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**Datasheet for the decision
of 18 January 2007**

Case Number: T 0546/05 - 3.2.07

Application Number: 98307632.4

Publication Number: 0903412

IPC: C21D 7/13

Language of the proceedings: EN

Title of invention:

Ultra-fine texture steel and method for producing it

Applicant:

NATIONAL RESEARCH INSTITUTE FOR METALS

Opponent:

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Headword:

-

Relevant legal provisions:

EPC Art. 54, 123(2)

Keyword:

"Extension beyond content of the application as originally
filed (main and auxiliary request - no)"

"Novelty (main and auxiliary request - no)"

Decisions cited:

-

Catchword:

-



Case Number: T 0546/05 - 3.2.07

D E C I S I O N
of the Technical Board of Appeal 3.2.07
of 18 January 2007

Appellant:

NATIONAL RESEARCH INSTITUTE FOR METALS
1-2-1 Sengen
Tsukuba-shi
Ibaraki (JP)

Representative:

Mathews, Derek Peter
Frank B. Dehn & Co.
St Bride's House
10 Salisbury Square
London EC4Y 8JD (GB)

Decision under appeal:

Decision of the Examining Division of the
European Patent Office posted 3 December 2004
refusing European application No. 98307632.4
pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: H. Meinders
Members: H. Hahn
E. Lachacinski

Summary of Facts and Submissions

- I. The applicant lodged an appeal against the decision of the Examining Division to refuse the European patent application No. 98 307 632.4.

The Examining Division held that the subject-matter of process claim 1 and product claim 5 according to the main request as filed with letter of 22 July 2004 (which comprised claims 1 to 5) and of process claim 1 according to the first auxiliary request as filed during the oral proceedings of 23 November 2004 (which comprised claims 1 to 4) lacked novelty over D2 (US-A-4 466 842), and that both claims 1 lacked an inventive step in view of the closest prior art D2 if novelty would be acknowledged.

- II. With a communication dated 13 October 2006 accompanying the summons to oral proceedings, the Board presented its preliminary opinion with respect to claims 1 to 4 of the main request (which corresponds to claims 1 to 4 of the first auxiliary request underlying the impugned decision), and claims 1 to 4 of the first auxiliary request, both requests as filed together with the grounds of appeal dated 13 April 2005.

The Board stated that it needed to be discussed what is implied by the definition "**compressing it with anvils**" of claim 1 of both requests.

The conclusion of the Examining Division, i.e. that the subject-matter of claim 1 of the present main request does not represent a selection invention with respect to the hot-working process according to D2 which

encompasses "hot forging" as an alternative, which general term "hot forging" appeared to include "anvil compression", seemed to be correct with respect to claim 1 of the main request, particularly in view of the two text book documents D4 (Metals Handbook, Ninth Edition, Vol. 14, Forming and Forging, page 41, right hand column, third paragraph) and D5 (Ullmann's Encyclopedia of Industrial Chemistry, Sixth Edition, 2003, Vol. 34, pages 101-105) which were introduced into the proceedings by the Board. The arguments appeared to apply likewise to claim 1 of the first auxiliary request. Consequently, none of the two requests appeared to comply with Article 54 EPC.

The Board further stated that provided that a request were to be considered to meet the requirements of Article 54 EPC the issue of inventive step would be dealt with by taking into consideration the problem-solution approach. Starting from the closest prior art document D2 and taking account of the technical problem to be solved - which would be based on the effect obtained by the distinguishing features - it would be discussed whether or not the available prior art rendered the subject-matter claimed obvious.

III. With fax of 18 December 2006 the appellant submitted further arguments and stated that the anvil compression in the method of the present invention is to be classified under open die forging.

IV. Oral proceedings before the Board were held on 18 January 2007.

The appellant requested that the decision under appeal be set aside and a patent be granted on the basis of the claims 1 to 4 of the main request, or alternatively that a patent be granted on the basis of the claims 1 to 4 of the auxiliary request, both requests as filed together with the grounds of appeal dated 13 April 2005.

- V. Independent claim 1 according to the main request reads as follows (emphasis added by the Board):

"1. A method for producing ultra-fine grain steel which has in its mother phase ferrite grains having a mean **grain size of not larger than 3 μm** surrounded by large angle ferrite grain boundaries having misorientation not smaller than 15° , the method comprising heating starting steel at a temperature not lower than its Ac_3 point thereby austenitizing it, then compressing it with anvils at a temperature not lower than its Ar_3 point to **a reduction ratio of not smaller than 50%**, and thereafter cooling it."

- VI. Claim 1 according to the auxiliary request differs from claim 1 of the main request in that the mean grain size is restricted to "**smaller than 2 μm** " and in that the step of compressing with anvils is restricted to a reduction ratio of "**at least 70%**".

- VII. In addition to the aforementioned documents D2, D4 and D5 the following documents were discussed:

A1 = Materials Science and Technology, Vol. 17, December 2001, pages 1580-1588: "Effect of plastic strain on grain size of ferrite transformed from deformed austenite in Si-Mn steel", T. Inoue et al.

A2 = Graph "Comparison of strain between rolling and anvil compression",
as submitted by the appellant with its letter dated
22 July 2004

VIII. The appellant argued essentially as follows:

Claim 1 of the main request corresponds to claim 9, as dependent upon claim 6 of the application as originally filed while the dependent claims 2 to 4 are identical to claims 7, 8 and 10, respectively of that application. The dependencies of claims 7 to 10 as filed upon claim 6 and each other provide basis for the combinations of the subject-matter of claims 1 to 4 of the main request.

Claim 1 of the auxiliary request contains the same features as the main request and is further limited to a grain size smaller than 2 μm and a reduction ratio of at least 70%. Basis can be found at page 15, lines 11 to 13 of the application as originally filed. Therefore both requests meet the requirements of Article 123(2) EPC.

It is disputed that the subject-matter of method claim 1 is known from D2 which does not disclose any deformation by anvils (see column 6, lines 7 and 8). D2 only discloses the hot-rolling of steel sheet to produce ferritic steel having ultra-fine grains. Said hot-rolling is carried out during cooling from a temperature higher than the Ar_3 point and during the final stage of hot-rolling the steel is subjected to one or more workings with a total reduction ratio of at least 50%, according to the examples of 58%. The

working occurs at a temperature at approximately the Ar_1 point and preferably from the Ar_1 point plus $50^\circ C$ to the Ar_3 point plus $100^\circ C$ (see column 3, lines 51 to 63).

Hot forging as mentioned in D2 is defined as mechanically working or deforming a single piece of hot metal and covers a number of possible methods. Among those are closed die forging and open die forging as apparent from D5 which also discloses that the forging plants can be operated by compression (presses) or impact (hammers) (see pages 101 to 103, paragraphs 4.2.3.1 and 4.2.3.2).

Consequently, the generic disclosure of hot forging in D2 does not deprive the specific anvil compression in the method of claim 1 (which is to be classified under open die forging) of novelty. Furthermore, even when selecting open die forging the skilled person is confronted with a further choice between presses or hammers. The process according to the application uses a hydraulic oil compression of the anvils. Thus there is no clear and unambiguous disclosure of anvil compression, wherein the compression occurs from both sides on the workpiece (compare page 14, last paragraph and figures 4 and 5 of the present application), in D2. The strain introduced into the material per single pass is generally about 5% in a hot hammer forging process while that introduced by anvil compression is at least about 70% in a single pass. However, it is admitted that no evidence for proving this allegation has been submitted.

As apparent from the graph A2 a strain in excess of 2 can be introduced to the center portion of a material

at a reduction ratio of 50% with anvil compression which corresponds to a reduction ratio of approx. 85% for general hot forging which generally is performed at a higher temperature than anvil compression so that strain disappears immediately and the crystal grains grow rather than collapse.

Consequently, the high temperatures used in hot forging do not produce ultra-fine ferrite grains. In contrast, anvil compression of austenite grains causes their collapse to a pancake-like morphology from which then ultra-fine ferrite grains are formed. In hot forging the austenite grains would recrystallise to return to crystal grains of the original size.

D2 does also not disclose that the ferrite grains are surrounded by large angle ferrite boundaries having the required misorientation. The reasoning of the Examining Division that there is no difference between said misorientation of not smaller than 15° and the disclosure in D2 of grain boundaries having large inclination angles (see column 12, lines 31 and 32) cannot be followed since these angles and misorientations are undefined so that it cannot be concluded that the clear and unambiguous result of the method of D2 provides the required large angle ferrite grain boundaries of claim 1. The only specific discussion of crystal orientation in D2 relates to Figures 8 and 9 at column 11, lines 52 to 63 but these grains have an average diameter of 4 μm , which is excluded by claim 1. Thus claim 1 of the main request is novel over D2.

The reduction ratio of at least 70% provides unique results compared to D2 where all examples were made with a reduction ratio of 58% using multiple pass rolling. Figure 1 of D2 mentions only rolling techniques among which only wire rod rolling achieves a cumulative reduction ratio of about 90% corresponding to a cumulative strain of about 2.3. From the graph A2 it is clear that a reduction ratio of about 70% based on the anvil compression process produces a strain of about 4 which is nowhere suggested in D2. From the scientific paper A1 (see page 1587, left hand column, first paragraph, last sentence and figure 18) it is clear that with a plastic strain of more than about 2.5 can be introduced into the material fine ferrite grains of the same size will form uniformly through the material. There are no examples comprised in D2 which were made with cumulative reduction ratios above 90% which support the graphs shown in figures 2 and 6. Thus the subject-matter of claim 1 of the auxiliary request is novel over D2.

Therefore claims 1 of the main and of the auxiliary request meet the requirement of Article 54 EPC.

Reasons for the Decision

1. *Admissibility of amendments (Article 123(2) EPC)*

Main request

- 1.1 Claim 1 of the main request is based on claims 9 and 6 as originally filed and comprises the additional features that the grains are "**surrounded by large angle**

ferrite grain boundaries having misorientation not smaller than 15°" and that the temperature not lower than Ac_3 serves to "**thereby austenitizing it**".

The first feature has a basis at e.g. page 6, lines 7 to 12 and page 7, lines 7 to 10 while the latter can be derived from e.g. page 12, line 20 to page 13, line 2 and page 15, lines 1 to 5 of the application as originally filed.

Hence claim 1 of the main request meets the requirements of Article 123(2) EPC.

Auxiliary request

1.2 The amended features of a mean grain size of "**smaller than 2 μm** " and a reduction ratio of "**at least 70%**" of claim 1 of the auxiliary request have a basis at page 15, lines 11 to 13 of the application as originally filed.

Thus claim 1 of the auxiliary request meets the requirements of Article 123(2) EPC.

2. *Novelty (Article 54 EPC)*

The Board came to the conclusion that claim 1 of the more restricted auxiliary request lacks novelty over the disclosure of D2 for the following reasons:

2.1 Claim 1 of the auxiliary request comprises - identically to claim 1 of the main request - the feature "**compressing it with anvils**" which implies the use of (at least) two anvils due to the plural form "anvils".

Taking account of the description of the present application (see page 8, lines 19 to 22; page 13, lines 8 to 17; and page 14, lines 21 to 24) and of its figures 4 and 5 it is clear that a process of compressing steel material with anvils as in the definition "anvil compression" used in the description of the application falls under the definition "open die forging", as admitted by the appellant (see point III, above).

2.1.1 The said definition "compressing it with anvils" of claim 1, however, does not allow to conclusively derive whether said compression step is achieved by using a hydraulic press or by using an impact hammer, both having two rams (or anvils). The description of the application as originally filed is silent in this respect. As a first consequence of the absence of any disclosure in this respect the Board cannot accept the appellant's statement that a hydraulic press is used according to the present application. As a second consequence it is clear that both possibilities, i.e. a hydraulic press and an impact hammer - are covered by said definition since it is not possible to exclude one or the other from the two alternatives. As a further consequence the appellant's arguments that the skilled person would have to make a selection out of these two possibilities cannot be accepted.

2.1.2 The appellant argued that the strain introduced into the material per single pass is generally about 5% in a hot hammer forging process while that introduced by anvil compression is at least about 70% in a single pass. However, as the appellant did not submit any evidence for proving this allegation - as admitted in

the oral proceedings - this argument cannot be accepted by the Board.

- 2.2 D2 discloses ferritic steel having ultra-fine grains without adding a special alloying element and methods for producing the same by hot working at approximately the Ar_3 point and by one or more passes of the hot working having a total reduction ratio of at least 75% (see abstract; column 1, lines 7 to 21 and column 2, lines 50 to 53; claims 1 to 6).

The hot-working is carried out during cooling from a temperature higher than the Ac_3 point and during a final stage of hot-working said steel is subjected, at a temperature of from $(Ar_1 + 50^\circ C)$ to $(Ar_3 + 100^\circ C)$ and for less than a second, to one or more workings, the total reduction ratio being at least 50% (see claim 5).

The hot-working can be carried out using various methods such as plate rolling, but also hot extrusion and hot forging may be used and the conditions of the working step (heating, hot-rolling conditions) are desirably such that the grain diameter of austenite crystals is small (see column 5, line 65 to column 6, line 8).

- 2.2.1 All examples described in D2 were made by hot-rolling using six passes with a reduction ratio of 58% between the last two passes within a second (see Tables 2, 5 and 8). Figures 2 and 6 of D2 illustrate the relationship between the cumulative strain and the grain diameter of the ferrite crystals for specific steels and show that a one pass working produces a smaller average grain diameter than 2-10 multiple

passes. It is apparent from figure 2 that a reduction ratio of 75% or more results in an average grain diameter of ferrite crystals of 2 μm or less (see column 8, lines 9 to 11).

- 2.2.2 Since said examples were made by multiple pass hot-rolling the Board is convinced that their described microstructure does not necessarily conform to that of an open die forging step, preferably the one-pass anvil compressing step, as discussed in the present application. However, claim 1 of the auxiliary request is not limited to such a single pass compression. In any case, D2 states in the context of its examples "Since the structure of the steel ... is obtained after hot-rolling, it is evident that the substructure is formed in grains which are surrounded by boundaries having large inclination angles and, further, due to such substructure, that the dislocation density is increased and the subgrain structure is formed" (see column 11, line 52 to column 12, line 42) which by the Board is considered to be identical with the definition of the present application: "ferrite grain boundaries in which the misorientation is not smaller than 15° are referred to as large angle grain boundaries" (see present application, page 16, second paragraph).

Furthermore, as the steel composition does not limit the microstructure (see present application, page 16, penultimate paragraph) the single (one) pass hot forging method according to D2 including heating the steel material to a temperature above the A_{c3} point and hot-working said steel at a temperature in the range between A_{r3} (see column 4, lines 28 to 37) and ($A_{r3} + 100^\circ\text{C}$) is therefore considered to result in the

same structure as described in the present application wherein said open die forging step is preferably carried out in the temperature range between Ar_3 and $(Ar_3 + 200^\circ C)$ (see dependent claim 4).

Consequently, the appellant's arguments that the process according to D2 results in a different structure and that hot forging is generally performed at higher temperatures than anvil compression cannot be accepted.

- 2.2.3 A comparison of figures 2 and 6 of D2 teaches the skilled reader that single pass working and a cumulative reduction ratio of at least 95% allows to achieve an average grain diameter of the ferrite crystals of well below 2 μm , i.e. less than about 1.5 μm . D2 further states that such single pass working is preferred (see column 9, lines 43 to 48).

The appellant's arguments that D2 does not comprise examples which were made with cumulative reduction ratios above 90% which support the graphs shown in figures 2 and 6 cannot be accepted as the same holds true for the cumulative reduction ratio range between 58% and 90% which according to the interpretation based on figures 1 and 7 of D2 was achieved by wire rod rolling. Furthermore, the Board is of the opinion that in order to be able to draw up the graphs of figures 2 and 6 more experiments than are actually disclosed in D2 must have been carried out which included the use of further different hot working techniques.

- 2.2.4 From a comparison of figures 1 and 7 of D2 it is additionally clear to the skilled reader that a single

pass working resulting in a reduction ratio of at least 95% cannot be achieved by any of the suggested rolling techniques since these two graphs indicate that reverse hot rolling only achieves about 35% cumulative reduction ratio in one second, that continuous hot rolling achieves only about 60% while wire rod rolling achieves about 90% cumulative reduction ratio in one second, respectively. Hence with wire rod rolling a cumulative strain in one second of only about 2.3 can be introduced into the steel material.

2.2.5 Consequently, if the skilled reader wishes to produce steel plates having an average grain diameter of ferrite crystals of less than about 1.5 μm then he is taught by D2 that hot working the steel material in a single pass with a reduction ratio of at least 95% is necessary and that the rolling techniques are not suitable for achieving such a reduction ratio. The remaining specifically disclosed hot working methods in D2 are hot forging and hot extrusion. It is clear to the skilled person that forging is a possible route to industrially obtain such high deformation ratios.

Taking account of the fact that steel **plates** should be produced according to the invention it is evident that hot extrusion represents no viable choice. Consequently, for the production of steel plates having an average grain diameter of less than about 1.5 μm hot forging is the hot working method suggested in D2.

As the method of hot forging consists of the two alternatives of open die forging and closed die forging (compare D5, pages 101 to 103) the skilled person, for applying the teachings of D2, at least theoretically

has to select one of these two. However, as closed die forging is normally used for making large numbers of complicated three-dimensional objects it is thus excluded for producing steel plates, thus this alternative represents no choice for the skilled person.

2.2.6 It belongs to the common general knowledge of the skilled person in the technical field of metallurgy and working of metal that hammers are primarily used for the hot forging (see the text book D4, page 41, right hand column, third paragraph) and that counterblow hammers having an upper ram and a lower ram (which can be designated as anvils as referred to in the claim) which move against each other with exactly one-half of the closure speed onto the workpiece are commonly used. A counterblow hammer has the advantage compared to an anvil hammer that it requires a smaller foundation and that relatively little energy is lost through vibration (compare D4, page 42, left hand column, fourth paragraph to middle column, first paragraph).

2.2.7 Taking account of points 2.2.1, 2.2.5 and 2.2.6 above, the appellant's arguments that there is no clear and unambiguous disclosure in D2 of anvil compression, wherein the compression occurs from both sides on the workpiece cannot be accepted.

2.2.8 Furthermore, taking account of paragraphs 2.2.1 to 2.2.6 above it is clear that D2 teaches the skilled person applying his common general knowledge a method for producing ultra-fine grain steel plates which has in its mother phase ferrite grains having a mean grain size of smaller than 2 μm surrounded by large angle ferrite grain boundaries having misorientation not

smaller than 15°, wherein the starting steel material is heated to a temperature not lower than its Ac₃ point to austenitize it, and then compressing it with a counterblow hammer having two rams (anvils) at a temperature above its Ar₃ point to a reduction ratio of at least 95%, and thereafter cooling it.

- 2.2.9 Consequently, the process inherently taught to the skilled person by D2 meets all the requirements of the process of claim 1 of the auxiliary request.

Hence the subject-matter of claim 1 of the auxiliary request lacks novelty and thus does not meet the requirement of Article 54 EPC. The auxiliary request is therefore not allowable.

3. Since claim 1 of the auxiliary request is narrower in scope than claim 1 of the main request (compare point VI, above) the above conclusion with respect to claim 1 of the auxiliary request applies *mutatis mutandis* to claim 1 of the main request.

The Board therefore concludes that claim 1 of the main request does not meet the requirements of Article 54 either. Consequently, the main request is not allowable, too.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar:

The Chairman:

G. Nachtigall

H. Meinders