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COATED ALUMINUM PRODUCT

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The present invention relates to coated aluminum products, and more particularly to coated aluminum alloys with a corrosion resistant protective layer having high tensile strength.

It is well known in the art that the problem of utilizing aluminum in the structural field has been divided into two parts. One problem concerned the production of aluminum alloys of high tensile strength and the other concerned increasing the corrosion resistance of aluminum products. The problem of increasing the tensile strength of aluminum products was met by the introduction of various alloys, such as the duraluminums. However, such alloys have unfortunately been subject to more corrosion than pure aluminum. It seemed that as the tensile strength increased the resistance to corrosion decreased. It was then suggested that aluminum alloys having high tensile strength but a low resistance to corrosion should be clad with an aluminum coating of high corrosion resistance. This practice resulted in a sacrifice in tensile strength. It has been known that such a protective coating has been comparatively thin, but in the aircraft art even such a thin coating has constituted an important part of the cross-section of the article, especially when the difference in tensile strength of the base element and the coating is considerable. For example, a coating having a thickness of 5% of the cross-section of the base element, the coating represented 10% of the total cross-section of the article. When pure aluminum was used as the coating, the loss in tensile strength can be appreciated by comparing the tensile strength (10 kgms. per square millimeter) of pure aluminum with the tensile strength (45 kgms. per square millimeter) of duraluminum. This loss in tensile strength has been known to constitute an important factor in the construction of aircraft. The realization of the importance of such a loss led to the proposal to use alloys such as those which contain about 1% magnesium and about 1% manganese having a tensile strength of about 20 to about 22 kgms. per square millimeter and possessing resistance to corrosion as a protective coating. However, it was recognized very quickly that such alloys had little chance of greater success since the resistance of the protective coating to corrosion was reduced after application to the base element, espe-

cially when the articles were annealed. The experience of the art with these alloy protective coatings was practically the same as with pure aluminum. The reduction of corrosion resistance of such magnesium-manganese alloys as with pure aluminum coatings was probably due to the diffusion of copper from the base element into the protective coating. This diffusion became particularly noticeable when annealing such composite articles because in annealing aluminum alloys containing copper and magnesium, temperatures above 400° C. were required and at these temperatures there was some softening of the alloys. In as much as the protective coating had to be as thin as possible in order to reduce the loss of tensile strength, there was the danger that copper might diffuse to the very surface of the protective coating when the annealing operation was prolonged with the consequent loss of corrosion resistance which the virgin coating possessed. For the purpose of reducing or preventing the diffusion, and of maintaining the resistance to corrosion, it was suggested to interpose another layer between the base element and the protective coating. This increased the cost of manufacture considerably. To escape this difficulty, attempts were made to use aluminum alloys containing 1 to 4% manganese, 0.5 to 6% magnesium, and up to 1% antimony. These protective coatings had the shortcoming that copper had to be absent for wholly satisfactory results. The explanation for this improvement was the subject of discussion and was thought to be the result of the presence of magnesium in the aluminum in solid solution. However, no one ventured to suggest that the use of high magnesium content alloys or the increase of the magnesium content above 6% would result in almost complete elimination of diffusion of copper into the protective layer while at the same time retaining an equal measure of corrosion resistance and tensile strength. The expert authorities in this field rejected the suggestion that alloys containing more magnesium would be more resistant to diffusion and thus to lowering of the corrosion resistance as unlikely. As a matter of fact, one expert authority known throughout the world for his researches in the field of aluminum alloys, stated that he had little confidence in the so-called "high magnesium"

aluminum alloys containing up to 6% magnesium particularly because of manufacturing difficulties. There seemed to be no reason to expect that increasing the magnesium content above 6% would make any marked improvement in the qualities of the alloy. The use of magnesium-aluminum alloys of the magnalium type as protective coatings for copper-aluminum alloys of the duralumin type presented many manufacturing difficulties. Among them perhaps the most serious was the lowering of the resistance to corrosion of the protective coating on annealing and the reduction of the tensile strength of the coated article compared with the uncoated base element. Although many proposals have been made, none, as far as I am aware, has been wholly successful and satisfactory when carried into industrial practice for the production of commercial products.

I have discovered that a coated aluminum article may be produced the tensile strength of which is substantially as great as that of the base element and the corrosion resistance of the coating is not substantially reduced even after annealing.

It is an object of the present invention to provide an article of manufacture with a protective coating for an aluminum alloy with a high resistance to corrosion.

It is another object of the present invention to provide an article of manufacture with a protective coating for an aluminum alloy substantially insensitive to the diffusion of copper.

It is a further object of the present invention to provide an article of manufacture with a protective coating of an aluminum alloy having a high tensile strength.

Other objects and advantages of the invention will become apparent from the following description.

Broadly stated, it has been discovered that the loss of resistance to corrosion of aluminum and aluminum alloy coatings on copper-bearing aluminum articles may be substantially eliminated. As a result of extended research and prolonged experimental investigation concerning the effect of increasing the magnesium content of aluminum alloys, an article constituted of a copper-bearing aluminum alloy coated with an aluminum alloy of high corrosion resistance in which the corrosion resistance of the coating is not substantially reduced when in contact with the base element was found. Contrary to the beliefs of the art and the expectations and predictions of expert authorities, it has been discovered that a high magnesium alloy or a magnesium content above 6% does substantially eliminate the reduction of corrosion resistance of aluminum alloy coatings by practically prohibiting the diffusion of copper from the base element into the protective coating. Thus, it is possible with the use of the present invention to produce a coated duralumin article, for example, in which the magnesium aluminum alloy coating has substantially the same corrosion resistance as such a magnesium aluminum alloy has when not in contact with a copper-bearing aluminum alloy. This discovery has the additional benefit of increasing the ease with which alloys of the duralumin type may be protected with corrosion resistant coatings and provides a means of maintaining the high tensile strength of the base element. Those skilled in the art will appreciate that this is an important factor, particularly in the problem of aircraft design. The advantage is readily

seen by comparing the tensile strength of duralumin with that of the various coatings which have been provided for the protection of copper-bearing alloys from corrosion.

Alloy	Tensile strength kgms./sq. mm.	Permeability to copper diffusion
Duralumin.....	22-24	Permeable.
Duralumin.....	45	Do.
Pure aluminum.....	10	Do.
Aluminum containing 1% magnesium 1% manganese.	20-22	Less permeable.
Aluminum containing more than 6% magnesium.	30-35	Impermeable.

In addition to a high tensile strength, aluminum alloys of the type containing more than 6% of magnesium have a Brinell hardness in excess of prior aluminum coatings.

The present invention contemplates coating aluminum alloy articles of high tensile strength and comparatively low resistance to corrosion with aluminum alloys containing from about 6.5% to about 12% or 13% magnesium. Such coatings may be applied by any of the well-known methods, such as welding, rolling, etc. as those skilled in the art know. In some instances, a binder of pure aluminum may be used in welding such coated articles.

For the purpose of giving those skilled in the art a better understanding of the invention, the following illustrative examples will now be given.

A rolled plate, about 70 mm. thick, of an aluminum alloy containing 4% of copper, 0.6% of manganese, 0.5% of magnesium and the usual impurity content of silicon and iron is carefully cleaned by milling and brushing. Thereupon this plate is enveloped on all sides with a clean brushed sheet, about 5 mm. thick, of a magnesium-aluminum alloy, containing about 7% of magnesium and as free as possible from the usual impurities, and the whole is next heated in a furnace at a temperature of about 350 to 500°. When the plate has been uniformly heated throughout and all parts thereof have reached this temperature, it is immediately placed between rollers and rolled down hot.

When employing an intermediate layer of pure aluminum, the rolled plate of alloy of the duralumin type is first enveloped in a very thin sheet of pure aluminum, of a thickness of for example about 0.5 mm. Only then is the sheet of magnesium-aluminum alloy fitted around the plate, the whole being now brought to welding temperature and hot-rolled.

In addition to the alloys hereinbefore specified, such as contain about 3.5 to 4.5% Cu, 1.3% Mn, 1.1 to 1.3% Mg. and 0.4 to 0.8% Si are suitable for the core alloy. Alloys containing only 4% of copper, 2% of magnesium and 2% of nickel, i. e. the so-called Y-alloys, may also be used as core material in view of their excellent strength properties.

Alloys high in magnesium are particularly suitable for the covering metal. Apart from the alloys hereinbefore mentioned, there are those containing 7% and also those containing 8 or 9% of magnesium. Such alloys may also contain some manganese, say 0.8%.

After the plates have been rolled in usual manner the edges are trimmed off, whereupon the sheets of clad metal are ready for use.

The procedure is the same in the production of pressed sections. For this purpose the core and covering material are placed in the press one upon the other and side by side in the usual

manner well known in the art, and then pressed all together.

Although the present invention has been described in connection with a preferred embodiment, it is to be understood that variations and modifications may be resorted to as those skilled in the art will readily understand. Such variations and modifications are considered to be within the purview and scope of the appended claims.

I claim:

1. As a new article of manufacture having high tensile strength and high corrosion resistance, a composite aluminum article comprising a base element of aluminum alloy containing copper and a welded coating of a magnesium-aluminum alloy substantially devoid of zinc and containing more than about 6% to about 13% of magnesium said composite article having substantially the same tensile strength per unit of cross section as the uncoated base element.

2. As a new article of manufacture having high tensile strength and high corrosion resistance, a composite article of aluminum alloys comprising a base element of aluminum alloy containing copper having high tensile strength and low corrosion resistance and a coating of a magnesium-aluminum alloy substantially devoid of zinc and containing about 7% of magnesium, said base and said coating being joined by welding said base, coating and an interposed sheet of originally pure aluminum having a thickness of about 1% of the thickness of said base, and forming a composite article, said composite article having a tensile strength per unit of cross section substantially the same as the uncoated base element.

3. As a new article of manufacture having high tensile strength and high corrosion resistance, a composite article of aluminum-bearing material comprising a base element of aluminum alloy containing copper and an aluminum alloy substantially devoid of zinc and containing more than about 6% to about 12% of magnesium, said base element and said coating being mutually bonded by welding to a thin intermediate layer of originally pure aluminum.

4. As a new article of manufacture having high tensile strength and high corrosion resistance, a composite article comprising a base element of aluminum alloy containing copper having high tensile strength and low corrosion resistance and a welded coating of an aluminum alloy substantially devoid of zinc and containing more than about 6% to about 12% magnesium.

5. As a new article of manufacture having high tensile strength and high corrosion resistance, a composite article comprising a base element of aluminum containing copper having high tensile strength and low corrosion resistance, a coating of aluminum material substantially devoid of zinc and containing more than about 6% to about 12% magnesium and an intermediate layer of originally pure aluminum, said base element and said coating being bonded by welding to said intermediate layer, said intermediate layer having a zone of diffused copper from said base element and a zone of diffused magnesium from said coating inhibiting further diffusion of copper.

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