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ALLOY ADDITION AGENT

Augustus B. Kinzel, New York, and Charles O. Burgess, Niagara Falls, N. Y., assignors, by mesne assignments, to Union Carbide and Carbon Corporation, a corporation of New York

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The invention relates to a method and agent for incorporating alloying elements into molten iron or steel.

Customarily alloying elements are added to molten steel in the form of ferro-alloys, which are mixtures or compounds of the alloying elements with iron, or iron and silicon. It is comcon practice, particularly in making low alloy steels, to add ferro-alloys directly to a ladle of molten steel. By this procedure the melting cycle in steel making may be shortened and the recovery of alloying elements more accurately controlled.

In general, alloying elements having high melting points or relatively poor solubility in molten steel are unsatisfactory as ladle additions. The length of time required for complete solution of such alloying elements may be of sufficient duration to effect excessive oxidation of the alloying elements, to produce segregation of alloying elements in the final product, or to cause heavy skull formations in the ladle due to cooling of the molten steel.

One method proposed to offset these difficulties is to add to molten steel an admixture of alloying elements and a material having marked exothermicity at the temperature of molten steel, the ignition of the exothermic material providing heat to counteract the temperature drop normally resulting from the addition of the alloying elements. Major disadvantages of this procedure are that use of proposed exothermic mixtures often results in the formation of a voluminous slag which acts to entrap the alloying elements, preventing their complete incorporation into the molten steel; and also that undesirable slag particles may become entrapped in the molten steel thus adversely affecting the cleanliness of the final metal product.

It is an object of the invention to provide a method and agent whereby alloy steels may be produced by the rapid incorporation of high melting point or difficultly soluble alloying elements into molten steel with a high percentage recovery of the alloying elements and a minimum formation of slag.

A further object is to provide an addition agent containing alloying elements; said agent being particularly characterized by the enhanced solubility of the alloying elements upon adding the agent to molten steel.

These objectives are achieved by adding to molten steel an agent comprising the alloying element or elements to be incorporated into the steel (as elemental metals, alloys thereof, or as ferro-

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alloys) and manganese ore (or dioxide). A suitable silicide added to the agent effects a further improvement in its solubility.

Silicides that decompose energetically upon contact with molten steel are most suitable for use with the agent of the invention. Calcium silicon and silicon zirconium are examples of such silicides. Ferrosilicon may be used as a minor part of the silicide constituent of the agent, but its effectiveness is not so great as that of thermally decomposable silicides. Silicon may be incorporated in the agent as an alloy of silicon and the major alloying element.

The agent of the invention may be in agglomerated form as for example a briquette or lump, preferably using sodium silicate as a binder, or it may be packaged in bags or other suitable containers and used as an unbonded mixture.

Incorporation of the agent into steel may be accomplished by adding the agent directly to a molten steel bath in a furnace or in any other suitable manner, as for example, by adding the agent to molten steel in a ladle; by adding the agent to a stream of molten steel as it is poured into a ladle; or by placing the agent into a ladle and thereafter adding the molten steel. Upon adding the agent to molten steel, progressive fragmentation of the agent occurs thereby enabling active reaction of the fragments with molten steel. In the reaction a minor amount of a fluid slag is formed which further aids rapid solution of the alloying elements by fluxing refractory oxides formed on the alloy particles, but which in no way entraps the alloy particles or otherwise prevents their rapid incorporation into molten steel.

The agent of the invention, in its broad and preferred forms comprises:

	Broad Range	Preferred Composition
	Per cent	*Per cent*
Alloying elements (as elemental metal or ferro-alloy)	60–85	about 70
Manganese ore (MnO_2)	4–30	about 20
Silicide	1–10	about 3
Sodium silicate [1]	1–10	about 7

[1] Value represents percent by weight 22° Baumé solution containing 4.11% Na_2O, 16.25% SiO_2.

Sodium silicate solution is used primarily as a binder in preparing briquettes of the agent. Its use in packaged unbonded mixtures of the agent is not essential; if used, however, for its fluxing value, the sodium silicate, preferably, should be in dehydrated form.

In preparing the agent in briquette form, the ingredients should be comminuted, preferably, to pass through a 100 mesh screen (0.149 mm. openings).

The method and agent of the invention will be described by examples wherein chromium, as ferrochromium, is the alloying element to be incorporated into molten steel. For this purpose, briquettes were prepared in accordance with the invention containing 80% ferrochrome (70% chromium-6% carbon grade), 10% manganese ore (80% to 90% MnO_2), 5% calcium-silicon alloy (25% to 35% calcium grade) and 5% sodium silicate solution as binder. In the examples, data of which are shown in Table I, the solubility of the agent of the invention (Type I briquette) was tested in comparison with standard high carbon ferrochrome of the 70% chromium-6% carbon grade and also commercially available briquettes of an exothermic type consisting essentially of iron, chromium, silicon and sodium nitrate (referred to in the table as agent C).

In the examples, single briquettes containing two pounds of chromium, were added to a ladle containing 125 pounds of molten steel. The steel was prepared in an arc furnace and contained: 0.15% carbon, 0.60% manganese and 0.05% silicon at tap.

Table I

Example No.	Addition Agent	Solubility time, in Seconds	Per Cent Chromium Recovery	Remarks
1	Lump Ferrochrome.	60	93.0	
2	Agent of the Invention (Type I Briquette).	46	97.5	Moderate slag. Good agitation. Briquette completely dissolved.
3	Agent C (Briquette).	57	94.8	Voluminous slag. Fumes. Piece of briquette still floating on slag after 57 seconds.

It will be noted that the agent of the invention, Example No. 2, not only dissolved in less time than either of the other tested materials but also resulted in the highest percentage recovery of chromium.

Many tests have been made using the agent of the invention as a means of incorporating alloying elements into molten steel. These tests uniformly have resulted in rapid solution of the agent and in a high percentage recovery of the alloying elements, often exceeding 99%.

The composition of the agent of the invention may be varied widely within the before indicated limits. For example, a briquetted agent, for incorporating chromium into steel, comprising 75 parts high carbon ferrochrome, 18 parts manganese ore, 4.5 parts calcium-silicon and 2.5 parts sodium silicate (dry) caused only a minor temperature drop when added to molten steel and, in addition, dissolved rapidly with a high percentage recovery of chromium.

The degree of exothermicity exhibited by the agent of the invention is influenced by the content of manganese ore in the agent; the degree of exothermicity reaching a maximum in agents containing about 20% manganese ore. This characteristic of the invention is illustrated by data in Table II obtained from comparative tests wherein the agents were added respectively to

100 pound baths of molten steel at a temperature of 1600° C. Exothermicity of the agent was determined by measuring the temperature drop in the bath resulting from the addition of the agent. The agents employed in the tests were the same as those shown in Table I together with an additional agent of the invention, referred to as Type II briquette, containing 70.8% low carbon ferrochromium, 20% manganese ore, 2.5% calcium-silicon and 6.7% sodium silicate as a binder.

Table II

Test No.	Addition Agent	Drop in Steel Bath Temperature
		Degrees C.
1	Agent of Invention (Type I Briquette)	−25
2	Agent of Invention (Type II Briquette)	−10
3	Lump ferrochromium	−29
4	Agent C (Briquette)	−13

It will be noted that an increase from 10% manganese ore (Type I briquette) to 20% manganese ore (Type II briquette) effects a considerable increase in the exothermicity of the agent of the invention. Type II briquettes, containing 20% manganese ore, exhibited the greatest exothermicity of any of the addition agents tested.

Test data further indicates that the degree of exothermicity exhibited by the agent of the invention is largely dependent on the manganese ore content, and is substantially independent of the silicide content, although the presence of a thermally decomposable silicide, such as calcium-silicon, does effect a further increase in the solubility of the agent. Test data also indicate that the exothermicity imparted by the manganese ore is largely independent of the carbon content of the alloying element or elements added. For example, there appears to be no material difference in the degree of exothermicity, for a given manganese ore content, between agents containing low-carbon ferrochromium and those containing high-carbon ferrochromium.

Although the method and agent of the invention have been described with particular reference to the incorporation of chromium into molten steel, it is to be understood that the invention is not limited thereto and is also effective in the incorporation of many other alloying elements into molten steel. In this application, the expression "alloying elements" as used in reference to the agent of the invention includes such metals as manganese, vanadium, tungsten, molybdenum, titanium, zirconium and any other difficultly soluble or refractory metal intended to be incorporated into steel for the purpose of modifying its final composition, such metals being in the form of elemental metals, alloys thereof, or ferroalloys.

What is claimed is:

1. An addition agent for incorporating chromium into molten iron and steel composed of between 4% and 30% manganese dioxide; between 1% and 10% calcium-silicon; remainder ferrochrome; said agent being in the form of a comminuted unbonded admixture.

2. An addition agent for incorporating chromium into molten iron and steel composed of between 4% and 30% manganese dioxide; between 1% and 10% calcium-silicon; between 1% and

and 10% sodium silicate; remainder ferrochrome; said agent being in the form of an agglomerated admixture.

3. A comminuted unbonded addition agent composed of about 70 parts ferrochrome; 20 parts manganese dioxide; and 3 parts calcium-silicon.

4. An agglomerate admixture composed of about 70 parts ferrochrome, 20 parts manganese dioxide; 3 parts calcium-silicon, and 7 parts sodium silicate.

AUGUSTUS B. KINZEL.
CHARLES O. BURGESS.

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