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METHOD OF MAKING ADDITIONS TO MOLTEN METAL

Nicolas Volianik, Sevres, France, assignor to Centre Technique des Industries de la Fonderie, Paris, France, a public utility institute of France

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This invention relates to methods of making additions to molten metals in metallurgical processes, especially the addition of relatively large amounts of carbon and/or silicon to a bath of molten steel or iron.

For the purpose just indicated it is well-known to impart agitation to the molten metal. Such agitation is obtained, for example, when the process is being performed in electric furnaces of the induction type. It is also known to incorporate additions to a bath of molten metal by an injection process, wherein a stream of a gaseous carrier medium in which the elements to be added are suspended is bubbled under pressure through the bath. Such elements should then be provided in a highly divided condition, such as fine graphite powder, so as to be suspended in the gas medium.

In other metallurgical processes, the chemical composition of a molten metal is sometimes modified by adding a refining slag ingredient adapted to remove various objectionable constituents from the bath such as sulfur and phosphorus. In such processes the slag is deposited on the surface of the bath and a vigorous blast of gas or air is discharged through the bath in order to stir it up and ensure that all of the portions of the molten metal will contact the slag reagent.

As further prior art pertinent to a definition of the scope of the present invention, it has been suggested to add to a bath of molten metal very small quantities, on the order of 0.1%, of an alloying metal such as magnesium or boron by sprinkling the bath surface with the added metal and discharging a moderate blast of gas through the bath at a low or moderate rate to provide small bubbles, the blast being discharged e.g. through a screen made of porous refractory material.

In connection with cast iron and other metallurgical processes it is sometimes desired to add into the bath comparatively large amounts, say on the order from 0.5 to 4%, of additions, such as carbon and silicon. It is found that the difficulty with which such additions will effectively combine with or dissolve in the metal in the bath increases as the initial content of the added element and other ingredients, e.g., carbon, silicon, and phosphorus, in the bath increases. More precisely, in connection with hypoeutectic cast iron, the difficulty encountered in enriching the iron with added carbon increases as the initial composition approaches closer to the eutectic point, and the enrichment becomes extremely difficult where hypereutectic cast iron is concerned.

It is an object of this invention to facilitate the addition of ingredients to a molten metal bath whereby the relative proportion of addition that may be effectively dissolved and/or combined with the metal can be substantially increased. More specifically it is an object to facilitate the addition of carbon and silicon to cast irons of composition approaching and exceeding the eutectic point.

The method of the invention comprises depositing on the surface of the bath the elements to be dissolved therein or materials containing such elements, preferably in a pulverulent condition, and imparting a vigorous stirring or agitation to the bath by means of gas discharged in one or more streams through the bath so as to generate a high degree of disorderly turbulence in the molten metal.

The blasts of gas are discharged through one or more tubes having outlets of suitable size in the bath. The added ingredients are then completely coated and enveloped on all sides by the molten metal stirred up at the surface of the bath and any cushion of air or other gas tending to separate the ingredients from the metal, as tend to occur in the conventional bubbling processes referred to above, is thus positively broken up and intimate contact is obtained. At the same time improved uniformity of distribution is achieved.

The turbulence should be such as to generate large gas bubbles and should not assume the form of a mere regular to-and-fro motion of the molten metal as would be obtained if the purpose were merely to renew the metal particles at the surface of the bath in order to place them all successively into contact with the addition material at the surface of the bath. The turbulence effect used according to the invention should, in fact, generate sufficiently violent eddies and vortices to ensure that the addition ingredients are made to sink to a relatively great depth into the bath so as to be protected from the atmosphere.

To achieve the above results it has been found that the blasts should be discharged through one or more tubes having relatively large outlet section areas of the order of about one square centimeter, and no porous barriers or the like should be interposed as are used in some of the methods referred to above in order to smooth the relative motion between the metal and additions.

The discharge tube or tubes used according to the invention may be made from various materials. However, especially satisfactory results are obtained when using graphite tubes of the type disclosed in U.S. Patent 2,853,376. This, in cases where the added material is carbon, contributes to achieve the desirable result that the carbon in the cast iron product is in the form of graphite and has not combined in part with the iron to form carbides.

The gas used is preferably a neutral gas such as nitrogen or argon. However, air may also be used if desired though the efficiency would then probably be reduced owing to the possibility of combustion of some of the elements added.

The method of the invention results in some unexpectedly desirable advantages especially as regards the high relative proportions of elements that can thus be added, which considerably exceed the amounts that it was heretofore found possible effectively to combine with the molten metals when using conventional methods of addition. Also, the time required to dissolve a given amount of addition in a given volume of molten metal is reduced and will not, usually, exceed about 2 minutes. This high rate of dissolution achieved by the invention is an important advantage in that it minimizes the degree of cooling of the molten metal in the treating ladle or crucible. Advantageously however, whenever possible heat-isolating means may be provided for further retarding the cooling.

Another advantage specific to the important embodiment of the invention as applied to the simultaneous addition of both carbon and silicon, is that the method is found to induce a dissociation of any silicon carbide that would otherwise tend to form under such circumstances. It is known that, normally, silicon carbide will not decompose in a cast iron bath. It has been found however that when applying the method of the invention, silicon carbide can be added to the iron bath and that it rapidly decomposes into carbon and silicon, thereby producing improved grades of cast iron having higher characteristics than similar grades as produced by conventional methods.

The method of the invention makes it possible inter alia to use low-carbon cupola iron to produce high-carbon iron having a carbon concentration in the range from

3.50 to 4.20% in a very efficient, reliable and economical way.

It is also made possible to use a cast iron made entirely from a steel charge, e.g. cupola iron, in order to produce any desired one of the full commercial grades of cast iron, regardless of their carbon and silicon content, and including the high-tensile grades.

Example 1

The invention was applied to a cast iron produced in an acid lined cupola using cold blast, from a 100% steel charge and having the composition C 2.96%; Si 1.25%; MnO .42%; S 0.1%; P 0.08%. It is desired to increase the carbon to 0.8% concentration.

800 kg. of the iron are cast in a ladle, and over the surface of the molten iron there is spread 6.9 kg. of graphite containing 93% carbon. Nitrogen is then bubbled through the bath through graphite tubes for a period of two minutes. It is found that the carbon content in the iron after the treatment has increased from 2.96 to 3.70%, giving a yield

$$R=\frac{\text{Effectively incorporated C}}{\text{Introduced C}}=\frac{0.74}{0.80}\times 100=92.5\%$$

Example 2

This example relates to the production of iron for ingot moulding from a charge containing 50% steel. Before treatment the iron had the composition C 2.74%, Si 1.50, Mn 0.92, S 0.04, P 0.11. It was desired to increase its carbon content to 3.60.

The same general procedure is followed as in Example 1, with an amount of 900 kg. molten iron and 9.205 kg. of graphite containing 93% C spread over the surface of the bath. After treatment the C has increased from 2.74 to 3.53%, a yield of 83%.

Example 3

This example relates to re-carburizing and silicon-loading an iron having the following composition before treatment: C 3.19, Si 0.56, Mn 0.5, S 0.1, P 0.08. Using 900 kg. of the iron, 7 kg. of 93%-C graphite is spread over the bath surface and nitrogen is bubbled as before for two minutes. Analysis of the iron after treatment shows that the C content has increased from 3.19 to 3.87% and the Si content from 0.56 to 1.22%, representing yields of 94.4% for the carbon and 93.0% for the silicon.

Example 4

Cast iron made in a cupola from a 100% steel charge and having the composition C 3.20, Si 0.75, Mn 0.4, S 0.10, P 0.04, was treated with silicon carbide using a similar procedure to that in the foregoing examples, and the composition was thereby changed to C 3.50, Si 1.47, Mn 0.4, S 0.10, P 0.04. The yield of the addition elements was about 82%. The resulting cast iron had a tensile strength of 35 kg./sq. mm.

All compositions above are given in percent.

What I claim is:

1. In a metallurgical process for increasing the content of at least one of the elements carbon and silicon in a molten iron containing bath by an amount ranging from about 0.5 percent to about 4 percent of the bath, the steps of placing said element on the surface of the bath, and discharging gas through the bath at a rate and for a time sufficient to cause violent agitation and turbulence in the bath and thereby cause said element to be completely surrounded and coated with molten metal, said gas being at least in part an inert gas so as to deter oxidation of the added element.

2. The method claimed in claim 1, wherein said gas is discharged through at least one tube immersed in the bath and having an outlet area of the order of one square centimeter.

3. The method claimed in claim 1, which includes heat-isolating said bath during said gas discharging step.

4. In a process for producing cast iron in which the elements carbon and silicon are added to a molten iron bath in a proportion ranging from about 0.5% to about 4% of the metal, the step of placing silicon carbide on the surface of the bath and discharging gas through the bath at a rate and for a time sufficient to cause said carbide to be completely surrounded and coated with molten metal whereby said carbide is dissociated into carbon and silicon.

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