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Datasheet for the decision of 22 October 2008

Case Number: T 0379/07 - 3.2.03

Application Number: 01971500.2

Publication Number: 1326723

IPC: B22D 11/06

Language of the proceedings: EN

Title of invention:
A method of producing steel

Applicant:
NUCOR CORPORATION

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Relevant legal provisions (EPC 1973):
-

Keyword:
"Inventive step (yes)"

Decisions cited:
-

Catchword:
-

Case Number: T 0379/07 - 3.2.03

D E C I S I O N
of the Technical Board of Appeal 3.2.03
of 22 October 2008

Appellant: NUCOR CORPORATION
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 9 October 2006 refusing European application No. 01971500.2 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: U. Krause
Members: G. Ashley
K. Garnett

Summary of Facts and Submissions

I. This appeal lies from the decision of the Examining Division to refuse European patent application EP-A-01 971 500 for lack of novelty and inventive step.

II. The decision was posted by the Examining Division on 9 October 2006; the Appellant (Applicant) filed notice of appeal on 11 December 2006, having paid the appeal fee on 7 December 2006; a statement containing the grounds of appeal was filed on 16 February 2007.

III. In accordance with Article 15(1) of the Rules of Procedure of the Boards of Appeal, the Board issued a summons to attend oral proceedings together with a preliminary opinion, setting out its views *inter alia* on novelty and inventive step. The oral proceedings were duly held on 21 and 22 October 2008.

IV. Requests

The Appellant requests that the decision under appeal be set aside and that a patent be granted on the basis of the third auxiliary request, filed during the oral proceedings on 22 October 2008.

V. Claims

Claim 1 of the third auxiliary request reads as follows:

"1. A method of producing cast steel strip in a strip casting process, comprising the steps of:

(a) continuously casting molten low carbon steel into a strip of no more than 5 mm thickness having austenite grains that are coarse grains of 100-300 micron width, the low carbon steel being a silicon/manganese killed low carbon steel with the following composition by weight:

Carbon	0.02 - 0.08%
Manganese	0.30 - 0.80%
Silicon	0.10 - 0.40%
Sulphur	0.002 - 0.05%
Aluminium	less than 0.01%

(b) hot rolling the cast strip to a thickness reduction of up to 15% and

(c) cooling the cast strip and transforming the austenite grains to ferrite in a temperature range between 850°C and 400°C;

(d) the cooling of the cast strip being controlled to provide a desired yield strength in the cast strip by selecting the cooling rate so that:

(i) the cooling rate in step (c) is in the range 15-100°C/sec in order to produce cooled strip that has a microstructure that is a mixture of polygonal ferrite and bainite and has a yield strength in the range of 300-450 MPa; or

(ii) the cooling rate in step (c) is at least 100°C/sec in order to produce cooled strip that has a microstructure that is a mixture of polygonal ferrite, bainite and martensite and has a yield strength of at least 450 MPa."

Dependent claims 2 to 5 concern preferred embodiments of the method of claim 1.

VI. Prior Art

The following documents, cited in the examination proceedings, are of relevance for this decision:

D1: WO-A-98/57767

D11: WO-A-00/42228

D12: W. Blejde, R. Mahapatra & H. Fukase, "Application of Fundamental Research at Project "M", The Belton Memorial Symposium, Sydney, Australia 10-11 January 2000.

VII. Submissions of the Appellant

(a) Document D12

Referring to the research paper D12, the Appellant emphasised that the comments on page 47 only refer to the "potential" of strip casting to produce a broad range of properties because of the coarse austenite grain structure, and schematic Figure 19 only discloses the "potential" effect of strip cooling rates on yield strength. This part of the disclosure in D12 merely gives an insight into where the authors thought the technology would be going in the future, and would have been seen as pure speculation by the audience. The step of going from the musings of D12 to the claimed method is large.

In particular, D12 implies that it does not matter whether aluminium or silicon killed steels are used, whereas the Appellant has found that the free oxygen produced in silicon/manganese killed steels is important for the nucleation of the desired transformation phases.

The effectiveness of the process when using silicon/manganese killed steels enables hot rolling up to 15% to be used, which in turn provides the steel with improved surface properties and removes porosity. This is utterly contrary to the teaching of D12, which discloses that a coarse austenite grain size is needed for strip cooling to produce low temperature transformation microstructures, particularly those comprising bainite and martensite; the effect of hot rolling would be to break up the austenite grains. The skilled person is thus taught away from employing any hot rolling step.

Although hot rolling is commonly used to reduce porosity in cast strip, the skilled person would employ alternative means for achieving this effect, such as modifying the solidification conditions, in order to retain the large austenite grain size.

(b) Document D1

Hot rolling of cast steel strip to provide a thickness reduction of less than 15% is disclosed in D1 to reduce porosity. However, at page 3, lines 9 to 12 it is said that the phase transformation features of coarse grain austenite, which form during the continuous casting process without hot rolling are exploited by controlled cooling and coiling. In order to produce steels having modest yield stresses, the steel chemistry is changed (page 4, lines 30 to 35), yet all of the compositions relate to aluminium killed steels. There is no indication that an even higher yield stress can be achieved whilst still using hot rolling and that this can be brought about by using silicon/manganese killed steels.

(c) Document D11

D11 concerns strip casting plain carbon steel and discloses an optional hot rolling step with a reduction of up to 40%, and there is a single disclosure of 36%. Hot rolling to this degree results in refinement of the austenite grains; there is no disclosure in D11 of the high yield strengths of claim 1 in combination with hot rolling.

Reasons for the Decision

1. The appeal is admissible.

2. *Article 123(2) EPC*

Claim 1 of the third auxiliary request is based upon claims 1, 6, 11, 12 and 14 of the application as originally filed (WO-A-02/26422), and hence the requirements of Article 123(2) have been met.

3. *Novelty (Article 54 EPC)*

Claim 1 of the third auxiliary request before the Board is considered to be novel for the following reasons.

D1 concerns the casting of a low carbon aluminium-killed steels having an aluminium content of 0.01 to 0.05%. Since claim 1 is directed to a silicon/manganese killed steel with an aluminium content of less than 0.01%, the claimed method is novel over the disclosure of D1.

D11 discloses the strip casting of coarse grained silicon/manganese killed steel. After an optional hot rolling step, the strip is cold rolled to give it a high tensile strength of at least 680 MPa. The hot rolling of D11 is said to produce a thickness reduction of not more than 40% (page 5, lines 18 to 21) and examples of 36% (page 9 lines 23 to 26) and 25% (page 12, lines 2 to 4) are given; this implies that when employed, hot rolling is carried out to a greater degree than is defined in claim 1. The microstructure resulting from the method of D11 is said to be a mixture of polygonal ferrite and Widmanstatten and acicular ferrite (page 7, line 31 to page 8, line 2); there is no indication that bainite or martensite, as required by claim 1, are formed. The method of claim 1 is therefore novel in light of D11.

Claim 1 of the third auxiliary request before the Board corresponds in substance to the fifth auxiliary request in the examination proceedings. The Examining Division considered that the claim lacked novelty, since the starting material and the process conditions of claim 1 and D11 were the same, and consequently the same microstructure would inevitably follow. However, D11 fails to disclose the combination of hot rolling and cooling that would result in a bainitic or martensitic microstructure, and given that the microstructure in D11 is said to be a mixture of polygonal ferrite and Widmanstatten and acicular ferrite, it is not inevitable that a low temperature transformation products would be formed.

4. *Inventive Step (Article 56 EPC)*

4.1 Claim 1 concerns a method for producing cast steel strip having microstructures that include low temperature transformation products, and which consequently exhibit high yield strengths.

Document D12 is a paper about continuous strip casting that was presented at a symposium in January 2000. The section "Microstructure Evolution and Properties" towards the end of the paper concerns the development of microstructure during strip casting low carbon steel, as does claim 1. D12 thus provides an appropriate starting point for the assessment of inventive step. As argued by the Appellant, the task facing the skilled person reading D12 is how to put its teachings into practice.

4.2 In the introduction to the paper (sentence bridging first and second columns on page 43) it is said that, "since 1999, development has concentrated on production of thinner gauge material (< 1.4 mm)" and in the Process Overview (also on page 43) reference is made to Table 1, which indicates a strip thickness of 1.6 mm.

It is therefore clear that D12 is directed to strip casting material having a thickness in the claimed range of no more than 5 mm.

4.3 In the section "microstructure evolution " (page 47) it is explained that the microstructures observed in strip casting are the inevitable outcome of the coarse austenite grain size that is inherent to a strip casting process; Figure 18 shows examples of austenite grains having sizes between 100 and 140 µm, ie within the claimed range of 100 to 300 µm. D12 goes on to teach (see "properties" on page 47) that "unlike conventional processes, in which chemistry changes are necessary to produce a broad range of properties, strip casting has the potential to achieve the same outcome with a single chemistry because of its unique coarser austenitic grain structure". Here the message to the skilled person is that coarse austenite grains can be transformed into a wide range of microstructures from polygonal ferrite to martensite (see last paragraph of the section "properties" and Figure 20), depending upon the cooling rate of the cast strip.

Mechanical properties of a steel, such as tensile strength and yield strength, are principally derived from its microstructure, with low temperature transformation structures such as martensite and bainite, giving rise to higher values; Figure 20 of D12 shows, for example, how tensile strength relates to microstructure. This is also reflected in Figure 19 of D12 (page 47), which shows that yield strength increases along with an increase in cooling rate of the strip. Although no values can be derived from Figure 19, it is clear that yield strength is more responsive to cooling rate in strip casting than in conventional hot strip mills.

A microstructure containing low temperature transformation products is obtained by appropriate choice of cooling rate, which itself can be determined by routine experimentation. The mechanical properties, including the yield strengths defined in (d)(i) and (d)(ii) of claim 1 are a consequence of the given microstructures. Thus, the microstructures defined in claim 1 and the resultant yield strengths can be achieved without difficulty by the skilled person merely by determining suitable cooling for the cast strip.

4.4 Claim 1 also requires "hot rolling the cast strip to a thickness reduction of up to 15%". The Examining Division considered that this is an optional step as no lower limit is defined. The Board disagrees with this view, because on the plain meaning of the wording, the skilled person would understand that a step of hot rolling is deliberately carried out, with the amount of reduction limited to 15%.

D12 makes no mention of hot rolling, and the Board agrees with the argument of the Appellant that carrying out hot rolling would be contrary to the teaching of D12. According to D12, the ability to produce a wide range of microstructures from a single chemistry steel and the enhanced effect of strip cooling on producing low temperature transformation products, is a consequence of the coarse austenite grain size present in the cast strip. The effect of hot rolling generally is to reduce the austenite grain size, and given that

that large grains are essential for the process of D12, the skilled person would tend to avoid hot rolling.

Hot rolling is, however, known in the context of strip casting. For example, D11 envisages hot rolling to a thickness reduction of not more than 40% (page 5, lines 18 to 21), and two values, namely 36% and 25%, are cited (see page 9, lines 23 to 26 and page 12, lines 2 to 4 respectively). D11 discloses (page 7, line 31 to page 8, line 10) that large austenite grains (150 to 250 µm, ie within the claimed range) result in a microstructure consisting of polygonal ferrite and Widmanstatten/acicular ferrite; however a hot reduction of over 30% results in a predominantly polygonal ferrite microstructure. There is no indication that a microstructure containing transformation products, such as bainite or martensite, as required in claim 1, could be achieved if the strip were hot rolled.

D1, which concerns strip casting aluminium-killed steels, discloses up to 15% hot rolling of the cast strip in order to reduce porosity. The yield strengths (examples A to C on pages 6 and 7) are generally lower than those defined in claim 1, and it is not apparent that higher values could be obtained. In particular, there is no indication that such values could be achieved if hot rolling is carried out.

4.5 The teaching of the prior art is therefore that hot rolling is incompatible with the desire to have high yield strength. The Appellant submitted that, in contrast to the aluminium-killed steel of D1, a silicon/manganese killed steel is more susceptible to forming low temperature transformation products which lead to higher yield strengths. By using a silicon/manganese killed steel, a small amount of hot rolling (up to 15%) in order to reduce porosity and improve surface finish can be tolerated whilst retaining the ability to form low temperature transformation products. On the basis of the documents before the Board, there is no reason to doubt the submission of the Appellant.

Starting from D12 the skilled person would avoid introducing a hot rolling step and would seek to reduce porosity, for example, by adjusting the solidification conditions in the casting rolls. Since none of the available prior art documents indicate how hot rolling could be accommodated in strip casting steel with a microstructure based on low temperature transformation products, the claimed method has an inventive step.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the Examining Division with the order to grant a patent on the basis of the third auxiliary request filed during the oral proceedings on 22 October 2008, consisting of:

   (a) Claims 1 to 5;

   (b) Description pages 1, 2, 2a and 3 to 11, as filed during the oral proceedings on 22 October 2008;

   (c) Figure sheets 1 to 3, as originally filed.

The Registrar The Chairman

A. Counillon U. Krause