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Datasheet for the decision of 16 October 2007

Case Number: T 0701/05 - 3.2.02

Application Number: 02712642.4

Publication Number: 1386011

IPC: C21C 7/06

Language of the proceedings: EN

Title of invention:
Ladle refining of steel

Applicant:
NUCOR CORPORATION

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step - yes: (after amendment)"

Decisions cited:
-

Catchword:
-

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0701/05 - 3.2.02

D E C I S I O N
of the Technical Board of Appeal 3.2.02
of 16 October 2007

Appellant: NUCOR CORPORATION
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Representative: Lerwill, John
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 20 January 2005 refusing European application No. 02712642.4 pursuant to Article 97(1) EPC.**

Composition of the Board:

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

Summary of Facts and Submissions

I. This appeal is against the decision of the examining division dated 20 January 2005 to refuse European patent application No. 02712642.4.

II. The application was refused on the ground that the subject matter of the claims 1 to 16 as originally filed (i.e. the set of claims enclosed with the applicant's letter of 7 October 2003 when entering the European regional phase of the International Application WO 02/079522) did not involve an inventive step (Article 56 EPC) having particular regard to the documents:

D1: Fruehan: "The Making, Shaping and Treating of Steel", 11th Edition, Steelmaking and Refining Volume 1998, AISI, USA, pages 140 to 150 and 677 to 683,

D2: Turkdogan: "Fundamentals of Steelmaking", 1996, The Institute of Metals, London, pages 262 to 276

D3: Turkdogan: "Physicochemical Properties of Molten Slags and Glasses", The Metals Society, London, pages 289 to 301 and 423 to 425.

D4: N.N: "Stability Diagrams" AFS Inclusion Atlas, 1998, pages 1 to 4

In view of the basic metallurgical knowledge disclosed in the textbooks D1 to D4, the examining division held that the claimed method of refining steel in a ladle was obvious to a person skilled in the art. Faced with

the problem of obtaining a Si/Mn deoxidised steel with a low sulphur content of less than 0.01% S, the skilled metallurgist would use calcium-aluminate slags in combination with strong argon stirring the steel in the ladle to promote a rapid reaction at the metal-slag interface. Such slags provided a high sulphur absorbing capacity and a low oxygen activity which were both required for efficient sulphur removal from the melt. Hence, the claimed steel refining method amounted to nothing more than the basic metallurgical practice reflected in documents D1 to D4.

III. On 18 March 2005, the appellant (applicant) lodged an appeal against the decision and paid the prescribed fee on the same day. A statement setting out the grounds of appeal was filed on 18 May 2005.

IV. At the end of the oral proceedings held on 16 October 2007, the applicant requested that the decision under appeal be set aside a patent be granted on the basis of

Claims 1 to 11 as filed during the oral proceedings before the board;

Description

pages 3 and 4 as filed during the oral proceedings before the board;
page 1 as filed with letter dated 29 September 2007;
page 6 as file with letter dated 18 May 2005;
pages 2, 5, 7 to 11 as published;

Figure 1 as published.

Amended claim 1 reads as follows:

"1. A method of continuous thin strip casting in a twin roll caster, which method includes refining steel in a ladle, including heating a steel charge and slag forming material in a ladle to form molten steel covered by a slag containing silicon, manganese and calcium oxides, and stirring the molten steel by injecting an inert gas into it to cause silicon/manganese deoxidation and desulphurisation of the steel to produce a silicon/manganese killed molten steel having a sulphur content of less than 0.01% by weight and a free oxygen content of no more than 20 ppm, wherein at the conclusion of desulphurisation, the slag is thickened to prevent reversion of sulphur into the steel and oxygen is injected into the steel to increase the free oxygen content thereof to the order of 50 ppm and produces a steel which has a sulphur content of less than 0.01% by weight and an aluminium content of 0.01% or less by weight, and then delivering the steel to a twin roll caster and casting the steel into thin strip."

Claims 2 to 11 relate to preferred embodiments of the method set out in claim 1.

V. The appellant's arguments can be summarised as follows:

None of the documents D1 to D4 taught or suggested that a Si/Mn killed steel having a sulphur content of less than 0.01% could be prepared by refining the steel in a ladle by inert gas injection to cause effective Si/Mn deoxidation and desulphurisation followed by thickening the slag and oxygen injection to increase the free

oxygen level in the melt to the order of 50 ppm. The refining steps featuring in amended claim 1 resulted in a steel melt which was successfully castable in a twin roll caster without the agglomeration of non-metallic inclusions and nozzle clogging, as set out on pages 6 and 8 of the application. The claimed process, therefore, involved an inventive step.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments, Article 123(2) EPC*

The subject matter of claim 1 results from a combination of claims 1, 2, 10, 13 (and 15) and the technical information given in the description, page 4, lines 2 and 3, and page 8, lines 9 to 15 of the published International Application WO 02/079522. Dependent claims 2 to 11 have a basis on the published claims 14, 9, 6, 11, 12, 3 to 5, 7 and 8, respectively.

The description has been adapted to the revised claims. Hence, there are no formal objections to the amended application documents.

3. *The application:*

3.1 It is apparent from the patent specification considered as a whole and also from the wording of amended claim 1 that the application is concerned with a process for continuous casting thin steel strip (e.g. of less than 5 mm thickness) in a twin roll caster. This known

casting process is acknowledged in the patent specification on page 11, lines 11 to 15 in the form of documents US-A-5 184 668 and US-A-5 277 243. It requires that the molten steel is constrained to flow through very small flow passages of a refractory delivery nozzle which is located beneath the tundish and distributes the melt within the nip between the rolls to form a casting pool. It has been observed that various steel grades which are fully or partly killed with Al and exhibit a residual Al-content of 0.01% or more cannot be strip cast satisfactorily because the solid non-metallic inclusions formed during deoxidation and desulphurisation have a strong propensity towards agglomeration which results in clogging the fine flow passages in the metal delivery system to form defects and discontinuities in the resulting strip product (cf. the application, page 2).

3.2 Problem and solution:

3.2.1 Hence, the problem the application sets out to solve resides in providing a method of refining a steel melt which is not prone to the agglomeration of the non-metallic inclusion and to nozzle clogging and which results in a steel which is readily castable in a twin roll caster.

This problem is successfully solved by the method defined in claim 1.

3.3 The board notes that the documents D1 to D4 are concerned with fundamentals of ladle metallurgical reactions in general, such as deoxidation with Si/Mn or Al or Si/Mn/Al, desulphurisation etc. or, more

specifically, with refining steel melts in the ladle including inert gas stirring (argon rinsing for inclusion floatation) e.g. in the presence of calciumaluminate slags etc. (cf. in particular D1, chapters 2.10; 11.4: Refining in the Ladle; D2, points 9.7.2; 9.7.2b;, 9.7.4 and 9.8.1 and 9.8.2). However, none of these documents addresses the continuous casting of thin steel strip in a twin roll caster and the problems associated therewith.

3.4 It is well known in the art that a low free oxygen level in the melt is prerequisite for effective desulphurisation of the steel melt. However, none of the cited documents mentions the process step of reducing the free oxygen content of the steel melt to a level of not more than 20 ppm [O] by Si/Mn contained in a lime rich slag in combination with intensive stirring the melt by injecting inert gas. This finding is surprising, all the more so D1 discloses that free oxygen levels of $\leq$ 20 ppm are generally not achievable by Si/Mn deoxidation alone but require the addition of silicomanganese plus a small amount of Al or, alternatively, the use of a prefused calciumaluminate slags plus hard inert gas stirring (cf. D1, Figure 2.127, 2.1278; Chapter 11.4.1 Deoxidation, 11.4.1.1 and 2; Deoxidation with Silicomangangese; 11.4.2 Desulphurization; D2, page 266, chapter 9.7.2b; 9.8.1 and 2).

Moreover, none the prior art proposes the injection of oxygen after the desulphurisation step as to increase the free oxygen content in the melt to a level in the order of about 50 ppm [O]. In doing so, the chemistry of the inclusions (samples L5 to L7) is modified to

include increased amounts of MnO + SiO_2 and reduced amounts of Al_2O_3, MgO and CaO, as it is evident from the comparative inclusion analysis given on page 10 of the application after oxygen injection. This type of inclusion can be better absorbed by the slag and, as a consequence, the risk of the agglomeration of the inclusions and nozzle clogging is significantly reduced or even avoided.

Since none of the textbooks D1 to D4 could provide a clear pointer to the solution of the problem underlying the present application, the claimed method involves an inventive step.

3.5 The dependent claims 2 to 11 relate to preferred embodiments of the process set out in claim 1 and are, therefore, also allowable.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the first instance with the order to grant a patent with the following documents:

Claims: 1 to 11 filed during the oral proceedings before the board;

Description:
pages 3 and 4 filed during the oral proceedings before the board;
page 1 filed with letter dated 28 September 2007;
page 6 filed with letter dated 18 May 2005;
pages 2, 5, 7 to 11 as published;

Figure: 1 as published.

The Registrar: The Chairman:

V. Commare T. Kriner