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Aluminum clad zinc bimetallic planchet

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Abstract

A composite metal laminate planchet comprises commercially pure aluminum cladding layers metallurgically bonded to zinc or a zinc alloy core. The zinc alloy core may contain a hardening agent, such as copper, aluminum or titanium, used to increase the hardness of the alloy above that of pure zinc. Trace amounts of other elements may also be present in the zinc alloy core or in the commercially pure aluminum cladding layers which do not affect their pertinent properties. The bimetallic is produced by a process comprising providing a strip or sheet of a zinc alloy core and creating a strip or sheet of composite material by metallurgically bonding commercially pure aluminum cladding layers to the zinc alloy. The bimetallic material can be applied for manufacturing keys, coins or any architectonical application. The bimetallic is fully recyclable.

Keywords: Sandwich structures; Scanning electron microscopy; Zinc–aluminum alloys; Adhesion

1. Introduction

The realization that two metals can be joined together by cladding during rolling or extrusion has gained special importance for heavy metals. Copper sections clad with silver for electrical contacts are produced in this way in a wide variety of shapes. Recently, the plating of copper onto aluminum has been developed. The cladding is usually a layer on each side of the core alloy and usually comprises 2.5–5% of the total thickness. This thickness is enough to protect the zinc alloy and give a good combination of mechanical properties to the surface for minting. The process requires the clean and oxide-free contacting surfaces of the two metals forming the billet to be enlarged during deformation and new surfaces formed. These weld together under the action of the pressure and temperature. The flow stresses of the two metals must be similar [1].

The present work is directed to develop an article and a process that satisfy the need for an inexpensive, tarnish resistant, wear resistant, sufficiently hard, composite metal laminate material which is silver in color, does not require secondary annealing, and has a composition such that the byproduct of its production process has economic value. The article comprises a two commercially pure aluminum cladding layers, bonded by pressure, to a zinc or zinc alloy core. The combination of the zinc alloy core and the commercially pure aluminum cladding layers is ideal for the manufacturing of architectural profiles, keys or coin planchets. The zinc alloy and commercially pure aluminum are inexpensive, silver in color, and sufficiently hard. Zinc and zinc alloys are heavier than the commercially pure aluminum, so the ratio of each may be adjusted to achieve an acceptable weight for a given application. Further, the tarnish resistance of the commercially pure aluminum cladding layers compensates for the zinc alloy's poor tarnish resistance.

2. Materials and methods

The zinc alloy used in the present work is Zn–21wt.%Al–2wt.%Cu (zinalco). This alloy is a high resistant Zn alloy (yield strength of 400 MPa) and a moderate density (5.4 g/cm^3) [2]. Below 550 K the alloy shows a microstructure (Fig. 1) composed of a Al solid solution (α) and a zinc solid solution (γ), with small amounts of the intermetallic $CuZn_4$

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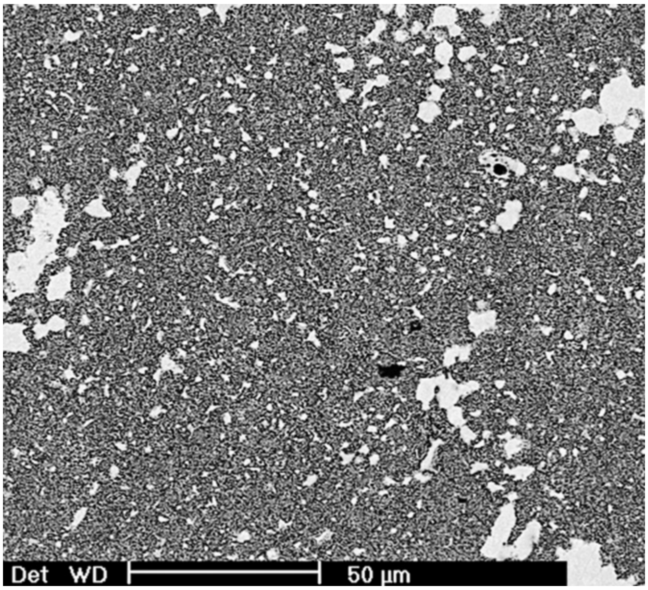

Fig. 1. Microstructure of the zinalco alloy before cladding. Aluminum is dark and zinc is bright.

(ε). After 550 K the alloy shows an eutectic phase transformation. The high temperature phase (β) can be described as an aluminum fcc distorted structure [3].

The strength of the zinalco alloy decrease with the temperature (Fig. 2), reaching a yield strength of 10 MPa at 530 K. After 550 K the strength increases slightly (up to 25 MPa at 630 K) [4]. Zinc and zinalco alloy, however, are not tarnish resistant. When they are exposed to the atmosphere, the surface of these materials, becomes dull gray in color in a relatively short period of time. Because a planchet with a dull gray finish is not desirable or marketable, the zinc alloy core is combined with a cladding of aluminum that is tarnish resistant.

The core material used in the present work, was commercial zinc high grade and zinalco alloy (Zn–21wt.%Al–2wt.%Cu) prepared from aluminum and copper of commercial purity. The aluminum cladding layers (upper and lower) are composed of commercially pure aluminum, which is at least about 98.5% aluminum. Commercially pure aluminum is silvery-white. Further, this aluminum is relatively inexpensive and is of sufficient hardness to ensure a long life and to allow to the products manufactured with it, also has excellent resistance to corrosion and tarnishing, providing a long lasting lustrous finish. Additionally, commercially pure aluminum is relatively lightweight.

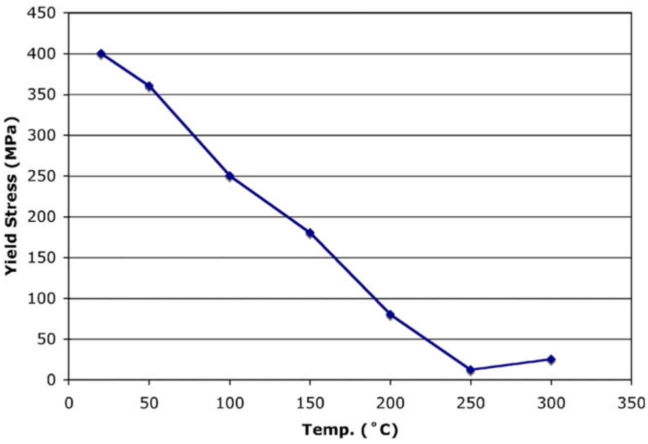

Fig. 2. Changes of the yield strength of the zinalco alloy with temperature.

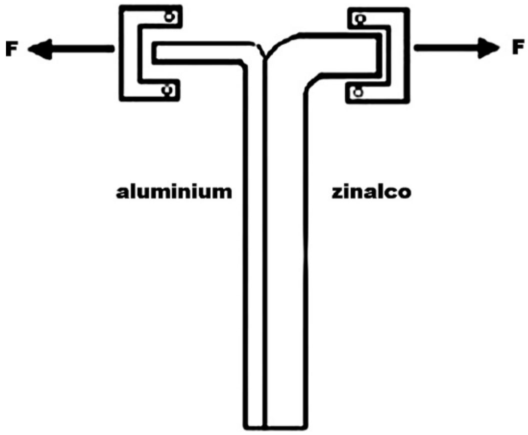

Fig. 3. System used for measurement of the bonding force required to separate the aluminum from the zinalco.

Zinc and zinalco alloys billets of 25 mm wide, 100 mm length and with a thickness of 5 mm, was used as core material and aluminum sheet as the sheath material. The initial thickness of sheath material was 0.6 mm. The aluminum sheet were fixed at both sides of the zinc billet and then rolled [5]. The range of rolling temperature was varied from 400 K to 480 K for the pure zinc and from 500 K to 650 K for the zinalco alloy. At this range of temperature zinc and zinalco shows a strength similar to the aluminum strength. A thickness reduction of 50% was applied in one pass. After rolling the bonding strength test for the specimens produced under different rolling temperatures was performed peeling the aluminum layer (ASTM D1876, 1983), as is shown in Fig. 3. Another simple way to fix the aluminum to the surface of zinc or zinc alloy was using thermal spraying and then rolling at room temperature. This may be an easier way for commercially production of the bimetallic.

3. Results and discussion

Fig. 4 is a side view of one embodiment of the resultant planchet, made of a zinc alloy (zinalco) core having opposed sides, a first aluminum cladding layer, and a second aluminum cladding layer. Zinalco core, shows two phases, aluminum dark and zinc bright.

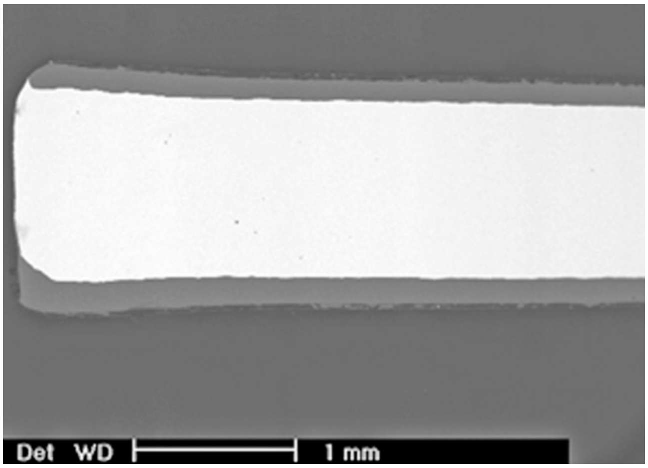

Fig. 4. Transversal section of the bimetalic Al–zinalco–Al.

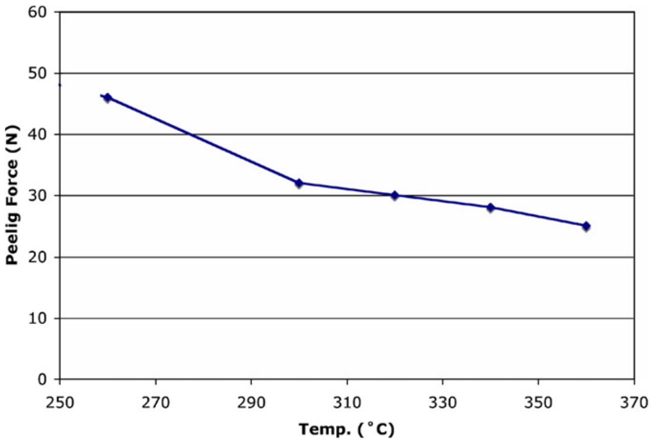

Fig. 5. The peeling force to separate the aluminum sheath from the zinalco core vs the rolling temperature.

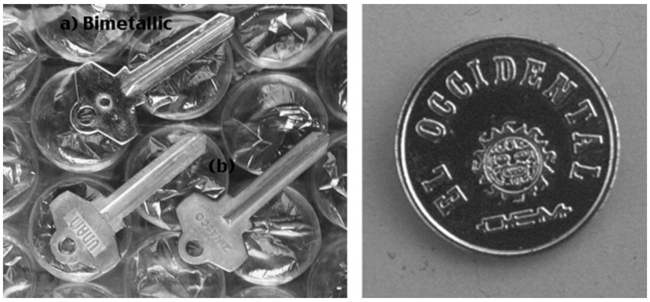

Fig. 6. Left, keys elaborated with aluminum clad zinalco (a) and without cladding (b). Right, token minted on bimetallic aluminum clad zinc planchet.

Some zinc diffusion in aluminum is expected take place at room temperature increasing the hardness of the aluminum coat after several months.

The flow stress of aluminum was 30–15 MPa in pure aluminum and 35–25 MPa in zinalco between 500 K and 650 K. Therefore, the flow stress ratio is close to 1 at this temperature range. The required stress to tear out the aluminum sheath from the zinalco core, is 50 N when rolling at 520 K and decreases to 25 N when rolling is performed at 650 K. It suggested that the phase transformation that takes place at 549 K, in the core material during the cooling of the bimetallic sheet after rolling, affects the strength of the bonding (Fig. 5).

The yield strength of the zinalco alloy is around 400 MPa at room temperature, so the bimetallic zinalco–aluminum give us a high strength-low density (5.4 g/cm^3) material, with a great variety of applications in the automotive industry, building and construction or the manufacturing of low cost keys.

The required force to peeling off, the Al sheath from a pure zinc core was 40 N at any of the temperatures used in this work.

The bimetallic zinc–aluminum is a heavy and soft planchet with excellent applications in the coin production Fig. 6 is a top plan view of some products produced with this bimetallic.

Scrap may be reused or sold. This economic benefit is obtained by heating the scrap above its melting point, which produces a zinc–aluminum alloy desired in the die-casting industry. Zinc–aluminum die-cast products are extensively used in the automotive, architectural, aeronautical, and other industries.

4. Conclusions

In this study, the optimum rolling conditions to obtain an optimum bimetallic planchet, were determined that the rolling temperature was around 550 K ± 20 for the alloy Zn–21Al–2Cu, and 480 K ± 20 for the zinc. On this rolling conditions the bonding force was around 50 N for aluminum–zinalco and 40 N for aluminum–zinc bimetallic planchet

Acknowledgements

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