1,017,414

PATENT SPECIFICATION 1,017,414

DRAWINGS ATTACHED.

Date of Application and filing Complete Specification:
Oct. 10, 1962. *No. 38430/62.*

Application made in Austria (No. 7753) on Oct. 13, 1961.

Complete Specification Published: Jan. 19, 1966.

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Index at Acceptance :—C7 D(3G1B, 3G1K, 3G2A1, 3G7H2); F4 B44.

Int. Cl.:—C 21 b.

COMPLETE SPECIFICATION.

Method of and Vessel for Carrying Out Top Blowing Processes.

We, BOT BRASSERT OXYGEN TECHNIK AG., a Company organized under the laws of Switzerland, of 31, Tellstrasse, Zurich, Switzerland, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to top blowing processes in which a charge of liquid crude iron, with an optional addition of further admixtures such as scrap, ore, or slag-forming substances, is refined with oxygen supplied from above in a refining vessel such as a crucible or converter provided with a refractory lining.

Whereas there is a fairly comprehensive literature on top blowing processes and the equipment used for carrying them out, the previous information has not been sufficient for evaluating all design factors and result determining factors which are significant for operating a crucible or converter with optimum efficiency.

The present invention has as its object to give definite teachings, which should be followed in the design or vessels such as crucibles and converters and in the operation of the refining process in order to achieve optimum results. More particularly, it is an object of the invention to furnish such teachings for refining vessels of large capacity, i.e., crucibles or converters having a free internal space of more than 50 cubic metres, and for a blowing time of less than 20 seconds per metric ton of the charge, preferably of less than 14 seconds per metric ton, a lower limit being about 8 seconds per metric ton.

As far as the applicants know it has never been attempted heretofore to give definite teachings for the design and operation of refining vessels of large capacity so as to achieve a minimum blowing time in spite of the need existing everywhere for an optimum utilization of the capacity of equipment available and for minimizing the blowing time.

The previously used refining vessels were cylindrical or pear-shaped, having a bottom portion in the shape of a hemisphere or of a spherical cap, or of flat shape, and an upwardly tapering, conical, symmetrical or asymmetrical upper portion, on which a cover was placed, if desired. With vessels having a free internal space up to 50 cubic metres, the blowing time could not be reduced below 22—34 seconds per metric ton of the charge, even with best organized operating conditions. Beside the necessary setting-up and handling times, the net blowing time is a decisive factor for the efficiency and productivity of the operation of the refining vessel. Even with a minimum setting-up time, the above-mentioned times could not be reduced below the values stated above without involving a disturbance in the normal operation of the vessel. In this connection, a disturbance may be caused by increased slopping with undesirable iron losses and loss times caused by the need for clearing operations in the basement of the vessel installation.

The interrelations between the blowing time and the dimensions of the refining vessel were not sufficiently known before, and there is no model which teaches the measures to be adopted to reduce the blowing time when using vessels of large capacity. This reduction of the blowing time for such vessels is the problem to be solved by the present invention.

According to the invention a method of carrying out a top blowing process in a vessel such as a crucible or converter having a refractory lining and a free internal space of more than 50 cubic metres is characterised

by charging the converter to such a depth that the following relationships prevail:—

(a) the ratio of the specific bath surface area in square metres per metric ton of charge is larger than 0.11, preferably 0.12;
(b) the ratio of the reaction space above the bath in cubic metres to the volume of the melt in cubic metres is larger than 4, preferably 5;
(c) the ratio of the bath diameter to the depth of the bath in metres is 2.5 to 4.0, preferably 3.0—3.6.

From another aspect the invention comprehends a vessel for carrying out the method comprising a shell having a refractory lining and a free internal space of more than 50 cubic metres, an indication being provided on the vessel of the depth to which the vessel is to be charged such that:—

(a) the ratio of the specific bath surface area in square metres per metric ton of charge is larger than 0.11, preferably 0.12;
(b) the ratio of the reaction space over the bath in cubic metres to the volume of the melt in cubic metres is larger than 4, preferably 5;
(c) the ratio of the bath diameter to the depth of the bath in metres is 2.5—4.0, preferably 3.0—3.6.

The various ratios resulting from carrying out the method of the invention are shown graphically in the accompanying drawings.

The relation (a) is graphically shown in Fig. 1. The values available show an approximately linear dependence between the specific bath surface area in square metres per metric ton of the charge and the blowing time in seconds per metric ton of the charge. When the ratio is 0.10 or less, blowing times of 25—30 seconds are required whereas the blowing times are reduced to as low as 14 seconds per metric ton with the ratio greater than 0.11 and preferably 0.12 suggested according to the invention.

To illustrate its significance, the relation between the absolute bath surface area of a new crucible in square metres and the blowing time in seconds is shown in Fig. 2 which indicates a dependence similar to that of Fig. 1, namely, that the blowing process is accelerated as the bath surface area increases. This is quite in accordance with the known theory of the top blowing processes that the course of reactions in a crucible or LD converter is mainly controlled at the bath surface rather than in the interior of the bath of crude iron or steel. The numerical dependence stated hereinbefore, however, has not yet been described.

The second relation of the proposal according to the invention is illustrated in Fig. 3 of the drawing. It is apparent from the results available that longer blowing times of more than 20 seconds per metric ton will be obtained if the ratio is less than 4, and short blowing times of less than 20 seconds per metric ton will be obtained if the ratio is larger than 4, blowing times of less than 14 seconds being possible when the preferable ratio of 5 is used, i.e., with a sufficiently large free reaction space above the bath.

Instead of the volumetric relation cubic metre: cubic metre, Fig. 4 shows for greater clearness the linear relations in dependence on the blowing time. Fig. 4 shows the same regular dependence, namely, that with small ratios of the distance of the bath surface from the mouth of the crucible to the depth of the bath in metres the blowing times will be prolonged whereas the blowing times will be decreased with larger ratios. This relation is of special interest because even with an existing installation the nose and mouth diameter of a crucible can be changed to conform to the relations according to the invention.

The relation (c) of the proposal according to the invention is shown in more detail on the graph of Fig. 5 of the drawing. From this graph it is apparent that the condition for the desired best blowing performance, i.e., about 14 seconds per metric ton of charge, will be obtained if the ratio of the bath diameter to the depth of the bath, both in metres, is 3.5 to 4. With a ratio of less than 2.5, the blowing times increase beyond 20 seconds per ton.

It has been found that the relations stated above apply to refining vessels of up to 200 metric tons and can be extrapolated with sufficiently high probability to vessel capacities of 300 metric tons.

According to a further feature of the invention is it proposed to dimension the free space of the refining vessel in cubic metres in proportion to the ingot production of the vessel in metric tons so as to obtain a ratio of 0.9—1.1, preferably 0.9—0.95. This dependence is illustrated in Fig. 6 of the drawing in accordance with experience made. It is apparent that with a value below 0.8 the blowing times are higher than 20 seconds per metric ton of the charge whereas the optimum blowing times of 14 seconds per metric ton are obtained with a ratio of 0.9—0.95 cubic metres per metric ton. The preferred range, however, applies only to the production of steel from steelmaking crude iron. When refining Thomas crude iron, an increase will be required in many cases to

reliably prevent foaming or overflowing of the slag.

It has also been found that the size of the vessel mouth in dependence on the weight of the charge is an important factor regarding the addition of scrap and the durability of the lining.

These relations are explained more in detail in Figs. 7 and 8. The invention teaches to provide for a ratio of 2.5 to 3.5 of the refining vessel mouth area in square decimetres to the metallic charge in metric tons. It will be understood that the scrap charge will also depend on the silicon content of the crude iron. To correlate this factor with the teaching of the invention, results obtained with charges having different silicon contents are shown in Fig. 7. The dash-and-dot line relates to crude iron having a silicon content of 0.60—0.70% Si, the solid line to crude iron containing 0.80—0.90% Si, and the dash-and-dot double line to one containing 1.0—1.30% Si.

It is apparent that the analysis of all curves gives the surprisingly definite ~~results~~ that the scrap charge may always be increased when the ratio is less than 3.5 whereas the permissible amounts of scrap are relatively greatly reduced above this value.

Fig. 8 shows the relation between the specific mouth area of the refining vessel, i.e., the area in square decimetres per metric ton of the metallic charge, and various groups of vessels in order of capacity. The crucible sizes are classified in two groups, of 50—70 metric tons and 70—90 metric tons. It is apparent from Fig. 8 that the durability of the lining is influenced by the size of the cross-sectional area of the vessel mouth. This can be explained in that with a larger vessel mouth a larger amount of fresh air can enter when the vessel has been tilted and will adversely affect the durability of the lining bricks by involving additional stresses due to cyclic changes in temperature.

WHAT WE CLAIM IS:—

1. A method of carrying out top blowing processes in a vessel such as a crucible or converter having a refractory lining and a free internal space of more than 50 cubic metres, characterised in that to obtain a blowing time of less than 20 seconds per metric ton of the charge, particularly of less than 14 seconds per metric ton, the vessel is charged to such a depth that the following relationships prevail:—

(a) the ratio of the specific bath surface area in square metres per metric ton of charge is larger than 0.11, preferably 0.12;
(b) the ratio of the reaction space over the bath in cubic metres to the volume of the melt in cubic metres is larger than 4, preferably 5;
(c) the ratio of the bath diameter to the depth of the bath in metres is 2.5—4.0, preferably 3.0—3.6.

2. A method according to Claim 1, wherein the free internal space of the vessel is 0.9—1.1 cubic metres per metric ton of ingot, and preferably 0.9—0.95 cubic metres per metric ton of ingot.

3. A method according to Claim 1, wherein the ratio of the vessel mouth area in square decimetre to the weight of the charge in metric tons is 2.5—3.5.

4. A method of carrying out top blowing processes as herein described.

5. A vessel such as a crucible or a converter adapted to be used in a top blowing process according to any of Claims 1 to 4, said vessel comprising a shell having a refractory lining and a free internal space of more than 50 cubic metres, an indication being provided on the vessel of the depth to which the vessel is to be charged such that:—

(a) the ratio of the specific bath surface area in square metres per metric ton of charge is larger than 0.11, preferably 0.12;
(b) the ratio of the reaction space over the bath in cubic metres to the volume of the melt in cubic metres is larger than 4, preferably 5;
(c) the ratio of the bath diameter to the depth of the bath in metres is 2.5—4.0, preferably 3.0—3.6.

6. Steel when made by the method according to any of Claims 1 to 4.

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Abingdon: Printed for Her Majesty's Stationery Office, by Burgess & Son (Abingdon), Ltd.—1966.
Published at The Patent Office, 25 Southampton Buildings, London, W.C.2,
from which copies may be obtained.

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These relations are explained more in detail in Figs. 7 and 8. The invention teaches to provide for a ratio of 2.5 to 3.5 of the refining vessel mouth area in square decimetres to the metallic charge in metric tons. It will be understood that the scrap charge will also depend on the silicon content of the crude iron. To correlate this factor with the teaching of the invention, results obtained with charges having different silicon contents are shown in Fig. 7. The dash-and-dot line relates to crude iron having a silicon content of 0.60—0.70% Si, the solid line to crude iron containing 0.80—0.90% Si, and the dash-and-dot double line to one containing 1.0—1.30% Si.

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WHAT WE CLAIM IS:—

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3. A method according to Claim 1, wherein the ratio of the vessel mouth area in square decimetre to the weight of the charge in metric tons is 2.5—3.5.

4. A method of carrying out top blowing processes as herein described.

5. A vessel such as a crucible or a converter adapted to be used in a top blowing process according to any of Claims 1 to 4, said vessel comprising a shell having a refractory lining and a free internal space of more than 50 cubic metres, an indication being provided on the vessel of the depth to which the vessel is to be charged such that:—

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Abingdon: Printed for Her Majesty's Stationery Office, by Burgess & Son (Abingdon), Ltd.—1966.
Published at The Patent Office, 25 Southampton Buildings, London, W.C.2,
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