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D E C I S I O N
of 23 October 1996

Case Number: T 1087/92 - 3.2.2

Application Number: 85300073.5

Publication Number: 0150909

IPC: C21D 8/12

Language of the proceedings: EN

Title of invention:
Method of manufacturing grain-oriented silicon steel sheets

Applicant:
Kawasaki Steel Corporation

Opponent:
(01) Thyssen Stahl AG
(02) Nippon Steel Corporation

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step - (no)"

Decisions cited:
-

Catchword:
-

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Case Number: T 1087/92 - 3.2.2

D E C I S I O N
of the Technical Board of Appeal 3.2.2
of 23 October 1996

Appellant: (Proprietor of the patent)
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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 26 October 1992 revoking European patent No. 0 150 909 pursuant to Article 102(1) EPC.**

Composition of the Board:

Chairman: H. Seidenschwarz
Members: S. Crane
C. Holtz

Summary of Facts of Submissions

I. European patent No. 0 150 909 was granted on 28 March 1990 on the basis of European patent application No. 85 300 073.5.

II. The patent was opposed by the present respondents on the ground **inter alia** that its subject-matter lacked inventive step with respect to the state of the art.

Among the prior art documents relied upon by the respondents in this respect were:

(1) JP-A-5858228,

(2) US-A-4 280 856.

III. With its decision given at oral proceedings on 16 September 1992, and issued in written form on 26 October 1992, the Opposition Division revoked the patent.

This decision was taken on the basis of amended claims 1 and 2 filed on 15 July 1992, of which claim 1 reads as follows:

"A method of manufacturing a grain-oriented silicon steel sheet having mainly an orientation of (101)[001] which method comprises

(i) providing a silicon steel slab containing 2.0 to 4.5% by weight of silicon, 0.02 to 0.10% by weight of manganese, 0.005 to 0.06% by weight in total of at least one element selected from sulphur, selenium and aluminium, 0.030 to 0.080% by weight of carbon and from 0.01 to 0.2% by weight in total of at least one element selected from antimony, nickel and molybdenum;

(ii) heating said silicon steel slab in a slab heating furnace of the gas fired type until the temperature of the central portion of the slab which exhibits the smallest temperature increase during the heating reaches 900-1,230°C,

(iii) placing the slab in an induction heating furnace before the temperature of said central portion becomes less than 900°C and then heating the slab in an inert gas atmosphere containing not more than 1% of oxygen so as to maintain the temperature of said central portion at 1,250-1,380°C for not less than 10 minutes and to maintain the temperature of the slab surface at not less than 1,250°C,

(iv) hot rolling the slab to form a sheet of thickness of 1.4-3.5 mm,

(v) cold rolling the sheet in one-step or in two-steps inclusive of an intermediate annealing to obtain a sheet of finished thickness of 0.15-0.50 mm, and

(vi) subjecting the sheet to decarburisation annealing and a subsequent high temperature box annealing."

Dependent claim 2 relates to a preferred embodiment of the method according to claim 1.

In the decision it was held that the subject-matter of claim 1 lacked inventive step with respect to document (1) and GB-A-1 244 439 (3) which was cited in the contested patent as closest state of the art and belonged to the same patent family as a document referred to in document (1).

IV. An appeal against this decision was filed on 5 December 1992 and the fee for appeal paid on 22 December 1992. The statement of grounds of appeal was filed on 26 February 1993.

The appellants (proprietors of the patent) requested that the contested decision be set aside and the patent maintained in amended form on the basis of claims 1 and 2 filed on 15 July 1992 as considered by the Opposition Division.

V. The submissions of the appellants in support of their request can be summarised as follows:

Document (1) proposed that the slab be heated to a uniform temperature of 1250°C in the first furnace, which temperature was higher than that allowed by claim 1. Furthermore, claim 1 required that the atmosphere in the induction heating furnace contained not more than 1% of oxygen whereas document (1) indicated that satisfactory results would be achieved with an atmosphere containing up to 10%. The person skilled in the art would therefore have no incentive to take the technically difficult and expensive step of reducing the oxygen level to that required by the claim. There were also other differences between the disclosure of document (1) and the claimed method which had not been properly taken account of in the contested decision. In particular, the first furnace was fuel fired and not gas fired, the temperature of the slab on transfer to the second furnace was not mentioned and the composition of the silicon steel did not correspond to that claimed.

VI. The respondents requested that the appeal be dismissed. They made essentially the following submissions in support of this request:

The English translation of document (1) contained a clerical error with respect to the steel composition. The correct values were to be found in the German translation, which could be seen to correspond to the Japanese original. It was clear that if a massive slab

was heated in a furnace having a temperature of 1250°C then the central portion of the slab would only attain a significantly lower temperature, certainly less than the 1230°C required by present claim 1. It was apparent to the person skilled in the art that the amount of slag formation would be dependent on the oxygen content of the atmosphere in the induction heating furnace. There was no technical difficulty involved in reducing this level to less than 1% to achieve a predictable effect if this was felt justified in the circumstances.

Reasons for the Decision

1. The appeal is admissible.

2. The claimed invention is concerned with the manufacture of grain-oriented silicon steel sheet having desired magnetic properties. As is made clear in the introductory description of the patent specification, the basic metallurgical principles involved are well-known. The required grain orientation is obtained by selective crystal growth on annealing following rolling. For this purpose it is necessary to obtain a uniform dispersion of crystal growth inhibitors (MnS, MnSe, AlN) by dissolving the precipitated inhibitors to form a solid solution during heating prior to rolling. The temperature required for this is high and when using a conventional furnace the length of time the slab has to be heated to obtain the necessary temperature at its centre is considerable. This leads to an inordinate amount of liquid slag formation and also to an undesirable coarsening of the grain structure with consequential deterioration in the magnetic properties of the steel.

The claimed invention therefore proposes first heating the slab in a gas fired furnace until the temperature of the central portion of the slab which exhibits the smallest temperature increase during heating reaches 900°C to 1230°C (feature (ii) of claim 1) and then placing the slab in an induction heating furnace before the temperature of said central portion becomes less than 900°C and then heating the slab in an inert gas atmosphere containing not more than 1% of oxygen so as to maintain the temperature of said central portion at 1250°C to 1380°C for not less than 10 minutes and to maintain the temperature of the slab surface at not less than 1250°C (feature (iii) of claim 1).

3. It is already known from document (3) to improve the magnetic properties of the steel by using a two-stage heating process in which the slab is first heated in a conventional tunnel furnace and then brought up to the required rolling temperature by heating in an induction furnace.

Document (1) relates to an improvement in the method of document (3) by which slag formation is reduced by having an oxygen content of not more than 10% in the atmosphere of the induction heating furnace. The absence of slag formation in turn however leads to another problem in that powder used to prevent adhesion during continuous casting of the slab stays embedded in its surface with consequential surface defects in the rolled product. It is therefore proposed to use a plasma melting step for removing this powder.

In the English translation of document (1) reference is made to a steel containing 0.004% C, 3.19% S, 0.06% Mn and 0.02% S. By a comparison with the German translation and the appropriate passage of the original document (last paragraph, left-hand column, page 134) it can however be seen that the value of 0.004% C is a

clerical error and should read 0.04% C. It is therefore clear that document (1) relates to a silicon steel of a composition corresponding to that defined in part (i) present claim 1. The steel is continuously cast into 250 mm thick slabs and then charged into a fuel-fired heating furnace set at 1250°C. After being uniformly heated to 1250°C in this furnace the slabs are then charged into an induction heating furnace with an oxygen concentration of not more than 10% in its atmosphere and are rapidly heated and then soaked at 1350°C for 30 minutes (Example 1) or rapidly heated and then soaked at 1370°C for 15 minutes (Example 2). The slabs are then rolled and annealed in conventional manner to give finished strip of 0.30 mm thickness.

Although document (1) does not clearly disclose all of the features of parts (iv) to (vi) of present claim 1 it is known from the introductory description of the patent specification that these are wholly conventional. Accordingly, it is clear that the issue of inventive step resolves to the question of whether, having regard to the teachings of document (1) and the general knowledge of the person skilled in the art, it was obvious to use a two-stage heating process as defined in parts (ii) and (iii) of the claim to bring the slab up to the required hot rolling temperature.

In this respect the appellants have argued strongly that document (1) teaches the skilled person to continue heating of the slab in the fuel-fired furnace until it reaches a uniform temperature of 1250°C, which is higher than that permitted by the claim. From an isolated consideration of the language of the English translation of document (1) that might appear to be the case. For the person skilled in the art it is however self-evident that with a slab of 250 mm thickness and a furnace set to 1250°C that it would take an inordinate length of time for the centre of the slab to come up to

a temperature even within a few degrees of 1250°C and that in practice the temperature of the centre of the slab will remain significantly below this temperature, that is below the maximum of 1230°C allowed by the claim. That there are these significant temperature differences when a slab is heated in a fuel-fired furnace is well-known in the art and confirmed by the patent specification itself from which it is clear that the success of the claimed method depends on the temperature attained at the "central portion of the slab which exhibits the smallest temperature increase during heating".

The second main distinction seen by the appellants is that claim 1 requires an oxygen content of not more than 1% in the atmosphere of the induction heating furnace, whereas the range permitted by document (1) extends up to 10%. As the Opposition Division and respondents have however pointed out, it is clear to the person skilled in the art that the amount of slag formation at any given temperature will be closely dependent on the level of oxygen content in the furnace atmosphere. It lies within the routine competence of the person skilled in the art to choose, on a balance between the cost of providing a particular atmosphere and the benefits associated with it, the level of oxygen content with which to work. The appellants have not demonstrated that at a level below 1% some unexpected benefit is obtained and that there would be any technical difficulties associated with providing such a level.

The appellants have also pointed out that according to document (1) the first furnace is "fuel fired" whereas according to present claim 1 it is "gas fired". However, since it is well-known to use gas as the fuel for firing a furnace, and there is no suggestion that the choice of this particular fuel bears any

relationship to the problem of slag formation with which the patent is concerned, it is evident that this distinction can have no influence on the issue of inventive step.

Lastly, the appellants argue that document (1) does not indicate the temperature of the slab as it is transferred between the furnaces. Here, the Board is of the opinion that in the circumstances it is axiomatic that the slab transfer should be performed in such a way that the loss in temperature of the slab is held as low as possible. Certainly, it would run counter to logic if the slab were left unheated for so long between the furnaces that the temperature of its central portion could fall below the minimum of 900°C stated in the claim.

4. The Board therefore comes to the conclusion that the subject-matter of claim 1 does not involve an inventive step (Article 56 EPC).

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

S. Fabiani H. Seidenschwarz