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Datasheet for the decision of 27 Februay 2008

Case Number: T 0356/06 - 3.2.02

Application Number: 98104713.7

Publication Number: 0866139

IPC: C21C 5/52

Language of the proceedings: EN

Title of invention:
Method using a burner/lance for injecting gas into molten metal

Patentee:
PRAXAIR TECHNOLOGY, INC.

Opponent:
AIR PRODUCTS AND CHEMICALS, INC.

Headword:
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Relevant legal provisions:
-

Relevant legal provisions (EPC 1973):
EPC Art. 56

Keyword:
"Inventive step (no)"

Decisions cited:
-

Catchword:
-

Case Number: T 0356/06 - 3.2.02

D E C I S I O N
of the Technical Board of Appeal 3.2.02
of 27 Februay 2008

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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 4 January 2006 revoking European patent No. 0866139 pursuant to Article 102(1) EPC.**

Composition of the Board:

Chairman: T. Kriner
Members: R. Ries
A. Pignatelli

Summary of Facts and Submissions

I. The appellant (patent proprietor) lodged an appeal on 1 March 2006 against the decision of the opposition division posted 4 January 2006 on the revocation of European patent No. 0 866 139 and paid the appeal fee simultaneously. The statement setting out the grounds of appeal was received at the EPO on 15 May 2006.

II. The opposition division held that the subject matter of claim 1 of the main request lacked novelty and that the subject matter of claim 1 of the auxiliary request then on file lacked an inventive step.

III. Oral proceedings were held before the Board on 27 February 2008 and focused on the discussion of inventive step having regard to the following documents

D1 : US-A-4 622 007

D11: BOF STEELMAKING volume 1, Introduction, Theory, and Design Part 1, Process Technology Division Iron and Steel Society of the American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., Second Printing 1982, pages 551 to 553, 580 to 590, 627,

D14: US-A-3 427 151

and to the general technical knowledge of the skilled person.

The following request were made:

The appellant requested that the decision under appeal be set aside and the patent be maintained on the basis of the set of claims filed as main request or on the basis of the set of claims according to one of the first to fourth auxiliary requests, all requests filed with letter of 25 July 2007.

The respondent (opponent) requested that the appeal be dismissed.

IV. Claim 1 of the main request reads:

"A method for injecting oxygen into, and penetrating the surface of, a pool of molten metal in an electric arc furnace from an injection point located in the furnace at a significant distance above the surface of the molten metal pool, wherein the molten metal pool has a layer of slag on its top surface, said method comprising:

(A) forming a coherent supersonic jet of oxygen in the furnace by

(1) injecting into the furnace above the molten metal pool, through a nozzle directed toward the surface of the pool, (a) a main oxygen stream whose initial jet axis velocity is supersonic and is at least 457 m/s (1500 fps) and (b) a fuel and a secondary oxygen both of which are coaxial with and parallel to the supersonic main oxygen stream, wherein the fuel and secondary oxygen are injected into the furnace in two streams, each of said two streams being concentric with the main oxygen stream, wherein said secondary oxygen stream is

located radially outwardly to said fuel stream, and

(2) surrounding the supersonic main oxygen stream with a flame envelope which is formed by combusting the fuel with the secondary oxygen and which extends substantially the entire length of the supersonic main oxygen stream in the furnace from the exit of the nozzle to the molten metal pool, wherein the fuel gas flow rate is greater than that required to combust stoichiometrically with the secondary oxygen, wherein the nozzle has a main oxygen exit diameter d and wherein the distance from the exit of the nozzle to the top surface of the molten metal pool along the jet axis is at least 20d; and

(B) penetrating the surface of the molten pool with the main oxygen stream whose jet axis velocity at that point is still supersonic."

Claim 1 of the first auxiliary request differs from this claim in that in part (2) after "which extends" the term "substantially" is deleted.

Claim 1 of the second auxiliary request has the following additional features (in bold letters) over claim 1 of the main request:

"A method for...comprising

(I) a lancing mode comprising:

(A) forming a coherent supersonic jet of oxygen in the furnace by

(1) injecting...to said fuel stream, and **wherein the fuel stream is ejected through an inner ring**

of holes and the secondary oxygen stream is ejected through an outer ring of holes, and

(2) surrounding...with the secondary oxygen, **wherein the flow of secondary oxygen is from 5% to 10% of the total oxygen flow,** wherein the nozzle has a main oxygen exit diameter d and wherein the distance from the exit of the nozzle to the top surface of the molten metal pool along the jet axis is **from 30d to 60d**; and

(B) penetrating the molten surface of the molten metal pool with the main oxygen stream whose jet axis velocity at that point is still supersonic;

(II) a lancing/burner mode comprising:

increasing, relative to the lancing mode, the flow rate of secondary oxygen and fuel in order to generate heat for the furnace for penetrating and melting scrap metal in the furnace, wherein the flow rate of the main oxygen is 75% to 99% of the total oxygen flow rate and wherein the total oxygen flow rate is more than 150% stoichiometric oxygen required to burn the fuel to completion; and

(III) a burner mode

wherein the secondary oxygen flow rate is 40% to 60% of the total oxygen flow rate and the total oxygen flow rate is 100% to 200% of stoichiometric oxygen required to burn the fuel to completion, and wherein combustion of the fuel stream with the secondary oxygen stream and the main oxygen stream is used to provide heat into the furnace for preheating and melting cold metal scrap in the furnace."

Claim 1 of the third auxiliary request has the following additional features (in bold letters) over claim 1 of the main request:

"A method for...

(1) injecting into the furnace above the molten metal pool, through **an orifice of** a nozzle **of a lance, said nozzle** directed toward ...fuel stream, **and wherein the fuel stream is ejected through passageways terminating in an inner ring of holes in substantially the same plane as the orifice of the main oxygen nozzle and the secondary oxygen stream is ejected through passageways terminating in an outer ring of holes in substantially the same plane as the orifice of the main oxygen nozzle;** and ..

(2) surrounding...pool, **wherein the flame envelope forms within 25.4 mm (one inch) to the lance tip,** wherein the fuel...still supersonic."

Claim 1 of the fourth auxiliary request includes the following additional feature (in bold letters) over claim 1 of the main request:

"A method...along the jet axis is **from 30d to 60d;** and (B) penetrating... is still supersonic."

V. The appellant's arguments are summarised as follows:

The closest prior art document, D14, related to a lance in which an oxygen jet, enclosed with a flame envelope, was produced by the combustion of fuel and secondary oxygen supplied through circumferential passages surrounding the main oxygen jet. However, the main oxygen jet velocity was at maximum sonic or below both at the nozzle exit and at the surface of the molten bath, and the radial arrangement of the passages for supplying fuel and oxygen in D14 was different to that of claim 1 of the patent in suit.

Starting from D14, the technical problem which was also reflected in the passages [0006] to [0010] of the patent in suit essentially resided in providing a method for supplying oxygen to an electric arc furnace containing a pool of molten metal, wherein the oxygen jet entered the molten metal to react with the constituents dissolved therein while avoiding splashing and significantly damaging the oxygen-fuel lance.

The process as defined by claim 1 of the main request and solving this problem was not obvious to the skilled person. It was basic physics that gas laws alter drastically between sonic and supersonic flows. Owing to shock waves, turbulence, etc the behaviour of supersonic jet in a flame envelope would be quite different to (sub-) sonic conditions. Also the textbook D11 gave no incentive for a skilled person to surround a supersonic jet with a flame envelope since the supersonic oxygen lance was only used in a quiescent atmosphere. The document further taught that the ratio of densities of the central jet and quiescent atmosphere was decisive for the jet quality. The skilled person therefore would not expect that shielding a central oxygen jet with a shroud of flame was beneficial also in case of a supersonic jet.

The feature stipulated in claim 1 of the patent in suit that the fuel was discharged through the inward circumferential passage 3 (Figures 2 and 3 of the patent) rather than through the outward passage, as taught in D14, Figure 2, was not merely a matter of design but supported the formation of a coherent flame envelope promoted by the claimed process.

As to the method stipulated in claim 1 of the first to fourth auxiliary requests, no motivation was given to the skilled person for combining the technical process taught by D14 with that of D1. In particular, document D1 was silent about the provision of a flame envelope around the main oxygen jet for improving the penetration capability of the oxygen jet, as taught by D14. Moreover, the fuel and secondary oxygen jets in D1 were angled towards the main oxygen channel. This structural arrangement resulted in a significant mixing of the flame with the main oxygen jet and did not provide a flame envelope serving to improve the main oxygen jet velocity. Hence the claimed process was not obvious from the combined teaching of D14 and D1 either.

VI. The respondent's arguments are summarised as follows:

Document D14 disclosed all the technical features of the claimed process, except for the supersonic velocity of the central oxygen jet, the radial arrangement of the ports for supplying fuel and secondary oxygen surrounding the main oxygen jet and the restriction of the process to the electric arc furnace. The skilled person was well aware of the fact that only divergent-convergent nozzles increased the jet momentum to a level sufficiently high for achieving deep penetration of the metal bath, as was taught in the textbook D11 and/or D1. The specific process parameters featuring in claim 1 of the main request and the auxiliary requests merely represented the optimisation of a heating-refining method that was in principle known from D14 and D1. This optimisation of process parameters did, however, not involve an inventive step.

Reasons for the Decision

1. The appeal is admissible.

2. *Main request - claim 1 - inventive step*

2.1 Like the patent at issue, document D14 relates to a process for introducing an oxygen stream into a molten metal bath covered with a slag layer in such a manner as to enable the oxygen stream to pierce through the slag layer and deeply penetrate into the molten metal without appreciable splashing for refining the molten metal. The process allows the lance to be operated from heights in the order of 4 to 40 inches (0.1 to 1 m) above the molten metal bath, thus preventing excessive wear of the lance tip (see D14, column 1, abstract, column 3, lines 38 to 66). As depicted in Figure 2 of document D14 and described in column 5, lines 55 to 60, the substantial larger amount of oxygen (main stream) is discharged at a high velocity, preferably sonic (see column 7, lines 28 to 33), through central passage 20 whereas a small percentage of the main oxygen stream is diverted into annular passage 22 by passing through annularly spaced circularly arranged ports 34 (secondary oxygen stream). The fuel gas stream leaving the lance through outward annular passage 25 and the secondary oxygen stream passing through inward port 34 form a post-mixed combustible mixture downstream the lance which upon ignition forms a circumferentially continuous hollow shroud of flame (flame envelope). The document points out that the shroud of flame confines the central gaseous stream such that the cross sectional area of said gaseous stream remains substantially constant (coherent) from the point of discharge through a vertical distance of as much as 48 inches. Put the other way, the shroud of flame is formed over the entire length of the central jet (see column 4, lines 56 to 74, column 5, lines 3 to 10, lines 54 to 69; column 6, lines 53 to 59; claim 2). As further set out in claim 1 of D14, the amounts of oxygen to fuel are supplied in a ratio (by volume) ranging from 7,5% to 62,5% of the stoichiometric requirements. Given that the objects of the process known from D14 comply with those referred to in paragraphs [0006], [0007], [0009] of the patent specification, D14 qualifies as the closest prior art document, as agreed by the parties.

2.2 Starting from the disclosure of D14, the technical problem underlying the claimed process is seen in providing a process for injecting oxygen through a lance, kept well above the bath surface, onto a metal bath which allows for increasing the amount oxygen that impacts and deeply penetrates the bath surface so that more oxygen becomes available to react with the constituents of the bath in an EAF.

2.3 The solution to this problem resides in the technical features (i) to (iv) not mentioned in D14, i.e. in that:

(i) the main oxygen stream supplied through the lance exhibits an initial supersonic jet axis velocity of at least 457 m/s,

(ii) the velocity upon impingement of the jet on the bath surface is still supersonic;

(iii) the secondary oxygen is supplied through a port located radially outwardly to that for the fuel stream and

(iv) the lance is used in an electric arc furnace (EAF).

2.4 Considering features (i) and (ii), the skilled metallurgist is well aware of the fact, e.g. from the textbook D11, page 580 to 582 that for maximum penetration capability it is indispensable that the momentum of the oxygen jet leaving the nozzle should be maximum and not spread too rapidly, thereby reducing the concentration of momentum in the jet. D11 teaches that this high lance performance is achieved only by a convergent-divergent nozzle (Laval nozzle) which enables supersonic nozzle exit jet stream velocities up to 2 Mach (see D11, page 627, first and second paragraph). According to the exemplifying calculation given in D11 on pages 589 to 590, the supersonic velocity of the jet centreline is maintained over a long distance. For the conditions assumed in the example, a jet velocity of 1450 ft/s (441 m/s) is to be expected at a lance distance of 5 feet (1,52 m). The disclosure of D11 thus infers that the axis velocity of the oxygen jet is still supersonic when it impacts and penetrates the molten bath, and therefore satisfies feature (ii).

2.5 The appellant argues in this context that the skilled person, upon consideration of the physical changes occurring within the gas jet, in particular the effects of shock waves, turbulences and the surrounding atmosphere, would not expect any benefits from increasing the gas jet velocity in document D14 from sonic to supersonic while maintaining a flame envelope. Moreover, higher costs would deter him from using a convergent-divergent nozzle. Hence, it was not obvious to use a Laval nozzle in D11 in replacement for the (sub) sonic lance configuration disclosed in D14.

In the Board's assessment, these arguments are not convincing. The fact that the use of a supersonic jet within a flame envelope per se was known in the prior art, as correctly acknowledged as background art in the patent specification, paragraph [0003] by referring to document D1, demonstrates that the metallurgist would not be dissuaded from attempting to increase the oxygen jet axis velocity in the D14 device to above supersonic within a flame envelope. Moreover, the patent does not even remotely describe any difficulties associated with the use of a supersonic jet within a flame shroud, or how they were overcome. Hence the skilled person faced with the above-mentioned problem would undoubtedly consider and put into practice the teaching of D11 and transfer it to the process described in D14. Specifically he would consider increasing the jet velocity beyond sonic in document D14 in order to achieve a deeper penetration into the molten metal and, in consequence thereof, a higher refining efficiency.

The use of an initial jet axis velocity of at least 457 m/s (1500 f/s) upon ejection from the lance tip is rated in this context as describing only one preferred jet speed which is, however, merely a matter of optimisation rather than an inventive concept.

Turning to the feature (iii), the patent specification itself points out several alternatives, including that the fuel may be supplied through the lance either through the outermost passageway and the secondary oxygen in the inner annular passageway, or vice versa. As a third alternative embodiment, the patent even suggests pre-mixing of the fuel and secondary oxygen and supplying the mixture through one passageway (cf. the patent specification, column 4, lines 41 to 52). Given that both (or the three) embodiments are obvious interchangeable alternatives, the selection of the claimed configuration for discharging the secondary oxygen and fuel, vis-à-vis that disclosed in Da14, does not justify an inventive step.

As to feature (iv), the injection of oxygen gas through a lance onto the surface of a molten pool of metal (in particular steel) contained in e.g. a converter, a ladle or any kind of furnace is common practice in metallurgy (see for instance D14, column 5, lines 11 to 17). The high flexibility of the oxygen-fuel lance technology in metallurgy is known to encompass several modes, including the heating and melting of scrap (burner mode), the provision of additional heat to a metallurgical vessel (lancing/burner mode) or the refining of a molten metal (lancing mode). Using such a lance in an electric arc furnace (EAF), as defined in claim 1 of the main request, for heating, melting and refining therefore amounts to nothing more than common metallurgical practice.

2.6 Consequently, the process set out in claim 1 of the main request does not involve an inventive step since it is obvious to a skilled person by combining the technical disclosure given in documents D14 and D11.

3. *First, third and fourth auxiliary requests*

The arguments set out in section 2 above also apply to the claims of the first, third and fourth auxiliary requests.

This is particularly true for claim 1 of the first auxiliary request which differs from claim 1 of the main request merely by the deletion of the term "substantially". However, it is clear for the skilled person that the disclosure of D14 (see in particular column 4, lines 71 to 74) includes the case where the flame envelope extends over the entire length of the main oxygen stream.

Regarding the additional features stipulated in claim 1 of the third auxiliary request, the supply of fuel gas and secondary oxygen through an inner and outer ring of holes that is arranged in the same plane as depicted in Figure 3 of the patent rather than through two separate annular passages, as depicted in D1, merely describes an obvious alternative structural arrangement which is, however, not associated with a particular technical effect. The same statement applies to the feature that the flame envelope should form very close, e.g. within 25.4 mm, to the lance tip (see the patent specification in column 5, lines 51 to 55). However, the patent specification fails to mention any specific technical advantage or effect that is attributed to this feature. Therefore, the provision of these design features has to be regarded as simple design option, which in case of the rings of holes is anyway well known from D14 (see Figure 6).

The distance of the lance from the molten metal pool being within the range of 30 to 60d (d = the main oxygen exit diameter of the nozzle) stipulated in claim 1 of the fourth auxiliary request is anticipated by the technical data disclosed in the Table in column 8, line 43 to 56 of document D14, disclosing heights above the bath of 15 to 30 inches for a lance having a 0.5 inch diameter orifice. Hence the claimed distance lance-bath level appears to be typical in the art if excessive wear of the lance tip is to be avoided.

Consequently, claim 1 of the first, third and fourth auxiliary requests do not comprise subject matter which supports an inventive step.

4. *Second auxiliary request*

Claim 1 of the second auxiliary request defines various specific process parameters for the

(I) lancing mode (secondary oxygen flow = 5 to 10% of the total oxygen flow, distance lance tip to the pool = 30 to 60d),

(II) the lancing/burner mode (main oxygen flow = 75% of the total oxygen flow which is 150% of the stoichiometrically required oxygen) and

(III) the burner mode (secondary oxygen flow = 40 to 60% of the total oxygen flow which is 100% to 200% of the stoichiometrically required oxygen flow).

As previously mentioned (see section 2.5) it is conventional metallurgical practice that one and same oxy-hydrocarbon fluid fuel burner may be used for various purposes such as high temperature heating, melting, refining and superheating materials including scrap or metals, in particular when treating metals in an electric arc furnace (see for instance D1, Abstract; column 1, lines 14 to 32; column 4, lines 50 to 68). The known oxy-fuel device therefore may be used in the lancing, lancing/burner or burner modes featuring in claim of the second auxiliary request. During the heating, melting, refining and superheating cycles, the heat input, flame velocity, temperature, luminosity, the shape of the flame envelope and the chemistry of the combustion product are controlled continuously by variation of the supply of fuel, air and/or oxygen and also by the variations of the ways they are introduced into the combustion chamber, in order to satisfy the heating requirements with minimum operating cost (see e.g. D1, column 5, lines 30 to 68). Thus in each mode, the process parameters are to be optimised for a given application. Adapting the flow rate of secondary oxygen in relation to the main oxygen stream with particular respect to the selected mode and providing a reducing or oxidising flame depending on the mode therefore falls within the normal competence of the skilled metallurgist who is familiar with oxy-fuel lance/burner technology.

Moreover, contrary to the appellant's allegation, D1 specifically mentions the existence of a flame envelope and that its shape may be controlled depending on the intended purpose and that the excess oxygen can be directed through the flame toward the molten bath at a supersonic velocity to improve the ability of the jet to penetrate and refine the molten metal (see D1, column 5, lines 1 to 9).

Hence, the appellant's argument that a skilled person was not prompted to consider D14 and D1 in combination is not convincing, given that both documents belong to the same technical field and disclose a flame envelope surrounding the central oxygen jet that is used for penetrating and refining the metal bath. Moreover, document D1 was already acknowledged as technical background in the patent at issue.

Hence, claim 1 of the second auxiliary request does also not comprise technical features justifying the presence of an inventive step.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

V. Commare T. Kriner