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Datasheet for the decision of 7 July 2008

Case Number: T 0039/07 - 3.2.02

Application Number: 02000816.5

Publication Number: 1225242

IPC: C22C 38/22

Language of the proceedings: EN

Title of invention:
Ferritic stainless steel with excellent workability and method for making the same

Patentee:
JFE Steel Corporation

Opponent:
UGINE & ALZ FRANCE

Headword:
-

Relevant legal provisions:
EPC Art. 56

Relevant legal provisions (EPC 1973):
-

Keyword:
"Inventive step (yes)"

Decisions cited:
-

Catchword:
-

Case Number: T 0039/07 - 3.2.02

D E C I S I O N
of the Technical Board of Appeal 3.2.02
of 7 July 2008

Appellant: (Opponent)
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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 14 December 2006 rejecting the opposition filed against European patent No. 1225242 pursuant to Article 102(2) EPC.**

Composition of the Board:

Chairman: T. Kriner
Members: R. Ries
C. Vallet

Summary of Facts and Submissions

I. An opposition was filed by the appellant (opponent) against European patent No. 1 225 242. The opposition division held that the grounds for opposition pursuant to Article 100(a) EPC cited by the appellant did not prejudice the maintenance of the patent and therefore decided on 5 December 2006 to reject the opposition. The decision was posted on 14 December 2006.

II. The appellant lodged an appeal by notice received at the EPO on 8 January 2007 and paid the prescribed fee on the same day. A statement setting out the grounds of appeal was filed on 20 April 2007.

In support of its arguments the appellant essentially referred to the documents

D2: J. Harase et al.: "Metallurgy for the production of 17% Cr ferritic stainless steel sheet without hot band annealing", Proceedings of the International Conference on Stainless Steels, JISJ, pages 856 to 863, Chiba, 1991

D4: T. Sawatani et al.: "The r-values and recrystallized textures of Ti-stabilised low-C, N-17%Cr stainless steel sheets, Transactions ISIJ, volume 18, 1978, pages 676 to 685

D7: Y. Yazawa, Y. Kato, M. Kobayashi: "Development of Ti-bearing high performance ferritic stainless steels R430XT and RSX-1*", Kawasaki Steel Technical Report No. 40, May 1999, pages 23 to 29

D8: K. Ishii et al.: "Stainless Steel for Automotive Exhaust System", Kawasaki Steel Technical Report No. 40, May 1999, pages 39 to 41

D10: JP-A-03-264652 published 25 November 1991

D10':Translation of D10 into English language of

D11: H. Sumitomo: "Press Formability of High-Purity Ferritic Stainless Steel Sheets", Nippon Steel Technical Report No. 71, October 1996, pages 17 to 23

D12: F. Robbe-Valloire et al.: "Influence of Recrystallisation on the Ridging and Formability of Ferritic Stainless Fe 17Cr", 7. International Conference on Texture of Materials, ICOTOM 7, 21. September 2004 (published after the priority date of the patent at issue), and

D13: T. Hong and M. Nagumo: "Effect of surface roughness on early stages of pitting corrosion of type 301 stainless steel", Corrosion Science, 1997, volume 39, No. 9, pages 1665 to 1672, Publication Elsevier Science Ltd..

III. The appellant requested that the decision under appeal be set aside and the European patent No. 1 225 242 be revoked.

The respondent (patentee) requested that the appeal be dismissed. Oral proceedings were requested by the appellant as an auxiliary request.

IV. The wording of the independent claims 1 and 5 reads as follows:

"1. A ferritic stainless steel sheet having an average r-value of at least 2.2 and a ferrite crystal grain size number determined according to Japanese Industrial Standard (JIS) G 0552 of at least 6.0, the ferritic stainless steel sheet comprising, by mass percent:
not more than 0.1% C, not more than 1.0% Si, not more than 1.5% Mn, not more than 0.06% P, not more than 0.03% S, 11% to 23% Cr, not more than 2.0% Ni, 0.5% to 3.0% Mo, not more than 1.0% Al, not more than 0.04% N, at least one of not more than 0.8% Nb and not more than 1.0% Ti, optionally not more than 0.3% Co, optionally not more than 0.01% B, optionally not more than 0.5% Zr, optionally not more than 0.1% Ca, optionally not more than 0.3% Ta, optionally not more than 0.3% W, optionally not more than 1% Cu, optionally not more than 0.3% Sn, and the balance being Fe and unavoidable impurities, satisfying relationship (1):

$$18 \leq Nb/(C+N) + 2Ti/(C+N) \leq 60 \quad (1)$$

wherein C, N, Nb and Ti in relationship (1) represent the C, N, Nb and ti contents by mass percent, respectively."

"5. A method for making a ferritic stainless steel sheet, the method comprising the steps of:
preparing a steel slab containing not more than 0.1% C, not more than 1.0% Si, not more than 1.5% Mn, not more than 0.06% P, not more than 0.03% S, 11% to 23% Cr, not more than 2.0% Ni, 0.5% to 3.0% Mo, not more than 1.0% Al, not more than 0.04% N, at least one of not more than 0.8% Nb and not more than 1.0% Ti, optionally not more than 0.3% Co, optionally not more than 0.01% B,

optionally not more than 0.5% Zr, optionally not more than 0.1% Ca, optionally not more than 0.3% Ta, optionally not more than 0.3% W, optionally not more than 1% Cu, optionally not more than 0.3% Sn, and the balance being iron (Fe) and unavoidable impurities, satisfying relationship (1):

$$18 \leq Nb/(C+N) + 2Ti/(C+N) \leq 60 \quad (1)$$

wherein C, N, Nb and Ti in relationship (1) represent the C, N, Nb and Ti contents by mass percent, respectively;

heating the steel slab at a temperature in the range of 1,000°C to 1,200°C, hot-rough-rolling the steel slab at a rolling temperature of at least one pass of 850°C to 1,100°C by a reduction of 35%/pass or more, hot-finish-rolling the slab at a rolling temperature of at least one pass of 650°C to 900°C by a reduction of 20 to 40%/pass to prepare a hot rolled sheet;

annealing the hot-rolled sheet at a temperature in the range of 800°C to 1,100°C;

cold-rolling the resulting annealed sheet at least twice with intermediate annealing therebetween, said cold rolling being performed at a gross reduction of 75% or more and a reduction ratio (reduction in the first cold rolling)/(reduction in the final cold rolling) in the range of 0.7 to 1.3;

finish annealing the cold-rolled sheet at a temperature in the range of 850°C to 1,050°C."

V. The appellant's arguments can be summarized as follows:

As to product claim 1, the composition of the ferritic stainless steel sheet RSX-1 in D7 anticipated the claimed steel alloy, and the same problem underlying the patent at issue were addressed in this document. Therefore, D7 qualified as the closest prior art. The document however failed to disclose (i) the ferrite grain size number (JIS) of at least 6.0 and (ii) the average r-value of at least 2.2. Starting from this prior art, the objective problem to be solved by the opposed patent resided in (a) reducing the surface roughness, in particular preventing the "orange peel" surface complexion after forming the sheets, and (b) improving the formability, i.e., compared to the known steel sheet, in achieving a higher deep-drawability expressed by a r-value of 2.2 or more.

The problem of surface roughness (also called "ridging") was described in D12 as a heterogeneous plastic deformation, on a macroscopic scale, of thin cold rolled and annealed ferritic stainless steel sheets. As set out in D12, point 4, page 682, "ridging" could be minimized by low temperature final annealing at about 850°C which resulted in a reduction of the crystal grain size from 30 μm to 15 μm, corresponding to JIS grain sizes G = 6 and G = 9 in the patent. The skilled person hence was prompted, by the disclosure of D12, to perform the recrystallisation annealing at a rather low temperature (850°C) below the temperature level which results in complete recrystallization, so that a fine grain size of G > 6 was actually achieved. In conclusion, the subject matter of claim 1 was obvious from the technical disclosure of documents D7 and D12

The r-value of more than 2.2 as such was not to be considered as an essential characterizing feature of claim 1 since it represented, like the tensile strength or yield strength, merely a mechanical property of the ferritic steel sheet and hence the result to be achieved by the method claimed in the patent. Moreover, document D11 taught in paragraph 3.3 and the conclusions given on page 22 that the r-value exhibited a relatively high correlation with the multi-stage deep drawability. A skilled person would, therefore, always aim at reaching a high r-value of 2.2- or more as to improve the steel's formability. Besides, ferritic stainless steels of the type claimed with r-values of 2.2 or more were known in the art, e.g. from document D4 (see for instance Figure 13: cold reduction 90%).

Turning to method claim 5, document D4 qualified as the closest prior art. Ferritic stainless steel sheets having a composition free of Mo, but falling within the claimed elemental ranges were hot rolled, reheated and finishing hot rolled, annealed between 750°C to 950°C, cold rolled at least twice with intermediate annealing and final annealing between 850 and 1000°C (see e.g. D4, Table 1: samples; Figures 19 and 20, conclusions).
The process of D4 did not disclose

(i) a reduction rate of 35% or more per pass for the hot rough rolling

(ii) a finishing hot rolling with a reduction rate between 20 to 40 % per pass and

(iii) a Mo-containing ferritic steel.

Starting from document D4, the problems to be solved therefore resided in improving the workability of the sheets by avoiding large amounts of unrecrystallized portions, improving the r-value and minimizing ridging. To solve these problems, specifically to improve ridging, the skilled person would turn to document D2 which addressed the same problems and pointed to the need of controlling the recrystallisation during hot rolling (see D2, page 857, line 9 to 15, Figure 1) and of increasing the r-value while reducing ridging (see page 858, Figure 2). For producing 17%Cr ferritic stainless steel sheets, the document thus recommended the hot rolling schedule IRP-II comprising high reductions rates between 40 to 50% for the first hot rolling passes as to promote recrystallisation and finishing hot rolling at a reduction rate of 20-40% to increase the r-value and reduce ridging.

As to the molybdenum content in the claimed ferritic steel sheets, the skilled person was taught by the technical disclosure of documents D8, D10' and D11 that Mo was without any significant influence on the r-value but merely provided a better corrosion resistance. Adding Mo to a ferritic stainless steel to improve its corrosion resistance therefore did not involve an inventive step. Hence the claimed process was obvious from the combination of the technical teaching given in documents D4 and D2.

VI. The respondent argued as follows:

With respect to product claim 1 and process claim 5, document D7 qualified as the closest prior art. It disclosed neither the combination of an r-value ≥ 2.2 and the ferrite crystal grain size number ≥ 6 set out in claim 1 nor the process steps stipulated in claim 7. None of the remaining documents taken individually or in combination with D7 would prompt a skilled person to select in an obvious way the claimed process steps to produce a corrosion resistant ferritic stainless steel sheet exhibiting the claimed combination of properties.

The subject matter of independent claims 1 and 5 therefore involved an inventive step.

Reasons for the Decision

1. The appeal is admissible.

2. *The patent*

2.1 The first object of the patent at issue addressed in the paragraphs [0008], [0009] [0014] and [0017]) of the specification is to provide ferritic stainless steel sheets exhibiting

- an enhanced deep-drawability expressed by an r-value to 2.2 or more,
- a crystal grain size number in the finally annealed steel sheet of 6 or more as the parameter of the surface roughness and
- an improved corrosion resistance, in particular against red rust that is developed by deteriorated gasoline containing 800 ppm formic acid at 50°C for 500h.

Such steel sheets allow the production of automobile fuel tanks and pipes.

Another object of the patent is to provide a method for making the same ferritic stainless steel sheet.

2.2 The technical data given in Tables 1 to 6 and depicted in Figures 1 to 4 of the patent specification show that these objects are actually achieved by the steel sheets set out in claim 1 and the method for making a ferritic steel sheet as defined in claim 5.

3. As to method claim 5, the central plank the appellant has chosen to construct its case on inventive step is the set of premises that the claimed process was obvious from the technical teaching of document D4 as the closest prior art in combination with D2 and that the presence or absence of Mo in the steel sheet was of less relevance regarding the deep drawability. The Board cannot however concur with the appellant's assessment for the following reasons.

3.1 Document D4 deals with the effects of the mill processing variables on the r-values and textures of Ti-stabilised low C, N-17%Cr stainless steel sheet (see D4, synopsis). Except for molybdenum, the composition of the stainless steel sheets given in D4, Tables 1 and 2 satisfies the elemental ranges defined for the claimed steel sheet.

The known process comprises the steps of (see D4, page 676: Experimental procedure; Figures 19 and 20):
heating the steel ingots to 1100°C,
hot rough rolling to 110 mm square billets,
reheating to 1100°C and hot rolling to 3.8 mm sheet at a finishing hot rolling temperature between 890°C and 780°C;
annealing the hot rolled sheet between 750 to 950°C, water quenching, air cooling or furnace cooling,
cold rolling in several steps 30-70% → 40-60% → 50-50% →70-30% with a total reduction of 82% with intermediate annealing between 800 to 1000°C;
final annealing between 850 to 1000°C.

3.2 The Board concurs with the appellant's evaluation that, vis-à-vis the claimed process, D4 fails to disclose:

(i) a hot rough rolling at a reduction of ≥35%/pass,
(ii) a reduction of 20 to 40%/pass in a hot-finishing rolling step and
(iii) a steel composition comprising Mo.

It is evident from paragraphs [0054] and [0055] of the specification that the distinguishing process parameters and the compositional difference in the claimed process are selected on purpose. As to feature (i) large amounts of unrecrystallized portions remain when performing a hot rough rolling at a reduction below 35%/pass which adversely affect the deep-drawability and could promote seizure during forming. Hot finishing rolling below 20% reduction causes ridging and a decrease of the r-value (see the patent specification [0057]). Above 40% reduction, biting and/or shaping failure causing degradation of the surface characteristics of the steel sheet occurs (feature (ii)). The presence of Mo (feature iii) in the claimed ferritic steel infers a better corrosion resistance against low quality gasoline without the disadvantage of impairing the deep-drawability and the surface roughness normally encountered when including large amounts of Mo (see the patent specification paragraphs [0013] [0030], [0031]).

It can be inferred from the numerous examples given in the patent specification that the desired combination of the chemical and physical properties of the steel sheet is not obtained unless the compositional requirements and the prescribed process parameters are strictly adhered to.

3.3 Document D2, referred to by the appellant, is concerned with the hot and cold rolling of 17%Cr stainless steel sheet designated as SUS 430 (C ≤ 0.12%, Si ≤ 0.75%, Mn ≤ 1.0%, P ≤0.04%, S ≤0.03%, Cr: 16 to 18%, Ni ≤ 0.6% balance Fe; see C.W. Wegst: Stahlschüssel, Verlag Stahlschlüssel 1983, page 323, Stainless and heat resisting steels of Japan, alloy no. 37). The Board notes that this steel comprises neither Mo nor Ti (and/or Nb); see also the composition of the starting material given on page 858, lines 1 to 5. Mo and Ti (and/or Nb) are, however, indispensable alloying elements in the claimed steel composition to provide corrosion resistance against red rust and to improve the r-value (see the patent specification [0030], [0036], [0037]).

The Board concurs with the appellant's argument that document D2 describes a newly developed hot rolling process called Interpass Recrystallization Process, IRP-II including hot rough rolling reduction rates of 39.4% and 40% in passes 6 and 7 which improves ridging about 40% and the r-value compared to IRP-I (see D2, Tables I and II, Figure 2). It is, however, noted that the authors of D2 essentially aimed at clarifying the conditions which permit producing SUS 430 stainless steel sheet without the need of hot band annealing before cold rolling. These conditions are summarised in point 5, page 863 and also on page 856, Synopsis, paragraph I: Introduction, point 4.1 Experimental procedure). Contrary thereto, the addition of 0.2 to 0.3% Ti and hot band annealing are rated as being indispensable in the process given in document D4 to improve the r-value, see page 679, point 3 - effect of annealing conditions of hot rolled sheets, and also in the claimed process to develop a grain size as fine as possible and free of unrecrystallized structure (cf. the patent specification, [0059]). Hence there is no reason to transfer the technical disclosure of D2 to the teaching of document D4. Moreover, nothing in D4 or D2 is concerned with a corrosion resistant steel which comprises specific amounts of Mo to prevent red rust formation.

3.4 Based on the disclosure of documents D8, D10' and D11 the appellant has argued that the presence or absence of Mo was of little or no influence on the formability i.e. on the r-value of the stainless steel sheet but was known to improve the corrosion resistance. The technical disclosure of D4 and D2 could therefore be simply transferred to the Mo-bearings steels claimed in the patent.

According to the patent specification, however, the Mo-range has been selected to achieve an improvement in the corrosion resistance without running the risk of degrading the workability. Moreover, Mo is found to interact with Cr. Both elements contribute to improving pitting corrosion resistance but when surpassing a specific upper limit, hardening of the steel occurs (see the patent specification, paragraphs [0030], [0031]. Hence, the presence or absence of Mo is not a negligible technical feature in the claimed steel sheet.

3.5 Consequently, the combination of documents D4 and D2 does not lead in an obvious way to the claimed process set out in claim 5.

4. Turning to claim 1, the claimed ferritic stainless steel was considered obvious by the appellant from the disclosure of documents D7 and D12. Moreover, the technical disclosure of documents D4, D11 and D13 was taken into account.

4.1 Document D7 relates to the composition of Ti-bearing high performance ferritic stainless steel RSX-1 which falls completely within the elemental ranges and satisfies the relationship (1) defined in claim 1 of the patent at issue (see D7, Table 2 page 28). Moreover, document D7 aims at solving the same problem addressed in the patent at issue, i.e. to improve the r-value and the corrosion resistance and to minimize ridging (see D7, page 23, synopsis and column 2, first full paragraph; page 24, column 1, lines 2 to 7). A high r-value and low ridging are achieved simultaneously by adopting an ultra-low C, low N steel composition. High formability, corrosion resistance and weldability are obtained by adding appropriate amounts of Ti for stabilising C and N and of molybdenum (see D7, page 25, column 1, lines 5 to 9; page 26, column 1, lines 3 to 12; Figure 6). As to further improve the r-value and the ridging property, the hot and cold rolling conditions have been optimised without, however, reporting any details about the reduction rates during hot and cold rolling and the annealing temperatures (see D7, point 4: Study of the production process; page 25, column 2, line 1 to 22). As further disclosed in D7, Table 3, an r-value of 1.50 for RSX-1 steel sheet is achieved at maximum. Therefore this document qualifies as the closest prior art.

The ferritic stainless steel sheet according to claim 1 differs from the RSX-1 steel sheet of D7 by

(i) an average r-value of at least 2.2 and

(ii) a ferrite crystal grain size number of at least 6.0 not reported in D7.

Starting from the technical disclosure of D7 as the closest prior art, the objective problem to be solved by the patent at issue is seen in providing a ferritic stainless steel sheet exhibiting an improved formability, in particular a better deep drawability and a smooth surface quality (low roughness) after the steel has been subjected to a forming process.

The solution to this problem resides in a specific microstructure which results from the claimed process and provides an r-value ≥ 2.2 and a ferrite crystal grain size number of ≥ 6 in the finished annealed sheet.

As already emphasised in document D7, obtaining this combination of high deep-drawability and superior surface quality affords a carefully balanced steel composition (RSX-1) and a sophisticated hot and cold rolling process including very specific reduction rates and intermediate and final annealing conditions. Due to the absence of any precise data, the process parameters for hot and cold rolling and annealing used in D7 cannot be compared with those applied in the patent at issue. The Board concurs with the appellant's position that the high r-value of the claimed sheet is a mechanical property which depends on the intrinsic features of the sheet. The appellant's view that this property did not represent an essential technical feature of claim 1 can, however, not be followed. The r-value of ≥ 2.2 as a physical property reflects the existence of a specific microstructure conferred to the steel sheet by its chemical composition and through the sequences of the thermal and mechanical treatment which results in a combination of properties of deep-drawability, surface quality and corrosion resistance not achieved by the already optimized process, steel RSX-1 has been subjected to in document D7. Contrary to the appellant position, the r-value actually represents a distinguishing feature to D7 characterizing the steel sheet's formability.

4.2 Document D12 referred to by the appellant in support of lack of inventive step has been published in 2004, i.e. after the priority date of the patent at issue (cf. statement of the grounds of appeal, page 2). Hence, this document does not belong to the state of the art.

4.3 When discussing inventive step of the subject matter of claim 1, the appellant also referred to the document D4, D11 and D13.

Document D4 teaches that the r-value of Ti-stabilized low-C, N-17Cr stainless steel sheet can be improved significantly when the cold reduction exceeds 60% and reaches up to 90% (see Figure 15). It is mentioned that a maximum r-value is obtained by the optimum combination of the first and second reduction at which a cold rolled texture with {112}<110> texture as the main orientation is developed and that the r-value is decreased by the presence of structures other than

{112}<110> (see D4, page 682, column 2, first full paragraph, Figure 16: r-value below 2). The document further states that the r-value is improved as the final annealing temperature rises (see page 682, column 2, last paragraph, page 683, Figures 19 and 20: r-values up to about 2.2 maximum at 1000°C). The skilled reader is, however, dissuaded from applying such high temperatures for the final annealing in the conclusions on page 685, first column, last paragraph. Although the r-values are improved with increasing final annealing temperature, this temperature should be preferably be 850°C to forestall problems arising from grain coarsening. As shown in Figure 20, final annealing at 850°C results in an r-value of about 1.8. Thus, even when following the technical guidelines given in document D4, a ferritic stainless steel sheet exhibiting a r-value ≥ 2.2 and ferrite crystal grain size ≥ 6 is not obtained or made obvious.

Regarding document D11, the r-values disclosed in this document are below 2.0 and nothing is taught about the ferrite crystal grain size number of the microstructure in the finally annealed product (see Table 1: composition; Table 2, Lankford value).

Document D13 is concerned with a 17Cr-6.5Ni austenitic stainless steel type 301 which is outside the claimed ferritic stainless steel composition. The document merely teaches that roughness of the surface is a major influence on pitting corrosion (see D13, page 1665, introduction, second paragraph).

4.4 Hence, even if the technical contents of documents D4 and/or D11 or D13 were taken into account when assessing inventive step on the basis of document D7 as the closest prior art, the subject matter of claim 1 is not immediately obvious therefrom.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

V. Commare T. Kriner