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D E C I S I O N
of 22 July 2003

Case Number: T 1190/01 - 3.2.2

Application Number: 98929636.3

Publication Number: 1007248

IPC: B22D 11/06

Language of the proceedings: EN

Title of invention:
Continuous casting process for producing low carbon steel strips and strips so obtainable with good as cast mechanical properties

Applicant:
ThyssenKrupp Acciai Speciali Terni S.p.A.
Voest-Alpine Industrieanlagenbau GmbH

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 54, 56, 82, 84

Keyword:
"Novelty, inventive step, unity of invention (yes) after amendment"

Decisions cited:
-

Catchword:
-

Case Number: T 1190/01 - 3.2.2

D E C I S I O N
of the Technical Board of Appeal 3.2.2
of 22 July 2003

Appellant:
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Decision under appeal:
Decision of the Examining Division of the European Patent Office posted 10 May 2001 refusing European application No. 98929636.3 pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: W. D. Weiß
Members: R. Ries
E. J. Dufrasne

Summary of Facts and Submissions

I. This appeal is against the decision of the examining division dated 10 May 2001 to refuse European patent application No. 98 929 636.3.

The ground of refusal was that, having regard to the following documents

D1: EP-A-0 707 908

D2: WO-A-95/13155

D3: EP-A-0 706 845

D4: Metals Technology, January 1979, pages 33 to 37,

the Examining Division held that the subject matter of independent claims 1 and 2 lacked novelty, in particular with respect to document D1 or, alternatively, to document D3. Objections were also raised with respect to the unity of invention (Article 82 EPC) and to clarity (Article 84 EPC) since claim 1 defined both an "as-cast" and "hot rolled" product. Moreover, the "product-by-process" claim 2 was regarded as not being admissible.

The Examining Division argued that, apart from the contents of chromium and nickel of the alloy and the step of cooling the strip at a cooling speed of 5 to 80°C/s down to a temperature between 500 and 800°C, all other technical features of claim 1 were known from document D1. The amount of chromium and nickel were, however, found to represent merely the conventional

impurity levels for these elements, as was confirmed by document D4. In case of producing steel from scrap material, it would be practically impossible to avoid the claimed ranges for nickel and chromium.
The cooling speed in the range of 5 to 80°C/s to the claimed temperature range was held to be implicitly disclosed in document D1 because of the similarity of the caster lay-out, the steel composition and the processing conditions. Hence, the subject matter of claim 1 lacked novelty with respect to the process known from document D1. Moreover, a lack of inventive step was seen vis-à-vis the technical teaching given in documents D1 and D3. The Examining Division also held that product claims 4 and 5 were not linked by a common general inventive concept so that the unity of invention was questionable.

II. On 4 July 2001 the appellant (the co-applicants) lodged an appeal against the decision and the prescribed fee was paid on 16 July 2001. On 19 September 2001, a statement of grounds of appeal was filed.

With the grounds of appeal the appellant cited the following documents in support of his arguments:

R1: The Making, Shaping and Treating of Steel, US steel, 10th edition, 1985, pages 1069 to 1073

R2: E.T. Stephenson: "Effect of Recycling of Residuals, Processing and Properties of Carbon and Low Alloy Steels", Metallurgical Transactions A, volume 14A, March 1983, pages 343 to 353

R3: S. L. Wigman: "Demands on refining processes in thin slab casting", Steel Times November 1992, pages 516 to 518

R4: European Commission, Technical Steel Research: Report EUR 16672 EN, 1995, ISBN 92-827-5636, Luxembourg, pages 153 to 160

R5: I. Tamura: "Thermomechanical Processing of high strength low alloy steels" 1988, 3 pages.

III. Oral proceedings were held on 22 July 2003. The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the claims 1 to 3 submitted at the oral proceedings.

IV. Independent claims 1 to 3 read as follows:

"1. A process for the production of low carbon steel strips having a good combination of strength and formability, and a good weldability after the pickling by usual processes, comprising the following steps:

- casting, in a twin rolls casting machine (1) comprising pinch rolls (3), a strip with a thickness comprised between 1 and 8 mm, having the following composition as weight percentage of the total weight:

- C 0,02-0,10; Mn 0,1-0,6; Si 0,02-0,35; Al 0,01-0,05; S<0,015; P<0,02; Cr 0,05-0,35; Ni 0,05-0,3; N 0,003-0,012; and, optionally, Ti<0,03; V<0,10; Nb<0,035, the remaining part being Fe apart from unavoidable impurities;

- cooling on both sides the strip in the area comprised between the casting rolls and the pinch rolls (3), immediately downstream the casting rolls, the cooling being selected from the group consisting of water cooling and mixed water-gas cooling;

- hot deforming the strip cast through said pinch rolls (3) at a temperature comprised between 1000 and 1300°C until reaching a thickness reduction sufficient to encourage the closing of the shrinkage porosities maintaining the austenite grain dimensions larger than 150 µm, said reduction being less than 15%;
- cooling the strip at a speed > 10 °C/s down to a temperature (Tavv) comprised between 480 and 750°C; and
- coiling into a reel (5) the so obtained strip.

"2. A low carbon steel strip obtainable according to the process of claim 1, having the following composition as percent by weight:

- C 0,02-0,10; Mn 0,1-0,6; Si 0,02-0,35; Al 0,01-0,05; S<0,015; P<0,02; Cr 0,05-0,35; Ni 0,05-0,3; N 0,003-0,012; and, optionally, Ti<0,03; V<0,10; Nb<0,035, the remaining part being Fe apart from unavoidable impurities, and having a final microstructure consisting of

acicular ferrite and/or bainite: 20-50% in volume
coarse equiaxed grained ferrite: < 80% in volume
pearlite: < 2% in volume,
and the mechanical properties:
yield stress: Rs = 200 - 300 MPa
fracture stress: Rm ≥ 300 MPa
Rs/Rm ratio ≤ 0.75
total elongation ≥ 28 %
Erichsen index ≥ 11 mm."

"3. A low carbon steel strip obtainable according to the process of claim 1, having the following composition as percent by weight:

- C 0,02-0,10; Mn 0,1-0,6; Si 0,02-0,35; Al 0,01-0,05; S<0,015; P<0,02; Cr 0,05-0,35; Ni 0,05-0,3; N 0,003-0,012; and, optionally, Ti<0,03; V<0,10; Nb<0,035, the remaining part being Fe apart from unavoidable impurities; and having a final microstructure consisting of

acicular ferrite and/or bainite: > 50% in volume
coarse equiaxed grained ferrite: < 50% in volume
pearlite: < 2% in volume,
and the mechanical properties:
yield stress: Rs = 210 - 350 MPa
fracture stress: Rm > 330 MPa
Rs/Rm ratio ≤ 0.8
total elongation ≥ 22 %
Erichsen index ≥ 10 mm."

V. The appellant argued as follows:

Contrary to the position of the Examining Division in the impugned decision, the control the amounts of Cr an Ni is a successful and usual practice when producing low carbon steel sheet. By selecting the specific starting material, the target levels for Cr and Ni can be obtained in the steel melt, as is apparent from document D4. Moreover, small amounts of chromium and Ni encourage the formation of acicular ferrite and prevent the refining of the coarseness of austenitic grains, objects which are both aimed at in the claimed process.

When putting into practice the process disclosed in documents D1 to D3, the essential operational step for a person skilled in the art would be to refine the coarseness of the austenite grains when coming from the caster. Consequently, none of the resulting steel strips would provide the acicular ferrite and/or bainite plus coarse equiaxed grained ferrite structure which is obtained and claimed in the present application. Based on the teaching given in these documents, a skilled person would, therefore, not have any motivation to go into the direction suggested by the present invention and to modify the operational steps and the composition of the steel to be cast according to document D1 to D3. Novelty and inventive step of the claimed process and the products obtained by the process are, therefore, given.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

Claim 1 has been amended by defining a "closed" steel composition consisting of the compulsory and optional components with the balance being iron and unavoidable impurities. This limitation represents an admissible clarification which excludes components other than those listed from the steel alloy. In addition, claim 1 specifies the minimum austenite grain size to be larger than 150 µm after the steel strip has been hot deformed or squeezed by the pinch rolls, and defines the cooling speed of > 10°C/s down to a temperature range between

480 and 750°C. The basis for these amendments is found on page 7, lines 28 to 30 of the originally filed description.

Independent claims 2 and 3 result from a combination of originally filed claims 2, 4 and 5.

Present claims 1 to 3, therefore, satisfy the requirements of Articles 84 and 123(2) EPC.

3. *Novelty*

The process defined in claim 1 of the present application stipulates, *inter alia*, (i) to cast a twin-roll steel strip having a narrowly defined composition and (ii) to maintain the austenite grains at a size larger than 150 µm when hot deforming the strip by the pinch rolls. None of the cited documents D1 to D4 discloses the technical features (i) and (ii). The steel compositions cast according the processes disclosed in documents D1 and D2 do not comprise exemplifying heats exhibiting Cr and Ni amounts in the claimed ranges, and perform an in-line hot rolling to achieve a homogeneously refined crystal grain structure rather than coarse grains of austenite having a size of more than 150 µm as provided by the claimed process (cf. D1, page 4, lines 26 to 30; page 12, lines 44 to 48; page 13, lines 39 to 43; D2, page 10, lines 10 to 17). Document D3 is completely silent about the austenite grain size after hot deforming the cast strip through the pinch rolls.

3.1 The Examining Division referred to document D4 arguing that the claimed ranges for chromium and nickel merely represent the typical impurity level for these components.

3.2 However, there is evidence from document D3 that such a simple allegation is not justified in the present case. In particular Table 10 of document D3 discloses steel compositions comprising chromium as a residual (steel nos. 31, 33, 36, 39) and heats to which chromium has been added on purpose (steel nos. 30, 32, 34). It is evident that chromium as an impurity ranges from 10 to 30 ppm, i.e. far below the minimum limit of 500 ppm claimed in the application. This estimation is corroborated by document R4, page 156, teaching that, by using low-residual scrap in combination with iron ore sources (pig iron, pre-reduced iron etc), a high purity in metallic tramp elements in the resulting steel composition can be successfully obtained. Based on these considerations it is, therefore, concluded that the ranges for chromium (and nickel) featuring in all independent claims of the application under consideration do not simply represent the "typical" impurity levels, as set out in the impugned decision but are intentionally controlled.

3.3 As to the product claims 2 and 3, none of the cited documents discloses the metallurgical structure of the twin-roll cast low carbon steel strip featuring in these claims.

3.4 Consequently, the subject matter of independent claims 1 to 3 is novel vis-à-vis the cited prior art.

4. *Inventive step*

4.1 The patent application; problem and solution

The object of the present application is to provide a process for producing thin low-carbon twin-roll cast steel strip exhibiting a good combination of strength and ductility, a low yield/fracture stress ratio as well as a continuous pattern of the tension strain curve (good formability), allowing the effective removal of superficial oxide scale by pickling, and exhibiting a good weldability (cf. the description, page 2,lines 10 to 21; page 3, lines 22 to 29; page 8, lines 6 to 15).

These objects are achieved, as defined in claim 1, by casting a thin strip of a specifically controlled steel composition, deforming or squeezing the hot strip through the pinch rolls at a rate of less than 15% to close the shrinkage pores while maintaining the austenite grains at a size larger than 150 µm, selecting a specific cooling regimen and coiling the strip. In so doing, the desired final microstructure of the strip featuring in claims 2 and 3 and consisting of definite fractions of acicular ferrite and/or bainite and coarse equiaxed grained ferrite could be obtained and undesired phases, such as martensite and pearlite, could be minimized or avoided (cf. the application page 3, lines 16 to 19, 24 o 29; page 6, lines 15 to 29; page 7, lines 28 to 33; page 8, lines 1 to 5; page 9, lines 27 to 32).

4.2 The prior art

4.2.1 Like the application, document D1 aims at providing a twin-roll continuous casting process which can produce a thin sheet or strip of the claimed thickness and having excellent mechanical strength and ductility. However, the teaching of document D1 does not render obvious the technical features (i) and (ii) which distinguish the claimed process from that given in D1 as is shown in the following.

Particular reference is made to D1, example 7, page 15 and Tables 10 and 11 on page 16 disclosing the steel compositions A and B, the process steps and the mechanical properties of the final strip. Although the amounts of C, Si, Mn, P, S, Al and N of steels A and B in Table 10 fall within the claimed ranges, these steels do not comprise Cr or Ni in the prescribed amounts. As is evident from D1, page 5, lines 36, 37, Cr and Ni (like Cu and Sn) are tolerated merely as unavoidable residuals in steels A and B and are, therefore, not present on purpose in higher quantities.

More importantly, the process according to document D1 advocates that in-line rolling which is to be performed with a reduction ratio ranging from 5 to 50% in a temperature range in which the austenite structure exists. Contrary to the claimed process, this step is, however, performed to uniformly and finely reduce the crystal grain size of the casting to a fine grain size by a suitable rolling force (cf. D1, page 4, lines 22 to 30; page 5, lines 6 to 11; claim 1). Preferably, a reduction ratio of 20 to 50% by in-line rolling in the austenite temperature zone is used in order to obtain a thin sheet having a (final) crystal grain size between 20 and 30 µm (cf. D1, page 12, lines 39 to 48). As is apparent from all Tables, even with a reduction ratio of 0%, the grain size is always 100 µm or lower, indicating that the claimed austenite grain size of more than 150 µm has not been achieved. There is no indication anywhere in document D1 prompting the person skilled in the art to perform an in-line hot rolling of the cast strip in the austenite temperature zone in a manner to maintain the austenite grain size above 150 µm as required in the claimed process so that the objects of the present invention, in particular the desired microstructure, are achieved. Document D1 further fails to mention that a particular microstructure in the final strip is aimed at or preferred.

4.2.2 The process disclosed in document D2 strives to modify in the final steel strip the acicular ferrite and/or bainite structure which is, however, aimed at by the claimed process. To this end, document D2 proposes thermal cycling (continuous casting → cooling to transform the steel to ferrite → reheating to retransform the strip to austenite → recooling to retransform austenite to ferrite; see D2, page 2, lines 8 to 21). Although the process suggested in document D2 also provides the step of passing the strip - after casting - through reduction rolls (pinch rolls) for gauge control and the reduction of porosity, a reduction rate in the range of 20 to 50%, rather than < 15% as claimed, is performed to refine the austenite grain size. This refinement of the austenite grain size significantly increases the transformation temperature at which austenite will transform to ferrite on cooling which helps to significantly reduce the total energy consumed by the process (cf. D2, page 2, lines 29 to 32; page 3, lines 5 to 25). Therefore, the strip leaving the reduction roll stand is to exhibit an austenitic structure with a grain size of about 100 µm (cf. D2, page 10, lines 3 to 18). Document D2 even dissuades from having a coarse austenite grain size in general since the "coarse" grained austenite tends to transform to acicular ferrite or bainite leading to a poor ductility of the final strip (cf. D2, page 9, lines 21 to 27). Consequently, also the teaching of document D2 is leading away from the claimed method.

4.2.3 Document D3 is concerned with a process for producing twin-roll continuous cast steel strip having only a thin layer of oxide scale and, therefore, good surface properties. This object is achieved by holding the strip after casting in a sealed chamber 5 within an atmosphere comprising up to 5% oxygen and the balance being an inert gas (cf. D3, claim 1, page 16, lines 11 to 15). Although the strip after casting is transferred through the seal chamber by pinch rolls 6a, 6b (cf. Figure 1; page 4,lines 22 to 24; page 14, example 4, lines 8 to 10), document D3 is silent about the reduction rate performed by the pinch rolls 6a, 6b, the austenite grain size after "pinching" and the microstructure of the final strip. Hence, like D1 and D2, the teaching given in document D3 does not provide any incentive to a person skilled in the art to adhere to an austenite grain size of more than 150 µm in the strip after passing the pinch rolls so that the desired microstructure is obtained in the final strip.

4.3 The remaining documents are less relevant in that they essentially refer to the impurity level of various components observed and admitted in different countries.

4.4 Consequently, the subject matter of claim 1 involves an inventive step.

4.5 Independent product claims 2 and 3 define a low carbon steel strip exhibiting a specific composition, microstructure and level of mechanical properties. As has been previously shown, none of the cited documents discloses this combination of technical features or makes them, in particular the microstructure of the claimed strips, obvious.

Hence, the subject matter of product claims 2 and 3 is novel and involves an inventive step either vis-à-vis the technical teaching given in documents D1 to D3 for the same reasons discussed already with regard to process claim 1.

5. *Unity of invention*

It is evident from various parts of the description that the single common inventive concept underlying the present invention resides in providing a process to develop in a continuous cast thin strip, the desired microstructure consisting of acicular ferrite and/or bainite, equiaxed ferrite and only minor amounts (< 2%) of pearlite (cf. for instance the description, page 6, lines 15 to 29; page 7, lines 28 to 33). In consequence of the specific microstructure, and in particular due to the significantly low amounts of pearlite, that is stipulated in product claims 2 and 3, the low-carbon steel strip exhibits an almost continuous stress-strain diagram and an improved formability (cf. in particular Figure 12 of the application). It is, therefore, concluded that the application relates to one invention only, as required by Article 82 EPC.

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 claims 1 to 3 as submitted at the oral proceedings, the figures as originally filed and a description still to be adapted.

The Registrar: The Chairman:

V. Commare W. D. Weiß