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Nakamura

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[54] **SLIDING MEMBER HAVING A SPRAY-COATED LAYER**

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[52] **U.S. Cl.** **29/195**

[51] **Int. Cl.** **B32b 15/00**

[58] **Field of Search** ..... 29/195 A, 195 M

[56] **References Cited**

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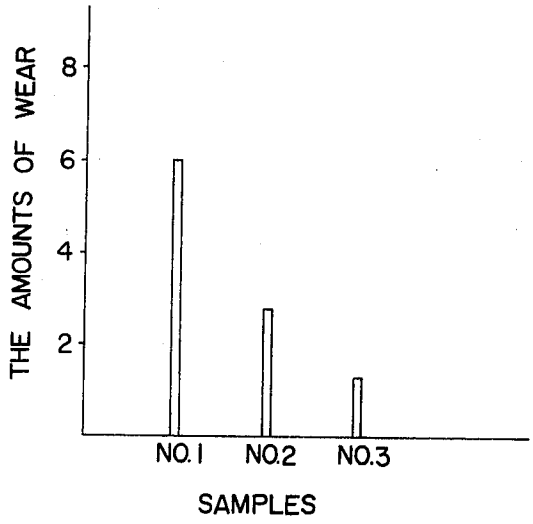
[57] **ABSTRACT**

A sliding member, such as a piston ring in an internal combustion engine, having a spray-coated layer on at least its sliding surface comprising from about 10 to 50 percent by weight of molybdenum, about 10 to 50 percent by weight of a self-fluxing alloy and from about 20 to 60 percent by weight of a metal carbide or a metal oxide. The sliding member has excellent scuff resistance and abrasion resistance.

6 Claims, 1 Drawing Figure


THE AMOUNTS OF WEAR
8
6
4
2
NO.1
NO.2
NO.3
SAMPLES

SLIDING MEMBER HAVING A SPRAY-COATED LAYER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an improvement in a sliding member, for example, a piston ring or cylinder liner of an internal combustion engine. More particularly, this invention provides a sliding member having excellent scuff resistance and abrasion resistance.

2. Description of the Prior Art

Internal combustion engines recently have tended to be operated under increasingly high loads at higher speeds of rotation in order to provide increased power output. To accomplish this, it is essential to improve the performance of piston rings. For example, chromium plating is now used for this purpose. However, since chromium plating has poor thermal resistance and its hardness rapidly decreases at about 350°C, it is not suitable for use under high thermal loads.

As another approach, attempts have been made to spray molybdenum which has superior scuff resistance. But molybdenum does not possess excellent abrasion resistance, and therefore, an improved spray material has been desired.

SUMMARY OF THE INVENTION

The present invention has been accomplished as a result of various research on spray materials with properties which are superior to molybdenum.

According to the present invention, there is provided a sliding member having a spray coated layer on at least its sliding surface comprising 10 to 50 percent by weight of molybdenum, 10 to 50 percent by weight of a self-fluxing alloy and 20 to 60 percent by weight of a metal carbide or a metal oxide.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWING

The accompanying drawing is a diagram showing comparative test results obtained with the sliding member of this invention using molybdenum, a self-fluxing alloy and a metal oxide or carbide in comparison with sliding members using molybdenum alone and molybdenum and a self-fluxing alloy only.

DETAILED DESCRIPTION OF THE INVENTION

Thus, the spray coated layer in accordance with this invention comprises three components, i.e., molybdenum, a self-fluxing alloy, and a metal oxide or a metal carbide.

Generally, molybdenum is a high-melting material and has superior scuff resistance. Therefore, piston rings whose sliding surfaces are spray coated with molybdenum have been used. The hardness of the molybdenum coating is not satisfactory, and at a temperature of about **350**°C for prolonged periods of time, the hardness decreases just as in the case of chromium plating.

Furthermore, molybdenum readily undergoes oxidation in air at about 300°C, and therefore its properties are not altogether desirable for use in piston rings of internal combustion engines which are operated under high thermal loads. The abrasion resistance of a molybdenum coating is little different from that of a chromium plating.

A critical feature of the present invention resides in the addition of the self-fluxing alloy for improving the hardness of the spray coated layer.

Suitable self-fluxing alloys are Ni-B-Si alloy, Ni-Cr-B-Si alloy, and Co-Ni-Cr-Mo (or W)-B-Si alloy. In the present invention, self-fluxing alloys having a hardness of at least **50** (HRC) after spraying are employed, and, for example, powders of an alloy consisting, by weight, of 17% Cr, 1.0% C, 4.0% Si, 3.5% B, 4% Fe and the remainder being Ni are most preferred.

In general, self-fluxing alloys have high hardness and some of them have a hardness greater than 60 HRC. At about 350°C, therefore, their hardness is not reduced, and these alloys have excellent abrasion resistance and corrosion resistance. After spraying, the self-fluxing alloys are fused to a very compact structure.

This fusing treatment is carried out by heating the sprayed material to a temperature as high as about 1,050°C to diffuse it. Therefore, the tension of the piston ring is reduced, and it becomes totally useless; the use of such a piston ring has not been taken into consideration heretofore.

The present invention is based on the discovery that when the self-fluxing alloy is plasma-sprayed, the coating becomes a compact structure without the need for fusing and can be used as such. If this self-fluxing alloy having excellent abrasion resistance is added to molybdenum and the mixture is sprayed, the resulting coating becomes a compact structure while a spray coating of molybdenum alone has a porous structure. If the content of the self-fluxing alloy is greater than **50**%, the structure of the coating is hardly porous.

A porous structure, as is well known, is very important because of its oil retaining properties. From the standpoint of this oil retaining property alone, a spray material comprising 30 percent by weight of the self-fluxing alloy and 70 percent by weight of molybdenum brings about superior results. However, since the incorporation of a large quantity of molybdenum is not desirable for hardness at high temperatures, the amount of molybdenum should preferably be not greater than 50 percent by weight. The decreased amount of molybdenum may be made up for by the addition of a third component.

This third component is a metal oxide such as Al_2O_3 or Cr_2O_3 or a metal carbide such as WC or Cr_3C_2, which is a very hard material and which is stable at high temperatures. It has excellent abrasion resistance and corrosion resistance, but has poor adhesion when spray coated. When these powders of such metal compounds are sprayed onto a piston ring separately, each sprayed layer tends to be readily peeled off, giving rise to a problem which has to be solved before considering the abrasion resistance of the coating.

When the metal oxide or carbide is added to the mixture of molybdenum and the self-fluxing alloy, the resultant sprayed layer sprayed onto the piston ring can be prevented from being peeled off due to the excellent adhesion of the molybdenum. Therefore, a piston ring coated with such a sprayed layer exhibits excellent abrasion resistance as a sliding member.

From the viewpoint of porosity of the coating, the amount of the self-fluxing alloy should preferably be from 10 to 50 percent by weight, and the amount of the metal oxide or carbide should preferably be from 20 to 60 percent by weight for good adhesion.

The surface of a sliding member (such as a piston ring) on which a spray coated layer is to be formed is subjected to a conventional pre-treatment with grit of 20–80 mesh to improve the adhesion between the spray material and the base material.

As one example of the sliding member of this invention, a spray coated piston ring was produced and tested in an engine. The results obtained are shown in the accompanying drawing.

The tested piston ring was used as a first ring, and contained thereon a spray layer either composed of No. 1, No. 2 or No. 3.

No. 1: A spray layer composed of molybdenum

No. 2: A spray layer composed of 70 percent by weight of molybdenum and 30 percent by weight of a self-fluxing alloy of 1.0% C; 4.0% Si; 17% Cr; 3.5% B; 4.0% Fe; and 70.5% Ni by weight

No. 3: A spray layer composed of 30 percent by weight of molybdenum, 30 percent by weight of the above-described self-fluxing alloy and 40 percent by weight of Cr_2O_3

Engine Used for Testing

Type: Forcedly air cooling horizontally opposed two-cylinder 4-cycle gasoline engine

Cylinder Bore × Stroke: 83 × 73

Total Displacement: 790 cc

Maximum Power Output: 36 PS/4,000 r.p.m.

Experimental Conditions

1. Speed of Rotation: 5,000 r.p.m.
2. Horsepower: 22 PS
3. Load: 7 Kg
4. Operating Time: 50 hours
5. Oil Temperature: 110° ± 10°C
6. Cylinder: FC 25

As illustrated in the drawing which is a diagram showing a comparison of the amounts of wear of the spray coated piston rings Nos. 1, 2 and 3 in the engine test, the piston ring according to the present invention (spray-coated with No. 3 layer) had a very small amount of wear, and therefore, contributed greatly to an improvement in the performance of the internal combustion engine.

While the invention has been described in detail and with reference to preferred embodiments thereof, it will be apparent to one skilled in the art that various changes and modifications can be made therein without departing from the spirit and scope thereof.

What is claimed is:

1. A sliding member having a spray coated layer on at least a sliding surface thereof comprising 10 to 50 percent by weight of molybdenum, 10 to 50 percent by weight of a self-fluxing alloy and 20 to 60 percent by weight of a metal carbide or metal oxide, wherein said self-fluxing alloy is one selected from the group consisting of a Ni-B-Si alloy, a Ni-Cr-B-Si alloy, a Co-Ni-Cr-Mo-B-Si alloy and a Co-Ni-Cr-W-B-Si alloy.

2. A sliding member having a spray coated layer on at least a sliding surface thereof comprising 10 to 50 percent by weight of molybdenum, 10 to 50 percent by weight of a self-fluxing alloy and 20 to 60 percent by weight of a metal carbide or metal oxide, wherein said self-fluxing alloy comprises, by weight, 17% Cr, 1.0% C, 4.0% Si, 3.5% B, 4% Fe and the remainder being Ni.

3. The sliding member of claim **1,** wherein the constituent in the amount of 20 to 60 percent by weight is WC or metal oxide.

4. The sliding member of claim **2,** wherein the constituent in the amount of 20 to 60 percent by weight is WC or metal oxide.

5. The sliding member of claim **1,** wherein said self-fluxing alloy has a hardness of at least 50 HRC.

6. The sliding member of claim **3,** wherein said metal oxide is Al_2O_3 or Cr_2O_3.

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