CLAD COMPOSITES AND ALUMINOUS METAL COMPOSITIONS FOR CLADDING

Original Filed Dec. 23, 1966 2 Sheets-Sheet 1

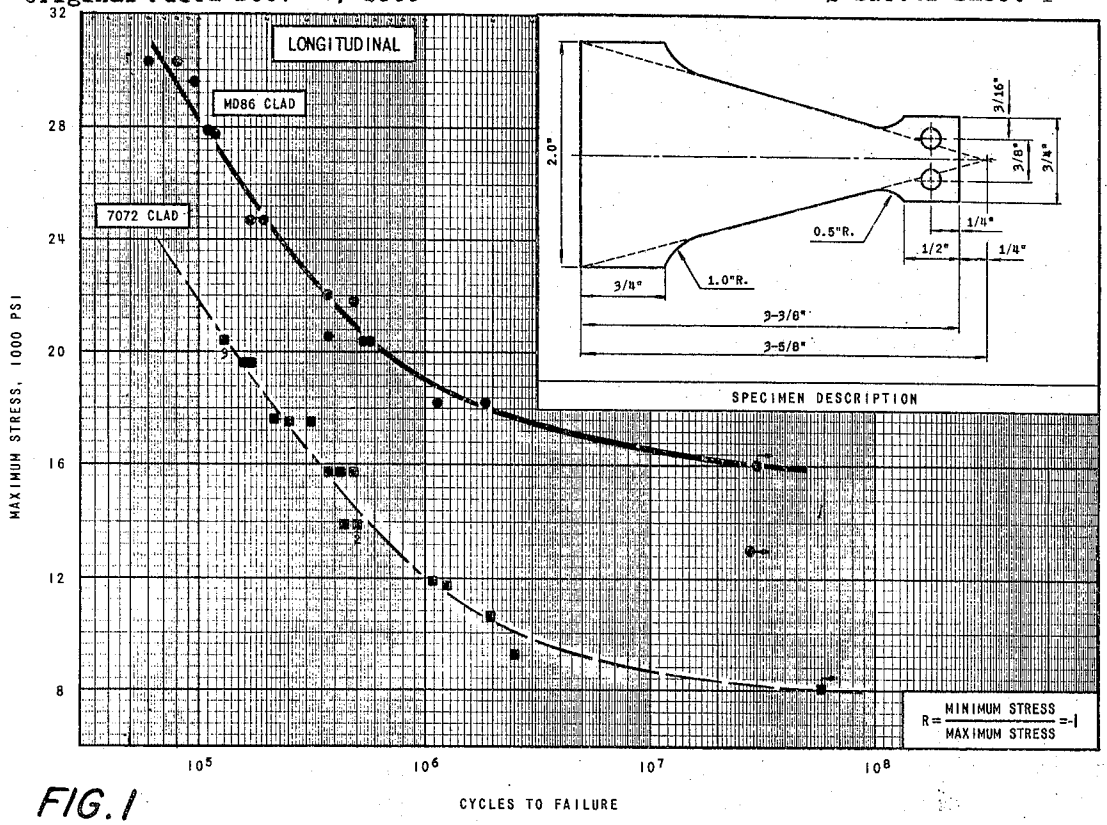


FIG. 1

FLEXURAL FATIGUE
OF 0.063" 7079 ALLOY SHEET CLAD WITH 7072 AND MD86 ALLOYS

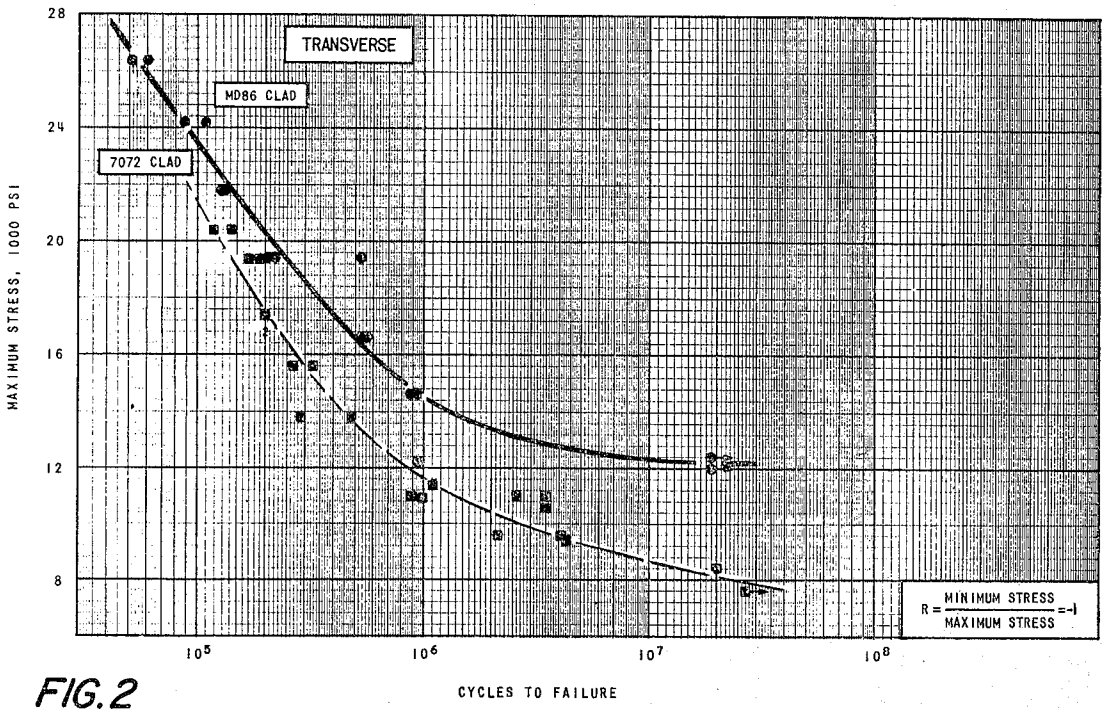


FIG. 2

FLEXURAL FATIGUE
OF 0.063" 7079 ALLOY SHEET CLAD WITH 7072 AND MD86 ALLOYS

CLAD COMPOSITES AND ALUMINOUS METAL COMPOSITIONS FOR CLADDING

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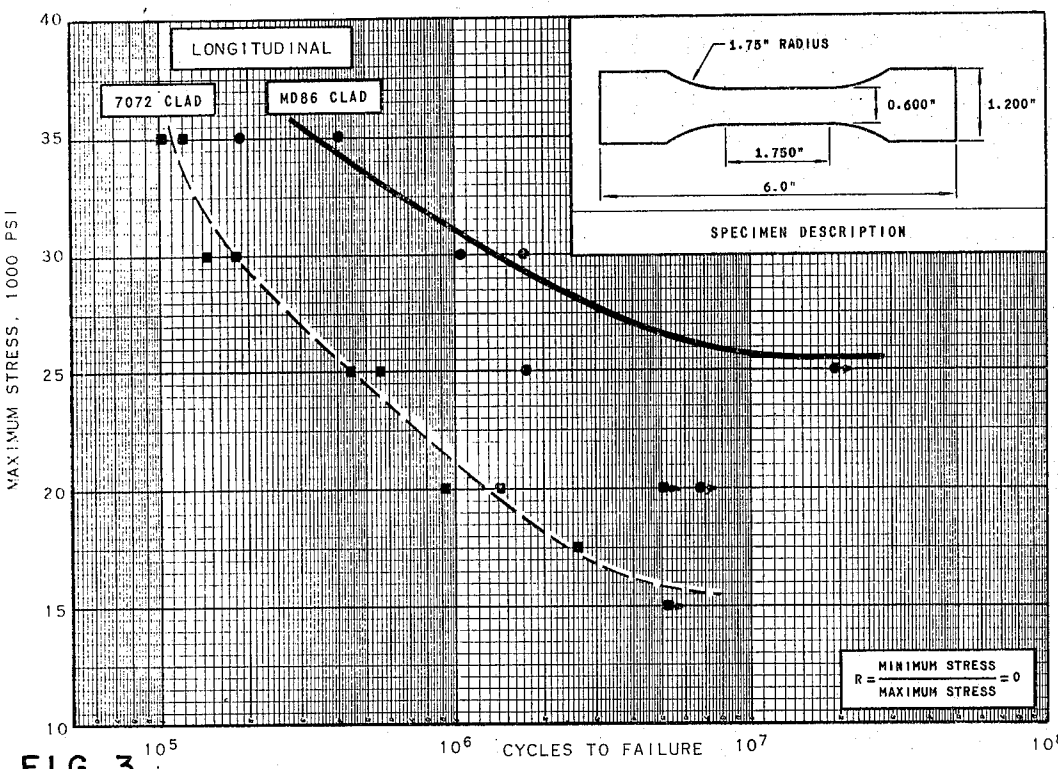


FIG. 3

AXIAL TENSION FATIGUE
OF 0.063" 7079 ALLOY SHEET CLAD WITH 7072 AND MD86 ALLOYS

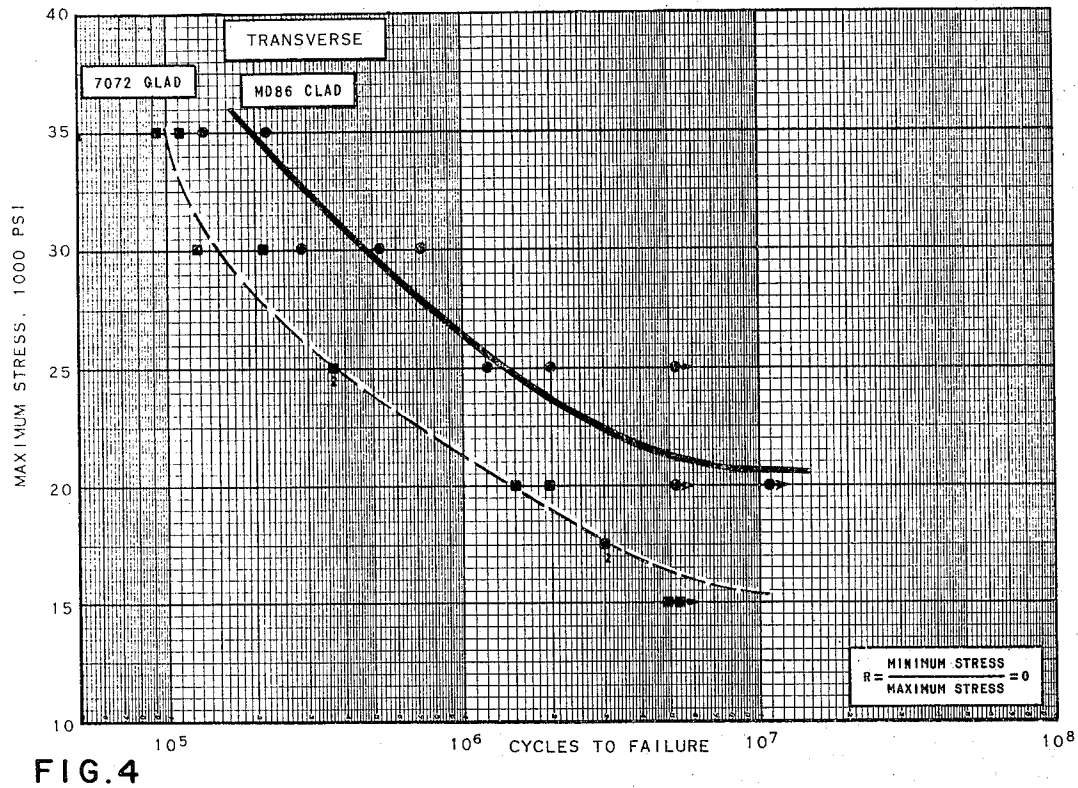


FIG. 4

AXIAL TENSION FATIGUE
OF 0.063" 7079 ALLOY SHEET CLAD WITH 7072 AND MD86 ALLOYS

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CLAD COMPOSITES AND ALUMINOUS METAL COMPOSITIONS FOR CLADDING

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Continuation of application Ser. No. 838,013, June 17, 1969, which is a continuation of application Ser. No. 609,707, Dec. 23, 1966, both now abandoned, which in turn is a continuation-in-part of application Ser. No. 538,085, Mar. 14, 1966, now Patent No. 3,418,090. This application June 1, 1971, Ser. No. 148,868
The portion of the term of the patent subsequent to Dec. 24, 1985, has been disclaimed
Int. Cl. B32b *15/00*
U.S. Cl. 29—197.5 10 Claims

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 allowing elements, clad with an alloy containing about 4–5.5% zinc and about 1–1.6% magnesium; and improved cladding alloys of that type.

This application is a continuation of Ser. No. 838,013 filed June 17, 1969 now bandoned, which is a continuation of Ser. No. 609,707 filed Dec. 23, 1966 and now abandoned, as a continuation-in-part of Ser. No. 538,085 (now U.S. Pat. 3,418,090) filed Mar. 14, 1966. The invention relates to aluminous metal cladding materials and composite 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 any aluminum-zinc-magnesium-copper alloy having an electrode potential less electro-negative than the cladding, preferably by at least about 0.10 volts 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.

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. A further improvement exhibited by such clad composites is a substantial increase in the endurance limit for fatigue purposes, as shown in the accompanying drawings. The results presented in graphical form in the drawings are based on tests described in Example III.

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

EXAMPLE I

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

Cu	0.4
Fe	0.11
Si	0.11
Mn	0.24
Mg	1.22
Zn	5.39
Cr	0.11
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 inches, 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

Alclad (Al–1% Zn) 7079–T6:

	Volts
Cladding	−0.94
Core	−0.86

Clad (Alloy A) 7079–T6:

Cladding	−0.98
Core	−0.85

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

B. Mechanical Properties

	Tensile strength (k.s.i.)	Yield strength (k.s.i.)	Elongation (percent)
Alcad (Al-1% Zn) 7079, .085 T6[a]	71.2	63.0	13.3
Clad (Alloy A) 7079:			
.085 T6[b]	75.8	68.6	13.0
.085 T6[c]	78.6	67.6	14.5

[a] Heat treat: 10 min. at 825-840° F., Quench-aged 48 hrs. at 250° F.
[b] Heat treat: 10 min. at 825-840° F., Quench-incubate 5 days, aged 48 hrs at 250° F.
[c] Heat treat: 10 min. at 885-840° F., quench-incubate 5 days, aged 8 hrs at 200° F. plus 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
Alcad (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, maximum Each	Others, maximum 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	0.6	.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

	Cladding, v.	Core, v.
.063 gauge	−1.01	−0.88
0.125 gauge	−0.99	−0.88
0.188 gauge	−1.00	−0.77

B. Mechanical Properties

	Tensile strength (k.s.i.)	Yield strength (k.s.i.)	Elongation (percent)
.063 gauge	79.4	67.0	12.8
0.125 gauge	80.0	70.1	11.3
0.188	79.8	68.1	12.0

EXAMPLE III

Additional samples from the same lot as the .063 gauge clad sheets of Example II (having the same ingot and liner compositions), as wel las comparison sheets of conventional 7072-clad alloy 7079 also .063" thick, were heat treated at 825–840° F. for about 7 minutes, quenched in water (100° F. max.) and aged in two steps consecutively at about 200° F. for 8 hours and 250° F. for 24 hours. Flexural fatigue and axial tension fatigue specimens were prepared from the thus heat-treated (—T6) materials, the configuration of the fatigue specimens being shown in FIGS. 1 and 3 of the accompanying drawings. In the drawings, the designation MD86 is employed to denote the products having a cladding layer in accordance with the invention.

Both longitudinal and transverse specimens were tested in each case. Prior to testing, the specimens were deburred and edges smoothed with 600 grit emery paper.

The axial fatigue tests were done on an Amsler Vibrophore operated at a frequency of approximately 110 cycles per second.

The flexural fatigue tests were done on Krouse machines at a frequency of 1725 cycles per minute, with each specimen loaded as a cantilever beam.

The results of the flexural fatigue tests are displayed graphically in the drawings, where it can be seen (FIG. 1) that the endurance limit at 10,000,000 cycles, with a minimum-to-maximum stress ratio of minus one (R=—1) was about 16,000 p.s.i. (longitudinal) for the products of the invention, compared to only about 8000 p.s.i. for the conventional material under the same test conditions; and (FIG. 2) about 12,000 p.s.i. (transverse) compared to somewhat less than 8000 p.s.i.

The corresponding axial fatigue data for 10,000,000 cycles (and R=0) were about 25,000 p.s.i. (longitudinal) and about 20,000 p.s.i. (transverse), compared to about 15,000 p.s.i. (both longitudinal and transverse) for the conventional material. These data are shown graphically in FIGS. 3 and 4.

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. A heat-treated clad composite article having aluminum alloy core and cladding layers strengthened by solution heat treatment and precipitation hardening, said article comprising a core composed of an 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 providing sacrificial protection of the core, said article in its heat treated condition exhibiting flexural fatigue properties of at least about 16,000 p.s.i. (longitudinal) and at least about 12,000 p.s.i. (transverse) at 10,000,000 cycles with a minimum-to-maximum stress ratio of minus one.

2. An article according to claim 1 wherein said core alloy contains about 2–4% magnesium.

3. An article according to claim 2 wherein said core alloy has a solution potential of about −0.85 to −0.88 volts.

4. An article comprising a heat treated clad composite having a core composed of an 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 providing sacrificial protection of the core, said article having both said core and cladding alloys strengthened by solution heat treatment and precipitation hardening.

5. The article of claim **4** in which the cladding alloy has silicon, iron and copper not exceeding about 0.20% silicon, about 0.25% iron and about .05% copper.

6. The article of claim **4** in which the cladding alloy includes about 0.10–.30% manganese.

7. The article of claim **4** in which the cladding alloy includes about .05–.20% chromium.

8. The article of claim **4** in which the cladding alloy consists essentially of aluminum, about 4–5.5% zinc, about 1–1.6% magnesium, about 0.10–30% manganese, and about .05–.20% chromium, by weight, with copper not exceeding .05%, and with silicon up to about 0.20% and iron up to about 0.25%.

9. The article of claim **8** in which the cladding alloy has 4.2–4.8% zinc.

10. The article of claim **8** in which the cladding alloy has 1.0–1.4% magnesium.

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HYLAND BIZOT, Primary Examiner

U.S. Cl. X.R.

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