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METHOD OF PREPARING BERYLLIUM ALLOYS

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The present invention relates to the production of beryllium alloys and has for its general object to manufacture such alloys by decomposition of beryllium minerals, and particularly of double salts of beryllium by fusion with metals which will displace and alloy with the liberated beryllium.

More specifically, it is an object of the present invention to displace beryllium from one of its double salts by means of a metal capable of replacing beryllium in the salt and alloying the liberated beryllium with such metal and with a second metal, or with the second metal alone, at approximately the melting point of the latter metal.

According to the present invention, a fused double beryllium salt, preferably a double fluoride of beryllium and an alkali metal, which is at the present time the commercially most available mineral, is reacted with an alkali or alkali earth metal, such as sodium, potassium, lithium, magnesium and calcium and the liberated beryllium then separated or precipitated from the fusion by means of a metal which will alloy with the beryllium.

It has already been proposed to reduce double fluorides of beryllium and sodium or potassium by means of certain metals, but in all such cases the beryllium remained diffused in the dross or slag and was difficult to remove.

I have found that the so diffused beryllium can be readily and easily separated from the fusion with the aid of a metal which will alloy with the beryllium, such alloy becoming deposited at the bottom of the fusion in the form of a button and being thereby easily separated from the fused salt.

When the alkaline earth metal magnesium is employed as the reducing agent for the beryllium salt there is obtained a suspension of fused beryllium and magnesium in the melt which can be precipitated in the form of a beryllium-magnesium-copper alloy by the addition of copper, preferably in finely divided form. In place of the magnesium I may use the alkali metals, sodium, potassium and lithium. When an alkali metal is employed, the alloy obtained is generally a binary alloy of beryllium and copper or equivalent metal.

I have found that when magnesium is employed as the reducing metal, the beryllium and magnesium are alloyed with the second metal in about the same proportions. Thus an alloy can be prepared in accordance with my process having as much as 25% beryllium, 25% magnesium, and the remainder practically all copper. Larger proportions of beryllium and magnesium may be incorporated in the alloy, but I prefer, however, so to proportion the various materials entering into the reaction, when a ternary copper alloy is to be obtained, that the copper alloy contains 2 to 12½% of beryllium and 2 to 12½% of magnesium. When no magnesium is employed, the preferred range of beryllium in the alloy is still 2 to 12½%, although higher proportions can be obtained.

If desired, more than two metals can be fused with the beryllium salt. Thus the salt may be treated with magnesium, aluminum and copper, in which case I may obtain an aluminum-copper-beryllium-magnesium alloy which in many respects is superior to the aluminum-magnesium-copper alloy known as "Duralumin". A quaternary alloy of this type may have a copper-beryllium-magnesium content of 5 to 15%, such ternary alloy containing preferably ½ to 2½% each of beryllium and magnesium.

Where a binary alloy of beryllium is desired, the alkali metals are employed as the reducing agents. With sodium beryllium fluoride, for example, I prefer to employ potassium, and with a potassium-beryllium salt I prefer to use sodium.

In place of the copper there may be employed aluminum, nickel, iron, cobalt, chromium, etc., or alloys or mixtures thereof and where the temperature of fusion of such metals or alloys with the salt is such as to cause volatilization of any of the materials, particularly sodium, potassium or magnesium, the operations may be conducted under pressure. Because of the strong affinity of beryllium for oxygen, the reactions should be carried out in a non-oxidizing or inert atmosphere.

The alloys may be used in the forms in which they are obtained; for example, where the beryllium content is high, the alloy may be employed as a master alloy for adding beryllium to other alloys.

The invention will be further explained with the aid of a specific example. A small quantity of pure copper is melted in a carbon crucible, and to the molten copper there is then added one or more brickettes composed of magnesium, sodium beryllium fluoride and some powdered or flaky copper. The three ingredients in the brickette can be compressed readily into a solid brickette in a hydraulic press. The use of the magnesium, the fluoride and the powdered or flaky copper in the form of a brickette is not essential but is preferred because of its convenience. Any desired proportions of materials may be employed except that the magnesium should be in excess of the theoretical amount required to reduce the beryllium salt.

A temperature just sufficient to keep the mass fluid is maintained in the crucible. With the materials just mentioned this temperature is about 1100° C. After 2½ to 3 hours of heating the reaction is complete. If the mass from the crucible were poured out it would be found that

the free metal was diffused throughout the dross or slag. I have found that the addition of a small amount of powdered or flaky copper spread over the surface of the molten mass in the crucible will, upon melting, cause the diffused metal to collect into a button and precipitate with such copper to the bottom of the crucible. This operation usually requires about ten minutes but the completion of this treatment may be determined with a stirring rod as the fused salt feels as fluid as water when the button has been precipitated. To keep the metals from oxidizing the heating should be conducted in an atmosphere of hydrogen, helium, nitrogen or other reducing or inert gas.

The weights of the various materials may, for example, be as follows: 870 grs. of sodium beryllium fluoride, containing about 60 grs. of beryllium, are reacted with 190 grs. of magnesium and 814 grs. of copper. The mixture yields about 904 grs. of alloy. The loss of beryllium is about 25% or 15 grs., so that about 45 grs. of beryllium are contained in the copper alloy. Approximately the same amount of magnesium will be contained in the alloy; the latter will thus comprise approximately 814 grs. of copper, and 45 grs. each of beryllium and magnesium. It will be noted that the magnesium is employed in the reaction in an excess of about 20%, and I have found that for best results there should be a considerable excess of magnesium.

The temperatures should be carefully controlled to keep the metals molten and at the same time avoid or reduce loss by evaporation. Especially when high melting point metals are employed, such as nickel, chromium, cobalt and iron, pressure should be employed to avoid loss of the more volatile magnesium and alkali metals, if the latter are used.

The alloy of beryllium, magnesium and copper obtained as above described may be heat-treated to harden the same. The alloys are fairly soft when poured, but when heated to about 1500° F. and quenched and then heated in an oven for about three hours at about 450° F., their hardness and tensile strength are greatly increased and they become practically fatigue-proof.

In place of iron, chromium, nickel, cobalt and other high melting point metals, lower melting point alloys of such metals may be employed to reduce the losses resulting from volatilization.

As above indicated, when an alkali metal is employed as the reducing or substituting metal, together with an alloying metal, such as copper, a binary alloy of beryllium and copper will be obtained. As when magnesium is used, two or more alloying metals or their alloys may be used together with the alkali metal, including copper, aluminum, cobalt, nickel, chromium, iron, etc. Thus sodium beryllium fluoride may be fused with potassium, copper and aluminum or other metal to yield a ternary alloy.

I claim:

1. The method of producing beryllium alloys which comprises reacting molten metal of the group comprising copper, nickel, iron and aluminum with an alkali or alkaline-earth metal and a double fluoride salt of beryllium and an alkali metal.

2. The method of producing beryllium alloys which comprises adding magnesium and a double fluoride of an alkali metal and beryllium to molten metal of the group comprising copper, nickel, iron and aluminum.

3. The method of producing beryllium alloys which comprises adding magnesium and sodium-beryllium-fluoride to molten metal of the group comprising copper, nickel, iron and aluminum.

4. The method of producing beryllium alloys which comprises adding magnesium and sodium-beryllium-fluoride to molten copper.

5. The method of producing beryllium alloys which comprises adding a briquetted mixture of magnesium and sodium-beryllium-fluoride to molten copper.

6. The method according to claim 1 which comprises treating the molten reaction products with finely divided copper to precipitate the beryllium alloy.

7. The method according to claim 2 which comprises treating the molten reaction products with finely divided copper to precipitate the beryllium alloy.

8. The method according to claim 3 which comprises treating the molten reaction products with finely divided copper to precipitate the beryllium alloy.

9. The method according to claim 4 which comprises treating the molten reaction products with finely divided copper to precipitate the beryllium alloy.

10. The method according to claim 5 which comprises treating the molten reaction products with finely divided copper to precipitate the beryllium alloy.

11. The method of producing beryllium alloys which comprises adding magnesium and sodium-beryllium-fluoride to molten nickel.

12. The method of producing beryllium alloys which comprises thermically reacting magnesium on sodium-beryllium-fluoride in the presence of metal of the group comprising copper, nickel, iron and aluminum.

13. The method of producing beryllium alloys which comprises thermically reacting magnesium on sodium-beryllium-fluoride in the presence of copper.

14. The method of producing beryllium alloys which comprises thermically reacting magnesium on sodium-beryllium-fluoride in the presence of nickel.

15. The method of producing beryllium alloys which comprises thermically reacting an alkali metal or an alkaline earth metal on a double fluoride salt of beryllium and an alkali metal in the presence of a metal of the group composed of copper, nickel, iron and aluminum.

16. The method of producing beryllium alloys which comprises thermically reacting an alkali metal or an alkaline earth metal on a double fluoride salt of beryllium and an alkali metal in the presence of a finely divided metal of the group composed of copper, nickel, iron and aluminum.

17. The method of producing beryllium alloys which comprises reacting a metal of the group consisting of copper, nickel, iron and aluminum with an alkali or alkaline-earth metal and a double fluoride salt of beryllium and an alkali metal.

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