

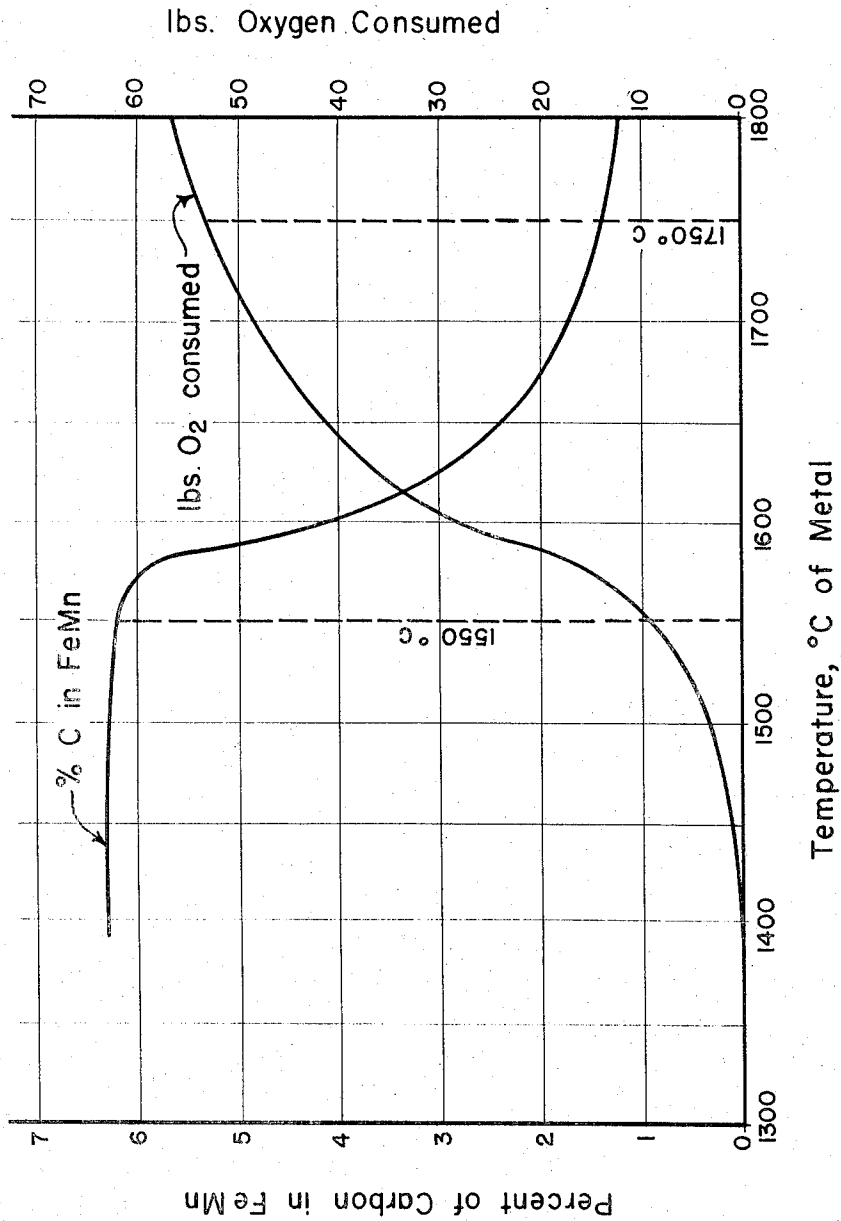
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R. W. DAY

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PROCESS OF PRODUCING ALLOYS

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INVENTOR

Robert W. Day

BY

Pennie, Edmonds, Morton, Taylor & Adams

ATTORNEYS

1

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PROCESS OF PRODUCING ALLOYS

Robert W. Day, Lookout Mountain, Tenn., assignor, by
mesne assignments, to Union Carbide Corporation, a
corporation of New York

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1 Claim. (Cl. 75-80)

This invention relates to the production of ferromanganese alloys, and in particular to medium carbon ferromanganese.

Ferromanganese, the principal metallurgical form of manganese, is an alloy containing about 80% or more of manganese, the balance being mainly iron. It is ordinarily produced by smelting high grade manganese ore either in a blast furnace or in an electric furnace, and its principal use is as a deoxidizer and alloying material in steel making. The ferromanganese product of the smelting furnace ordinarily contains from about 3% to 8%, and typically from 5% to 7.5%, by weight of carbon, and therefore it cannot be used in the production of low carbon and other special steels unless the carbon content of the FeMn alloy is first reduced preferably to not more than 1.5% carbon. However, previously proposed processes for decarburizing the high carbon ferromanganese product of a manganese smelting furnace to obtain a medium carbon product suitable for use in making low carbon steels and the like are complicated, impractical and/or uneconomic. As a result, the conventional method for making medium carbon FeMn is a triplex procedure involving first the smelting of high grade manganese ore to produce a siliceous slag containing from 25 to 35% Mn, second the reaction of the high Mn slag with a further amount of high grade manganese ore to produce silicomanganese, and finally the reaction of the silicomanganese with a manganese ore-lime melt in an open arc furnace to produce the desired medium carbon ferromanganese product.

It is known that the carbon content of molten pig iron and other high carbon ferrous alloys can be reduced by blowing the molten metal with an oxidizing gas, and it previously has been proposed that pig iron containing up to 20% Mn (i.e. spiegeleisen) be decarburized in this manner. However, it is also well known that manganese is a relatively volatile metal (its boiling point is about 1900° C. as compared to about 3000° C. for iron, and it has heretofore been the belief of those skilled in the art that the temperature of molten manganese-containing iron should be held below about 1450° C. in order to avoid excessive loss of manganese through volatilization. In addition, it is known that oxygen reacts preferentially with manganese rather than with carbon at the relatively low temperatures heretofore thought to be necessary in order to minimize loss of manganese by volatilization. Therefore, the decarburization of manganese-containing iron, and in particular high carbon ferromanganese, by blowing the molten metal with an oxidizing gas has been universally regarded as being impractical and uneconomic due to the apparently unavoidable excessive loss of manganese either by oxidation at low temperatures or by volatilization at higher temperatures.

I have now made the unexpected and surprising discovery that, contrary to the previous experience of workers skilled in the art, high carbon ferromanganese can readily be decarburized by blowing the molten metal with an oxidizing gas without excessive loss of manganese either by oxidation or by volatilization provided certain specific conditions involving control of the temperature of the melt and the rate at which it is blown with the oxidizing gas are observed. Specifically, I have found that if high carbon ferromanganese is heated to a certain minimum temperature and then is blown with an oxidiz-

2

ing gas at a certain minimum rate, the carbon content of the molten metal can be reduced to the desired level before a significant amount of manganese is lost by oxidation or volatilization. As a result of my discovery I have devised a new process for producing medium carbon ferromanganese containing at least about 75% by weight Mn and not more than 1.5% by weight C which comprises bringing high carbon ferromanganese containing about 80% Mn and at least about 3% C to a decarburization temperature of at least about 1550° C. followed by blowing the molten metal with at least one stream of an oxidizing gas at a rate sufficient to heat the molten metal to a temperature in excess of about 1700° C. before the carbon content of the molten metal has been reduced to 1.5%, and then continuing the blowing operation until the carbon content of the molten metal has been reduced to not more than about 1.5% by weight of C, whereby decarburization of the ferromanganese is achieved without excessive loss of manganese due to volatilization or oxidation of this metal. It should be noted that the high carbon ferromanganese alloy can be brought to the initial decarburization temperature of 1550° C. by any suitable means that does not result in excessive loss of manganese. However, in this connection, I have found that the molten high carbon ferromanganese product of a ferromanganese smelting furnace which is tapped from the furnace at a temperature of about 1450° C. or below, or which has solidified and then is remelted, can be brought to the initial decarburization temperature and then be decarburized in accordance with my new process by blowing the molten metal with the oxidizing gas at a rate such that not more than about 25% of the total oxygen requirement is consumed before the initial decarburization temperature is reached.

As previously noted, the successful decarburization of high carbon ferromanganese (hereinafter referred to H.C. FeMn) by blowing the molten metal with an oxidizing gas and without excessive loss of Mn by oxidation or volatilization is contrary to what one skilled in this art would ordinarily expect. However, my unexpected discovery that this result can be obtained if certain temperature conditions and oxidizing rates are observed is substantiated by a large number of experimental tests in which quarter ton melts of H.C. FeMn were successfully decarburized in accordance with my process. As a result of these tests I have found that the molten metal is not decarburized to any important extent until the temperature of the melt reaches about 1550° C. at which temperature oxygen apparently begins to react preferentially with carbon rather than with manganese. It is necessary, therefore, to bring the melt to the initial decarburization temperature of 1550° C. in order to obtain any significant degree of reduction in the carbon content of the melt, and if the melt is to be heated to the decarburization temperature by blowing the melt with an oxidizing gas, the rate at which the melt is blown should be sufficiently fast to bring it to the required temperature before an excessive amount of manganese is lost or, as established by my test melts, before 25% of the total oxygen required to achieve decarburization is consumed.

After the melt is brought to the initial decarburization temperature and the blowing thereof to oxidize the carbon content begins to take effect, the carbon content of the metal must be reduced to the desired level (i.e., not more than 1.5% C) before an excessive amount of manganese is lost through oxidation and, as the temperature increases, through volatilization. To achieve this result I have found it necessary to blow the molten metal at a rate sufficient to consume the desired quantity of carbon before the manganese loss becomes excessive or, as established by my test melts, at a rate sufficient to raise the temperature of the melt to at least about 1700° C. before the carbon con-

tent of the melt has been reduced to 1.5% C. Thereafter, the blowing operation is continued, and the temperature of the melt continues to rise, until the desired medium carbon ferromanganese product (hereinafter referred to as M.C. FeMn) containing not more than 1.5% C is obtained.

The importance of control of the temperature of the melt, the rate at which the molten metal is blown with the oxidizing gas and the significant correlation between these two factors and the carbon content of the melt is shown graphically in the single figure of the accompanying drawing. The data presented graphically in the drawing were obtained in the course of the decarburization of a one-quarter ton heat of H.C. FeMn blown at the top with oxygen at the rate of 1.4 pounds of O₂ per minute. The molten metal had an initial temperature of about 1385° C. and was brought to the required decarburization temperature of 1550° C. by blowing the metal with oxygen. However, if desired, the melt could just as well have been brought to the decarburizing temperature by heat supplied by an external source. As shown in the drawing, when the blowing of the molten metal was commenced the temperature of the melt rose fairly rapidly to about 1550° C., and this was accompanied by the evolution of dense brown fumes indicative of the loss of manganese by oxidation. About 15% of the total oxygen required to effect decarburization was consumed to bring the melt to the decarburization temperature, and very little carbon was oxidized in this initial period. At about 1550° C. the carbon content of the melt began to drop rapidly due to the oxidation thereof, and this was accompanied by a steady increase in temperature and the evolution of bright flames from the melt characteristic of the oxidation of CO to CO₂. When the temperature of the melt reached 1700° C. the carbon content had been reduced to about 1.7% C, and when the temperature reached 1750° C. the required M.C. FeMn specification of not more than 1.5% C had been safely met.

The high carbon ferromanganese employed as the starting material in my new process is the normal product of a conventional manganese smelting operation wherein high grade manganese ore is reduced with carbon (e.g. coke) in a blast furnace, submerged arc electric furnace or the like. The ferromanganese product of the smelting operation may contain anywhere from 70 to 93% Mn, and usually at least about 80% Mn, from 3 to 7.5% C, up to 5% Si and the balance mainly iron, depending on the grade of the ore and the furnace practice employed. For convenience, this product is referred to herein as H.C. FeMn containing about 80% Mn and at least about 3% C, although the specific composition of the starting material may vary from this nominal composition within the limits previously mentioned. Molten H.C. FeMn may be obtained at a temperature of below about 1450° C. directly from the blast furnace or electric smelting furnace in which it is produced, in which case this molten metal may be transferred directly to the treating vessel or furnace in which it is to be decarburized in accordance with my invention. Alternatively, the H.C. FeMn may be in its solidified or cast state in which case it must first be remelted in a suitable furnace—for example, in an arc, induction, reverberatory or similar furnace—before being decarburized.

In either case, the molten FeMn must be heated to the decarburization temperature of 1550° C. in a manner that will avoid excessive loss of manganese during this preliminary heating operation. If an external source of heat is available such as an induction furnace or the like, the molten metal can be brought to the desired decarburization temperature without the need to blow the metal with an oxidizing gas to generate the required heat. However, if such equipment is not available, or if for reasons of economy or convenience the oxygen treatment is performed in a vessel such as a ladle or converter with no provision for heating other than the oxidation reaction

(i.e. the oxidation, at first, of manganese and then of carbon), the melt must be blown with oxygen at a rate fast enough to raise the temperature of the melt to above 1550° C. before more than 25% of the total oxygen requirement is consumed, or before more than 20% of the manganese in the starting ferro alloy is oxidized. Then, irrespective of the means by which the molten metal has been heated to the decarburization temperature, the metal must be blown with an oxidizing gas at a rate sufficient to raise the temperature of the melt to above about 1700° C. before the carbon content of the molten metal has been reduced to 1.5% C, whereby the desired degree of decarburization of the molten metal without excessive loss of manganese by either volatilization or oxidation is achieved.

It will be appreciated that the oxygen flow rate necessary to achieve these objectives will depend upon the size and type of the vessel in which the oxidation reaction is being carried out, and upon the quantity and initial temperature of the metal being treated. A large insulated vessel from which heat losses are low will permit a much lower rate of oxygen addition per pound of metal per minute than a small uninsulated vessel from which heat losses are relatively high. Oxygen flow rates expressed in terms of pounds of O₂ per minute that are found applicable to a specific quantity of metal in one type of vessel will not necessarily be applicable to a different quantity of metal in another type of vessel. By way of example I have found that, when decarburizing a 500 pound melt contained in an uninsulated ladle, an oxygen flow rate of 0.5 pound of O₂ per minute is inadequate to achieve the desired degree of decarburization before manganese losses become economically unacceptable. An oxygen flow rate of 0.9 pound per minute is barely adequate to achieve the desired degree of decarburization, and due to the length of time required to decarburize the melt refractory wear is excessive. However, an oxygen rate of 1.4 pounds per minute is adequate to obtain the desired degree of decarburization without excessive loss of manganese, and an oxygen rate of 4.9 pounds per minute produces exceptionally good results. These oxygen addition rates are of course applicable only to a 500 pound melt in an unheated ladle. The number of pounds per minute of oxygen or another oxidizing gas that would have to be blown into a different quantity of metal in another type of treatment vessel in order to decarburize the metal in accordance with my invention would have to be determined in each case by means of the temperature, oxygen consumption and carbon consumption criteria set forth herein.

The oxidizing gas employed to decarburize H.C. FeMn in accordance with my invention is oxygen or a mixture of oxygen and an inert diluent gas (e.g. air). Mixtures of oxygen with any significant amount of a reducing gas are to be avoided. The molten H.C. FeMn may be blown from below the surface as in a conventional converter or, preferably, from above by means of a conventional oxygen blowing lance. When the molten metal is blown at the top, the tip of the lance may be immersed in the molten metal or, preferably, it may be positioned an inch or two above the surface of the melt so that the oxidizing gas will impinge against the surface of the melt. In the latter event the velocity of the gas stream must be sufficient to penetrate an appreciable distance below the surface of the molten metal. When a large quantity of metal—say, from 5 to 10 tons of metal—is being decarburized in accordance with my invention, it is sometimes desirable to blow the melt with more than one stream of oxidizing gas in order to reach the decarburizing temperature and reduce the carbon content of the melt within the time permitted.

The following specific example is illustrative but not limitative of the practice of my invention:

Five hundred pounds of H.C. FeMn containing 77.59% Mn and 6.31% C were melted in an arc furnace,

5

poured into a vessel adapted to carry out the process, skimmed of slag and top blown with oxygen in accordance with my process. The blowing vessel was a 20 inch inside diameter by 30 inch high basic lined ladle with a top splash guard. The orifice of the water cooled, copper tipped, oxygen lance was located about one inch above the surface of the molten metal perpendicular to this surface. For efficient ignition and to maintain efficient reaction, the oxygen stream must impinge on the molten metal at a considerable velocity, and therefore an initial oxygen pressure of 150 p.s.i. was employed which resulted in an oxygen flow rate of 4.8 pounds per minute. Large volumes of heavy brown fumes were at first seen to evolve from the ladle, and after the temperature reached about 1550° flames appeared above the ladle characteristic of the burning of CO to CO₂. When the temperature reached about 1600° C. the oxygen pressure was reduced to 110 p.s.i. and the oxygen flow rate to 4.25 pounds per minute. After the predetermined amount of oxygen, as established by earlier tests, had been consumed, the lance was withdrawn, the slag was skimmed, and the M.C. FeMn product containing 79.1% Mn and 1.25% C was cooled and poured into a mold. The results of this test run are summarized in the following table:

H.C. FeMn starting material:

Amt., lbs. -----	500	
Percent Mn -----	77.59	30
Percent C -----	6.31	
Percent Si -----	1.29	
Percent Fe -----	14.06	
Percent P -----	0.269	35

Oxygen blowing conditions:

Initial temperature, ° C. -----	1395	
Initial O ₂ pressure, p.s.i. -----	150	
Initial O ₂ flow rate, lbs./min. -----	4.8	
Temperature at the end of initial blow, ca. ° C. -----	1600	40
Final O ₂ pressure, p.s.i. -----	110	
Final O ₂ flow rate, lbs./min. -----	4.25	
Total blowing time, min. -----	12.16	
Total O ₂ flow, lbs. -----	54	45
Final temperature, ° C. -----	>1750	

6

M.C. FeMn product obtained:

Amt., lbs. -----	389.5
Percent Mn -----	79.1
Percent C -----	1.25
Percent Si -----	0.35
Percent Fe -----	17.75
Percent P -----	0.294

Slag obtained:

Amt., lbs. -----	72
Percent Mn -----	52

From the foregoing description of my new method of producing medium carbon ferromanganese it will be seen that I have made an important contribution to the art to which my invention relates.

I claim:

A process for producing medium carbon ferromanganese containing not more than 1.5% by weight carbon which comprises

- (1) providing molten high carbon ferromanganese at a temperature below 1550° C., said ferromanganese containing at least about 3% carbon and up to 5% silicon;
- (2) blowing the molten ferromanganese with oxidizing gas at a rate sufficient to heat the molten metal to a temperature of about 1700° C. before the carbon content of the molten metal has been reduced to 1.5% C;
- (3) continuing the blowing operation until the temperature of the molten metal is about 1750° C.; and
- (4) discontinuing the blowing operation after this temperature has been reached whereby a ferromanganese alloy is obtained having a carbon content of not more than 1.5%.

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DAVID L. RECK, *Primary Examiner*.

HYLAND BIZOT, H. W. TARRING,

Assistant Examiners.