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**Datasheet for the decision  
of 3 April 2008**

**Case Number:** T 0707/06 - 3.2.03

**Application Number:** 03005402.7

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**Title of invention:**  
Reducing casting method

**Applicant:**  
NISSIN KOGYO CO., LTD.

**Opponent:**  
-

**Headword:**  
-

**Relevant legal provisions:**  
EPC Art. 56

**Relevant legal provisions (EPC 1973):**  
-

**Keyword:**  
"Inventive step - no"

**Decisions cited:**  
T 0056/87

**Catchword:**  
-



Case Number: T 0707/06 - 3.2.03

**D E C I S I O N**  
of the Technical Board of Appeal 3.2.03  
of 3 April 2008

**Appellant:**

NISSIN KOGYO CO., LTD.  
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**Representative:**

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**Decision under appeal:**

Decision of the Examining Division of the  
European Patent Office posted 19 December 2005  
refusing European application No. 03005402.7  
pursuant to Article 97(1) EPC.

**Composition of the Board:**

**Chairman:** U. Krause  
**Members:** G. Ashley  
I. Beckedorf

## Summary of Facts and Submissions

I. European patent application EP-A-1 346 785 concerns the technique of reduction casting, which involves casting whilst reducing the oxide film formed on the surface of the molten metal. This appeal arises from the decision of the Examining Division to refuse the application for lack of novelty and/or inventive step.

II. The decision was posted by the Examining Division on 19 December 2005; the Appellant (Applicant) filed notice of appeal on 25 January 2006, paying the appeal fee at the same time; a statement containing the grounds of appeal was filed on 21 April 2006.

In accordance with Article 15(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. The oral proceedings were duly held on 3 April 2008.

III. The Appellant requests that the appeal be set aside, and a patent be granted on the basis of the application documents as originally filed (main request) or alternatively, on the basis of the claims filed on 21 April 2006 with the grounds of appeal (auxiliary request).

IV. Claims

(a) Claim 1 of the main request reads as follows:

"1. A reduction casting method, comprising the steps of:

pouring a molten metal into a cavity of a molding die in a state in which the molding die is forcibly cooled by a cooling device, whereby the molten metal is rapidly cooled;

and

performing casting while reducing an oxide film formed on the surface of the molten metal by allowing the molten metal and a reducing substance to come into contact with each other in the cavity,

wherein a solidification speed at which the molten metal is rapidly cooled is set to be 600°C/min or more; and wherein the molten metal is filled into the cavity in a filling time of from 1.0 second to 9.0 seconds."

Dependent claims 2 to 9 relate to preferred embodiments of the method of claim 1.

(b) Independent claims 1 and 2 of the auxiliary request are as follows:

"1. A reduction casting method, comprising the steps of:

pouring a molten AC2B or AC4B aluminum alloy into a cavity of a molding die is [sic] forcibly cooled by a cooling device, whereby the molten metal is rapidly cooled;

and

performing casting while reducing an oxide film formed on the surface of the molten metal by allowing the molten metal and a reducing substance to come into contact with each other in the cavity,

wherein a solidification speed at which the molten metal is rapidly cooled is set to be in a range of 600 - 2000/min [sic]; and

wherein the molten metal is filled into the cavity in a filling time of from 2.7 second to 9.0 seconds."

"2. A reduction casting method, comprising the steps of:

pouring a molten 2017, 2024 or 2618 aluminum alloy into a cavity of a molding die is [sic] forcibly cooled by a cooling device, whereby the molten metal is rapidly cooled;

and

performing casting while reducing an oxide film formed on the surface of the molten metal by allowing the molten metal and a reducing substance to come into contact with each other in the cavity,

wherein a solidification speed at which the molten metal is rapidly cooled is set to be in a range of 600 - 2000/min [sic]; and

wherein the molten metal is filled into the cavity in a filling time of from 1.2 second to 4.0 seconds."

Dependent claims 3 to 8 define preferred embodiments of the methods of claim 1 or claim 2.

V. Prior Art

The following document was cited, among others, in the disputed decision:

D1: EP-A-1 153 678

The following document was referred to in the provisional opinion of the Board as providing evidence of the general knowledge of the skilled person working in the field of casting:

D7: P. Beeley, "Foundry Technology", 2<sup>nd</sup> Edition, pages 25 and 240 to 241, Butterworth-Heineman, 2001.

## VI. Submissions of the Appellant

### (a) Main Request

The Appellant submits that D1 does not disclose the filling time of the mould, and hence the claimed method is novel.

Concerning inventive step the Appellant, citing T 56/87 OJ 1990, 188, emphasised that when investigating inventive step, the technical disclosure in a prior art document should be considered in its entirety. In the case of D1, the teaching of the document is that the cooling rate of the molten metal in the feeder head is lower than that of the metal in the mould cavity. The purpose of this is that the filling time of the mould is longer than the solidification time of the metal, so that surface defects can be avoided (paragraphs [0062], [0063] and [0065] of D1).

Claim 1 of the main requests requires an extremely short filling time, defined as 1 to 9 s; this filling time corresponds approximately to the local solidification times within the mould cavity. Since D1

requires the filling time to be longer than the solidification time, the claimed invention represents a completely different concept for solving the problem of surface defects.

The method of D1 is essentially a two-stage process, in which the mould is filled, and then on solidification a further filling from the feeder head compensates for the shrinkage of the solidified metal. However, according to the method of the invention, the mould is filled with all the molten metal, including that required for compensating shrinkage, in a single step. This is a further indication that the filling time of D1 is longer than that defined in claim 1.

The invention takes advantage of the high fluidity of the metal that results from the reduction of the oxides, however, this effect does not last long, and hence the need to complete the filling of the mould in a relatively short space of time.

The claimed method addresses the problem of reducing surface defects, whilst improving the efficiency of the process by avoiding a second filling and reducing the cycle time. The solution of filling the mould in a short time (1 to 9 seconds) would not occur to the skilled person either directly from D1, as this points in the opposite direction, as explained above, or from reading D1 in light of the general knowledge in the field of casting, as described in D7.

Textbook D7 describes several different ways by which casting imperfections caused by the failure of the metal to run properly can be avoided, of which the rate

of mould filling is only one. In particular, the present application concerns the casting of aluminium alloys, which are known to have poor fluidity (paragraph [0002] of the description). In order to ensure that such metals adequately fill the mould cavities and develops a smooth skin, D7 clearly recommends the use of high superheat and special techniques of gating, but makes no mention of filling speed in this context.

There is no clear indication derivable from either the cited prior art or from the general knowledge of the skilled person that a short mould filling time, as defined in claim 1, should be employed. The method of claim 1 therefore has an inventive step.

#### VII. Auxiliary Request

The Appellant emphasised that the invention is to reduce defects and improve efficiency by avoiding the second filling step of D1.

Independent claims 1 and 2 of the auxiliary request are directed to alloys that are particularly suitable, and the filling times defined in the claims have been especially tailored to these alloys. Since there is no indication in the prior art that reduction casting of these alloys results in the advantages of the invention, the claimed methods have an inventive step.

### **Reasons for the Decision**

1. The appeal is admissible.



*Main Request*

2. *Novelty (Article 54 EPC)*

2.1 Document D1 discloses a reduction casting method, in which a mould cavity (12b) and a feeder head (16) are filled with molten metal. The metal in the mould cavity is cooled at a rate of 500°C/min, preferably 700°C/min or more (paragraph [0047]), which corresponds to the cooling rate defined in claim 1 (600°C/min or more). The cooling rate of the metal in the feeder head of D1 is slower than that in the mould cavity (preferably by a difference of 200°C/min or more, see paragraph [0047]), thereby molten metal in the feeder head is able to fill the gap formed when the metal in the mould cavity shrinks on solidification (paragraphs [0063], [0066] and [0067]).

2.2 However, D1 makes no explicit mention of the time required to fill the mould. The Examining Division considered that a mould filling time of 1.0 to 9.0 seconds is implicit to the method of D1, because of the short time available for completion of solidification, especially as a dendritic spacing of less than 20 µm is required (paragraph [0050]).

2.3 The Appellant argues that D1 discloses a two-step process, ie the mould cavity is first filled with metal that solidifies to form a gap, which in a second step is filled with liquid metal from the feeder head. By contrast, according to the invention all filling of molten metal, including that required for compensating shrinkage, is completed in a single step within 1.0 to

9.0 seconds. The fact that filling takes place in two steps in D1, is a strong indication that the filling time is greater than 9 seconds.

However, claim 1 makes no mention how many stages are required to complete the filling; there is also no requirement in claim 1 that the mould cavity is filled with sufficient metal to compensate for shrinkage. The claim merely states that molten metal is filled into the cavity in a filling time of 1 to 9 seconds, and this can correspond to the first filling step of claim 1. It therefore cannot be concluded with any degree of certainty that the filling time of D1 is longer than 9 seconds.

2.4 On the other hand it is also not possible to derive unambiguously that the mould must be filled in less than 9 seconds, as was the view of the Examining Division. Although it is possible that such rates would be applied in view of the fast solidification rates given in paragraph [0041], this is also no disclosed with the degree of certainty necessary for a novelty objection.

2.5 The fact is that D1 is silent regarding the filling time, and any attempt to put a figure to it is mere speculation.

The method of claim 1 thus differs from that of D1 in that filling of the mould cavity takes place in a time of between 1.0 and 9.0 seconds, and hence is novel.

3. *Inventive Step (Article 56 EPC)*

3.1 The method described in the present application seeks to address the problem that, when the solidification rate is high, molten metal prematurely solidifies in the mould; this disrupts the flow of molten metal around the cavity, which leads to insufficient filling and surface defects (see paragraph [0002] of the published application). In addition, the method also seeks to shorten the cycle time of casting (paragraphs, [0006] and [0007]).

3.2 The problem of failure to flow sufficiently around a mould is particularly prevalent in aluminium alloys because of the ease by which oxide films are formed on the surface of the molten metal; these films increase surface tension which reduces the flow properties (paragraph [0002]). A solution to this problem is provided by reduction casting, in which the aluminum alloys are cast in an atmosphere that reduces the oxide film, thereby improving the ability of the molten metal to flow; this technique is described in D1 (paragraph [0012]).

3.3 D1 makes no mention of the time taken to fill the mould, hence the method of claim 1 differs in that the filling time is defined as being in the range 1.0 to 9.0 seconds.

3.4 Starting from D1, the objective problem to be solved is how to reduce the time for casting whilst preventing defects, and the question to be answered is whether or not it would be obvious to fill the mould of D1 in a

time corresponding to that of claim 1 in order to solve this problem.

3.5 As mentioned above, the defects in question arise because the metal flowing, especially into the thin sections, begins to solidify and obstruct or reduce the flow of metal so that it does not completely fill the thin section. This is a well known type of defect, often referred to as "misrun" or "short run", and is discussed in D7, which is an extract from a standard textbook on foundry technology and is considered to form part of the basic knowledge of a foundryman. At page 240 of D7, "Shaping faults arising in pouring", it is said that the first requirement of any casting process is that the liquid metal should satisfactorily fill the mould cavity. This is therefore of a fundamental nature, and the average foundryman would be expected to deal with it.

3.6 Some of the causes of misrun defects are described at page 241 (second paragraph) of D7; the first one mentioned is that of an inadequate rate of mould filling relative to the freezing rate of the casting. Faced with these defects, the skilled person would therefore consider the speed of filling relative to the cooling rate of the metal.

According to D1, the cooling rate of molten metal in the mould cavity is 500°C/min or more (preferably 700°C/min or more) (see paragraph [0047] of the published application); this is in order to produce solidified metal having a close crystal structure (paragraph [0050]). Consequently, the time for filling must also relate to this cooling rate if defects are to

be avoided. The Board agrees with the analysis of the Examining Division that, for the above conditions, the solidification time must be about 2 to 10 seconds, and consequently the filling time should also be less than 10 seconds in order to avoid surface defects of the nature described above (see page 4, first paragraph of the decision).

Hence, a filling time of between 1.0 and 9.0 seconds would be obvious given the casting requirements of D1.

- 3.7 The Appellant argues that the skilled person would not consider adapting the filling time as a way of dealing with the problem of surface defects, because D7 teaches that gating techniques and superheat should be used for alloys that have poor running characteristics.

This, however, does not apply to the alloys of D1. The method of D1 is that of reduction casting, which provides aluminium alloys with good flow characteristics; the skilled person reading D1 is not considering casting using an alloy that flows poorly, but rather the opposite (see D1, paragraph [0012]).

The skilled person would therefore not be limited just to using high superheat or to adapting the gating, as suggested by the Appellant, but would also consider the rate of filling as providing a solution, as described in D7. Nevertheless, it is well known in the art that the speed of filling is determined largely by the gating system, ie the diameter, shape, position and number of sprue or channels through which the liquid metal flows. D7 (page 25, "The gating of castings") teaches that gating must ensure that the rate and

direction of metal flow results in complete filling of the mould before freezing. Thus, the skilled person would consider the gating as a means for achieve the required filling rate. Indeed, the fast rate of filling described in the present application is also achieved by arranging appropriate gating and use of pressure, depending on the shape of the product to be cast (see paragraph [0047]).

- 3.8 The Appellant submits that the invention recognises that it is possible to take advantage of the good flow characteristics the reducing environment imparts to the metal, but since the reducing atmosphere in the mould is short lived, the mould must be filled quickly.

This advantage is also apparent to the reader of D1, since the method of D1 employs the same reducing environment as the present application. D1 teaches that the deoxidising compounds improve the fluidity so that the surface quality can be improved (paragraph [0012]), and it is clear that this can only function so long as deoxidising is taking place.

- 3.9 Citing T 56/87, the Appellant argues that the disclosure of D1 as a whole must be considered, and emphasis is made that D1 discloses a additional step of filling the mould after the metal has solidified in order to compensate for shrinkage.

The Board agrees with the Appellant that it is the teaching of a document as whole that is important, but as mentioned above, claim 1 simply requires that the mould cavity is filled in a time of between 1.0 and 9.0 seconds, and this does not exclude further processing

steps described in D1. The claimed method is thus not inconsistent with that of D1. Notwithstanding this view, it is also considered that shrinkage can be compensated for without recourse to the second filling step described in D1. It is usual in casting to provide a reservoir or riser of additional feed metal that compensates for shrinkage as the liquid metal cools and solidifies. When a mould cavity is filled, solidification generally proceeds from the mould wall and occurs first at the extremities and in thin sections. The solidification front is continuously supplied with liquid metal that compensates for shrinkage on solidification, initially from the bulk of the casting itself and then from the sprue, riser and feeder head. The last metal to solidify is in the region of the riser or feeder head. In the absence of metal flowing from a feeder head, a depression would form in the surface. In the method of D1, liquid metal does not flow from the feeder head until the bulk of the metal in the mould cavity has solidified, hence the formation of a gap. However, it is apparent that the metal in the mould would also solidify following the conventional solidification pattern, with extra liquid metal in feeder head compensating for shrinkage near the surface.

- 3.10 In summary, D1 teaches that reduction casting improves the fluidity of aluminium alloys so that casts free of surface defects can be produced, and that in order to achieve a close dendritic microstructure, a cooling rate of at least 500°C/min or more, preferably 700°C/min or more is required.

It is well known in the art that filling rate should correspond to cooling rate in order to avoid surface defects; there is no indication in the prior art that the filling rate is an inappropriate measure for preventing defects arising out of the casting method of D1. The filling rate appropriate for the cooling rate of D1 lies within the claimed range. Consequently, all the features of claim 1 are derived in an obvious manner, with the result that castings free of surface defects can be produced with a short casting cycle time. The claimed method thus lacks an inventive step.

*Auxiliary Request*

4. *Inventive Step (Article 56 EPC)*

The independent claims of the auxiliary request are directed to specific aluminium alloys and their corresponding filling times. In particular, independent claim 1 limits the metal to an AC2B or AC4B aluminium alloy, with a filling time of 2.7 to 9.0 seconds, and independent claim 2 concerns 2017, 2024 or 2618 aluminium alloys, with a filling time of 1.2 to 4.0 seconds.

It is clear that the fluidity and hence the ease by which alloys can be cast is influenced by alloying elements. Faced with the problem of applying the casting method of D1 to specific aluminium alloys, the skilled person would arrange a filling system according to well known criteria, as described above. As for the method of claim 1 of the main request, the defined time for filling is simply an indication that an appropriate filling system has been designed for casting a



particular alloy with a particular microstructure without surface defects. The limitation of the claimed subject-matter to specific alloys does not lead to an inventive step.

**Order**

**For these reasons it is decided that:**

The appeal is dismissed.

The Registrar:

The Chairman:

A. Counillon

U. Krause