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Datasheet for the decision of 16 March 2010

Case Number: T 0953/08 - 3.2.08

Application Number: 03733230.1

Publication Number: 1553198

IPC: C22C 38/00

Language of the proceedings: EN

Title of invention:
Heat-resistant ferritic stainless steel and method for production thereof

Applicant:
JFE Steel Corporation

Opponent:
-

Headword:
-

Relevant legal provisions:
-

Relevant legal provisions (EPC 1973):
EPC Art. 56

Keyword:
"Inventive step (no: main request)"
"Inventive step (yes: auxiliary request)"

Decisions cited:
-

Catchword:
-

Case Number: T 0953/08 - 3.2.08

D E C I S I O N
of the Technical Board of Appeal 3.2.08
of 16 March 2010

Appellant: JFE Steel Corporation
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 29 November 2007 refusing European application No. 03733230.1 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: T. Kriner
Members: R. Ries
A. Pignatelli

Summary of Facts and Submissions

I. The appellant (applicant) lodged an appeal against the decision of the examining division dated 29 November 2007 to refuse European patent application No. 03733230.1.

The examining division held that the subject matter of the main and the auxiliary requests then on file lacked novelty or did at least not involve an inventive step with respect to the documents

D1: EP-A-1 207 214 and

D3: EP-A-1 087 028.

II. The appeal was received at the European Patent Office on 18 January 2008 and the appeal fee was paid on the same date. The statement setting out the grounds of appeal was received on 31 March 2008.

III. Oral proceedings before the Board took place on 26 March 2008.

The appellant requested that

- the decision under appeal be set aside and
- a patent be granted
  on the basis of claims 1 to 7 according to the main request filed on 16 February 2010, or
  on the basis of claims 1 to 4 and the description pages, filed as auxiliary request during the oral proceedings.

Independent claims 1 and 5 of the main request read as follows:

"1. A ferritic stainless steel having a composition, on a % by mass basis, comprising:
C: 0.02% or less;
Si: 2.0% or less;
Mn: from 0.3% to 2.0%;
Mo: from 1.0% to 5.0%;
W: more than 2.0% and 5.0% or less;
Nb: from 5(C+N) to 1.0%,
N: 0.02% or less, and optionally
at least one element selected from the group consisting of Ti: 0.5% or less, Zr: 0.5% or less, and V: 0.5% or less, and/or
at least one element selected from the group consisting of Ni: 2.0% or less, Cu: 1.0% or less, Co: 1.0% or less, and Ca: 0.01% or less, and/or
Al: from 0.01% to 7.0%, and/or
at least one element selected from the group consisting of B: 0.01% or less, and Mg: 0.01% or less, and/or
REM: 0.1% or less,
with the balance being Fe and inevitable impurities, characterized in that
the total content of Mo and W is: (Mo + W) ≥ 4.3%,
the Cr content is more than 16.0% and 40.0% or less,
and a 0.2% proof stress at 900°C is 26 MPa or more."

"5. A method of producing a hot rolled ferritic stainless steel sheet having a 0.2% proof stress of 26 MPa or more, comprising the steps of:
adjusting the composition of molten steel comprising:
C: 0.02% or less;
Si: 2.0% or less;

Mn: from 0.3% to 2.0%;
Cr: more than 16.0% and 40.0% or less;
Mo: from 1.0% to 5.0%;
W: more than 2.0% and 5.0% or less;
wherein the total content of Mo and W: (Mo + W) ≥ 4.3%,
Nb: from 5(C+N) to 1.0%,
N: 0.02% or less, and optionally
at least one element selected from the group consisting of Ti: 0.5% or less, Zr: 0.5% or less, and V: 0.5% or less, and/or
at least one element selected from the group consisting of Ni: 2.0% or less, Cu: 1.0% or less, Co: 1.0% or less, and Ca: 0.01% or less, and/or
Al: from 0.01% to 7.0%, and/or
at least one element selected from the group consisting of B: 0.01% or less and Mg: 0.01% or less, and/or
REM: 0.1% or less,
with the balance being Fe and inevitable impurities to provide a steel slab, hot rolling the slab, and annealing and pickling the hot rolled sheet, as required."

Claim 1 of the auxiliary request reads as follows:

"A ferritic stainless steel having a composition, on a % by mass basis, consisting of
C: 0.02% or less;
Si: 2.0% or less;
Mn: from 0.3% to 2.0%;
Cr: more than 16.0% and 40.0% or less,
Mo: from 1.0% to 5.0%;
W: more than 2.0% and 5.0% or less;
the total content of Mo and W is: (Mo + W) ≥ 4.3%,
Nb: from 5(C+N) to 1.0%,

Al: from 0.5% to 7.0%
N: 0.02% or less, and optionally
at least one element selected from the group consisting of Ti: 0.5% or less, Zr: 0.5% or less, and V: 0.5% or less, and/or
at least one element selected from the group consisting of Ni: 2.0% or less, Cu: 1.0% or less, Co: 1.0% or less, and Ca: 0.01% or less, and/or
at least one element selected from the group consisting of B: 0.01% or less, and Mg: 0.01% or less, and/or
REM: 0.1% or less,
with the balance being Fe and inevitable impurities, and having a 0.2% proof stress at 900°C of 26 MPa or more."

IV. The appellant's arguments are summarized as follows:

The ferritic stainless steel composition set out in claim 1 of the main request differed from that disclosed in document D1 by defining a chromium content of more than 16%, by the proviso of (Mo + W) ≥ 4.3% and by exhibiting a 0.2% proof stress at 900°C of ≥ 26 MPa. The novelty of the claimed steel composition over the disclosure of document D3 was established by defining a Mn-content of 0.3 to 2.0% and a 0.2% proof stress at 900° of 26 MPa or more.

Starting from document D1 representing the closest prior art, the technical problem underlying the present application resided in providing a ferritic stainless steel having an improved oxidation resistance, a better high temperature strength and sufficient formability. The solution to this problem consisted in the distinguishing features set out above.

To solve this problem and in view of document D1, the skilled person was not obviously prompted to increase the Cr content to more than 16%. On the contrary, the skilled person was warned by the explanations set out in D1, paragraph [0029] that chromium contents higher than 16% promoted the precipitation of Laves phase which hardened the steel and impaired its formability. The presence of Laves phase was also taught in D1, paragraphs [0014] and [0048] not to contribute to the high temperature strength and, therefore, should be reduced as much as possible.

In addition, document D1 did not provide any hint as to controlling the amounts of tungsten and molybdenum which in the claimed steel were defined to satisfy the proviso of (Mo + W) ≥ 4.3% to improve the oxidation resistance at high temperature.

Hence, the subject matter of claim 1 was novel and involved an inventive step over the disclosure of document D1.

Document D3 was more remote given that it was essentially concerned with a high-Cr steel composition having an excellent long term creep strength a temperatures exceeding 650°C and an improved oxidation resistance.

Turning to the auxiliary request, the restriction of the range of aluminium for 0.5 to 7.0% set out in claim 1 resulted in a significant improvement of the high temperature salt corrosion resistance, as was mentioned on page 5, first line, page 14, lines 15 to

25 and was apparent from the test results of examples 22 to 25 and 30 listed in Tables 3 and 4. Neither of documents D1 and D3 comprised a pointer to do so in order to solve this problem. Hence the subject matter of claim 1 of the auxiliary request was novel and involved an inventive step.

Reasons for the Decision

1. The appeal is admissible.

2. *Main request*

2.1 Novelty

Like the present application, document D1 is concerned with a heat-resistant ferritic stainless steel which exhibits a high resistance to oxidation at temperatures of 900°C to 1000°C and is used for producing exhaust pipes of automobiles, casings for catalysts etc. (see e.g. D1, [0001]). The chromium content of the alloy is restricted to about 16% to guarantee that the steel has malleablility and superior formability at room temperature. Moreover, the lower limit for the total of (1.5% Mo + 0.5% W) ≥ 2.0% is disclosed as a preferred embodiment of the known alloy set out in claims 1, 2 and 5, in particular to increase the high-temperature proof stress $\sigma_{0.2 \text{ at } 900^\circ C}$ to at least 17 MPa or higher (see D1, paragraph [0007], [0033] and [0042]).

The composition of the claimed ferritic stainless steel differs from that in D1 by comprising

(a) more than 16 to 40% Cr,
(b) the proviso of (Mo + W) ≥ 4.3% and
(c) a 0.2% proof stress at 900°C ($\sigma_{0.2\ at\ 900°C}$) ≥ 26 MPa.

The subject matter of claim 1 and of method claim 5 of the main request is, therefore, novel over D1.

2.2 Inventive step

2.2.1 Like the effect of chromium on the steel's performance elucidated in paragraph [0029] of document D1, the passage on page 9 of the application as filed reflects that a good formability of the steel at room temperature could not be achieved unless the Cr content is restricted to about 16%. However, the passage also states that Cr should be desirably more than 16%, if the high temperature oxidation resistance of the steel should be improved and a low formability at room temperature is of minor importance. The beneficial effect of higher chromium contents (i.e. feature (a): Cr > 16%) upon the corrosion resistance is generally known in the art of metallurgy. Adding Cr in amounts higher than 16% is therefore close at hand for the skilled person faced with the problem of improving the high-temperature oxidation resistance of the ferritic steel composition known from D1 provided that a lower formability can be tolerated.

It is noted in this context that the examples 23 to 25, 30, 33 (and also 35) in Table 3 of the present application comprise chromium in amounts ranging between 16.2 to 16.8% i.e. in amounts close to or slightly above the upper limit of about 16% Cr specified in document D1. In the Board's view and compared to the known ferritic steel composition, such a small difference in the Cr content is not expected to promote the precipitation of the Laves phase so as to significantly harden the steel and to impair its formability. Moreover, the application does not comprise any comparative data or evidence in support of the appellant's allegation that the formability of the claimed ferritic steel composition remained essentially unchanged or was actually better than that of the steel of the prior art D1. The appellant's arguments in that respect are therefore not convincing.

2.2.2 Turning to feature (b), document D1 teaches the addition of tungsten in the range of 0.80% to 5.00% in order to increase the high-temperature proof stress $\sigma_{0.2 \text{ at } 900°C}$ and the high-temperature heat resistance of the ferritic stainless steels (see D1, paragraph [0042]). Should the room temperature formability not be impaired, the upper limit for tungsten in the steel is restricted to preferably 3.00%. If, as for the claimed composition, the ferritic stainless steel should exhibit a high resistance to oxidation at high temperatures rather than a high formability at room temperature, the skilled metallurgist would seriously contemplate adding tungsten in amounts up to about 3% or even above this to meet such requirement. Moreover, the known amount of "about 3% W" essentially complies with the composition of the examples 22 to 33 according to the present application comprising 2.81 to 3.52% W.

The same considerations apply to the addition of molybdenum. The skilled reader is taught by document D1, paragraph [0033] that the corrosion resistance and the high-temperature proof stress are effectively increased by adding 0.80%, preferably 1.50% Mo or more. In order to prevent hardening of the steel, a maximum of 3.00% should be adhered to. According to the preferred composition of the known steel set out in claims 2 and 6 of D1, the total of (Mo + W) should range from 2.0 and 6 % which overlaps the range of (Mo + W) ≥ 4.3 set out in claim 1 of the main request. Moreover, example 25 in Table 1 of D1 comprises a total of 4.2% (Mo + W) and a $\sigma_{0.2 \text{ at } 900°C}$ of 25 MPa, which is close to the claimed proviso of (Mo + W) ≥ 4.3% and the claimed $\sigma_{0.2 \text{ at } 900°C}$ ≥ 26 MPa, respectively.

2.2.3 The high temperature proof stress $\sigma_{0.2 \text{ at } 900°C}$ ≥ 26 MPa (feature (c)) is not rated as representing an independent technical feature but rather more results in particular from the added amounts of molybdenum and tungsten. Moreover, the beneficial effect of Mo and W on increasing the high temperature proof stress is amply disclosed in D1, page 6, lines 3, 4 and line 50.

2.2.4 Given that none of the distinguishing features (a) to (c) justifies the presence of an inventive step over the disclosure of document D1, claim 1 of the main request is not allowable.

2.3 The same reasoning is true for method claim 5 which, apart from the ferritic steel composition, merely comprises typical process features for producing steel sheet which comply with the process steps disclosed in D1, paragraph [0050]. Hence, the subject matter of claim 5 does not involve an inventive step either.

Consequently, independent claims 1 and 5 according to the main request are not allowable for lack of inventive step of their subject matter over D1.

3. Auxiliary request

3.1 Novelty

In addition to the distinguishing features (a) to (c) identified above, the composition of the ferritic steel according to claim 1 of the auxiliary comprises 0.5 to 7.0% Al. This limitation of the aluminium content is supported by the technical explanations given on page 14, lines 15 to 25 of the application as originally filed and, therefore, satisfy the requirements of Article 123(2) EPC.

Neither of documents D1 and D3 discloses this range for Al. In D1, aluminium is added in amounts ranging from 0.02 to 0.50% (see for instance D1, claims 8 to 11) and D3 remains silent on the presence of Al.

3.2 Inventive step

Starting from the disclosure of D1 as representing the most promising starting point, the objective technical problem underlying the claimed steel composition essentially resides in improving the alloy's resistance to salt corrosion at high temperatures.

Following the technical explanations given in the application as filed on page 14, last paragraph and also on page 5, first line, the resistance to salt corrosion at high temperatures significantly improves with increasing amounts of Al in the claimed ferritic steel composition. This finding is supported by the corrosion test results for examples 23 to 25 and 30 showing that the weight change of the test specimen affected by the salt corrosion is drastically reduced by adding Al in amounts higher than 0.5% and up to 4.85% Al (sample 25). The test results thus confirm the conclusion that the restricted range for Al has been selected on purpose rather than by guesswork.

By contrast, the identified technical problem is not addressed in any of documents D1 and D3. According to D1, paragraph [0043], Al if added intentionally functions as forming a scale protecting the surface during welding and as improving the toughness of the welded zone. If however the Al content exceeds 0.5%, the degradation of the workability becomes significant and, therefore, Al is limited to 0.5% or less or more preferably to 0.03 to 0.20%.

Document D3 does not even remotely address the presence of aluminium and it influence on the overall properties of the high-Cr ferritic steel.

3.3 Given that the prior art D1 and D3 does not provide any helpful pointer as to how the identified technical problem could be successfully solved, the subject matter of claim 1 of the auxiliary request involves an inventive step.

3.4 The dependent claims 2 to 4 relate to preferred embodiments of the ferritic stainless steel set out in claim 1 and are therefore likewise allowable.

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 grant a patent in the following version:

Claims:	1 to 4 filed during the oral proceedings as auxiliary request 1;
Description:	pages 1 to 4, 10 to 13, 15, 16, 18, 19, 21, 24 as originally filed; pages 5, 8, 9, 14, 17, 20, 22, 23, 25 to 28 filed during the oral proceedings; (pages 6, 7 as originally filed deleted);
Drawings:	Figures 1 and 2 as originally filed.

The Registrar: The Chairman:

V. Commare T. Kriner