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(54) Direct smelting furnace and process therefor

(57) Metallurgical vessel comprising a lower portion for accommodating a molten metal bath and part of a slag layer in use, an upper portion for accommodating the remainder of the slag layer in use and a plurality of lances which project into the upper portion of the vessel and supply oxygen containing gas to the upper portion of the vessel characterised in that a plurality of tuyeres are arranged around the circumference of the lower portion of the vessel suitable for supplying gas and/or liquid and/or solids and/or plasma into the slag layer in the lower portion of the vessel.

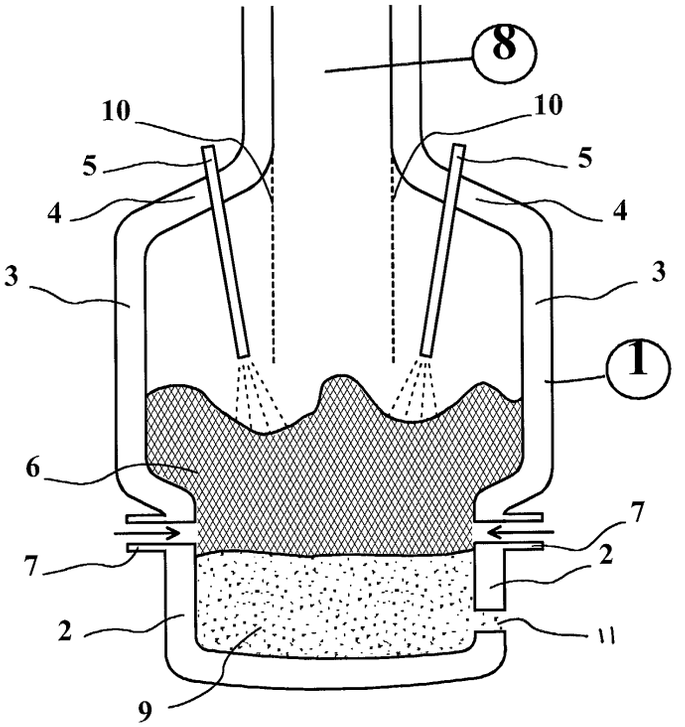

Fig. 1

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Description

[0001] The invention relates to a metallurgical vessel comprising a lower portion for accommodating a molten metal bath and part of a slag layer in use, an upper portion for accommodating the remainder of the slag layer in use and a plurality of lances which project into the upper portion of the vessel and supply oxygen containing gas to the upper portion of the vessel. The present invention also relates to a method of iron making.

[0002] The term metallurgical vessel refers to a vessel suitable for treating metal or metal oxide, metal smelting, refining or reducing.

[0003] EP 0 735 146 describes a metallurgical vessel of the converter type, in which pre-reduced iron compounds are further reduced. Oxygen is supplied by means of a plurality of lances that project through the wall of the vessel and extend to above the slag layer. It is known from this document to introduce a gas through the bottom of the vessel into the molten metal in order to rinse the iron melt. This procedure is also known as bottom stirring or bottom bubbling in the art and is performed to agitate the molten metal in the lower portion of the vessel. Bottom stirring ensures sufficient heat transfer to the molten metal bath beneath the slag layer and sufficient stirring of the lower slag layer itself so that it does not become quiescent and so that heat generated in the upper slag layer is also transferred to the lower slag layer. Bottom stirring has considerable drawbacks such as, for example, increasing refractory erosion along the walls of the vessel in the area of the hot metal as well as requiring injection points beneath the tap level of the vessel that have a relatively short lifetime and are difficult to maintain.

[0004] The object of the present invention is to provide a metallurgical vessel having reduced refractory erosion and greater ease of maintenance without a reduction in production efficiency.

[0005] The present invention overcomes the problems of the prior art as the metallurgical vessel comprises a plurality of tuyeres arranged around the circumference of the lower portion of the vessel suitable for supplying gas and/or liquid and/or solids and/or plasma into the slag layer in the lower portion of the vessel.

[0006] The plurality of lances supply oxygen containing gas, and thereby heat, to the slag in the upper portion of the vessel whilst the gas and/or liquid and/or solids and/or plasma supplied by the tuyeres ensure that the lower slag layer does not become quiescent. Quiescence results in a cooling of the lower slag layer and a loss of productivity. The tuyeres supply gas and/or liquid and/or solids and/or plasma directly to the lower slag layer whereas gas is injected through the bottom of the vessel into the molten metal in bottom stirring. The present invention thus does not generate high flow velocities in the molten metal thereby avoiding one of the major drawbacks of bottom stirring namely the fast erosion of the vessel wall in the part of the vessel containing the molten metal. The supply of gas and/or liquid and/or solids and/or plasma to the slag layer in the lower portion of the vessel by the tuyeres thus does not cause erosion of the refractory lining in the hot metal zone but it does maintain productivity by stirring the lower slag layer. Stirring the lower slag layer maximises reactions within the lower slag layer and ensures it does not become quiescent. The supply of combustible gas and/or liquid and/or solids by the tuyeres also increases heat transfer from the slag layer to the molten metal in the lower portion of the vessel. The tuyeres are also easier to maintain as they are positioned above the tap level of the vessel.

[0007] The diameter of the lower portion of the vessel may preferably be smaller than the diameter of the upper portion of the vessel. The tuyeres are arranged around the circumference of the lower part of the vessel and therefore the jets emitted by the tuyeres will penetrate into the slag layer in the lower portion of the vessel before rising through the slag into the upper portion of the vessel. Any "hot spots" i.e. areas of higher temperature, created by the gas and/or liquid and/or solids and/or plasma supplied by the tuyeres, in the slag layer in the upper portion of the vessel will therefore be sufficiently distant from the wall of the vessel to ensure that no increase in corrosion and/or erosion of the wall occurs.

[0008] The tuyeres may preferably comprise oxy-fuel burners to act as a direct heat source in the slag layer in the lower portion of the vessel. The oxy-fuel burners will increase the productivity of the reactor by increasing the occurrence of the endothermic reduction reactions and thereby increasing the reduction capacity of the slag layer.

[0009] The tuyeres preferably supply oxygen containing gas to the slag layer in the lower portion of the vessel. The oxygen contained in the gas will combust char into carbon monoxide thereby providing an additional source of heat in the slag layer and increasing the productivity of the reactor as explained for oxy-fuel burners.

[0010] At least ten tuyeres may be positioned around the lower portion of the vessel to ensure optimum distribution of the gas and/or liquid and/or solids and/or plasma, supplied by the tuyeres, into the slag layer.

[0011] The metallurgical vessel of the present invention preferably comprises a melting cyclone positioned above, and in open communication with, the vessel. Such a melting cyclone is described in Dutch patent NL C 257692 and EP 0690136.

[0012] The metallurgical vessel of the present invention may be used for iron making and steel making.

[0013] The present invention also relates to a method of reducing iron oxide to iron using a metallurgical vessel in accordance with the invention, comprising the steps of supplying iron oxide to the vessel, supplying oxygen containing gas to the interior of the metallurgical vessel, supplying carbonaceous material to the iron oxide and supplying gas and/or liquid and/or solids and/or plasma

into the slag layer in the lower portion of the vessel via the plurality of tuyeres.

[0014] The present invention also relates to a method of iron making comprising the steps of:

- conveying iron-oxide containing material into the melting cyclone,
- pre-reducing said iron-oxide containing material by means of a partially post-combusted reducing process gas originating from the metallurgical vessel,
- at least partly melting the iron-oxide containing material in the melting cyclone by supplying oxygen containing gas to the melting cyclone and effecting a post-combustion in said reducing process gas,
- permitting the pre-reduced and at least partly melted iron-oxide containing material to pass downwardly from said melting cyclone into the metallurgical vessel in which final reduction takes place and
- effecting the final reduction in the metallurgical vessel in a slag layer, by supplying oxygen containing gas to the interior of the metallurgical vessel via a plurality of lances, by supplying coal to the interior of the metallurgical vessel and by supplying gas and/or liquid and/or solids and/or plasma to the lower slag layer via a plurality of tuyeres, and thereby forming said reducing process gas and effecting a partial post-combustion in said reducing process gas in said metallurgical vessel by means of said oxygen containing gas supplied thereto.

BRIEF INTRODUCTION TO THE DRAWINGS

[0015] Figure 1 shows an apparatus in accordance with the invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

[0016] The apparatus in figure 1 comprises a metallurgical vessel 1 and a melting cyclone 8. Details of the melting cyclone are not shown. The metallurgical vessel itself comprises a lower portion 2 which accommodates the iron bath 9 and part of the slag layer 6 and comprises at least one tap hole 11 for tapping off molten iron and slag. The vessel also comprises an upper portion 3, which accommodates the remainder of the slag layer 6, and a roof portion 4. The slag layer 6 thus rests on top of the iron bath 9 and extends from the lower portion of the vessel 2 into the upper portion 3. Pre-reduced iron oxide 10 falls or flows from the melting cyclone into the metallurgical vessel and is finally reduced in the slag layer. A plurality of lances 5 supply oxygen containing gas to the slag layer 6 in the upper portion 3 of the vessel. Two lances are shown in the figure but more may be present depending on, for example, the size of the vessel and the performance parameters of the lances. A plurality of tuyeres 7 are arranged around the circumference of the lower portion of the vessel. The tuyeres are suitable for supplying gas and/or liquid and/or solids (such as recycled dust) and/or plasma to the slag layer in the lower portion 2 of the vessel. The number of tuyeres arranged around the circumference of the lower part of the vessel can be varied depending on the size of the vessel and the performance parameters of the tuyeres. The tuyeres may comprise oxy-fuel burners. During the final reduction of the pre-reduced iron oxide a process gas comprising reducing CO is produced that is partially post-combusted above the slag layer 6 in the vessel 1, whereby heat needed for the final reduction is released. The reducing process gas rises and is further post-combusted in the melting cyclone 8 with oxygen containing gas supplied to the melting cyclone. Iron oxide supplied to the melting cyclone is pre-reduced approximately to FeO and at least partly melted in the melting cyclone. The pre-reduced iron oxide 10 then falls or flows down into the metallurgical vessel 1.

[0017] While the invention has been illustrated by a particular embodiment, variations and modifications are possible within the scope of the inventive concept.

Claims

1. Metallurgical vessel comprising a lower portion for accommodating a molten metal bath and part of a slag layer in use, an upper portion for accommodating the remainder of the slag layer in use and a plurality of lances which project into the upper portion of the vessel and supply oxygen containing gas to the upper portion of the vessel **characterised in that** a plurality of tuyeres are arranged around the circumference of the lower portion of the vessel suitable for supplying gas and/or liquid and/or solids and/or plasma into the slag layer in the lower portion of the vessel.

2. Metallurgical vessel according to claim 1 **characterised in that** the diameter of the lower portion of the vessel is smaller than that of the upper portion.

3. Metallurgical vessel according to claims 1 or 2 **characterised in that** the tuyeres comprise oxy-fuel burners.

4. Metallurgical vessel according to any of the previous claims comprising a melting cyclone positioned above and in open communication with the metallurgical vessel.

5. Method of reducing iron oxide to iron using a metallurgical vessel in accordance with any one of claims 1-4, comprising the steps of supplying iron oxide to the vessel, supplying oxygen containing gas to the upper portion of the metallurgical vessel via the plurality of lances, supplying carbonaceous material to the iron oxide and supplying gas and/or liquid and/or solids and/or plasma into the slag layer

in the lower portion of the vessel via the plurality of tuyeres.

6. Method of reducing iron oxide according to claim 5 **characterised in that** the tuyeres supply oxygen containing gas into the lower slag layer.

7. Method of iron making comprising the steps of:

- conveying iron-oxide containing material into the melting cyclone,
- pre-reducing said iron-oxide containing material by means of a partially post-combusted reducing process gas originating from the metallurgical vessel,
- at least partly melting the iron-oxide containing material in the melting cyclone by supplying oxygen containing gas to the melting cyclone and effecting a post-combustion in said reducing process gas,
- permitting the pre-reduced and at least partly melted iron-oxide containing material to pass downwardly from said melting cyclone into the metallurgical vessel in which final reduction takes place and
- effecting the final reduction in the metallurgical vessel in a slag layer, by supplying oxygen containing gas to the interior of the metallurgical vessel via a plurality of lances, by supplying coal to the interior of the metallurgical vessel and by supplying gas and/or liquid and/or solids and/or plasma to the lower slag layer via a plurality of tuyeres, and thereby forming said reducing process gas and effecting a partial post-combustion in said reducing process gas in said metallurgical vessel by means of said oxygen containing gas supplied thereto.

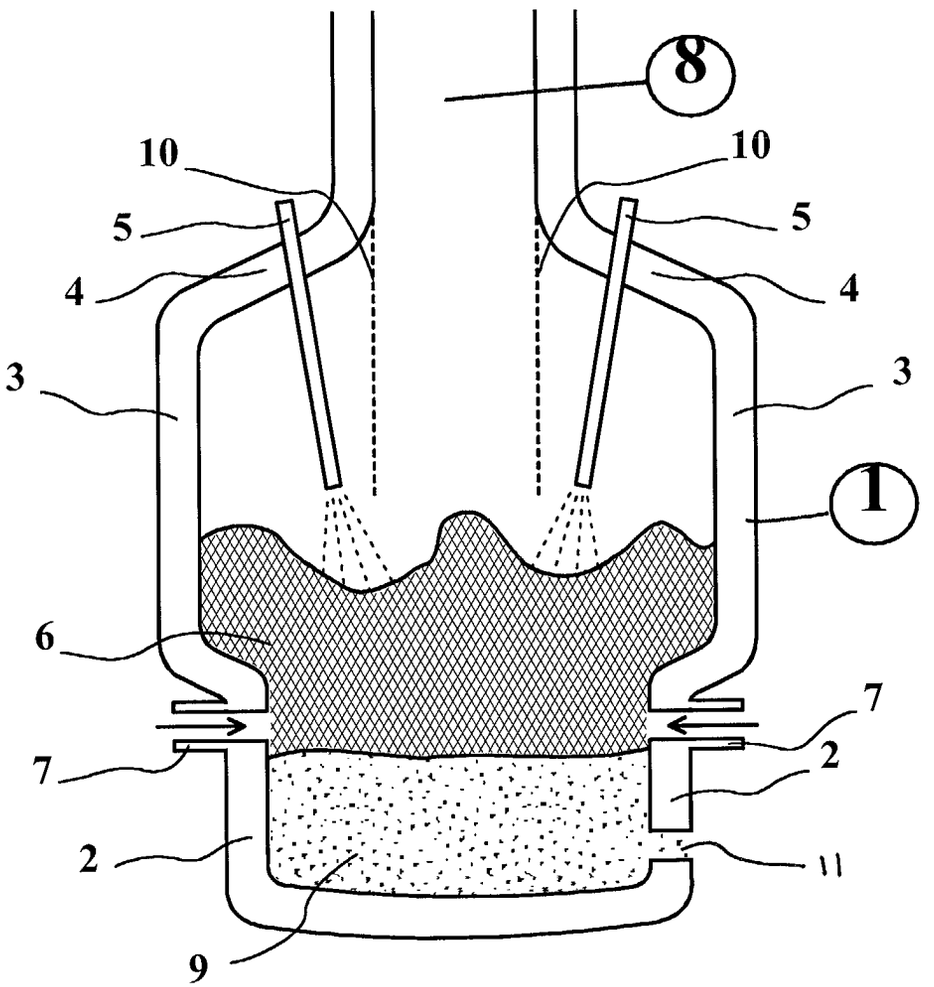

Fig. 1

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PARTIAL EUROPEAN SEARCH REPORT

which under Rule 45 of the European Patent Convention shall be considered, for the purposes of subsequent proceedings, as the European search report

Application Number EP 02 07 7781

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	"ROMELT OFFERS FLEXIBLE SINGLE STEP HOT METAL WITHOUT COKE" STEEL TIMES INTERNATIONAL.(INC. STEEL TIMES), DMG WORLD MEDIA, REDHILL, SURREY, GB, vol. 20, no. 1, 1996, pages 40-41, XP000547906 ISSN: 0143-7798	1,2,5,6	C21C5/56
Y	* page 40, left-hand column, last paragraph - middle column, paragraph 1 * * figures 2,3 *	4,7	
X	WO 97 20954 A (WMC RESOURCES LTD ;BLANDY CHARLES WILLIAM DOUGLAS (AU)) 12 June 1997 (1997-06-12) * abstract * * page 13, last paragraph - page 14, paragraph 4 *	1,2	

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TECHNICAL FIELDS SEARCHED (Int.Cl.7)

C21C
C21B
F27B

INCOMPLETE SEARCH

The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC to such an extent that a meaningful search into the state of the art cannot be carried out, or can only be carried out partially, for these claims.

Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

see sheet C

Place of search	Date of completion of the search	Examiner
THE HAGUE	2 December 2002	Ceulemans, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C07)

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INCOMPLETE SEARCH SHEET C

Application Number
EP 02 07 7781

Claim(s) searched incompletely:
1-7

Reason for the limitation of the search:

Present claims relate to an extremely large number of possible apparatus and method using said apparatus.
Support within the meaning of Article 84 EPC and/or disclosure within the meaning of Article 83 EPC is to be found, however, for only a very small proportion of the apparatus claimed.
In the present case, the claims so lack support, and the application so lacks disclosure, that a meaningful search over the whole of the claimed scope is impossible. Consequently, the search has been carried out for those parts of the claims which appear to be supported and disclosed, namely those parts relating to a metallurgical vessel suitable for the direct melting of iron oxide (see page 2, lines 26-27 and page 3, lines 19-25).

Hence, vessels for treating metals and metal oxides different from iron and iron oxide have not been searched.
Furthermore, since the applicant does not disclose anything related to the creation of a sub-atmospheric pressure or to the use of an electric arc to generate the heat in the melting furnace, the search has not been extended into specific vacuum furnaces or electric arc furnaces.

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PARTIAL EUROPEAN SEARCH REPORT

Application Number
EP 02 07 7781

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
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	* claims 1,2,5,14-16; figure 1 *		

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X	US 6 368 548 B1 (INNES JOHN ALEXANDER) 9 April 2002 (2002-04-09)	1-7	
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	* claims 1-4,7-9,12,15; figure *		

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EPO FORM 1503 03.82 (P04C10)

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PARTIAL EUROPEAN SEARCH REPORT

Application Number
EP 02 07 7781

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
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