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METHOD OF MAKING COMPOSITE BODIES OF ZINC AND ALUMINUM

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This invention relates to the production of composite bodies of zinc and aluminum, particularly plates, sheets and foils having a zinc core and faced with aluminum.

The desirability of laminating zinc and aluminum to provide aluminum coated zinc has long been recognized, many of the important advantages to be secured by the use of such laminated metal being set out in the United States patent to Franz Jordan, No. 1,985,784, of December 25, 1934, and various proposals have heretofore been made as to methods for producing the same, the more practicable of which methods have included the rolling of sheets of zinc and aluminum into close mechanical adherence, sometimes at an elevated temperature so as to effect some dispersion between the metals. But some of the very characteristics of aluminum which render it highly desirable as the facing material for a laminated body also oppose the formation of a satisfactory bond between the diverse metals by the methods heretofore proposed. For example, the high surface tension, tenacity and resistance to rupture of the aluminum oxide film, which serve importantly in rendering aluminum a desirable surfacing material, also render difficult the effecting of a uniform adhesion of zinc to aluminum under mechanical pressure, even though the temperature of one or both of the metals may be raised so as to render the metals relatively soft. Furthermore, even though the temperature of the metals be raised so as to facilitate dispersion between the metals as a concomitant of the establishment of high pressure between the metals, as by rolling, it is very difficult, if possible, to so control the dispersion as to obtain either uniformity of bond or controlled depth of bond between the metals. Therefore, so far as I am aware, no commercially feasible procedure has heretofore been suggested for producing laminated zinc and aluminum with assurance of a substantially uniform bond between the laminations.

It is an object of this invention to produce laminated zinc and aluminum by an improved procedure which assures a substantially uniform alloy bond throughout the contiguous surfaces of the laminations.

Another object of this invention is to provide a method for producing laminated bodies of aluminum coated zinc wherein the depth of the alloy bond connecting the laminations may be controlled so as to secure a predetermined depth as well as a substantially uniform character of bond.

Another object of this invention is to provide a method of the type characterized which is of such character that it may be efficiently and economically performed in large-scale commercial operations.

Another object of this invention is to produce a billet, ingot, block, or other body composed of a zinc core and a coating of aluminum on one or more faces thereof which has a substantially uniform alloy bond between the zinc and aluminum throughout the contiguous surfaces thereof.

Another object of this invention is to produce rolled plates, sheets, foils, etc., of aluminum coated zinc wherein the laminations are united by a substantially uniform alloy bond throughout the contiguous surfaces thereof and in which at the same time are preserved the desirable characteristics of the zinc as a core metal and of the aluminum as a surfacing metal.

Another object of this invention is to produce aluminum coated zinc foil which though relatively thin is strong, ductile and tough, so that it may be used as a wrapping medium with a material saving in weight and cost as compared with metal foils now in use.

Another object of this invention is to produce aluminum coated zinc which is ductile, malleable and pliable so that it may be readily drawn, pressed, shaped, and otherwise worked, and therefore applied to a wide variety of uses, with assurance that the alloy bond between the laminations will not be destroyed.

Another object of this invention is to produce aluminum coated zinc which while preserving the desirable characteristics of the zinc as a core metal and the aluminum as a surfacing metal also secures various advantages to be derived from their association in laminations, the character and thickness of the alloy bond between the laminations being such as not to interfere with or detract from the characteristics to be desirably obtained from the association of these two metals into a laminated structure.

Other objects will appear as the description of the invention proceeds.

In conformity with the present invention a composite metal body of aluminum coated zinc is formed by effecting a substantially uniform alloy bond between the zinc and aluminum. To this end an alloy of the zinc and aluminum is first created at the surface of the aluminum which is to be united to the zinc, said alloy being formed under such conditions as to assure a substantially uniform character and depth of the alloy throughout the surface which is to be united to the zinc.

Then zinc is fused to said alloy, establishing an alloy bond between the zinc and aluminum which is substantially continuous and uniform in character. Thereby the discontinuities and irregularities of bond which have characterized procedures heretofore proposed are avoided. By suitably controlling the relative temperatures of the zinc and aluminum, with regard to the heat capacities of the volumes of the respective metals employed, the alloy bond may be increased in depth to a controlled extent, if desired, during the fusing operation. By this procedure a substantially uniform alloy bond between the zinc and aluminum is established throughout the contiguous surfaces thereof, and as the depth of said bond can be nicely predetermined, the laminated body can be given the desired characteristics suitable for the use to which the laminated metal is to be put.

For most purposes, it is preferable to have the aluminum coating coextensive with opposed outer faces when the ultimate product is a plate, sheet or foil, but it is within the contemplation of the present invention to provide an aluminum coating on all, or on any number less than all of the faces of the billets, ingots, blocks or other bodies formed in the practice of the present invention, depending on the desired characteristics and contemplated uses of the aluminum coated zinc produced. Furthermore, while it is preferred to cast the zinc in an aluminum envelope so as to first form a billet, ingot, block, or the like, it is to be expressly understood that the invention is not restricted thereto, as the composite metal may be initially formed in conformity with the present invention in other shapes, including tubes, bars, etc., or in fact in any suitable form that is appropriate for the ultimate product to be produced, and therefore the invention is not restricted to the formation of billets, ingots, blocks, etc., but the term "billet" as used herein is to be construed as a term generic to any suitable form in which the aluminum is united to a zinc core as herein explained. For purposes of illustrating the invention, however, it will be assumed that the composite metal body is to be formed as a billet or the like with a coating of aluminum that is coextensive with opposed faces thereof.

The preferred procedure is a follows:—Aluminum in a form to provide a suitable envelope is first provided. The thickness of said envelope may be varied within relatively wide limits depending upon the use to which the composite metal is to be put, the desired characteristics in the ultimate product, etc. The envelope, particularly if the composite body is to be subjected to a plurality of rolling operations, must not be too thick because the alloy bond, formed as hereinafter described, is likely to be destroyed during the "breaking down" passes through the rolls. Practical experience to date has shown that from three-eighths to possibly one-half inch in thickness is about the upper limit that can be satisfactorily used for the envelope. On the other hand, the envelope must not be so thin, in comparison with the volume of zinc to be used in the core, that the relative heat capacities of the two metals are such as to cause the alloying of the zinc and aluminum to extend through to the outer surface of the aluminum. If the zinc core is made sufficiently thin or small, or the temperature relations between the zinc and aluminum are otherwise suitably controlled, however, this does not prevent the aluminum envelope from being only a few thousandths of an inch in thickness if desired. Between these limits the thickness of the envelope may be selected with regard to the percentage of aluminum to zinc desired in the ultimate product, which will vary with the use to which the composite metal is to be put and the characteristics desired.

The envelope is preferably formed from hot rolled sheet aluminum, as this provides an envelope which is well annealed and has a relatively clean surface. However, cold rolled aluminum sheets may be employed if preferred, provided the sheets are sufficiently annealed and the surface thereof is properly cleaned to enable the carrying out of the process as herein described.

The envelope metal is suitably heated and the face of the sheet or sheets which, when the envelope is assembled or formed, is to be at the inner surface thereof and be united to the zinc, is then provided with a substantially uniform layer of zinc aluminum alloy of predetermined depth. When the aluminum is melted in contact with the zinc, the aluminum sheet is welded to a temperature at least as high as the melting point of zinc. The zinc is applied, to that face of the aluminum sheet which is to be united with the core, in such a way as to assure a uniform breakdown and detachment of the aluminum oxide film from the aluminum sheet and to obtain a uniform layer of alloy of desired depth. To this end the aluminum sheet may first be treated with zinc chloride or any other suitable flux that will break down the aluminum oxide, forming the zinc-aluminum alloy, but I prefer to use abrasion of the aluminum surface in the presence of molten zinc, as with any suitable wire brush, after the molten zinc which may be zinc melted by the temperature of the aluminum plate, has been spread over the surface of the aluminum so that it is applied uniformly thereover. The brush is worked through the coating of molten zinc to break down the oxide film while the zinc coating protects the aluminum surface from contact with the oxygen of the air. This procedure also avoids the presence of foreign material that may have to be removed to avoid formation of gas or other interference with the establishment of a uniform bond between the core and envelope when zinc is cast into said envelope as hereinafter explained.

The depth of the alloy formed can be varied depending upon the temperature of the aluminum and the time and character of the chemical or mechanical work which are used in breaking down the aluminum oxide film and assuring a penetration of the zinc into the aluminum. Ordinarily, a relatively thin layer of alloy is desired, deep penetration of the zinc into the aluminum being undesirable because the alloy is less ductile than the aluminum and zinc. The zinc goes into solution with the aluminum and establishes a zinc aluminum alloy, and this alloy when formed as heretofore described is substantially uniform in thickness and of controlled thickness throughout the surface of the aluminum sheet.

The envelope is then assembled or formed with the alloy surface thereof at the inside. For example it may be composed of a plurality of sheets suitably assembled so as to form a core cavity, but where the billet is to be subsequently rolled into plates, thin sheets, foils, and the like, I preferably form the envelope by bending a sheet into U form with the alloy layer on the inside, so that the parallel legs thereof are spaced at the distance predetermined for the thickness of the zinc core, the connection between said legs helping to maintain said legs at the predetermined

spacing, and where the envelope is sufficiently stiff, supporting and retaining the side sheets at that spacing. The envelope is mounted in any suitable mold, by which term is to be understood any suitable form which will properly retain the envelope in a position for the casting operation and, where necessary, complete the cavity between the elements of the envelope for reception of the molten zinc.

Zinc is then cast into the cavity of the mold at any suitable temperature. Ordinarily, the usual pouring temperature employed in the casting of zinc billets may be used, but higher degrees of superheat may be employed depending upon the depth of alloy bond desired. The molten zinc melts the alloy upon contact therewith, producing surface fusion of the alloy and thereby a fused bond between the zinc and alloy, whereby the zinc core and aluminum facing are united by an alloy of the core and facing metals. By suitably controlling the temperatures of the two metals with respect to the heat capacities of their respective volumes, the depth of alloy bond may be nicely controlled. Thus by heating the aluminum or by having such heat capacity due to the volume of zinc present, the depth of alloy bond may be increased over that established by the initial formation of the alloy during the preceding step, and the depth of this bond may thus be widely varied and accurately controlled. Excessive penetration of the zinc into the aluminum is undesirable, and therefore the temperature relationship between the aluminum envelope and the zinc cast therein, with respect to the relative heat capacities of the two, must be predetermined to avoid undue penetration of the zinc into the aluminum. To this end the mold may be water cooled if desired, such being ordinarily desirable where the molds are to be used at frequent intervals and it is desirable to withdraw therefrom at least some of the heat resulting from the previous casting operation.

Assuming that the billet is to be rolled into plates, thin sheets, or foils, the billet may be passed to the rolls as soon as it has cooled to a suitable rolling temperature. I prefer to roll the billet hot, to avoid drastic strain hardening of the composite metal. The temperature at which the composite metal is rolled, however, may vary within relatively wide limits, depending upon the character and desired characteristics of the ultimate product. Ordinarily, the temperature should not be so high as to cause substantial dispersion of one metal into the other and thereby unduly increase the depth of the alloy bond, but a temperature which gives some degree of plasticity to the aluminum, and may even approach the annealing temperature thereof, is sometimes desirable, particularly where the composite metal is to be rolled into relatively thin foil. For the break down passes, I have successively rolled aluminum coated zinc billets prepared in conformity with the present invention at temperatures varying from 200° F. to 650° F. The further rolling of the composite metal may be carried out at any suitable temperature, depending upon the characteristics desired in the finished product. Thus the composite metal may be rolled at temperatures approaching the annealing temperature of the aluminum or at any suitable lower temperature down to cold rolling where characteristics derived from cold working are desired. Aluminum coated zinc foil as thin as two or three ten-thousandths of an inch, or less, in thickness and having an aluminum coating on the order of 5% or 6% has been successfully produced and is found to be possessed of relatively high strength, toughness, ductility, etc.

Aluminum coated zinc plates or sheets of suitable thickness may be formed for fabrication into a wide variety of articles, and the composite metal may be subjected to drawing, spinning, pressing, and other mechanical operations without destroying the alloy bond between the laminations, inasmuch as the aluminum coated zinc so formed is highly ductile, pliable, malleable, etc.

The envelope may be composed of pure aluminum or a wide variety of aluminum base alloys, depending upon the character of the coating desired, and the core may be composed of pure zinc or any suitable zinc alloy. Ordinarily, for economy in the use of scrap, the core is preferably a zinc base alloy with a small percentage of aluminum therein, the presence of the aluminum also giving desirable characteristics to the core metal. Therefore, it is to be expressly understood that when aluminum or zinc are referred to herein it is intended to embrace within such terms any suitable alloy of aluminum for the coating metal and any suitable alloy of zinc for the core metal.

The present invention therefore provides billets and other bodies of aluminum coated zinc wherein the zinc and aluminum are united throughout their contiguous surfaces by a substantially uniform alloy bond of predetermined depth. The composite metal is possessed of the various desirable characteristics inherent in the use of aluminum as a coating metal and zinc as a core metal without detraction from their respective characteristics by the manner in which the composite metal is formed. The method of the present invention also assures the establishment of the substantially uniform alloy bond of substantially uniform depth between the two metals under conditions that may be readily carried out in large-scale operations. Therefore, the composite metal of the present invention, because of the characteristics thereof as produced by the method disclosed, may be put to a wide variety of uses because of the ductility, malleability, capacity for reduction and extension, etc., thereof. A wide variety of regular and irregular shapes may be formed therefrom, since the metal may be readily drawn, rolled or otherwise formed into sheets, wires, tubes, plates, foils, etc., and a wide variety of objects made therefrom by pressing, drawing and other working operations, and therefore the composite metal of this invention can be applied to many uses in the electrical, mechanical and chemical arts where advantage may be taken of the desirable characteristics of aluminum as a coating metal and zinc as a core metal.

While the preferred procedure has been described with considerable particularity, it is to be expressly understood that the invention is not restricted thereto, as various departures therefrom will now suggest themselves to those skilled in the art. For example, other methods of applying molten zinc to secure the alloy layer or of fusing the zinc core to the alloy layer may be used, and any other suitable metal such as tin may be used for effecting the alloy layer provided an alloy bond as herein disclosed is established between the zinc and aluminum as a result of applying the intermediate metal to the aluminum, to break through and remove the oxide

film, and thereafter fusing the zinc core to said alloy layer. Reference is therefore to be had to the claims hereto appended for a definition of the limits of the invention.

What is claimed is:

1. In the method of making aluminum coated zinc plates, sheets, foils, and other bodies having an aluminum coating at opposite sides of a zinc core, the steps which include applying molten zinc to that face of the aluminum which is to constitute the inner face of an aluminum envelope while breaking down the aluminum oxide film on said face to form a predetermined layer of zinc aluminum alloy, forming the aluminum into an envelope for a billet or the like, fusing a core of zinc to said alloy within said envelope, and then subjecting said billet or the like to successive rolling operations to increase its surface area without destroying the bond between the aluminum and zinc.

2. In the method of making aluminum coated zinc plates, sheets, foils, and other bodies having an aluminum coating at opposite sides of a zinc core, the steps which include applying molten zinc to that face of the aluminum which is to constitute the inner face of an aluminum envelope while breaking down the aluminum oxide film on said face to form a predetermined layer of zinc aluminum alloy, forming the aluminum into an envelope for a billet or the like, casting into the cavity of said envelope a core of molten zinc to fuse the surface of said alloy and bond the zinc to the aluminum, and then subjecting said billet or the like to successive rolling operations to increase its surface area without destroying the bond between the aluminum and zinc.

3. In the method of making aluminum coated zinc plates, sheets, foils, and other bodies having an aluminum coating at opposite sides of a zinc core, the steps which include applying molten zinc to that face of the aluminum which is to constitute the inner face of an aluminum envelope while breaking down the aluminum oxide film on said face to form a predetermined layer of zinc aluminum alloy, forming the aluminum into an envelope for a billet or the like, casting into the cavity of said envelope a core of molten zinc to fuse the surface of said alloy and establish an alloy bond between the aluminum and zinc while controlling the relative temperatures of said aluminum and zinc with respect to their relative heat capacities so as to predetermine the depth of alloy bond so formed, and then subjecting said billet or the like to successive rolling operations to increase its surface area without destroying the bond between the aluminum and zinc.

4. In the method of making aluminum coated zinc plates, sheets, foils, and other bodies having an aluminum coating at opposite sides of a zinc core, the steps which include forming an envelope of aluminum having alloyed to the inner face of said envelope a thin coating of zinc, fusing a core of zinc to said thin coating to form an aluminum coated zinc billet or the like, and then subjecting said billet or the like to successive rolling operations to increase its surface area without destroying the bond between the aluminum and zinc.

5. In the method of making aluminum coated zinc plates, sheets, foils, and other bodies having an aluminum coating at opposite sides of a zinc core, the steps which include forming an envelope of aluminum having alloyed to the inner face of said envelope a thin coating of zinc, casting a core of molten zinc into said envelope to form an aluminum coated zinc billet or the like which has its aluminum coating bonded to said core by the fusion of said core to the zinc coating on said envelope, and then subjecting said billet or the like to successive rolling operations to increase its surface area without destroying the bond between the aluminum and zinc.

6. In the method of making aluminum coated zinc plates, sheets, foils, and other bodies having an aluminum coating at opposite sides of a zinc core, the steps which include forming an envelope of aluminum having alloyed to the inner face of said envelope a thin coating of zinc, casting a core of molten zinc into said envelope to form an aluminum zinc billet or the like having a fused bond between said zinc and said coating while controlling the relative temperature of the aluminum and zinc with respect to their relative heat capacities to predetermine the depth of alloy bond formed between said aluminum and zinc, and then subjecting the aluminum coated zinc billet or the like to successive rolling operations to increase its surface area without destroying the bond between the aluminum and zinc.

7. In the method of making aluminum coated zinc plates, sheets, foils, and other objects having an aluminum coating at opposite sides of a zinc core, the steps which include alloying zinc to the face of sheet aluminum to provide a relatively thin alloy layer, forming an envelope from said sheet aluminum with the alloy layer on the inside, fusing to said alloy layer a core of zinc to form an aluminum coated zinc billet or the like, and then subjecting said billet or the like to successive rolling operations to increase its surface area without destroying said bond.

8. In the method of making aluminum coated zinc plates, sheets, foils, and other objects having an aluminum coating at opposite sides of a zinc core, the steps which include alloying zinc to the face of sheet aluminum to provide a relatively thin alloy layer, forming an envelope from said sheet aluminum with the alloy layer on the inside, casting molten zinc into said envelope to form an aluminum coated zinc billet or the like having a fused bond with said alloy layer, and then subjecting said billet or the like to successive rolling operations to increase its surface area without destroying said bond.

9. In the method of making aluminum coated zinc plates, sheets, foils, and other objects having an aluminum coating at opposite sides of a zinc core, the steps which include alloying zinc to the face of sheet aluminum to provide a relatively thin alloy layer, forming an envelope from said sheet aluminum with the alloy on the inside, fusing said alloy layer to a zinc core while controlling the relative temperatures of said aluminum and zinc to form an aluminum coated zinc billet or the like having an alloy bond of predetermined depth between said aluminum and zinc, and then subjecting said billet or the like to successive rolling operations to increase its surface area without destroying said bond.

10. In the method of making aluminum coated zinc plates, sheets, foils, and other bodies having an aluminum coating on a zinc core, the steps which include applying molten zinc to that face of the aluminum which is to be at the inner face of an envelope while breaking down the aluminum oxide film on said face to form a predetermined layer of zinc aluminum alloy,

forming an envelope for a billet or the like with said alloy layer at the inner face thereof, casting into the cavity of said envelope a core of molten zinc to fuse the surface of said alloy and bond the zinc to the aluminum, and then subjecting said billet or the like to successive rolling operations to increase its surface area without destroying the bond between the aluminum and zinc.

11. In the method of making aluminum coated zinc plates, sheets, foils, and other objects having an aluminum coating on a zinc core, the steps which include alloying zinc to that face of sheet aluminum which is to be at the inner face of an envelope so as to provide thereon a relatively thin alloy layer, forming an envelope with the alloy layer on said sheet aluminum at the inside of said envelope, casting molten zinc into said envelope to form an aluminum coated zinc billet or the like having a fused bond at said alloy layer, and then subjecting said billet or the like to successive rolling operations to increase its surface area without destroying said bond.

12. In the method of making aluminum coated zinc plates, sheets, foils, and other bodies having an aluminum coating at opposite sides of a zinc core, the steps which include applying a metal known to be alloyable with aluminum and fusible with zinc to that face of the aluminum which is to constitute the inner face of an aluminum envelope while breaking down the aluminum oxide film on said face to form a predetermined layer of said alloy, forming the aluminum into an envelope for a billet or the like, fusing a core of zinc to said alloy within said envelope, and then subjecting said billet or the like to successive rolling operations to increase its surface area without destroying the bond between the aluminum and zinc.

13. A malleable and ductile aluminum coated zinc body composed of a relatively thin aluminum coating layer having a zinc aluminum alloy layer at its inner face united to a zinc core by a substantially continuous cast bond of controlled thickness, said bond being composed of a relatively thin layer of aluminum-zinc alloy which is substantially coextensive with the contiguous surfaces of the aluminum and zinc and uniformly bonded to both of said metals.

14. A malleable and ductile aluminum coated zinc body composed of a relatively thin aluminum coating layer having an alloy layer at its inner face united to a zinc core by a substantially continuous cast bond of controlled thickness, said bond being composed of a relatively thin layer of said alloy which is substantially coextensive with the contiguous surfaces of the aluminum and zinc and uniformly bonded to both of said metals.

15. A rolled aluminum coated zinc sheet or foil which is composed of a surface layer of zinc having a zinc aluminum alloy layer at its inner face united to a zinc core by a substantially continuous cast bond of controlled thickness, said bond being composed of a relatively thin layer of aluminum-zinc alloy which is substantially coextensive with the contiguous surfaces of the aluminum and zinc and uniformly bonded to both of said metals.

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CERTIFICATE OF CORRECTION.

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, second column, line 22, for the word "welded" read heated; page 3, first column, line 62, for "successively" read successfully; page 4, second column, line 20, claim 6, for "temperature" read temperatures ; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 29th day of March, A. D. 1938.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)