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FOAMED METAL

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ABSTRACT OF THE DISCLOSURE

Foamed metals having improved cellular structure are produced by melting a metal, adding dross to the molten metal, and foaming the molten by means of a heat decomposable foaming agent.

BACKGROUND OF THE INVENTION

Field of the invention

This invention is in the field of metallurgy and, more specifically, pyrometallurgy.

Description of the prior art

In the production of foamed metal, that is, metal having a plurality of randomly dispersed closed cells throughout a metal matrix, a preferred method is to use a heat decomposable foaming agent to generate the gas to foam the cells. This technique is disclosed in U.S. Pats. 2,751,289; 2,895,819; 2,983,597; 3,300,296; and 3,297,431.

Prior art foams frequently display non-uniform cellular structure. This problem has been to some extent alleviated by incorporating metal oxide into the foam. The metal oxide serves to thicken the molten metal and thereby assist the subsequent blowing step.

Unfortunately, employment of metal oxide normally adds to the cost of the foamed metal produced. While this cost is more than offset by the advantages realized, the process would be even more attractive if such cost could be reduced. Such reduction is a principle objective of the present invention.

SUMMARY OF THE INVENTION

The present invention involves the use of dross in a foamed metal process as a source of metal oxide.

More particularly, the present invention concerns a process for foaming a molten metal or molten metal alloy where the improvement resides in mixing dross with the molten metal or molten metal alloy. Preferably, the dross is taken from a molten metal or molten metal alloy separate from that being foamed. A preferred metal is aluminum, and aluminum-magnesium alloys are especially preferred.

In accordance with the above-described procedure, the present invention provides several advantages which more than achieve the mentioned objective of the invention. Thus, not only is the cost of the metal foam not increased since the oxide source is dross which is normally a waste produce, but the metal content of the dross, which would normally be lost, is recovered. This results in significant savings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The dross which is used in accordance with this invention is a scum that forms on the surface of a molten metal. It is a waste or foreign matter which is usually disposed without recovery of its components.

Among the metals suitable for this invention, such as aluminum, magnesium, titanium, and the like, aluminum is preferred. Aluminum alloys are highly preferred and especially desirable are alloys of about 96 to about 85 percent by weight aluminum with about 4 to about 15 percent by weight magnesium.

The first step in the practice of the process of this invention is to melt the metal or its alloy. This may be achieved with any suitable apparatus known in the art. It is desirable that such apparatus be susceptible to being maintained under an inert gas purge. Gases such as nitrogen are especially suitable for this purge. If a melting pot is employed, the pot is raised to a temperature well above the temperature at which the metal or its alloy normally becomes a liquid. This facilitates quickly melting the metal or its alloy inasmuch as the temperature is allowed to slowly recede as the metal or its alloy becomes completely liquid. Desirably the temperature of the metal or its alloy is stabilized to the point of about 10° F. to about 50° F. above its melting point in order to insure that it will remain liquid during the remainder of the process.

Once the metal or its alloy has been liquified, it is agitated or stirred by means known in the art, e.g. an impeller, propeller, turbine, or the like. Where a turbine is employed, a rotation rate of 100 r.p.m. to 10,000 r.p.m. is suitable although 3,000 r.p.m. to 6,000 r.p.m. is generally preferred. It also appears useful to employ a slow rate of stirring before the foaming agent, described hereinbelow, is added to the molten metal or its alloy.

Once stirring or agitation of the molten metal or its alloy is well under way, the dross is added to the molten material. Preferably the dross is drawn from other aluminum processing operations. The metal oxide furnished by the dross functions both as a viscosity increasing agent. While the mechanism by which the metal oxide increases the viscosity of the molten metal or molten metal alloy is unknown, it is speculated that nucleation sites are created in the metal which function to increase its viscosity.

The physical state of the dross is not critical inasmuch as this material may be employed as a solid or liquid. Generally, it is most convenient to employ the material as a solid since it is solid at ambient temperatures.

On the other hand, it is critical that the dross be uniformly admixed within the molten metal or its alloy. Thus, it is not enough to deposit the dross on the surface of the molten metal without mixing it thereinto. The dross must be blended uniformly into the molten material by agitation or stirring, preferably at the rates above described.

It is suitable to use from about 0.01 or less to about 0.2 or more pound of the dross per pound of the metal or its alloy; preferably from about 0.02 to about 0.1 pound of dross is employed for each pound of the metal or its alloy. More preferably, per each pound of the metal or its alloy there is employed from about 0.03 to about 0.06 pound of dross.

The dross preferably is added to the molten material at a rapid rate. The time period of addition may vary from about 2 seconds or less to about 2 minutes or more and is subject to lengthening where very large quantities of dross are employed.

Generally, the pressure at which the dross is added to the molten metal or its alloy is not significant. Subatmospheric, super-atmospheric or ambient pressures can be used but ambient pressure is preferred for reasons of economics.

Once the dross has been added, the metal or its alloy is now ready for the foaming step. A wide variety of blowing agents can be used in the foaming process of this invention. Broadly, all blowing agents described in the prior art are suitable although some blowing agents are better than others. However, whatever the blowing agent, the foams of this invention have more uniform

cellular structure than foams produced from the same metal or metal alloy which have not been mixed with dross.

Among the various blowing agents, the metal hydrides are preferred, among which titanium, hafnium, or zirconium hydrides, especially the latter, are most preferred. Dihydrides and annealed hydrides of less than stoichiometric composition also can be employed. Generally, the best hydride blowing agents are those which decompose to yield gaseous hydrogen at the temperature of the metal or its alloy which is to be foamed and release hydrogen at a relatively slow rate.

The amount of foaming desired determines the amount of hydride or other blowing agent employed; that is, for a dense foam less blowing agent is used than for a lighter foam. It generally is preferred to make foams having a 20 percent density or less, or to make foams which weigh no more than about 20 percent of the weight per given volume of the unexpanded metal. For such foams it is suitable to employ from about 0.04 pound to about 0.4 pound of zirconium hydride for each pound of molten metal or its alloy to be foamed. A preferred range is from about 0.08 pound to about 0.15 pound per pound of molten metal to be foamed.

In the foaming step, a temperature is employed which is above that at which the metal or its alloy to be expanded is molten and above the temperature required to thermally decompose the blowing agent. The temperature, however, must not be so high that the blowing gas is released so fast as to cause foaming at an uncontrollable rate. Thus it is preferred to have the temperature of the molten metal or its alloy comparatively cool. Ideally, a temperature is employed at which the melt is barely viscous. Taking all these factors into consideration, the metal or its alloy is foamed at temperatures within the range from about 1,130° F. to about 1,250° F. and preferably from about 1,150° F. to about 1,200° F., being dependent of course upon the metal or its alloy used.

While it is suitable to carry out the foaming process at ambient pressure, greater or lesser pressures can be employed with better results under some circumstances. Lower pressures can be deleterious since they can encourage evolution of blowing gas outside the confines of the mass to be foamed. Super-atmospheric pressures up to 1,500 p.s.i.g. or higher can be used.

In conducting the blowing step above described, the foaming agent is preferably admixed with the molten metal or its alloy to be foamed by using the agitating or stirring means earlier set forth. In the course of such stirring or agitation, the rate is preferably increased above the initial agitation rate at which time the foaming agent is added. Without exception, the more uniform the mixing, the better the foam. All techniques of mixing known in the art which ensure efficient mixing of materials and liquids can be employed. Preferably the mixing step is performed in as short a time as is feasible to achieve uniform mixing. For best results with a typical mixture of blowing agent and molten metal or its alloy, sufficient mixing achieves homogeneity within about 10 seconds. This time period may require an agitation rate with a stirring device of up to 10,000 r.p.m.

As a rule it is preferable that the addition of foaming agent be at a lower temperature than the addition of the dross. Accordingly, it is preferred to cool the viscous metal before adding the foaming agent. Frequently, the cooling is best carried out in a second vessel, i.e., a vessel other than the hot chamber in which viscosity was increased. The second vessel is preferably generally to within plus or minus 50° C., preferably plus or minus 20° C. of the foaming temperature, whereupon the viscous material is added thereto.

Subsequent to the addition of the blowing agent, the molten metal or its alloy is allowed to foam. Foaming may occur within an open or closed mold. The size of closed foaming chambers relative to the quantity of metal or its alloy determines density of the product. Regulation of the mold temperature determines the smoothness and thickness of the skin on the finished article.

Having thus described the invention, the following example is presented only as being illustrative and not as being limiting of the invention.

EXAMPLE

Two hundred pounds of a molten aluminum alloy at about 1,200° F. with 7 percent magnesium is poured into an agitated vessel. Four pounds of dross which is normally discarded from another aluminum processing operation is added to the vessel. The viscosity is then increased slightly by agitating the mixture in the presence of air. Two pounds of zirconium hydride is then added and the mixture vigorously agitated for fifteen seconds, after which the foaming mixture is immediately transferred to a mold. Significant raw materials are saved by the process.

I claim:

1. In a process for foaming a molten metal or molten metal alloy, comprising melting the metal or metal alloy and mixing a blowing agent therewith for foarming the metal or metal alloy, the improvement comprising mixing dross with said molten metal or molten metal alloy prior to mixing the blowing agent, said dross being taken from a molten metal or molten metal alloy which is separate from said molten metal or molten metal alloy being foamed.

2. The process of claim **1** wherein said molten metal is aluminum.

3. The process of claim **1** wherein said molten metal alloy is an aluminum-magnesium alloy.

4. The process of claim **3** wherein from about 0.01 to about 0.2 pound of dross is added per pound of aluminum-magnesium alloy.

5. The process of claim **3** wherein said aluminum-magnesium alloy is heated to from about 1,150 to about 1,250° F. before said dross is added.

6. The process of claim **3** wherein said dross is intimately mixed with said aluminum-magnesium alloy by a turbine at from about 500 r.p.m. to about 8,000 r.p.m. for from about 2 seconds to about 2 minutes.

7. The process of claim **3** wherein said molten metal or molten metal alloy is foamed within 30 minutes after said dross is added.

8. The process of claim **1**, wherein said dross is taken from a molten aluminum or aluminum-magnesium alloy.

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