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D E C I S I O N
of 9 October 2002

Case Number: T 0862/99 - 3.2.2

Application Number: 95201483.5

Publication Number: 0686705

IPC: C22F 1/053

Language of the proceedings: EN

Title of invention:

Aluminium alloy plate and method for its manufacture

Applicant:

Corus Aluminium Walzprodukte GmbH

Opponent:

-

Headword:

-

Relevant legal provisions:

EPC Art. 56

Keyword:

"Inventive step (no) "

Decisions cited:

-

Catchword:

-



Case Number: T 0862/99 - 3.2.2

D E C I S I O N
of the Technical Board of Appeal 3.2.2
of 9 October 2002

Appellant: Corus Aluminium Walzprodukte GmbH
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Decision under appeal: Decision of the Examining Division of the
European Patent Office posted 8 April 1999
refusing European patent application
No. 95 201 483 pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: W. D. Weiß
Members: R. Ries
U. J. Tronser

Summary of Facts and Submissions

I. The present appeal is against the decision of the examining division to refuse European patent application 95 201 483.5 (EP-A-0 686 705) for lack of novelty with respect to the teaching given in document

D1: EP-A-0 666 333,

and for lack of inventive step having regard to the documents

D2: P. E. Magnusen et al., "Durability Assessment based on Initial Material Quality", Journal of Testing and Evaluation, volume 18, No. 1, January 1990, pages 439 and 435,

D3: US-A-5 277 719.

In the decision under appeal, the examining division reasoned that, although document D1 belonging to the state of the art under Article 54(3) EPC did not explicitly refer to the parameters of the fatigue test method E-466 and the logarithmic fatigue life as claimed in the application, Table 1 of document D1, in particular melt (coulée) B 93193, disclosed - albeit described differently - the same aluminium plates as claimed in the patent application. Hence, the novelty requirement of the subject matter of claim 1 was not met for the designated Contracting States DE, FR and GB.

Moreover, the examining division argued that, when starting from the technical teaching given in documents D2 or D3, the claimed subject matter would be obvious to the expert and, therefore, lacked an inventive step.

II. In its notice of appeal, the appellant (patent applicant) requested that the decision be set aside and that a patent be granted on the basis of amended sets of claims "A", "B", "C" or "D". Moreover, oral proceedings were requested.

III. The appeal board issued a summons to oral proceedings expressing doubts that the claimed aluminium alloy plate material could be unambiguously distinguished from that disclosed in the prior art D1 or D3 and that the claimed method comprised process steps justifying an inventive step, in particular vis-à-vis the technical teaching given in document D3.

IV. Oral proceedings took place before the appeal board on 9 October 2002.

The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the set of claims "A" (main request) or set of claims "B" (first auxiliary request), or set of claims "C" (second auxiliary request), or set of claims "D" (third auxiliary request) respectively submitted at the oral proceedings.

The independent claims 1 and 15 according to the main request read as follows:

"1. An aluminium alloy rolled plate for the manufacture of an aircraft structural member with a thickness of more than 5 cm (2 inches) having an average logarithmic fatigue life of more than 100,000 cycles, determined in accordance with ASTM test method E-466 described herein, characterized in that the density of micropores with a size larger than 80 μm in all locations of the midplane (T/2) position of the finished plate as measured by Optical Microscopy of samples in any plane perpendicular to the midplane is

less than 0.025 micropores per cm² and wherein the density of clusters of micropores with a size larger than 150 μm in all locations in the midplane (T/2) position of the finished plate as measured by Optical Microscopy of samples in any plane perpendicular to the midplane is less than 0.025 clusters per cm², manufactured without forging prior to rolling."

"15. Method of manufacture of an aluminium alloy plate with a thickness of more than 10 cm (4 inches) having an average logarithmic life of more than 100,000 cycles determined in accordance with ASTM test method E466 described herein, comprising the steps of:

- (a) preparing a melt of the alloy,
- (b) casting the melt into an ingot,
- (c) hot rolling the ingot into the plate by rolling the ingot in a plurality of passes,

characterised in that the melt is degassed before the casting to such an extent that in the solidified ingot before said hot rolling the density of micropores with a size larger than 80 μm as measured by Optical Microscopy of samples taken from the midplane (T/2) position of the ingot and perpendicular to the length direction of the ingot is less than 0.1 micropores per cm² and wherein during at least one pass of said hot rolling the ingot is rolled with a reduction ratio

$$\gamma = \frac{h_0 - h_1}{h_0}$$

in which expression h₀ is the entry thickness of the ingot in that pass and h₁ is the exit thickness in that pass, the reduction ratio γ satisfying the condition:

$$\frac{\sqrt{4(R/h_0)\gamma - \gamma^2}}{2 - \gamma} \geq 0.50$$

in which R is the radius of the work rolls of the hot rolling stand, and further wherein the ingot is formed into said plate without forging."

Independent claim 1 of the first auxiliary request ("B") differs from this wording by "a thickness of 10 cm (4 inches)", whereas method claim 14 is unchanged.

Claim 1 of the second auxiliary request "C" differs from claim 1 of the main request by "a fatigue life of more than 250,000 cycles". Method claim 12 of the second auxiliary request reads as follows:

"12. Method of manufacture of an aluminium alloy plate in accordance with any one of claims 1 to 11, comprising the steps of:

- (a) preparing a melt of the alloy,
 - (b) casting the melt into an ingot,
 - (c) hot rolling the ingot into the plate by rolling the ingot in a plurality of passes,
- characterised in that during at least one pass of said hot rolling the ingot is rolled with a reduction ratio

$$\gamma = \frac{h_0 - h_1}{h_0}$$

in which expression h_0 is the entry thickness of the ingot in that pass and h_1 is the exit thickness in that pass, the reduction ratio γ satisfying the condition:

$$\frac{\sqrt{4(R/h_0)\gamma - \gamma^2}}{2 - \gamma} \geq 0.50$$

in which R is the radius of the work rolls of the hot rolling stand, and further wherein the ingot is formed into said plate without forging."

Claim 1 of the third auxiliary request ("D") differs from claim 1 of the main request by "a thickness of 10 cm (4 inches) or more and having an average logarithmic fatigue life of more than 250,000 cycles", whereas the wording of method claim 11 corresponds to claim 12 of the second auxiliary request.

- V. The arguments of the appellant in support of the appeal can be summarized as follows:

Document D1 discloses neither the product nor the method claimed in the application because this prior art does not take into account the presence and size of clusters of micropores. Moreover, the fatigue life in example 1 of D1 was determined on the basis of the "stair-case test" that cannot be compared with results obtained by the E466 test. In example 2 and Table III of document D1, the size of the test specimen is not disclosed and, although only 4 pores were found in "B-coulée 96381", this document remains silent about the actual size of the pores. Hence, novelty of the claimed subject matter with respect to the teaching in document D1 is given.

Also document D3 is silent about the density of the largest micropores, the density of the "clusters of micropores" and the necessity to control these clusters. While the method disclosed in document D3 considers "forging" in a sufficient amount as an indispensable requirement for decreasing the microvoids fraction before rolling the pre-formed ingot into a final plate product whose thickness ranges from 3 to 10 inches, such "pre-forging" is avoided by the method claimed in the present application. The number of large micropores in a given unit area is reduced to very low levels exclusively by degassing and by hot rolling without forging as set out in claims 1 and 15 of the application. No suggestion is given anywhere in document D3 to do this. On the contrary, as shown in Figure 6 of D3, unforged 7050-T451 standard plates do not exhibit the improved fatigue lifetime obtained by pre-forging and rolling. Hence, document D3 neither implies nor suggests that the desired high average logarithmic fatigue life specified in the application could be achieved without a pre-forging step merely by rolling the degassed ingot with the reduction ratio specified in the formula featuring in claim 15 of the present application. The claimed subject matter, therefore, involves an inventive step.

Reasons for the Decision

1. The appeal complies with the provisions mentioned in Rule 65(1) EPC and is therefore admissible.
2. *Original disclosure*

The amendments to the sets of claims of all requests are based on claims 1, 4, 7, 10, 16, 18, 21 and 29 of

the application as originally filed. Hence, there are no formal objections to these claims.

3. *Main Request*

3.1 Technical background; closest prior art

The present application relates to aluminium alloy plates having a thickness ranging from 5 cm to 15 cm (2 to 6 inches) or more. Such "thick" Al-plates are used for the manufacture of aircraft structural members and, therefore, the requirements as regards the fatigue properties of such parts are very high. Compared with the fatigue properties of "thin" Al-plates, it has been observed in the art that the logarithmic average fatigue life of such "thick" Al-plates decreases as the thickness increases. Numerous studies of the fatigue properties of various Al-alloys have revealed that cracks start at sites of high stress concentrations such as secondary phase inclusions, both metallic and non-metallic, and micropores (cf. D2, page 439, right hand column, lines 4, 5, lines 20, 21). Pores are formed when gaseous components, in particular hydrogen, dissolved in the melt are released during solidification thus generating microvoids and holes in the cast ingot. Another reason for the formation of pores is seen in the "interdendritic shrinkage" phenomenon which occurs by limited liquid filling of the interdendritic regions upon solidification. In "thick" Al-plates, the volume and density of pores is concentrated in the mid-plane (T/2 location) of the longitudinal and long-transverse (L/T) directions of the cast slab because the mid-plane is the last region to solidify. It is also known in the art that improved processing results in a reduced microporosity of thick Al-plates. This technical background knowledge of the expert is amply reflected by the documents cited in the

Al publication of the application on page 2, lines 24 to 55 and also in document D3, column 2, lines 53 to 64.

In particular the latter document D3 aims at maximizing the fatigue properties of "thick" (i.e. 3 to 10 inches) Al-plate products without adversely affecting other mechanical properties such as tensile strength and ductility. Since also in D3 porosity (i.e. the size and spatial distribution of the pores) is held to trigger the crack formation and thus lower the fatigue life in the long and short transverse directions of the Al-plate products, this document suggests a method comprising (i) an effective degassing operation in combination with (ii) a forging operation to effectively reduce the microporosity prior to rolling or working (cf. D3, column 2, line 65 to column 4, line 49). As in the application under consideration, the fatigue life of the plate is determined under cyclic loading pursuant to the ASTM test method E-466 (cf. D3, column 1, lines 65 to column 2, line 2, column 5, lines 61 to 64).

The object and the test method described in document D3 and the present application being the same, this document is considered to represent the closest prior art.

3.2 Problem and solution

As mentioned in D3, it is "desirable" to reduce the porosity in the ingot to "as low a level as possible". In the ideal case, the ingot would exhibit the theoretical density, ie. would be "porous-free". The type of pores ("clusters") and the maximum limits for the size and density of micropores in the Al alloy plate product defined in claim 1 of the present application is, therefore, regarded to represent an

ideal product (a "desideratum") which possibly could not be achieved by the prior art because no suitable method of manufacture existed at the priority date of the application. In this situation, the patentability of a claim to a product achieving a "desideratum" would depend on the patentability of the method disclosed. That is, a desired product may be patentable, if the claimed method for its preparation is the first to produce it and does so in an inventive manner (see Case Law of the Boards of Appeal, 4th edition, 2001, page 132). It is, therefore, sensible to start by examining whether the method claimed in claim 15 for producing the product defined in claim 1 satisfies the requirements for patentability pursuant to Article 52 EPC.

Starting from document D3 as the closest prior art, the problem underlying the present application is the same i.e. to improve the fatigue properties of "thick" Al-plate by reducing its microposity.

The features in method claim 15 which are novel with respect to the disclosure of document D3 involve reference to

- (a) the degassing step before casting, to such an extent that the density of the micropores having a size $> 80 \mu\text{m}$ in the mid-plane is less than $0.1 \text{ micropores/cm}^2$ and
- (b) a hot-rolling step with a specific reduction ratio, whereby the entry thickness and the radius of the work rolls are taken into account.

3.3 Inventive step

The solution to this problem expressed by the distinguishing features (a) and (b) is, however, obvious to the metallurgist for the following reasons.

First it is noted that feature (a) is merely defined by the result to be achieved and not by a specific degassing technology that has been unknown in the art. Given that the interrelationship between the fatigue strength and porosity promoted by dissolved gases is widely known in the art, it has been obvious to the expert in this technical field to reduce the number and size of the pores in the finished plate to the lowest level possible (cf. D3, column 3, lines 1 to 4). To this end, document D3 proposes subjecting the molten aluminium to an "effective" degassing operation in order to minimize the hydrogen content dissolved in the melt (cf. D3, column 3, lines 7 to 10). Hence, specifying a degassing operation to the desired extent as claimed by feature (a) according to claim 15 of the application cannot support an inventive step.

Turning to feature (b), the expert knows at least from the production of "thin" Al-plate that the effect of hot reduction, e.g. by forging or rolling, is to reduce the number of pores. Since the (T/2) mid-plane of "thick" plate tends to have the highest concentration of micropores, the amount of deformation needs to be sufficiently high to reach the mid-plane area so that the micropores or "clusters of micropores" resulting from the casting process are effectively "healed". To this end, the method disclosed in document D3 includes a forging or pre-forging operation. Reference is made in this context to document D3, Figure 6, showing an improved fatigue lifetime of pre-forged Al 750-T 7451 plate in relation to standard plate produced without pre-forging. Although document D3 focuses on a working

operation by "forging" or "pre-forging", this document nevertheless envisages in column 5, lines 27 to 31, that "other kinds of ingot deformation to improve fatigue life" are to be contemplated within the scope of its teaching. Consequently, it was obvious to the skilled person, when carrying out the process described in D3, to employ other kinds of hot reduction, provided the alternative hot working technique results in a reduction ratio sufficiently high to reach the mid-plane of the ingot and to "heal" the pores. Apart from forging, such an effective hot deformation is normally achieved by hot rolling, if the rolling mill is capable of performing the desired high degree of deformation. This technical background is reflected by the formula

$$\frac{\sqrt{4(R/h_0)\gamma - \gamma^2}}{2 - \gamma} \geq 0.50$$

stipulated in method claim 15. Based on these considerations, the claimed process amounts to no more than the mere optimisation of an existing technology including rolling as an obvious alternative for forging. Hence the subject matter of claim 15 does not involve an inventive step.

For the same reason it cannot be regarded as inventive to specify in product claim 1 suitable upper limits for the density of micropores per cm² with a size larger than 80 μm and for the concentration of "clusters of micropores" in a rolled rather than a pre-forged plus rolled plate product. The expert always seeks to avoid any formation of pores or to minimize the size, number and density of pores (i.e. the spatial distribution) in the finished product. Hence, also the subject matter of product claim 1 does not involve an inventive step.

4. Auxiliary requests; sets of claims "B", "C" and "D"

4.1 Independent claims 1 of the first to third auxiliary request differ from claim 1 of the main request either by a higher thickness of the plate (4 inches, 10 cm; set of claims "B) or by a higher logarithmic fatigue life (250,000 cycles; set of claims "C") or by both features (4 inches, 10 cm, 250,000 cycles, set of claims "D").

However, the thickness range and the fatigue life claimed in independent claim 1 of the auxiliary requests fully comply with the thickness of the Al-plates produced by the method given in document D3. As shown in Figure 6 of D3 and set out in the accompanying text, a 5.7 inch thick Al-plate exhibited a fatigue life ranging from 125,000 to 2,000,000 cycles (cf. D3, column 5, lines 23 to 27; line 61 to column 6, line 23). Hence also the independent claim 1 of each of the first, second and third auxiliary request does not comprise technical features on which an inventive step could be based.

Order

For these reasons it is decided:

The appeal is dismissed.

The Registrar:


V. Commare

The Chairman:


W. D. Weiß