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FILLING SUBSTANCE FOR PRODUCING CHROMIUM-MOLYBDENUM STEEL

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This invention relates to an additive mixture of a specific composition for refining steel which contains various special constituents including chromium and molybdenum.

Heretofore, in order to supply ordinary steel with additives or a deoxidation agent for refining special steel, mother alloy has usually been prepared beforehand which contains the chief constituents, e.g., ferrochromium, ferromanganese, ferromolybdenum, ferrosilicon, etc.

These ferroalloys, however, are all made in an electric furnace or a blast furnace, or by thermit method, so that the price of the additive materials, including refining cost of such mother alloy, is bound to be quite high and besides, carbon and other impurities are introduced in the processing of the mother alloy. It is very troublesome, to impart the proper constitution to steel, containing such impurities, in the principal refining process thereof.

The object of the present invention is to provide means of avoiding these drawbacks of known methods by virtue of a special new additive mixture which is of low price and whereby desired constituents can be incorporated in the steel without losing any of their activities.

In an ordinary refining process of ferrochrome, chromite is heated to give the following reaction:

$$FeOCr_2O_3+4C=Fe+2Cr+4CO$$

This chromium, having strong affinity for carbon, makes carbides such as $Cr_{23}C_6$, Cr_7C_3, Cr_3C_2, etc. and thus ferrochromium never fails to contain a certain quantity of carbon. Treated with some reducing substance other than carbon, it makes ferrochromium containing no carbon, reacting as follows:

$$3FeOCr_2O_3+8Al=3Fe+6Cr+4Al_2O_3$$

$$FeOCr_2O_3+4Ca=Fe+2Cr+4CaO$$

$$FeOCr_2O_3+2Si=Fe+2Cr+2SiO_2$$

$$FeOCr_2O_3+4Mg=Fe+2Cr+4MgO$$

In this, when molybdenum oxide is mixed in the material, chromium-steel-molybdenum mother alloy can be made through the same reducing reaction.

When this reaction is not conducted in a separate process of preparing mother alloy beforehand but in a steel refining process itself, that is, in molten steel in a furnace or a ladle, chromium-steel alloy and chromium-steel-molybdenum alloy fuse into the body of steel about them on their forming, and thus the incorporation of chromium and molybdenum becomes very effective and besides such impurities as carbon can be prevented from mixing therein.

But then, in order to increase the incorporation efficiency, it is necessary not only to make said reductive

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reactions quick and smooth, but to promptly diffuse said mother alloy formed thereby all through the body of steel and make its constitution homogeneous.

With these objects in view, the present invention provides a new additive mixture of the following composition, of which the effects will be shown in appended embodiments,

First, for chromium, the principal material, is used chromite obtained through careful ore dressing and concentration, or, if necessary, pure chromium oxide obtained through chemical treatment to prevent any undesirable metal element mixing therein as a constituent of the alloy.

Next, for a reducing agent is used aluminum, magnesium, calcium, silicon or one of their alloys, or some other highly active reducing metal in order to quicken the reductive reaction in molten steel, and further, to make it smooth, the principal material and the reducing agent are both ground into grains or powder and mixed well, which tends make uniform the reactions.

Third, a thermal cracking oxidizer such as potassium nitrate, sodium nitrate, calcium nitrate, potassium nitrite, potassium chlorate, manganese dioxide, or the like is mixed therein not only to cause immediate heating on adding the mixture to molten steel and thus raising the temperature of the reacting parts to increase the speed of the reductive reaction, but to quicken the diffusion of the added and reduced elements all through the molten steel and accomplish in a few moments desirable homogenization of the steel constitution by volatile substance generated in this decomposition violently agitating the molten steel.

Fourth, in order to give proper constitution to the slag, which consists of various kinds of compounds produced in these reactions, and thereby facilitate its separation from the metal, some flux such as lime, silica, cryolite, fluor-spar, magnesia or some other salt is added, well mixed therein.

Fifth, this powdery mixture is formed into grains or blocks to facilitate its handling. In such forming operation, water glass, bittern, silica gel or other inorganic binder is used for a plasticizer so as to avoid the addition of carbon-containing elements as much as possible, but if necessary, a small quantity of organic binder may be used, such as cellulose derivative, sodium alginate, polyvinyl alcohol or the like. This powdery mixture, the binder and water or other solvent are thoroughly mixed and formed into a desired form.

The range of effective proportions of these materials is as follows: chromium oxide 20–70% (in using refined chromite for this, the quantity of chromium contained therein), molybdenum oxide 1–15%, a reducing agent 8–45%, a thermal cracking oxidizer 5–25% and a flex 1–15%, and when refined chromite containing chromium oxide 50% is used, refined chromite 50–70%, molybdenum oxide 5–10%, a reducing agent 15–30%, a thermal cracking oxidizer 5–20% and a flux 3–10%.

Not only chromium and molybdenum but also, if necessary, other alloy constituents, e.g., oxides of various kinds of metal such as nickel, vanadium, manganese, tungsten, titanium, zirconium, cobalt, etc. (NiO, V_2O_5, MnO, MnO_2, MnO_3, etc., WO_3, TiO_2, ZrO_2, CoO) can be mixed and introduced effectively into molten

steel with almost the same reactions, given as much reducing agents as can deoxidize them.

According to the present invention, wherein a reducing agent is made to act upon refined chromite (or chromic oxide) with molybdenum oxide in molten steel itself, not through a known separate process of making mother alloy, the alloy constituents can be more easily incorporated in the steel, and at the same time, deoxidization and degassing therein are effectively done by the reducing agent and mixing of carbon or other impurities can be strictly prevented to make it easy to give proper constitution to the steel.

Furthermore, various other alloy constituents such as nickel, vanadium, manganese, tungsten, titanium, zirconium, cobalt, etc., can be incorporated in the steel, by mixing therein the oxides of these metals, and thus various alloys of desired constitution can be obtained without so much difficulty.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, as to its method and effect, together with additional objects and advantages thereof, will be best understood from the following examples in which are shown the preferred embodiments of the present invention.

Example 1

	Percent
Refined chromite powder containing cromium oxide (50%)	65
Molybdenum oxide powder (85%)	4
Silicon powder	17
Lime	6
Potassium nitrate	8

These are mixed well, formed into some desirable form with a small quantity of water glass added, and then dried. Next this composition is added to molten steel in a furnace at the rate of 0.6 ton of it per ton of steel.

The constitution of the steel after refining is as follows and there is an increase of 170 kg. of molten steel per 1 ton of the initial steel.

	C (Percent)	Si (Percent)	Mn (Percent)	Cr (Percent)	Mo (Percent)
Initial steel	0.38	2.45	0.54	2.03	0.05
Additive modified steel	0.40	2.15	0.45	11.64	1.18

Quantities of chromium and molybdenum in the additive:

Cr: 600 kg.$\times$0.50$\times$0.6842$\times$0.65=121.319 kg.
Mo: 600 kg.$\times$0.85$\times$0.6666$\times$0.04=13.5986 kg.

Quantities of chromium and molybdenum which add to those in the initial steel when the additive is incorporated therein:

Cr: 1170 kg.$\times$0.1164$-$1000$\times$0.0203=115.888 kg.
Mo: 1170 kg.$\times$0.0118$-$1000$\times$0.0005=13.306 kg.

Therefore the modifying efficiencies of the two are:

$$\text{Cr: } \frac{115.888}{121.319}\times 100=95.52\%$$

$$\text{Mo: } \frac{13.306}{13.5986}\times 100=97.85\%$$

Example 2

	Percent
Refined chromite powder containing chromium oxide (50%)	60
Molybdenum oxide powder (85%)	9
Aluminium powder	8
Calcium, silicide powder (Si 60%)	12
Calcium nitrate	8
Silica	3

These are mixed well and shaped as in Example 1. This composition is added to molten steel in a furnace at the rate of 60 kg. of it per ton of steel.

The constitution of the steel after refining is as follows and there is an increase of 18 kg. of molten steel per 1 ton of initial steel.

	C (Percent)	Si (Percent)	Mn (Percent)	Cr (Percent)	Mo (Percent)
Initial steel	0.34	0.24	0.75		
Steel modified by additive	0.35	0.26	0.73	1.15	0.28

The quantities of chromium and molybdenum in the additive:

Cr: 60 kg.$\times$0.50$\times$0.6842$\times$0.60=12.3156 kg.
Mo: 60 kg.$\times$0.85$\times$0.6666$\times$0.09=2.9997 kg.

The quantities of chromium and molybdenum incorporated into the steel when modified by the additive are:

Cr: 1018 kg.$\times$0.0115=11.707 kg.
Mo: 1018 kg.$\times$0.0028=2.8404 kg.

Therefore the modifying efficiencies of the two are:

$$\text{Cr: } \frac{11.707}{12.3156}\times 100=95.06\%$$

$$\text{Mo: } \frac{2.8404}{2.9997}\times 100=94.69\%$$

As shown in Examples 1 and 2, the modifying efficiency of the modifying composition according to the present invention is not less than that of any known method using ferro-alloy such as ferrochrome, ferromolybdenum, etc., and besides, when ferroalloy containing much carbon is used in this, the refining operation becomes difficult, the quantity of carbon contained in the molten steel or refined product increasing greatly, but according to the present method the operation is easy, carbon never being added thereto. The steel used in this method cannot but gain a little in quantity, but the satisfactory separation of slag makes the drawback rather insignificant. Futhermore, the cost is low, the modifying operation is easy and the product is by no means worse in quality than that by any known method.

It is thought that the invention and its advantages will be understood from the foregoing description and it is apparent that various changes may be made in the process and the composition of materials without departing from the spirit and scope of the invention or sacrificing its material advantages, the examples hereinbefore described being merely preferred embodiments thereof, the invention being limited only by the claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent of the United States is:

1. A modifying composition for producing chromium-molybdenum steel comprising, in combination, finely divided reactants as follows:

	Percent
(a) Chromium oxide	20 to 70
(b) Molybdenum oxide	1 to 15
(c) Reducing agent	8 to 45
(d) Thermal cracking oxidizer	5 to 25
(e) Flux	1 to 15

said finely divided reactants being intimately mixed and formed into bodies with the aid of a binder, said binder comprising essentially

(f) inorganic binder material.

2. Composition according to claim 1, wherein reactant (a) is refined chromite containing 50% chromium oxide, and wherein the proportions of the reactants (a) through (e) are as follows:

(a)—50 to 70% (refined chromite)
(b)—5 to 10%
(c)—15 to 30%
(d)—5 to 20%
(e)—3 to 10%.

3. Composition according to claim 2, wherein the proportions of the reactants are as follows:

(a)—65%
(b)—4%
(c)—17%
(d)—8%
(e)—6%.

4. Composition according to claim 2, comprising the following specific reactants in the proportions set forth, namely:

	Percent
(a) Refined chromite powder (50% chromium oxide)	60
(b) Molybdenum oxide powder (85%)	9
(c) Aluminum powder	8
and calcium silicide powder (Si 60%)	12

	Percent
(d) Calcium nitrate	8
(e) Silica	3

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