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D E C I S I O N
of 4 October 2001

Case Number: T 0549/98 - 3.2.2

Application Number: 91900936.5

Publication Number: 0458987

IPC: C21D 8/02

Language of the proceedings: EN

Title of invention:
Process for producing thin austenitic stainless steel plate and equipment therefor

Patentee:
NIPPON STEEL CORPORATION

Opponent:
USINOR

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (yes)"

Decisions cited:
-

Catchword:

Case Number: T 0549/98 - 3.2.2

D E C I S I O N
of the Technical Board of Appeal 3.2.2
of 4 October 2001

Appellant: (Opponent)
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Decision under appeal: **Interlocutory decision of the Opposition Division of the European Patent Office posted 23 March 1998 concerning maintenance of European patent No. 0 458 987 in amended form.**

Composition of the Board:

Chairman: W. D. Weiß
Members: M. G. Noël
J. C. M. De Preter

Summary of Facts and Submissions

I. The appellant (opponent) lodged an appeal against the interlocutory decision of the Opposition Division stipulating the amended form in which the European patent No. 0 458 987 could be maintained.

One opposition had been filed against the patent in its entirety and based on the ground according to Article 100(a) EPC that the subject-matter of the patent lacked an inventive step.

The Opposition Division held that the subject-matter of the amended independent claims 1 and 4 according to the main request, submitted at the oral proceedings before the Opposition Division, involved an inventive step with respect to the documents

D1: JP-A-63115654 (Patent Abstracts of Japan, in English)

D1': Translation of the Original of D1 into English submitted on 5 February 1998 by the appellant

D2: US-A-2 851 384

D3: EP-A-0 309 247

D4: J. Bénard et al.: Métallurgie Générale ed. Masson 1984, pp. 297-298

D5: Pat. Abtracts of Japan of JP-A-138013.

D4 was even not considered by the Opposition Division because it was cited too late and regarded as less relevant.

With its grounds for appeal, the appellant cited for the first time document

D6: "The Making, Shaping and Treating of Steel", 9th edition 1971, United States Steel, pages 1179 and 1180.

II. At the oral proceedings before the Board, which took place on 4 October 2001, the following final requests were submitted:

The appellant requested that the decision under appeal be set aside and that the patent be revoked in its entirety.

The respondent requested that the appeal be dismissed.

III. The independent Claims 1 and 4 in the version underlying the decision under appeal read as follows:

"1. A method of manufacturing an austenitic steel sheet comprising:

(a) a casting process of casting a molten austenitic (γ) stainless steel into a thin cast plate by a twin-roll thin plate casting method employing a pair of cooled rolls;

(b) a cooling process of cooling the thin cast plate in a single-phase state of the γ phase;

(c) a heat-treating process of heating and holding the thin cast plate in a dual phase state of the δ and γ phase or a single phase state of the δ phase and then cooling the thin cast plate to restore the single phase state of the γ phase; and

(d) a cold rolling process of cold-rolling the thus heat-treated thin cast plate.

4. An austenitic stainless steel sheet manufacturing system comprising:

(a) a twin-roll casting machine for casting a molten (γ) stainless steel, provided with a pair of cooled rolls disposed opposite to each other; at least one set of

(b) a heating unit for heating a thin cast plate cast by the twin-roll casting machine at a temperature in the range of 1200°C to 1450°C, and

(c) a cooling unit for cooling the thin cast plate heated by the heating unit to a temperature not higher than 1200°C with (b) ant (c) alternating;

(d) a plastic working unit for the plastic working of the thin cast plate before heating the thin cast plate by the heating unit and

(e) a cold rolling unit after the said set(s)."

V. The appellant argued as follows:

The appellant concurred with the opposition Division to rank document D3 as the closest prior art which disclosed the steps (a), (b) and (d) of the claimed invention. Starting from this closest prior art the technical problem to be solved by the patent in suit consisted in providing an austenitic steel sheet having insignificant minute surface concavities and convexities, insignificant roping or ridging and a negligible uneven surface gloss, which problem was solved by the application of the claimed step (c).

It had been known to the practitioner that ridging was a phenomenon promoted by preferred orientation of the recrystallized grains and diminished by randomising the orientations of the grains (see e.g. document D2, col. 3, lines 31 to 44). Such a fine grained randomized structure was, according to document D2, achieved by a, preferably repeated, heat treatment which involved a phase transformation. In the case of the ferritic stainless steels treated according to document D2 the (α)-(γ)-transformation was used for this purpose. Contrary to the finding of the Opposition Division in the decision under appeal (see the paragraph bridging the pages 8 and 9), this grain refining effect of the phase transformation was known as a principle to the skilled practitioner (see document D6 and D4) and was independent of the particular (α)-(γ)-transformation and of further alloying measures described in document D2.

According to document D1, the same principle was applied in a method to reduce the grain size of a continuously cast thin plate of plain carbon steel. Here, like in the patent in suit, the steel was directly cast to a thin plate which needed not be hot rolled before cold rolling. This economic advantage entailed the drawback that the coarse as cast structure was no longer crushed by hot-rolling before the cold rolling step and, therefore other measures had to be found for its refining. Since it had been known that certain austenitic stainless steels were prone to the formation of a (δ)-phase (see Figure 14 of the patent in suit), it was obvious to apply the known principle of grain refining by phase transformation also to continuously cast thin plates of this type of steel.

V. The respondent argued as follows:

Document D3, being the only document concerned with continuous twin roll casting of austenitic steel, had to be considered as the closest prior art. It gave, however, no indication at all that a treatment of the cast plate according to the heating/cooling regime specified in the independent claims would serve a useful purpose whatsoever. On the contrary, this document (see page 6, lines 43 to 51) regarded as the transformation which occurs in austenitic stainless steels of the standard type JIS SUS 304 during solidification as harmful, because δ-to-γ-transformation causes a cyclic small wave of the solidified shell from which cracking, including small scale cracking originated. Document D3 itself, therefore taught away from any use of this transformation. Document D6 did not alter this situation, it even reinforced the irrelevance of document D2.

Document D1 concerned a simple carbon steel and the phase change heating/cooling treatment described therein had the sole object of improving the mechanical properties of the cast strip. There was no prior suggestion that the austenitic steel treated according to the patent in suit needed any improvement in the mechanical properties, its only aim being the improvement of the surface properties.

Document D4 was too general and had no relevance to a continuously cast thin plate of austenitic stainless steel.

Reasons for the decision

1. Formal aspects have not been raised nor has novelty of the claimed subject-matter been challenged by the appellant and the Board sees no cause to revisit these issues of its own motion.

2. *Inventive step*

2.1 Independent Claim 1

2.1.1 The Board concurs with both parties and the Opposition Division that, of all the documents cited, Document D3 is the closest prior art with respect to the method according to Claim 1.

This document discloses a method of manufacturing an austenitic stainless steel sheet according to which a molten austenitic (γ) stainless steel (e.g. of the US standard type 304) is cast into a thin cast plate by a twin-roll thin plate casting method employing a pair of cooled rolls.

According to the description of the patent in suit (see EP-B-0 458 987, page 3, lines 13 to 40), this continuous casting method permits casting plates of a thickness in the range of 0.5 to 10 mm which may be directly cold-rolled to the desired final thickness. The plates cast according to this known method have, however, a coarse crystal grain structure, which, after cold rolling and final annealing causes surface irregularities like concavities and convexities, roping and uneven gloss. These surface irregularities could hitherto only be avoided either by hot-rolling the plate before cold-rolling or applying a considerably high draft during the cold-rolling process, which measure prolonged the processing time and increased the costs of the sheets.

Consequently, the problem underlying the patent in suit is to provide an economic method of manufacturing an austenitic stainless steel sheet having insignificant minute surface concavities and convexities, insignificant roping, and negligible uneven gloss (see EP-B-0 458 987, page 3, lines 44 to 46). Since it had been known that the coarse grain structure of the cast plate was the cause for the surface irregularities, the person skilled in the art knew that this phenomenological problem implied the technical problem of providing an economic method of refining the grain structure of the cast plate of austenitic stainless steel.

2.1.2 The Board concurs with the appellant that it belongs to the basic knowledge of any metallurgist that allotropic transformations existing in a metal or alloy can be used to refine its crystal structure and to suppress anisotropies of the crystallization (see e.g. the general textbook D4). The allotropic transformation from the body-centered cubic (α)-phase to the face-centered cubic (γ)-phase which occurs in certain steels has been used to put this general principle into practice (see documents D1′ and D2). Document D4 (see page 298, second paragraph) also cites only the (α)-(γ)-transformation in steels as a practical application of this general principle.

Dokument D1′ even aims at solving the same problem as the patent in suit, namely to refine the grain structure of a thin (0.8 to 10 mm) plate which has been produced employing a twin-roll casting machine, the only difference being that the steel is a plain carbon steel (see D1′, page 4, penultimate paragraph; page 8, lines 8 to 15 from the bottom). To solve this problem the steel plate which has been cooled to a temperature in the range of 650 to 700°C is heated to a temperature in the range of 900 to 950°C (see D1', page 8, second paragraph; page 4, penultimate paragraph, to page 5, fifth paragraph) i.e. 20 to 50°C higher than the (α-γ)-transformation temperature and then cooled again to a temperature well below the transformation temperature (see page 7, second paragraph). This cycling treatment is preferably repeated several times. The skilled practitioner will appreciate that plain carbon steel suffers a complete phase transformation in each of the said heating/cooling steps.

According to document D2, the said principle is applied to a ferritic stainless steel which has a chromium content of about 17%. This steel, when heated above a critical temperature of about 870°C, does not undergo a complete phase transformation into austenite but only has a certain potential to form austenite which is expressed as a percentage of the total grain structure. The problem with this conventionally cast and then hot-rolled steel is that the hot-rolled structure is such that it promotes a preferred orientation in final cold-rolled and recrystallized sheet which is the cause of the phenomenon of ridging or roping when the final sheet is drawn (see D2, column 1, penultimate paragraph; column 3, lines 31 to 36). For the said ferritic steel the problem of ridging is solved by two combined measures:

(i) The austenite forming potential is increased to a value in excess of 35% by compositional measures, and

(ii) the steel is cycled through the critical transformation temperature at least once before the final cold-rolling step (see D2, e.g. the claims).

Consequently, the Board concurs with the appellant also insofar that the generally known principle of grain refining by cycling through an allotropic phase transformation temperature had been practised with steels which are able to at least partly transform from an (α)- to a (γ)-structure at temperatures far below 1000°C.

2.1.3 At the priority date of the patent in suit, the phase diagram according to Figure 14 of the patent in suit belonged to the state of the art (see EP-B-0 458 987, page 4, lines 44 to 46). Moreover the skilled person knew from document D3 (see page 6, lines 43 to 44): "This embodiment is particularly effective for preventing cracking, including small scale cracking, typically of strips or steels in which a transformation occurs during solidification, such as JIS SUS 304 stainless steel."

Following the consideration in the preceding paragraphs the decisive question to be answered is, therefore, whether this knowledge of the (δ)-phase and its transformation into the austenitic (γ)-phase qualified this allotropic transformation as an promising candidate for the application of the generally known grain refining principle set out in paragraph 2.1.2 above.

2.1.4 The allotropic (α)-(γ)-transformation which, according to documents D1' and D2, has been practically used for grain-refining purposes occurs in a large compositional variety of steels starting from plain carbon steels (see D1') up to highly chromium alloyed ferritic stainless steels (see D2). The transformation temperature, in all these cases is below 900°C, i.e. far from the melting temperature of above 1400°C. Consequently, there is a large temperature range in the solid state above the transformation temperature to be used by an annealing treatment to exhaust the austenite forming potential of the respective steel and to form as much austenite-phase as possible, because, as document D2 proves, the grain-refining effect is expected to increase with the quantity of the high-temperature phase formed.

The (δ)-phase in austenitic steels, according to Figure 14 of the patent in suit, forms in a rather narrow compositional range of from about 9% to about 12% Nickel in a temperature range adjacent to the melting temperature. The Nickel content of US standard alloy of the type 304, which is treated according to the patent in suit (see page 4, lines 7 to 8) as well as according to D3 (see page 6, line 44), may vary between 9 to 11%. Even in this narrow compositional range, the austenite forming potential of the alloy at a predetermined temperature between the states Z and Y in Figure 14 of the patent in suit may vary from a pure austenitic state to mixed (δ)-(γ)-state. Therefore, a high austenite forming potential can, even in 304 type steels, only be expected according to the phase diagram when the slab is reheated to a temperature close to the melting temperature.

There are two reasons, however, that strongly dissuade a person skilled in the art from annealing a thin slab at a temperature so close to the melting temperature:

(i) There is a danger of at least partial reliquefaction and disintegration of the slab; and

(ii) the (δ)-phase forming during the solidification has been suspected to cause transformation stress in the steel resulting in cracking (see document D3, page 6, lines 43 to 48).

For all these reasons before the priority date of the patent in suit, the (γ)-(δ)-transformation occurring in some austenitic steels did not qualify as an allotropic transformation suitable for refining the grain-structure in as-cast thin slabs.

The patent in suit nevertheless suggests to anneal in close proximity of the melting point (see Table 1 of the patent in suit).

The subject-matter of Claim 1, therefore, involves an inventive step.

2.2 Independent Claim 4

The Board concurs with the decision under appeal that document D1' constitutes the closest prior art with respect to Claim 4.

The subject-matter of Claim 4 differs from the system disclosed in D1' not only by the plastic working unit before the heating unit and by a cold rolling unit (after coiling) as stated in the decision under appeal, but also in that the heating unit(s) and the cooling unit(s) are adapted to operate at the temperatures indicated in Claim 4 which make the system fitted for carrying out the method according to Claim 1 and which temperatures are considerably higher than the temperatures to which the known device is adapted to operate.

Consequently, the subject-matter of Claim 4 equally involves an inventive step.

3. Since the dependent claims and the description are also not subject to any objection, the patent as amended meets the requirements of the EPC.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

V. Commare W. D. Weiß