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D E C I S I O N
of 27 April 1995

Case Number: T 0275/93 - 3.2.5

Application Number: 86110690.4

Publication Number: 0211422

IPC: B22D 11/12

Language of the proceedings: EN

Title of invention:
Continuous casting method

Patentee:
Nippon Steel Corporation

Opponent:
VOEST-ALPINE Industrieanlagenbau Gesellschaft m.b.H.

Headword:
-

Relevant legal provisions:
EPC Art. 56

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

Decisions cited:
-

Catchword:
-



Case Number: T 0275/93 - 3.2.5

D E C I S I O N
of the Technical Board of Appeal 3.2.5
of 27 April 1995

Appellant:
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Decision under appeal: Decision of the Opposition Division of the
European Patent Office dated 2 February 1993
rejecting the opposition filed against European
patent No. 0 211 422 pursuant to Article 102(2)
EPC.

Composition of the Board:

Chairman: G. H. O. Gall
Members: A. Burkhart
W. D. Weiß

Summary of Facts and Submissions

I. The Appellant (Opponent) lodged an appeal against the decision of the Opposition Division rejecting the opposition against the patent No. 0 211 422.

Opposition was filed against the patent as a whole and based on Article 100(a) EPC.

The Opposition Division held that the grounds for opposition mentioned in Article 100(a) EPC did not prejudice the maintenance of the patent unamended, having regard to the following documents:

- E1: US-A-3 974 559,
- E2: Nippon Kokan Technical Report Overseas, No. 36 (1982), and
- E3: DE-C-2 444 443.

II. Oral proceedings were held before the Board of Appeal.

- (i) The Appellant requested that the decision under appeal be set aside and the patent be revoked.
- (ii) The Respondent (Proprietor of the patent) requested that the appeal be dismissed and the patent be maintained unamended (main request), alternatively according to the claims submitted as auxiliary requests No. 1 to 5, presented during the oral proceedings and the description and the drawings as granted.

(iii) Claim 1 according to the patent as granted reads as follows:

"1. A method for continuous casting of molten metal by continuously withdrawing a strand and by reduction of the thickness of the strand in the semi-solidified region, characterized in

(a) that the thickness of the strand is continuously reduced at a rate of 0.5 to 2.5 mm/min during casting in the intermediate solidification region (I-2) between the solidification stage when the center of the strand has a temperature corresponding to a fraction of solid of 0.1 to 0.3 and the solidification stage when said temperature reaches a level corresponding to a particular fraction of solid at the limit of fluidity; and

(b) that substantially no reduction in thickness is applied to the strand in the final solidification region (II) between the solidification stage when the center of the strand has a temperature corresponding to said fraction of solid at the limit of fluidity and the solidification state when said temperature reaches the solidus temperature."

Claim 1 according to the auxiliary request 1 reads as follows:

"1. A method for continuous casting of molten metal by continuously withdrawing a strand and by reduction of the thickness of the strand in the semi-solidified region, characterized in

(a) that the thickness of the strand is continuously reduced at a rate of 0.5 to 2.5 mm/min during casting in the intermediate solidification region (I-2) between the

solidification stage when the center of the strand has a temperature corresponding to a fraction of solid of 0.1 to 0.3 and the solidification stage when said temperature reaches a level corresponding to a fraction of solid at the limit of fluidity within the range of 0.6 to 0.9; and

(b) that substantially no reduction in thickness is applied to the strand in the final solidification region (II) between the solidification stage when the center of the strand has a temperature corresponding to said fraction of solid at the limit of fluidity and the solidification state when said temperature reaches the solidus temperature."

(iv) The Appellant argued essentially as follows:

Claim 1 of the patent in suit did not define an exact upper limit for the "intermediate solidification region (I-2)" wherein a thickness reduction is carried out. Even in the light of the description no such definite limit could be established. Therefore, a distinction between the reduction region mentioned in documents E2 or E1 and the reduction region (I-2) according to Claim 1 of the patent in suit could not be established.

Moreover, the method of Claim 1 was obvious in the light of the teaching of document E2 which suggested a soft-reduction to be carried out before completion of the solidification at a reduction rate of 0.5 to 2.0 mm/min. Also the teaching of document E1 rendered obvious the method of Claim 1, since the expression "reducing ... the portion of said steel sandwiched between the liquidus line and the solidus line ..." in the

claim of the this document had to be interpreted in the sense that it excluded values of a fraction of solid of 0 and 1.0, and since the reduction rate of "less than 1.5% for each pair of rolls" suggested in this document in practice covered the reduction rate of 0.5 to 2.5 mm/min claimed in Claim 1 of the patent in suit. Furthermore, document E3 suggested to the person skilled in the art the essential features of the method of Claim 1 of the patent in suit, because this document taught that center segregations could be avoided, if a very low thickness reduction of 0.1 to 2.0% was carried out in the region of the front end of a crater which was produced as the liquidus part was solidified.

Also the method according to the auxiliary request 1 did not involve an inventive step with respect to the state of the art according to documents E1, E2 and E3, although in this amended claim the upper limit of the intermediate solidification region (I-2) was specified as being within a range of 0.6 to 0.9 for the fraction of solid. In practice, the limit of thickness reduction could not be held exactly at a value of 0.9, and therefore, it was not possible to clearly exclude a thickness reduction within the solidification region between a f_s -value between 0.9 and 1.0. As a consequence, also Claim 1 of the auxiliary request 1 was unclear in this respect.

The methods of the respective Claims 1 according to the auxiliary requests 2 to 5 were also obvious to a person skilled in the art in the light of the teachings of documents E1, E2 and E3.

(v) The Respondent argued essentially as follows:

None of the documents cited by the Appellant disclosed or suggested the essential feature of the invention that, in order to avoid linear center segregation, substantially no reduction in thickness should be applied in the final solidification region as defined in feature (b) of Claim 1 of the patent in suit.

In the light of the description the person skilled in the art obtained sufficient information to establish "the particular fraction of solid at the limit of fluidity" mentioned in Claim 1 of the patent in suit and was thus able to determine the final solidification region wherein no thickness reduction should be carried out.

Although Claim 1 according to the granted patent was considered to be sufficiently clear with respect to the term "the particular fraction of solid at the limit of fluidity", an amended Claim 1 according to auxiliary request 1 was presented which contained a numerical value for the particular fraction of solid at the limit of fluidity.

The auxiliary requests 2 to 5 contained further restrictions with respect to the thickness reduction range, for which restrictions no suggestions in the state of the art could be found.

Reasons for the Decision

1. *Main request*

Document E1 (cf. Claim 1, Fig. 8 and col. 4, line 59 to col. 5, line 11) discloses a method for continuous casting of molten metal by continuously withdrawing a strand and by slight reduction of the thickness of the strand at the final semi-solidified region. The reduction of the cross-section is less than 1.5% for each pair of reducing rolls between a solidification stage, where the center of the strand has a temperature corresponding to the liquidus line (fraction of solid in the center $f_s = 0$), and a solidification stage where the center of the stand has a temperature corresponding to the solidus line (fraction of solid in the center $f_s = 1$).

In the method of document E1 the thickness reduction of the strand is continuously carried out starting from a solidification stage when the center of the strand has a temperature corresponding to a fraction of solid of $f_s = 0$ to a solidification stage when the center of the strand has a temperature corresponding to a fraction of solid of $f_s = 1.0$.

Therefore, also in the method according to document E1 a thickness reduction in an intermediate solidification region (I-2) as defined in feature (a) of Claim 1 of the patent in suit is carried out. The indication of a lower limit of a fraction of solid of 0.1 to 0.3 in feature (a) of Claim 1 does not establish a difference with respect to the method of document E1, since feature (a) does not specify that no reduction in thickness should be applied to the strand in the semi-solidified region upstream of the region (I-2).

As to feature (b) of Claim 1 of the patent in suit, which requires that substantially no reduction in thickness is applied to the strand in the final solidification region between the solidification stage when the center of the strand has a temperature corresponding to said fraction of solid at the limit of fluidity and the solidification stage when said temperature reaches the solidus temperature, the following stated:

On page 3, line 34 of the patent in suit it is mentioned that the term "at the limit of fluidity" means the state of the melt near or just above the solidus line. This vague and indefinite interpretation of the term "at the limit of the fluidity" covers, for example, also a value of $f_s = 0.99$.

The Board cannot follow the contention of the Respondent that the term "at the limit of fluidity" is clearly defined in the patent as the range of $f_s = 0.6$ to 0.9 , since this range is specifically claimed in Claim 2 and is qualified on page 3, line 31 as a preferred range ("in particular").

Assuming that in practice the crater end position can be controlled only with an accuracy of about 0.3 m, as the Respondent himself convincingly submits in his letter of 27 March 1995, such a value of $f_s = 0.99$ clearly would lie within the range of practical control accuracy of the method of document E1 which aims at stopping the thickness reduction at a solidification stage of $f_s = 1.0$.

Therefore, in practice, the feature (b) of Claim 1 of the patent in suit cannot establish a difference with respect to the method of document E1.

In the example given in column 5, line 26 to column 6, line 12 of document of E1 a reduction rate of 0.5 to 4 mm per one roll pair is recommended, when the withdrawing speed is 1 m/min. Based on a set up length of the reduction rolls of 11.6 m (see col. 5, lines 19 and 20) and a number of reduction rolls of 12 (see Fig. 9), a preferable range of 0.5 to 4 mm/min can be calculated for the reduction rate.

Consequently, the method of Claim 1 of the contested patent differs from the method known from document E1 in that the upper limit of the thickness reduction rate should be 2.5 mm/min.

This difference, although it renders the method of Claim 1 novel, is obvious to the person skilled in the art for the following reasons:

Following the teaching of document E1, the person skilled in the art, which carries out thickness reduction tests within the recommended range of 0.5 to 4 mm/min in order to optimise this known process with respect to the problem minimising the undesirable center segregation will find out that the optimum thickness reduction rate has to be lower than 2.5 mm/min.

The person skilled in the art is even guided by the teaching of document E2 towards the lower range of thickness reduction of 0.5 to 2.5 mm/min, since from this document (cf. page 71, Fig. 9 and left hand column, lines 13 and 14) an optimum range for the thickness reduction between 0.5 and 2.0 mm/min can be derived.

Thus, the person skilled in the art, without doing an inventive step, arrives at the process according to Claim 1 of the patent in suit.

Since Claim 1 of the patent in suit is not allowable for the reason of lack of inventive step, the main request of the Respondent as a whole is not allowable.

2. Auxiliary request 1

2.1 Amendments

Claim 1 according to auxiliary request 1 differs from Claim 1 according to the main request in that the "particular fraction of solid at the limit of fluidity" is specified as being "within the range of 0.6 to 0.9".

This specification is based on the originally filed Claim 2 and restricts the scope of the granted Claim 1.

Claim 2 of the auxiliary request 1 has only been amended in the sense that the term "preferably within the range of 0.6 to 0.9" has been deleted.

Therefore, the amended claims according to the auxiliary request 1 are not objectionable under Article 123(2) and (3) EPC.

2.2 Novelty

The method according to Claim 1 of the auxiliary request 1 is new with respect to the state of the art under consideration, since none of the documents E1, E2 or E3 discloses a method for continuous casting of molten metal by continuously withdrawing a strand and by reduction of the thickness of the strand in the semi-solidified region wherein substantially no

reduction in thickness is applied to the strand in the final solidification region between the solidification stage when the center of the strand has a temperature corresponding to a fraction of solid at the limit of fluidity within the range of 0.6 to 0.9 and the solidification stage when said temperature reaches the solidus temperature.

The Appellant contended that in practice, the limit of thickness reduction could not be held exactly at a value of 0.9, and therefore, it was not possible to exclude a thickness reduction within the solidification region between a f_s -value between 0.9 and 1.0, and thus novelty could not be based on this feature.

However, the Appellant did not substantiate this contention and was not able to refute the submissions of the Respondent in his letter of 27 March 1995, wherein the Respondent presented convincing arguments and calculations that it was possible without any problem to set and hold the end position of the thickness reduction at a f_s -value of 0.9.

2.3 Inventive step

2.3.1 Closest prior art

The closest prior art is represented by document E1 which discloses a method for continuous casting of molten metal by continuously withdrawing a strand and by reduction of the thickness of the strand in the semi-solidified region, wherein the thickness of the strand is continuously reduced at a rate of 0.5 to 4 mm/min during casting in the semi-solidified stage when the center of the strand has a temperature corresponding to a fraction of solids $f_s = 0$ (liquidus

line) and the solidification stage when the said temperature reaches a level corresponding to a fraction of solid of $f_s = 1.0$ (solidus line) (see point 1 above).

2.3.2 Problem

The Respondent has found that undesirable linear center segregation develops when the strand is subjected to reduction in thickness at the final stage of solidification (see page 2, line 65 to page 3, line 1 and page 4, lines 48 to 50 of the patent in suit).

Since, according to document E1, the strand is subjected to a reduction of thickness until it is fully solidified, this known method suffers from the drawback of producing linear center segregation.

Therefore, the problem to be solved with respect to the closest prior art consists in providing a method by which a strand having no linear center segregation is produced.

2.3.3 Solution

This problem is solved by the feature (b) of the method according to Claim 1 of the auxiliary request 1, namely in that substantially no reduction in thickness is applied to the strand in the final solidification region between the solidification stage when the center of the strand has a temperature corresponding to a fraction of solid at the limit of fluidity within the range of 0.6 to 0.9 and the solidification stage when said temperature reaches the solidus temperature.

This feature has the effect that the linear form of center segregation is prevented which is deleterious to the product quality (see page 4, lines 48 to 52 and comparative Examples H of Table 2 and L of Table 4 of the patent in suit).

2.3.4 This solution is not rendered obvious by the state of the art referred to by the Appellant, for the following reasons:

2.3.4.1 Document E1 (cf. Fig. 8, col. 1, lines 6 and 7 and the claim) teaches that the strand should be reduced in thickness in the final solidification region at the portion between the liquidus and solidus line, in order to eliminate center segregation and center porosity. In particular, Figure 8 shows (see the expression "distance to be reduced") that the thickness reduction should be carried out in the whole region between the liquidus tip and the solidus point at the center of the strand, including the solidus point where the strand is fully solidified.

No hint can be derived from document E1 that the linear center segregation can be prevented, if substantially no reduction in thickness is applied to the strand in the final solidification region upstream of the solidification stage where the strand is fully solidified.

2.3.4.2 The Appellant refers to the passage bridging pages 69 and 70 of document E2, wherein it is mentioned that "the soft-reduction is carried out to the preset value before completion of the solidification" and that "it is unnecessary to carry on the reduction still after completion of solidification". He submits that this

passage leads the person skilled in the art to the measure of not carrying out a thickness reduction in a region upstream of the solidus point.

The Board cannot agree with this submission. The said passage refers to Figure 8 of document E2 demonstrating that a roll gap deviation from the preset value appears after completion of solidification (downstream of the crater end). There is nothing in the said passage which could teach the person skilled in the art to avoid a thickness reduction in a certain solidification region upstream of the crater end, in order to prevent linear center segregation.

2.3.4.3 Document E3 teaches that a very low thickness reduction of between 0.1 to 2.0% should be applied to the strand in the region of the tip of the liquid crater in order to prevent center segregations.

However, there can be found no hint in document E3 that linear center segregation could be prevented, if substantially no reduction in thickness is applied to the strand at a certain solidification region upstream of the tip of the liquid crater.

2.3.5 For these reasons, the method of Claim 1 according to auxiliary request 1 is not obvious to a person skilled in the art having regard to the state of the art referred to by the Appellant, and therefore this method also involves an inventive step in the meaning of Article 56 EPC.

The same applies to the particular embodiments of the method of Claim 1 according to the dependent Claims 2 to 6 of the auxiliary request 1.

3. In conclusion, the patent can be maintained in amended form according to the auxiliary request 1 of the Respondent.

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 on the basis of the following documents:

Description: pages 2 to 15 of the patent as granted.

Claims: 1 to 6 according to the auxiliary request 1, presented during the oral proceedings of 27 April 1995.

Drawings: Figures 1 to 4 of the patent as granted.

The Registrar:


A. Townsend

The Chairman:


G. Gall