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Process for obtaining a continuous metallurgical bond between the linings of the cylinders and the cast which constitutes the crankcase of an internal-combustion engine.

A process for obtaining a continuous metallurgical bond between the linings of the cylinders and the cast which constitutes the crankcase of an internal-combustion engine, which crankcase is made from a material different from the material which constitutes the linings, is disclosed, which process comprises carrying out a surface treatment by depositing a thin metal layer on the external surface of the lining, which metal is different from the metals which constitute the lining and the crankcase cast, and is capable of increasing the wettability of, and the heat transfer coefficient between, the materials which constitute the lining and the cast; and casting around the same lining, positioned inside the mould, the metal or metal alloy from which the crankcase is made.

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The present invention relates to a process for obtaining a continuous metallurgical bond between the linings of the cylinders and the cast which constitutes the crankcase of an internal-combustion engine.

In an internal - combustion engine, each piston, made from an aluminum alloy, slides with precision inside a cylindrical hollow provided inside the crankcase of the engine, which is generally made from cast iron, but which can also be obtained from a cast made from an aluminum alloy.

The precision of such a sliding is secured by segments or elastic piston remade from steel or cast iron, arranged around the piston. In particular, in the crankcases made from aluminum alloys, the friction of the piston rings on the inner walls of the cylinder cause the latter to be worn and, over time, such a wear decreases the sliding precision, with the efficiency of the engine being consequently reduced.

In order to obviate this drawback, inside the hollow of the cylinders linings are inserted, which are made from high-wear-strength materials, such as, e.g., steel or other aluminum alloys.

These linings are inserted inside the engine crankcase, after the latter is manufactured by casting, by heat-fitting or, during the same casting step, arranging the linings as inserts inside the casting mold. In both cases, the coupling between the lining and the crankcase is achieved by mechanical gripping, without material continuity, and this may cause drawbacks in the cooling down of the internal surface of the cylinders by effect of poor heat conductivity due to the discontinuity between the materials. Furthermore, owing to such a discontinuity, and to the difference between the coefficient of heat expansion of the different materials, in the mean time, following repeated thermal cycles, the adhesion and the mechanical hooking between the crankcase and the lining decreases, with said crankcase and lining consequently getting detached from each other and undergoing mutual movements, causing, due to the effect of insufficient cooling, a rapid decay of the quality of the internal lining surface finish.

The present Applicant has found now that by means of a suitable surface treatment of the linings of the cylinders, a strong metallurgical bond can be obtained between said linings and the cast which constitutes the crankcase of an internal-combustion engine.

In particular, the process according to the present invention secures that the classic requirements of the welding operations are met: removal of surface impurities and oxides, intimate contact and coalescence of the materials to be bonded.

However, this type of welding is very different from other methods in that no external energy

sources are required (e.g., heat, ultrasounds, and so forth) and the welding takes place during the course of the same casting.

Furthermore, metals which can be not easily coupled by means of other techniques can be bonded by means of such a welding type.

The process according to the present invention for obtaining a continuous metallurgical bond between the linings of the cylinders and the cast which constitutes the crankcase of an internal-combustion engine, which crankcase is made from a material different from the material which constitutes the linings, comprises carrying out a surface treatment by physically, chemically or electro-chemically depositing a thin metal layer on the external surface of the lining, which metal is different from the metals which are contained in the materials of the lining and of the crankcase, and is capable of increasing the wettability of, and the heat transfer coefficient between, the alloy which constitutes the crankcase and the material which constitutes the lining and the cast, and casting around the same lining, positioned inside the mould, the metal or metal alloy from which the crankcase is made.

The lining and the cast can be constituted by aluminum or magnesium or by aluminum or magnesium alloys: however, they must have mutually different compositions.

The lining may also be made from a composite material having as its metal matrix, aluminum or magnesium or aluminum or magnesium alloys: such a type of material is constituted by a metal phase (or a metal alloy phase), which surrounds and links other phases, which constitute the reinforcement (powders or ceramic fibres).

The reinforcement is endowed with high values of mechanical strength and hardness, and the stresses to which the matrix is submitted are transferred to it. The matrix, on the other hand, should be endowed with suitable characteristics as a function of the envisaged type of application.

The reinforcement can be constituted by long ceramic fibres or short ceramic fibres (Al_2O_3 , SiC , Si_3N_4 ; BN , SiO_2) or by ceramic "whiskers" (SiC , Si_3N_4 , B_4C , Al_2O_3) or by non-metal powders (Si , BN , Si_3N_4 , B_4C , SiO_2 or Al_2O_3).

The methods for preparing the composites can be the following:

- Dispersion of the reinforcement in the matrix on the molten state;
- Dispersion of the reinforcement in the matrix in a partially solid state;
- Powder metallurgy;
- Fiber metallurgy;
- Layer compacting;
- Infiltration.

The composite material can be obtained either

directly or by means of a following mechanical machining/processing.

The metal which constitutes the thin layer, preferably having a thickness comprised within the range of from 10 to 100 nm, to be deposited onto the surface of the metal material or of the metal-matrix composite material, which should be different from those contained in the materials and in the cast, can be preferably Selected from among Au, Ag, Cu, Ni, Pt, Pd, Cr, W, Ir, Mo, Ta, Nb, Os, Re, Rh, Ru and Zr.

The deposition of said thin metal layer can be preferably carried out by "sputtering" or by electrochemical deposition.

Also any other methods known in the art, of chemical, physical, and so forth, types, for surface coating can be used: for example, plasma-spraying, laser-assisted deposition, thermal-evaporation deposition, magnetron-assisted deposition, CDV ("Chemical Vapour Deposition"), and so forth.

By using a suitable coating, the liquid to be cast will be capable of wetting the metal material or the metal-matrix composite to a sufficient extent to transfer heat to it, wash out the layer of oxide which is unavoidably formed on the surface of said material and directly binding to the material, in case a metal material is used, or to the metal matrix, if a composite is used.

Once that the material is adequately cleaned, coated and positioned inside the casting die, the casting operating parameters have to be so adjusted as to secure that a suitable stream of overheated liquid will lap the surfaces of the materials.

It is important that the position of the material inside the die is suitably selected and that the shape of the downward duct (ingress duct) and of the upward duct (egress duct) inside the die is properly designed, so that the liquid metal will be obliged to lap, wet and wash out the walls of the material before said liquid metal is cooled down to a too low temperature.

Hence, the matter is of keeping under control the following three parameters: material pre-heating temperature, metal (or alloy) casting temperature, flux conditions. In such a way, an excellent metallurgical bond between the material and the cast can be obtained.

The linings of the cylinders can be obtained by means of techniques known in the art (for example: gravity casting or pressure casting or die-casting or squeeze-casting; or powder metallurgy, or by infiltration or blending), and either directly or by a successive mechanical machining by tool machines or by plastic-working processes (such as extrusion, lamination or forging). Some examples are now given, which have the purpose of better illustrating the invention, but which in no way should be construed as being limitative of the

same invention:

EXAMPLE 1

(Laboratory test)

- The lining is constituted by a tube made from a hypereutectic alloy of Al-Si with a content of 17% of Si, with an outer diameter of 50 mm, a thickness of 5 mm and a height of 65 mm, obtained by gravity casting.
- The outer surface of the lining is coated by sputtering with a thin gold layer.
- The material which constitutes the cast is an Al-Si alloy with a content of 9% of Si.
- The casting die is made of graphite (**see the Figure**) wherein:
(1) is the graphite die,
(2) is the lining, and
(3) is the casting channel.
- The lining and the die are pre-heated at 350° C.
- The temperature of the metal of the cast is of 700° C.
- The volume of cast material is of approximately 400 cm³.
- The casting is carried out in by bottom casting.

EXAMPLE 2

(Laboratory test)

- The lining is constituted by a tube made from a composite material with an outer diameter of 50 mm, a thickness of 5 mm and a height of 65 mm, obtained by gravity casting.
- The composite material, obtained by infiltration, is constituted by a matrix of an eutectic Al-Si alloy, with a content of 13% of Si, and with a reinforcement constituted by an SiC powder at 55% by volume (average diameter of powder particles: 20µm).
- The outer surface of the lining is coated by sputtering with a thin gold layer.
- The material which constitutes the cast is an Al-Si alloy with a content of 9% of Si.
- The casting die is made of graphite (**see the Figure**), as in Example 1
- The lining and the die are pre-heated at 300° C.
- The temperature of the metal of the cast is of 650° C.
- The volume of cast material is of approximately 400 cm³.
- The casting is carried out by bottom casting

EXAMPLE 3

(Industrial Test)

- The test was carried out on an industrial facility for casting crankcases for four-cylinder engines.
- The linings, obtained by extrusion, are constituted by tubes made from a composite material, with an outer diameter of approximately 95 mm, a thickness of about 5 mm and a height of about 130 mm.
- The composite material, obtained by infiltration and dilution, is constituted by a matrix of an eutectic Al-Si alloy, with a content of 13% of Si, and with a reinforcement constituted by an SiC powder at 25% by volume (average diameter of the powder 20 μ m).
- The outer surface of the lining is coated by sputtering with a thin gold layer.
- The material which constitutes the cast is an Al-Si alloy with a content of 99% of Si.
- The industrial casting die is made of cast iron.
- The linings are pre-heated at 300 ° C.
- The temperature of the cast metal is of about 700 ° C.
- The volume of cast material is of approximately 10 dm³.
- The casting is carried out by bottom casting.

EXAMPLE 4(Industrial Test)

- The test was carried out on an industrial facility for casting crankcases for four-cylinder engines.
- The linings, obtained by extrusion, are constituted by tubes made from a composite material, with an outer diameter of approximately 95 mm, a thickness of about 5 mm and a height of about 130 mm.
- The composite material, obtained by mixing, is constituted by a matrix of an eutectic Al-Si alloy, with a content of 9% of Si, and with a reinforcement constituted by an SiC powder at 15% by volume (average diameter of the powder 20 μ m).
- The outer surface of the lining is coated by sputtering with a thin gold layer.
- The material which constitutes the cast is an Al-Si alloy with a content of 9% of Si.
- The industrial casting die is made of cast iron.
- The linings are pre-heated at 300 ° C.
- The die is preheated at about 370 ° C.
- The temperature of the cast metal is of about 700 ° C.
- The volume of cast material is of approxi-

mately 10 dm³.

- The casting is carried out by bottom casting.

Claims

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1. Process for obtaining a continuous metallurgical bond between the linings of the cylinders and the cast which constitutes the crankcase of an internal-combustion engine, which crankcase is made from a material different from the material which constitutes the linings, comprising carrying out a surface treatment by depositing a thin metal layer on the external surface of the lining, which metal is different from the metals which are contained in the materials of the lining and of the crankcase, and is capable of increasing the wettability of, and the heat transfer coefficient between, the alloy which constitutes the cast and the material which constitutes the lining, and casting around the same lining, positioned inside the mould, the metal or metal alloy from which the crankcase is made.

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2. Process according to claim 1, in which the crankcase is constituted by aluminum or magnesium, or by alloys of aluminum or magnesium.

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3. Process according to claim 1, in which the lining is constituted by aluminum or magnesium, or by alloys of aluminum or magnesium.

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4. Process according to claim 1, in which the lining is constituted by a composite material having aluminum or magnesium, or aluminum or magnesium alloys as its matrix.

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5. Process according to claim 4, in which the lining is constituted by a composite material containing non-metal powders selected from among SiC, BN, Si₃N₄, B₄C, SiO₂ or Al₂O₃, as its reinforcement.

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6. Process according to claim 4, in which the lining is constituted by a composite material having ceramic whiskers selected from among SiC, Si₃N₄, B₄C, SiO₂ or Al₂O₃, as its reinforcement.

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7. Process according to claim 4, in which the lining is constituted by a composite material having long or short ceramic fibres selected from among SiC, BN, Si₃N₄, B₄C, SiO₂ or Al₂O₃, as its reinforcement.

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8. Process according to claims 5 or 6 or 7, in which the lining is constituted by a composite

material containing powders, whiskers or long or short ceramic fibres, in a concentration of from 10 to 60% by volume, as its reinforcement.

9. Process according to claim 1, in which the metal to be deposited on the external surface of the lining is selected from among Au, Ag, Cu, Ni, Pt, Pd, Cr, W, Ir, Mo, Ta, Nb, Os, Re, Rh, Ru and Zr.

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10. Process according to claim 1, in which the deposition of a thin layer of metal takes place by sputtering.

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11. Process according to claim 1, in which the deposition of a thin layer of metal takes place by electrochemical deposition.

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12. Process according to claim 1, in which the deposition of a thin layer of metal takes place by chemical deposition.

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13. Process according to claim 1, in which the deposition of a thin layer of metal takes place by plasma-spraying or by thermal evaporation or by CVD (Chemical Vapor Deposition), or by a laser-assisted or magnetron-assisted deposition technology.

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14. Process according to claim 1, in which the lining is obtained by gravity-casting; or pressure-casting or die-casting or squeeze-casting, or by powder metallurgy or by infiltration or blending, either directly or with successive mechanical tool-machining or mechanical plastic processing, such as extrusion, lamination or forging.

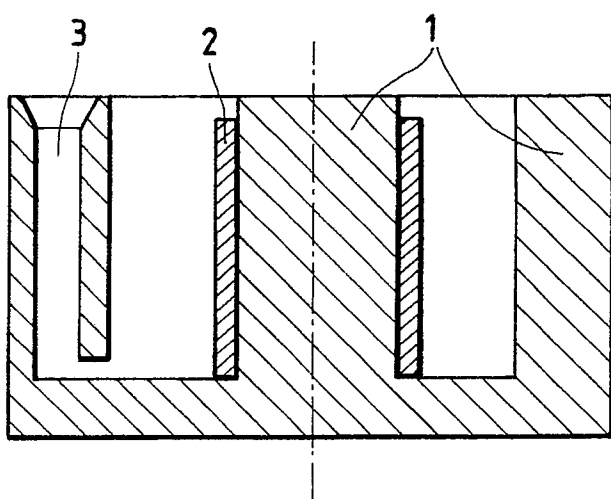
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15. Process according to claim 4, in which the composite material is obtained by dispersing the reinforcement in the matrix in the molten state, or by dispersing the reinforcement in the matrix in a partially solid state, or by powder metallurgy, or by metal-coating the fibres, or by layer-compacting, or infiltration.

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16. Process according to claim 1, in which the thin metal layer deposited on the outer surface of the lining is comprised within the range of from 10 nm to 100 nm.

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EUROPEAN SEARCH REPORT

Application Number

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	PATENT ABSTRACTS OF JAPAN vol. 11, no. 54 (M-563)(2501) 19 February 1987, & JP-A-61 215439 (YANMAR DIESEL ENGINE CO LTD) 25 September 1986, * the whole document *	1,2,9,14	F 02 F 7/00 F 02 F 1/10
A	PATENT ABSTRACTS OF JAPAN vol. 14, no. 113 (M-944)(4056) 02 March 1990, & JP-A-01 313652 (ISUZU MOTORS LTD) 19 December 1989, * the whole document *	1,5,6,7,8, 13	
A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 145 (M-693)(2992) 06 May 1988, & JP-A-62 265453 (HONDA MOTOR CO LTD) 18 November 1987, * the whole document *	1,5,6,7,8	
T,A	DE-A-3 837 254 (BMW) * the whole document *	1,2,3,9, 10,11,13	
A	FR-A-1 340 869 (WILLYS MOTORS INC) * the whole document *	1,2,3	TECHNICAL FIELDS SEARCHED (Int. Cl.5) F 02 F B 22 B
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of search 28 May 91	Examiner WASSENAAR G.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			