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Sasame et al.

[11] **3,877,854**

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[54] **RELATIVE COMBINATION OF APEX SEAL AND ROTOR HOUSING IN ROTARY PISTON INTERNAL COMBUSTION ENGINE**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** ..... **418/178**; 29/195 M; 117/93.1 PF; 277/235 A

[51] **Int. Cl.** **F01c 21/00**

[58] **Field of Search** ..... 418/178, 179; 117/93.1 PF, 93.1 R, 105, 105.1, 105.2; 148/31.5; 29/195 M; 277/235 A

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Attorney, Agent, or Firm—Sughrue, Rothwell, Mion, Zinn & Macpeak

[57] **ABSTRACT**

In the relative combination of an apex seal and a rotor housing in a rotary piston internal combustion engine, the apex seal made of a ferrous or nonferrous metal is provided with a sparyed layer of FE—O compound, which contains oxygen in the range from 15.0 to 30.05 wt.%, having the thickness of more than 0.1 mm at least on the sliding surface thereof and the rotor housing is provided with a cast-iron member of which graphite is precipitated on the surface thereof in the range from 1 to 15%, by area, based on the surface area of the cast-iron member at least on the sliding surface on which the apex is slided, whereby the wear and scuffing resistances of both sliding surfaces of the apex seal and the rotor housing are improved.

1 Claim, 2 Drawing Figures

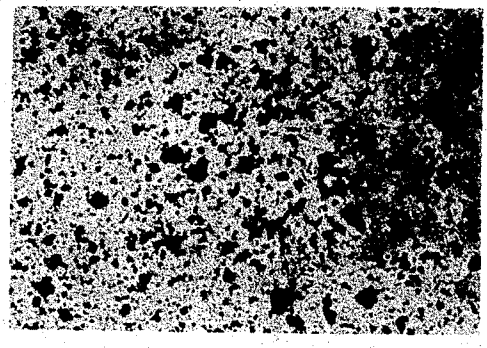


FIG. 1

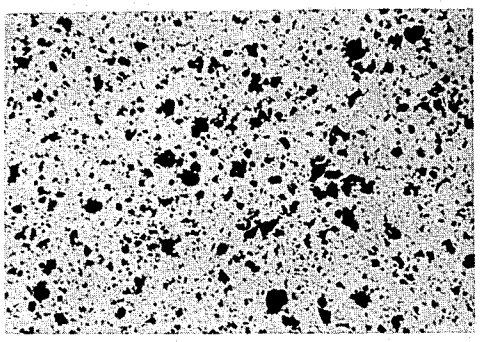
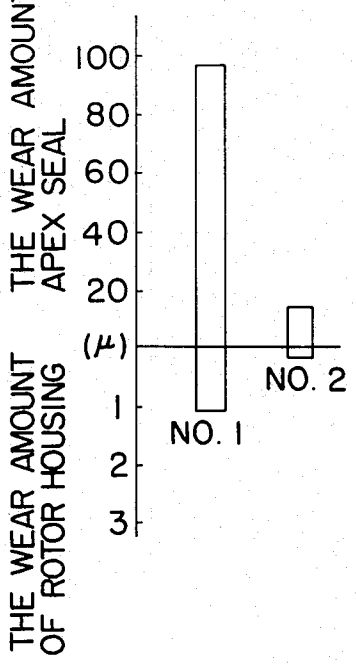


FIG. 2


THE WEAR AMOUNT OF APEX SEAL
100
80
60
40
20
(μ)
1
2
3
THE WEAR AMOUNT OF ROTOR HOUSING
NO. 1
NO. 2

RELATIVE COMBINATION OF APEX SEAL AND ROTOR HOUSING IN ROTARY PISTON INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the relative combination of an apex seal and a rotor housing in a rotary piston internal combustion engine, more particularly to the improvements of both sliding surfaces of the apex seal and the rotor housing, which contact slidingly with each other, so that wear and scuffing resistances of both sliding surfaces are improved.

2. Description of the Prior Art

Heretofore, in view of the wear resistance, a rotor housing, which is made of a light alloy, such as Al, as its base metal, in a rotary piston internal combustion engine is provided with a nickel plated layer having a hardened part of hard chrome, silicon carbide, etc., on the sliding surface thereof on which an apex seal is slided, however, manufacturing processes for applying the plating treatment to the sliding surface of the rotor housing and machining process after applying the plating treatment are considerably complex because the shape of the sliding surface of the rotor housing is very complex. As a result of this, the cost of the article becomes dear. In addition, a problem on the relative combination between the conventional apex seal and rotor housing, that is to say, "chatter mark" which is considered to be resulted mainly from a discontinuity of the lubrication between the apex seal and the rotor housing has not been solved completely.

SUMMARY OF THE INVENTION

A primary object of this invention is to provided the relative combination of an apex seal and a rotor housing in a rotary piston internal combustion engine which exhibit high wear and scuffing resistances on both sliding surfaces of the apex seal and the rotor housing so that the durability of the engine may increase.

Another object of this invention is to provide the relative combination of an apex seal and a rotor housing in a rotary piston internal combustion engine which overcomes the problem of "chatter mark" which is considered to be resulted mainly from a discontinuity of the lubrication between the apex seal and the rotor housing.

Further object of this invention is to provide an apex seal and a rotor housing which have high wear and scuffing resistances and which are produced very economically.

According to this invention, an apex seal which is made of a ferrous or nonferrous metal as its base metal and which is provided with a sprayed layer of Fe—O compound, which contains oxygen in the range from 15.0 to 30.05 wt.%, having the thickness of more than 0.1 mm is used in a rotary piston internal combustion engine in the relative combination with a rotor housing which is provided with a cast-iron member of which graphite is precipitated on the surface thereof in the range from 1 to 15 %, by area, based on the surface area of the cast-iron member.

The amount of oxygen in the Fe—O compound sprayed at least on the sliding surface of the apex seal is closely relative to the self-lubrication of the apex seal, and accordingly restricted to the above described range, namely from 15.0 to 30.05 wt.%.

The thickness of the sprayed layer of the Fe-O compound must be at least 0.1 mm. Because, if the thickness is not more than 0.1 mm, the desired durability of the apex seal will not be expected. And the upper limit of the thickness is determined from the results of many experiments and from the economical reason, and is preferably 5 mm or less.

On the other hand, the cast-iron member is formed at least on the sliding surface of the rotor housing by casting a body of the rotor housing with a cast-iron or, in view of lightening the weight of the rotor housing body and of the radiation of heat on the rotor housing, by fixing the cast-iron member at least to the sliding surface of the rotor housing made of a light alloy, such as Al or the like, as its base metal by a metallurgic method, such as included casting, etc., or a mechanical method, such as the press-fitting, etc.

The shape of graphite precipitated on the surface of the cast-iron member, which functions as the sliding surface of the rotor housing, in the range from 1 to 15 %, by area, based on the sliding surface of the rotor housing may be effectually selected from flakes globules and spherical.

If the precipitating amount of graphite is less than 1.0 %, the scuffing resistance of the sliding surface of the rotor housing becomes worse since the oil-humidity and the self-lubricating property peculiar to graphite become worse, on the contrary, if the amount is over 15%, the wear resistance of the sliding surface of the rotor housing becomes worse. Therefore, the precipitating amount of graphite on the sliding surface of the rotor housing is determined in the range from 1 to 15 %, by area, based on the sliding surface of the rotor housing.

As for the hardness of the cast-iron member, the cast-iron member having the hardness in the range of 150 to 300 HB may be used preferably. But, at least one element selected from the group consisting of Cr, B, Mo, etc., which form a carbide is effectually contained in the cast-iron member or a proper heat treatment is subjected to the cast-iron member since the cast-iron member must be possessed of the durability and a high hardness in response to the type of the engine. In the case of this, the hardness of the cast-iron member becomes in the range from 300 to 700 HB.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an enlarged photograph showing a microstructure (magnitude **100**) of a sprayed layer of Fe—O compound formed on the sliding surface of an apex seal according to this invention, and

FIG. **2** is a graph showing the comparison between the wear resistance of the sliding surface in the conventional combination of the apex seal and the rotor housing and that in the combination according to this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. **1** showing an enlarged photograph which shows a microstructure (magnitude 100) of a sprayed layer of Fe—O compound formed on the sliding surface of an apex seal according to this invention, a white part indicates the sprayed layer of Fe—O compound containing oxygen therein in the range from 15.0 to 30.05 wt.% and black parts indicate void spaces formed into the sprayed layer during the spraying treatment.

Such structure of the sprayed layer exhibits the excellent wear resistance and scuffing resistance due to the self-lubricating property of the Fe—O compound. Besides, the void spaces in the sprayed layer cause the porous and oil-impregnating structure. As the Fe—O compound is readily converted into drops during the spraying treatment due to the relatively low melting point (about 1,500°C), the sprayed particles are mutually entangled to increase the strength of the sprayed layer itself. Accordingly, the acceleration of the abrasion of the apex seal and the rotor housing by the peeled off particles is never coused.

As for the rotor housing, by forming the cast-iron member of which graphite is precipitated on the surface thereof in the range from 1 to 15 %, by area, based on the surface area of the member at least on the sliding surface of the rotor housing, the sliding surface of the rotor housing exhibits the wear and scuffing resistances due to mutual effect of the oil-humidity and the self-lubricating property which are peculiar to graphite, at the same time, graphite functions to absorb a load of the apex seal to the rotor housing caused by the mechanical vibration of the engine, thereby resulting in the stable operation of the apex seal.

As described above, the combination of the apex seal and the rotor housing according to this invention brings out unexpectedly high wear resistance therebetween, and reduces the forming of the scuffing due to mutual effect of the self-lubricating property and the oil-impregnating property of the sliding surface of the apex seal, and the self-lubrication property, the oil-humidity and the vibration absorbing property of graphite formed on the sliding surface of the rotor housing even if the discontinuity of the lubrication exists between the apex seal and the rotor housing, thus resulting in the prevention of the occurrence of "chatter mark".

Now, some examples of this invention will be described hereinafter with reference to the drawings.

EXAMPLE I

A Fe—O compound containing 27.6 wt.% of oxygen was plasma-sprayed on the sliding surface of cast-iron apex seal made of the castiron (JIS FC-25) as its base metal to form the layer of 1 mm thickness. The Hv(30) hardness of the resultant sprayed layer was 700.

The spraying conditions were as follows:

spraying gun;	Meteco 3M type plasma spraying gun
N_2 gas pressure;	50 lb/in².
N_2 gas flow rate;	150 ft³/hr.
H_2 gas pressure;	50 lb/in².
H_2 gas flow rate;	10 ft³/hr.
electric current applied;	500A
spraying distance;	4 inch

On the other hand, a rotor housing is formed by casting with the following cast-iron.

Composition:

Element	Total C	Si	Mn	P	S	Fe
Content (Wt.%)	3.25	1.82	0.55	0.20	0.07	balance

Matrix structure:	pearlite
Shape of graphite:	flakes of graphite
The precipitating amount of graphite:	9.8 % (by area)
Hardness:	215 (HB)

The apex seal and the rotor housing thus treated wear combined with each other, and the combination was subjected to the wear resistance test in the actual engine.

Specification of the engine used:

1. Type;	water cooled 2 rotor type Rotary Piston Internal Combustion Engine
2. total exhaust volume;	982 cc
3. maximum output;	100 PS/7000 r.p.m.
4. maximum tork;	13.5 Kg-m/3500 r.p.m.
test conditions;	
1. rotating number;	2680 r.p.m.
2. boosting pressure;	−350 mm.Hg.
3. running time;	50 hr.

EXAMPLE 2

In order to compare the properties of the combination of the apex seal and the rotor housing according to this invention with that of the conventional combination, the same wear resistance test as described above was subjected to the conventional combination of a rotor hausing made of Al as its base metal of which a Cr plating layer (having the thickness of 0.15 mm and the hardness of 950 Hv) is provided on the sliding surface thereof under the following plating conditions and an apex seal made of a special cast-iron having the following Specifications under the same testing conditions in the above described EXAMPLE I.

plating conditions of the Cr plating layer;	
current density;	60A/diameter²
liquid temp. in the plating bath;	60°C
composition of the liquid;	chromic acid anhydride 250g/l sulfuric acid 2.5 g/l

The test result are shown in the FIG. **2**, wherein No. **2** is the test result for the combination according to this invention and No. **1** is that for the conventional combination.

It will be apparent from the FIG. **2** that the wear amount of apex seal No. **2** is only about one-seventh of that of the apex seal No. **1**, and the wear amount of rotor housing No. **2** is only about one-fifth of that of rotor housing No. **1** accordingly this invention has the excellent durability.

The chatter mark is not observed in the combination according to this invention.

EXAMPLE 3

The scuffing resistance test was carried out with using the rotary type wear resistance tester.

A specimen having the sprayed surface layer was thrusted on a turn table which was rotated supplying the lubricating oil between the surface layer of the specimen and the upper surface of the turn table. The load to thrust the specimen on the turn table was gradually increased at every one hour to detect the limit load to cause the scuffing.

testing conditions:

1. testing specimen;

obtained by plasma-spraying Fe—O compound containing oxygen 27.6 % on the surface of a cast-iron (JIS FC-25) to have the thickness of 0.1 mm and the Hv (30) hardness of 700.

2. turn table;

composition;

composition; element	total C	Si	Mn	P	S	Fe
content (wt. %)	3.32	2.05	0.61	0.18	0.09	balance

the matrix structure:	pearlite	
the shape of graphite:	flakes of graphite	
the precipitating amount of graphite:		10.9 % (by area)
the hardness:	223 HB	
3. temperature of the lubricating oil;		80°C.
4. rate of feeding the lubricating oil;		0.6 l/hr.
5. lubricating oil;	Daphni oil No. 65 50% and lamp oil 50%	
6. running time;	every 1 hr. for the load 50kg/cm², 100 kg/cm², 150 kg/cm² and 200 kg/cm².	

As a result of the above, the specimen was observed to cause the scuffing by the load of 300 kg/cm². It will be, therefor, understood from this test result that the combination of the apex seal and the rotor housing according to this invention exhibits the high resistance to the scuffing under the high compression.

The base metal of the apex seal is not restricted to the cast-iron, but may be Al, Cu or the like nonferrous metals.

While the invention has been described with reference to particular embodiments thereof, it will be understood that the numerous modifications may be made by those skilled in the art without actually departing from the scope of the invention.

Therefore, the appended claim is intended to cover all such equivalent variations as coming within the true sprit and scope of the invention.

What is claimed is:

1. A relative combination of an apex seal and a rotor housing in a rotary piston internal combustion engine wherein said apex seal is made of ferrous or nonferrous metal and is provided with a sprayed layer of Fe—O compound, which contains oxygen in the range from 15.0 to 30.05 wt.%, having the thickness of more than 0.1 mm and said rotor housing is provided with a cast-iron member of which graphite is precipitated on the surface thereof in the range from 1 to 15 %, by area, based on the surface area of said cast-iron member, at least on the apex seal sliding surface of said rotor housing.

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