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D E C I S I O N
of 22 February 2002

Case Number: T 0741/98 - 3.2.2

Application Number: 90107030.0

Publication Number: 0392535

IPC: C21D 8/12

Language of the proceedings: EN

Title of invention:

Process for preparation of grain-oriented electrical steel sheet having superior magnetic properties

Patentee:

NIPPON STEEL CORPORATION

Opponent:

USINOR SACILOR S.A.

Headword:

-

Relevant legal provisions:

EPC Art. 52(1), 54, 56

Keyword:

"Novelty (yes)"
"Inventive step (yes)"

Decisions cited:

-

Catchword:

-



Case Number: T 0741/98 - 3.2.2

D E C I S I O N
of the Technical Board of Appeal 3.2.2
of 22 February 2002

Appellant:
(Proprietor of the patent)

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Respondent:
(Opponent)

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Decision under appeal:

Decision of the Opposition Division of the
European Patent Office posted 18 May 1998
revoking European patent No. 0 392 535 pursuant
to Article 102(1) EPC.

Composition of the Board:

Chairman: W. D. Weiß
Members: S. S. Chowdhury
J. C. M. De Preter

Summary of Facts and Submissions

- I. The appellant (patent proprietor: Nippon Steel Corporation) lodged an appeal against the decision of the opposition division to revoke European patent No. 0 392 535. The decision was dispatched on 18 May 1998.

The appeal and the fee for the appeal were received on 23 July 1998. The statement setting out the grounds of appeal were received on 24 September 1998.

The opposition was filed against the whole patent and was based on Article 100(a) EPC (lack of novelty and inventive step) and on Article 100(b) EPC, that the patent specification did not disclose the invention sufficiently clear and complete for it to be carried out by a person skilled in the art.

The opposition division had found that the requirement of sufficient disclosure was met satisfactorily and that the claimed subject-matter was novel, but that, starting from the document D1 (FR-A-2 419 328) as the closest prior art document, the subject-matter of none of the claims involved an inventive step.

The following additional documents are cited in the appeal procedure:

D5: US-A-3 895 974

D7: US-A-3 671 337

D10: "The dissolution and precipitation behaviour of AlN and MnS in grain-oriented 3% silicon-steel with high permeability", Journal of Magnetism and Magnetic Materials, 19, (1980) pages 15-17.

II. Requests

At the end of oral proceedings held on 22 February 2002 the appellant requested that the decision under appeal be set aside and that the patent be maintained on the basis of the following documents (main request):

- Claims 1 and 2 as submitted at the oral proceedings
- Description pages 4 and 9 as submitted at the oral proceedings
- pages 2, 3, 5 to 8, and 10 to 21 as granted
- Figures as granted,

or alternatively on the basis of the auxiliary request submitted by letter of 24 September 1998.

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

III. Claim 1 of the main request reads as follows:

"A process for the production of a grain-oriented electrical steel sheet, which comprises heating at a temperature lower than 1280°C a slab comprising 0.021 to 0.075% by weight of C, 2.5 to 4.5% by weight of Si, 0.010 to 0.060% by weight of acid-soluble Al, 0.0030 to 0.0130% by weight of N, up to 0.014% by weight of (S + 0.405Se) and 0.05 to 0.8% by weight of Mn, with the balance consisting of Fe and unavoidable impurities, hot-rolling the slab and winding the hot-rolled sheet, subsequently annealing the hot-rolled sheet according to need, subjecting the hot-rolled steel sheet to at least one cold rolling including final cold rolling at reduction ratio of at least 80% and, if necessary, intermediate annealing, and

subjecting the cold-rolled sheet to decarburization annealing and final finish annealing, wherein the hot rolling-finish temperature is adjusted at 750 to 1150°C, the cumulative reduction ratio at a final three passes of the hot rolling is adjusted to at least 40%, and the hot-rolled sheet is maintained at a temperature not lower than 700°C for at least 1 second after termination of the hot rolling and the winding temperature is maintained at a level lower than 700°C."

Dependent claim 2 specifies that the reduction ratio at the final pass of the finish hot rolling is at least 20%.

IV. The appellant presented the following arguments:

The slab of the patent in suit, which slab was heated to a temperature below 1280°C, could not be equated with the bar of document D1 since this document stated that the slab from which the bar was made was heated to a temperature of 1400°C. However, the decisive point of the claimed invention was not only the use of a slab heating temperature lower than 1280°C, but the use of AlN as the main inhibitor for obtaining good magnetic properties, and it was the combination of the features of claim 1, particularly the finishing hot-rolling conditions, that produced the required good magnetic properties.

Document D1 did not represent the closest prior art but was, in fact, quite remote prior art since it employed a high slab heating temperature. Document D5 was also remote since it related to a very low C steel and also disclosed different hot rolling conditions and S content. This also applied to document D7, whose problem was to match the Mn and S contents so that MnS and AlN could be used in combination as inhibitors.

The step of maintaining the hot-rolled sheet at a temperature not lower than 700°C for at least 1 second after termination of the hot rolling was significant and not automatically realised in an industrial process, as argued by the respondent, since it was normal practice that after hot rolling the steel was sprayed immediately with cold water.

V. The respondent presented the following arguments:

According to the description the term "slab" did not cover a cast steel product but identified an intermediate product obtained after rough rolling, and the temperature at which the slab was heated before the rough rolling was of no importance. The only explanation in the entire patent of what was meant by a slab was given on page 9, lines 32 and 33, and this slab had a thickness of 100 mm to 400 mm before being heated, rough rolled, and finish rolled. All the Examples given started with a slab 26 to 40 mm thick, and this was heated to a temperature of below 1280°C before the step of finishing rolling.

Therefore, a slab within the meaning of the patent in suit meant a bar, slab, etc heated to a given temperature just before the finishing rolling step, and consequently the opposition division was correct in stating that in document D1 the bar in example 1, that was heated to 1250°C, was equivalent to the slab of the patent in suit, which was heated to a temperature of below 1280°C.

The slab heating temperature was strongly dependent on the slab thickness since a lower thickness of slab would require a lower surface temperature to achieve the same effect at the centre of the slab that a given temperature achieved in a thicker slab. In the case of document D1 a slab heating temperature of 1400°C was

necessary since the slab thereof was 200 mm thick, but the slabs of the patent in suit, with a thickness of only 20-60 mm, did not need to be heated to such a high temperature, as was the case with the slab of document D7.

Document D1 related to the same problem as the patent in suit, which was to use a low slab heating temperature for the sake of economy. This document showed that slab heating temperatures below 1280°C were normal in the art, and it also disclosed the steel composition as in claim 1 of the patent in suit, and the finishing rolling conditions, either explicitly or implicitly, and it anticipated the process of claim 1.

AlN and MnS were present simultaneously as residual constituents in steels of the type under discussion, and both were normal inhibitors used in the art, as shown by document D7. This document disclosed that MnS was an effective inhibitor despite a low S content comparable with that of the patent in suit. For the amounts of Mn and S used and the process steps disclosed in documents D1 and D5, documents D7 and D10 indicated that temperatures significantly below 1300°C were required for the complete dissolution of MnS.

Document D5 also disclosed all the features of the process of claim 1 including the steel composition, the finishing rolling conditions, and the steps of maintaining the hot-rolled sheet at a temperature not lower than 700°C for at least 1 second after termination of the hot rolling and the winding temperature at a level lower than 700°C. The process here was similar to that of document D1 and the slab heating temperature was correspondingly low.

Documents D1 and D5 related to the same type of steel so that they could be easily combined to lead to the process of claim 1 in an obvious manner. These documents could also be combined with document D7, so that if the process of claim 1 was considered novel, then it would lack inventive step in view of these combinations.

Reasons for the Decision

1. The appeal is admissible.

Main request

2. *Amendments*

- 2.1 Claim 1 differs from claim 1 as granted by the following features:

- (i) The words "and winding the hot-rolled sheet" have been added after "hot-rolling the slab".
- (ii) In the penultimate line of the claim the lower limit of the temperature range has been changed from 700°C to 750°C.
- (iii) In the last line of the claim the steps "and the hot-rolled sheet is maintained at a temperature not lower than 700°C for at least 1 second after termination of the hot rolling and the winding temperature is maintained at a level lower than 700°C" have been added.

2.2 All these amendments are allowable under Article 123(2) and (3) EPC since they are supported by the original disclosure and narrow the scope of protection. It is also observed that the respondent had no formal objections against the amendments.

3. *The claimed invention*

The patent in suit relates to a grain-oriented electrical steel sheet for use as a core material for electrical devices such as a transformer. This grain-oriented electrical steel sheet should have superior magnetic properties such as exciting characteristics and core loss characteristics, which are achieved by developing a Goss structure during the final annealing step. By means of such a Goss texture, in which a {110} plane is formed on the surface of the steel sheet and a $\langle 001 \rangle$ axis is produced in the rolling direction, the steel sheet has a good magnetic flux density and core loss value when magnetised in the rolling direction. The patent strives to attain a magnetic flux density $B_0 \geq 1.90T$.

The steel comprises Si, and also MnS and/or AlN as inhibitor of normal grain growth, which is distributed so as to inhibit the growth of unfavourably oriented grains and enable only the Goss grains to grow during the secondary recrystallisation. In order to be able to perform this function the inhibitor must be finely precipitated during the hot rolling process, and be present at the grain boundaries during the final annealing step.

Although a slab heating temperature of lower than $1280^\circ C$ is used the inhibitor is precipitated in a suitable form in that AlN is used as the main inhibitor and in that the S content is kept low enough to prevent

MnS precipitates adopting an unfavourable configuration (page 2, lines 35 to 41).

The finish hot rolling which takes place after rough rolling and before the annealing and cold rolling steps is optimised to increase the number of sites for the formation of nuclei at the recrystallisation subsequent to the final pass so that the crystal grains are made finer and the result is an enhanced matrix of $\{110\}\langle 001\rangle$ recrystallised grains. Together with the finishing rolling wherein the cumulative reduction ratio at the final three passes of the hot rolling is adjusted to at least 40% and the hot rolling-finish temperature is adjusted at 750 to 1150°C, the subsequent steps of cold rolling including final cold rolling at reduction ratio of at least 80%, and maintaining the hot-rolled sheet at a temperature not lower than 700°C for at least 1 second after termination of the hot rolling and maintaining the winding temperature at a level lower than 700°C, are important for obtaining the right inhibitor precipitates and for finally attaining a magnetic flux density $B_0 \geq 1.90T$.

4. *Meaning of the term "Slab"*

The patent in suit relates to a process for the production of a grain-oriented electrical steel sheet, which is an industrial process of which the starting product is a slab which is a semi-finished product that may be produced from a cast ingot or directly cast by continuous casting. According to page 9, lines 32 and 33 of the patent a slab has a thickness of 100 mm to 400 mm before being heated, rough rolled, and finish rolled, which, as the respondent agrees, is the normal thickness for such slabs.

The professionally accepted meaning of the term "slab" is not otherwise qualified by the subsequent two sentences of the paragraph which state that "The rough rolling method is not particularly critical and can be performed according to customary procedures. The present invention is characterized by the finish rolling conducted after the rough rolling". When these two sentences are read, not in isolation but in the context of the whole paragraph (page 9, lines 32 to 48), it is unambiguously clear that this statement refers to the rolling and finishing phases of the hot rolling step and not to the slab heating treatment to be performed before the hot rolling step.

This interpretation is also not inconsistent with the Examples given in the patent specification, which use as the starting product a "slab" having a thickness of 26 or 40 mm thick immediately before the hot rolling steps, because these Examples obviously report the results of experiments carried out on laboratory samples, and these experiments were shortened by simply omitting the non-critical step of rough rolling. In an industrial process, however, this step would be included as defined in claim 1, but carried out conventionally. That the patent describes laboratory tests rather than an actual industrial process is supported by, for example, the step of only simulating the winding step rather than actually winding the hot-rolled sheet (page 10, lines 48 to 50), the former being possible in laboratory conditions.

What the claims of the patent in suit cover, then, is an industrial process in which a steel slab of thickness of the order of 100 mm is used as the starting product and heated to a temperature lower than 1280°C.

In contrast thereto, in document D1 a temperature of 1400°C is used as the heating temperature for a slab of 200 mm thickness, whereas the temperature of the bar after four rolling passes was 1250°C. This bar is an intermediate product, and not the initial slab that was heated (up) to 1400°C. Nor was this bar heated at (the preposition used in claim 1 of the patent in suit) the temperature of 1250°C, it attained this temperature by the cooling down of the initially heated slab from 1400°C. Therefore, it is not correct to equate this bar with the of slab claim 1.

5. *Novelty*

In view of the foregoing the process of claim 1 differs from the process disclosed in document D1 by the features that the slab heating temperature is lower than 1280°C, whereas that in document D1 is at least 1300°C (page 6, lines 9 and 10). Moreover, this document is silent about the amounts of N, S or Se, and Mn specified in claim 1, nor does this document disclose the steps of maintaining the hot-rolled sheet at a temperature not lower than 700°C for at least 1 second after termination of the hot rolling and maintaining the winding temperature at a level lower than 700°C.

Regarding the time and temperatures, the respondent's argument, that document D1 implicitly discloses these, is not accepted. The appellant has stated that after hot rolling the steel sheet is typically immediately cooled on a run-out table by spraying water and then wound into a coil, whereas in the patent in suit the sheets are maintained at a high temperature for up to 30 seconds (page 7, lines 44 to 47) in a heated chamber. While Table 3 of document D5 does indeed disclose the last two steps of claim 1, these are not

necessarily typical conditions in the art, and not necessarily present in the process described in document D1.

What document D1 in fact describes is that, instead of being wound into a coil after the hot rolling step the steel sheet is continuously annealed (see example 1), in which case the annealing plant would be positioned directly adjacent the finish hot rolling stage. There is not clearly any inherency in there being a delay of less than one second between the annealing plant and the finish hot rolling stage as the respondent argues since this is a different sequence of steps to that disclosed in document D5.

Document D5 does not disclose the slab heating temperature, the S content, or that the hot rolling-finish temperature is adjusted at 750 to 1150°C and the cumulative reduction ratio at the final three passes of the hot rolling is adjusted to at least 40%. With respect to the last of these features the respondent has cited page 3, lines 42 and 43 and example 1 on page 5, but these do not disclose a cumulative reduction ratio at the final three passes of the hot rolling of at least 40%, the parameters of the final three passes of the finishing rolling steps being critical to the claimed invention, as discussed above.

The process of claim 1 is novel, accordingly.

6. *Inventive step*

- 6.1 The respondent suggests that the process of claim 1 is obvious in view of the fact that the person skilled in the art could combine the disclosures of documents D1 and D5, or the disclosures of documents D1 and D7 and

arrive at the process of claim 1 in an obvious manner. The Board does not concur with this suggestion for the following reasons:

All the process steps and parameters of claim 1 of the patent in suit, together with the composition of the steel, act together to achieve the desired result as set out in point 3 above, there being a fine interplay between the process and composition parameters. This is demonstrated by the numerous Examples given in the patent in suit, according to which if a single one of the process steps does not accord with claim 1, then the magnetic flux density B_0 does not attain the value 1.90T. These results are summarised in Tables 5 to 9 and Figures 1 and 6.

It is not permissible to mosaic the various process steps and parameters, each from its particular context in a different document, so as to synthesise the process of claim 1 without good grounds, which the respondent has not provided. It is for this reason that the respondent has argued that the person skilled in the art could easily combine the documents, rather than convincingly argue that he would combine them with the expectation of a desired result. The situation is analysed below in more detail.

- 6.2 Starting from document D1: This document describes a process for producing a grain-oriented Si steel sheet having a grain orientation of $\{110\}\langle 001\rangle$, made by heating a slab to a "high" temperature. If such slab heating temperatures are used the grain growth becomes excessive and coarse grains having the $\langle 110\rangle$ zone grain axis parallel to the rolling direction are not fully broken down, and unless adequate steps are taken, may remain in the subsequent process steps and there prevent complete secondary recrystallisation in the

final annealing, and the incompletely recrystallised grains remain in the final product as streaks.

In the examples given in this document an initial slab of thickness 200 mm is heated to a temperature of 1400°C and coarse grains which grow during the slab heating are broken down in a finishing hot rolling step with conditions chosen so as to perform controlled recrystallisation rolling during which complete secondary recrystallisation occurs. The final product after the final annealing is then free of streaks.

If the person skilled in the art wanted to use a lower slab temperature he might consider employing the steel composition of example 3 of document D7 (the only example whose steel composition matches that of claim 1 of the patent in suit) and, additionally, maintain the hot-rolled sheet at a temperature not lower than 700°C for at least 1 second after termination of the hot rolling as suggested in Table 3 of document D5.

However, this combination of the teaching of three documents requires selecting particular steps or parameters from a variety of steps and parameters and out of the context of the respective particular process, and mosaicing them to produce all the steps and parameters of claim 1 of the patent in suit. Although it may be considered obvious to lower the slab heating temperature, there is no good reason for selecting particular composition parameters of one particular example of document D7, and particular process parameters of one particular Table of document D5, and combining these with other particular parts of document D1, since each of these parameters is set in the context of its own technical problem.

6.3 Starting from document D7: Similar considerations apply when starting from this document. Although this document uses a steel having the composition of the steel of claim 1 of the patent in suit (see Example 3) and employs a low slab heating temperature of 1230°C, it requires to be supplemented by the particular finishing hot rolling parameters of document D1, as well as the step of maintaining the hot-rolled sheet at a temperature not lower than 700°C for at least 1 second after termination of the hot rolling from Table 3 of document D5.

Again, this entails selectively plucking particular parts of different documents from their respective different contexts and combining them together, for which there is no good ground.

6.4 For the above reasons the process of claim 1 of the main request involves an inventive step.

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 maintain the patent in amended form on the basis of the following documents:

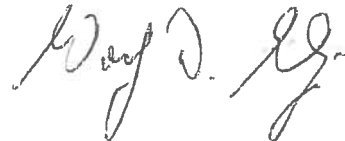
- Claims 1 and 2 of the main request as submitted at the oral proceedings
- Description pages 4 and 9 as submitted at the oral proceedings,
pages 2, 3, 5 to 8, and 10 to 21 as granted
- Figures as granted.

The Registrar:



G. Rauh

The Chairman:



W. D. Weiß

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22/3/02

