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(54) **CHILL MOULD FOR THE CASTING OF LIGHT METAL CASTING MATERIALS, AND THE USE OF SUCH A MOULD, AS WELL AS OF A CAST IRON MATERIAL**

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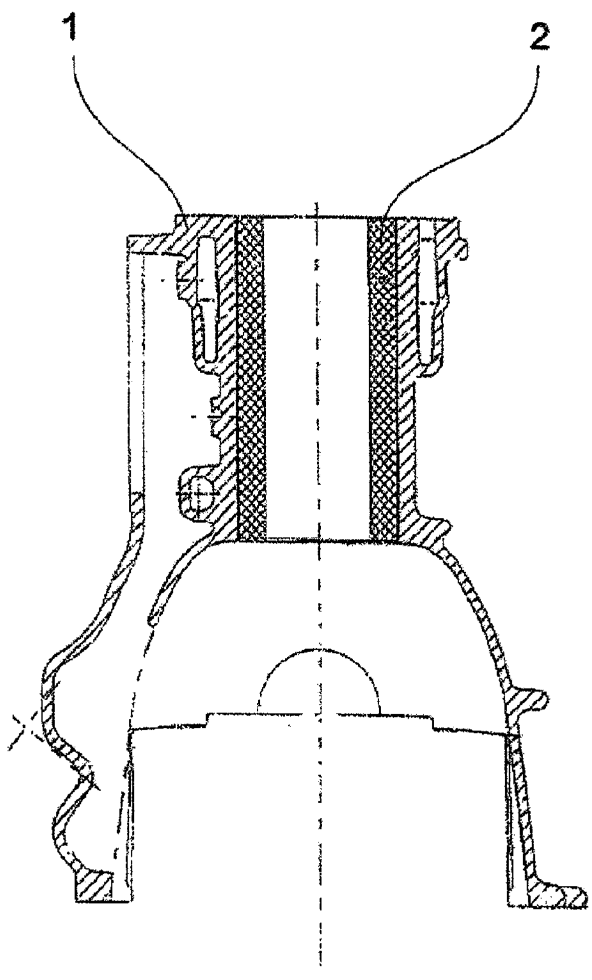
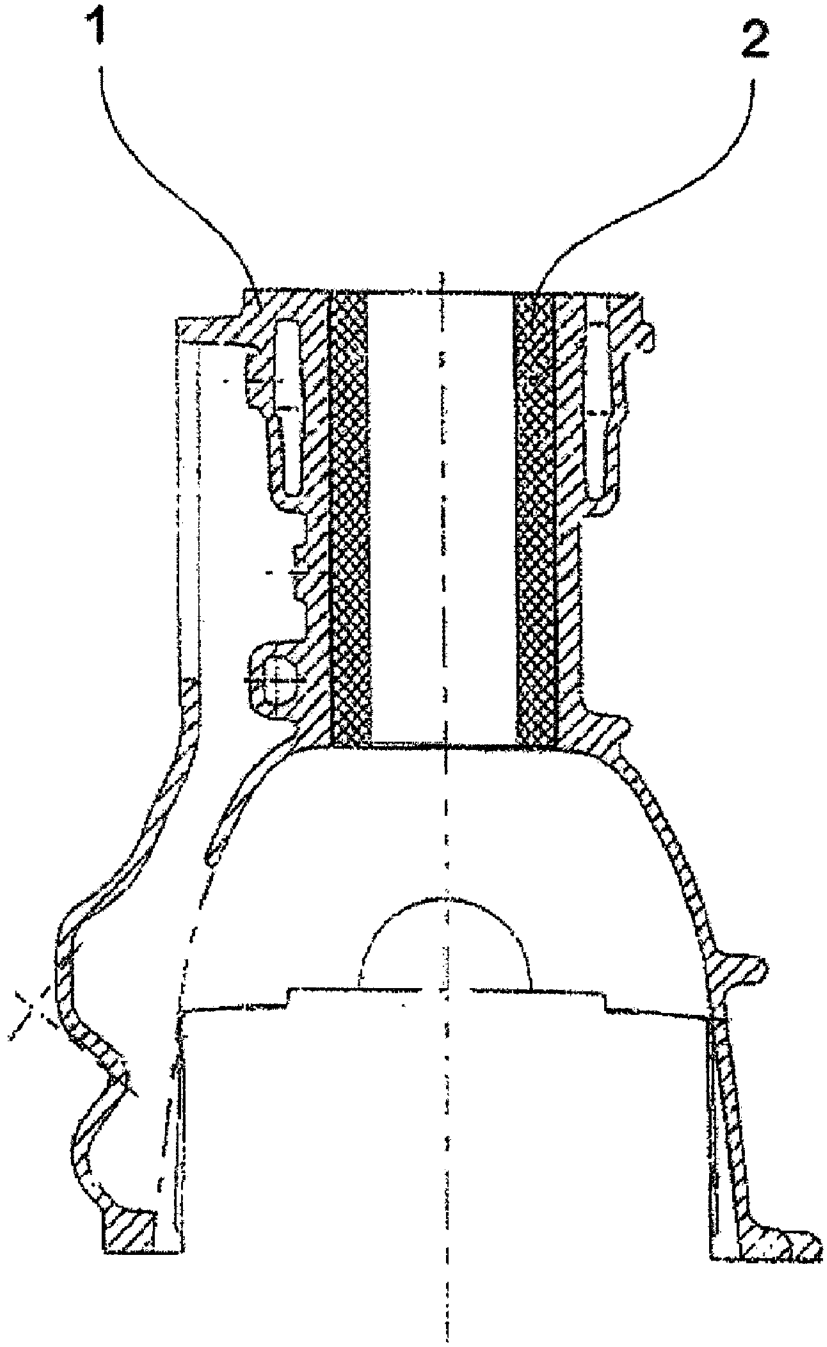
(57) **ABSTRACT**

A chill mould for the casting of light metal casting materials is provided. The chill mould is manufactured from an Ni-alloyed and/or Mn-alloyed cast iron material, of which the Ni and/or Mn content is dimensioned in such a way that the thermal coefficient of expansion of the chill mould is adjusted to the thermal coefficient of expansion of the light metal casting material, which is to be cast in each case. A chill mould is provided which can be manufactured in an economical manner which possesses optimized properties of use and at the same time allows for optimized casting results. Such a chill mould can be a constituent part of a sand casting mould for the casting of a cylinder block from a light metal casting material.





Figure

CHILL MOULD FOR THE CASTING OF LIGHT METAL CASTING MATERIALS, AND THE USE OF SUCH A MOULD, AS WELL AS OF A CAST IRON MATERIAL

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a National Phase Application of International Application No. PCT/EP2006/000701, filed Jan. 27, 2006, which claims the benefit of and priority to German Application No. DE 10 2005 004 481.6, filed Jan. 31, 2005, which is owned by the assignee of the instant application. The disclosure of each of the above applications is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0002] The invention relates to a chill mould for the casting of light metal casting materials. The invention likewise relates to the use of such a mould.

BACKGROUND

[0003] The principle is known of using chill moulds in casting moulds, in particular in sand casting moulds, in order specifically to cool more substantially a cast material cast into the casting mould, in particular a light metal casting material, such as an aluminum or magnesium material, in the contact area between the casting material and the chill mould, than the sand mould is capable of doing (Stephan Hasse, Ernst Brunhuber: "Giesserei Lexikon" [Casting Plant Encyclopaedia], page 735, 18^{th} edition, 2001). In this way, a specifically directed solidification of the casting material is achieved, taking as a basis the areas of the casting material coming in contact with the chill mould. In addition to this, the accelerated cooling achieved by the use of chill moulds allows a microstructure of the solidified casting to be obtained which is improved in respect of its mechanical properties, in particular denser, in the area cooled by the chill mould.

[0004] Chill moulds are accordingly usually used in such sections of the casting mould which form areas of the casting which is to be formed at which particularly high demands are placed on the microstructure properties. This applies in particular to the technical casting manufacture of engine blocks or cylinder heads of combustion engines from a light metal alloy.

[0005] A typical example for the sector of casting moulds, in which chill moulds are used for local improvement of the microstructure, is the cylinder chambers of combustion engines. The running surfaces of the cylinder chambers are subjected to heavy loads when in operation, so that high demands are placed in particular on their wear resistance properties, their toughness and their strength.

[0006] Conventional chill moulds are manufactured from cast iron material. In terms of casting technology, they can be manufactured in a simple and economical manner. In practice, however, cast iron chill moulds have proved to be problematic with the casting of light metal casting materials, such as aluminum or magnesium melts, due to the lower thermal coefficient of expansion of the cast iron in comparison with the light metal casting material. During casting, the chill mould which comes in contact with the light metal melt heats up and its thermal coefficient of expansion expands accordingly. If the temperature drops during the subsequent solidification process, the chill mould shrinks again back to its initial volume.

[0007] If the melt and the moulds have different thermal coefficients of expansion, stresses or even relative movements may occur in the contact areas between the chill moulds and the solidified casting material, as a result of which defects are caused in the finished casting. In particular, porosities and other comparable surface defects may occur. Such defects prove to be problematic in particular in situations in which particularly high loadings occur on the individual casting when in operation.

[0008] Added to this, is the fact that the stresses which occur between the chill mould and the casting can be so great that the chill mould can only be separated from the solidified casting with relatively high effort, which has a negative outcome in particular in the automated manufacture of light metal castings.

[0009] Attempts have been made to resolve the problem inherent with using grey cast iron cores by using moulds formed from brass. The principle is known from DE 195 33 529 A1, for example, of forming the cylinder chambers of combustion engines by means of brass chill moulds inserted into a sand mould intended for the casting of aluminum melts. The composition of the brass of these known moulds in this case is preferably determined in such a way that they have thermal coefficients of expansion of at least 20×10^{-6} K^{-1}, which are adjusted to that of an Al melt. Inasmuch as the thermal coefficient of expansion of the moulds is adjusted to that of the aluminum which is to be cast, it can be guaranteed that mould and cast casting material expand and contract to essentially the same degree. In this way, stresses between the casting and the chill mould can be reduced to a minimum.

[0010] A disadvantage of the known brass moulds is their high price and their unfavorable wear behavior. Their handling is also unwieldy, since brass moulds cannot be held with magnets, for example. With automatic manufacturing techniques in particular, this makes it difficult to provide casting moulds which are equipped with brass moulds. In order to avoid the adherence of the cast material to the mould, and to obtain an optimum surface quality, it is also necessary in practice, as a rule, for the surface of the mould to be provided with a sizing. This procedure also leads to a complication of the manufacturing process, which inevitably incurs additional costs.

SUMMARY OF THE INVENTION

[0011] The invention, in one embodiment, features a chill mould capable of being manufactured economically, which possesses optimized properties of use and at the same time makes optimized casting results possible.

[0012] In addition to this, a preferred application is described for such a chill mould.

[0013] Finally, the invention features a new application possibility for an inherently known casting material.

DESCRIPTION OF THE INVENTION

[0014] With regard to the chill mould for the casting of light metal casting materials, this object is resolved in that it is manufactured from an Ni and/or Mn alloyed cast iron material, of which the Ni content and/or Mn content is dimensioned in such a way that the thermal coefficient of expansion of the chill mould is adjusted to the thermal coefficient of expansion of the light metal casting material which is to be cast in each case.

[0015] A chill mould provided in accordance with the invention can be used preferably as a constituent part of a sand casting mould for the casting of a cylinder block from a light metal casting material.

[0016] The invention takes advantage of the possibility of alloying cast iron in such a way that its thermal coefficient of expansion corresponds with the thermal coefficient of expansion of the light metal melt which is to be cast in each case. Appropriately alloyed cast iron is already inherently known. Thus, for example, in the German published application DE 27 19 456 A1 a cast iron material is already described which has a thermal coefficient of expansion of between 16.0×10^{-6} and 21.0×10^{-6} K^{-1} at temperatures lying between 20° C. and 100° C. This corresponds, for example, to the thermal coefficient of expansion of typical cast aluminum alloys in the temperature range concerned. Hitherto, however, such cast iron materials have only be used for structural components which are cast into or shrunk onto light metal elements, or compressed with them. Thus, for example, a typical example of use for the alloy known from DE 27 19 456 A1 is in the manufacture of ring grooves, used as sealing elements in light metal pistons for combustion engines.

[0017] For the adjustment of the thermal coefficient of expansion of iron and light metal casting material which is sufficiently precise for the purposes of the invention, preferably the deviation between the thermal coefficient of expansion of the particular iron cast material used for the chill mould and the thermal coefficient of expansion of the particular light metal casting material is restricted to a maximum range of $\pm0.4\times10^{-6}$/K.

[0018] Surprisingly, it has been shown that cast iron materials alloyed according to the model of the known material with manganese and/or nickel can be adjusted in respect of their thermal expansion behavior in such a way that chill moulds manufactured from them possess optimum behavior in a casting mould, in particular a sand casting mould, in respect of the casting result being aimed for. This was not foreseeable, since in the prior art in each case, with regard to the expected individual functional performance, the focus has been on the essential mechanical and microstructure properties of the known cast iron material. By contrast, the invention is based on the finding that cast iron alloys procured in this manner are especially well-suited, due to the thermal expansion behavior expanding beyond the mechanical and microstructure properties, to be used as material for the manufacture of chill moulds.

[0019] The use of a cast iron material according to the invention, alloyed by Mn, Ni, in each case alone or by a suitable combination of these elements, for the manufacture of chill moulds, can minimize the stresses in the contact area between the chill mould and the solidified casting material, which otherwise arise with chill moulds when light metal melts are being cast. Due to the adjustment of the thermal coefficient of expansion of the chill mould to that of the light metal casting material, the stresses which occur in the course of the solidification of the casting material between the mould and the casting material are reduced to a minimum. At the same time, with the chill moulds, the advantageous effects inherently known from the prior art with regard to the controlled solidified microstructure are reliably attained. In this situation, moulds according to the invention can be manufactured economically in an inherently known manner and have a wear resistance which is far greater than that of the known brass moulds.

[0020] On the basis of their magnetic properties, they are easier to handle for automated processing, with the result that they have perceptibly improved usability in the sector of light metal casting in relation to the known types. It is of particular significance for actual practice that the surface qualities of the casting achieved with the use of cast moulds according to the invention are so good that the elaborate dressing of the moulds required with the prior art before the casting process is no longer required.

[0021] According to the invention, it is both possible to add only nickel or only manganese to the cast iron material, as well as to provide both these elements as alloy constituents. The decisive factor is that the thermal coefficient of expansion of the chill mould is adjusted to the thermal coefficient of expansion of the casting material.

[0022] Chill moulds according to the invention are particularly well-suited for use when casting aluminum alloys, since the thermal coefficient of expansion of the mould material can be adjusted particularly well to that of the aluminum alloys. The chill moulds can, however, also be used in the casting of other light metal alloys, such as, for example, magnesium alloys.

[0023] Preferably, chill moulds according to the invention are well-suited for use in sand casting moulds for the casting of a cylinder block made of a light metal casting material. In this situation, chill moulds which are formed in accordance with the invention can serve in particular to form the cylinder cavities of a cast cylinder block for combustion engines. This is the case regardless of whether the cavities themselves serve as cylinder running surfaces or whether additional cylinder liners are provided.

[0024] If the inner walls of the cavity themselves serve as the cylinder running surfaces, after the solidification of the casting the cavity inner walls can be coated in an inherently known manner with a material, such as nickel or silicon, in order to increase their wear resistance. It is also possible, however, to use as a casting material an inherently known hypereutectic alloy which precipitates silicon, wherein the chill moulds according to the invention reliably guarantee that the desired precipitations of Si occur in the area of the cylinder running surfaces thanks to an accelerated solidification induced in a controlled manner by means of the chill moulds. It is, of course, possible in this situation, after the solidification of the casting, for machining of the running surfaces to be carried out in order to expose the precipitated silicon in a likewise inherently known manner.

[0025] According to a preferred embodiment, the cast iron material can have a nickel fraction of 0.1 to 13.0% by weight. With such a nickel fraction, the adjustment of the thermal coefficient of expansion can be realized in a particularly simple manner. Higher Ni contents cause increased expansion of the cast iron on heating, while with lower Ni contents, which are combined with likewise small quantities of Mn, if present, adjust smaller thermal coefficients of expansion. Thermal coefficients of expansion of the chill moulds according to the invention which are particularly well adjusted to the thermal expansion behavior of aluminum based melts are produced if the content of Ni is more than 6.00% by weight, in particular at least 6.5% by weight. The range for the nickel contents can be limited upwards, at which the effects used by the invention occur particularly reliably, in setting the upper limit for this range at a maximum 8.00% by weight, preferably less than 8.00% by weight.

[0026] As an alternative or in addition, the cast iron material may also have a manganese fraction for adjusting the thermal coefficient of expansion, which lies in the range from 0.1 to 19.0% by weight. Higher Mn contents lead to a displacement of the thermal coefficient of expansion towards higher values, while lower Mn fractions, with at the same time low or non-existent Ni fractions, cause a lower expansion of the cast iron on heating. Preferably, the contents of Mn lie in the range from 4 to 12% by weight, in order to guarantee an optimum adjustment to the expansion behavior of Al melts.

[0027] In order to achieve optimum results with regard to the wear resistance of the cast iron material, the cast iron material can also, in an inherently known manner, as well as iron and unavoidable impurities, contain the following elements (in % by weight):

[0028] C: 1.5-4.0%,

[0029] Si: 0.5-4.0%,

[0030] Cu: 0.3-7.0%,

[0031] Cr: <2.0%,

[0032] Al: 0.3-8.0%,

[0033] Ti: 0.01-0.5%

[0034] Accordingly, the solution to the object referred to heretofore, with regard to the use of a cast iron material inherently known from DE 27 19 456 A1, lies in the fact that this material, in addition to iron and unavoidable impurities, containing (in % by weight) C: 1.5-4.0%, Si: 0.5-4.0%, Cu: 0.3-7.0%, Cr: <2.0%, Al: 0.3-8.0%, Ti: 0.01-0.5%, 0.5%, as well as at least one element from the group Ni, Mn, with the proviso that the content of Ni amounts to: 0.1-13.0% and the content of Mn to: 0.1-19.0%, is used to manufacture a chill mould for casting light metal casting materials.

[0035] The invention is explained in greater detail hereinafter on the basis of an exemplary embodiment represented in a drawing. The single figure shows a cast cylinder block **1** with a chill mould **2** inserted in it, in a cross-section.

[0036] In FIG. **1** a finished solidified cylinder block **1** is represented, cast in an inherently known manner in a sand casting mould, not shown, of a multi-cylinder combustion engine, in a cross-section through one of the cylinder chambers. After solidification and cooling, the sand casting mould was removed from the cylinder block **1**, being destroyed in the process.

[0037] The cylinder block **1** was cast from a conventional AlSil7Cu4Mg alloy (Si: 16.0-18.0; Cu: 4.0-5.0; Fe: <=0.7; Mg: 0.4-0.7; Mn: <=0.2; Ti: <=0.2; Zn: <=0.2; Σ others: <=0.2; remainder Al, figures as % by weight). This casting material possesses a thermal coefficient of expansion of 19.4×10^{-6}/ K.

[0038] The chill mould **2** was manufactured from a commercial GGL-NiCr 20-2 cast iron alloy known under the name "Ni-Resist". By choosing the Mn and Ni contents, the chill moulds have a thermal coefficient of expansion which lies in the range from 20° C. to 200° C. 18.7×10^{-6}/ K. This thermal coefficient of expansion lies so close to the coefficient of expansion of 19.4×10^{-6}/ K of the AlSil7Cu4Mg alloy from which the engine block is cast that the chill moulds, on heating and cooling, behave in essentially the same manner as the Al casting material. As a consequence, only minimal stresses occur in the contact area between the casting part and the chill mould in each case, and an optimum casting result is achieved.

What is claimed:

1. A chill mould for a casting light metal casting material, comprising at least of one of a Ni and Mn alloyed cast iron material of which the Ni and Mn content, respectively, is manufactured so that the thermal coefficient of expansion of the chill mould is adjusted to the thermal coefficient of expansion of the light metal casting material being cast.

2. The hill mould according to claim **1**, characterized in that wherein the alloyed cast iron material has a Ni content from 0.1% by weight to 13.0% by weight.

3. The hill mould according to claim **1**, wherein the alloyed cast iron material has a Mn content from 0.1 to 19.0% by weight.

4. The hill mould according to claim **1** wherein the alloyed cast iron material includes, in addition to Ni and/or Mn, as well as Fe and unavoidable impurities, the following alloy constituents (in % by weight):

C: 1.5-4.0%,
Si: 0.5-4.0%,
Cu: 0.3-7.0%,
Cr: <2.0%,
Al: 0.3-8.0%,
Ti: 0.01-0.5%

5. Use of a chill mould, including a cast iron material and at least one of a Ni and Mn content in an amount sufficient so that the thermal coefficient of expansion of the chill mould is adjusted to the thermal coefficient of expansion of a light metal casting material, the chill mould a constituent part of a sand casting mould for the casting of a cylinder block from the light metal casting material.

6. Use of a cast iron material, which contains (in % by weight)

C: 1.5-4.0%,
Si: 0.5-4.0%,
Cu: 0.3-7.0%,
Cr: <2.0%,
Al: 0.3-8.0%,
Ti: 0.01-0.5%

as well as at least one element from the group Ni, Mn, with the proviso that the content amounts to:

Ni: 0.1-13.0%
and
Mn: 0.1-19.0%,

and as the remainder iron and unavoidable impurities,

for the manufacture of a chill mould for the casting of light metal casting materials.

7. Use according to claim **5** wherein the light metal casting material is an alloyed material based on aluminum.

8. The chill mould according to claim **1** wherein the alloyed cast iron material has a Ni content of about 6% by weight to about 8% by weight.

9. The chill mould according to claim **2** wherein the alloyed cast iron material has a Mn content from 0.1 to 19.0% by weight.

10. A method of forming a chill mould for casting a light metal casting material, comprising:

providing a cast iron material;

adding at least one of Ni and Mn to the cast iron material;

adjusting the thermal coefficient of expansion of the cast iron material to the thermal coefficient of expansion of the light metal casting material using the content of the at least one of Ni and Mn; and

solidifying the cast iron material and the content of the at least one of Ni and Mn to form the chill mould.

11. The method according to claim **10** further comprising adjusting the deviation between the thermal coefficient of expansion of the iron cast material used for the chill mould and the thermal coefficient of expansion of the light metal casting material to a range of $\pm10.4\times10^{-6}$/K.

12. The method according to claim **10** further comprising adding a Mn content of 0.1 to 19.0% by weight.

13. The method according to claim **10** further comprising adding a Ni content of 0.1% by weight to 13.0% by weight.

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