**Title:** PATTERN FOR OBTAINING A CASTING BY THE LOST FOAM CASTING TECHNIQUE AND METHOD FOR MANUFACTURING SUCH PATTERN

**Abstract:** A pattern for obtaining a casting within which a duct is present through the lost foam casting technique comprising a mass of expanded material having a shape and dimensions according to the casting which is to be obtained, within which there is embedded a shaped insert (3) of refractory material in order to form a duct (2) in the said mass.
before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments. For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
DESCRIPTION

"Pattern for obtaining a casting by the lost foam casting technique and method for manufacturing such pattern"

This invention relates to a pattern of expanded material for use in the manufacture of a casting using the "LOST FOAM" casting technique.

In accordance with a further aspect the invention also relates to a method for manufacturing a pattern of expanded material for use in the manufacture of a casting through the lost foam casting technique.

As is known, the lost foam casting process is currently used to manufacture castings, that is parts of complex shape or having a plurality of cavities manufactured through a fusion process. In fact, in comparison with more conventional casting techniques the special feature of the lost foam process lies in the use of polymer foam patterns to manufacture the casting. In fact the production of a metal casting depends on the manufacture of a corresponding pattern made of polyurethane foam through an injection moulding technique. It should be pointed out that the pattern of expanded material must be a faithful copy of the metal casting which has to be produced.
Once the pattern has been completed it is covered with a refractory paint, which is generally water-based, dried and then placed in a casting box to be covered with refractory sand which is suitably vibrated and compacted. The molten metal is then poured onto the foam pattern causing thermal degradation of the expanded material of which the pattern is made and filling the volume of the pattern with the cast metal. Ultimately a perfect replica in metal of the pattern of expanded material is obtained.

One strength of the lost foam technique lies in the possibility of producing even very complex patterns in a simplified way, including patterns incorporating openings, ducts and the like such as, for example, the pattern for an engine head block to which reference will be made below in the description for the sake of simplicity.

The manufacture of complex patterns of expanded material is rendered more advantageous by the possibility of subdividing the pattern into several layers, which can be joined together by adhesive bonding before sand casting is carried out. This technique of manufacturing a complicated pattern through joining several parts or layers of expanded material is particularly advantageous where the pattern which has to be produced provides for the presence of one or more internal ducts.
In connection with patterns of expanded material manufactured through joining several parts or layers adhesively bonded together it must be pointed out that the adhesive inserted along the edges of the parts gives rise to the formation of bonding edges along the joint lines when the parts which have to be adhesively bonded are joined together by force.

Generally the presence of bonding edges corresponding to the aforesaid joint lines does not cause any problems in casting of the metal material which has to be obtained, as these are dimensional defects which do not interfere with the structure and function of the part.

There are however situations in which the dimensional variations due to the presence of the aforesaid bonding edges corresponding to the joints cannot be tolerated, because it is necessary to comply with the design geometry and dimensions. This for example occurs in the case of car engine head blocks in which the geometry and dimensions of the inlet ducts have to be complied with. In fact any imperfections, even small ones, in the aforesaid inlet ducts could have an effect on the fluid dynamic behaviour of the air drawn into the combustion chamber, with adverse repercussions on the engine's performance.

In this context it is obvious that machining of the pattern
to remove the bonding edges from the pattern of expanded material or machining of the metal casting to remove the marks left by the latter on the finished piece is a possibility, although an onerous one, in the case of easily accessible joint lines, but it is substantially impossible within an inlet duct.

In the light of the above it is obvious that there is a strong need to be able to have a pattern of expanded material incorporating one or more ducts which are free of dimensional defects due to the presence of adhesion bonding edges.

At the present time manufacturers of castings of this type have decided to tolerate the presence of the aforesaid imperfections both in the pattern of expanded material and in the metal casting obtained at the end of the lost foam process, while benefiting from the advantages and simplification deriving from the lost foam casting technique.

The problem underlying this invention is that of devising and providing a pattern for obtaining a casting within which there is a duct, using the lost foam casting technique, the said pattern having structural and functional characteristics such as to satisfy the abovementioned requirement, while at the same time overcoming the
disadvantages mentioned.

This problem is resolved by a pattern according to Claim 1 used for obtaining a casting within which there is a duct, using the lost foam casting technique.

According to another aspect the invention further relates to a method according to Claim 17 for the production of a pattern incorporating a duct which is used to obtain a casting through the lost foam casting technique.

Other features and the advantages of the pattern according to the present invention will become clear from the following detailed description which is given with reference to the appended drawings which are provided purely by way of non-limiting example and in which:

- Figure 1 shows a simplified perspective view in partial cross-section of a pattern according to the invention,

- Figure 2 shows a perspective view of the pattern in Figure 1 in a different condition of use,

- Figure 3 shows a perspective partly exploded view of the pattern in Figure 1, and
- Figures 4 and 4a relate to the stage of moulding a layer of the pattern in Figure 1.

With reference to the appended figures, 1 indicates as a whole a pattern of expanded material for obtaining a casting within which there are a plurality of ducts.

In the example in the figure, pattern 1 comprises an exact reproduction in expanded material of the head block of a diesel engine incorporating a plurality of internal ducts, among which may be recognised the inlet ducts, identified in the figure by 2. Inlet ducts 2 present in the pattern are open at both ends so as to form a through path through the said mass of expanded material.

Head block pattern 1 is intended to be used for obtaining a metal casting, in the example the aluminium head block of a diesel engine, through the lost foam casting technique.

Pattern 1 therefore comprises a mass of expanded material having a shape and dimensions corresponding to those of the aluminium casting which is to be obtained. In greater detail, and in accordance with the lost foam casting procedure, pattern 1 is designed to be:

- coated with a refractory paint, which is preferably water-based,
- dried, and
placed in a casting box (not illustrated) in which it is covered with refractory sand, suitably vibrated and compacted, to receive the cast molten metal, in the example aluminium.

The cast metal is poured into the casting box through suitable casting channels so that it can reach the expanded material of pattern 1 within the refractory sand. Contact between the molten metal and the expanded material gives rise to thermal degradation of the expanded material of pattern 1 and progressive replacement of the expanded material with cast molten metal. After the metal has solidified the metal casting is obtained.

The expanded material in pattern 1 is a polymer foam, preferably a polystyrene, a polymethylmethacrylate or polyalkylene carbonate.

In the case where the aluminium casting which has to be obtained has some structural complexity, pattern 1 may comprise several parts or layers adhesively bonded together. In the example in the figure, pattern 1 comprises a central layer 1a and two opposing peripheral layers 1b above and below connected together by adhesive bonding. In Figure 1 the dividing planes between the layers are shown by dashed lines, while Figure 3 shows the pattern according to the invention with the layers partly exploded.
In accordance with an advantageous feature, pattern 1 comprises a shaped insert 3, preferably of refractory material, for each inlet duct 2, that is a material capable of withstanding contact with the molten metal. Each shaped insert 3 is embedded within the mass of expanded material to form a corresponding duct within the expanded mass.

Each shaped insert 3 projects from the mass of expanded material of pattern 1 with at least one end portion 4 forming an appendix portion through which the insert can be handled, as will be better described in the remainder of the description.

The portion of each shaped insert 3 which is embedded within the mass of expanded material has a shape and dimensions which match those of the corresponding duct which it is desired to obtain in pattern 1 of expanded material and, as a consequence, also in the aluminium casting.

In the case illustrated, inserts 3 are mostly embedded within central layer 1a of pattern 1. Consequently inlet ducts 2 present in pattern 1 lie completely within central layer 1a with the exception of a negligible part. Advantageously this makes it possible to obtain inlet ducts 2 which are free from imperfections due to the presence of bonding edges. In this respect it is worth pointing out that
the bonding edge formed along inlet ducts 2 along the joint lines between central layer 1a and upper layer 1b is wholly negligible, in that it gives rise to a circumferential ring located in a position of the inlet duct which is intended to receive the sealing rings or the seats of the valves in the engine head block.

The presence of the shaped members of inert material therefore makes it possible to form the inlet ducts in such a way that they comply with the geometry and dimensions required by the design specifications, and are free from any geometrical anomalies giving rise to the fluid dynamic turbulence phenomena mentioned with reference to the patterns of expanded material in the known art.

As indicated above, shaped inserts 2 are preferably made of a refractory material, that is a material which does not deteriorate or dissolve following contact with the molten metal.

A refractory material which may be used is for example friable silica sand, with the possible addition of a binding agent. Phenol or furan resins or the like which burn and/or vaporise at the temperatures reached by the molten metal may be used for example as the binder.

It is also possible to use a water-soluble material, for
example a material based on urea, for shaped inserts 3. In this case it is desirable that the surface of the refractory material be treated with a paint or other product capable of rendering the shaped insert non-soluble, at least on the surface, so as to prevent the shaped inserts from dissolving following contact with the molten metal.

Shaped inserts 3 may be removed from pattern 1 before the latter is inserted into the casting box (as shown in Figure 2) or may be left within pattern 1 of expanded material in order to be removed from the aluminium casting after it has cooled.

Removal of the shaped inserts from pattern 1 of expanded material, obviously without damaging it, or from the metal casting, may be effected by conventional techniques such as breaking, vibration, shot blasting, dissolution in water or other suitable liquid.

In the case where the shaped inserts are removed from the pattern before the molten metal is cast it is not necessary that the shaped inserts should be of a refractory material or that the same should be surface treated so as to become insoluble.

The method of manufacturing pattern 1 substantially provides for the following operational stages:
- providing a mould 5 formed from two half-moulds defining between them a cavity 6 corresponding to the shape and dimensions of the shaped model which has to be obtained,
- positioning shaped inserts 3 of refractory material within cavity 6 in mould 5, each shaped insert 3 having a shape and dimensions matching those of the duct which has to be obtained in pattern 1,
- blowing the expandable plastics material into mould 5 in such a way as to obtain a mass of expanded material having the shape and dimensions of the pattern which has to be obtained and incorporating the shaped inserts 3 of refractory material embedded within it.

In accordance with what has been described above, shaped inserts 3 of refractory material are positioned and/or held in position within the mould through their end portions 4 forming an appendix portion through which the insert may be manipulated.

In the case in which shaped inserts 3 are removed from pattern 1 and do not therefore have to come into contact with the molten metal, these may be manufactured of non-refractory material. In this case it is desirable to use a material, such as for example a water-soluble resin, which is capable of withstanding the injection moulding process used to produce the pattern of expanded material.
As may be appreciated from what has been described, the pattern of expanded material and the method according to the invention make it possible to satisfy the abovementioned requirement and at the same time overcome the disadvantages mentioned in the introductory part of this description.

In fact, problems associated with the geometrical abnormalities brought about through the presence of bonding edges corresponding to the joints between several layers are wholly overcome in the pattern of expanded material according to the invention in that all the ducts in respect of which design geometrical and/or dimensional tolerances have to be complied with are obtained through the presence of shaped members of refractory material whose dimensions and shapes can be easily determined with maximum accuracy.

Naturally, the principle of the invention remaining the same, the forms of embodiment and details of construction may be varied widely with respect to those described and illustrated, which have been given purely by way of example, without thereby departing from the scope of the invention.
CLAIMS

1. Pattern for obtaining a casting within which there is a duct through the lost foam casting technique, comprising a mass of expanded material having a shape and dimensions according to the casting which has to be obtained, characterised in that it comprises a shaped insert (3) embedded within the said mass of expanded material to form a duct (2) within the said mass.

2. Pattern according to Claim 1, in which the said duct (2) opens at the two ends to form a through path within the said mass of expanded material.

3. Pattern according to Claim 1 or 2, in which at least one portion of the said shaped insert (3) projects from the said mass of expanded material.

4. Pattern according to any of Claims 1 to 3, in which the portion of the said shaped insert (3) which is embedded within the said mass has a shape and dimensions matching that of the duct (2) which is to obtained in the casting.

5. Pattern according to any of Claims 1 to 4, comprising a plurality of shaped inserts (3) to form several ducts (2) in the said mass of expanded material.
6. Pattern according to any of Claims 1 to 5, in which the said insert is of refractory material.

7. Pattern according to Claim 5, in which the said refractory material comprises friable sand.

8. Pattern according to Claim 6, in which the said friable sand is bound with a resin which burns and/or vaporises at temperatures such as those reached by the molten metal.

9. Pattern according to any of Claims 1 to 5, in which the said shaped insert is manufactured using a water-soluble material.

10. Pattern according to any of Claims 1 to 5, in which the said shaped insert is manufactured using a material based on urea.

11. Pattern according to any of Claims 1 to 10, in which the said expanded material is a polymer foam.

12. Pattern according to Claim 11, in which the said expanded material is a polystyrene.

13. Pattern according to Claim 11, in which the said expanded material is a polymethylmethacrylate.
14. Pattern according to Claim 11, in which the said expanded material is a polyalkylene carbonate.

15. Pattern according to any of Claims 1 to 14, in which the said mass of expanded material is formed from at least two layers (1a, 1b) joined together by adhesive bonding, in which at least one of the said layers has the said shaped insert (3) of refractory material embedded within it.

16. Pattern according to any of Claims 1 to 15, in which the said pattern reproduces the pattern for a combustion engine head block.

17. Method for the manufacture of a pattern (1) according to any of Claims 1 to 16 in which a duct (2) is present, which is to be used for obtaining a casting through the lost foam casting technique, the method comprising the stages of:
   - providing a mould (5) having a cavity (6) corresponding to the shape and dimensions of the pattern (1) which is to be obtained,
   - positioning a shaped insert (3) having a shape and dimensions matching the duct (2) which is to be obtained in the pattern (1) within the cavity of the said mould (5),
   - blowing an expandable plastics material into the said mould (5) in such a way as to obtain a mass of expanded material having the shape and dimensions of the pattern (1) which is to be obtained and incorporating the said shaped
insert (3) of refractory material embedded within it.

18. Method according to Claim 17, in which the said insert comprises at least one appendix portion (4) to allow the shaped insert to be positioned within the mould (5), the said appendix portion being housed in a seat of the mould external to the said cavity (6) so as to lie outside the mass of expanded material of the pattern.

19. Method according to Claim 18, in which the said insert of refractory material is held in position within the mould through the said projecting portion (4).

20. Method according to any of Claims 17 to 19, comprising the stage of positioning within the cavity of the said mould a plurality of shaped inserts (3) having shapes and dimensions matching a plurality of ducts which are to be obtained within the pattern (1).

21. Method according to any of Claims 17 to 20, comprising the stage of removing the said insert (3) from the mass of expanded material.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

B22C7/02

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

B22C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO—Internal, PAJ

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**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>US 4 093 018 A (TRUMBAUER ET AL) 6 June 1978 (1978-06-06) column 1, line 18 - line 27 column 2, line 56 - line 60 column 3, line 3 - line 6 column 5, line 9 - line 13 claims 1-9; figures 1-5</td>
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**Further documents are listed in the continuation of Box C.**

**See patent family annex.**

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* Special categories of cited documents:

  *A* document defining the general state of the art which is not considered to be of particular relevance
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  *E* earlier document but published on or after the international filing date
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**Date of the actual completion of the international search**

23 February 2006

**Date of mailing of the international search report**

02/03/2006

**Name and mailing address of the ISA**

European Patent Office, P.B. 5818 Patentlaan 2 NL—2280 HV Rijswijk Tel. (+31-70) 240-2040, Tx. 31 651 epo nl, Fax: (+31-70) 240-3016

**Authorized officer**

Lombois, T
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<td>HARSLEY R: &quot;THE FUNCTION OF TOOLING IN EVAPORATIVE PATTERN MOLDING&quot; MODERN CASTING, AMERICAN FOUNDRY SOCIETY, Schaumburg, IL, US, vol. 79, no. 9, 1 September 1989 (1989-09-01), pages 32-33. XP000103832 ISSN: 0026-7562 the whole document</td>
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<td>A</td>
<td>GB 2 228 882 A (* OUTBOARD MARINE CORPORATION) 12 September 1990 (1990-09-12) claims 41-44; figures 2,3,22</td>
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Box No. VIII (iii)  DECLARATION: ENTITLEMENT TO CLAIM PRIORITY

The declaration must conform to the standardized wording provided for in Section 213; see Notes to Boxes Nos. VIII (i) to (v) (in general) and the specific Notes to Box No.VIII (iii). If this Box is not used, this sheet should not be included in the request.

Declaration as to the applicant’s entitlement, as at the international filing date, to claim the priority of the earlier application specified below, where the applicant is not the applicant who filed the earlier application or where the applicant’s name has changed since the filing of the earlier application (Rules 4.17(iii) and 51bis.1(a)(iii)):

in relation to this international application,

Alluminio Dongo S.p.A. is entitled to claim priority of earlier application No.
PCT/IT2004/000568

by virtue of an assignment from:
Casti S.p.A. Via Cascina dei Ferrandi 85 - I-21044 Cavaria con Premero (VA) - Italy

This declaration is made for the purposes of all designations, except for the designation of the United States of America.