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(54) **Frictional material**

(57) As the railroad speed becomes higher, frictional materials having magnetic properties, frictional properties, and a resistance to melting and depositing more excellent than those of conventional frictional materials are desired. The present invention provides a frictional material comprising a metal matrix and hard particles, wherein the frictional material contains: 1 to 5% by weight of Cu; 0.1 to 1.0% by weight of P; 1 to 5% by weight of at least one soft metal selected from the group consisting of Bi, Sb, In, and Ag; 1 to 6% by weight of hard particles of at least one member selected from the group consisting of zircon ($ZrSiO_4$) and zirconia (ZrO_2); and the balance comprising Fe and an unavoidable impurity. The frictional material of the present invention has excellent magnetic properties and excellent frictional properties as well as excellent resistance to melting and depositing, and exhibits excellent damping properties particularly when used as a magnetic rail brake.

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a frictional material for use in a means for arbitrarily controlling the rotation or movement of various machines, specifically a clutch or brake. More particularly, the present invention is concerned with a frictional material advantageously used in a magnetic rail brake or electromagnetic clutch.

Background Art

[0002] A frictional material generally used in a magnetic rail brake is obtained by mixing metal powder forming a matrix with hard particles and sintering the resultant mixture. Examples of conventional frictional materials for magnetic rail brake include a sintered material comprised of a wear-resistant material comprised of at least one member selected from the group consisting of Al_2O_3, ZrO_2, Al_2TiO_5, Y_2O_3, SiC, Si_3N_4, WC, Cr_3C_2, and TiC, and powder of at least one member selected from the group consisting of nodular cast iron, graphite, iron sulfide, manganese sulfide, lead, and molybdenum sulfide (see, for example, Patent document 1).

[0003] [Patent document 1] Japanese Unexamined Patent Publication No. Hei 11-78882

[0004] When a magnetic rail brake operates, a frictional material is pressed against a rail and, simultaneously, the magnetic force causes tension between the frictional material and the rail, so that the friction of the frictional material against the rail causes the train to slow down. In a magnetic field generated from an electromagnet in the magnetic rail brake, the higher the magnetic flux density of the frictional material, the stronger the magnetic force, or the stronger the tension between the frictional material and the rail, that is, the magnetic rail brake increases in damping force. The frictional material has a high coefficient of friction and hence, when the frictional material is unlikely to be melted and deposited, the frictional material achieves higher frictional force, thus increasing the damping force. Further, when the frictional material has excellent wear resistance, the frequency of replacement of the frictional material by another can be reduced. Therefore, it is desired that the frictional material for use in magnetic rail brake has excellent frictional properties evaluated in terms of a wear resistance and a coefficient of friction, excellent resistance to melting and depositing, and excellent magnetic properties evaluated in terms of a magnetic flux density. Accordingly, an object of the present invention is to provide a frictional material having excellent frictional properties and excellent resistance to melting and depositing as well as excellent magnetic properties.

SUMMARY OF THE INVENTION

[0005] The present inventors have made extensive and intensive studies on frictional materials. As a result, they have succeeded in obtaining a frictional material having excellent frictional properties and excellent resistance to melting and depositing as well as excellent magnetic properties. Specifically, the present invention is directed to a frictional material comprising a metal matrix and hard particles, wherein the frictional material contains: 1 to 5% by weight of Cu; 0.1 to 1.0% by weight of P; 1 to 5% by weight of at least one soft metal selected from the group consisting of Bi, Sb, In, and Ag; 1 to 6% by weight of hard particles of at least one member selected from the group consisting of zircon ($ZrSiO_4$) and zirconia (ZrO_2); and the balance comprising Fe and an unavoidable impurity.

DETAILED DESCRIPTION OF THE INVENTION

[0006] The frictional material of the present invention comprises a metal matrix comprised mainly of Fe containing Cu, P, and Bi, Sb, In, or Ag, and hard particles of at least one member selected from zircon and zirconia.

[0007] In the frictional material of the present invention, when the Cu content is less than 1% by weight, the resistance to melting and depositing is lowered. On the other hand, when the Cu content is more than 5% by weight, the coefficient of friction is lowered, and further the relative Fe content is reduced, so that the magnetic flux density is lowered. Therefore, the Cu content must be 1 to 5% by weight. It is preferred that the Cu content is 2 to 4% by weight.

[0008] In the frictional material of the present invention, when the P content is less than 0.1% by weight, the resistance to melting and depositing is lowered. On the other hand, when the P content is more than 1.0% by weight, the coefficient of friction is lowered, and further the relative Fe content is reduced, so that the magnetic flux density is lowered. Therefore, the P content must be 0.1 to 1.0% by weight. It is preferred that the P content is 0.3 to 0.5% by weight.

[0009] When the content of at least one soft metal selected from the group consisting of Bi, Sb, In, and Ag in the frictional material of the present invention is less than 1% by weight, the resistance to melting and depositing is lowered. On the other hand, when the soft metal content is more than 5% by weight, the coefficient of friction is lowered, and further the relative Fe content is reduced, so that the magnetic flux density is lowered. Therefore, the soft metal content must be 1 to 5% by weight. It is preferred that the soft metal content is 1.5 to 3.0% by weight.

[0010] When the content of hard particles of at least one member selected from the group consisting of zircon and zirconia in the frictional material of the present invention is less than 1% by weight, both the coefficient of friction and the resistance to melting and depositing are lowered. On the other hand, when the hard particle content is more than 6% by weight, the relative Fe content is reduced, so that the magnetic flux density is lowered. Therefore, the hard particle content must be 1 to 6% by weight. It is preferred that the hard particle content is 2 to 4% by weight.

[0011] As an example of a method for producing the frictional material of the present invention, there can be mentioned the following method.

Commercially available Fe powder having an average particle size of 60 to 140 μm, Cu powder having an average particle size of 30 to 70 μm, Fe-P powder having an average particle size of 60 to 140 μm, Cu-P powder having an average particle size of 60 to 140 μm, Bi powder having an average particle size of 40 to 100 μm, Sb powder having an average particle size of 40 to 100 μm, In powder having an average particle size of 50 to 150 μm, Ag powder having an average particle size of 5 to 15 μm, $ZrSiO_4$ powder having an average particle size of 100 to 400 μm, ZrO_2 powder having an average particle size of 400 to 800 μm, MoS_2 powder having an average particle size of 3 to 10 μm, C powder having an average particle size of 50 to 350 μm, and SiC powder having an average particle size of 2 to 8 μm are prepared. These powders are weighed and mixed to achieve a desired composition. The resultant mixture is subjected to cold molding under a pressure of 196 and 490 MPa. The cold-molded mixture is placed in a sintering furnace and sintered in a hydrogen gas atmosphere under conditions such that the sintering temperature is 900 to 1,100°C and the sintering time is 0.5 to 2 hours, thus producing the frictional material of the present invention. When the sintering is performed while uniaxial pressing under a pressure of 0.49 to 3.92 MPa, the resultant frictional material advantageously has an improved wear resistance.

[0012] With respect to the frictional material of the present invention, for increasing the tension between the frictional material and a rail, it is preferred that the frictional material has a magnetic flux density of 1.38 to 1.42 T in a magnetic field at a strength of 50 kA/m.

Further, with respect to the frictional material of the present invention, for further increasing the tension between the frictional material and a rail, it is more preferred that the frictional material has a magnetic flux density of 2.05 to 2.09 T in a magnetic field at a strength of 400 kA/m.

[0013] Examples of uses of the frictional material of the present invention include means for arbitrarily controlling the rotation or movement of various machines, such as machine tools, construction machineries, agricultural machineries, automobiles, two-wheeled vehicles, railroads, aircrafts, or marine structures, specifically, so-called clutches and brakes. Of these, more preferred are uses of the frictional material as a magnetic rail brake or an electromagnetic clutch, which fully utilize excellent magnetic properties of the frictional material, i.e., high magnetic flux density, and especially, the most preferred is use of the frictional material as a magnetic rail brake.

[0014] The frictional material of the present invention has excellent frictional properties including wear resistance and coefficient of friction, excellent resistance to melting and depositing, and excellent magnetic properties including magnetic flux density. When the frictional material of the present invention is used as a frictional material for clutch or brake in various machines, such as machine tools, construction machineries, agricultural machineries, automobiles, two-wheeled vehicles, railroads, aircrafts, or marine structures, the frictional material not only exhibits excellent damping properties but also extends the use life. The frictional material of the present invention has excellent magnetic properties and hence, when used as a frictional material for magnetic rail brake or electromagnetic clutch, the frictional material exhibits especially excellent damping properties and extends the use life.

Example 1

[0015] Commercially available Fe powder having an average particle size of 100 μm, Cu powder having an average particle size of 49 μm, Fe-P powder having an average particle size of 100 μm, Cu-P powder having an average particle size of 100 μm, Bi powder having an average particle size of 70 μm, Sb powder having an average particle size of 70 μm, Ag powder having an average particle size of 10 μm, $ZrSiO_4$ powder having an average particle size of 200 μm, ZrO_2 powder having an average particle size of 600 μm, MoS_2 powder having an average particle size of 7 μm, C powder having an average particle size of 200 μm, and SiC powder having an average particle size of 5 μm were prepared. These raw material powders were weighed and mixed to achieve compositions shown in Table 1. The resultant mixture was subjected to cold molding under a pressure of 392 MPa, and then placed in a sintering furnace. The mixture was sintered using a hot press in a hydrogen gas atmosphere at a sintering temperature of 1,000°C under a pressure for uniaxial pressing of 1.5 MPa for one hour as a sintering time.

[0016]

[Table 1]

	Composition (wt%)											
	Fe	Cu	P	Bi	Sb	Ag	$ZrSiO_4$	ZrO_2	MoS_2	C	SiC	Total
Example 1	91.7	2.9	0.5	2.0	-	-	3.0	-	-	-	-	100
Example 2	93.6	1.0	0.5	2.0	-	-	3.0	-	-	-	-	100
Example 3	89.8	4.8	0.5	2.0	-	-	3.0	-	-	-	-	100
Example 4	92.1	2.9	0.1	2.0	-	-	3.0	-	-	-	-	100
Example 5	91.2	2.9	1.0	2.0	-	-	3.0	-	-	-	-	100
Example 6	92.6	2.9	0.5	1.0	-	-	3.0	-	-	-	-	100
Example 7	88.8	2.8	0.5	5.0	-	-	3.0	-	-	-	-	100
Example 8	88.8	2.8	0.5	3.0	1.0	1.0	3.0	-	-	-	-	100
Example 9	93.6	2.9	0.5	2.0	-	-	1.0	-	-	-	-	100
Example 10	88.8 8	2.8	0.5	2.0	-	-	6.0	-	-	-	-	100
Example 11	91.7	2.9	0.5	2.0	-	-	1.0	2.0	-	-	-	100
Comparative Example 1	94.5	-	0.5	2.0	-	-	3.0	-	-	-	-	100
Comparative Example 2	86.9	7.6	0.5	2.0	-	-	3.0	-	-	-	-	100
Comparative Example 3	92.2	2.9	-	2.0	-	-	3.0	-	-	-	-	100
Comparative Example 4	90.3	2.9	1.9	2.0	-	-	3.0	-	-	-	-	100
Comparative Example 5	93.6	2.9	0.5	-	-	-	3.0	-	-	-	-	100
Comparative Example 6	85.9	2.7	0.4	8.0	-	-	3.0	-	-	-	-	100
comparative Example 7	94.6	2.9	0.5	2.0	-	-	-	-	-	-	-	100
Comparative Example 8	86.9	2.7	0.5	2.0	-	-	8.0	-	-	-	-	100
Comparative Example 9	77.0	3.0	-	3.0	-	-	-	-	3.0	7.0	10.0	100
Comparative Example 10	93.5	5.0	-	-	-	-	-	-	0.5	0.5	0.5	100

[0017] A sample obtained by sintering was machined into a test specimen having a size: 10 mm × 10 mm × 8 mm, and a magnetic flux density of the sample was measured using a magnetic property tester (BH analyzer). The results are shown in Table 2. Further, an abrasion test shown below was conducted to measure a coefficient of friction, an abrasion wear, and an amount of melting and deposition. The results are also shown in Table 2.

[0018] Abrasion test

Test machine:	Inertia abrasion tester
Moment of inertia:	7.35 kgm^2
Speed:	33 m/s
Contact pressure:	980 kPa
Test specimen size:	25mm × 25mm × 10 mm

Brake starting temperature: 100°C or lower

[0019]

[Table 2]

	Magnetic properties		Frictional properties		Resistance to melting and depositing	Overall judgment (Good, Bad)
	Magnetic flux density (T)		Coefficient of friction (-)	Abrasion wear (mm)	Amount of melting and deposition (Large, Medium, Small, None)	
	In magnetic field at strength of 50 kA/m	In magnetic field at strength of 400 kA/m				
Example 1	1.41	2.09	0.40	0.339	Small	Good
Example 2	1.42	2.09	0.39	0.345	Small	Good
Example 3	1.40	2.08	0.40	0.320	Small	Good
Example 4	1.41	2.09	0.39	0.365	Small	Good
Example 5	1.40	2.05	0.39	0.335	Small	Good
Example 6	1.41	2.08	0.40	0.350	Small	Good
Example 7	1.38	2.06	0.40	0.426	None	Good
Example 8	1.39	2.07	0.40	0.402	Small	Good
Example 9	1.39	2.08	0.39	0.389	Small	Good
Example 10	1.40	2.09	0.38	0.418	Small	Good
Example 11	1.38	2.06	0.40	0.311	None	Good
Example 12	1.41	2.09	0.40	0.352	Small	Good
Comparative Example 1	1.39	2.09	0.39	0.366	Large	Bad
Comparative Example 2	1.36	2.02	0.36	0.388	Large	Bad
Comparative Example 3	1.40	2.07	0.38	0.335	Large	Bad
Comparative Example 4	1.39	2.03	0.37	0.412	Medium	Bad
Comparative Example 5	1.41	2.09	0.40	0.338	Large	Bad
Comparative Example 6	1.34	2.01	0.35	0.456	Small	Bad
Comparative Example 7	1.41	2.07	0.34	0.433	Large	Bad
Comparative Example 8	1.35	2.00	0.40	0.310	Small	Bad
Comparative Example 9	1.23	1.85	0.40	0.341	Small	Bad
Comparative Example 10	1.42	2.09	0.32	0.620	Large	Bad

[0020] Table 2 indicates: that the higher the magnetic flux density, the more excellent the magnetic properties; that the higher the coefficient of friction or the smaller the abrasion wear, the more excellent the frictional properties; and that the smaller the amount of melting and deposition, the more excellent the welding resistance. As can be seen from Table 2, in the Examples of the present invention, the balance between the magnetic properties, frictional properties, and resistance to melting and depositing is excellent and therefore, overall judgments better than those of the Comparative Examples were obtained.

Claims

1. A frictional material comprising a metal matrix and hard particles, wherein said frictional material contains:

   1 to 5% by weight of Cu;
   0.1 to 1.0% by weight of P;
   1 to 5% by weight of at least one soft metal selected from the group consisting of Bi, Sb, In, and Ag;
   1 to 6% by weight of hard particles of at least one member selected from the group consisting of zircon ($ZrSiO_4$) and zirconia (ZrO_2); and
   the balance comprising Fe and an unavoidable impurity.

2. The frictional material according to claim 1, which has a magnetic flux density of 1.38 to 1.42 T in a magnetic field at a strength of 50 kA/m.

3. The frictional material according to claim 1 or 2, which has a magnetic flux density of 2.05 to 2.09 T in a magnetic field at a strength of 400 kA/m.

4. Use of the frictional material according to any one of claims 1 to 3 as a frictional material for magnetic rail brake or electromagnetic clutch.

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EUROPEAN SEARCH REPORT

Application Number
EP 07 10 5839

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 59 197549 A (MITSUBISHI METAL CORP) 9 November 1984 (1984-11-09) * abstract; table 1 *	1-4	INV. C22C32/00 C22C38/16 C22C38/00
A	EP 0 620 286 A1 (HITACHI LTD [JP]) 19 October 1994 (1994-10-19) * claims 1-20; tables 1,2 *	1-4	
A	JP 2000 277315 A (TOYOTA CENTRAL RES & DEV) 6 October 2000 (2000-10-06) * abstract *	1-4	
A	US 2001/052373 A1 (KANAOKA JYUNJI [JP]) 20 December 2001 (2001-12-20) * abstract; claims 1-6 *	1-4	
A	JP 63 092842 A (TOYOTA MOTOR CORP) 23 April 1988 (1988-04-23) * abstract *	1-4	
A	JP 09 301256 A (TOSHIBA TUNGALOY CO LTD) 25 November 1997 (1997-11-25) * abstract *	1-4	TECHNICAL FIELDS SEARCHED (IPC): C22C
A	US 4 050 619 A (TARR WALTER R) 27 September 1977 (1977-09-27) * claims 1-6; table 1 *	1-4	

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	18 July 2007	Catana, Cosmin

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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18-07-2007

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 59197549 A	09-11-1984	JP 1016906 B	28-03-1989
		JP 1530534 C	15-11-1989
EP 0620286 A1	19-10-1994	DE 69414902 D1	14-01-1999
		DE 69414902 T2	22-04-1999
		JP 2914076 B2	28-06-1999
		JP 6271956 A	27-09-1994
		US 5589652 A	31-12-1996
JP 2000277315 A	06-10-2000	NONE	
US 2001052373 A1	20-12-2001	DE 10127891 A1	07-03-2002
		JP 2001354951 A	25-12-2001
JP 63092842 A	23-04-1988	NONE	
JP 9301256 A	25-11-1997	NONE	
US 4050619 A	27-09-1977	CA 1063333 A1	02-10-1979

EPO FORM P0459

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP HEI1178882 A **[0003]**