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PRODUCTION OF ALUMINUM CONTAINING IRON BASE ALLOYS

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This invention relates to the production of aluminum-containing ion base alloys, and in particular it concerns a melting process for the preparation of ductile alloys containing about 2 to 18 weight percent of aluminum.

Alloys containing aluminum have been known for some time to possess very desirable magnetic and electrical properties. They also have oxidation and heat resistant properties of significant usefulness. Addition of other elements provide other valuable properties such as strength at room and elevated temperatures, corrosion resistance, etc. However these alloys have not been commercially available, prior to this time, for no satisfactory method of melting had been developed which would produce an alloy with sufficient ductility to permit fabricating into the forms necessary to make useful articles.

Recently issued patents and technical literature disclose various methods of preparing and fabricating ductile aluminum-containing alloys having up to about 18 weight percent of aluminum. These methods of preparation have been studied and tried and it has been found that while they have some utility in making small quantities such as might be useful for laboratory purposes or for very limited applications, they were not satisfactory for producing aluminum containing alloys in commercial quantities. It was, therefore, necessary that other methods of preparing aluminum containing alloys be developed which would permit production of them on a large scale such as would be encountered in commercial operations.

It is therefore a major object of the present invention to provide a process for the preparation of ductile aluminum-containing iron base alloys on a large scale suitable for commercial operations.

It is a further object of the present invention that the process be a safe method for commercial production of aluminum-containing alloys.

It is another object of the present invention that the process be a convenient, easily practiced method for the economical production of aluminum-containing iron base alloys on a large scale suitable for commercial operations.

In practicing the processes described in the prior art, it was learned that when applying these previously known methods to large commercial quantities of metal the ductility of the resulting alloy was not sufficient to permit commercial fabrication of the cast product. It was also learned the aluminum distribution throughout the alloy was not very uniform when these methods were employed with large amounts of metal. A very dangerous condition is also encountered with large amounts of molten metal which, evidently, is not apparent when small quantities of metal are used. This condition is a very violent reaction when the molten aluminum is added to the molten iron bath. This condition was very dramatically demonstrated in the inventor's melt shop. In an actual experience approximately 6,000 pounds of molten iron were prepared in an electric arc furnace by the prior art method following the deoxidation procedure recommended. Approximately 800 pounds of molten aluminum were simultaneously prepared in a separate furnace by the recommended procedure. Again following the recommended procedure, the molten aluminum was poured into the molten iron bath. At the instant the metals were mixed a very brilliant light occurred which is evidence of a very high temperature reaction taking place. Further evidence of the severity of the reaction was the violent boiling of the metal, so violent that a considerable quantity of the metal boiled out of the containing vessel. No metal was recovered as useful product. The extreme heat of the reaction severely eroded the containing vessel. With this experience it was evident that while the known procedures may be satisfactory when small quantities of the alloy are being prepared, they could not be used in commercial size operations.

The present invention eliminates this problem and results in the production of ductile aluminum-containing iron base alloys that are fully satisfactory for subsequent commercial operations. I have found that upon adding a portion of the aluminum, that is to be alloyed with the refined iron, to the molten iron in its container as a final addition prior to the alloying step itself, no violent reaction occurs when forming the alloy melt. It is believed that this advantage results as a consequence of the gettering action of the aluminum for the elements or compounds which are present at that time and are the cause of the violent reaction just referred to. Since the violent reaction has been attributed principally to the oxygen content of the molten baths at the time of mixing causing the exothermic reaction witnessed, the effect of the aluminum addition in accordance with this invention is particularly surprising. Although calcium is considered a better deoxidizer than aluminum, it is preferred to keep the amount of this element to a minimum since its effect upon the properties of the alloy are undesirable. Moreover, as the above experience has shown, the use of calcium alone in quantities calculated to deoxidize thoroughly does not avoid the violent reaction upon subsequent alloying.

The advantages of the invention are attained upon incorporating in the molten iron as a final addition in the refining of that iron and just prior to alloying a portion of refined aluminum metal. This aluminum addition is in an amount up to about 5 percent, based on the weight of the iron present, though it generally does not exceed about 50 percent of the aluminum content of the alloy being produced. Preferably from 0.5 to 2 percent by weight of aluminum is used. The aluminum is added under conditions to insure that it actually enters the molten iron and is thoroughly mixed therewith. In other words, the molten iron has been previously treated to refine it so that it is receptive to the aluminum and the aluminum is not expended in preliminary deoxidation. One method of making the addition comprises attaching solid aluminum to an iron rod and then thrusting the rod rapidly through the slag towards the bottom of the molten iron in the furance. The bath is then stirred with the rod which generally is an adequate measure to provide the requisite mixing. Solid metallic aluminum which has been properly degassed is preferred for this purpose. Other methods of adding aluminum which result in the aluminum entering the iron rather than remaining in the slag also can be used. The major portion of this aluminum is retained in the molten iron bath with the remainder being lost to the slag throgh deoxidation.

In producing alloys in accordance with this invention, scrap or other form of iron, of a character designed to meet the required chemical composition, is melted in an electric arc furnace. When melting is complete, the car-

bon content is adjusted to the melting aim. In this example the carbon reduction was accomplished by passing oxygen through the melt.

After completing the melt down and carbon reduction the oxidized slag formed is then reduced. This is accomplished by additions of lime, fluorspar, aluminum and titanium. The bath temperature is maintained relatively high at this point, for example, around 3000° F. to increase fluidity of the bath and thereby permit the various oxides to rise to the slag.

The reduced slag is then removed from the molten metal bath. A second or finishing slag made up of lime and fluorspar sufficient to cover the bare bath is then added. The temperature of the bath is adjusted to about 2900° F. Lime and aluminum are added as needed to maintain a properly reduced slag. At this point the deoxidation of the bath is commenced by the addition of a small amount of aluminum metal. Usually about 0.2 to 0.6 percent by weight of aluminum is added at this time, preferably by steps to obtain the most effective use of the aluminum. About 0.2 to 0.4 percent by weight of manganese is then added. During this time the slag is maintained in proper condition by additions of lime and aluminum if necessary. Up to 0.5 percent by weight of ferro-titanium may be added. This partially serves to achieve further deoxidation as well as to enhance the properties of the metal.

At this time a first addition of calcium metal is made under conditions which insure that the calcium enters the molten metal and is not wasted on the slag. After the reaction of this first calcium addition is complete, a second calcium addition is made. Generally, about 0.1 to 0.3 percent by weight of calcium is added each time. After the calcium additions, up to 5 percent by weight of degassed solid aluminum metal depending on the aluminum content of the alloy to be produced, is poled into the melt. This addition of aluminum is made as rapidly as possible and is constantly stirred into the metal. The temperature of the molten metal is then adjusted to that desired for tapping after which the molten iron bath is ready for alloying with the molten aluminum.

Molten aluminum is prepared for alloying with the molten iron so that both the molten iron and molten aluminum will be in proper condition for mixing at the same time. The aluminum is melted and after adjusting to the proper temperature, about 1600° F., it is treated for an extended period of time with chlorine, the time depending upon the amount of aluminum melted. After the chlorine treatment the molten aluminum is further treated with calcium metal. Here again at least two calcium additions are made each in an amount of 0.1 to 0.3 percent by weight. The dross is then skimmed from the top of the molten aluminum. Fluorspar is then placed on top of the molten bath. The molten aluminum is now ready for alloying with the molten iron.

Several methods of mixing the two molten baths may be employed. It is not pertinent to this invention how the mixing is achieved.

It is believed that excessive oxygen content resulting from incomplete or improper deoxidation treatment during melting is a contributing factor to the lack of ductility in aluminum containing alloys. The refining procedures used are intended to lower the oxygen content to a minimum. Aluminum-containing alloys made by methods disclosed in this invention have been processed in commercial quantities to finished mill products in the form of bars, sheets and wire using the usual mill equipment.

A number of commercial heats ranging from 2000 to 10,000 lbs. have been made by the method disclosed

and there was no evidence of a violent reaction during the mixing operation. A satisfactory ingot product was produced and as indicated in the previous paragraph the material was wrought into various useful mill products.

While the method has been described as applying to the electric arc furnace it nevertheless can be equally useful in large heats melted in other types of furnaces.

Specifically the method described relates to the production of aluminum-iron alloys. It has also been applied where other elements have been added to the alloy to achieve particular properties. Additions of such elements as chromium, nitrogen, molybdenum, tungsten, cobalt, columbium, titanium, tantalum, vanadium, silicon, and manganese may be added to achieve special properties.

In accordance with the provisions of the patent statutes the principle of this invention has been explained and there has been described what is now considered to represent its best embodiment. However, it is to be understood that, within the scope of the appended claims, the invention can be practiced otherwise than as specifically described.

I claim:

1. In the method of preparing aluminum-containing iron base alloys in which iron is melted and is then refined by adding deoxidants thereto while said iron is maintained under a reducing slag and the resulting deoxidized iron is alloyed with about 2 to 18 percent by weight of deoxidized aluminum, the improvement comprising adding to said refined, deoxidized molten iron, just prior to alloying, an effective amount up to 5 percent by weight, based on the iron, of refined aluminum metal sufficient to prevent violent reaction upon subsequent alloying of aluminum with said iron, and thoroughly mixing said refined aluminum throughout said iron.

2. In the method of preparing aluminum-containing iron base alloys in which iron is melted, the resulting molten iron is partially deoxidized by maintaining it under a first reducing slag, and then said iron is further deoxidized under a second reducing slag by the addition of manganese and calcium metals and the resulting iron is alloyed with about 2 to 18 percent by weight of deoxidized aluminum, the improvement comprising incorporating in said refined, deoxidized iron, just prior to alloying, an effective amount up to 5 percent by weight, based on the iron, of degassed aluminum metal sufficient to prevent violent reaction upon subsequent alloying of aluminum with said iron, and thoroughly mixing said degassed aluminum throughout said iron.

3. In the method of preparing aluminum-containing iron base alloys in which iron is melted, the resulting molten iron is partially deoxidized by maintaining it under a first reducing slag, and then said iron is further deoxidized under a second reducing slag by the addition of manganese and calcium metals and the resulting iron is alloyed with about 2 to 18 percent by weight of deoxidized aluminum, the improvement comprising incorporating in said refined, deoxidized iron, just prior to alloying, about 0.5 to 2 percent by weight, based on the iron, of degassed aluminum metal, and thoroughly mixing said degassed aluminum throughout said iron.

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