

1

3,725,048

VALVE SEAT MATERIAL FOR AN INTERNAL COMBUSTION ENGINE

Soichiro Honda, Tokyo, Yoshitoshi Hagiwara, Yamato-machi, and Kenya Motoyoshi, Itami-shi, Japan, assignors to Honda Giken Kogyo Kabushiki Kaisha, Tokyo, and Sumitomo Denki Kogyo Kabushiki Kaisha, Higashi-ku, Osaka-shi, Japan

No Drawing. Filed Sept. 14, 1971, Ser. No. 180,467
Claims priority, application Japan, Sept. 15, 1970, 45/80,841

Int. Cl. C22b 9/00; C22c 39/54

U.S. Cl. 75-122

3 Claims

ABSTRACT OF THE DISCLOSURE

A valve seat of an internal combustion engine is composed of an alloy of 0.3-20% by weight of lead, 5-45% by weight of copper or copper oxide, 0.2-4% by weight of carbon, the balance being iron.

BACKGROUND

(a) Field of the invention

This invention relates to valve seat material for an internal combustion engine.

(b) Description of the prior art

Conventional materials for a valve seat of an internal combustion engine are low alloy cast irons (for example, Cu-Cr-Mo, Ni-Cr-Mo) in the case of light loads and a high alloy, such as high Cr, cast iron or cast steel in the case of heavy loads. Generally, a valve seat is exposed to the combustion gases in an internal combustion engine and is subjected, under a high temperature of between at least 200° C. and an estimated maximum of 700° C., to impact of an engine valve face and sliding abrasion by rotation of the valve. In an internal combustion engine using ordinary leaded gasoline, the lead

2

of the valve from the valve seat surface is worsened and the valve temperature and the valve seat temperature are greatly increased, whereby a rapid abrasion is caused and the tappet clearance becomes zero and the engine function is lost.

In an attempt to obviate this deficiency, instead of using the foregoing conventional materials, it has been attempted to use Monel metal (high Ni-Cu), high alloy die steel and super heat-resisting steel. These compositions are expensive and are considered to be high in heat and abrasion resistance, and are used to form respective valve seats. Actual machine endurance tests have been made for such compositions, but a satisfactory result has not been obtained although the life of the parts has been somewhat increased.

DESCRIPTION OF THE INVENTION

An object of the invention is to provide a composition of valve seat material which avoids the above deficiencies.

According to the invention, the valve seat material is constituted of lead, copper and carbon with the balance being iron.

Table 1 shows the relation of different fuels and valve and valve seat temperatures and Table 2 shows abrasion degrees in actual machine endurance tests for conventional materials and for materials according to this invention.

Table 3 shows the composition of the adhered matter on the sliding surface in the same test, and the adhered matter is considered to be a combustion product and a sliding surface portion product.

Test condition:

Engine: 2 cylinder 360 cc. OHC engine, 750 r.p.m.

Gasoline:

Octane rating 90 non-lead gasoline (0.002 g./gallon tetraethyl lead)

Octane rating 90 lead-added gasoline (0.3 g./gallon tetraethyl lead)

TABLE 1.—VALVE AND VALVE SEAT TEMPERATURE

Fuel.....	Material					
	SKD 1		Propane	Fe-20Cu-5Cr-2Pb-1C*	Fe-5Cr-2Pb-1C	Fe-25Cu-4Pb-1C*
	Lead-added gasoline	Non-lead gasoline		Non-lead gasoline	Non-lead gasoline	Non-lead gasoline
Exhaust valve maximum temperature, ° C.....	700	730	720	725	730	725
Valve face temperature, ° C.....	600	700	680	585	700	575
Valve seat temperature, ° C.....	360	500	450	340	500	330

*Material according to the invention.
NOTE.—Operation time 10 hrs. + 10° C.

in the gasoline reacts with S, P and other elements contained in the gasoline or oil, and thereby produces combustion products such as PbO, PbSO₄ and the like, these products forming thin films on contacting surfaces between the valve and the valve seat serving as an anti-friction material.

However, in an internal combustion engine using propane gas or non-lead gasoline, such combustion products having an anti-friction effect are not produced and the valve and the valve seat are brought into direct metal contact with one another, so that the coefficient of friction is increased, the generation of heat is increased, the heat conductivity is lowered, the heat radiation effect of

TABLE 2.—VALVE SEAT ABRASION DEGREE

Material	Duration time, hour	Decrease in tappet clearance
Fe-Cu-Cr-Mo.....	2	0.15 NG
Fe-2.0C-12Cr.....	10	0.15 NG
Fe-1.0C-8Cr-0.2Pb.....	19	0.15 NG
Monel S.....	33	0.15 NG
Fe-25Cu-4Pb-1C*.....	200	0.02 OK
Fe-20Cu-5Cr-2Pb-1C*.....	200	0.00 OK
Fe-5Cr-2Pb-1C.....	70	0.15 NG
Fe-25Cu-7.5Zn-2Pb-1C*.....	200	0.01 OK

*Material according to the invention.

NOTE.—Judging method: The tappet clearance is initially 0.15 mm. N.G. is the time when the clearance becomes zero by abrasion and thereby the engine stops. The test is limited to 200 hrs., and is not further carried out.

TABLE 3.—SLIDING SURFACE ADHERED MATTER

Fuel.....	Material				
	SKD 1		Fe-25Cu-4Pb-1C*	Fe-20Cu-5Cr-2Pb-1C*	Fe-25Cu-7.5Zn-2Pb-1C*
	Lead-added gasoline	Non-lead gasoline	Non-lead gasoline	Non-lead gasoline	Non-lead gasoline
Products.....	PbO, Pb ₂ O ₄ PbSO ₄	CaSO ₄ (NH ₄) ₂ SO ₄	CaSO ₄ PbSO ₄ , PbO CuO, Cu ₂ O	CaSO ₄ PbSO ₄ , PbO CuO, Cu ₂ O Cr ₂ O ₃	CaSO ₄ PbSO ₄ , PbO CuO, Cu ₂ O ZnO
	Pb ₃ (PO ₄) ₃ OH	(FeMn)PO ₄			

*Material according to the invention.

As seen from the foregoing Table 1, a valve seat made of conventional SKD 1 material in such that the valve face temperature and the valve seat temperature, which are not great when lead-added gasoline is used, increase substantially when non-lead gasoline or propane is used. A valve seat made of material containing Cu and Pb produces lowered temperatures, even when non-lead gasoline is used, as compared to the temperatures when the valve seat is made of SKD 1 material and lead-added gasoline is used.

This reduction is not seen when the valve seat material contains Pb but not Cu.

According to Table 2, a valve seat made of the material containing Cu and Pb and lower in temperature as mentioned above, is small in abrasion degree and is extremely improved in duration time in comparison with the valve seat of the conventional materials.

This invention has a first characteristic feature that Cu and Pb are contained in an alloy for a valve seat material, and thereby, even in an internal combustion engine using non-lead gasoline, the valve seat surface temperature can be equal to or lower than the temperature in the case of using lead-added gasoline, and thus the life can be improved.

It is believed that the reason for this effect is as follows:

As can be seen in Table 3, even if Pb is not contained in the fuel, when Pb and Cu are incorporated in the valve seat in accordance with this invention, a chemical compound having an anti-friction effect such as PbSO₄, PbO, Cu₂O, CuO, ZnO and others is produced by the engine combustion gas at the combustion temperature, and the aforesaid compounds serve as a lubricating agent for preventing direct metal contact between the valve and the valve seat and lowering the coefficient of friction therebetween.

When, additionally, this tendency is observed in detail, it has become clear that if the temperature reaches about 250° C., Pb is exuded and forms a chemical compound thereof in addition to its own lubricating effect, and if the temperature reaches 400–450° C., the valve seat surface structure is further changed and Cu is oxidized and forms, along with the contained iron oxide, a strong and fine lubricating film with coexistence of PbO and CuO, and thus there is exhibited a lubricating effect throughout from a comparatively low temperature to a high temperature.

Additionally, in the material according to this invention, the heat conductivity of the material itself is improved in that Cu is distributed to the alloy grain boundaries, and by virtue of the improved heat conductivity, the heat radiating effect from the valve seat is greatly improved, whereby it becomes possible for the valve seat surface temperature to become lowered more than about 100° C. in comparison with the conventional material.

Though Pb has in itself a lubricating effect and presents, even in the case of using non-lead gasoline, an excellent lubricating effect as a compound at the combustion temperature and additionally by its coexistence with a Cu compound as mentioned above, this effect is not obtained if the lead content is below 0.3% by weight whereas practical strength is difficult to obtain if the lead content is above 20% by weight. Thus, the range of the lead must be 0.3–20% by weight. Cu has a lubricating effect similar to Pb and improves the heat conductivity by existing in

the alloy grain boundaries, but it does not contribute to the lubricating effect and heat conductivity because it is dissolved in Fe in solid solution, when the copper content is below 5% weight, and a practical strength for the valve seat is difficult to obtain if the copper content is above 45% by weight. Thus, the range of the copper must be 5–45% by weight.

Additionally, a Fe-Cu alloy matrix is low in hardness, and therefore C must be contained in the alloy to provide the necessary abrasion resistance for the valve seat material. Though C is in solid solution in Fe, the carbon is not effective if the content thereof is below 0.2% and it makes the material brittle if it is present in an amount above 4%. The range of carbon therefore is 0.2–4% and preferably 0.2–2%.

Thus according to the invention Cu and Pb and additionally a small amount of C are contained in the composition but additives such as Cr or Zn as seen in the Tables 1, 2 and 3, may be employed when any improvement in the valve seat material is required depending on the engine to be used.

In addition to the Cr, and Zn additives whose effects are clear from the foregoing tables, a small amount of Sn, Ag, Bi, S, P, Al, Co, Mo, Si, Ti, Sr, Mn, and the like is also possible.

These additives improve the strength and abrasion resistance of the material by existing in the Fe-Cu-C alloy in the form of a solid solution or an intermetallic compound, or independently, and also serve as an anti-friction material in the form of a combustion product.

Two examples of the valve seat material in the tables are manufactured by the following processes:

The composition of 25% by weight of Cu, 4% weight of Pb, 1% by weight of C and the balance Fe is manufactured by producing a mixed powder of the above composition and forming it into a mold product of 7.0 gr./cc. which is sintered for about 30 minutes at a temperature of 1120° C. within a reducing atmosphere.

The composition of 20% by weight of Cu, 5% by weight of Cr, 2% by weight of Pb, 1% by weight of C and the balance Fe is manufactured by producing a mixed powder of the above composition and forming a mold product of the same of a density of 7.0 gr./cc. which is sintered for about 30 minutes at 1250° C. within a reducing atmosphere.

Pb and Cu are uniformly distributed within the valve seat by this powder formation and sintering process, and first Pb is exuded by the action of the combustion gas, oil, heat, striking and sliding of the valve against the seat at the time of operation of the engine, and then Pb which contains Cu is exuded and additionally their chemical compounds are formed on the surface for exhibiting a lubricating effect. The lubricating and anti-friction effects depend on the Pb and Cu, and it is not always necessary to disperse the same throughout the entire valve seat but the seat may be modified so that a powder layer containing Pb and Cu is formed only on the surface at the time of molding of the mixed powder before sintered, or after a sintered product not containing Pb and Cu is formed, the product is impregnated with Pb and Cu at the outer surface thereof. It may be contemplated that Pb and Cu are separately used for mixing or impregnation, but this may be modified by using these elements in the form of

5

a composition of Pb-Cu coexistence (for example, Kelmet alloy).

Though the valve seat material of this invention can be manufactured easily and economically by a powder metallurgy process as mentioned above, the material may be manufactured by other processes such as a casting process or the like. Additionally, it is of course permissible that, when the elements are present within the range disclosed, other additives can be incorporated and a reinforcing treatment or working can be additionally employed.

What is claimed is:

1. An alloy for a valve seat of an internal combustion engine consisting essentially of 0.3-20% by weight lead, 5 to 45% by weight copper, 0.2-4% by weight of carbon with the balance being iron, the alloy being capable of forming lubricant films of compounds of lead and copper for use with non-leaded gasoline to reduce wear of the valve seat.

6

2. An alloy as claimed in claim 1 wherein the carbon is present in an amount of 0.2-2% by weight.

3. An alloy as claimed in claim 1 which is present only in a surface layer of the valve seat.

References Cited

UNITED STATES PATENTS

1,647,491	11/1927	Whiteley	-----	75-125
1,964,702	6/1934	Summers	-----	75-123 F
1,975,742	10/1934	Critchett	-----	75-125
2,266,762	12/1941	Jerabek	-----	75-125

HYLAND BIZOT, Primary Examiner

U.S. Cl. X.R.

75-125