 4.50 to 5.50% magnesium, 0.05 to 0.20% chromium, 1.50 to 2.50% zinc, 0.02 to 0.06% titanium, balance aluminum and impurities in normal amounts. The preferred range of composition is 0.40 to 0.70% manganese, 4.85 to 5.35% magnesium, 0.05 to 0.15% chromium, 1.75 to 2.25% zinc, 0.03 to 0.05% titanium, balance aluminum and impurities in normal amounts.

The weld filler metal alloys of this invention consist essentially of from about 0.20 to 0.90% manganese, 5.00 to 6.00% magnesium, 0.05 to 0.20% chromium, 2.00 to 3.00% zinc, 0.04 to 0.15% titanium, balance aluminum and impurities in normal amounts. The preferred range of composition is 0.40 to 0.70% manganese, 5.25 to 5.75% magnesium, 0.05 to 0.15% chromium, 2.25 to 2.75% zinc, 0.04 to 0.10% titanium, balance aluminum and impurities in normal amounts.

With regard to impurities content, it is preferable to limit the beryllium content to about 0.008%. It will be noted that the preferred magnesium, zinc and titanium contents of the filler alloys are slightly higher than those of the base or parent metal, the purpose being to compensate for some burnout of the elements during welding due to the high temperatures involved.

It has also been found that further improvement of the strength of fabricated and welded alloys of the invention can be obtained where the base or parent metal has been solution heat treated prior to welding. The heat treatment employed may comprise heating the metal to a temperature above 800° F. and maintaining the metal at that temperature for a period of time which may be as short as ten minutes. The metal is then quenched in a suitable means such as water. Where the thickness of the metal is not too great, the metal may be air cooled. This treatment may be followed by cold rolling and stabilizing at an elevated temperature.

The following examples illustrate several alloys within the scope of this invention. The composition of these alloys is indicated in Table I, the alloys within the scope of this invention being designated by the letters A thru F. For purposes of comparative tests, alloys falling within the ranges fixed by the Aluminum Association for commercial alloys 5083 and 5183 were prepared, the compositions of which are also indicated in Table I.

Table I

Alloy	Percent Si	Percent Fe	Percent Cu	Percent Mn	Percent Mg	Percent Cr	Percent Zn	Percent Ti
A	.09	.16	.05	.74	5.00	.16	2.21	.02
B	.10	.24	tr.	.69	5.46	.12	2.68	.06
C	.14	.16	.08	.72	5.08	.12	2.03	.03
D	.08	.06	tr.	.83	5.51	.12	2.45	.05
E	.15	.16	.06	.73	5.03	.12	2.00	.03
F	.10	.22	.05	.57	4.55	.11	1.78	.06
5183	.11	.17	.08	.62	5.08	.10	0.02	.07
5083	.13	.21	.05	.75	4.70	.12	0.05	.04

Properties of weldments made by welding plates of an alloy of this invention with filler metal of an alloy of this invention and also with filler metal of 5183 are shown in Table II. For comparison the properties are shown for weldments made from 5083 alloy plate welded with 5183 filler. The welds were made in the flat position using the inert gas shielded arc welding process with a consumable filler metal electrode. The inert gas used in making these welds was argon, although other inert gases such as helium could be employed.

The plates of alloy A were heat treated prior to welding at a temperature between 860 and 880° F. for a period of twenty-five minutes. The plates were then water quenched, cold rolled 55% and stabilized for one hour at 300° F. The remaining alloys in these examples were not subjected to a heat treatment.

The tensile tests indicated in Table II were performed on specimens obtained by cutting a slice from the welded composite transverse to the weld.

above described, over the properties of the weldments which did not employ heat treated base plates. Table II also demonstrates that when employing base plates of the alloy of this invention with a 5183 filler alloy superior properties are obtained over those obtained with 5083 base plate and 5183 filler wire though not as good as welds produced with both the base plate and the filler of the alloy of this invention.

It will be understood that various changes, modifications and alterations may be made in the instant invention without departing from the spirit and scope thereof and as such the invention is not to be limited except by the appended claims wherein what is claimed is:

1. An aluminum base alloy consisting essentially of from about 0.20 to 0.90% manganese, 4.50 to 6.00% magnesium, 0.05 to 0.20% chromium, 1.50 to 3.00% zinc, 0.02 to 0.15% titanium, balance substantially all aluminum and impurities in normal amounts.

2. An aluminum base alloy consisting essentially of from about 0.20 to 0.90% manganese, 4.50 to 5.50% magnesium, 0.05 to 0.20% chromium, 1.50 to 2.50% zinc, 0.02 to 0.06% titanium, balance substantially all aluminum and impurities in normal amounts.

3. An aluminum base alloy consisting essentially of from about 0.40 to 0.70% manganese, 4.85 to 5.35% magnesium, 0.05 to 0.15% chromium, 1.75 to 2.25% zinc, 0.03 to 0.05% titanium, balance substantially all aluminum and impurities in normal amounts.

4. An aluminum base alloy consisting essentially of from about 0.20 to 0.90% manganese, 5.00 to 6.00% magnesium, 0.05 to 0.20% chromium, 2.00 to 3.00%

Table II

Plate Thickness	0.090″	0.625″	1.00″	1.25″	1.25″	1.25″.
Filler Diam	1/16″	3/32″	3/32″	3/32″	3/32″	3/32″.
Alloy:						
Parent	A	C	E	F	F	5,083.
Filler	B	D	D	D	5,183	5,183.
Arc Volts	21	25	25	25	25	25.
Arc Amps	200	310	320	350	350	350.
Welding Speed (inches per minute)	65	18	16	16	16	16.
Shielding Gas Flow, Cu. ft./hr	80	80	80	60	60	60.
Joint Design	Sq. Butt	60° V groove.	70° double V.	70° double V.	70° double V.	70° double V.
Number of Passes	1	5	8	14	14	14.
Tensile Str. (p.s.i.):						
Bead On	55,000	48,500	47,200	43,000	44,500	44,000.
Bead Off	45,400	49,000	52,500	50,600	44,700	42,000.
Parent Metal	66,100	51,100				
Yield Str. (p.s.i.):						
Bead On	34,000	27,400				
Bead Off	30,100	25,300		26,500		20,000.
Parent Metal	53,500	31,500				
Percent Elong. in 2″:						
Bead On	3.6	12.4	7.2	9.1	9.2	14.0.
Bead Off	4.2	15.0	13.0	12.5	12.1	14.0.
Parent Metal	8.0	18.2				

The aluminum base alloys of this invention exhibit good weldability with any of the standard welding processes. However, these alloys are particularly adaptable to welding by the inert gas shielded arc welding process with a consumable filler metal electrode wherein helium or argon are employed as the inert gas.

From the results shown in Table II the superior properties obtained when employing base plate and filler wire of the alloy of this invention is clearly demonstrated. While the tensile strength obtained with the bead on from the specimen of the weld between base plates of alloy "F" using filler of alloy "D" was slightly lower than the specimens from the weld between base plates of 5083 with 5183 filler, the tensile strength from the specimens with the bead on was substantially higher for the alloy "F" and "D" weldment as was the yield strength. Further, it should be noted that while the magnesium content of alloy "F" is within the broad range of this invention, it is below the minimum of the preferred range for the base plate.

It can also be seen from Table II that superior properties were obtained from the weldments employing the base plates of alloy "A" which were heat treated, as

zinc, 0.04 to 0.15% titanium, balance substantially all aluminum and impurities in normal amounts.

5. An aluminum base alloy consisting essentially of from about 0.40 to 0.70% manganese, 5.25 to 5.75% magnesium, 0.05 to 0.15% chromium, 2.25 to 2.75% zinc, 0.04 to 0.10% titanium, balance substantially all aluminum and impurities in normal amounts.

6. A solution heat treated aluminum base alloy consisting essentially of from about 0.20 to 0.90% manganese, 4.50 to 5.50% magnesium, 0.05 to 0.20% chromium, 1.50 to 2.50% zinc, 0.02 to 0.06% titanium, balance substantially all aluminum and impurities in normal amounts.

7. A solution heat treated aluminum base alloy consisting essentially of from about 0.40 to 0.70% manganese, 4.85 to 5.35% magnesium, 0.05 to 0.15% chromium, 1.75 to 2.25% zinc, 0.03 to 0.05% titanium, balance substantially all aluminum and impurities in normal amounts.

8. An aluminum base alloy article consisting essentially of from about 0.20 to 0.90% manganese, 4.50 to 5.50% magnesium, 0.05 to 0.20% chromium, 1.50 to 2.50%

zinc, 0.02 to 0.06% titanium, balance substantially all aluminum and impurities in normal amounts fabricated by welding together two solution heat treated plates of said aluminum base alloy.

9. An aluminum base alloy article consisting essentially of from about 0.40 to 0.70% manganese, 4.85 to 5.35% magnesium, 0.05 to 0.15% chromium, 1.75 to 2.25% zinc, 0.03 to 0.05% titanium, balance substantially all aluminum and impurities in normal amounts fabricated by welding together two solution heat treated plates of said aluminum base alloy.

References Cited in the file of this patent

UNITED STATES PATENTS

2,511,551 Smith et al. ---------- June 13, 1950

FOREIGN PATENTS

973,802 France ---------- Sept. 20, 1950