(12) UK Patent Application (19) GB (11) 2 386 610 (13) A

(43) Date of A Publication 24.09.2003

(21) Application No 0301240.8

(22) Date of Filing 20.01.2003

(30) Priority Data
(31) 2002074148 (32) 18.03.2002 (33) JP

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(51) INT CL^7
F16C 33/12 , C22C 9/00

(52) UK CL (Edition V)
C7A AB249 AB25X AB25Y AB250 AB26X AB261 AB263 AB265 AB267 AB269 AB27X AB271 AB273 AB275 AB277 AB279 AB289 AB309 AB319 AB32X AB32Y AB320 AB325 AB327 AB329 AB33X AB331 AB333 AB335 AB337 AB349 AB369 AB37X AB37Y AB370 AB375 AB377 AB379 AB38X AB381 AB383 AB385 AB387 AB389 AB399 AB419 AB42X AB42Y AB420 AB422 AB424 AB425 AB427 AB429 AB43X AB431 AB433 AB435 AB437 AB439 AB44Y AB440 AB449 AB45X AB46X AB46Y AB460 AB469 AB470 AB473 AB475 AB477 AB479 AB48X AB481 AB483 AB485 AB487 AB489 AB50Y AB500 AB509 AB51X AB511 AB513 AB515 AB517 AB519 AB52Y AB528 AB53X AB531 AB533 AB535 AB537 AB549 AB559 AB610 AB613 AB616 AB617 AB619 AB62X AB62Y AB621 AB624 AB627 AB630 AB633 AB635 AB66X AB66Y AB661 AB662 AB663 AB665 AB666 AB667 AB668

(52), (56) and (58) continued overleaf

(54) Abstract Title
A sliding bearing material

(57) A sliding bearing made from an alloy comprising: 0.5-15 mass % Sn, 0.2-10 mass % Ni, 0.4-10 volume % in total of hard particles comprising one or more of WC, W_2C, Mo_2C, W and/or Mo, 0-40 mass % in total of Fe, Al, Mn, Co, Zn, Si and/or P, 0-10 volume % in total of MoS_2, WS_2, h-BN and/or graphite, 0-10 mass % in total of Bi and/or Pb, with the balance being copper. The matrix contains Cu, Sn and Ni and has a grain size of not more than 0.070 mm. Preferably the WC, W_2C and Mo_2C has an average size of 0.1-10 μm the W and Mo has an average size of 1-25 μm. The bearing is made by mixing an alloy powder with the hard particles, spreading the mixed powders on a copper-plated steel substrate, sintering at 800-950 °C in a reducing atmosphere, rolling and then re-sintering and re-rolling. The final sinter is performed no higher than 920 °C.

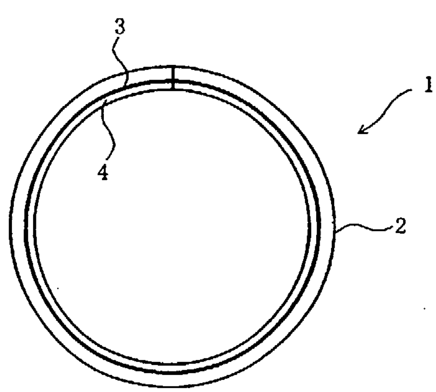

FIG.1

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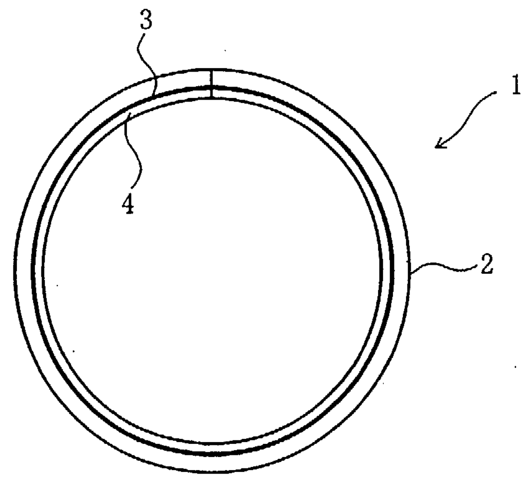

FIG.1

Background of the Invention

The present invention relates to a sliding material consisting of a Cu-based alloy, particularly to a sliding material excellent in corrosion resistance and fatigue resistance.

A Cu-Sn-Pb-based alloy bearing has heretofore been used as a sliding material of a Cu-based alloy in a bush, thrust washer, and the like. However, for the bearings in use under high-temperature environment, such as a piston bush used at a small end of a connecting rod, there has been a problem of corrosion by a lubricant, and there has been also a problem of fatigue resistance to large variations of load. To improve this, an attempt has been made to improve corrosion and fatigue resistances with utilization of a Cu-Sn-Ni-based or Cu-Sn-Ni-Pb-based material in which Ni is added by reducing or without Pb. However, in recent years, the piston bush of an internal combustion engine has been increasingly used under the high-temperature environment, and the problem of corrosion has not completely been solved by such improvement.

Brief Summary of the Invention

The present invention has been made taking the above background into consideration, and an object thereof is to provide a sliding material in which a Cu-based alloy is used and which is excellent in corrosion and fatigue resistances.

While, in general, a sliding material of a Cu-based alloy has been manufactured by sintering, but the present inventors have found that with addition of a certain type of hard particles (particles of WC, W_2C, Mo_2C, W, Mo) to a Cu-Sn-Ni alloy, growth of crystal grains is inhibited in a final process of sintering resulting in that the alloy has fine crystal grains. It has been found also that by grain refining, strength is improved, fatigue resistance becomes excellent, and corrosion by a lubricant is particularly effectively prevented.

Thus, according to the present invention, there is provided a sliding material comprising: 0.5 to 15 mass % of Sn; 0.2 to 10 mass % of Ni; 0.4 to 10 volume % of hard particles; and the balance being essentially Cu, wherein the hard particles are of one or more selected from the group consisting of WC, W_2C, Mo_2C, W, and Mo and a grain size of the matrix of a Cu-Sn-Ni base is set to be not more than 0.070 mm. The grain size is determined in accordance with a method for estimating average grain size of wrought copper and copper-alloys which is defined in JIS H 0501.

In this case, with regard to an average particle size of the hard particles, that of WC, W_2C, or Mo_2C is preferably 0.1 to 10 μm, and that of W or Mo is

1 to 25 μm.

According to one feature of the present invention, the sliding material may contain not more than 40 mass % in total of one or more selected from the group of Fe, Al, Mn, Co, Zn, Si and P.

According to another feature of the present invention, the sliding material may contain not more than 10 volume % in total of one or more selected from the group consisting of MoS_2, WS_2, h-BN and graphite.

According to a still another feature of the present invention, the sliding material may contain not more than 10 mass % in total of Bi and/or Pb.

Herein below, there will be provided a description of reasons for the above specified features.

(1) Sn: 0.5 to 15 mass %

Sn strengthens the Cu alloy matrix, and improves fatigue resistance property. If the Sn content is less than 0.5 mass %, it is impossible to obtain an improvement effect of strengthening the Cu alloy matrix. When the Sn content exceeds 15 mass %, a lot of Cu-Sn compounds are formed resulting in that the alloy becomes brittle.

(2) Ni: 0.2 to 10 mass %

Ni is dissolved in the Cu alloy matrix to improve it in the corrosion resistance property, the fatigue resistance property and mechanical strength.

If the Ni content is less than 0.2 mass %, it is impossible to obtain an improvement effect of the corrosion resistance property and mechanical strength of the Cu alloy matrix. When the Ni content exceeds 10 mass %, the Cu alloy matrix becomes too hard and is not preferable as the sliding material.

(3) Hard Particles: WC, W_2C, Mo_2C, W and Mo

Since these hard particles have good wettability with the Cu alloy matrix, the alloy strength is not deteriorated and no void is formed in the alloy. Thus, penetration of the lubricant into the Cu alloy matrix is prevented resulting in improved corrosion resistance property.

(4) Hard Particles: 0.4 to 10 Volume %

If a content rate of the hard particles is less than 0.4 volume %, it is impossible to obtain a grain refining effect of the Cu alloy matrix resulting in no improvement effect of the corrosion resistance property. When the content rate exceeds 10 volume %, a mating material will be attacked by the alloy too intensively resulting in inferior anti-seizure property of the alloy.

(5) Grain Size of Cu-Sn-Ni Alloy Matrix: not more than 0.070 mm

In the case where the grain size of the Cu-Sn-Ni alloy matrix (i.e. the Cu alloy matrix) exceeds 0.070 mm, the improvement effect of the corrosion resistance property can not be obtained.

(6) Size of Hard Particles of WC, W_2C, Mo_2C:
0.1 to 10 μm

In the case where the particle size of WC, W_2C and Mo_2C is less than 0.1 μm, the hard particles are too fine, and poor in the refining effect of crystal grains resulting in that the improvement effect of the corrosion resistance property can not be obtained. On the other hand, if the particle size exceeds 10 μm, they attack the mating material too strongly resulting in deteriorated anti-seizure property. In this case, the particles are not dispersed uniformly resulting in an inferior refining effect of crystal grains.

(7) Size of Hard Particles W, Mo: 1 to 25 μm

In the case where the particle size of W and Mo is less than 1 μm, they are too fine, and poor in the refining effect of crystal grains resulting in that the improvement effect of the corrosion resistance property can not be obtained. On the other hand, if the particle size exceeds 25 μm, they attack the mating material too strongly resulting in deteriorated anti-seizure property. In this case, the particles are not dispersed uniformly resulting in an inferior refining effect of crystal grains.

(8) Fe, Al, Mn, Co, Zn, Si, and P: not more than
40 mass % in total

These strengthen the Cu alloy matrix to improve the fatigue resistance property. If the content of those exceeds 40 mass %, they do not contribute to improvement of the fatigue resistance property.

(9) MoS_2, WS_2, h-BN, graphite: not more than 10 volume % in total

These are solid lubricating materials. An additive of those further improves anti-seizure and wear resistance properties. If the total content of those exceeds 10 volume %, the alloy strength is reduced.

(10) Bi, Pb: not more than 10 mass % in total

These are dispersed in the Cu alloy matrix to form a soft phase resulting in improved embeddability and anti-seizure property. If the content of those exceeds 10 mass %, the strength of the Cu alloy matrix is reduced.

Brief Description of the Drawings

Fig. 1 is a sectional view of a bush showing one embodiment of the invention.

Detailed Description of the Invention

Herein below there will be described one embodiment in which the present invention is applied to a piston pin bush mounted on a small end of a connecting rod. A piston pin bush 1 is of a so-called wrapped bush. It is configured such that, as shown in FIG. 1, an inner peripheral surface of a back metal 2 made of a thin steel plate is provided with a bearing alloy layer 4 as a sliding material according to the present invention via a Cu plating layer 3 for improving adhesiveness.

The bearing alloy layer 4 is made of a sintered Cu alloy, and has a chemical composition defined in the claims as represented by Invention Examples 1 to 11 described later. That is, the bearing alloy layer 4 comprises 0.5 to 15 mass % of Sn, 0.2 to 10 mass % of Ni, 0.4 to 10 volume % of hard particles, and the balance being essentially of Cu. The hard particles are of one or more selected from the group of WC, W_2C, Mo_2C, W and Mo. The grain size of a Cu-Sn-Ni matrix is not more than 0.070 mm.

In this case, preferably an average particle size of WC, W_2C and Mo_2C is 0.1 to 10 μm, and preferably that of W and Mo is 1 to 25 μm. Further, the bearing alloy may contain not more than 40 mass % in total of one or more selected from the group of Fe, Al, Mn, Co, Zn, Si, and P. It may contain also not more than 10 mass % in total of Bi and/or Pb. It may contain also not more than 10 volume % in total of one or more selected from the group of MoS_2, WS_2, h-BN, and graphite.

Here, there will be briefly described a manufacturing method of the bush 1. First, a Cu alloy powder having a given composition and hard particles are mixed in a mixer to obtain a predetermined rate. The Cu alloy powder may be of a Cu-Sn-Ni alloy, Cu-Sn-

Ni-Zn alloy and so on. In the mixing process, the Cu alloy powder comprises not less than 90 mass % of particles having a particle size of not more than 75 μm and not less than 60 mass % of particles having a particle size of not more than 45 μm in order to uniformly mix with the hard particles.

Subsequently, the powder mixture is spread onto a 1.3 mm thick steel strip (the back metal 2) previously provided with the Cu plating layer 3, subsequently heated for a first sintering at 800 to 950°C for about 15 minutes in a reducing atmosphere. Thereafter, the processed material is rolled to compact the bearing alloy layer. Further processes of sintering and rolling are repeated in order to compact the bearing alloy layer, whereby a bimetal is obtained, which has a total thickness of about 1.6 mm and an about 0.4 mm thickness of the bearing alloy layer.

In the manufacturing process of the bimetal, a sintering temperature in the finally performed sintering process was set at not higher than 920°C in order to inhibit the growth of crystal grains. The temperature of not higher than 920°C is a temperature at which no liquid phase is generated in the Cu-Sn-Ni matrix. A specimen of comparative Example 3 was processed at a final sintering temperature of 970°C, which was used in the tests described below. The bimetal was machined and formed to be a cylindrical shape, and finally coated with an overlay layer 5 so that the bush 1 was manufactured.

With regard to the invention examples and the comparative examples having chemical compositions shown in Table 1, the present inventors measured the grain sizes of those Cu alloys, and conducted a corrosion, seizure and fatigue tests in order to confirm advantages of embodiments of the invention.

The grain size of the respective Cu alloy was measured in accordance with a method for estimating average grain size for wrought copper and copper-alloys which is defined in JIS H 0501. The corrosion test was conducted in a lubricating oil with regard to a respective specimen, having a total thickness of 1.5 mm (including 0.3 mm of the bearing alloy layer thickness), a width of 25 mm and a length of 50 mm, which was produced from the bimetal. The seizure test was conducted with regard to a respective specimen bush having a total thickness of 1.5 mm (including 0.3 mm thickness of the bearing alloy layer), an inner diameter of 20 mm, and a width of 15 mm. And the fatigue test was conducted with regard to a cylindrical bearing which was prepared by mating two semi-circular bearings each having a total thickness of 1.5 mm (including 0.3 mm thickness of the bearing alloy layer). Conditions of the tests are shown in Tables 2 to 4.

Table 1

	No.	Chemical composition							
		Cu mass %	Sn mass %	Ni mass %	Hard particles (vol %)				others
					Mo_2C	WC	Mo	W	
Invention Example	1	bal.	10	8	8	-	-	-	
	2	bal.	0.8	0.3	0.5	-	-	-	
	3	bal.	6	3	0.5	-	-	-	
	4	bal.	6	3	1.5	-	-	-	
	5	bal.	6	3	9.5	-	-	-	
	6	bal.	6	3	-	1.5	-	-	
	7	bal.	6	3	-	-	1.5	-	
	8	bal.	6	3	-	-	-	1.5	-
	9	bal.	6	3	1.5	-	-	-	Bi 3 mass %
	10	bal.	6	3	1.5	-	-	-	Graphite 1 vol %
	11	bal.	6	3	1.5	-	-	-	Zn 20 mass %
Comparative Example	1	bal.	6	3	-	-	-	-	
	2	bal.	10	-	3	-	-	-	
	3	bal.	-	3	3	-	-	-	
	4	bal.	6	3	1.5	-	-	-	Al_2O_3 1.5 vol %
	5	bal.	6	3	1.5	-	-	-	SiC 1.5 vol %

Cont'd ...

In Comparative Example 3, a final sintering temperature of 970°C was used.

Table 1 (Cont'd ...)

	Size Crystal grains mm	Corrosion depth at grain boundaries µm	Specific load when seizure occurred MPa	Occurrence of fatigue
	0.015	4	18	no
	0.065	35	15	no
	0.055	6	27	no
	0.025	6	27	no
	0.010	1	15	no
	0.025	6	24	no
	0.045	12	24	no
	0.045	10	27	no
	0.015	30	30	no
	0.025	45	30	no
	0.025	4	12	no
	0.095	80	9	no
	0.006	110	15	no
	0.080	90	6	no
	0.050	125	12	yes
	0.050	130	12	yes

Table 2

Item	Conditions
Size of specimen	Width 25 mm × Length 50 mm
Used oil	CD grade for diesel, Fresh
Test temp.	150°C
Test time	100 hours

Table 3

Item	Conditions
Bearing inner diameter	φ 20 mm
Bearing width	15 mm
Peripheral speed	1.0 m/sec
Lubricant	SAE #10
Shaft material	JIS S55C as quenched
Shaft roughness	Rmax 1.0 μm or less

Table 4

Item	Conditions
Surface load	120 MPa
Test time	20 hours
Speed	9 m/sec
Lubricant	SAE #30
Lubrication pressure	0.49 MPa
Test temp.	100°C
Partner material	JIS S55C Hardened
Partner material roughness	Rmax 1.0 μm or less

In the seizure test, the surface load was increased step-by-step in increments of 5 MPa and held under operation at each increment of surface load for 10 minutes, wherein a bearing surface load one-step lower than an actual bearing surface load, when a back surface temperature of the bearing exceeds 200°C or when a driving current of a motor for driving a rotary shaft exhibited an abnormal value, was regarded as a maximum specific load without seizure. In the fatigue test, the respective semi-circular bearing was exposed to a sliding-contact state under a predetermined load. After the test, the respective test specimen was checked to confirm whether or not fatigue occurred in the bearing alloy.

As is apparent from Table 1, in comparison with Comparative Examples 1 to 5, Invention Examples 1 to 11 are significantly excellent in corrosion resistance property, and exhibit similar or excellent results with regard to anti-seizure and fatigue resistance properties.

Herein below, there will be described the grain size of the Cu alloy matrix, constituent elements of the Cu alloy matrix, and type of the hard particles and test result of corrosion resistance property.

(1) As is apparent from Table 1, Invention Examples 1 to 11 are substantially the same as Comparative Examples 2,4 and 5 in the point that the grain size of the Cu alloy matrix is not more than 0.070 mm.

(2) In Invention Examples 1 to 11, the Cu alloy matrix is of the Cu-Sn-Ni system (Invention Examples 1 to 10 are of Cu-Sn-Ni, and Invention Example 11 is of Cu-Sn-Ni-Zn), and Mo_2C, WC, Mo and W are used as the hard particles.

(3) On the other hand, in Comparative Example 1, the Cu alloy matrix is of the Cu-Sn-Ni system, but does not contain the hard particles.

(4) In Comparative Examples 2 and 3, Mo_2C is used as the hard particles, but the Cu alloy matrix does not contain Ni and Sn.

(5) In Comparative Examples 4 and 5, the Cu alloy matrix is of the Cu-Sn-Ni system, and Al_2O_3, SiC are used as the hard particles in addition to Mo_2C.

(6) Additionally, Invention Examples 1 to 11 are excellent than Comparative Examples 1 to 5 in corrosion resistance property.

(7) It can be seen from the above that for the Cu alloy matrix of the Cu-Sn-Ni system having the grain size not more than 0.070 mm and containing Mo_2C, WC, Mo and W, the corrosion resistance property is improved.

It should be noted that the present invention is not limited to the above-described embodiment with reference to the drawing, and can be expanded or varied as follows.

The hard particles may be W_2C.

The hard particles may also contain two or more selected from W_2C, Mo_2C, WC, Mo and W.

The present invention is not limited to the bush for the piston pin disposed in the small end of the connecting rod, and may also be applied to a main bearing of an internal combustion engine constituted as the semi-circular bearing.

CLAIMS:

1. A sliding material comprising 0.5 to 15 mass % of Sn, 0.2 to 10 mass % of Ni, 0.4 to 10 volume % of hard particles, and the balance being essentially Cu, wherein the hard particles are one or more selected from the group of WC, W_2C, Mo_2C, W and Mo, and wherein a grain size of the matrix of the sliding material is not larger than 0.070 mm, the matrix being of a Cu-Sn-Ni alloy.

2. A sliding material according to claim 1, wherein:

when the hard particles are of WC, W_2C or Mo_2C, an average particle size thereof is 0.1 to 10 μm, and

when the hard particles are of W or Mo, an average particle size thereof is 1 to 25 μm.

3. A sliding material according to claim 1 or 2, which further comprises 40 mass % in total of one or more selected from the group of Fe, Al, Mn, Co, Zn, Si and P.

4. A sliding material according to any one of claims 1 to 3, which further comprises not more than 10 volume % in total of one or more selected from the group of MoS_2, WS_2, h-BN and graphite.

5. A sliding material according to any one of claims 1 to 4, which further comprises not more than 10 mass % in total of Bi and/or Pb.

6. A sliding material substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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Application No: GB 0301240.8
Claims searched: 1-6

Examiner: Matthew Lawson
Date of search: 2 July 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
X	1-5	US 20010021353 A1	(SAKAI) - the whole specification, especially paragraphs [0029]-[0030] and Examples 2, 5 & 8 of Table 1.
X	1-5	JP 20010050273 A	(DAIDO) - WPI Abstract Accession No. 01-261193/27, the PAJ abstract and Examples 1 & 2.
X	1-3,5	JP 20010107106 A	(NIPPON) - WPI Abstract Accession No. 01-401321/43, the PAJ abstract, Examples 8 & 14 and the figure.
X	1-3,5	JP 070166278 A	(TOKAI) - WPI Abstract Accession No. 95-261641/34, the PAJ abstract and Tables 2 & 3 Example 12.
X	1-3	GB 2365935 A	(DAIDO) - the whole specification, especially page 6 lines 11-12, page 6 line 20 - page 7 line 10, page 15 line 25 - page 16 line 2 and Examples 6, 7 & 9 and Comp. Examples 2, 5 & 6.
X	1,2	GB 2360294 A	(DAIDO) - the whole specification, especially page 7 lines 17-22, page 9 lines 3-5, 17 & 25 and Examples 1, 2 & 7 and Comp Example 3 of Table 1.
X	5	JP 20000104132 A	(NIPPON) - WPI Abstract Accession No. 00-342755/30, the PAJ abstract, Examples 10 & 15 and figure 1.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Application No: GB 0301240.8
Claims searched: 1-6
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{V}:

F2A

Worldwide search of patent documents classified in the following areas of the IPC^{7} :

C22C; F16C

The following online and other databases have been used in the preparation of this search report :

Online: PAJ, WPI