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BERYLLIUM-ALUMINUM ALLOY AND
METHOD OF HEAT TREATING THE SAMEJoseph Kent Smith, Detroit, Mich., assignor to
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This invention relates to the product, as a new article of manufacture, of heat treating an alloy and to a method of heat treating such alloy and also to the working of the metal. The invention is particularly useful in alloys such as high beryllium aluminum alloys, in connection with which the invention will be described.

The eutectic of such beryllium aluminum alloys is fusible at a point below the temperature to which one must heat treat to obtain a symmetrical and equiaxed arrangement of the crystals of the matrix in commercial periods. By "equiaxed" crystals, is meant crystals whose vertical and horizontal axes are approximately the same order of length, in contra-distinction to those in which one axial dimension is much greater than the other. In consequence when heat treating such alloys in order to get the strength and other desirable characteristics for which heat treatment is employed, the eutectic "sweats" out and the piece is rendered practically valueless.

It is the primary object of the invention to overcome this difficulty and to make it possible to heat treat such alloys and thereby secure, in the finished piece, the advantages which flow from heat treatment.

Starting with the cast ingot of beryllium aluminum alloy, I prefer to proceed as follows: I first reduce the piece from about 25% to 50% by a flat pressing operation (as between flat plates or discs) rather than by rolling, for while the latter has a curling or tearing effect, the former breaks up and comminutes the dendrites by squeezing or kneading them. Rolling pulls or destroys the general crystalline structure, while proper squeezing improves it. The cast piece should be heated before pressing to about 1000 to 1050° F. After this, the piece is further reduced by rolling at substantially the same temperature. These temperatures are below the incipient melting point of the eutectic. This eutectic melting point may vary in different alloys of aluminum and beryllium and the temperature of heating for pressing and rolling may accordingly be varied somewhat to suit the needs of a particular alloy.

The piece is then heat treated in a manner to be hereinafter described and then cold rolled to secure the desired strength, etc. In some cases it may be further rolled at temperatures not substantially exceeding 1000° F. The hot working is stopped and the heat treatment begun at a point sufficiently far in advance of the final working to secure the desired results. This also

will depend somewhat upon the particular alloy and can be readily determined by experiment.

The heat treatment given after the hot working is as follows: The piece is placed in a closed pressure vessel or sealed heating furnace of suitable construction and the air is displaced, if necessary, by the introduction of a gas with which the alloy will not react. Helium is well suited for this purpose. I have discovered that if sufficient pressure be maintained in the heating furnace, the sweating hereinbefore referred to is obviated. I have found that with beryllium aluminum alloys a pressure of about 150 lbs. per sq. inch in the vessel is adequate. The maintenance of this pressure may alter the melting point of the eutectic, or it may merely maintain the eutectic in situ, preventing its movement to the surfaces. Whatever the theory, I have found in actual practice that when operating under these conditions, the sweating does not occur. For most beryllium aluminum alloys I prefer a heat treatment at a temperature of about 1250° F. to 1350° F., the treatment being continued sufficiently long only to secure the desired grain rearrangement, without seriously inviting the grain growth which takes place in practically all metals at elevated temperatures. It will be seen that this temperature of heat treatment is well above the incipient melting point of the eutectic.

Generally, before heat treatment the arrangement of crystals is "stringy" and the piece is characterized by brittleness. After heat treatment the crystals are symmetrically arranged and substantially equiaxed.

The final cold working which gives the last and relatively small reduction in the piece, results in a product which has all of the properties secured by heat treatment, namely, high tensile strength with absence of brittleness, and the piece has capacity for bendability.

I have found beryllium aluminum alloys, such, for example, as a 70—30 alloy, are especially useful for sheets to be employed in aeroplane wings in place of the usual fabric. These sheets can be of extreme thinness while yet having great strength and bendability, coupled with lightness. The product is much stronger and also much lighter than duralumin and is far more highly resistant to corrosion. The product is also useful in all cases where relatively great strength with extreme lightness are desired.

It will be understood that the invention is applicable, among other things, also to other alloys containing an eutectic whose fusibility is below that of the equiaxed of the matrix crystals in commercial periods.

What I claim is:—

1. The process of heat treating an alloy of beryllium and aluminum the fusibility of the eutectic of which is below the temperature at which the matrix crystals are substantially equiaxed, which comprises heating the piece in a vessel filled with gas such as helium at a pressure of approximately 150 pounds, the temperature being sufficiently high to equiax the matrix crystals.

2. The process of heat treating an alloy of approximately 70% beryllium and 30% aluminum, which consists in heating the piece approximately to the temperature at which the matrix crystals equiax, the heating being conducted in the presence of a gas under a pressure substantially above atmospheric and sufficient to prevent sweating of the eutectic.

3. The process of heat treating an alloy composed of approximately 70% beryllium and 30% aluminum, which comprises heating the piece to a temperature of approximately 1250° F., in the presence of a gas under a pressure substantially above atmospheric and sufficient to prevent the sweating of the eutectic.

4. In the heat treatment, to equiax crystals, of an alloy of beryllium and aluminum the fusibility of the eutectic of which is below the temperature at which the matrix crystals are substantially equiaxed, the step of preventing sweating out of the eutectic by subjecting the alloy to a gas at a pressure appreciably above atmospheric and preferably in the neighborhood of approximately 150 pounds per square inch during the heating thereof from the temperature of fusibility of the eutectic up to the temperature at which the crystals are equiaxed.

5. The method of forming an article from a beryllium-aluminum ingot or equivalent piece which includes three general steps, as follows: first working the piece to partially reduce it, then heating the partially reduced piece to a temperature sufficiently high to equiax the matrix crystals while maintaining the piece under a gas pressure sufficiently high to prevent sweating out of the eutectic, and finally again working the piece to further reduce it and form the article.

6. A method of treating beryllium-aluminum

alloys which includes the steps of working an alloy ingot or equivalent piece to reduce said piece from about 25% to about 50%, thereafter heating the worked piece in the presence of a gas under pressure appreciably above atmospheric and preferably in the neighborhood of about 150 pounds per square inch, the temperature of heating being above the point of fusibility of the eutectic and preferably in the neighborhood of about 1250° F. to 1350° F. whereby to substantially equiax the matrix crystals without, however, sweating out the eutectic, and after the heat treatment again working the piece to further reduce it.

7. A method of treating beryllium-aluminum alloys which includes the steps of working an alloy ingot or equivalent piece to reduce said piece from about 25% to about 50%, the working being effected at a temperature below the point of fusibility of the eutectic and preferably in the neighborhood of about 1000° F. to about 1050° F., thereafter heating the worked piece in the presence of a gas under pressure appreciably above atmospheric and preferably in the neighborhood of about 150 pounds per square inch, the temperature of heating being above the point of fusibility of the eutectic and preferably in the neighborhood of about 1250° F. to 1350° F. whereby to substantially equiax the matrix crystals without, however, sweating out the eutectic, and after the heat treatment again working the piece to further reduce it.

8. A beryllium-aluminum alloy heat treated above the temperature of fusibility of the eutectic, characterized by equiaxed matrix crystals and the presence of the eutectic "in situ".

9. A beryllium-aluminum alloy of which the beryllium and aluminum respectively comprise approximately 70% and 30%, the alloy being characterized by equiaxed matrix crystals and the presence of the eutectic "in situ".

10. As an article of manufacture, a metallic piece made from a beryllium-aluminum alloy by heat treating the piece to a temperature sufficiently high to equiax the matrix crystals in the presence of a gas under pressure sufficient to prevent sweating out of the eutectic.

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