United States Patent Office

3,418,090

Patented Dec. 24, 1968

3,418,090

COMPOSITE ALUMINUM ARTICLE

Thomas L. Fritzlen, Henrico County, Va., assignor to Reynolds Metal Company, Richmond, Va., a corporation of Delaware

No Drawing. Filed Mar. 14, 1966, Ser. No. 538,485
9 Claims. (Cl. 29—197.5)

ABSTRACT OF THE DISCLOSURE

Composite articles having a core and cladding composed of heat-treatable aluminum base alloys, in particular a core alloy containing zinc, magnesium and copper as the principal alloying elements, clad with an alloy containing about 4–5.5% zinc and about 1–1.6% magnesium.

This invention relates to composite aluminous metal articles and, more particularly, to a heat-treatable clad composite having a core composed of an aluminum base alloy containing zinc, magnesium and copper, and a cladding composed of a compositionally similar alloy containing little or no copper.

It is conventional in the art to employ cladding materials for protecting base metals from corrosion, and for other purposes. Included in this category are Alclad products in which the cladding consists essentially of aluminum or aluminum alloyed with a small percentage of zinc. Various aluminum base alloys have been so clad, including 7000 series alloys (Aluminum Association designation) which contain zinc as the principal alloy addition, as well as magnesium and copper in some instances, in lesser amounts. It is also known in the art to clad other than aluminum-zinc alloys with a cladding which contains both zinc and magnesium alloyed with aluminum.

While the aluminum-zinc-magnesium-copper alloys exhibit relatively high mechanical properties, particularly after heat treatment, they are susceptible in many instances to various types of corrosion, and it has long been a problem facing the art to devise effective means of assuring protection against corrosion, while maintaining the desirable strength characteristics of composite articles having a core composed of such an alloy. One of the disadvantages of conventional cladding materials is their dissimilarity to aluminum-zinc-magnesium-copper alloys in response to heat treatment. Pure aluminum and conventional cladding composed of aluminum alloyed only with zinc do not respond to solution or precipitation heat treatment. A noteworthy advantage of the present invention is the provision of a composite metal article that is entirely heat-treatable, and in which the cladding and core alloys are responsive to a common solution heat treatment and precipitation hardening practice.

In accordance with the invention, a clad composite is provided which includes a cladding layer composed of an aluminum-base alloy containing about 4 to 5.5% zinc, about 1 to 1.6% magnesium and substantially no copper, with a solution potential close to −1 volt. The core alloy may be aluminum-zinc-magnesium-copper alloy having an electrode potential less electro-negative than the cladding, preferably by at least about 0.10 volt in order to assure adequate protection of the core. Suitable core alloys include 7001, X7002, 7075, 7079 and 7178. Such alloys generally contain up to about 8% zinc, 4% magnesium and 3% copper, ordinarily with less copper than magnesium and less magnesium than zinc. The composition limits of alloy 7079, for example, are: 3.8–4.8% zinc, 2.9–3.7% magnesium, 0.40–0.8% copper, 0.10–0.30% manganese, 0.10–0.25% chromium, up to 0.40% iron, up to 0.30% silicon, up to 0.10% titaninm, others up to .05% each and 0.15% total, remainder aluminium.

A preferred cladding alloy is one which consists essentially of 4.2–4.8% zinc, 1.0–1.4% magnesium, about 0.10–.30% manganese, about .05–.20% chromium, and not more than .05% copper, balance substantially aluminum. The cladding may contain up to about 0.20% silicon and 0.25% iron, typically introduced as incidental impurities in the aluminum.

The combination of cladding and core alloys according to the invention produces the additional advantage of superior stress corrosion resistance compared to either the cladding alloy itself or a composite of the same core alloy clad with an alloy of aluminum and a small percentage of zinc.

The following examples are illustrative of the invention, but are not to be regarded as limiting.

EXAMPLE I

A 12×45 inch ingot was produced from an aluminum alloy A containing the following:

Cu	.04	Mg	1.22
Fe	0.11	Zn	5.39
Si	0.11	Cr	0.11
Mn	0.24	Ti	.05

The ingot was homogenized 24 hours at 915–940° F., and hot rolled to 0.330 inch thickness. A scalped and homogenized ingot of 7079 alloy was clad with the 0.330 inch stock of alloy A by slabbing to 3¼ inches, reheating to about 840° F., rolling to 0.125 inch, annealing, and cold rolling to final thickness, to produce .085-inch thick sheet having a nominal 2½% cladding.

Additional specimens of Alclad 7079 (having the same core composition and a nominal 4% cladding of 7072 alloy) were provided for purposes of comparison.

The aforesaid clad products in heat treated (—T6) condition were found to have the following characteristics:

A. Solution potentials

	Volts
Alclad (Al, 1% Zn) 7079–T6:	
Cladding	−0.94
Core	−0.86
Clad (Alloy A) 7079–T6:	
Cladding	−0.98
Core	−0.85

NOTE: Measured against a 0.1 N calomel electrode in 1.0 N NaCl + 0.3% H_2O_2 electrolyte.

B. MECHANICAL PROPERTIES

	T.S. (K s.i.)	Y.S. (K s.i.)	Elong. (percent)
Alclad (Al, 1% Zn) 7079—.085 T6 [1]	71.2	63.0	13.3
Clad (Alloy A) 7079:			
.085 T6 [2]	75.8	68.6	13.0
.085 T6 [3]	76.6	67.6	14.5

[1] Heat treat: 10 min. at 825–840° F.—Quench-aged 48 hrs. at 250° F.
[2] Heat treat: 10 min. at 825–840° F.—Quench-incubate 5 days, aged 48 hrs. at 250° F.
[3] Heat treat: 10 min. at 825–840° F.—Quench-incubate 5 days, aged 8 hrs. at 200° F. +24 hrs. at 250° F.

C. Stress corrosion

Specimens cut in the long transverse direction from each of the sheet materials were subjected to an alternate immersion test (10 minutes each hour in 3½% NaCl solution) under a constant load of 75% of the yield strength, and the results were as follows:

Material	Exposed stress level (K s.i.)	Time to failure
Alclad (Al–1% Zn) 7079–T6	44.2	49–51–79 days.
Clad (Alloy A) 7079–T6	50.6	No failures at 90 days.
Alloy A–T6	41.8	50–43–57.

D. General corrosion

The material clad with alloy A also exhibited good corrosion resistance when totally immersed in Richmond tap water, when exposed for 96 hours in 5% NaCl spray, and when exposed to the 20-hour CASS test.

EXAMPLE II

Following generally the procedure of Example I, additional clad sheets were produced in thicknesses of .063 inch (nominal 2½% cladding), 0.125 inch (nominal 2½% cladding) and 0.188 inch (nominal 1½% cladding), using the following aluminum alloy combinations containing the indicated additional elements:

	Cu	Fe	Si	Mn	Mg	Zn	Cr	Ti	Others (max.)	
									Each	Total
.063 gauge:										
Ingot	.64	.15	.11	.20	3.49	4.67	.15	.05	.05	0.15
Liner	.02	.12	.06	.20	1.24	4.43	.10	.03	.05	0.15
0.125 gauge:										
Ingot	.64	.14	.09	.19	3.61	4.67	.12	.05	.05	0.15
Liner	.02	.12	.06	.20	1.24	4.43	.10	.03	.05	0.15
0.188 gauge:										
Ingot	.69	.14	.10	.21	3.39	4.57	.16	.05	.05	0.15
Liner	.02	.12	.06	.20	1.29	4.42	.11	.03	.05	0.15

Specimens of each have completed more than 117 days without stress corrosion failure, under test conditions described in Example I. Results with respect to solution potential and mechanical properties are given below:

A. SOLUTION POTENTIALS

Gauge	Cladding (volts)	Core (volts)
.063	−1.01	−0.88
0.125	−0.99	−0.88
0.188	−1.00	−0.87

B. MECHANICAL PROPERTIES

Gauge	T.S. (K s.i.)	Y.S. (K s.i.)	Elong. (percent)
.063	79.4	67.0	12.8
0.125	80.0	70.1	11.3
0.188	79.8	68.1	12.0

While present preferred embodiments of the invention have been described, it will be apparent that the invention may be otherwise variously embodied and practiced within the scope of the following claims.

What is claimed is:

1. An article comprising a clad composite having a core composed of a heat-treatable aluminum base alloy consisting essentially of aluminum, zinc, magnesium and copper in amounts up to about 8% zinc, 4% magnesium and 3% copper, by weight, and a cladding composed of a substantially copper-free aluminum base alloy consisting essentially of aluminum, about 4–5.5% zinc and about 1–1.6% magnesium, said cladding alloy having a solution potential of substantially −1.0 volt, and the core alloy being at least about 1/10 volt less electronegative than the cladding, said core and cladding alloys being susceptible to a common solution heat treatment and precipitation hardening practice.

2. An article comprising a clad composite in accordance with claim 1, wherein said cladding alloy also contains about 0.10–.30% manganese, about .05–.20% chromium, up to about 0.20% silicon, and up to about 0.25% iron.

3. An article comprising a clad composite in accordance with claim 1, wherein said cladding alloy contains 4.2–4.8% zinc, 1.0–1.4% magnesium, about 0.10–.30% manganese, about .05–.20% chromium, not more than .05% copper, up to about 0.20% silicon and up to about 0.25% iron.

4. An article comprising a clad composite in accordance with claim 1, wherein said core alloy is selected from the group consisting of aluminum alloys 7001, X7002, 7075, 7079 and 7178.

5. An article comprising a clad composite having a core composed of an aluminum-zinc-magnesium-copper alloy consisting essentially of aluminum and up to about 8% zinc, 4% magnesium and 3% copper by weight, with more zinc than magnesium, and more magnesium than copper, and a cladding adhered to the core, said cladding being composed of an aluminum-zinc-magnesium alloy consisting essentially of aluminum, about 4–5.5% zinc, about 1–1.6% magnesium, and not more than .05% copper, said core alloy having a solution potential less electronegative than the cladding, and said cladding and core alloys being susceptible to a common solution heat treatment and precipitation hardening practice to increase the strength of each.

6. An article comprising a clad composite having a core and cladding each of which is composed of a heat-treatable aluminum base alloy, said cladding alloy consisting essentially of aluminum, about 4–5.5% zinc and about 1–1.6% magnesium, by weight, and having a solution potential of substantially −1.0 volt, said core alloy being at least about 1/10 volt less electronegative than the cladding alloy and consisting essentially of aluminum, zinc, magnesium and copper in amounts up to about 8% zinc, 4% magnesium and 3% copper by weight; said core and cladding alloys being susceptible to a common solution heat treatment and precipitation hardening practice.

7. An article according to claim 6, wherein said core alloy consists essentially of aluminum, about 3.8–4.8% zinc, about 2.9–3.7% magnesium and about 0.40–0.8% copper by weight.

8. An article according to claim 1, wherein said core alloy also contains at least one of the elements manganese and chromium.

9. An article according to claim 5, wherein said core alloy contains at least 0.40% copper by weight.

References Cited

UNITED STATES PATENTS

2,354,006	6/1944	Gauthier	29—197.5
1,997,166	4/1935	Brown	29—197.5
1,865,089	6/1932	Dix	29—197.5

HYLAND BIZOT, *Primary Examiner.*