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METHOD OF BLOWING BESSEMER STEEL

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1

This invention relates to the blowing of Bessemer steel and more particularly to the blowing of such steel in side-blow converters.

An object of our invention is to provide a method of blowing Bessemer steel which affords the advantages of side-blowing but prevents the formation of too fluid slag which ordinarily results from such process. Another object is to lessen the time required in conventional side-blowing. Another object is to provide a method for lowering the carbon content of side-blown Bessemer steel below that obtainable in conventional side-blowing practice.

Bessemer converters may be classified according to the method of blowing into two types, denominated bottom-blown and side-blown converters. In bottom-blown vessels the tuyères are placed in the vessel bottom and air is blown through the charge from bottom to top. In side-blown converters the tuyères are placed in the side of the vessel and air is blown through the charge from one side to the other. Bessemer converters may also be classified according to shape as the vertical or upright type and the drum or cylindrical type. The former is usually of circular plan, with tapered bottom and nose; the latter is more or less circular in section, except for the nose, with flat or dished ends. The method of this invention is particularly adapted to side-blown converters of the drum or cylindrical type.

It is known that steel produced in side-blown converters is generally lower in nitrogen content than that from bottom-blown vessels. This relatively low nitrogen content is in fact the most significant characteristic of side-blown Bessemer steel and is highly advantageous for many applications, since it has been found by experiment that steels with lower nitrogen contents are less sensitive to the hardening and enbrittling effects of cold work. "Cold work" is here defined as work performed on the metal below its temperature of recrystallization. However, the process of side-blowing as heretofore carried on produces in the converter an extremely fluid slag ("sloppy" in the terminology of steel men) which is difficult to separate from the steel when the later is poured from the converter into the steel ladle. The presence in the ladle of any considerable amount of this slag, which is high in iron oxide, renders the deoxidation of the steel erratic, reduces the efficiency of the manganese addition, and is detrimental to dephosphorization, if this additional step is included. This undesirable nature of the slag is one of the factors which have militated against the general use of the side-blown converter in the steel industry.

2

A second factor unfavorable to the side-blown converter is the length of time required for a blow, which is appreciably greater than that required by a bottom-blown vessel handling an equal weight of metal.

We have invented a process of side-blowing which largely avoids the slag difficulties incidental to conventional side-blowing. In addition, our process requires a shorter blowing time than has heretofore been achieved in side-blowing.

In conventional side-blowing the vessel is tilted so that the tuyère mouths are substantially at the bath surface. It is possible under these conditions to produce blown metal with nitrogen contents in the range .003%–.004%, or substantially that of the iron charged. However, the slag formed on the bath is high in iron-oxide—ranging up to 40% or more FeO—and in consequence is sloppy, with the undesirable effects previously mentioned.

We have found that if the tuyère mouths are submerged a short-distance beneath the bath surface the slag produced is lower in iron-oxide and consequently less sloppy. Unfortunately, the nitrogen contents of blows so made are appreciably higher than those of blows made in the conventional manner, and as the depth of immersion increases, results rapidly approach those of bottom-blowing, where nitrogen contents of .015% to .025% are usual. However, by further experimentation, we have discovered that if the blowing process is so conducted that the tuyères are substantially at the bath surface during a certain portion of the blow and below the bath surface during a portion or portions of the blow, the nitrogen content of the blown metal can be kept at a reasonably low figure while the iron-oxide content of the slag can be held below the level at which a sloppy slag results.

It is recognized that in Bessemer blowing, the silicon in the iron is burned out to a substantial degree before the bulk of the carbon begins to burn. We have discovered that the combustion of silicon is accelerated by blowing with the tuyères submerged, and the length of the blow appreciably reduced thereby. We have also discovered that, during approximately this same period of refining, blowing with submerged tuyères does not cause any considerable increase in nitrogen pick-up over that incidental to conventional side-blowing. And finally, we have discovered that the slag formed by blowing in this

manner while the silicon is being oxidized is relatively low in iron-oxide and not fluid or sloppy. Slag of this type is called "dry" by Bessemer operators.

After the bulk of the silicon is oxidized and the carbon begins to burn at an appreciable rate, we find it necessary to tilt the vessel so that the tuyère mouths lie approximately at the bath surface, if nitrogen pick-up is to be kept low. Surface blowing during the period of rapid carbon oxidation tends to produce a thin, sloppy slag high in iron-oxide; however, this merely dilutes the dry slag formed during the period of subsurface blowing, and if the surface blowing period is not too long the final slag is not objectionably thin.

The simplest embodiment, therefore, of the practice of our invention comprises blowing the charge with the tuyère mouths an appreciable distance below the bath surface during the silicon portion of the blow, then tilting the vessel so that the tuyère mouths are substantially at the bath surface and finishing the blow in this manner. The blown metal so produced generally contains less than .004% to .005% nitrogen, while the slag formed in the vessel generally contains less than about 30% FeO, and so is thick enough to be conveniently skimmed off the blown metal in pouring. The time required for a blow so made is appreciably less than that of conventional practice.

Under certain conditions a modification of this simple two-stage practice may be desirable. We have observed that in conventional side-blowing the carbon content of the blown metal, before ladle additions, averages .06% to .07%. The addition of manganese in the usual form of 80% ferro-manganese, which generally contains 6% or 7% carbon, raises the blown-metal carbon content, of course, so that it is difficult, if not impossible, to make side-blown Bessemer steel of normal manganese content—.30% and above—with the low carbon desired. This difficulty is not avoided by the simple embodiment of our invention so far described. However, we have found that if the surface-blowing stage of our above-described practice is discontinued before the blow's end, and the vessel tilted again so that the tuyère mouths are submerged a short distance below the bath surface, in which position the blowing is finished, the carbon content of the blown metal will average no more than about .04%. An extra point or two of nitrogen is picked up in this second sub-surface blowing, but even so the blown metal nitrogen content seldom exceeds .006% to .007%. The steel resulting has been found to have excellent cold-forming and working properties, as compared with conventional bottom-blown Bessemer steel.

The practice of our invention, modified as described above, comprises blowing the charge with the tuyère mouths a substantial distance below the bath surface during the period of pronounced silicon oxidation, blowing with the tuyère mouths substantially at the bath surface during the major portion of the period of pronounced carbon oxidation, and finally finishing the blow with the tuyères again submerged below the bath surface. The slag produced by such practice is thick or dry enough to be skimmed off the blown-metal by the usual methods. The time required for a blow is appreciably less than that of conventional side-blowing, and the steel produced is lower in carbon content and only slightly higher in nitrogen than conventional side-blown steel.

Having presented the essential features of our invention we now describe certain phases of the

process in more detail. The duration of the first or sub-surface stage of our process corresponds to the time of the silicon blow in which the bulk of the silicon in the iron is oxidized. This period can be determined approximately by visual observation of the converter flame, which is short, transparent and colorless until appreciable amounts of carbon begin to burn. It then becomes more intense, brighter, opaque and yellowish in color. More precise control is afforded by the photocell method of H. K. Work, Patent No. 2,207,309, which we prefer to use. When the converter flame displays in full the above described characteristics of the carbon blow, the vessel may be tilted so that the tuyère mouths are approximately at the bath surface, and the blow continued until completion in this way.

In the three-stage embodiment of our invention, we prefer to terminate the first sub-surface stage of the blow as described above. The second, or surface blowing stage, may continue until the carbon appears to be oxidized to the limit of normal side-blowing, which is indicated by the drop of the flame familiar to Bessemer operators and others skilled in the art of Bessemer steelmaking. At this point the vessel is again tilted so that the tuyère mouths are submerged, and the blow continued for a short period of time. We have observed that when the vessel is tilted at this point a reaction of some violence takes place in the vessel, which in itself causes an appreciable reduction in the carbon content. If minimum blowing time is desired, however, the surface blowing stage is terminated several minutes before the normal completion of the blow and the last 20% to 25% of the blowing time, which may amount to 4 or 5 minutes, is given over to subsurface blowing. This practice results in lowest blowing time, lowest carbon content and least troublesome slag, with nitrogen contents only slightly higher than those of the two-stage or first-mentioned embodiment of our three-stage practice.

The depth of tuyère mouths below the bath surface is not critical in the first or sub-surface blowing stage of either embodiment of our invention. In the second sub-surface blowing stage, however, we find it desirable to submerge the tuyères not more than 2 to 3 inches, in order to minimize nitrogen pick-up.

The invention is not limited to the preferred embodiment but may be otherwise embodied or practiced within the scope of the following claims.

We claim:

1. The process of converting molten iron to steel in a side-blown Bessemer converter, which comprises blowing air into the iron bath, substantially the entire blast being admitted below the bath surface during an early part of the blow and substantially at the bath surface during a later part of the blow.

2. The process of converting molten iron to steel in a side-blown Bessemer converter, which comprises blowing air into the iron bath, substantially the entire blast being admitted below the bath surface during the silicon blow and substantially at the bath surface during the carbon blow.

3. The process of converting molten iron to steel in a side-blown Bessemer converter, which comprises blowing air into the iron bath, substantially the entire blast being admitted below the bath surface from substantially the commencement of the blow until the carbon of the iron is burning vigorously, and substantially at

the bath surface for at least a portion of the remainder of the blow.

4. The process of converting molten iron to steel in a side-blown Bessemer converter, which comprises blowing air into the iron bath, substantially the entire blast being admitted below the bath surface during the silicon blow, thereafter substantially at the bath surface during the carbon blow, and thereafter below the bath surface for a period not exceeding about one-fourth of the total blowing time.

5. The process of converting molten iron to steel in a side-blown Bessemer converter, which comprises blowing air into the iron bath, substantially the entire blast being admitted below the bath surface during the silicon blow, thereafter substantially at the bath surface during the carbon blow until the drop of the flame, and thereafter below the bath surface.

6. The process of converting molten iron to steel in a side-blown Bessemer converter, which comprises blowing air into the iron bath, substantially the entire blast being admitted below

the bath surface from substantially the commencement of the blow until the carbon of the iron is burning vigorously, then substantially at the bath surface, and finally below the bath surface again for the final period of the blow, this final period not exceeding about one-fourth of the total blowing time.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
277,929	Reese	May 22, 1883
553,875	Sherk et al.	Feb. 4, 1896
1,312,474	Fisk	Oct. 5, 1919

FOREIGN PATENTS

Number	Country	Date
13,275	Great Britain	of 1885