METHOD FOR MAKING METAL ALLOYS

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ABSTRACT OF THE DISCLOSURE

An apparatus and method are provided for making metal alloys in which at least one of the alloying metals is reactive with air. The method involves the introduction of distinct particles of the air-reactive metal directly into a liquid bath of a non-air-reactive metal in combination with the use of an inert, protective gas (which is non-reactive with the air-reactive metal) as a covering for the alloying process.

The apparatus in turn is used to introduce air-reactive metal into a liquid bath of non-air-reactive metal and includes: an open-ended housing which can be inserted into the bath, a supply container used to contain the air-reactive metal, a valve located between the housing and the lead bath, the supply system to adjust the flow of air-reactive metal from the supply, a gas inlet for introducing inert gas into the bath, and a mixing device, such as an agitator, disposed within the housing and used to promote the alloying reaction.

BACKGROUND OF THE INVENTION

This invention relates generally to a method and apparatus for preparing metal alloys and more particularly to a unique method and apparatus for preparing alloys in which at least one of the alloy components is reactive with air.

It is well known that various alkaline earth metals such as calcium react readily with air. At elevated temperature over 1,000° F., for example, calcium reacts rapidly with oxygen to form calcium oxides (CaO2 or CaO). Likewise at ordinary and elevated temperatures, calcium reacts with nitrogen to form nitrides such as CaN2. Various other useful alloy components, such as phosphorus, arsenic, potassium, sodium, lithium, magnesium, strontium and barium are also reactive with air under proper conditions. Consequently, all of these highly desirable alloy components present a host of practical problems which limit their use as alloying components.

Nonetheless the demand for alloys containing such components is high and several techniques have evolved to cope with some of the alloying problems.

It has been found, for example, that alkaline earth lead alloys can be prepared by first forming alkaline earth carbides, such as calcium carbide, and then dissolving the carbide in a molten lead bath. One example of this carbide technique is illustrated in U.S. Pat. No. 1,941,534 to Betterton. Because of the high temperatures (1400° F.) employed in the carbide processes, a slag of flux is provided as a cover for the surface of the molten lead bath to dissolve oxides formed on the surface of the carbide particles. Naturally, such carbide processes have proved undesirable, first because they involve the costly step of carbide formation, secondly, because of the limited life of the covering flux, thirdly, because of the high reaction temperatures, and fourthly, because of the short kettle life resulting from continued use at high temperatures.

Another method for preparing alloys containing air or atmosphere-reactive components, e.g., calcium, is disclosed in U.S. Pat. No. 2,364,503 to Zink. In this second type process, a perforated container which holds metallic calcium or the like is introduced into a molten bath of lead. The container is suspended within the lead bath for a time sufficient to effect the exothermic alloying reaction. A number of problems, however, are associated with this technique. For example, high temperatures, such as 1400° F., are required. In addition, when a large volume of a low specific gravity alloying component is contained in the perforated container, the method is difficult to carry out, since the container tends to float to the surface of the bath and burns in the atmosphere making the method both hazardous and inefficient.

SUMMARY OF THE INVENTION

The new method and apparatus of this invention obviate many of the problems of the prior art techniques by providing a safe, efficient, low temperature system for alloying air-reactive metals with non-air-reactive components. According to the method of this invention: (1) a liquid bath of a non-air-reactive metal is formed; (2) particles of at least one air-reactive metal are introduced directly into the liquid bath; and (3) an inert gas which is non-reactive with the air-reactive metal is provided in the area of the liquid bath where the air-reactive metal is introduced.

On the other hand, the apparatus of this invention for introducing air-reactive metals into a liquid bath of non-air reactive metal includes: (1) a housing assembly being open at one end and adapted for insertion into a liquid bath; (2) a supply assembly used to contain the air-reactive metal; (3) a valve assembly disposed between the housing and the supply assemblies for adjusting the flow of air-reactive metal from the supply assembly; (4) an assembly for introducing an inert gas into the supply assembly; and (5) a mixing assembly disposed within the housing for mixing the air-reactive metal with the non-air-reactive metal contained in the liquid bath.

BRIEF DESCRIPTION OF THE DRAWING

Various embodiments of this invention and particularly the apparatus of this invention will be more readily understood by reference to the accompanying drawing which illustrates an end view, partially in section, of one embodiment of the apparatus of this invention.

DESCRIPTION OF THE EMBODIMENTS

A suitable apparatus for introducing air-reactive metals into liquid bath of non-air-reactive metal is illustrated in the drawing. Generally, the apparatus includes a feed hopper 11 used to contain a supply of air-reactive metal; a seal 12 located at the top of the feed hopper to allow displacement of air contained in the hopper with inert gas; a supply chute 25 communicating with the bottom end of hopper 11 for delivery of air-reactive metal into the liquid bath 26; a housing 16 which is closed at its top end 27 and open at its opposite bottom end 28; support arm 20 which secures housing 16 to movable frame 24; an inner chamber 18 centrally disposed within housing 16; a propeller 19 disposed within chamber 18, and which is attached to shaft 29 and driven by driving assembly 21; a sliding gate valve 13 located between the supply chute 25 and housing 16 to adjust the flow of air-reactive metal into liquid bath 26; and an inert gas inlet assembly 14 located between valve 13 and supply chute 25.
As shown in the drawing, driving assembly 21 is also mounted on stationary frame 24. Shaft 29 interconnects propeller 19 and driving assembly 21 and extends downwardly through gland 17 into housing 16. A vibrator 15 is connected to the base of supply chute 25 to assist the flow of air-reactive metal into liquid bath 26. In addition, it should be noted that inert gas inlet 14 is desirable located at a point 13 to permit the velocity of the entering gas stream to prevent blockage of the valve by accumulated particles of air-reactive metal. With the gas inlet located in this position, the entering stream of inert gas also tends to assist the movement of air-reactive particles into housing 16.

The apparatus of this invention is designed to accommodate and adapt to the standard framework of typical variable driving mixing machines used in the alloying industry. Although the operation of the apparatus of this invention will be described herein for the manufacture of calcium-lead alloys, it should be understood that the same apparatus can just as easily be used in preparing other alloys containing at least one air-reactive alloy component.

Generally, metallic calcium particles having diameters in the range of about $\frac{1}{8}$ to $\frac{1}{4}$ inch are desirable for use in the practice of this invention. One suitable sequence of operating steps is as follows. Frame 24 is moved across the bath containing lead or some other non-air-reactive metal or alloy. The liquid bath level is indicated at 22. Frame 24 is positioned so as to insert a portion of housing 16 and all of inner chamber 18 below the bath level indicated at 22. It should be understood, of course, that the apparatus of this invention can be used with kettles of varying size, so that the quantity of premade and the relative concentration levels of the alloying metals can be varied virtually at will.

After insertion of housing 16 into bath 26, sliding gate valve 13 is closed. Then an inert gas supply, containing a gas which is non-reactive with the air-reactive metal, is connected to inlet line 14 and inert gas such as argon is introduced into the apparatus, desirably at a rate of about 5 to 10 standard cubic feet per minute.

Seal 12 is opened and metallic calcium particles are poured into feed hopper 11. With seal 12 open and argon gas being introduced through gas inlet 14, any air contained in feed hopper 11 or supply chute 25 is rapidly displaced through seal 12. After displacement of air, the seal is closed.

When large sized kettles are used in the practice of this invention, it is both desirable and safer to first fill the feed hopper with air-reactive metal and then purge the supply chute and hopper with inert gas before housing 16 is inserted into bath 26.

After the housing has been inserted into the lead bath 26, the bath temperature is adjusted to about 900° to 950° F. At this temperature calcium particles can desirably be added to the lead bath at a rate of 15 pounds per minute. Although lower lead bath starting temperatures can be used in the practice of this invention it has been found that increased alloying reaction times result.

With a starting lead bath temperature of 900° F. in a five ton kettle and a calcium addition rate of 15 pounds per minute, it has been observed that the temperature of the lead bath will increase to about 1100° F. in ten minutes, primarily a result of heat released from the exothermic lead-calcium alloying reaction. Thus, measurement of the bath temperature or the rate of increase of that temperature provides a useful indicator of both reaction rate and the rate of calcium addition. If, for example, the rate of calcium addition is either too low or too high, it can be adjusted by merely sliding valve 13 to a different position. Consequently, calcium addition rate and therefore overall reaction rate can be controlled by first sensing bath temperature changes and then adjusting the position of valve 13 to allow more or less calcium into the reaction system.

Prior to introducing calcium from feed hopper 11 into liquid bath 26, driving assembly 21 for propeller 19 is started. Typically the propeller is rotated at such a speed to generate a rather deep vortex in the bath, e.g., 280 r.p.m. Then vibrator 15 is started and valve 13 is opened to allow calcium from hopper 11 to be delivered through chute 25 and couplings 30 into housing 16 and ultimately into liquid bath 26. Vibrator 15 and inert gas flowing through inlet 14 and across the lip of valve 13 both function to assist the flow of calcium particles into the lead bath.

As a precaution valve 13 is closed before propeller 19 is shut down to avoid any accumulation and combustion of unalloyed metallic calcium. Likewise, propeller 19 is placed in operation before valve 13 is opened to prevent the accumulation of unalloyed metallic calcium on the surface of the lead bath.

The flow of liquid lead contained in bath 26 is shown in the drawing. Rotation of propeller 19 tends to pull liquid lead upwardly through the annular space between housing 16 and inner chamber 18 and then downwardly through chamber 18 and back into the bath. Calcium particles, of course, are introduced through opening 31 in housing 16, mixed with lead in the housing and the mixture then delivered downwardly through chamber 18.

Using the method and apparatus of this invention, calcium-lead alloys have been made ranging in calcium content from about .025 percent to about 1.5 percent by weight calcium, based upon the combined weight of calcium and lead in the alloy. Of course, larger concentrations in excess of 1.5 percent by weight calcium can also be used in the practice of this invention.

In addition, the method and apparatus of this invention can be desirably used for other air-reactive metals, such as phosphorus, arsenic, potassium, sodium, lithium, and other alkaline-earth metals, such as magnesium, strontium and barium. Indeed, alloys containing two or more air-reactive components can also be prepared by the method and apparatus of this invention.

It has been observed that in preparing calcium-lead alloys, that the method and apparatus of this invention can accomplish calcium recovery efficiencies (using 6 mesh, e.g., $\frac{1}{4}$ to $\frac{1}{4}$ inch calcium nodules) in the range of about 88 percent by weight, e.g., 88 percent of all calcium input into the system eventually becomes a part of the calcium-lead alloy. Other advantages of the invention include, more rapid reaction rates, e.g., a calcium-lead alloy containing one percent by weight calcium can be prepared in ten minutes as compared to two hours using the carbide process. Lower operating temperatures, e.g., 900° F. in contrast with 1400° F., improve reaction efficiency, reduce alloy losses through oxidation and prolong kettle life. In addition, the process of this invention is direct in the sense that it does not require production of a master alloy as a prerequisite to alloy manufacture. In addition, reduced quantities of by-product slags and drosses are generated by the process of this invention, especially when compared to the carbide process where lead bearing calcium chloride slag is lost in the covering slag. Finally, the process or method of this invention reduces operating hazards, improves alloy reaction rates, increases reaction efficiency and reduces the cost of preparing metal alloys containing air-reactive alloy components.

Although only several embodiments of the invention have been described herein it should be understood that variations, modifications and changes can be made in these embodiments without departing from the spirit and scope of the invention as defined in the following claims.

I claim:

1. A method for making lead base alloys having at least one component which is actively reactive with air relative to lead comprising:

(a) forming a substantially lead-containing liquid bath; directly introducing particles of at least one air-
reactive metal into said liquid bath; said air-reactive metal being selected from the group consisting of an alkaline-earth metal, arsenic, potassium, lithium, sodium and phosphorus; and providing an inert, protective gas covering for said air-reactive metal, said inert gas being nonreactive with said air-reactive metal.

2. The method of claim 1 wherein said air-reactive metal is calcium.

3. The method of claim 2 wherein the temperature of said liquid lead bath before introduction of the particles of calcium is maintained at about 900 to 950° F.

4. The method of claim 1 wherein said particles of air-reactive metal have diameters in the range of about ⅛ to ⅛ inch.

5. The method of claim 1 wherein said air-reactive metal particles are introduced into said bath at the rate of about 15 pounds per minute.

6. The method of claim 1 which is further characterized in that said liquid bath is agitated for a time sufficient to permit an alloying reaction to take place between lead and said air-reactive metals.

7. The method of claim 1 wherein said inert protective gas is argon.

8. A method for making calcium-lead alloys comprising:

    forming a liquid bath of lead;

    adjusting the temperature of said liquid bath of lead to about 900 to 950° F.;

    directly introducing particles of metallic calcium into said liquid bath;

    providing a covering of an inert protective gas for the calcium being introduced into said bath; and agitating the mixture of calcium and lead until a calcium-lead alloy is formed.

9. The method of claim 8 wherein about .025 to 1.5 percent by weight calcium, based on the combined weight of calcium and lead is introduced into said liquid bath of lead.

10. The method of claim 8 wherein the rate at which calcium is introduced into the liquid lead bath is adjusted in a manner sufficient to increase the overall reaction rate between lead and calcium.

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