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D E C I S I O N
of 9 July 2003

Case Number: T 1141/00 - 3.2.2

Application Number: 93114263.2

Publication Number: 0585956

IPC: H01F 1/147

Language of the proceedings: EN

Title of invention:
Thick grain-oriented electrical steel sheet exhibiting excellent magnetic properties

Patentee:
NIPPON STEEL CORPORATION

Opponent:
EBG Gesellschaft für elektromagnetische Werkstoffe mbH

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no)"

Decisions cited:
-

Catchword:
-

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 1141/00 - 3.2.2

D E C I S I O N
of the Technical Board of Appeal 3.2.2
of 9 July 2003

Appellant: (Proprietor of the patent)
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Respondent: (Opponent)
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Representative:
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Decision under appeal:
Decision of the Opposition Division of the European Patent Office posted 25 September 2000 revoking European patent No. 0585956 pursuant to Article 102(1) EPC.

Composition of the Board:

Chairman: W. D. Weiß
Members: R. Ries
R. Menapace

Summary of Facts and Submissions

I. On 29 November 2000, the proprietor of the patent lodged an appeal against the decision of the opposition division of 25 September 2000 to revoke the European patent No. 0 585 956, and the fee for appeal was paid on the same day. The statement setting out the grounds for appeal was received on 2 February 2001.

II. The patent was opposed on the grounds of lack of inventive step (Article 100(a) EPC) and insufficiency of disclosure (Article 100(b) EPC).

The opposition division held that the claimed subject matter did not involve an inventive step and, therefore, revoked the patent.

III. In the appeal stage the discussion was still based on the following documents:

D1b: translation of JP-A-3-72 027 into German of the full text of D1;

D2: Journal of Magnetic Materials, vol. 2, 1976, pages 151 to 161

D8: Theoretical values of the shape factor SF for different grain forms (2 pages)

D9: EP-A-0 184 891

D10: EP-A-0 150 909

IV. Oral proceedings were held on 9 July 2003, at the end of which the requests of the parties were as follows:

The appellant (patentee) requested that the decision under appeal be set aside and the patent be maintained on the basis of the single claim filed together with the grounds of appeal (main request) or of the single claims submitted during the oral proceedings as first, second and third auxiliary requests.

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

V. Claim 1 according to the main request reads as follows:

"A thick grain-oriented electrical steel sheet with excellent magnetic properties, the electrical steel sheet

containing 2.5 - 4.5% Si by weight,
measuring 0.36 - 1.00 mm in thickness,
having a C content of not greater than 0.0050% by weight
exhibiting a magnetic flux density B_8 of not less than 1.83 T,
exhibiting an average value of SF of less than 0.80, where SF is an index representing the boundary configuration characteristics of the individual sheet grains with the same area as the circle with diameter exceeding 5 mm has and is defined as

$$SF = (\text{grain area} \times 4\pi) / \text{grain boundary length})^2 ,$$

the average value of SF being the average value of the individual SF values,

the grains of a diameter exceeding 5 mm having a crystal orientation deviation at the point farthest from the grain center of gravity in the rolling direction of 0.2 - 4 degrees in relation to that at the grain center, and
as a product of a thickness t (mm) exhibiting a core loss of $W_{17/50}$ (W/kg) of not more than 3.3 x t + 0.35."

Compared with the main request, the single claim of the first auxiliary request additionally comprises the wording (in bold letters):

"1. A thick grain-oriented electrical steel sheet....not more than 3.3 x t + 0.35, **said thick grain oriented electrical steel sheet being obtained by the steps:**
preparing a slab comprising 0.025-0.075% of C, by weight, Si, optionally one or more selected from Al, N, Mn, S, Se, Sb, B, Cu, Nb, Cr, Sn, Ti and Bi as inhibitor-forming elements, and the balance being iron and unavoidable impurities,
heating the slab to a temperature not higher than 1,300°C,
hot rolling the slab to a hot-rolled sheet by a reduction ratio of not less than 80% by using one stage cold rolling or two or more stages of cold rolling with intermediate annealing,
decarburization annealing the cold-rolled sheet at a temperature between 700-1000°C,
treating the cold rolled sheet for nitriding by using NH_3 gas,

coating the cold rolled sheet with an annealing separation agent consisting mainly of MgO, coiling the cold rolled sheet into a coil having an inside diameter of 10-100,000 mm, and annealing the cold rolled sheet for final finishing."

Compared with the first auxiliary request, the single claim of the second auxiliary request additionally includes the wording (in bold letters):

"A thick...

treating the cold rolled sheet for nitriding by using NH_3 gas, **if the inhibitor strength is insufficient for evolving secondary recrystallization in the decarburized sheet;**
coating..... "

Compared with the secondary request, the single claim of the third auxiliary request additionally comprises the wording (in bold letters):

"A thick ...

treating the cold rolled sheet for nitriding by using NH_3 gas, if the inhibitor strength is insufficient for evolving secondary recrystallization in the decarburized sheet;
coating the cold rolled sheet with an annealing separation agent consisting mainly of MgO,
coiling the coated cold rolled sheet into a coil having an inside diameter of **200 - 1500 mm**, and
annealing the cold rolled sheet for final finishing."

VI. The appellant argued as follows:

The patent is directed to "thick" grain-oriented Si steel sheet having a thickness of 0.36 to 1.00 mm rather than to "thin" sheet which is strongly recommended by the prior art to reduce the iron loss to a level as low as possible. The problem underlying the patent is, therefore, not addressed in documents D1 and D9 referred to by the opponent, and the technical teaching given in these documents dissuades a person skilled in the art from producing "thick" grain-oriented Si steel sheet. In contrast thereto, the patent teaches that an acceptable iron loss combined with good magnetic properties can be achieved even in "thick" grain oriented Si sheet, provided that a plurality of parameters including the carbon content, the magnetic flux density B_8, the shape factor SF and the crystal orientation deviation in grains having a diameter exceeding 5 mm (COD>5mm) are kept within narrow ranges. In particular the COD>5mm is not mentioned in any of the cited documents and, in consequence thereof, it could not have been obvious to a skilled person to adhere to the range specified for this parameter in the patent. The claimed crystal orientation deviation is obtained (i) by adhering to a specific inside diameter of the coil during finish annealing in combination with (b) the heat history of the sheet. The product per se is therefore novel and involves an inventive step.

As to the product-by-process claims according to the auxiliary requests, the steps of selecting a carbon content of less than 0.0050% in the final product, heating the slab to a temperature not higher than

1300°C and performing a nitriding treatment are closely related to each other so that the desired magnetic properties even when using a low slab heating temperature process (<1300°C) can be obtained. The relatively low slab heating temperature of less than 1300°C specified in the claim has not only been selected with the aim to save energy but also to favourably influence the behaviour of the inhibitors which in the end determine the magnetic properties of the final product. The starting carbon content is important to promote a favourable primary recrystallisation texture, and in the following decarburisation step this carbon is reduced to less than 0.0050% to obtain better magnetic properties. The nitriding step using an atmosphere containing NH_3 is necessary whenever the inhibiting effect of the inhibitors such as MnS and AlN is insufficient. Thus, apart from being directed to the production of "thin" grain-oriented Si steel sheet, the processes disclosed in documents D1 or D9 neither provide a heat treatment of the slab at less than 1300°C nor include a nitriding step and hence teach away from the process steps stipulated in the patent.

VII. The respondent argued as follows:

The electrical and magnetic properties featuring in the product claim for thick grain-oriented Si steel sheet are generally desired also when producing "thin" grain oriented Si sheet. Thus, except for the thickness values, the examples given in documents D1 and D9 exhibit the same magnetic flux density B_8 (or alternatively B_{10}) of not less than 1.83T, a shape factor of less than 0.80 and final carbon content of

less than 0.005%. The crystal orientation deviation, which is considered to comply with that known in the art and described in document D2, page 157, left hand column, second paragraph, is generally maintained below $\Delta\psi = 3^\circ$ at maximum and is improved by the inhibitor AlN. If, however, the crystal orientation deviation in the patent is meant to define something different from the generally accepted definition given in document D2, the specification fails to provide the expert with a clear teaching how this particular property can be successfully achieved. In the latter case, the requirements of Article 83 EPC would not be met.

Moreover, the relationship between the watt loss and thickness of the sheet expressed by the formula merely defines the acceptable core loss which increases with higher thickness. As admitted in the specification on page 2, lines 32/33, this interdependency has been known to the expert ever since. Consequently, the electrical and magnetic properties of the grain oriented Si steel sheet claimed according to the main request merely represent typical material values which are expected and aimed at by the person skilled in the art when producing sheet thicknesses higher than conventional and ranging from 0.36 to 1.00 mm. Contrary to the patentee's allegation, a prejudice against producing such "thick" grain-oriented sheet did not exist, provided that the inferior properties, in particular the expected higher core loss, could be tolerated by the customer.

Reasons for the Decision

1. The appeal is admissible.

2. *Main request*

2.1 Novelty

None of the prior art documents discloses a "thick" grain oriented Si steel sheet exhibiting all the technical features as claimed in the disputed patent. The novelty of the claimed subject matter, which has not been challenged by the opponent, is therefore given.

2.2 Inventive step

The claimed "thick" grain-oriented Si steel sheet is characterized by six different parameters. It has therefore, to be examined whether one or more of these parameters could justify an inventive step vis-à-vis the technical parameters obtained in "thin" steel sheet according to the prior art.

It belongs to the technical background knowledge of a skilled person that in order to produce grain-oriented electrical steel (exhibiting a Goss-texture) it is necessary to restrict the silicon content to a range of about 3.0 to 3.5% and to reduce the carbon content in the final product to below 0.005% to prevent magnetic ageing (cf. D2, page 156, column 1, paragraph 2 and page 159, Figure 11 and column 1, first paragraph). These typical ranges are corroborated by the carbon and silicon contents disclosed in Tables 1 to 3 of

document D9. The limitation to the ranges for Si and C stipulated in the claim, therefore, merely represents common practice.

The magnetic flux density B_8 (or alternatively B_{10}) is a consequence of the steel composition and the production route. A specific magnetic flux density may be also chosen on demand by the customer. Given that the claimed steel composition as well as the process steps for the sheet material described in the patent are typical, in particular as compared with the process disclosed in document D9, a magnetic flux density B_8 of not less than 1.83T merely represents a usual value aimed at also when producing conventional "thin" electrical steel sheet.

As set out in the specification on page 4, lines 25, 26, the basic principle underlying the disputed patent resides in achieving a specific combination of the grain boundary configuration (expressed by the shape factor SF) and the crystal orientation deviation of the grains having a diameter exceeding 5 mm. It is, however, beyond dispute that the grains in the final steel sheet are always irregularly shaped (rather than circular, i.e. SF = 1) which will automatically result in a shape factor of less than 0.8. Moreover, document D9 advocates on page 13 to page 14 second paragraph a shape factor of less than 0.6 for even more effectively reducing the watt loss, and that the resulting steel sheets are screened with an image analyser to ascertain whether the SF and the contents of C, N and S fall within the target ranges.

The crystal orientation deviation set out in the patent is a parameter which has been defined by the patentee and appears to have not been known in the art before. The specification sets out on page 5, paragraph 1, that the presence of a 0.2 - 4° crystal orientation deviation in relation to that at the center of gravity can be ensured in the grains exceeding 5 mm, when the inside diameter of the coil during finishing annealing is 10 to 100,000 mm, preferably 200 to 1500 mm (underlining added). For lack of any other specific measure to adjust the crystal orientation deviation, the argument that conventional coiling always meets this proviso and therefore generally results in the desired orientation deviation could not be refuted by the patentee. It is further noted that - except for the inside diameter of the coil - no information is discernable in the patent specification teaching a skilled person by which other process steps the desired orientation deviation can be successfully obtained.

As argued by the patentee, the patent has satisfied for the first time the demand for "thick" grain oriented Si steel sheet material which exhibits excellent magnetic properties and which allows the number of laminations to be reduced in large rotating electrical machines.

However, having regard to the technical background D2 and also to document D9, a prejudice against the production and use of "thick" electrical steel sheet having a thickness or more than 0.35 mm cannot be recognised. Such thicker electrical steel sheet material has been used e.g. in large electrical machines whenever higher core losses - compared to thin sheet - could be tolerated. For this reason, even non-

orientated electrical steel sheet material of 0.50 mm or 0.35 mm exhibiting very high core losses is commercially available, as is apparent from document D2, page 160, Table 1. The selection of a particular material is, therefore, also influenced by economic considerations of the customer. Thus, if an energy saving material is desired for electrical machinery and apparatuses, a "thin" grain-oriented Si steel sheet exhibiting low or ultra-low watt losses will be preferred. If, on the other hand, a high productivity is the pre-dominant factor and high core losses are of minor importance, steel sheet having a thickness greater than conventional ones can be used. This balancing of the properties is reflected for example on page 3, lines 23 to 31 of document D9.

It is therefore, concluded that none of the technical features characterizing the "thick" electrical steel sheet set out in the single claim of the main request justifies the presence of an inventive step.

3. *Auxiliary Requests*

The product-by-process claims according to the first, second and third auxiliary request further comprise the production steps for producing grain oriented Si steel sheet. Compared with the process route disclosed in document D9 for producing "thin" steel sheet, the claimed route is, however, considered to be a typical one as is shown in the following:

In document D9, the ingots containing 1.1 to 3.6% silicon, 0.0055 to 0.071% carbon and different amounts of acid-soluble aluminium, nitrogen, manganese, sulphur and selenium were

- heated to 1360°C,
- hot rolled followed by
- cold rolling with a final cold rolling reduction between 81 to 93%,
- decarburization annealing at 800°C to 860°C in wet hydrogen,
- coated with a MgO coating and
- coiled and
- finish annealed (cf. document D9, example 1 page 20, 21; page 17, lines 25 to 27, lines 32, 33).

In the claimed process the heat treatment before hot-rolling is restricted to 1300°C which in patentee's view is an essential difference to 1360°C used in D9. It is, however, clearly stated in the patent specification on page 4, lines 42 to 44 that no particular limit is set to the heating temperature and that merely for energy cost considerations the temperature is preferably not higher than 1300°C. Moreover, in the experiment disclosed on page 3 of the patent specification, lines 20, 21, the temperature range is set to be 1150 to 1380°C.

As to the nitriding step, the patent sets out on page 4, lines 57, 58 that this treatment is only carried out if the inhibitor strength is insufficient. In fact, example 2 of the disputed patent does not comprise a nitriding treatment. It is, therefore,

evident to a person skilled in the art, that nitriding is an optional treatment which is only performed when the need arises.

The coiling of the sheet with an inside diameter 10 to 100,000 mm (auxiliary request 1) or 200 to 1500 mm (auxiliary request 3) for finish annealing and flattening the sheet after coiling is merely conventional technology, as has been shown when discussing the single claim of the main request. No evidence has been produced by the patentee to prove the contrary.

Consequently, the process steps in the product-by-process claims according to the first, second and third auxiliary request do not involve any inventive step over the prior art. There is no evidence for the appellant's allegation that only the combination of the three steps not explicitly mentioned in D9 bring about an unforeseen effect. The subject matter of the product-by-process claims of all the auxiliary requests therefore, does not involve an inventive step.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar:

V. Commare

The Chairman:

W. D. Weiss