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METHOD OF BLOWING STEEL MELT WITH OXYGEN CONTAINING GAS

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This invention relates to the manufacture of steel in Bessemer and Thomas converters and more particularly to a process of blast refining which may be used to produce steel of a predetermined low nitrogen content.

This application is a continuation-in-part of prior copending application of Hans (Johannes) Kosmider, Serial No. 191,729, filed October 23, 1950 (now abandoned), and our application Serial No. 331,318, filed January 14, 1953, said application Serial No. 331,318 being a continuation-in-part of our prior application Serial No. 143,601, filed on February 10, 1950 (now abandoned).

It is a primary object of our invention to provide a process of blast refining whereby steel having a substantially predetermined nitrogen content of between 0.002% and 0.010% by weight may be produced.

The process can be applied both in the manufacture of Thomas steel and Bessemer steel, and is particularly suitable for manufacture of a Thomas steel low in nitrogen content. There have already been proposed different processes for the manufacture in Thomas converters of steel low in nitrogen content. These processes consist in lowering, by suitable measures, the solubility of nitrogen in iron. This result is obtained by proceeding to fusion at a low temperature, or by lowering the temperature of the steel at determined instants in the course of the blowing operation. The lowering of the temperature of the molten mass, or the lowering of the temperature at which melting takes place is effected by addition of ore, scrap iron, scale of rolling mills, or other similar fluxes.

It is also known to steel makers that towards the end of the life of a Thomas converter there can be obtained, with badly worn sides and bottom, low contents of nitrogen in the course of manufacture of Thomas steel. This is due to the shorter path that the blast must traverse in passing from the bottom of the converter through the molten bath. On the basis that the short path taken by the current of air through the metal bath exercises a favorable effect upon the ultimate nitrogen content, it has been proposed to introduce the refining blast of air into the metal bath at the sides. These methods of operation allow the production of steel low in nitrogen content, but all have the defect that the resulting nitrogen content cannot be predicted with any degree of precision, and in fact is subject to considerable variations. To obtain a steel having a nitrogen content of 0.010%, it is often necessary to melt several charges by one of the above mentioned processes before the desired nitrogen content is obtained.

With the known processes of air refining, the refining is effected by means of oxygen in the air blast. The oxygen of the air enters into reaction, through the intermediary of ferrous oxide with the accompanying elements of the pig iron, according to known physical-chemical laws.

In the Bessemer process, silicon, manganese, and carbon are eliminated by the refining while in the Thomas

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process the combustion of phosphorous only commences after the silicon, manganese and carbon have been burned. The two processes of refining are accomplished exothermically. When the Bessemer or Thomas process is operated with an air blast there is blown into the iron an oxygen containing gas consisting of approximately 79% nitrogen by volume. This nitrogen withdraws from the bath an appreciable quantity of heat and a portion of the nitrogen dissolves in the liquid iron.

In the Bessemer process the nitrogen content of the iron increases to an extent dependent upon the blowing period while in the Thomas process the nitrogen content of the iron remains practically constant untl the dephosphorization stage is reached, at which time the nitrogen content increases sharply during the dephosphorization stage. The content of nitrogen varies in the acid process and the basic process of blast refining between 0.012 and 0.025%.

The harmful effect of nitrogen on the capability for deep drawing and on the resilience of air refined steel is well known.

By practicing the present invention, there is obtained a Bessemer or Thomas process for making steel in which a harmful increase of nitrogen content is avoided and in which the converter is not exposed to excessive thermal strain.

According to the present invention, a Bessemer or Thomas process for making steel of a predetermined low nitrogen content from iron containing more than 0.2% silicon in the Bessemer process, and from iron containing more than 0.6% phosphorous in the Thomas process is characterized by the use of a blast consisting of steam and oxygen containing gas. In the Bessemer process this blast is used during a part of or the entire blowing period while in the Thomas process the blast is employed during at least the dephosphorizing part of the blowing period.

We have found that by using a blowing gas composed of a known proportion or mixture ratio of an oxygen containing gas and steam, that the nitrogen content of the steel is not only substantially reduced but by suitable manipulation of the proportion of oxygen introduced into the metal melt by the blowing gas, the nitrogen content of the steel may be calculated in advance to a sufficient degree of accuracy. It will be noted that prior to our discovery, the use of steam in the blowing gas was generally believed to be undesirable and to be avoided if possible because it was thought that its presence would be deleterious to the steel by introducing hydrogen into the steel. We have found, however, that water vapor or steam may be used without such harmful effects and, in addition, greatly reduces the cost of production by providing an economical substitute for previously used gases such as carbon dioxide as well as reducing the amount of commercial oxygen required. We have found that the best results are obtained by the use of a blast gas that contains at least 14% by volume of steam and that a practical range of steam content of the blast gas is from about 14% to about 67%.

The oxygen containing gas employed with steam in our process may vary in purity, that is the amount of pure oxygen contained in the gas, from between 50% and 98%. The remainder of the oxygen containing gas is substantially entirely nitrogen. In general, the mixture ratio of oxygen containing gas to steam may vary from between one part of oxygen containing gas to two parts of steam to six parts of oxygen containing gas to one part of steam as indicated above. The amount of oxygen in the mixture is obviously dependent upon the purity of the oxygen containing gas and the proportion of steam employed.

There follow below a number of examples showing how our invention may be employed in practice. The term "mixture ratio" expresses the relation of the oxygen containing gas to steam. The term "purity of the oxygen containing gas" expresses the percentage of oxygen in the oxygen containing gas. The oxygen containing gases used in the following examples are composed essentially of oxygen and nitrogen.

Example 1

Oxygen containing gas of 98% purity was used with steam in a mixture ratio of 3:1 and gave a steel having a nitrogen content of 0.005%.

Example 2

Oxygen containing gas of 98% purity was used with steam in a mixture ratio of 1:2 and gave a steel having a nitrogen content of 0.002%.

Example 3

Oxygen containing gas of 94% purity was used with steam in a mixture ratio of 1:2 and gave a steel having a nitrogen content of 0.003%.

The proportions of the foregoing examples can be interpolated to give approximate intermediate values of nitrogen in the steel or to allow for other purity values of the oxygen containing gas, the final values used being readily found by trial and error. It will be clear that the degree of purity of the oxygen also affects the composition of the mixture used for blowing, since nitrogen content of the exhaust gas affects the desired nitrogen content in the final steel. In general, it can be said that with reference to the indicated variables, the nitrogen content of the final steel in relation to the nitrogen content of waste gases can be substantially determined. When employing the process proposed by the invention, it is preferable to keep one of the several variables constant in order to maintain the temperature variations of the molten gas within practical ranges.

As indicated from the foregoing examples, the percentage of oxygen in the blast may vary from between about 16% to about 85%. We have found it desirable to stay within this range since the lower percentage content of oxygen tends to cool the metal melt while the higher concentrations of oxygen tend to raise the temperature to impractical values. It should be realized that the temperature of the metal melt may be increased by burning the waste gases such as hydrogen and carbon monoxide in a suitable manner and that the addition of scrap will cool the metal melt.

The conventional manner in which the blast is introduced into the metal melt is by means of conduits which

connect a plurality of openings in the converter bottom to a pressurized source of blast gas. We have found that a greater degree of accuracy in the final nitrogen content is obtained when the blast of gas is introduced from the sides and from above the metal melt.

Having described exemplary applications of our process, we claim:

1. A process for making steel having a predetermined nitrogen content of less than 0.010 percent by blowing a metal melt in a converter with a mixture of an oxygen containing gas and steam in a mixture ratio between 3:1 and 1:2, the mixture containing at least 30% oxygen and not more than 21 percent nitrogen.

2. A process for making steel having a predetermined nitrogen content of less than 0.010 percent by blowing a metal melt in a converter with a blast consisting essentially of an oxygen containing gas and steam wherein the ratio of the oxygen containing gas to steam is between 3:1 and 1:2 and the blast contains at least 30% oxygen and not more than 21 percent nitrogen.

3. A process for making steel having a predetermined nitrogen content of less than 0.010 percent by blowing a metal melt in a converter for the entire conversion period with a blast consisting of an oxygen containing gas and steam wherein the ratio of the oxygen containing gas to steam is between 3:1 and 1:2 and the blast contains at least 30% oxygen and not more than 21 percent nitrogen.

4. A process for making steel having a predetermined nitrogen content of less than 0.010 percent by blowing a metal melt in a converter with a blast consisting of an oxygen containing gas and steam wherein the ratio of the oxygen containing gas to steam is between 3:1 and 1:2 and said oxygen containing gas has an oxygen content of at least 94 percent.

5. A process for making steel having a predetermined nitrogen content of less than 0.010 percent by blowing a metal melt in a converter for the entire conversion period with a blast consisting of an oxygen containing gas and steam wherein the ratio of the oxygen containing gas to steam is between 3:1 and 1:2 and the oxygen containing gas has an oxygen content of at least 94 percent.

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