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(54) High density metal alloy piston for internal combustion engine and process for manufacturing such piston

(57) A high-density metal alloy piston for internal combustion engine is disclosed, comprising a main body (10) in a single piece, such main body (10) having an external sliding skirt (19) along an engine cylinder and equipped with at least one seat (17) for inserting an elastic sealing band, and with a closing member (30) adapted to operate as piston crown when joined to said main body (10).

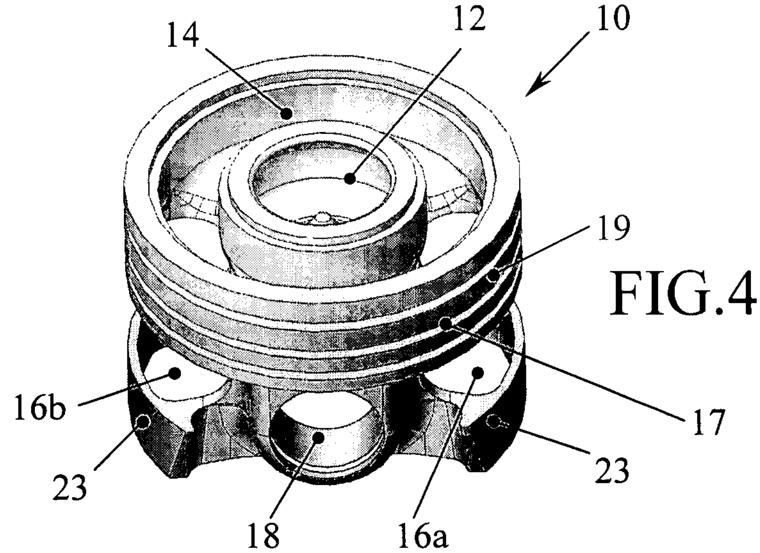

FIG.4

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Description

[0001] The present invention refers to a high-density metal alloy piston for internal combustion engines; the present invention further refers to a process for manufacturing a high-density metal alloy piston for internal combustion engines.

[0002] Pistons are traditionally manufactured in a single piece from an aluminium alloy through stamping or melting. Recently, however, there has been a development in the art for internal combustion engines with very high performance characterised by specific very high outputs: this in particular is the case for diesel engines, both due to the introduction of direct injection, common rail or multi-jet technologies, and for providing a response to future requirements imposed by anti-pollution laws against CO_2 emission. Consequently, thermal and mechanical stresses have dramatically increased, to which engine parts, and in particular pistons, are subjected. This in particular is the case for direct injection diesel engine pistons in which the high gas-oil injection pressures into the combustion chamber and in particular against the piston crown, make now traditional aluminium-made pistons fragile and scarcely reliable, if not even unusable.

[0003] In order to solve the above-mentioned problems, therefore, arrangements have been introduced for modifying structure and manufacturing methods for aluminium pistons, in order to make them compatible with increasing power levels of engines on which they had to be used; for such purpose, pistons made of an aluminium alloy have been proposed that are equipped with reinforcing ceramics fiber, steel inserts to reduce their thermal expansion, having external liners covered with deposits with solid lubricants for reducing the sliding friction in the cylinder, subjected to particular mechanical workings for realising cooling channels to allow recirculation of air or oil in order to keep the piston at an acceptable operating temperature: it is however clear that all above-stated arrangements generate an unavoidable increase of piston costs, consequently making them scarcely attractive.

[0004] An alternative arrangement is using steel pistons which, with the same geometry, have, with respect to traditional pistons made of an aluminium alloy, a better resistance to fatigue and thermal and mechanical stresses. Already in the past, steel was used for manufacturing pistons; however, steel was badly suited for realising pistons for high-performance engines: in fact, due to its higher specific weight with respect to aluminium, with the same geometry, a steel piston has quite a higher inertia, making therefore more performance-prone, within compatible power limits, the use of pistons made of an alimunium alloy. In order to make a steel piston competitive in terms of efficiency with aluminium pistons, it was necessary to strongly reduce its mass by producing extremely thin walls, such arrangement requiring the use of extremely costly metallurgic or forging technologies, consequently making, from the economic point of view, almost impossible to use steel pistons.

[0005] In order to solve the traditional problems of steel pistons and make it possible to more technically and economically advantageously use them with new internal combustion engines, and in particular with new diesel engines, recently several arrangements have been proposed: for example, US-A-2004129243 discloses a steel piston made in a single piece from a billet taken from a condition included between a temperature in which it is in a solid state and a temperature in which it is in a liquid state and moulded through thixo-forging. This arrangement however produces a piston that has scarce accessibility to the necessary tools for following workings, for example in order to further reduce its mass by removing excess material from inside it, thereby still resulting lower from the performance point of view than those that are the possible potentials of steel pistons associated with high-performance engines.

[0006] Several patents and arrangements have also been proposed that disclose steel pistons made of two or more parts that are separately moulded and forged and then are mutually welded: these arrangements, though economically more advantageous and technically more accessible, allow producing only pistons with relatively low performance since steel fibers of individual parts cannot obviously be mutually continuous, but are interrupted and not uniformly distributed, consequently giving the piston a quite lower thermal and mechanical resistance than the potential one.

[0007] Therefore, object of the present invention is providing a piston made of a high-density metal alloy for internal combustion engines that is able to support, with respect to traditional pistons made of an aluminimum alloy or to known steel pistons, quite higher pressures and thermal stresses with a relevant combustion improvement, a consequent reduction of polluting emissions and a higher use reliability.

[0008] Another object of the present invention is providing a process for manufacturing a high-density metal alloy piston for internal combustion engines with high efficiency.

[0009] The above and other objects and advantages of the invention, as will appear from the following description, are obtained by a high-density metal alloy piston for internal combustion engines as claimed in claim 1.

[0010] Moreover, the above and other objects and advantages of the invention are reached with a process for manufacturing a high-density metal alloy piston for internal combustion engines as claimed in claim 9. Preferred embodiments and non-trivial variations of the present invention are the subject matter of the dependent claims.

[0011] The present invention will be better described by some preferred embodiments thereof, provided as a nonlimiting example, with reference to the enclosed drawings, in which:

- FIG. 1 shows a plan view of an embodiment of the high-density metal alloy piston for internal combustion engines according to the present invention;

- FIG. 2 shows a sectional view of the piston along section-line A-A in FIG. 1;
- FIG. 3 shows a sectional view of the piston along section-line B-B in FIG. 1;
- FIG. 4 shows a perspective view of the piston according to the present invention of FIG. 1;
- FIG. 5 shows a plan view of a component of the piston according to the present invention; and
- FIG. 6 shows a sectional view of the component of FIG. 5 along section line A-A.

[0012] With reference to the Figures, it is possible to note that the high-density metal alloy piston for internal combustion engines according to the present invention is composed of a main body 10 in a single piece, having an external sliding skirt 19 along an engine cylinder, typically equipped with at least one seat 17 for inserting an elastic sealing band (not shown) and with a closing member 30, mentioned below, adapted to operate as piston crown when joined to the main body 10. The high-density metal alloy of which the piston according to the present invention is made, is preferably an alloyed carbon steel equipped with mechanical and physical characteristics that are adequate for its use, but it is clear that, as an alternative, other alloys can be used that have similar properties suitable for its purposes.

[0013] As it is possible to note in particular from Figures 1 to 4, the main body 10 is equipped with a central recess 12 next to the piston crown that operates as fuel entry and combustion chamber; between the central recess 12 and the skirt 19, a circular recess 14 is defined for internal cooling; from the circular recess 14, two ducts 16a, 16b depart, that are orthogonal to a seat 18 for inserting a pin (not shown) and are longitudinal to the piston stroke direction; through the circular recess 14 and the two ducts 16a, 16b, it is possible to advantageously proceed with internal mechanical workings of the piston following its moulding, being able to access, for removing material, to areas that are inaccessible in known monolithic pistons, allowing to obtain a piston made of an aluminium alloy, but with quite higher thermal and mechanical characteristics. The circular recess 14 and the two ducts 16a, 16b further allow the oil sprayed by engine basement jets to produce a homogeneous cooling thereof, making thereby possible to accurately check the engine operating temperature, in addition to a correct lubrication of piston pin and skirt 19.

[0014] The piston according to the present invention can further be equipped with at least other two weight-reducing recesses 21a, 21b that are parallel to the pin-inserting seat 18 and orthogonal to the piston stroke direction, that define a sliding portion 23 for settling the piston stroke itself in the piston own cylinder passing between the two ducts 16a, 16b, such two weight-reducing recesses 21a, 21b communicating with the two ducts 16a, 16b and with the circular recess 14.

[0015] The closing member 30 shown in FIG. 5 and 6 is an annular body that is preferably made of the same metal alloy with which the main body 10 is produced, adapted to be joined to the main body 10 itself for covering the circular recess 14 and with a central hole 25 thereof that is concentric with the central recess 12 in order to realise the piston crown and leave the central recess 12 open. Advantageously, the closing member 30 can be joined to the main body 10 once having ended the mechanical working steps of the main body 10 itself, allowing an easy access of tools inside it for an optimum removal of excess material, obtaining a high global weight-reduction of the piston with respect to what is known in the art. Obviosuly the closing member 30 can be joined to the main body 10 through the most appropriate techniques, such as for example through spot welding or welding with beads that are internal and/or external to the circular recess 14.

[0016] The piston according to the present invention, as previously described, thereby allows reaching a weight that is equal or lower than a piston made of an aluminium alloy with high operating advantages for the following reasons:

- it is possible to optimize the mechanical and thermal steel characteristics at a maximum allowing to reduce piston thicknesses more than 50% with respect to a similar piston made od an aluminium alloy;
- the lower steel elongation, that is a known fact, with respect to aluminium alloys allows a better tolerance between cylinder and piston, a lower coupling clearance, a consequent better elastic band seal, a higher load seal during explosions, and thereby a lower blow-by (seepage of burnt particles towards the lower engine part);
- the piston is unloaded of relevant masses in areas where it would be impossible to work a piston claimed by other patented arrangements, and/or any monolithic arrangement that is realised differently.

[0017] Moreover, the piston according to the present invention, given the mechanical and thermal resistance of the high-density metal alloy of which it is made, can allow an increase of fuel injection pressure without requiring further different arrangements, though keeping high efficiency and reliabiity levels.

[0018] Moreover, being the main body 10 realised starting from a single high-density metal alloy extrusion, metal fibers are uninterrupted and can be distributed in order to reinforce in spots with higher fatigue and tension, thereby allowing to realise a piston equipped with greater mechanical and therma resistance.

[0019] Due to high fuel injection pressures, the piston according to the present invention finds its wider application in the field of diesel engines, even if it is obvious that it can advantageously be used in internal combustion engines supplied with different fuels.

[0020] The present invention further deals with a process for manufacturing a high-density metal alloy piston for internal combustion engines, comprising the steps of:

- hot-forging an extruded bar of high-density metal alloy and creating a first pre-forming of the main body 10;
- pressing the first pre-forming in dies defining the final shape of the main body 10 by arranging the high-density metal alloy fibers orthogonally to maximum load and traction points and realising a second pre-forming;
- roughing the second pre-forming for defining the central recess 12 and/or the two ducts 16a, 16b and/or the two weight-reducing recesses 21a, 21b and the pin-inserting seat 18 and creating the circular recess 14 till the crown is smashed in the area that is perpendicular to the pin-inserting area 18;
- making the closing member 30 and joining it to the main body 10, for example through welding, around the circular recess 14 and concentrically to the central recess 12 for making the piston crown.

Claims

1. High-density metal alloy piston for internal combustion engine, **characterised in that** it comprises a main body (10) in a single piece, said main body (10) having an external sliding skirt (19) along a cylinder of said engine and equipped with at least one seat (17) for inserting an elastic sealing band, and with a closing member (30) adapted to operate as crown of said piston when joined to said main body (10).

2. Piston according to claim 1, **characterised in that** said high-density metal alloy is alloyed carbon steel.

3. Piston according to claim 1, **characterised in that** said main body (10) is equipped with a central recess (12) operating as fuel entry and combustion chamber and with a circular recess (14) for internal cooling arranged between said central recess (12) and said skirt (19).

4. Piston according to claim 1 or 3, **characterised in that** from said circular recess (14) at least two ducts (16a, 16b) depart, which are orthogonal to a seat (18) for inserting a pin and are longitudinal to a stroke direction of said piston.

5. Piston according to any one of the previous claims, **characterised in that** said main body (10) is equipped with two weight-reducing recesses (21a, 21b) that are parallel to said pin-inserting seat (18) and orthogonal to said stroke direction of said piston, said two weight-reducing recesses (21a, 21b) communicating with said two ducts (16a, 16b) and with said circular recess (14) and defining a sliding portion (23) for stabilising said stroke of said piston, said sliding portion (23) passing between said two ducts (16a, 16b).

6. Piston according to claim 1, **characterised in that** said closing member (30) is an annular body covering said circular recess (14) and having a central hole (25) that is concentric with said central recess (12).

7. Piston according to claim 1, **characterised in that** said closing member (30) is made of a high-density metal alloy.

8. Piston according to claim 1, **characterised in that** said closing member (30) is joined to said main body (10) through welding.

9. Process for manufacturing a high-density metal alloy piston for internal combustion engines according to any one of the previous claims, **characterised in that** it comprises the steps of:

   - hot-forging an extruded bar of said high-density metal alloy and creating a first pre-forming of said main body (10);
   - pressing said first pre-forming in dies defining a final shape of said main body (10) by arranging the high-density metal alloy fibers orthogonally to maximum load and traction points and realising a second pre-forming;
   - roughing said second pre-forming for defining said central recess (12) and/or said two ducts (16a, 16b) and/or said two weight-reducing recesses (21a, 21b) and said pin-inserting seat (18) and creating said circular recess (14);
   - making said closing member (30) and joining it to said main body (10) around said circular recess (14) and concentrically to said central recess (12) for making said crown of said piston.

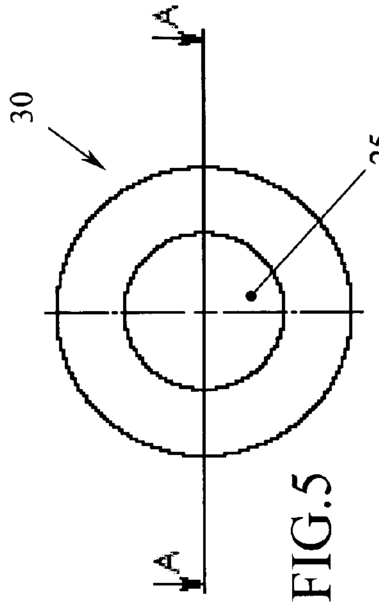

FIG.5

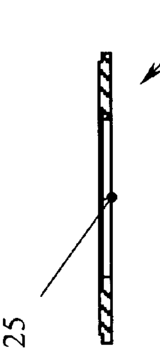

FIG.6

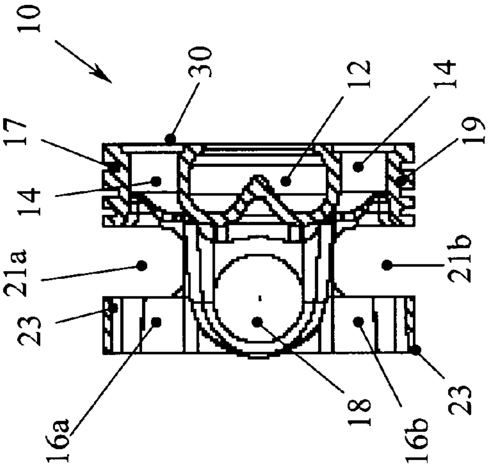

FIG.2

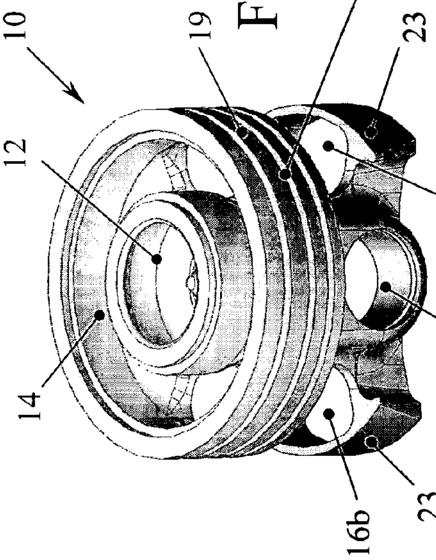

FIG.4

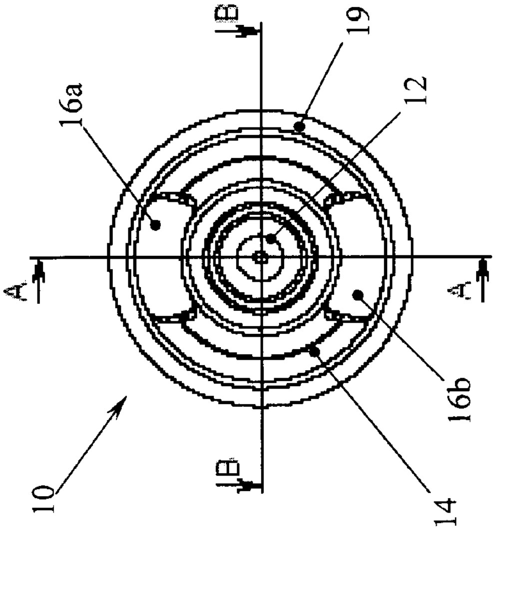

FIG.1

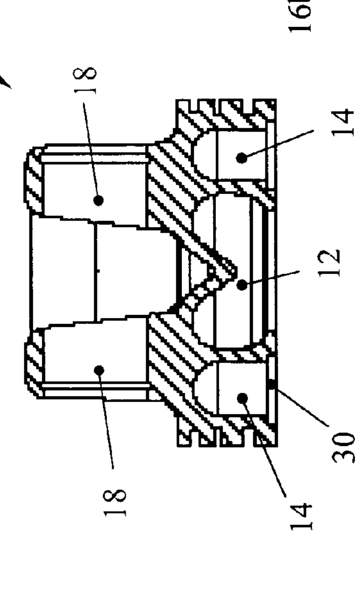

FIG.3

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EUROPEAN SEARCH REPORT

Application Number
EP 05 42 5291

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.7)
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TECHNICAL FIELDS SEARCHED (Int.Cl.7)
F02F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	25 October 2005	Luta, D

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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