United States Patent Office

2,849,790

Patented Sept. 2, 1958



2,849,790

# JOINTS BETWEEN IRON AND LIGHT METALS

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No Drawing. Application February 7, 1955
Serial No. 486,712

Claims priority, application Germany February 8, 1954

17 Claims. (Cl. 29—196.2)

This invention relates to joints between iron and light metals, as well as to intermediate products which may be used for making such joints and to processes for making such joints and intermediate products.

The adherence of light metals, particularly of aluminum and its alloys, when cast on iron and steel involves difficulties. Various processes have been suggested to enable a bond casting to be made which has sufficient adherence. For instance, a well-cleaned iron surface was dipped in aluminum or aluminum alloys under conditions causing the formation of an iron aluminide layer and the aluminum was cast on that iron aluminide layer before the aluminum or aluminum alloy adhering to the layer was permitted to solidify.

Such process requires quick work to avoid the solidification of the aluminum adhering from the application of the iron aluminide layer. Particularly where the light metal is to be cast around small parts and in the case of intricate castings these temperature requirements can be fulfilled only with difficulty or not at all.

Another process is known in which the layer produced by dipping need not be maintained liquid because after the formation of the iron aluminide layer a tin coating is applied which may solidify and on which the light metal is cast.

It is also known to dip the iron articles into a molten zinc-aluminum alloy and to cast the aluminum on that zinc-aluminum interlayer. However, that method has not provided a perfect bond between the iron base metal and the aluminum; more particularly, it does not give a serration bond which is desired for good adherence and good heat transfer.

It is an object of the invention to provide a bonding layer which forms a serration bond on one side with iron and on the other side with light metal when the material of the bonding layer is applied in a liquid state on an iron surface, even if the same is solid, and if light metal is applied in a liquid state on the bonding layer, even if the same is solid.

Other objects of the invention will become apparent as the specification proceeds.

The invention is based on the surprising discovery that the above object is fulfilled by a bonding layer consisting of an alloy of at least two elements of the group consisting of tin, zinc, and cadmium, with an addition consisting of at least one element of the group consisting of the rare earth elements, alkali metals, and alkaline earth metals. A preferred alloy of this type contains up to 50%, preferably 20–30% zinc and besides said zinc and addition consists substantially of tin. The said addition may be present in the alloy in an amount of between 0.01 and 5%, preferably of the order of 0.5%. The said addition consists preferably of rare earth elements.

Therefore, the invention teaches to provide on an iron surface a bonding layer well bonded thereto and adapted to give a good bond with light metal when the same is applied in a liquid state on said bonding layer, by contacting said iron surface with the bonding layer alloy



described hereinbefore in a liquid state. When contacted by said liquid alloy the iron surface should be in an oxide-free condition. Preferably the iron surface is contacted by said liquid alloy in a zone which contains said liquid alloy and has relative movement to said iron surface.

The invention further provides a process of joining light metal to iron by applying said light metal in a liquid state on a surface of an iron article covered by a bonding layer consisting of the alloy described hereinbefore.

The invention further provides an article of manufacture having an iron surface covered by a bonding layer well bonded thereto and adapted to give a good bond with light metal when the same is applied in a liquid state on said bonding layer, which bonding layer consists of the alloy described hereinbefore.

The invention also provides a joint between iron and light metal, which comprises an interlayer consisting of the alloy described hereinbefore and contacted on one side by iron and on the other side by light metal.

Other aspects of the invention will become apparent as the specification proceeds.

In this specification and the appended claims, the term "iron" includes also the meaning of "steel," the term "rare earth elements" is restricted to the elements with atomic numbers from 57 to 71, the term "alkali metals" includes also "lithium," and the term "alkaline earth metals" includes also "magnesium."

It has been found that a particularly good adherence between iron and steel and a light metal, particularly aluminum or an aluminum alloy, is obtained when the iron surface, which should preferably be cleaned and more particularly be free from scale, is dipped first into a melt of an alloy containing tin and/or zinc and/or cadmium, preferably tin and zinc, with an addition of rare earth elements, particularly a mixture of rare earth elements including cerium, for instance in an amount of 0.01–5%, preferably 5%, followed by casting the light metal on the interlayer thus applied. Desirably the iron article is moved in the molten alloy containing the rare earth elements. The light metal can be cast on the iron article while the latter is at room temperature or, preferably, at an elevated temperature, e. g. 100–150° C., to eliminate any moisture which may adhere to the surface.

The rare earth elements may be replaced by alkali metals, including lithium, and/or by alkaline earth metals, including magnesium, or may be used together with alkali metal or alkaline earth metal additions in the alloy. These components of the alloy are used in about the same quantities as the rare earth elements. The light metal may, but need not be cast on the interlayer while the latter is still liquid.

The casting step need not immediately follow the application of the interlayer. The parts provided with the interlayer may be stored and have light metal cast around them at a later time. Owing to the low melting point of the interlayer it may be desirable to quench after dipping into the melt, e. g. by dipping in water.

It may be desirable to clean the iron surface before the interlayer is applied and particularly to eliminate oxide skins, i. e., layers of low oxides of iron, which might adversely affect the application and adherence of the interlayer. To this end an aqueous salt solution is preferred, which reduces the lower oxides of iron, e. g. an aqueous solution of zinc chloride. For instance, the solution may be applied to the surface and then the iron article may be dried in a furnace. At temperatures of, e. g., 100° C. the lower oxides of iron will be reduced. The surfaces thus treated can be dipped into the molten metal without a separate rinsing step.

By the addition of rare earth elements, particularly in a mixture including cerium, a fine serration bond with both metals is obtained, as may be seen from the photo-micrographs of the compound castings. Whereas an iron aluminide layer forms a serration bond only with the iron, not with the aluminum cast thereon, the compound castings made by the process according to the invention show a good serration bond between the interlayer and the iron and between the interlayer and the light metal.

Tin-cadminum alloys or zinc-cadmium alloys or tin-zinc-cadmium alloys may be used with similar results as are obtained with tin-zinc alloys, if rare earth elements and/or alkali metals and/or alkaline earth metals are added to said base alloys.

The invention may be illustrated with reference to the following examples:

*Example 1*

An aluminum part is to be cast on a steel bolt. To this end the steel bolt is first dipped into an alloy of 74.5% tin, 25% zinc, 0.5% of a rare earth element mixture containing cerium. The molten alloy is maintained at 700° C. and the steel bolt is dipped into and moved in that melt. Portions which require no bonding layer because no light metal is to be cast around them are previously covered with a kaolin layer.

After a dip of three minutes the bolt was removed from the melt, allowed to cool, placed into a chill mold at room temperature, and cast around with pure aluminum. When the adherence of the compound casting was inspected, a photo-micrograph showed a fine serration between the interlayer and the iron base material and a considerable serration between the interlayer and the aluminum cast thereon. When it was attempted to pull the bolt out from the aluminum the adherence proved so strong that no crack occurred at the junction but the aluminum was torn apart in the base material when it was under a load of 2.7 tons.

*Example 2*

An aluminum-silicon alloy is to be cast around a cast iron core. The cast iron core is first covered with an aqueous 1% zinc chloride solution, the water of which is removed by drying at 110° C. The bright cast iron, from which the oxides had been removed, was dipped for five minutes into a melt of 69% tin, 30% zinc, and 1% rare earth element mixture including cerium, and was moved in the melt. The melt had a temperature of 400° C. After the removal from the melt the surplus liquid metal adhering was thrown off and the casting was quenched in water. After the casting had been heated to 120° C. it was placed into the chill mold and an aluminum alloy containing 12% silicon was cast around it.

Other examples of alloys for the bonding layer are

(1)
15% zinc
84.5% cadmium
0.5% rare earth elements

(2)
3% cadmium
30% zinc
66% tin
1% rare earth elements

What is claimed is:

1. A process of providing a bonding layer on an iron surface for bonding with light metal cast thereon, comprising contacting said iron surface with a molten alloy consisting essentially of tin, at least one metal selected from the group consisting of cadmium and zinc, the selected metal being present in an amount up to 50% when the selected metal is zinc and the selected metal being present in an amount up to 84.5% when the selected metal is cadmium, and between about 0.01% and 5% of a rare earth.

2. The process set forth in claim 1 in which said molten alloy contains 20% to 30% zinc.



3. The process set forth in claim 1 in which said iron surface is treated with an aqueous salt solution for reducing iron oxides on said iron surface prior to contacting said iron surface with said molten alloy.

4. The process set forth in claim 3 in which the salt solution is an aqueous zinc chloride solution.

5. A process of providing a bonding layer on an iron surface for bonding with a light metal cast thereon, comprising contacting said iron surface with a molten alloy consisting essentially of zinc in an amount up to 50%, a rare earth in an amount between 0.01% and 5%, and tin.

6. A process of providing a bonding layer on an iron surface for bonding with a light metal cast thereon, comprising contacting said iron surface with a molten alloy consisting essentially of zinc in an amount of up to 50%, tin, and at least one metal selected from the group consisting of alkali metals and alkaline earth metals in an amount between 0.01% and 5%.

7. A process of providing a bonding layer on an iron surface for bonding with a light metal cast thereon, comprising contacting said iron surface with a molten alloy consisting essentially of zinc in an amount of up to 50%, an alkaline earth metal in an amount between 0.01% and 5%, and tin.

8. A process of providing a bonding layer on an iron surface for bonding with a light metal cast thereon, comprising contacting said iron surface with a molten alloy consisting essentially of zinc in an amount of up to 50%, an alkali metal in an amount between 0.01% and 5%, and tin.

9. A process of providing a bonding layer on an iron surface for bonding with a light metal cast thereon, comprising contacting said iron surface with a molten alloy consisting essentially of zinc in an amount of up to 50%, cadmium in an amount up to 84.5%, and between about 0.01% and 5% of a rare earth.

10. A process of providing a bonding layer on an iron surface for bonding with a light metal cast thereon, comprising contacting said iron surface with a molten alloy consisting essentially of zinc in an amount up to 50%, cadmium in an amount up to 84.5%, and between about 0.1% and 5% of at least one metal selected from the group consisting of alkali metals and alkaline earth metals.

11. A process of providing a bonding layer on an iron surface for bonding with a light metal cast thereon, comprising contacting said iron surface with a molten alloy consisting essentially of about 15% zinc, about 84.5% cadmium, and about 0.5% of at least one rare earth.

12. An article of manufacture comprising a ferrous metal body having an iron surface united with a bonding layer of an alloy consisting essentially of tin, at least one metal selected from the group consisting of zinc and cadmium, said selected metal being present in an amount up to 50% when the selected metal is zinc and said selected metal being present in an amount up to 84.5% when the selected metal is cadmium, and between about 0.01% and 5% of a rare earth, the alloy also being bonded to a light metal to unite the light metal with the ferrous metal.

13. An article of manufacture comprising a ferrous metal body having an iron surface united with a bonding layer of an alloy consisting essentially of tin, at least one metal selected from the group consisting of zinc and cadmium, said selected metal being present in an amount up to 50% when the selected metal is zinc and said selected metal being present in an amount up to 84.5% when the selected metal is cadmium, and between about 0.01% and 5% of at least one metal selected from the group consisting of alkali metals and alkaline earth metals, the alloy also being bonded to a light metal to unite the light metal with the ferrous metal.

14. An article of manufacture comprising a ferrous metal body having an iron surface united with a bonding layer of an alloy consisting essentially of tin, zinc

in an amount up to 50%, between 0.01 and 5% of an alkali metal, the alloy also being bonded to a light metal to unite the light metal with the ferrous metal.

15. An article of manufacture comprising a ferrous metal body having an iron surface united with a bonding layer of an alloy consisting essentially of tin, zinc in an amount up to 50%, and between 0.01% and 5% of an alkaline earth metal, the alloy also being bonded to a light metal to unite the light metal with the ferrous metal.

16. An article of manufacture comprising a ferrous metal body having an iron surface united with a bonding layer of an alloy consisting essentially of zinc in an amount of up to 50%, cadmium in an amount of up to 84.5%, and between about 0.01% and 5% of a rare earth, the alloy also being bonded to a light metal to unite the light metal with the ferrous metal.

17. An article of manufacture comprising a ferrous metal body having an iron surface united with a bonding layer of an alloy consisting essentially of zinc in an amount of up to 50%, cadmium in an amount of up to



84.5%, and between about 0.01% and 5% of at least one metal selected from the group consisting of alkali metals and alkaline earth metals, the alloy also being bonded to a light metal to unite the light metal with the ferrous metal.


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