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(54) Wear resistant materials

(57) A sliding and/or bearing material having a superior wear resisting property, consisting of: a backing metal; an intermediate layer joined to the backing metal; a porous metallic layer joined to the intermediate layer; and a substance with which the porous layer is impregnated and/or coated, the substance being a mixture consisting essentially of 0.1 to 50 vol% of at least one composition selected from a group consisting of FEP, PFA, ETFE, PCDF, PCTFE and EPE; 0.1 to 35 vol% of at least one composition selected from a group consisting of solid lubricants such as a low melting point metallic lubricant such as Pb, Sn or their alloys, metal oxides, metal sulfides, metal fluorides, graphite or the like, fibrous materials such as carbon fibres, and ceramics such as SiC; and the balance substantially PTFE, the total of contents of constituents other than PTFE being in the range between 0.2 and 70 vol%.

GB 2 139 236 A

SPECIFICATION

Wear resistant materials

The present invention relates to wear resistant materials e.g. sliding and/or bearing materials and to products intended to have a sliding and/or bearing function which include such materials.

Conventional sliding and bearing materials shown in the following references are pertinent to the present invention:

(1) United States Patent Specification No. 2,995,462,
(2) United States Patent Specification No. 4,312,772,
(3) German Laid-Open Patent Publication No. 3,229,667/1983, and
(4) United States Patent Specification No. 4,208,472.

It has been found that wear resistant properties of the sliding and bearing materials shown in these documents can be improved. This is of particular advantage for materials intended to be employed in sliding bearings (plain bearings).

According to one aspect of the present invention, there is provided a wear resistant material comprising a substance selected from one of the following mixtures (A), (B) and (C):

(A) a first mixture consisting essentially of 0.1 to 50 vol% of at least one composition selected from a group consisting of tetrafluoroethylene-ethylene copolymer resin (hereinafter described as ETFE), vinylidene fluoride resin (PVDF), chlorotrifluoroethylene resin (PCTFE), fluoroethylene propylene ether resin (EPE), and the balance substantially polytetrafluoroethylene (PTFE), preferably the content of such one composition being 0.5–45 vol%;

(B) a second mixture consisting essentially of 0.1 to 50 vol% in total of at least two compositions selected from a group consisting of tetrafluoroethylenehexapropylene copolymer resin (FEP), tetrafluoroethyleneperfluoroalkylvinyl ether copolymer resin (PFA), ETFE, PVDF, PCTFE and EPE and the balance substantially PTFE, preferably the content of such two compositions being 0.5–45 vol%;

(C) a third mixture consisting essentially of 0.1 to 50 vol% (preferably 0.5 to 40 vol%) of at least one composition selected from a group consisting of FEP, PFA, ETFE, PVDF, PCTFE and EPE; 0.1 to 35 vol% (preferably 0.5 to 30 vol%) of at least one composition selected from a group consisting of solid lubricants such as a low-melting point metallic lubricant, e.g. Pb, Sn or their alloys, metal oxides, metal sulfides, metal fluorides, graphite or the like fibrous materials such as carbon fibers, and ceramics such as SiC; and the balance substantially PTFE, the total of contents of the compositions other than PTFE ranging between 0.2 and 70 vol% (preferably 0.5 to 60 vol%).

According to another aspect of the invention, there is provided a sliding and/or bearing material having a superior wear resisting property, consisting of: a backing layer e.g. of metal; a porous metallic layer supported by the backing layer with or without an intermediate layer joined to said backing layer, and a substance with which the porous layer is impregnated and/or coated, the substance being one selected from one of the following mixtures (A), (B) and (C):

(A) a first mixture consisting essentially of 0.1 to 50 vol% of at least one composition selected from a group consisting of tetrafluoroethylene-ethylene copolymer resin (hereinafter described as ETFE), vinylidene fluoride resin (PVDF), chlorotrifluoroethylene resin (PCTFE), fluoroethylene propylene ether resin (EPE), and the balance substantially polytetrafluoroethylene (PTFE), preferably the content of such one composition being 0.5–45 vol%;

(B) a second mixture consisting essentially of 0.1 to 50 vol% in total of at least two compositions selected from a group consisting of tetrafluoroethylenehexapropylene copolymer resin (FEP), tetrafluoroethyleneperfluoroalkylvinyl ether copolymer resin (PFA), ETFE, PVDF, PCTFE and EPE, and the balance substantially PTFE, preferably the content of such two compositions being 0.5–45 vol%;

(C) a third mixture consisting essentially of 0.1 to 50 vol% (preferably 0.5 to 40 vol% of at least one composition selected from a group consisting of FEP, PFA, ETFE, PVDF, PCTFE and EPE; 0.1 to 35 vol% (preferably 0.5 to 30 vol%) of at least one composition selected from a group consisting of solid lubricants such as a low-melting point metallic lubricant, e.g. Pb, Sn or their alloys, metal oxides, metal sulfides, metal fluorides, graphite or the like, fibrous materials such as carbon fibers, and ceramics such as SiC; and the balance substantially PTFE, the total of contents of the compositions other than PTFE ranging between 0.2 and 70 vol% (preferably 0.5 to 60 vol%).

The backing metal may be a steel strip, while the intermediate layer is a copper-plating layer. The porous metallic layer may be a sintered layer of a Cu-Sn-Pb alloy or other Cu-based alloys.

An explanation will be given hereinunder as to the reasons of limitation as to the constituents of the impregnated and/or coated substance in the sliding and/or bearing material of the invention, i.e. the reasons of limitation of upper and lower limits of contents of the constituents of the substance, as well as the advantageous effects brought about by these constituents.

Referring first to the mixture A, the wear resisting property of the sliding and/or bearing material is seriously degraded when the content of one of the compositions ETFE, PVDF, PCTFE and EPE is less than 0.1 vol%. On the other hand, when the content of one of the compositions ETFE, PVDF, PCTFE and EPE exceeds 50 vol%, such composition becomes the major constituent so that the friction coefficient and friction temperature are increased undesirably to deteriorate the sliding and/or bearing performance, although the wear resisting property is improved. For these reasons, the content of the mixture A is selected to range between 0.1 to 50 vol%, preferably between 0.5 and 45 vol%.

Regarding the mixture B, the wear resisting property of the sliding and/or bearing material is seriously degraded when the total of contents of at least two compositions selected from the group consisting of FEP, PFA, ETFE, PVDF, PCTFE and EPE is less than 0.1 vol%. On the other hand, when the total of the contents thereof exceeds 50 vol%, the bearing performance is degraded due to increase in the friction coefficient and friction temperature. For these reasons, the total content of these at least two compositions is selected in the range between 0.1 and 50 vol%, preferably between 0.5 and 45 vol%.

With regard to the mixture C, the content of at least one composition selected from the group consisting of a low-melting point metallic lubricant, solid lubricant, fibrous material and ceramics should be 0.1 vol% or greater, because otherwise the effect of addition of such a composition is not appreciable. On the other hand, when the content of at least one of these compositions exceed 35 vol%, the sliding and/or bearing material becomes too brittle to be used practically. Therefore, the content of at least one of these compositions should be 0.1 to 35 vol%, preferably 0.5 to 30 vol%, of the whole impregnating and coating substance.

When the total of the contents of constituents of mixture C is less than 0.2 vol%, the effect of addition of these constituents is not appreciable. When, on the other hand, the total of contents of these constituents exceeds 70 vol%, the sliding and/or bearing material becomes too brittle to be used practically and the combined effect produced by these constituents is lost while causing a rise in the friction coefficient and friction temperature to degrade the bearing performance. The total of the contents of these constituents, therefore, should be selected to fall within the range of between 0.2 and 70 vol%, preferably 0.5 and 60 vol%.

Examples of the metal oxides in the mixture C are PbO, Al_2O_3, SiO_2, Pb_3O_4, TiO_2, CdO, Sb_2O_3 and so forth, while examples of the metal sulfide in the mixture C are PbS, MoS_2, WS_2 and so forth. Metal fluorides such as PbF_2, AlF_3, CdF_2 and BaF_2 are usable as the metal fluoride in the mixture C. The fibrous material in the mixture C may be a natural or an artificial fiber such as carbon fibers, glass fibers, cotton (cellulose), asbestos, fibers of potassium titanate and so forth. Also, ceramic such as SiC, TiC, TiN, B_4C, BN and Si_3N_4 is usable as the ceramics in the mixture C.

Practical examples of the sliding and/or bearing material of the invention are shown below.

Examples:

A backing metal of an ordinary structural carbon steel having a thickness of about 1.24 mm was plated with copper having a thickness of about 5 microns. A porous layer consisting of a Cu-Ti-Pb alloy was formed by sintering on to the plated layer of the backing metal. Then, after application of one of the substances shown in Table 1, the backing metal was rolled by use of rolls so that the pores of the porous layer of Cu-Sn-Pb alloy were filled with such substances and at the same time the surface of this layer was coated with the same substance with the result that the product had a surface comprising one of the substances shown in Table 1. Then, the backing metal having the impregnated porous layer was fired by being held at a temperature of 327 to 400 degrees C for 2 to 5 minutes, and was rolled by use of rolls to obtain a sliding and/or bearing material of the invention having a total thickness of 1.50 mm.

Conventional bearing materials were also prepared by the same method by use of conventional composition shown in Table 1, for comparison. In Table 1, sample Nos. 1 to 4 show the conventional bearing materials, while sample Nos. 5 to 31 represent the sliding and/or bearing material in accordance with the invention. These materials were subjected to a wear resistance test conducted under the conditions shown in Table 2.

	No.	Impregnating and coating composition						
		PFA	FEP	PCTFE	ETFE	EPE	PVDF	Pb
Conventional materials	1							20
	2							
	3	20						
	4		20					
material of the invention	5			20				
	6				20			
	7					20		
	8						20	
	9	0.5	0.5					
	10	20			20			
	11		15		15	15		
	12		0.5		0.5		0.5	
	13	4	4	4	4	4		
	14	20						
	15	20						20
	16	20						6
	17	30						
	18	40						
	19	45						
	20	10						
	21	10						
	22	5						6
	23	0.5						
	24	0.5						5
	25		20					20
	26				20			20
	27					20		20
	28						20	
	29	10				10		
	30		0.5		0.5	0.5		0.5
	31	20	15				5	

Pb/Sn	PbF_2	Al_2O_3	MoS_2	SiC	CF	PTFE	Amount of wear (μm)
						bal.	22
14	8					bal.	9
						bal.	3.5
						bal.	5.9
						bal.	2.8
						bal.	1.2
						bal.	0.4
						bal.	2.9
						bal.	1.4
						bal.	1.2
						bal.	1.6
						bal.	1.4
						bal.	0.9
				2.5		bal.	0.4
						bal.	2.8
	6		6	6	6	bal.	0.9
			10			bal.	0.8
20						bal.	2.9
				0.5		bal.	1.0
10				10		bal.	1.4
5		5	5		5	bal.	2.6
	6		6	6	6	bal.	1.7
				0.5		bal.	0.3
	5	5	5	5	5	bal.	1.0
						bal.	2.0
						bal.	1.3
						bal.	2.1
				5		bal.	1.0
5			5	5		bal.	1.3
		0.5				bal.	1.9
20				10		bal.	1.5

Table 2

Test machine	Thrust washer type friction wear tester
Test piece size	40 mm in length, 40 mm in width and 1.5 mm in thickness
Load	200 kgF/cm²
Peripheral speed	0.5 metre/sec.
Test time	2 hours
Lubricating oil	Lubricating oil for shock absorber

The backing metal as used in the invention of this application may be a metal other than steel. The backing metal may be devoid of the plating layer or may be plated with an alloy or metal other than Cu. The porous layer formed on the backing metal may be formed from metals or alloys other than Cu-based alloys such as the aforementioned Cu-Sn-Pb alloy or bronze. In the described example the porous layer is both impregnated and coated with the substances; however, the invention does not exclude such a case where the porous layer is only impregnated without providing a surface coating layer.

As will be understood from Table 1, the test pieces (sample Nos. 5 to 31) of sliding and/or bearing material exhibit superior resistance to wear over the conventional materials (sample Nos. 1 to 4).

The sliding and/or bearing materials in accordance with the invention find various uses such as the bearing of a mechanism which makes a reciprocatory sliding motion, e.g. a hydraulic cylinder of an automotive shock absorber, a bearing for a pump and other oil-lubricated bearings.

As has been described, the invention provides an improved sliding and/or bearing material which exhibits a superior wear resisting property and, hence, offers great practical and economical advantages.

CLAIMS

1. A wear resistant material comprising a substance selected from the following mixtures (A), (B) and (C):
(A) a first mixture consisting essentially of 0.1to 50 vol% of at least one composition selected from a group consisting of ETFE, PVDF, PCTFE and EPE, and the balance substantially PTFE;
(B) a second mixture consisting essentially of 0.1 to 50 vol% in total of at least two compositions selected from a group consisting of FEP, PFA, ETFE, PVDF, PCTFE and EPE, and the balance substantially PTFE; and
(C) a third mixture consisting essentially of 0.1 to 50 vol% of at least one composition selected from a group consisting of FEP, PFA, ETFE, PVDF, PCTFE and EPE; 0.1 to 35 vol% of at least one composition selected from a group consisting of solid lubricants, metal oxides, metal sulfides, metal fluorides, graphite, fibrous materials.

2. A sliding and/or bearing material having a superior wear resisting property consisting of:
a backing layer;
a porous metallic layer supported by the backing layer with or without an intermediate layer joined to said backing layer, and
a substance with which said porous layer is impregnated or impregnated-and-coated, said substance being one selected from the following mixtures (A), (B) and (C):
(A) a first mixture consisting essentially of 0.1 to 50 vol% of at least one composition selected from a group consisting of ETFE, PVDF, PCTFE and EPE, and the balance substantially PTFE;
(B) A second mixture consisting essentially of 0.1 to 50 vol% in total of at least two compositions selected from a group consisting of FEP, PFA, ETFE, PVDF, PCTFE and EPE, and the balance substantially PTFE; and
(C) a third mixture consisting essentially of 0.1 to 50 vol% of at least one composition selected from a group consisting of FEP, PFA, ETFE, PVDF, and EPE; 0.1 to 35 vol% of at least one composition selected from a group consisting of solid lubricants, metal oxides, metal sulfides, metal fluorides, graphite, fibrous materials and ceramics; and the balance substantially PTFE, the total of contents of the compositions other than PTFE being in a range between 0.2 and 70 vol%.

3. A sliding and/or bearing material according to claim 2, wherein said backing layer is formed from steel strip, and an intermediate layer is included which is a copper plating layer.

4. A sliding and/or bearing material according to claim 2 or claim 3, wherein said porous metallic layer is of a sintered body of a Cu-based alloy.

5. A sliding and/or bearing material according to claim 4, wherein said Cu-based alloy is a Cu-Sn-Pb alloy.

6. A material as claimed in any one of claims 1 to 5 in which the one composition in the first mixture is 0.5 to 45 vol%.

7. A material as claimed in any one of claims 1 to 5 in which the two compositions in the second mixture is 0.5 to 45 vol%.

8. A material as claimed in any one of claims 1 to 5 in which at least one composition in the third mixture is 0.5 to 40 vol%.

9. A material as claimed in any one of claims 1 to 5 or 8 in which at least one composition selected from a group consisting of solid lubricants in the third mixture is 0.5 to 30 vol%.

10. A material as claimed in any one of claims 1 to 5, 8 or 9 in which the total of the composition other than PTFE in the third mixture is 0.5 to 60 vol%.

11. A material as claimed in any one of the preceding claims wherein the solid lubricant in mixture C is a low melting point metallic lubricant selected from the group of Pb or Sn.

12. A material as claimed in any one of the preceding claims in which the solid lubricant in mixture C is a metal oxide selected from the group comprising PbO, Al_2O_3, SiO_2, Pb_3O_4, TiO_2, CdO, and Sb_2O_3.

13. A material as claimed in any one of claims 1 to 11 in which the solid lubricant in mixture C is a metal sulfide selected from the group comprising PbS, MoS_2, and WS_2; or a metal fluoride selected from the group PbF_2, AlF_3, CdF_2 and BaF_2; or a ceramic selected from the group SiC, TiC, TiN, B_4C, BN and Si_3N_4.

14. A sliding and/or bearing material substantially as specifically described herein with reference to any one of the examples 5 to 31 of Table 1.

15. A sliding and/or bearing product incorporating material as claimed in any one of the

preceding claims.

CLAIMS (6 Jul 1984)

1. A wear resistant material comprising a mixture consisting essentially of 0.1 to 50 vol% of at least one composition selected from a group consisting of FEP, PFA, ETFE, PVDF, PCTFE and EPE; 0.1 to 35 vol% of at least one composition selected from a group consisting of solid lubricants, fibrous materials, and ceramics, and the balance substantially PTFE, the total of contents of the compositions other than PTFE being in the range between 0.2 and 70 vol%.

2. A sliding and/or bearing material having a superior wear resisting property consisting of:
a backing layer;
a porous metallic layer supported by the backing layer with or without an intermediate layer joined to said backing layer; and
a substance with which said porous layer is impregnated or impregnated-and-coated, said substance being a mixture consisting essentially of 0.1 to 50 vol% of at least one composition selected from a group consisting of FEP, PFA, ETFE, PVDF, PCTFE and EPE; 0.1 to 35 vol% of at least one composition selected from a group consisting of solid lubricants, fibrous materials and ceramics; and the balance substantially PTFE, the total of centents of the compositions other than PTFE being in a range between 0.2 and 70 vol%.

3. A sliding and/or bearing material according to Claim 2, wherein said backing layer is formed from steel strip, and an intermediate layer is included which is a copper plating layer.

4. A sliding and/or bearing material according to Claim 2 or Claim 3, wherein said porous metallic layer is of a sintered body of a Cu-based alloy.

5. A sliding and/or bearing material according to Claim 4, wherein said Cu-based alloy is a Cu-Sn-Pb alloy.

6. A material as claimed in any one of Claims 1 to 5, in which at least one composition in the mixture is 0.5 to 40 vol%.

7. A material as claimed in any one of the preceding claims, in which at least one composition selected from a group consisting of solid lubricants, fibrous materials and ceramics in the mixture is 0.5 to 30 vol%.

8. A material as claimed in any one of the preceding claims, in which the total of the composition other than PTFE in the mixture is 0.5 to 60 vol%.

9. A material as claimed in any one of the preceding claims, wherein the solid lubricant in the mixture is a low melting point metallic lubricant selected from the group of Pb, Sn or their alloys; a metal oxide selected from the group comprising PbO, Al_2O_3, SiO_2, Pb_3O_4, TiO_2, CdO and Sb_2O_3; a metal sulfide selected from the group comprising PbS, MoS_2 and WS_2; a metal fluoride selected from the group comprising PbF_2, AlF_2, CdF_2 and BaF_2; or graphite or the like.

10. A material as claimed in any one of the preceding claims in which the fibrous material in the mixture is a natural or an artificial fibre selected from the group comprising carbon fibres, glass fibres, cotton (cellulose), asbestors, fibres of potassium titanate.

11. A material as claimed in any one of the preceding claims, in which the ceramics in the mixture is selected from the group comprising SiC, TiC, TiN, B_4C, BN and Si_3N_4.

12. A sliding and/or bearing material substantially as specifically described herein with reference to any one of the Examples 14 to 31 of Table 1.

13. A sliding and/or bearing product incorporating material as claimed in any one of the preceding claims.

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