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PROCESS FOR PRODUCING CASTINGS OF ALUMINUM-BERYLLIUM ALLOYS

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This invention relates to new and useful improvements in processes for casting metal alloys, and more particularly for casting alloys comprising principally aluminum and beryllium.

The importance of aluminum-beryllium alloys in the manufacture of articles and devices requiring lightness, strength and high corrosion-resistance properties is well known. One outstanding property of these alloys is their extraordinary stiffness or rigidity. This may be as much as two or three times as great as the stiffness or rigidity of aluminum or aluminum alloys which contain no beryllium, and as much as from three to four or more times as great as the stiffness or rigidity of magnesium base alloys. Another distinct property of aluminum-beryllium alloys resides in their comparatively high hot strength which may be as much as three or more times that of aluminum or other aluminum alloys lacking in beryllium. This is no less true in respect to articles and devices produced by casting aluminum-beryllium alloys into the structural shape or form desired. Prior to the present invention, however, no one has been able practicably to produce large commercial castings of aluminum-beryllium alloys which are satisfactory.

This has been due to several problems arising from differences which exist between these two metals in respect to their physical and chemical properties and characteristics. For example, aluminum melts at about 650° C., a temperature very much lower than beryllium which melts at a temperature of about 1250° C., and to produce a complete alloy solution of aluminum and beryllium, the two metals must be heated at least to the melting point temperature of beryllium and generally somewhat above this temperature. At these high temperatures, the metals, and particularly the aluminum, readily combine with and absorb various combustion and surrounding gases such as nitrogen, oxygen and hydrogen, which are evolved from the molten mass during cooling and solidification thereof, thus producing large gas pockets and blow-holes in the solidified alloy.

Another difficulty is presented by the tendency for the beryllium in the alloy to solidify substantially more rapidly than the aluminum content and, because of its lower specific gravity, the more rapidly solidified beryllium rises to the surface of the mass. Hence, it has been necessary, to prevent segregation of the two metals, and lack of uniformity in the cast, that the melt be rapidly chilled. On the other hand, however, rapid chilling of the melt does not produce a uniform cast due to the fact that the outer portions of the metal are caused to set very much more rapidly than the interior portions, with the result that the interior remains liquid for a longer period and tends to become porous and spongy causing a pronounced difference in the flowing qualities of the metals as between the interior and exterior portions of the ingot, resulting in cracks, splits and other defects when forged or rolled.

With the foregoing in mind, the principal object of the present invention is to provide a novel process for making castings of aluminum and beryllium which are characterized by their uniformity in structure and composition and which are not subject to cracking and splitting upon forging or rolling.

Another object of the invention is to provide a process of the character described whereby large commercial castings of alloys of aluminum and beryllium may be successfully produced in both a practical and economic manner.

A further object of the invention is to provide a process as set forth whereby the occurrence of gas pockets and blow-holes are entirely eliminated from the casting produced.

These and other objects of the invention and the various details and steps comprised therein are hereinafter fully set forth, described and claimed.

In practicing the present invention, a suitable crucible of sufficient size is selected and this may be a crucible of standard graphite-clay mixture or other suitable construction. In preparing for the melt, the desired proportion of beryllium metal, preferably in the form of lumps, is first placed in the crucible at the bottom thereof. The desired proportion of aluminum metal is then placed in the crucible upon the beryllium, and on top of the aluminum there is placed a predetermined amount of a suitable flux material.

The selection of a suitable flux is important in that it must be non-volatile and exhibit a solvent action on the oxides present in the two metals to be alloyed. Too, the flux must be one having little vapor pressure in the temperature range of 1250° C. to 1350° C. and also must be a flux that is practical to use, both from the standpoint of economics and handling. The use of a flux comprising calcium chloride has been found most advantageous in practicing the present invention in that it meets all of the essential conditions just mentioned, and appears to be the only alkaline earth chloride capable of efficiently dissolving re-

fractory oxides. To the calcium chloride flux may be added a relatively smaller amount of a suitable fluoride. The fluoride employed preferably is calcium fluoride, but the fluorides of barium, strontium and magnesium can be used, although they are considerably more expensive than calcium fluoride.

The addition of the fluoride to the flux renders the latter more fluid and precludes any tendency for the melt to become "gummy" because of the solvent action of the chloride on the solid matter in the melt, producing an increase in the melting point. Care should be taken that the fluoride constitute the minor proportion of the flux to prevent reaction thereof with the crucible, and very good results have been obtained by the use of a flux consisting of about 85% calcium chloride and 15% calcium fluoride. The quantity of flux employed for a given amount of aluminum and beryllium may vary widely, although generally good results are obtained with the flux present in an amount approximately about 10% by weight of the aluminum and beryllium. Thus, in making an ingot weighing 50 pounds, the amount of flux used generally would be about 5 pounds.

After the aluminum and beryllium metals and the flux have been placed in the crucible in the manner previously described, the crucible cover is then placed in position to close the crucible and the latter and its contents are heated to a temperature of from about 1300° C. to 1350° C., and maintained within that temperature range for a length of time sufficient to insure complete alloy solution of the beryllium in the aluminum.

During heating of the crucible and its contents, and as the temperature thereof increases, it will be obvious that the aluminum which has a melting point of about 650° C. will first melt and flow downwardly through and into the interstices between the pieces of beryllium in the bottom of the crucible. This completely fills the bottom portion of the crucible, and as the temperature continues to rise, the flux in turn melts and covers the entire mass of metal within the crucible.

As previously stated, the flux employed is just sufficiently volatile at temperatures from about 1250° C. to 1350° C. to produce a vapor at slight pressure within the crucible, and this relatively slight vapor pressure serves to prevent the surrounding air and furnace gases from entering the crucible. In addition, this slight vapor pressure generated by the flux has been found to act in a rather peculiar and positive manner to cement the crucible cover to the crucible, thus making the latter substantially air-tight.

The length of time that the crucible and its contents must be maintained at the required temperature to insure complete alloy solution of the beryllium in the aluminum, of course, will depend upon the size of the melt and the conditions present in the furnace employed. Generally, however, a period of from two to four hours is required.

When the crucible and its contents have been heated, as aforesaid, for the required length of time to produce a completely liquid alloy solution of the beryllium and aluminum, the cover is removed from the crucible and the latter and its contents is allowed to cool sufficiently to solidify the alloy in the crucible. During solidification of the melt, large quantities of gas are evolved therefrom, and this evolution may continue until the alloy is substantially solidified. Cooling and solidification of the alloy is allowed to continue to a temperature from about 500° C. to 600° C., after which the crucible and its contents are again heated to a temperature of from about 1300° C. to about 1350° C. to again render the alloy completely liquid. The melt is then skimmed to remove any dross and other materials from the surface thereof.

At this point there is added to the melt a small amount of a silver-sodium alloy comprising from about 2% to 5% sodium, balance silver. The amount of silver-sodium alloy added to the melt, of course, will depend upon the weight of the melt, and good results generally are obtained by the addition of from about .50% to 4.0% by weight of such alloy. The addition of this silver-sodium alloy is advantageous in that it is substantially heavier than the aluminum-beryllium alloy, and, therefore, immediately sinks to the bottom of the melt in the crucible, where it is dissolved and the sodium content thereof liberated. The liberated sodium readily and quickly combines with any remaining gases and solid impurities, such as oxide, and carries them to the surface of the melt where the gases are liberated to the atmosphere and the oxide slags may be skimmed from the surface of the melt. The silver enters the melt and alloys therewith, functioning to increase the hardness of the ultimate cast. The sodium exerts a powerful scouring and scavenging action on the melt and also appears to function to produce a refined or smaller grain size in the ultimate cast. The excess sodium which does not combine in the liberation of gases and solid impurities in the melt burns off, and this action is evidenced by flashes of light appearing in the surface of the melt.

The temperature of the melt is now allowed to drop to about 1150° C., after which it may be poured or cast in suitable molds. The molds used may be cast iron, and very good results have been obtained using molds of this composition. It is to be pointed out, however, that the molds in which the melt is cast should be provided with relatively thick walls and with a generous "hot top". Experiments have shown that this "hot top" should contain an amount of alloy which is at least about 10% of the weight of the ingot, and preferably about 25% of the weight thereof, and when the melt is poured into the molds, they should be thoroughly dry and should be at about the temperature of the atmosphere in the foundry or general surroundings.

Generally, molds employed for casting bars, rods, or similar finished articles, such as pistons or the like, should be relatively short or squat and the length thereof roughly should not exceed three times the diameter. Preferably, the sides should be parallel. On the other hand, ingots for the production of sheet stock should be as thin as possible, and for commercial size ingots for this purpose, should not exceed about two inches in thickness and from twelve to twenty-four inches in width and depth.

It is desirable to permit the melt to cool down to a temperature of about 1150° C. before pouring, as this is about the lowest temperature at which the melt can be poured and cast with good feeding. By allowing the melt to cool down as far as practicable prior to pouring, along with other factors, such as a thick wall mold and a generous "hot top," causes the melt to be chilled sufficiently rapidly to prevent segregation when it is poured, with the result that castings of uniform structure, density and composition are obtained.

From the foregoing, it will be observed that the present invention provides a novel process or method for making commercial castings of aluminum-beryllium alloys of uniform structure and composition which are not subject to cracking or splitting and which are free from gas pockets and blow-holes, for the process provides both a practical and economic process for the manufacture of large commercial castings of aluminum-beryllium alloys wherein the disadvantages, objections and difficulties of prior practices are eliminated or overcome.

The present invention is not intended to be limited to the disclosure herein, and changes and modifications may be made within the scope of the claims without departing from the invention.

I claim:

1. The method of producing commercial castings of aluminum-beryllium alloys which comprises placing in a crucible predetermined proportions of aluminum and beryllium together with a suitable oxide solvent flux which exhibits substantially no vapor pressure at temperatures of from 1250° C. to 1350° C., covering the crucible to enclose the contents thereof from the atmosphere, heating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to produce a complete alloy solution of the aluminum and beryllium, degasifying the melt by cooling the same to solidification, reheating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to again render the alloy molten, adding to the melt a relatively small amount of a silver-sodium alloy, cooling the melt to a temperature of about 1150° C., and then pouring the melt into a suitable mold.

2. The method of producing commercial castings of aluminum-beryllium alloys which comprises placing in a crucible predetermined proportions of aluminum and beryllium together with a suitable oxide solvent flux which exhibits substantially no vapor pressure at temperatures of from 1250° C. to 1350° C., covering the crucible to enclose the contents thereof from the atmosphere, heating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to produce a complete alloy solution of the aluminum and beryllium, degasifying the melt by cooling the same to solidification, reheating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to again render the alloy molten, adding to the melt a relatively small amount of a silver-sodium alloy, cooling the melt to a temperature of about 1150° C., providing a mold having a hot-top of a volume about 10% to 25% the volume of the mold, and then pouring the melt to fill both the mold and the hot-top.

3. The method of producing commercial castings of aluminum-beryllium alloys which comprises placing in a crucible predetermined proportions of aluminum and beryllium together with an oxide solvent alkaline earth chloride which exhibits substantially no vapor pressure at temperatures of from 1250° C. to 1350° C., covering the crucible to enclose the contents thereof from the atmosphere, heating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to produce a complete alloy solution of the aluminum and beryllium, degasifying the melt by cooling the same to solidification, reheating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to again render the alloy molten, adding to the melt a relatively small amount of silver-sodium alloy, cooling the melt to a temperature of about 1150° C., and then pouring the melt into a suitable mold.

4. The method of producing commercial castings of aluminum-beryllium alloys which comprises placing in a crucible predetermined proportions of aluminum and beryllium together with an oxide solvent alkaline earth chloride which exhibits substantially no vapor pressure at temperatures of from 1250° C. to 1350° C., covering the crucible to enclose the contents thereof from the atmosphere, heating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to produce a complete alloy solution of the aluminum and beryllium, degasifying the melt by cooling the same to solidification, reheating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to again render the alloy molten, adding to the melt a relatively small amount of silver-sodium alloy, cooling the melt to a temperature of about 1150° C., providing a mold having a hot-top of a volume about 10% to 25% the volume of the mold, and then pouring the melt to fill both the mold and the hot-top.

5. The method of producing commercial castings of aluminum-beryllium alloys which comprises placing in a crucible predetermined proportions of aluminum and beryllium together with a flux comprising a mixture of calcium chloride and calcium fluoride in predetermined proportions exhibiting substantially no vapor pressure at temperatures of from 1250° C. to 1350° C., covering the crucible to enclose the contents thereof from the atmosphere, heating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to produce a complete alloy solution of the aluminum and beryllium, degasifying the melt by cooling the same to solidification, reheating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to again render the alloy molten, adding to the melt a relatively small amount of silver-sodium alloy, cooling the melt to a temperature of about 1150° C., and then pouring the melt into a suitable mold.

6. The method of producing commercial castings of aluminum-beryllium alloys which comprises placing in a crucible predetermined proportions of aluminum and beryllium together with a flux comprising a mixture of calcium chloride and calcium fluoride in predetermined proportions exhibiting substantially no vapor pressure at temperatures of from 1250° C. to 1350° C., covering the crucible to enclose the contents thereof from the atmosphere, heating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to produce a complete alloy solution of the aluminum and beryllium, degasifying the melt by cooling the same to solidification, reheating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to again render the alloy molten, adding to the melt a relatively small amount of silver-sodium alloy, cooling the melt to a temperature of about 1150° C., providing a mold having a hot-top of a volume about 10% to 25% the volume of the mold, and then pouring the melt to fill both the mold and the hot-top.

7. The method of producing commercial castings of aluminum-beryllium alloys which comprises placing in a crucible predetermined proportions of aluminum and beryllium together with

a flux comprising calcium chloride about 85% and calcium fluoride about 15% and exhibiting substantially no vapor pressure at temperatures of from 1250° C. to 1350° C., covering the crucible to enclose the contents thereof from the atmosphere, heating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to produce a complete alloy solution of the aluminum and beryllium, degasifying the melt by cooling the same to solidification, reheating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to again render the alloy molten, adding to the melt a relatively small amount of silver-sodium alloy comprising about 2% to 5% sodium and balance silver, cooling the melt to a temperature of about 1150° C., and then pouring the melt into a suitable mold.

8. The method of producing commercial castings of aluminum-beryllium alloys which comprises placing in a crucible predetermined proportions of aluminum and beryllium together with a flux comprising calcium chloride about 85% and calcium fluoride about 15% and exhibiting substantially no vapor pressure at temperatures of from 1250° C. to 1350° C., covering the crucible to enclose the contents thereof from the atmosphere, heating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to produce a complete alloy solution of the aluminum and beryllium, degasifying the melt by cooling the same to solidification, reheating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to again render the alloy molten, adding to the melt a relatively small amount of silver-sodium alloy comprising about 2% to 5% sodium, and balance silver, cooling the melt to a temperature of about 1150° C., providing a mold having a hot-top of a volume of about 10% to 25% the volume of the mold, and then pouring the melt to fill both the mold and the hot-top.

9. The method claimed in claim 7 wherein the amount of flux employed is about 10% by weight of the aluminum and beryllium, and the amount of silver-sodium added is about 0.50% to 4.0% by weight of the melt.

10. The method claimed in claim 8 wherein the amount of flux employed is about 10% by weight of the aluminum and beryllium, and the amount of silver-sodium added is about 0.50% to 4.0% by weight of the melt.

11. The method of producing commercial castings of aluminum-beryllium alloys which comprises first placing in a crucible a predetermined amount of beryllium, next placing in said crucible a predetermined amount of aluminum upon the beryllium, then placing in said crucible a suitable oxide solvent flux which exhibits substantially no vapor pressure at temperatures of from 1250° C. to 1350° C., covering the crucible to enclose the contents thereof from the atmosphere, heating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to produce a complete alloy solution of the aluminum and beryllium, degasifying the melt by cooling the same to sodidification, reheating the crucible and its contents to a temperature of from about 1300° C. to 1350° C. to again render the alloy molten, adding to the melt a relatively small amount of a silver-sodium alloy, cooling the melt to a temperature of about 1150° C., and then pouring the melt into a suitable mold.

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