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Datasheet for the decision of 10 January 2008

Case Number: T 1461/05 - 3.2.03

Application Number: 99305028.5

Publication Number: 0967036

IPC: B22D 27/04

Language of the proceedings: EN

Title of invention:
Unidirectionally solidified cast article and method of making

Applicant:
GENERAL ELECTRIC COMPANY

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 52(1), 56

Relevant legal provisions (EPC 1973):
-

Keyword:
"Inventive step - no"

Decisions cited:
-

Catchword:
-

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 1461/05 - 3.2.03

D E C I S I O N
of the Technical Board of Appeal 3.2.03
of 10 January 2008

Appellant: GENERAL ELECTRIC COMPANY
1 River Road
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Representative: Goode, Ian Roy
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 13 July 2005 refusing European application No. 99305028.5 pursuant to Article 97(1) EPC.**

Composition of the Board:

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

Summary of Facts and Submissions

I. European patent application EP-A-0 967 036 concerns the casting of superalloy articles having a unidirectional crystal structure and which are substantially free of defects, particularly those known as "freckles". This appeal arises from the decision of the Examining Division to refuse the application for lack of novelty (claims 1 of the main and first auxiliary requests) and for lack inventive step (claim 2 of the second auxiliary request).

II. In its decision, the Examining Division referred to the following documents:

D11: K.O. Yu *et al* "Investment Casting of NiAl Single-Crystal Alloys", JOM, Volume 45, No.5, pages 49 to 51, May 1993.

D13: T.M. Pollock & W.H. Murphy "The Breakdown of Single-Crystal Solidification in High Refractory Nickel-Base Alloys", Metallurgical and Materials Transactions A, Volume 27A, pages 1081 to 1094, April 1996.

The Board also makes reference to the following document, which is mentioned in the introduction to the application and also was cited in the European search report.

D2: US-A-3 915 761

III. The decision was posted by the Examining Division on 13 July 2005; the Appellant (applicant) filed notice of

appeal on 6 September 2005, paying the appeal fee at the same time; a statement containing the grounds of appeal was filed on 14 November 2005.

IV. In accordance with Article 11(1) of the Rules of Procedure of the Boards of Appeal, the Board issued a preliminary opinion, together with a summons to attend oral proceedings, which set out its view on novelty and inventive step. The oral proceedings were held on 10 January 2008.

V. The Appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of a single claim, which was filed during the oral proceedings as the sole request.

VI. The claim reads as follows:

"1. A method of making a directionally solidified columnar single crystal or columnar polycrystalline article comprising the steps of: pouring a molten superalloy metal in a heated zone into a preheated mold comprising a main cavity having the shape of the cast article; withdrawing the mold with the molten superalloy metal from the heated zone into a liquid cooling tank at a withdrawal rate sufficient to solidify the molten metal to form primary dendrite arm spaces greater than or equal to 150 μm but less than or equal to 800 μm corresponding to a length of the cast article between 102 and 1016 mm (4 and 40 inches), respectively; and subsequent cooling of the mold to effect the columnar single crystallization or columnar polycrystallization or mixtures thereof that is defect free."

VII. Submissions of the Appellant

The Appellant argued that the problem underlying the invention concerns the manufacture of large components, especially for turbines, that are free of defects. In particular, known techniques do not allow a large article to be cast with a low enough primary dendritic arm spacing (pdas), which is required to limit the formation of chains of small equiaxed grains known as "freckle defects".

D13 discloses the solidification of superalloys using a conventional Bridgman-type furnace. The cast samples are only 11.5 or 14 cm long, and D13 teaches that a pdas of less than 320 μm is required in order to ensure that they are defect free.

The invention concerns castings that are up to 40" (1016 mm) long and is based on the surprising discovery that if the pdas lies within the range of 150 μm to 800 μm, the castings are essentially free of defects. According to the invention, this is achieved by withdrawing the mould containing the molten metal into a liquid cooling tank, typically containing a low melting point molten metal - a technique known as liquid metal casting (lmc).

The Appellant agreed that lmc is a well known casting technique capable of producing high thermal gradients, but argued that the skilled person would only consider employing it for smaller components; for example, in D2 it is used in the production of small 4 inch blades. According to D2, lmc is used to reduce dendrite spacing

with the aim of reducing the annealing time; there is no indication in D2 that lmc could be used in a method for eliminating defects in large castings of the order of 1 m in length. The Appellant emphasised that the skilled person would not consider employing lmc for large components because it would not be expected that the high thermal gradients obtained with small castings could also be achieved in large components; hence, the skilled person would not think it worth the trouble to adapt existing equipment for larger sizes. In the view of the Appellant, the obvious step for the skilled person starting from D13 would be to attempt to make large cast articles using a Bridgman furnace, and in doing so, he would discover that sufficiently low pdas cannot be achieved.

Consequently, it is unreasonable to consider that, starting from D13, it would be obvious to the skilled person, either using his general knowledge or the teaching of D2, that large castings manufactured by lmc would be defect free. Such a conclusion can only be reached having knowledge of the invention and with the benefit of hindsight.

Reasons for the Decision

1. The appeal is admissible.

2. The claim filed during the oral proceedings as the Appellant's sole request corresponds to claim 11 of the application as originally filed, and hence meets the requirements of Article 123(2) EPC.

3. *Inventive Step (Article 56 EPC)*

3.1 The application relates to the directional casting of columnar polycrystalline or single crystal articles made from superalloys, such as components for gas turbine engines. During the solidification process certain alloying elements may segregate into the liquid metal regions between the solidified dendrites. This interdendritic segregation can give rise to defects, such as non-uniform distribution of strengthening precipitates, interdendritic porosity and in particular surface freckles, which are chains of small equiaxed grains. Since these defects arise in the interdendritic spaces, the primary dendrite arm spacing (pdas) has a significant effect on their formation. The claimed method is directed to the prevention of these defects.

3.2 Document D11 is a paper describing the casting of NiAl alloys, which were being considered in D11 as a replacement for superalloys. It concerns the effect of thermal conditions on secondary arm spacing and the formation of equiaxed grains, and mentions that no freckles were observed in NiAl alloys being studied.

D13 is a paper reporting on investigations into the directional solidification of single crystal Ni-based superalloys. It describes the effect of the temperature gradient on pdas, formation of equiaxed grains and freckle defects. Given that this document is specifically directed to the causes of interdendritic defects in superalloys, it provides a more appropriate starting point than D11 for the assessment of inventive step.

3.3 According to the experimental procedures of D13, cylindrical bars were produced using a laboratory scale Bridgman furnace (see page 1082, left-hand column). This type of furnace has a chill plate for cooling the base of the mould, and solidification of molten metal occurs by gradually withdrawing the mould from the heated zone. The cylinders made in D13 are 11.5 cm in length, which falls within the claimed range of 10.2 cm to 101.6 cm. The paper then goes on to describe the influence of varying thermal gradients and solidification rates on the formation of grain defects in the cylinders (page 1085, left-hand column "B. Alloy SX-1…"). Figure 3 (page 1083) shows the dependency of pdas on the processing conditions, and Figure 12 (page 1088) shows the number of freckle chains as a function of the pdas. According to Figure 12, freckling occurs in those samples having a pdas of 320 μm or more, and equiaxed grains appear when the pdas is greater than about 600 μm. Thus, those samples shown in Figure 12 which have a pdas between 150 μm and 320 μm fall within the claimed range of 150 μm to 800 μm and are free of grain defects.

3.4 The sole feature that distinguishes the claimed method from the disclosure of D13 is that the samples are solidified by withdrawing the mould into a liquid coolant tank, instead of on the cooled plate of a Bridgman-type furnace.

3.5 Starting from D13 the objective problem to be solved is to find an alternative means for producing directionally solidified castings.

3.6 The teaching throughout D13 is that high thermal gradients are required in order to eliminate grain defects (see, for example, page 1085, right-hand column, second paragraph; page 1092, left-hand column, penultimate paragraph, and right-hand column, last paragraph).

The benefit of liquid cooling, particularly liquid metal cooling (lmc) as a means of achieving high thermal gradients, was initially recognised in the 1970's and is common knowledge in the art; an example of unidirectional solidification using lmc is given in D2, which is dated 1975. As explained by the Appellant, this method of cooling is used in practice for casting small articles, and hence in the view of the Board, it is a suitable and obvious method for making the cylindrical bars of D13, which are only 11.5 cm (4.5 inches) in length. The method of making articles as defined in claim 1 thus lacks an inventive step.

The Appellant's assertion that lmc is really only used for smaller castings, and that the skilled person would not consider the technique for large castings, might well be valid. However, it should be emphasised that the method of claim 1 is not restricted to the casting of large articles, as it includes those that are only 102 mm (4 inches) long; the cylinders of D13 mentioned above fall within the claimed range for the length of cast article. Thus, the arguments of the Appellant concerning the casting of large articles are of little relevance.

It might well be that the invention lies in the directional casting of large defect-free articles, but

it is not inventive to cast small articles, 102 mm long, by the claimed method.

Since the claim encompasses subject-matter that lacks an inventive step, the application does not meet the requirements of Article 52(1) EPC.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

A. Counillon U. Krause