BESCHWERDEKAMMERN DES EUROPÄISCHEN PATENTAMTS

BOARDS OF APPEAL OF THE EUROPEAN PATENT OFFICE

CHAMBRES DE RECOURS DE L'OFFICE EUROPEEN DES BREVETS

A		B		C	X

File No.: T 0269/91 - 3.5.2

Application No.: 82 305 034.9

Publication No.: 0 076 109

Classification: H01F 1/16

Title of invention: Method of producing grain-oriented silicon steel sheets having excellent magnetic properties

D E C I S I O N
of 23 June 1993

Applicant:

Proprietor of the patent: KAWASAKI STEEL CORPORATION

Opponent: Thyssen Stahl AG

Headword:

EPC: Art. 54 and 56

Keyword: "Novelty and inventive step (yes, after amendment)"

Headnote
Catchwords

Europäisches Patentamt | European Patent Office | Office européen des brevets

Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0269/91 - 3.5.2

D E C I S I O N
of the Technical Board of Appeal 3.5.2
of 23 June 1993

Appellant: (Opponent)
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Decision under appeal: **Interlocutory decision of the Opposition Division of the European Patent Office dated 20 March 1991 concerning maintenance of European patent No. 0 076 109 in amended form.**

Composition of the Board:

Chairman: R.E. Persson
Members: A.G. Hagenbucher
W.D. Weiss

Summary of Facts and Submissions

I. European patent No. 76 109 was granted with eight claims, Claims 2 to 8 being dependent on Claim 1.

II. The Appellant filed a notice of opposition and requested revocation of the patent on the grounds of lack of novelty and inventive step. The following prior art documents were cited:

D1: DE-A-2 940 779 and
D2: GB-A- 999 462.

III. By the interlocutory decision under appeal, the Opposition Division found that the patent could be maintained on the basis of an amended Claim 1 and an adapted description received on 28 September 1990 (dependent Claims 2 to 8 being unamended).

IV. The Opponent lodged an appeal against this decision.

V. Oral proceedings were held before the Board on 23 June 1993 during which the Respondent (Patentee) requested that the patent be maintained on the basis of Claim 1 as filed with letter dated 20 May 1993 and Claims 2 to 8 as granted as well as pages 2, 3 and 8 of the description filed with the same letter and the rest of the description in accordance with the patent specification.

VI. New Claim 1 reads as follows:

"A method of producing a grain-oriented silicon steel sheet having excellent magnetic properties from a continuously cast slab, comprising the steps of (i) forming a hot rolled sheet by hot rolling a continuously cast slab of silicon steel consisting of from 2.8 to

4.0% by weight of Si, 0.02 to 0.15% by weight of Mn, 0.008 to 0.080% by weight in total of at least one of S and Se, and C within the range defined by the following formula

$$0.37[Si\%]+0.27 \leq \log([C\%]x10^{3}) \leq 0.37[Si\%]+0.57$$

wherein [Si%] and [C%] represent the contents (% by weight) of Si and C in the silicon steel, respectively, with the balance being Fe, incidental impurities and optionally grain boundary elements; (ii) coiling the hot rolled steel sheet; (iii) subjecting the coiled steel sheet to two or more cold rollings with an intermediate annealing between them and using a reduction rate of from 40 to 80% in the final cold rolling to produce a finally cold rolled steel sheet having a final gauge; and (iv) subjecting the finally cold rolled steel sheet to decarburization annealing and final annealing; the method including the step of removing 0.006-0.020% by weight of C from the steel after the completion of the above described hot rolling step and before the beginning of the above described final cold rolling."

VII. The Appellant's arguments can be summarised as follows:

The production of grain-oriented silicon steel sheets from continuously cast slabs was known from the most relevant prior art document D1. This document disclosed compositions of starting materials which lay within the area defined by the Si-C formula of Claim 1. It was clear from page 2 of the patent in suit that the problem of preventing fine grain streaks for a stable production of grain-oriented silicon steel sheets arose out of practice. According to the present patent, grain-oriented silicon steel sheets could be stably produced mainly due to removing 0.006 to 0.020% by weight of C

from the steel after the completion of hot rolling and before the beginning of the final cold rolling. D1 mentioned on page 15, first paragraph that a partial decarburisation could be carried out at that stage of the manufacturing process. Although D1 did not indicate the percentage of decarburisation, a person skilled in the art would carry out tests in order to determine the appropriate range.

D2 disclosed on page 3, lines 88 to 111 decarburisation before the final cold rolling which lay within the claimed range of decarburisation for the purpose of improving the magnetic properties. In view of the fact that the printed patent specification did not only refer to the production from continuously cast slabs but also to that from ingots it was clear to a person skilled in the art that the decarburisation known from D2 was also applicable to the method known from D1, especially as D2 did not explicitly exclude the production from continuously cast slabs.

Hence, a person skilled in the art would have tried and found the appropriate range of decarburisation.

VIII. The Respondent argued that the problem underlying the present invention was essentially solved by the combination of the use of a steel having a specified composition and the use of specified processing steps, i.e.:

(a) limiting the amount of γ-phase iron to between 10 and 30% during hot rolling by a certain compositional range of the starting material according to the Si-C formula given in Claim 1;

(b) removing 0.006-0.020% by weight of C from the steel after the completion of the hot rolling and before the beginning of the final cold rolling;

(c) a reduction rate of from 40 to 80% in the final cold rolling; and

(d) conventional decarburisation at the end.

The most relevant document D1 concerned the solution of the same problem but did not hint at the combination of the claimed steps. Although composition examples given therein overlapped with the area of compositions given by the Si-C formula in Claim 1, D1 did not teach to restrict the composition range so that the γ-phase iron lay between 10 and 30%. D1 mentioned the possibility of partial decarburisation after hot rolling and before the final cold rolling, but did not explain the importance of this step nor hint at the claimed range of decarburisation. Moreover, none of the examples in D1 made use of such a partial decarburisation. Hence, it must be concluded that the authors of D1 were not aware of the importance of this partial decarburisation. This was underlined by the fact that although D2 had been published long before D1, it had not influenced the method of D1 as can be seen from the examples in D1.

In a letter dated 7 July 1986, page 3, lines 8 to 11 the Respondent had declared that the claimed amount of decarburisation is removed additionally to any carbon which may be removed as a consequence of the hot rolling. Furthermore, the Respondent has submitted that the carbon may be removed either before the cold rolling has taken place (pre-cold rolling removal) or during the annealing step between two cold rollings (intermediate annealing removal).

IX. The Appellant requested that the decision under appeal be set aside and that the patent be revoked. The Respondent maintained his position as stated in paragraph V above.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

The amendments of Claim 1 and the description do not conflict with Article 123(2) and (3) EPC. The arguments given in paragraph 2.1 of the contested decision with respect to the amendment of factors 0.037 into 0.37 in Claim 1 and the description have not been criticised by the Appellant and are accepted by the Board. Restriction of Claim 1 and the description to continuous casting meets the requirements of Article 123(2) and (3) EPC because the application documents as filed make it clear that the problem to be solved according to the present invention arises in connection with continuous casting (cf. pages 2 and 3 of the description as filed). The description as filed (cf. page 24, fourth paragraph) refers to continuous casting. The scope of protection of present Claim 1 is restricted in comparison with Claim 1 as granted.

3. *Novelty*

In view of claim 1 filed with the letter of 20 May 1993 the objection as to lack of novelty was waived. Hence, it remains to be decided whether Claim 1 involves an inventive step.

4. *Inventive step*

4.1 Closest prior art

D1 discloses a method of producing a grain-oriented silicon steel sheet having uniform magnetic properties from a continuously cast slab, comprising the steps of forming a hot rolled sheet by hot rolling a continuously cast slab of silicon steel consisting of 2.5 to 4.0% by weight of Si, 0.04 to 0.08% by weight of Mn, 0.015 to 0.025% by weight in total of at least one of S and Se and 0.030 to 0.045% by weight of C, and the rest being Fe and incidental impurities, subjecting the hot rolled steel band to two or more cold rollings with an intermediate annealing between them and using a reduction rate of from 40 to 80% in the final cold rolling (see the table at the end of page 15) to produce a finally cold rolled steel sheet having a final gauge and subjecting the finally cold rolled steel sheet to decarburisation annealing and final annealing.

The Si and C contents disclosed in the examples of D1 meet the relationship defined by the respective formula of Claim 1 of the patent in suit.

Moreover, D1 contains as an isolated statement (page 15, first paragraph) that a partial decarburisation by the introduction of a wet hydrogen atmosphere may be effected at the occasion of the intermediate annealing performed after the first cold rolling. None of the examples includes, however, such an intermediate decarburisation.

Although coiling after hot rolling is not explicitly mentioned in D1, the Board takes it for granted that this conventional procedural step is also included in this known method.

4.2 Problem

According to the description of the patent in suit a particular problem may arise when a grain-oriented silicon steel sheet is produced starting from continuously cast slabs (EP-B-0 076 109, page 2, lines 28 to 59). That is, when it is intended to obtain fine precipitates of MnS, MnSe, AlN and the like, which are effective as inhibitors, it is necessary that the slab is heated at a high temperature of not lower than 1,250°C for a long period of time before the hot rolling to dissociate and to solid solve fully the inhibitor element into the steel, and that the cooling step on hot rolling is controlled to precipitate the inhibitor element having a proper fine size. However, in a continuously cast slab, extraordinarily coarse crystal grains are apt to develop during the high temperature heating of the slab, and incompletely developed secondary recrystallised texture, called fine grain streaks, is formed in the resulting silicon steel sheet product which is then poor in magnetic properties. The coarse crystal grains are, however, not developed before the hot rolling, whenever the Si and C contents are selected in a mutual relationship which warrants that between 10 and 30% γ.phase iron is formed at hot rolling temperatures.

The compositions of the examples of D1 meet this latter condition, although its maintenance is not warranted in the whole composition range disclosed in Claim 1 of D1 and this document does not expressly teach that such a relationship between Si and C should be selected.

But even when the necessary amount of γ-phase is present during the hot rolling step, the final recrystallisation of the grain-oriented steel sheet may not develop properly and, therefore, the desired magnetic properties

may not be achieved whenever the production process starts from a continuously cast slab.

Consequently, also starting from the examples of D1, the technical problem still persists to develop a method which, starting from a continuously cast slab, reliably warrants a proper secondary recrystallisation resulting in high grade magnetic properties.

4.3 Solution

The solution to the above technical problem presented by Claim 1 essentially consists in the **combination of features** that

- the Si and C contents are deliberately selected according to the claimed formula

and

- 0.006 to 0.020% by weight of C is removed from the steel after the completion of the hot rolling step and before the beginning of the final cold rolling.

4.4 Document D1 discloses a solution of the same problem as the patent in suit (see pages 5 to 8). However, the solution according to this document as defined by its main claim does not contain either of the two features above which form the essence of the solution claimed by the patent in suit.

According to this document, the material may be partially decarburised in the course of an intermediate annealing before the final cold rolling step (dependent Claim 8, page 15, first paragraph). This document, however, does not contain any teaching as to under which circumstances and to what extent this optional partial

decarburisation should be performed and which effect is then to be expected, nor does it give any hint to the extent that before this partial decarburisation the contents of Si and C should be in a particular relationship to each other. On the contrary, although the contents of C and Si in all the examples of document D1 meet the relationship as defined in Claim 1 of the patent in suit, none of these examples includes a partial decarburisation.

Consequently, D1 does not suggest experimenting with a combination of these two features with the aim of solving the basic technical problem of the invention.

D2 was published in 1962, that is at a time when steel was not yet continuously cast on an industrial scale. Therefore, no person would even take this document into consideration when looking for a solution to a problem which arises from the specific structure of a continuously cast slab. Besides that, D2 does not suggest selecting the Si and C contents in relation to each other for any reason. The only specific example which describes an intermediate partial decarburisation (page 3, lines 98 to 110) has Si and C contents which fall outside the respective range of the patent in suit.

The Board, therefore, comes to the conclusion that the subject-matter of Claim 1 cannot be derived in an obvious manner from the documents cited by the Appellant and must accordingly be seen as involving an inventive step as required under Article 56 EPC.

5. The independent Claim 1, together with the dependent Claims 2 to 8 and the revised description adapted thereto, can, therefore, form the basis for maintaining the patent.

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 documents as defined in paragraph V above.

The Registrar: The Chairman:

M. Kiehl E. Persson