Title: LIGHTWEIGHT ALUMINUM CAMSHAFT AND MANUFACTURING METHOD THEREOF

Abstract: A lightweight aluminum camshaft and manufacturing method thereof is provided. The method of manufacturing a lightweight aluminum camshaft having a cam portion having cams the number of which is same as that of valves in order to open and close suction and exhaust valves in an engine, and a shaft portion (3) on which the cam portion is mounted, includes the steps of separately fabricating the cam portion with cam pieces (2a), inserting the separately fabricated cam pieces as inserts into a mold, and injecting molten aluminum alloy into the mold (4) through an aluminum casting method, to thereby from the cam pieces (2a) and a shaft portion (3) called a journal portion in an integral form. Simultaneously, a lightweight aluminum camshaft manufactured by the lightweight aluminum camshaft manufacturing method is provided. Here, a binder portion whose diameter is larger than that of the shaft portion and having binders each formed in the form of a reinforced rib coming into contact with the side surface of each cam piece, is provided in the joining portion of the cam pieces and the shaft portion, in order to enhance a joining intensity. Thus, the lightweight aluminum camshaft becomes lighter, has an excellent wear-resistant property, possesses a high durability and strength, and is inexpensive.
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

LIGHTWEIGHT ALUMINUM CAMSHAFT AND MANUFACTURING METHOD THEREOF

Technical Field

[1] The present invention relates to a lightweight aluminum camshaft and a manufacturing method thereof, and more particularly, to a lightweight aluminum camshaft and a manufacturing method thereof, in which cam pieces are separately fabricated using sintering metal or metal and alloy which can be cold-formed or heat-treated, the separately fabricated cam pieces are inserted as inserts into a mold so as to be formed into an aluminum shaft portion called a journal portion, and the cam pieces and the aluminum shaft portion is integrally formed using aluminum casting methods, to thereby provide the lightweight aluminum camshaft which becomes lighter, has an excellent wear-resistant property, possesses a high durability and strength, and is inexpensive.

Background Art

[2] As is well known, a camshaft which is an essential component in an engine power system transmits power to a locker arm, a tappet, and a push rod sequentially in order to open and close a suction valve and an exhaust valve through a repetitive rotational movement, so that the valves are opened and closed in periodical accurate timing.

[3] In particular, a camshaft for use in an automobile engine receives a rotational force transmitted from a crankshaft and controls opening and closing times of a suction valve and an exhaust valve for a fuel combustion chamber. That is, the camshaft should be used under an adverse environment such as high-speed rotation, rotational bending fatigue and lubricational wear of 750 ~ 4500RPM, at low-temperature and high-temperature of -15 ~ 120°C.

[4] As described above, the camshaft is one of components playing an important role in an engine performance. Accordingly, a quantity of cam lift determining a quantity of valve lift, a cam profile determining an open/close time of a valve, and an angle of cam determining an open/close period of a valve, are also very important for the engine performance.

[5] In the case of a DOHC (Double Overhead Camshaft) engine, each one camshaft is used dedicated to suction and exhaust valves, respectively. In the case of a SOHC (Single Overhead Camshaft) engine, since only one camshaft is used both for suction and exhaust valves, the number of cams should be provided as many as the number of the suction and exhaust valves.

[6] Also, in the case of a V-shaped engine which is recently mounted in an automobile,
two camshafts are used for a SOHC type, and four camshafts are used for a DOHC type.

[7] Here, a general camshaft is will be described with reference to FIGs. 1 and 2. As shown in FIGs. 1 and 2, a camshaft is installed between a cylinder block 11 and a cylinder head 12 which are constructional elements of an engine 10.

[8] In addition, cams 32 are arranged in the camshaft 34 as many as the number of valves in order to open and close the valves.

[9] That is, thecams 32 having rods 30 as many as the number of the suction valve 13 and the exhaust valve 14 in the engine, are supported to the lateral portion or upper portion of a crank case by bearings and in parallel with a crankshaft 15 at a shaft portion on which the cams 32 are arranged at a correct position and angle. An eccentric cam driving a fuel pump and a helical gear 36 driving a distributor or an oil pump are mounted on the camshaft 34.

[10] Meanwhile, even if the curves of the surfaces of the cams 32 including the rods 30 vary slightly only, an open/close period or left of each valve varies, to thus make a big influence upon an engine performance. Thus, it is preferable that the camshaft 34 should be designed so that wear of the surfaces of the cams 32 or bending of the camshaft 34 can be prevented even in the case of a long-time use.

[11] The camshaft 34 is coaxially installed together with a timing gear 38 in order to link with a crankshaft 15 by a timing belt 40. Accordingly, The rotational force of the crankshaft can be transmitted to the camshaft 34. Locker arms 42 closely attached to the surfaces of the cams 32 according to rotation of the camshaft 34 open and close a number of suction and exhaust valves 13 and 14 and make respective devices linked with the valves 13 and 14.

[12] Meanwhile, a conventional camshaft used in an internal combustion engine is made of chilled cast iron, but the cast iron made camshaft cannot meet a requirement for pursuing high performance and lightweight of an engine continuously.

[13] That is, in the case of the conventional camshaft, the cams and shaft portion are made of an identical material. The conventional camshaft is formed of an integral rod shape. In this case, according to an annealing method, a cast iron mold is made of a special steel forging method.

[14] As described above, in the case of a camshaft fabricated by a conventional annealing method for a cast iron casting, the surfaces of rods in cams which are rubbed against locker arms or tappets by friction need to be hardened. Accordingly, heat treatment should be undergone through various kinds of methods.

[15] The cast iron casting camshaft weighs automobile fuel consumption since the weight of the camshaft weighs at the situation which requires enhancement of fuel efficiency, high speed output, and high power output, and increases the number of
valves for the high speed output and the high power output. However, since gaps between cams are narrow in this case, inferiorities due to the defects of casting often occur, and a wear-resistant property and corrosion-resistant property of the cam surfaces may be lowered.

Also, the cast iron casting camshaft has a high inferiority ratio in view of a cast iron casting manufacturing industry which belongs to a representative evading industry. Since it is also difficult to automate the cast iron casting manufacturing apparatus, the productivity thereof becomes low.

Thus, a new camshaft manufacturing method of manufacturing a camshaft need to be developed, in order to supplement defects of the conventional cast iron casting camshaft, optimize engine performance, countermeasure multiple valves according to a lightweight engine, and supply a camshaft having an excellent wear-resistant property.

Accordingly, a method of manufacturing a camshaft using a modular method has been proposed.

The modular method is a diffusion joining hollow camshaft manufacturing method or a mechanical modular camshaft manufacturing method.

The diffusion joining hollow camshaft manufacturing method is a metal joining method in which cams among camshaft components are formed of metal powder, sintered at 1000°C as a primary preliminary sintering, modularly sintered in a hollow tube with a jig, and the tube and sintered cams are joined by diffusion with each other, and in which a journal dam, a front piece, and a rear piece are joined. The mechanical modular camshaft manufacturing method is a method of assembling and fixing camshaft components in a hollow tube by a mechanical friction pressing and fixing method, or a method of injection molding, fixing and assembling camshaft components between other components by use of a plastic material.

The hollow camshaft has a merit of accomplishing a lightweight camshaft of approximate 30% in comparison with the conventional cast iron casting camshaft, but its manufacturing process is complicated and there are many variables of manufacturing conditions, to thereby cause a problem in mass-producing products regularly.

That is, Toring-Ton (a U.S. company), and Presta (a European company) partly produce camshafts using a modular method and Nippon Piston Ring (NPR) (a Japanese company) produces modular camshafts.

Here, since Toring-Ton employs a diffusion method and Presta adopts an injection method, various kinds of problems are exposed that a joining or binding force is low thereby causing a cam to secede, a wear-resistant property is remarkably lowered according to a heat treatment condition, and it is not possible to produce a camshaft unless the thickness of a cam lobe is 5mm or more.

In particular, modular camshafts produced by NPR are hollow sintering camshafts
which combine a wear-resistant property enhanced sintering cams with lightweight steel tubes, in order to meet requirements which the conventional cast iron casting camshafts could not meet.

That is, the modular camshafts using sintering cams using the powder metal is hollow by steel tube shafts. This can be applied to a cam whose width is narrow to thus make it difficult to produce a compact cam by a casting method or forging method. Accordingly, the modular camshafts have a degree of freedom of designing shapes of components and selecting materials of the components, and freely designing a gap between cams, in addition to realization of lightweight cams whose weights are considerably reduced.

PFC1, PFC2 and PFC4 which are widely used as the materials of sintering cams in the hollow sintering camshafts, show results of excellent pitching-resistance and wear-resistance under a high surface pressure, since a Cr-based high hardness carbide is uniformly dispersed in a bainite textile structure.

Thus, the hollow sintering camshaft has several merits that an investment cost is inexpensive, the product is greenness, the process is simplified, an error rate is reduced, and a production cost can be reduced.

Also, the hollow sintering camshaft has other merits that a high durability is secured due to formation of composite carbide, and the product can be made lighter by 30% or more than cast iron due to the hollow type.

As described above, the hollow sintering camshaft has some more merits that a degree of freedom in designing is large in addition to the merit of lightweight. Thus, as an engine is recently formed of a multiplicity of valves and made into a compact design, cams should be disposed proximately, and made into a high performance. As a result, the hollow sintering camshaft is widely employed.

**Disclosure of Invention**

**Technical Problem**

However, since the hollow sintering camshaft should be assembled so that cams are combined on a shaft portion while the cams are in phases, it is difficult to assemble the cams on the shaft portion.

In addition, in the case of the currently available camshaft, a shaft portion does not only play a role of a structural member which supports cams and transmits a rotational force, but also plays a role of an oil path through which engine oil is transmitted to a journal portion. However, an extruding material steel tube is used as the camshaft, it is limited to reduce size of the inner diameter of the tube.

For example, in the case that the outer diameter is 26mm, it is nearly impossible to draw the inner diameter down to 13mm or less. In this case, the camshaft makes a loss
of an effect of a lightweight product.

Thus, an oil supply from an oil fan positioned at the lower end of an engine to a camshaft is delayed during cold start. A wear proceeds due to no supply of oil. The wear affects mostly on the lifetime of the camshaft.

Meanwhile, it has recently attempted a reinforced output by making engine driving components light, and reducing a moment of inertia to thereby realize a high RPM(Revolutions Per Minute), in order to obtain a high output and a high efficiency of the engine. Accordingly, the hollow sintering camshaft using powder cams and a steel tube has been developed as described above from the cast iron camshaft which is a main stream until beginning of the past 1990s.

Finally, a high performance camshaft having a more lightweight feature, capable of overcoming wear during cold start, and having a price competition capability, need to be developed in the future.

**Technical Solution**

To solve the above problems, it is an object of the present invention to provide a high-performance lightweight aluminum camshaft and a manufacturing method thereof, in which a lighter camshaft is provided in comparison with a hollow sintering camshaft meeting a need to develop a new high-performance camshaft.

It is another object of the present invention to provide a high-performance lightweight aluminum camshaft and a manufacturing method thereof, which can enhance an output from an engine and realize a low fuel efficiency through enhancement of engine durability due to minimization of no-oil-supply wear occurring during cold start in the existing engine, reduction of an inertia of moment due to the lightweight camshaft, and high RPM(Revolutions Per Minute) of the engine.

**Advantageous Effects**

As described above, the present invention provides a lightweight aluminum camshaft and a fabrication method thereof. Here, a shaft portion in a camshaft is integrally cast of an aluminum alloy through a casting methods, in particular, a die casting method, together with separately fabricated cam pieces. Accordingly, the present invention has a merit of fabricating the lightweight aluminum camshaft to be lighter by at minimum 30% than the conventional hollow sintering camshaft, and provides an effect of providing the lightweight aluminum camshaft which possesses a high durability and strength, and is inexpensive.

Also, in the case of the lightweight aluminum camshaft according to the present invention, oil holes and a hollow portion should be worked through a separate drill work. As a result, the present invention has a merit of working the diameter of the hollow portion into a size meeting a lightweight condition and an optimal condition
necessary for an oil filling time based on an oil supply.

Additionally, when the cam pieces are separately fabricated in a sintering furnace in the present invention, only the cam pieces are charged into the sintering furnace. As a result, in comparison with the case when the conventional hollow sintering camshaft is fabricated, the present invention has a merit of enhancing a charging efficiency of the sintering furnace.

In particular, the present invention provides a high-performance lightweight aluminum camshaft and a manufacturing method thereof, which can enhance engine durability due to minimization of no-oil-supply wear occurring during cold start in the existing engine, reduction of an inertia of moment due to the lightweight camshaft, and realize enhancement of an output from an engine and realize a low fuel efficiency through high RPM (Revolutions Per Minute) of the engine.

**Brief Description of the Drawings**

The above and other objects and advantages of the present invention will become more apparent by describing the preferred embodiments thereof in detail with reference to the accompanying drawings in which:

**FIG. 1** shows that a conventional camshaft is mounted in a general engine;

**FIG. 2** is a perspective view showing the structure of the conventional camshaft shown in **FIG. 1**;

**FIG. 3** is a sectional view showing the structure of a conventional hollow sintering camshaft;

**FIG. 4** is a flowchart view showing a process of manufacturing a lightweight aluminum camshaft according to the present invention;

**FIGs. 5 and 6** are a perspective view and a sectional view showing the structure of a lightweight aluminum camshaft according to the present invention, respectively;

**FIGs. 7 through 9** sequentially show a process of manufacturing a lightweight aluminum camshaft according to the present invention, in which **FIG. 7** shows a state before cam pieces are inserted as inserts into a mold, **FIG. 8** shows a state where the cam pieces have been inserted as inserts into the mold, and **FIG. 9** shows a case where an aluminum camshaft has been taken out after undergoing an aluminum casting process;

**FIG. 10** is a perspective view showing a constructional model of a lightweight aluminum camshaft according to the present invention;

**FIG. 11** is a perspective view showing a constructional boundary condition of a lightweight aluminum camshaft according to the present invention; and

**FIG. 12** is a perspective view showing a constructional result of a lightweight aluminum camshaft according to the present invention.
Best Mode for Carrying Out the Invention

[52] To accomplish the above object of the present invention, according to an aspect of the present invention, there is provided a lightweight aluminum camshaft comprising: a cam portion having cams the number of which is same as that of valves in order to open and close suction and exhaust valves in an engine; and a shaft portion on which the cam portion is mounted, wherein the cam portion is separately fabricated with cam pieces and the shaft portion is made of an aluminum alloy, and wherein the separately fabricated cam pieces are inserted as inserts into a mold, molten aluminum alloy is cast into the mold through aluminum casting methods, to thereby form the cam pieces and a shaft portion called a journal portion in an integral form.

[53] To accomplish the above object of the present invention, according to another aspect of the present invention, there is provided a method of manufacturing a lightweight aluminum camshaft having a cam portion having cams the number of which is same as that of valves in order to open and close suction and exhaust valves in an engine, and a shaft portion on which the cam portion is mounted, the lightweight aluminum camshaft manufacturing method comprising the steps of: separately fabricating the cam portion with cam pieces; inserting the separately fabricated cam pieces as inserts into a mold; and casting molten aluminum alloy into the mold through an aluminum casting method, to thereby form the cam pieces and a shaft portion called a journal portion in an integral form.

[54] Here, when the cam pieces and the shaft portion are integrally formed in the mold, joint portions are respectively formed in the form of a reinforced rib whose diameter is formed larger than that of the shaft portion and which comes into contact with the side surfaces of the cam pieces, in order to heighten a joint strength at a joint portion between the cam pieces and the shaft portion.

[55] Here, the cam pieces can be fabricated with any one of a powder cam fabrication method using powder metal and a forging cam fabrication method which fabricates the cam pieces by a forging method. However, it is preferable that the cam pieces are fabricated by the powder cam method.

[56] Also, any one of a general gravitational casting method, a general die casting method, a squeeze casting method, a semisolid casting method can be used as the casting method. However, it is preferable that the diecasting method is used as the casting method.

[57] In particular, when the diecasting method is used, a die casting casting pressure is 60~1300kgf/f, and a diecasting casting velocity is 0.5~3.0f.

Mode for the Invention

[58] Hereinbelow, a lightweight aluminum camshaft and a manufacturing method
thereof according to the present invention will be described with reference to the accompanying drawings.

[59] FIGS. 5 and 6 show the structure of a lightweight aluminum camshaft according to the present invention, respectively. FIGS. 7 through 9 sequentially show a process of manufacturing a lightweight aluminum camshaft according to the present invention. FIGS. 10 through 12 show a constructional model of a lightweight aluminum camshaft, a constructional boundary condition, and a constructional result of a lightweight aluminum camshaft according to the present invention.

[60] As shown in FIGS. 5 and 6, a lightweight aluminum camshaft 1 includes a cam portion 2 having cams the number of which is same as that of valves in order to open and close suction and exhaust valves in an engine, and a shaft portion 3 called a journal portion on which the cam portion 2 is mounted, as in a conventional cast iron casting camshaft or a conventional sintering camshaft.

[61] Here, since the shaft portion 3 constituting the camshaft 1 is made of aluminum alloy, the lightweight aluminum camshaft according to the present invention can achieve a relatively lighter camshaft than the conventional available hollow sintering camshaft.

[62] That is, as shown in FIGS. 7 through 9, the cam portion 2 is separately fabricated with cam pieces 2a by sintering material powder cam fabrication method using conventionally well-known metal powder and the separately fabricated cam pieces 2a are inserted as inserts into a mold 4. Thereafter, molten aluminum alloy is injected into the mold 4 through an aluminum casting method, to thereby form the cam pieces 2a and the shaft portion 3 in an integral form.

[63] Here, the cam pieces 2a are separately fabricated in the form of a sintering material powder cam or a forging cam by the conventionally well-known technology. Accordingly, it has been confirmed that the cam pieces 2a have the features such as a wear-resistant property and a corrosion-proof property which are known to have been already possessed by the conventional camshaft.

[64] As described above, it is preferable that the cam pieces 2a are fabricated using a powder cam fabrication method using powder metal which is known as more preferable in view of a wear-resistant property and a corrosion-proof property, but is not limited thereto. The cam pieces 2a can be of course fabricated in the form of a forging cam by well-known forging other than the powder cam fabrication method.

[65] Also, since the aluminum camshaft 1 according to the present invention is used under various adverse conditions such as high-speed rotation, rotational bending fatigue and lubricational wear, at low-temperature and high-temperature, it is apparent that it should be designed to meet a stress condition. In particular, the features of the aluminum camshaft 1 according to the present invention have been confirmed through
a variety of experiments and computer simulations for mechanical features to be described later.

Also, although the conventional hollow sintering camshaft employs a shaft portion made of a steel tube, the lightweight aluminum camshaft according to the present invention adopts a shaft portion 3 made of aluminum alloy which is relatively lighter than the steel tube.

In particular, the method of joining the cam portion 2 and the shaft portion 3 in the present invention uses a casting method such as a diecasting method which is relatively easier and more precise than a sintering process which joins a hollow steel tube shaft and a sintering material powder cam by diffusion through a sintering furnace, as seen in a hollow sintering camshaft fabrication method which is one of the conventional modular camshaft fabrication methods. Accordingly, the present invention has a merit of further simplifying a fabrication process.

Detailed features of a method of fabricating a lightweight aluminum camshaft according to the present invention and a lightweight aluminum camshaft fabricated through the lightweight aluminum camshaft fabrication method according to the present invention, will be described below.

First, as shown in FIG. 4, a process of fabricating a lightweight aluminum camshaft according to the present invention in the form of an end-product, largely includes a material preparation process, a casting process, an oil hole working process, and a finish process.

1. Process of preparing materials

As described above, the material preparation process is a step where the cam pieces 2a corresponding to the cam portion 2 in the camshaft 1 are separately fabricated and prepared, but the separately fabricated and prepared cam pieces 2a are not inserted into a mold 4 as inserts as shown in FIG. 7.

Here, the separately fabricated and prepared cam pieces 2a are formed and sintered in the form of a powder cam using powder metal through a hollow sintering camshaft fabrication method among the conventional modular camshaft fabrication methods.

In particular, since only the cam pieces 2a are separately sintered and fabricated in a sintering furnace in the present invention, an amount of the powder metal being charged into the sintering furnace can be increased in comparison with the case that both a powder cam and a steel tube are charged into the sintering furnace and sintered and joined when the conventional hollow sintering camshaft is fabricated. Accordingly, the present invention has a merit of enhancing a charging efficiency of the sintering furnace.

However, other than the powder cam, cam pieces 2a which are fabricated in the form of a forging cam fabricated by forging, can be used as described above in the
present invention.

[75] Here, it is preferable that the separately fabricated cam pieces are fabricated using metal or alloy which can be cold-formed or heat-treated.

[76] That is, the chemical components and mechanical features of the quality of the material are illustrated in the following Tables 1 and 2, respectively.

[77] Table 1

<table>
<thead>
<tr>
<th>Name of Materials(Symbol)</th>
<th>Chemical components (wt%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
</tr>
<tr>
<td>4%Cr</td>
<td>1.4~2.8</td>
</tr>
<tr>
<td>8%Cr</td>
<td>2.3~3.0</td>
</tr>
<tr>
<td>12%Cr</td>
<td>1.5~3.0</td>
</tr>
<tr>
<td>S50-58C</td>
<td>0.47~0.61</td>
</tr>
<tr>
<td>SCM440</td>
<td>0.38~0.43</td>
</tr>
<tr>
<td>SUJ2</td>
<td>0.95~1.1</td>
</tr>
</tbody>
</table>

[78] Table 2

<table>
<thead>
<tr>
<th>Name of Materials(Symbol)</th>
<th>Mechanical features</th>
<th>Fabrication process</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hardness(HRC)</td>
<td>Density(g/cm³)</td>
</tr>
<tr>
<td>4%Cr</td>
<td>52~63</td>
<td>7.45↑</td>
</tr>
<tr>
<td>8%Cr</td>
<td>52~63</td>
<td>7.45↑</td>
</tr>
<tr>
<td>12%Cr</td>
<td>52~63</td>
<td>7.45↑</td>
</tr>
<tr>
<td>S50-58C</td>
<td>50~60</td>
<td>7.50↑</td>
</tr>
<tr>
<td>SCM440</td>
<td>50~60</td>
<td>7.50↑</td>
</tr>
<tr>
<td>SUJ2</td>
<td>50~60</td>
<td>7.50↑</td>
</tr>
</tbody>
</table>

[79] 2. Process of casting
[80] The cam pieces 2a which have been prepared through the material preparation process, are inserted as inserts into a mold 4 which is designed to meet the structure of a camshaft as shown in FIG. 8.

[81] Here, the cam pieces 2a are sequentially inserted into the mold 4 as inserts based on positions which have been set according to a disposition structure of the cam portion at the portion to be formed into the shaft portion in the mold 4.

[82] In this manner, if the cam pieces 2a are inserted into the mold 4 as inserts, aluminum alloy is injected in a molten state according to a casting method.

[83] Here, it is preferable that a casting method using diecasting equipment of a cold chamber diecasting type is used as the casting method. It is also preferable that atmosphere and vacuum or horizontal and vertical diecasting equipment is used as the diecasting equipment according to shapes and features required thereof.

[84] In particular, it is preferable that a casting pressure according to the diecasting method which is called an injection pressure ranges between 60~1300kgf/㎠. It is preferable that diecasting velocity which is called an injection velocity ranges between 0.5~3.0m/s.

[85] In addition, it is preferable that a diecasting molten metal temperature ranges between 600~800°C.

[86] Of course, a gravitational casting method, a squeeze casting method, or a semisolid casting method can be used as the aluminum casting method, in addition to the general diecasting method.

[87] Here, it is preferable that a molten metal temperature is maintained between 600~800°C even in the case of the gravitational casting method.

[88] Also, it is preferable that the injection pressure at the squeeze casting method corresponding to the pressurized casting ranges between 200~1600kgf/㎠, the injection velocity ranges between 0.5~2.0m/s, and the molten metal temperature ranges between 600~800°C. It is preferable that the injection pressure at the semisolid casting method ranges between 50~500kgf/㎠, the injection velocity ranges between 0.5~2.0m/s, and the semisolid molten metal temperature ranges between 450~650°C.

[89] Under the above-described conditions, molten aluminum alloy is injected into the mold 4, and then the cam pieces 2a and the aluminum shaft portion 3 are integrally formed to thus complete casting. The final aluminum camshaft 1 is taken out from the mold 4 as shown in FIG. 9, to thereby complete a casting process.

[90] Here, in the result of reviewing the mechanical features of the test product for the aluminum camshaft 1 taken out from the mold 4 in this manner, a tensile strength of the product is 200~350MPa, the proof stress is (0.2%) 180~300MPa, and the elongation ratio is 1~15%.

[91] In particular, the mold 4 has a structure that a binder portion 3a can be cast of
aluminum alloy, in which the binder portion 3a whose diameter is larger than that of the shaft portion 3 and which is extended and protruded from the side surfaces of the each cam piece 2a, is provided in the joint portion of the cam pieces 2a and the shaft portion 3, in order to enhance a joining intensity, when the cam pieces 2a and the shaft portion 3 are joined together.

That is, if the lightweight aluminum camshaft is cast in the form that the cam pieces 2a and the shaft portion 3 are joined together through the casting process, the binder portion 3a having a larger diameter than that of the shaft portion 3 is provided in the side surface of the cam pieces 2a.

The binder portion 3a has a structure that cannot be formed through the hollow sintering camshaft fabrication method in which powder cams are sintered and joined at the conventional steel tube, but can be formed through an aluminum casting forming fabrication method according to the present invention.

That is, the binder portion 3a in the lightweight aluminum camshaft according to the present invention has a structural feature that heightens a joint strength between the cam pieces 2a and the shaft portion 3.

3. Process of working oil holes

If the aluminum camshaft 1 is casting-formed through the die casting method, front pieces and oil holes 5 necessary for the structure of the camshaft 1 are formed.

In particular, the lightweight aluminum camshaft 1 taken out through the casting process has a structure of a filled camshaft. Accordingly, if the center of the shaft portion 3 in the camshaft 1 is made to be a hollow portion 6 at the same time when the oil holes 5 are worked through a drill work in the oil hole working process, the filled camshaft can be finally altered in the form of a hollow camshaft. As a result, a lighter aluminum camshaft 1 can be provided.

Meanwhile, in the case that a steel tube is used in the conventional hollow sintering camshaft as described above, the diameter of the hollow tube cannot be worked into a predetermined size or less in view of a steel tube feature fabricated through a drawing work. Thus, an oil supply from an oil fan to a camshaft which are located in the lower end of an engine is delayed at the time of a cold-start due to the problem of an oil filling time. Wear due to no oil supply can proceed. In other to solve this problem, a capacity of an oil pump should be increased. However, in the case of the lightweight aluminum camshaft 1 according to the present invention, the oil holes 5 and the hollow portion 6 should be worked through a separate drill work. As a result, the present invention has a merit of working the diameter of the hollow portion 6 into a size meeting a lightweight condition and an optimal condition necessary for an oil filling time based on an oil supply.

4. Finish process
After the oil holes 5 are worked in the casting-formed aluminum camshaft 1, the journal portion is roughly ground and precisely ground through a well-known common technique in order to perform a more precise finish. The cam portion 2 is also finished more precisely.

A final product of a lightweight aluminum camshaft is finally produced through the finish process such as the rough grinding and the precise grinding.

Of course, a particular heat treatment can be performed in the finish process, in order to enhance the feature such as a durability and to improve the quality of the surface of the cam portion.

Meanwhile, FIGs. 10 through 12 show a constructional model, a constructional boundary condition, and a constructional result of a lightweight aluminum camshaft according to the present invention, respectively.

That is, one end of a cam is fixed, and a rotational displacement of a journal portion is fixed, as constructional boundary conditions of the lightweight aluminum camshaft through a computer simulation, and a force of a mutually opposite direction (for example 129N) is applied to second and fourth cams at a direction of 45° as a load, respectively.

As a result, as shown in FIG. 12, it can be seen that a stress is distributed, and it can be confirmed that the stress is distributed between the minimum stress value of 1.57×10³MPa and the maximum stress value of 3.46MPa.

Also, it can be confirmed that the lightweight aluminum camshaft can be sufficiently applied to a high-performance engine through the computer simulation. Also, in the result of comparing the conventional hollow sintering camshaft with the lightweight aluminum camshaft of an identical dimension, it can be confirmed that a cam is 374g and a steel tube is 1308g, in the hollow sintering camshaft and thus the total weight thereof is 1682g, and that a cam is 254g and an aluminum shaft is 609g, in the lightweight aluminum camshaft and thus the total weight thereof is 863g.

That is, in comparison with the conventional hollow sintering camshaft, it can be confirmed that the lightweight aluminum camshaft according to the present invention becomes lighter by about 49% or so. It can be seen that the lightweight aluminum camshaft according to the present invention becomes lighter substantially by 30% or so, in comparison with the hollow sintering camshaft using the conventional powder cam and the steel tube.

As described above, the present invention has been described with respect to particularly preferred embodiments. However, the present invention is not limited to the above embodiments, and it is possible for one who has an ordinary skill in the art to make various modifications and variations, without departing off the spirit of the present invention. Thus, the protective scope of the present invention is not defined
within the detailed description thereof but is defined by the claims to be described later and the technical spirit of the present invention.

**Industrial Applicability**

[109] As described above, the present invention provides a lightweight aluminum camshaft and a fabrication method thereof, which can be applied to a high-performance engine.
Claims

[1] A method of manufacturing a lightweight aluminum camshaft having a cam portion having cams the number of which is same as that of valves in order to open and close suction and exhaust valves in an engine, and a shaft portion on which the cam portion is mounted, the lightweight aluminum camshaft manufacturing method comprising the steps of:
separately fabricating the cam portion with cam pieces;
inserting the separately fabricated cam pieces as inserts into a mold; and
casting molten aluminum alloy into the mold through an aluminum casting method, wherein the cam pieces and a shaft portion called a journal portion are formed in an integral form, and oil holes are worked on the cast aluminum camshaft through a drill work.

[2] The lightweight aluminum camshaft fabrication method according to claim 1, wherein when the cam pieces and the shaft portion are integrally formed in the mold, joint portions are respectively formed in the form of a reinforced rib whose diameter is formed larger than that of the shaft portion and which comes into contact with the side surfaces of the cam pieces, in order to heighten a joint strength at a joint portion between the cam pieces and the shaft portion.

[3] The lightweight aluminum camshaft fabrication method according to claim 1 or 2, wherein the cam pieces can be fabricated with any one of a powder cam fabrication method using powder metal and a forging cam fabrication method which fabricates the cam pieces by a forging method.

[4] The lightweight aluminum camshaft fabrication method according to claim 1 or 2, wherein the cam pieces can be cold-formed or heat-treated.

[5] The lightweight aluminum camshaft fabrication method according to claim 1 or 2, wherein any one of a gravitational casting method, a general diecasting method, a squeeze casting method, and a semisolid casting method can be used as the aluminum casting method, in order to melting an aluminum alloy and cast the melted aluminum alloy.

[6] The lightweight aluminum camshaft fabrication method according to claim 5, wherein a molten metal temperature ranges between 600~800°C, a diecasting casting pressure ranges between 60~1300kgf/㎠, and a diecasting casting velocity ranges between 0.5~3.0m/s, when the die casting method is used.

[7] The lightweight aluminum camshaft fabrication method according to claim 5, wherein a molten metal temperature ranges between 600~800°C, a casting pressure ranges between 200~1600kgf/㎠, and a casting velocity ranges between 0.5~2.0m/s, when the squeeze casting method is used.
The lightweight aluminum camshaft fabrication method according to claim 5, wherein a semisolid (semi-molten or semi-liquefied) metal temperature ranges between 450~650°C, a casting pressure ranges between 50~500kgf/㎠, and a casting velocity ranges between 0.5~2.0m/s, when the semisolid casting method is used.

A lightweight aluminum camshaft comprising:
a cam portion having cams the number of which is same as that of valves in order to open and close suction and exhaust valves in an engine; and
a shaft portion on which the cam portion is mounted,
wherein the cam portion is separately fabricated with cam pieces and the shaft portion is made of an aluminum alloy, and
wherein the separately fabricated cam pieces are inserted as inserts into a mold, molten aluminum alloy is cast into the mold through aluminum casting methods, to thereby form the cam pieces and a shaft portion called a journal portion in an integral form.

The lightweight aluminum camshaft according to claim 9, wherein joint portions are respectively formed in the form of a reinforced rib whose diameter is formed larger than that of the shaft portion and which comes into contact with the side surfaces of the cam pieces, in order to heighten a joint strength at a joint portion between the cam pieces and the shaft portion.

The lightweight aluminum camshaft according to claim 9 or 10, wherein the cam pieces can be fabricated with any one of powder campieces fabricated by a sintering method using powder metal and forging campieces fabricated by a forging method using metal which can cold-formed or heat-treated.

The lightweight aluminum camshaft according to claim 9 or 10, wherein any one of a gravitational casting method, a general die casting method, a squeeze casting method, and a semisolid casting method can be used as the aluminum casting method, in order to melting an aluminum alloy and inject the melted aluminum alloy.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC*: B22D 19/04

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)
IPC*: F01L 1/00, B22D 19/00

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 practicable, search terms used)
EPDOC, WPI, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>DE 40 04 505 A1 (BAYERISCHE MOTOREN WERKE AG) 22 August 1991 (22.08.1991) claims 1-6, columns 1-2.</td>
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<td>DE 0 083 927 A1 (NISSAN MOTOR COMPANY) 20 July 1983 (20.07.1983) figures 2-4, claim 8.</td>
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Further documents are listed in the continuation of Box C. See patent family annex.

Date of the actual completion of the international search 28 November 2005 (28.11.2005)

Date of mailing of the international search report 6 December 2005 (06.12.2005)

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