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(54) **Fast moving part of a plastic working apparatus**

(57) A fast moving part for a plastic working apparatus, such as a press. It is formed from a composite containing, e.g., aluminum as a light metal matrix. The composite contains 10% to 45% by volume of a ceramic material and 0.1% to 1.0% by weight of free-cutting inclusions.

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention:

[0001] This invention relates to a fast moving part for a press, or other plastic working apparatus (or a part for a machine tool), and more particularly, to a fast moving part formed from a lightweight material of high machinability.

[0002] The term "aluminum-based material" as herein used means aluminum, or an aluminum alloy containing a small amount of another element or elements (excluding magnesium and free-cutting inclusions), and the term "magnesium-based material" means magnesium, or a magnesium alloy containing a small amount of another element or elements (excluding aluminum and free-cutting inclusions).

2. Description of the Related Art:

[0003] Parts for industrial machines (or plastic working apparatus), particularly fast moving parts for, e.g. presses, are often complicated in shape. For example, a slide for a press is basically composed of a rectangular slide case having a middle wall by which it is connected to connecting rods midway of its height, a bottom wall to which an upper die is mounted, and a plurality of reinforcing ribs having through holes extending horizontally between those two walls. The slide case also has four vertical guide ribs formed along its corners, respectively. The connecting rods are used for connecting a crankshaft and the slide.

[0004] As is obvious from the foregoing, the slide has a hollow interior complicated in shape, and an uneven configuration around its exterior, too. Therefore, it is usually made by casting, and is often of cast iron (e.g., gray cast iron) for strength reasons. A frame for a press is also complicated in shape, is usually made by casting, and is of cast iron for strength reasons.

[0005] The frictional heat produced between the slide and frame by the reciprocating motion of the slide, and the frictional heat produced by the rotational motion of the crankshaft, are transmitted to the slide by the connecting rods, and to the frame directly, and raise the temperature of the slide and frame. The slide and frame have a virtually equal degree of thermal expansion, since they are made of a similar, or the same, material, as stated above. Therefore, their thermal expansion does not cause any problem at all.

[0006] Fast moving parts, such as a slide for a press, however, come to be required to have a higher speed and a higher accuracy. A slide made of cast iron, however, has a relatively large weight (mass), since cast iron has a high density (for example, gray cast iron has a density of $7,300 \text{ kg/m}^3$). Moreover, the upper die mounted to the slide adds to its weight (mass), and thereby increases the force of inertia acting upon it in proportion to its mass. Such an increase in force of inertia is a factor hindering the realization of a high-speed and high-accuracy press. A high-speed press requires a crankshaft which can change its direction of rotation while it remains under a large force of inertia. If its direction of rotation is changed by resisting a large force of inertia, the crankshaft has its axis displaced, and as a consequence, the press fails to display a high accuracy.

[0007] In order to obtain a fast moving slide having a reduced weight (mass), therefore, attempts have been made to cast a slide from a light metal of low density (for example, aluminum having a density of $2,700 \text{ kg/m}^3$), and particularly, a light alloy which may readily make a strong part. A slide made of a light alloy is, however, likely to be scored or worn easily by a cast iron frame along which it is slidable, when its temperature has been raised by the frictional heat resulting from its motion at a high speed, since there is a large difference in coefficient of thermal expansion between a light alloy and cast iron. For example, an aluminum alloy has a thermal expansion coefficient of $21.1 \times 10^{-6}/\text{m}^\circ \text{C}$, while that of gray cast iron is $9.8 \times 10^{-6}/\text{m}^\circ \text{C}$. Moreover, a slide of a light alloy is generally less strong than one of cast iron because of its lower rigidity. It is, therefore, likely that an upper die mounted to the bottom of the slide may cause it to sag and may be displaced from its right position in a press. If such is the case, it is difficult to realize any press working of high accuracy.

[0008] Japanese Patent Laid-Open No. 193196/1998 proposes a slide for a press which is formed from a composite having an aluminum-based matrix and containing a ceramic material. The slide as proposed is light in weight, and can overcome the problems of thermal expansion and strength as pointed out above. The composite, however, contains silicon carbide (SiC) or alumina (Al_2O_3) in its aluminum matrix, and these materials are by far harder than metals, and damage a cutting tool, and lower the machinability of the composite. It is particularly difficult to make a slide on an industrially acceptable basis, i.e., at a low cost and with high productivity, by cutting such a composite containing a large amount of SiC, since SiC is the hardest inorganic material except diamond and boron carbide (BC).

[0009] The use of a material of improved machinability is, therefore, necessary for enabling the manufacture of a fast moving machine part having a complicated shape at a low cost and with high productivity. The standardization of any fast moving machine part is also necessary for improving its productivity.

SUMMARY OF THE INVENTION

[0010] Under these circumstances, it is an object of this invention to provide a fast moving part of high accuracy for a plastic working apparatus which is comparable to, or higher than any known part made of gray cast iron in strength and rigidity, is lighter in weight, and is comparable to it in coefficient of thermal expansion, and which is easier to make by cutting than any known part formed from a composite containing an aluminum-based matrix.

[0011] This object is essentially attained by a part of which the whole, or a principal portion, is formed from a composite containing a ceramic material in a light metal matrix, and having a specific gravity not exceeding 3.2, a Brinell hardness of 130 to 400, and a coefficient of linear expansion not exceeding $16.0 \times 10^{-6}/^{\circ}\text{C}$, the composite further containing 0.1 to 1.0% by weight of free-cutting inclusions.

[0012] The light metal matrix may be of an aluminum-based material, and the composite may contain the ceramic material in the amount of 10% to 45%, preferably 15% to 35%, by volume, and the free-cutting inclusions in the amount of 0.20% to 0.35%, preferably 0.22% to 0.32%, by weight.

[0013] The light metal matrix may alternatively be of an aluminum-based material and a magnesium-based material mixed in a ratio by volume of 9/1 to 1/9, and the composite may contain ceramic material in the amount of 5% to 45% by volume, and free-cutting inclusions in the amount of 0.02% to 0.60% by weight.

[0014] The light metal matrix may also be of a magnesium-based material, and the composite may contain ceramic material in the amount of 10% to 45% by volume, and free-cutting inclusions in the amount of 0.20% to 0.70% by weight.

[0015] The part, or its principal portion, is usually made by casting. It preferably forms a slide for a press. The slide preferably comprises a main body formed by the principal portion of the part according to this invention and an adaptor attached detachably to the main body.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Fig. 1 is a perspective view of a slide embodying this invention;

Fig. 2 is a front elevational view of a press including the slide;

Fig. 3 is a perspective view of another form of slide embodying this invention;

Fig. 4 is a schematic view of a portion of a gripper feeder including a machine part embodying this invention; and

Fig. 5 is a schematic view of a transfer device including a machine part embodying this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] The invention will now be described in detail with reference to the accompanying drawings showing some preferred embodiments thereof, though the following description of its preferred embodiments is not intended to limit the scope of this invention, which is defined by the appended claims.

[0018] A fast moving part, or slide 10, embodying this invention is shown in Fig. 1, and is incorporated in a straight-sided press 1 as shown in Fig. 2. The slide 10 is connected to a crankshaft installed in a crown 2, but not shown, by connecting rods 5, and is mounted in a column (or frame) 3. The slide 10 carries at its bottom an upper die 6, which is reciprocable to and away from a lower die 9 supported by a bolster 7 on a bed 4. The slide 10 has four guide ribs 15, which are guided by the column 3 for moving the slide 10, while maintaining it in parallel to the lower die 9.

[0019] The slide comprises a main body 10 and an adaptor plate 13, attached detachably to a bottom of the main body 10 by bolts, or the like. Therefore, only the main body 10 (the fast moving parts main portion) is formed from a light metal composite containing free-cutting inclusions, since its complicated shape requires a cutting job of high accuracy, while the adaptor plate 13 can be formed from a light metal composite not containing any free-cutting inclusions, since its shape requires only little, or substantially no cutting work. This enables a corresponding reduction in the use of the composite containing free-cutting inclusions, which is expensive. Moreover, the whole slide does not have to be changed, but only the adaptor plate 13 has to be changed, when the dies have to be changed. Other parts, such as the guide ribs 15, can also be prepared as detachable members if they require only little, or no, cutting work.

[0020] The main body 10 is shaped like a rectangular case, and the guide ribs 15 extend along the four corners thereof, respectively, and project downwards below the adaptor plate 13. It has a rod-connecting wall 11 which lies midway of the height of the case, and to which the connecting rods 5 are connected. It has an open space above its rod-connecting wall 11, and the rod-connecting wall 11 and the adaptor plate 13 define therebetween a hollow space surrounded by a wall having a plurality of holes 10a through which core sand can be removed.

[0021] Fig. 3 shows a different form of slide 19 embodying this invention which is mainly used in a C type press. The slide 19 includes a pair of parallel guide posts 21 extending vertically along two opposite edges, respectively, of its

back, and each having a sloping surface, and a pair of ribs 27 projecting forwards from the guide posts 21, respectively, in parallel with each other. It also has a bearing 23 formed between the lower portions of the ribs 27 for supporting a connecting rod, and located above an adaptor plate 25 to which an upper die can be mounted.

[0022] The slide (fast moving part) 10 or 19 is designed for making a vertical reciprocating motion at a high speed to enable the upper die to apply pressure to the workpiece. Therefore, it is required to be wear resistant, rigid and hard enough to resist wear and deformation. The slide is also required to be light in weight, low in coefficient of thermal expansion, and easy to make by cutting.

[0023] This invention is also applicable to other parts of a press that are required to have the properties as stated above, including a link and lever mechanism and a connecting rod. The link and lever mechanism is a mechanism for changing a rotary motion into a rectilinear motion for driving a slide in a link press. The mechanism is required to be strong enough to resist any high-speed rotary motion and impact when the slide makes a reciprocating rectilinear motion at a high speed for applying pressure to the material to be pressed. Therefore, its connecting ends are desired to have a high wear resistance, a high rigidity, a light weight and a low coefficient of thermal expansion.

[0024] The connecting rod connects a crankshaft and a slide in a crank press, and is driven by the crankshaft for driving the slide. It is required to be wear resistant, particularly at its connecting ends, when the slide makes a reciprocating motion at a high speed for applying pressure to the material to be pressed. It is also desired that the connecting rod be highly rigid to resist any impact, as well as having a light weight.

[0025] This invention is also applicable to a fast moving part in a transporting device used with, or incorporated in a press, or other plastic working apparatus, for example, a gripper feeder 12 as shown in Fig. 4, or a transfer 22 as shown in Fig. 5. The gripper feeder 12 is used for conveying the workpiece (or material to be pressed) to a working position in a timely way for its press working. It includes a movable gripper 14 capable of a reciprocating motion at a high speed as a fast moving part embodying this invention. The gripper 14 is required to be wear resistant and light in weight. A crank lever 18 connecting the gripper 14, and a slide 16 connected to a drive shaft 17, drives the gripper 14 for its reciprocating motion along a pair of guide shafts 20. The crank lever is required to have a high wear resistance and a high rigidity.

[0026] The transfer 22 is a device for conveying the workpiece in straight lines to enable multiple steps of processing to be performed in parallel with each other. The transfer 22 includes a pair of feed bars 24 for making a rectangular motion at a high speed to feed the material for its continuous multi-stage working. This pair of feed bars 24 are, therefore, required to be light in weight, rigid and wear resistant. The device also includes a framework 26 and a cam case 28.

[0027] It is essential that every fast moving part, such as the slide 10 or 19, movable gripper 14, or each feed bar 24, be formed from a composite containing a light metal matrix. It is, however, not necessary to form the whole part from such a material, but it is sufficient to form at least its principal portion from such a material.

[0028] The composite further contains a ceramic material. The ceramic material which it may include is, for example, an oxide such as Al_2O_3 , TiO_2 , ZrO_2 , MgO or SiO_2 , a carbide such as SiC , B_4C , ZrC , WC , TiC or NbC , a boride such as TiB_2 or MoB_2 , a nitride such as AlN or BN , or a partly stabilized zirconia obtained by adding a silicide, CaO or Y_2O_3 , to zirconium. Alumina (Al_2O_3) or silicon carbide (SiC) is, among others, preferred, since each of these facilitates the preparation of an appropriately hard (and strong) composite having a low coefficient of linear expansion, while being a common material.

[0029] The ceramic material to be selected depends on the light metal used as the matrix, and the hardness and coefficient of linear expansion as required of the composite. The amount of the ceramic material to be incorporated depends on the hardness and coefficient of linear expansion as required of the composite. The high heat resistance of the ceramic material and its low coefficient of thermal expansion ensure the accuracy of working by an apparatus including a fast moving part according to this invention. Its high wear resistance protects the part from being easily worn as a result of its repeated motion at a high speed. Its high bending strength and rigidity minimize the possibility of deformation of the part. Its high hardness imparts an adequate hardness to the part if the composite has an adequate ceramic content.

[0030] Although the composition of the composite giving it the mechanical properties as will be stated below depends on the light metal employed as its matrix, it may usually have a ceramic content of at least 5%, preferably at least 10%, or more preferably at least 20%, by volume. Its maximum is limited to a level not affecting the machinability of the composite containing free-cutting inclusions, if any, and may usually be less than 50%, preferably not more than 45%, or more preferably not more than 35%, by volume.

[0031] The light metal means both a light metal and a light alloy, and more specifically, it is a material based on at least one metal selected from the group consisting of aluminum (Al), magnesium (Mg), titanium (Ti) and beryllium (Be). The alloy may contain a small amount of another metal, or nonmetal element or elements, too.

[0032] An aluminum- or magnesium-based material, or both, are usually employed, as they are relatively easily available. The aluminum- and magnesium-based materials are as defined before. The selection of the aluminum- or magnesium-based material depends on the properties as desired of the composite, particularly its desired specific

gravity. Therefore, a composition containing at least a specific amount of magnesium-based material is selected if a light weight is strongly desired.

[0033] Aluminum has a broad range of use as an industrial material, and is suitable for a fast moving part of light weight because of its specific gravity (or density) of 2.7, which is as low as about one-third of that of gray cast iron, while it also has a high affinity for a ceramic material and is of high uniformity in quality. It is also high in corrosion resistance, machinability and castability.

[0034] Magnesium can make a fast moving part of still lighter weight, as it has a specific gravity of 1.74, which is lower than that of aluminum (2.7), and of any other metal in practical use. It also has a high affinity for a ceramic material and is easy to work (cut).

[0035] Both aluminum and magnesium are usually employed in the form of their respective alloys, such as an aluminum alloy containing copper, nickel, manganese, silicon, zinc or chromium, and a magnesium alloy containing zinc, zirconium, a rare earth element or silver, since the alloys exhibit still better mechanical properties. Specific examples of those light alloys are:

- (1) An Al-Mg alloy (for casting) containing 0.1% Cu, 0.35% Si, 10% Mg, 0.1% Zn, 0.35% Fe, 0.1% Mn and 0.2% Ti in addition to aluminum;
- (2) An Al-Mg alloy (for die casting) containing 0.2% Cu, 0.3% Si, 4% to 11% Mg, 0.1% Zn, 1.8% Fe, 0.3% Mn, 0.1% Ni and 0.1% Sn in addition to aluminum;
- (3) A Mg-Al-Zn-Mn alloy (for casting) containing 5.3% to 6.7% Al, 2.5% to 3.5% Zn, 0.15% to 0.6% Mn, not more than 0.3% Si, 0.25% Cu and not more than 0.01% Ni in addition to magnesium; and
- (4) An Al-Si-Cu alloy (for die casting) containing 2.0 to 4.5% Cu, 4.5% to 7.5% Si, 0.3% Mg, 1.0% Zn, 1.3% Fe, 0.5% Mn, 0.5% Ni and 0.3% Sn in addition to aluminum.

[0036] The following is a summary of the mechanical properties required of a composite which can be used for making a fast moving machine part having a light weight, a high mechanical strength, a high wear resistance, and a low coefficient of thermal expansion:

- (1) A specific gravity not exceeding 3.2, preferably not exceeding 3.0, and more preferably not exceeding 2.5. No composite having a higher specific gravity may make any part having a satisfactorily light weight. A composite having a specific gravity not exceeding 2.5 usually has a light metal matrix containing at least 40% by volume of a magnesium-based material.
- (2) a Brinell hardness (HB) of 130 to 400, preferably from 130 to 200 or from 300 to 400 (more preferably from 135 to 185 or from 350 to 390) which is a common material. No composite having too low a hardness may make any satisfactorily strong and wear resistant part. No composite having too high a hardness may be of improved machinability, even if it is made to contain free-cutting inclusions. An increase in its proportion of free-cutting inclusions may hardly improve its machinability, but may undesirably affect other mechanical properties, for example, such an increase may bring about a shorter fatigue life.
- (3) A coefficient of linear expansion not exceeding $16 \times 10^{-6}/^{\circ}\text{C}$, and preferably not exceeding $15 \times 10^{-6}/^{\circ}\text{C}$. A composite having a higher coefficient of linear expansion may give a fast moving part liable to scoring by any part of cast iron or steel that it may contact as a result of thermal expansion.

[0037] Casting is a suitable method for making a fast moving machine part having a complicated shape as described above. A composite containing a light metal matrix, which was very difficult to prepare, has become easier to prepare by, for example, casting, or pressureless cementation. It is worthy of particular mention that a composite containing 20% or more of a ceramic material in a light metal matrix has recently become available for a wide range of uses as a lightweight and highly rigid material, and is applicable to a fast moving machine part having a complicated shape. A special casting method, such as die casting or thixotropic molding, has been drawing attention as a desirable method.

[0038] An oxide type ceramic material and aluminum often contain a considerable amount of oxygen, and require special care for adequate deoxidation prior to casting and degassing during casting. Stirring for the uniform dispersion of ceramic particles and bubbling by an inert gas are necessary before a fast moving machine part is made by casting.

[0039] The known composite containing a light metal matrix is very low in machinability because of its high ceramic content which is necessary for giving it mechanical properties, particularly a coefficient of linear expansion, close to those of steel, as stated before. Therefore, the composite for making a fast moving machine part according to this invention further contains 0.1% to 1.0% by weight of free-cutting inclusions which improve its machinability.

[0040] The improved machinability of the composite is essential, since a fast moving machine part is manufactured from an ingot, or a cast product, by machining, including cutting, such as lathing, drilling, boring, milling, planing, slotting or broaching, and grinding. The machinability is determined by considering (1) the wear resistance of a tool, (2) the disposability of chips, (3) the smoothness of a finished surface, and (4) the cutting resistance acting upon the tool. The

improvement of (1) the wear resistance of the tool, and (3) the smoothness of a finished surface is, among others, of importance.

[0041] While it has been well-known practice to add free-cutting inclusions to, for example, an aluminum alloy to improve its free-cutting property, it has also been a matter of common knowledge to anybody skilled in the art that the free-cutting inclusions added to any ordinary aluminum alloy, etc. cannot be expected to improve the free-cutting property of any such composite containing 10% or more of a ceramic material in a light metal matrix as is used according to this invention.

[0042] Any known free-cutting inclusions used for making free-cutting steel, free-cutting stainless steel, a free-cutting aluminum alloy, etc., can, however, be used for the purpose of this invention. A mixture of two or more substances is usually employed. The composite may contain, for example, metallic inclusions such as particles of lead (Pb), bismuth (Bi) or tellurium (Te), or nonmetallic inclusions in the form of an oxide such as anorthite $\text{CaO} \cdot \text{Al}_2\text{O}_3$ or gehlenite $2\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{SiO}_2$, or in the form of a compound of an element of the sulfur group, such as MnS, MnSe or MnTe. It is not always necessary to add any nonmetallic inclusions in the form of a compound when preparing the composite, but it is sufficient to add its constituents together or one after another so that they may eventually form a compound. The use of a metal, or a compound of an element of the sulfur group is desirable from a productivity standpoint.

[0043] The proportion of the free-cutting inclusions in the composite depends on the material used as the matrix, the ceramic material used and its proportion, but is usually from 0.1% to 1.0% by weight. If their proportion exceeds 1.0% by weight, these inclusions are likely to exert an adverse effect on the mechanical properties of the composite, and if they are lower than 0.1% by weight, These inclusions cannot be expected to improve the free-cutting property of the composite.

[0044] Thus, the composite may usually be of any of the following compositions:

(1) If the composite contains an aluminum-based material as its matrix and has a ceramic content of 10% to 45% by volume, it may contain 0.20% to 0.35% by weight of free-cutting inclusions. According to a preferred aspect, it may have a ceramic content of 15% to 35% by volume and contain 0.22% to 0.32% by weight of free-cutting inclusions.

(2) If the composite contains a mixture of an aluminum-based material and a magnesium-based material having a ratio by volume of 9/1 to 1/9 as its matrix and has a ceramic content of 5% to 45% by volume, it may contain 0.02% to 0.60% by weight of free-cutting inclusions.

(3) If the composite contains a magnesium-based material as its matrix and has a ceramic content of 10% to 45% by volume, it may contain 0.20% to 0.70% by weight of free-cutting inclusions.

[0045] The free-cutting inclusions are usually added when the alloying elements are added.

[0046] The fast moving part of this invention for a plastic working apparatus enables it to operate at a higher speed with a higher accuracy, since it has such a light weight owing to the light metal matrix that its fast motion does not produce any undesirably large force of inertia. The ceramic material which it contains also contributes to a higher speed and accuracy of operation, since the composite containing a ceramic material has a lower coefficient of thermal expansion and higher mechanical properties including wear resistance, strength and rigidity properties, than those of any known aluminum alloy. Moreover, the composite containing a small amount of free-cutting inclusions is easier to work on for making any machine part having a complicated shape than any known composite, and thereby enables any cutting tool to have a prolonged life.

[0047] The fast moving part of this invention which can be made by casting requires only a smaller amount of later cutting work, and thereby makes it possible to increase the productivity of the apparatus and process employed for making it, even though it may have a complicated shape. Moreover, the fast moving part of this invention may have a main body formed separately from its remaining portion, and used as a standardized part for a variety of types of dies, so that it may be possible to increase the productivity of the apparatus and process employed for making any such part.

[0048] Description will now be made of examples of composites used for making fast moving parts according to this invention and each containing a light metal matrix, as well as comparative examples. The composition of the composite according to each example or comparative example is shown in Table 1, and its mechanical properties in Table 2. Table 2 also shows the mechanical properties of cast iron FC250 for reference.

[0049] The aluminum- and magnesium-based materials were each of the following composition, while silicon carbide (SiC) was used as the ceramic material, and manganese sulfide as free-cutting inclusions:

[0050] Aluminum-based material - The Al-Mg alloy containing 0.1% Cu, 0.35% Si, 10% Mg, 0.1% Zn, 0.35% Fe, 0.1% Mn and 0.2% Ti in addition to aluminum; and

[0051] Magnesium-based material - The Mg-Al-Zn-Mn alloy containing 5.3% to 6.7% Al, 2.5% to 3.5% Zn, 0.15% to 0.6% Mn, not more than 0.3% Si, 0.25% Cu and not more than 0.01% Ni in addition to magnesium.

[0052] A diamond tool was used for making a cut depth of 0.05 mm by employing a cutting speed of 50 m/min., a feed rate of 0.01 mm/rev., and a water-soluble cutting oil. The results of the cutting tests and the overall evaluation of

each material were classified into 'Very good', 'Good', 'Somewhat poor' and 'Very poor, which are shown by a double circle, a circle, a triangle and an x, respectively, in Table 2.

[0053] As is obvious from Table 2, all of the composites according to this invention are lighter in weight (or lower in specific gravity) than cast iron, and all are comparable or superior to cast iron in hardness. It is also obvious that they have a drastically lower coefficient of linear expansion.

[0054] More specifically, the composite according to Example 1 contains about 20% by volume of ceramic material, about 80% by volume of aluminum-based material, and 0.25% by weight of free-cutting inclusions. It has a density of 3,100 kg/m³ and is, therefore, substantially as light in weight as any known aluminum alloy. Its linear expansion coefficient of $15.1 \times 10^{-6}/\text{m}^{\circ}\text{C}$ is considerably lower than that of any aluminum alloy, and although its linear expansion coefficient is about 1.6 times higher than that of gray cast iron, it falls within the acceptable range. Its tensile strength of 355 MPa is higher than that of any aluminum alloy, or gray cast iron, and it is satisfactory in elongation, too. Its breaking strain is also considered as not presenting any problem in use, since it is comparable to that of gray cast iron. This composite's superiority to gray cast iron in tensile strength, and its comparability to gray cast iron in breaking strain, can be considered as showing its high rigidity. All of the other examples are also satisfactory in density, coefficient of thermal expansion, strength and rigidity.

[0055] It is also obvious that all of the composites according to this invention and containing free-cutting inclusions are superior in machinability to the composite according to Control Example 3 and not containing any free-cutting inclusions. The composite according to Comparative Example 2 is hardly improved in machinability, though it contains free-cutting inclusions. It is apparent that its hardness of HB 450 is too high because of its high ceramic content. The composites containing both the aluminum- and magnesium-based materials (Examples 4 to 7) are not satisfactorily improved in machinability, irrespective of the amounts of the ceramic material and free-cutting inclusions which they contain, as is obvious from the results shown by triangles.

Table 1

Sample No.	Al-based material (vol%)	Mg-based material (vol%)	Ceramic (vol%)	Free-cutting inclusions (wt%)
Control Example 1	100	0	0	0.10
Example 1	80	0	20	0.25
Example 2	70	0	30	0.30
Example 3	60	0	40	0.33
Control Example 2	50	0	50	0.22
Example 4	80	10	10	0.15
Example 5	40	20	40	0.55
Example 6	40	30	30	0.05
Example 7	40	40	20	0.05
Control Example 3	40	40	20	0
Example 8	0	60	40	0.55
Example 9	0	80	20	0.55
Reference Example	Cast iron (FC250)			

Table 2

Sample No.	Density	Tensile strength	Elongation	Breaking strain	Hardness	Coefficient of linear expansion ($10^{-6}/m^{\circ}C$)	Overall evaluation	Machinability
	(g/cc)	(MP)	(%)	(%)	(H _{BS})			
Control	2.7	235	25	10.0	55	23.2	Poor	Excellent
Example 1	3.1	355	4.5	0.7	155	15.1	Good	Good
Example 2	3.0	371	4.1	0.5	180	14.1	Good	Good
Example 3	3.0	382	3.1	0.4	380	12.5	Good	Moderate
Control	2.9	395	1.1	0.4	450	10.3	Poor	Poor
Example 2								
Example 4	2.6	340	4.6	0.6	140	15.5	Good	Moderate
Example 5	2.7	378	2.8	0.4	375	13.1	Good	Moderate
Example 6	2.5	365	3.8	0.5	175	14.6	Good	Moderate
Example 7	2.4	350	4.4	0.7	150	15.5	Good	Moderate
Control	2.4	350	4.4	0.7	150	15.5	Good	Poor
Example 3								
Example 8	2.2	365	3.6	0.5	355	14.3	Good	Good
Example 9	2.1	350	2.8	0.5	155	15.0	Good	Good
Reference	7.3	275	7.2	0.5	160	9.8	-	Excellent
Example								

Claims

1. A fast moving part for a plastic working apparatus, the part as a whole, or a principal portion thereof, being formed from a composite containing at least 10% by volume of a ceramic material in a light metal matrix, and having a specific gravity not exceeding 3.2, a Brinell hardness of 130 to 400, and a coefficient of linear expansion not exceeding $16.0 \times 10^{-6}/^{\circ}\text{C}$, the composite further containing 0.1% to 1.0% by weight of free-cutting inclusions.
2. A fast moving part as set forth in claim 1, wherein said matrix is of an aluminum-based material, and said composite contains said ceramic material in the amount of 10% to 45% by volume and said free-cutting inclusions in the amount of 0.20% to 0.35% by weight.
3. A fast moving part as set forth in claim 2, wherein said composite contains said ceramic material in the amount of 15% to 35% by volume and said free-cutting inclusions in the amount of 0.22% to 0.32% by weight.
4. A fast moving part as set forth in claim 1, wherein said matrix comprises an aluminum-based material and a magnesium-based material mixed in a ratio by volume of 9/1 to 1/9, and said composite contains said ceramic material in the amount of 5% to 45% by volume and said free-cutting inclusions in the amount of 0.02% to 0.60% by weight.
5. A fast moving part as set forth in claim 1, wherein said matrix is of a magnesium-based material, and said composite contains said ceramic material in the amount of 10% to 45% by volume and said free-cutting inclusions in the amount of 0.20% to 0.70% by weight.
6. A fast moving part as set forth in claim 1, wherein at least said principal portion is made by casting.
7. A fast moving part as set forth in claim 6, wherein said apparatus is a press, and said part is a slide therefor.
8. A fast moving part as set forth in claim 7, wherein said slide comprises a main body formed by said principal portion, and an adaptor attached detachably to said main body.

Fig. 1

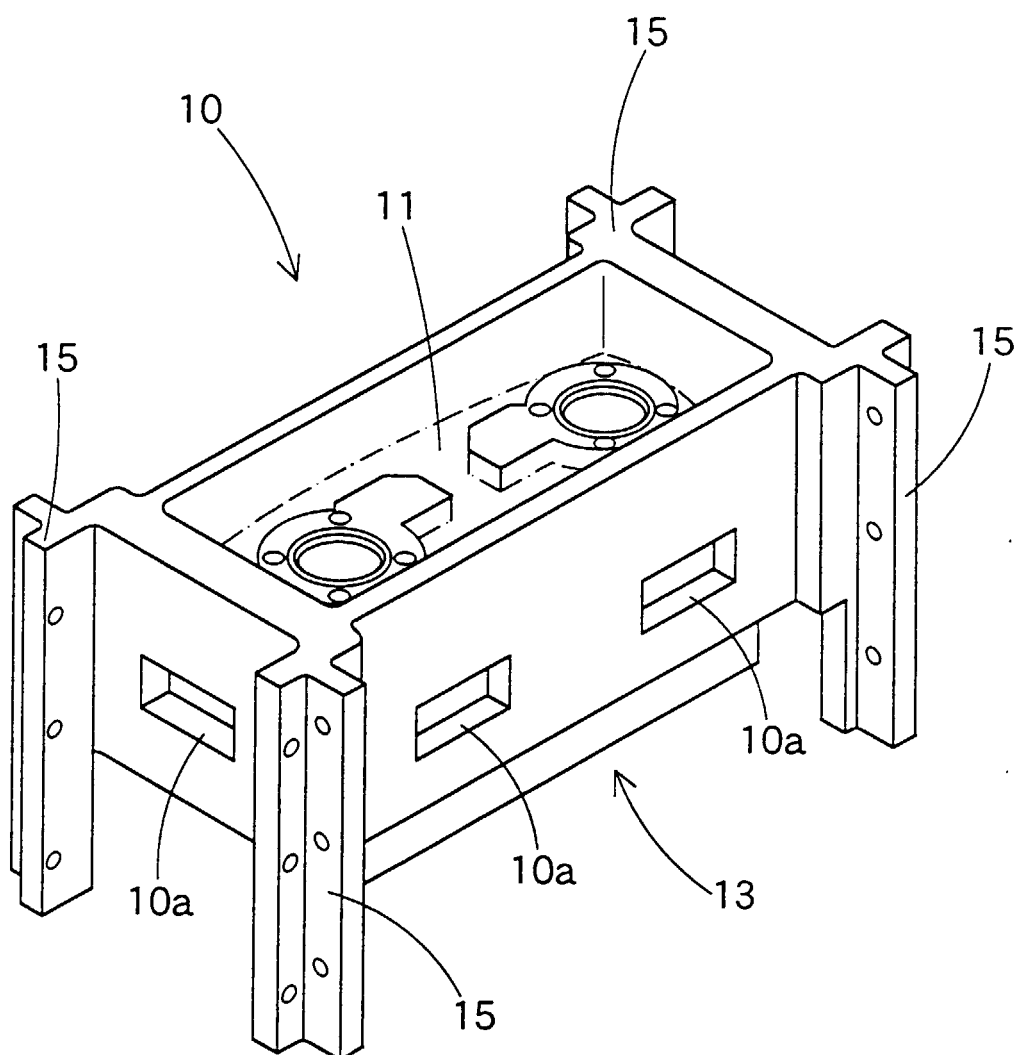


Fig. 2

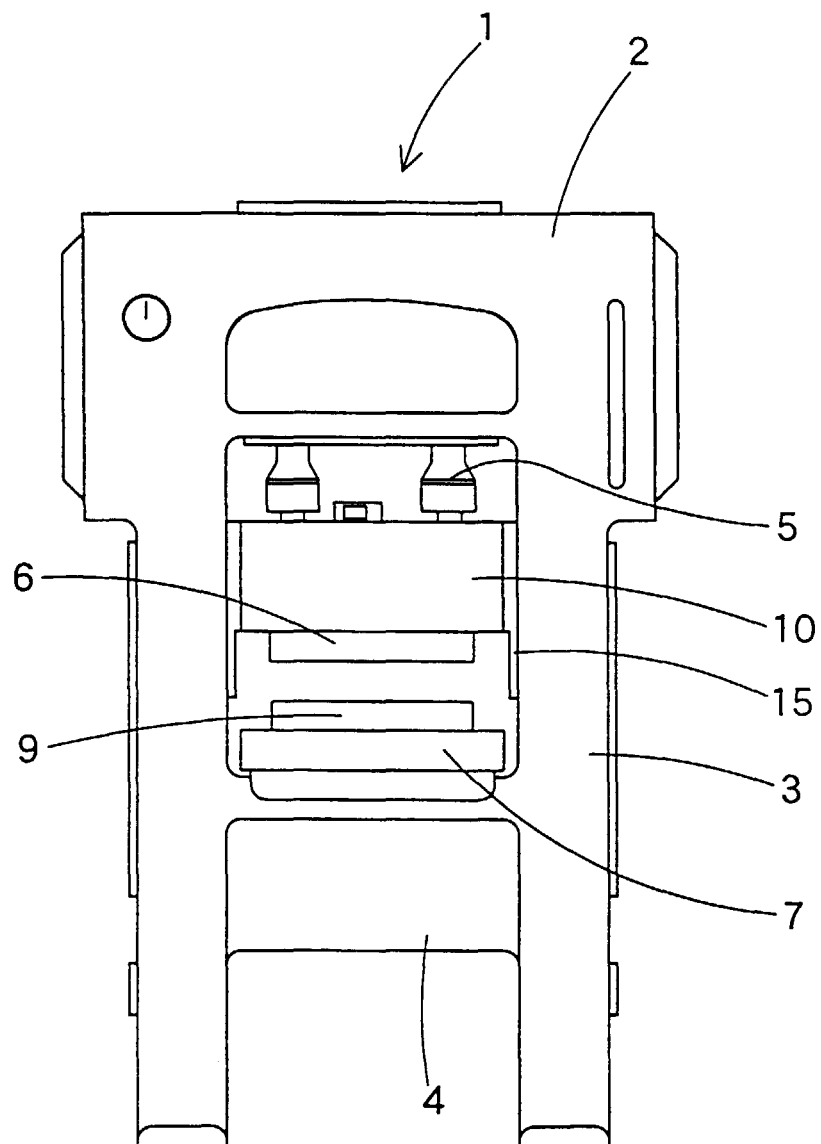


Fig. 3

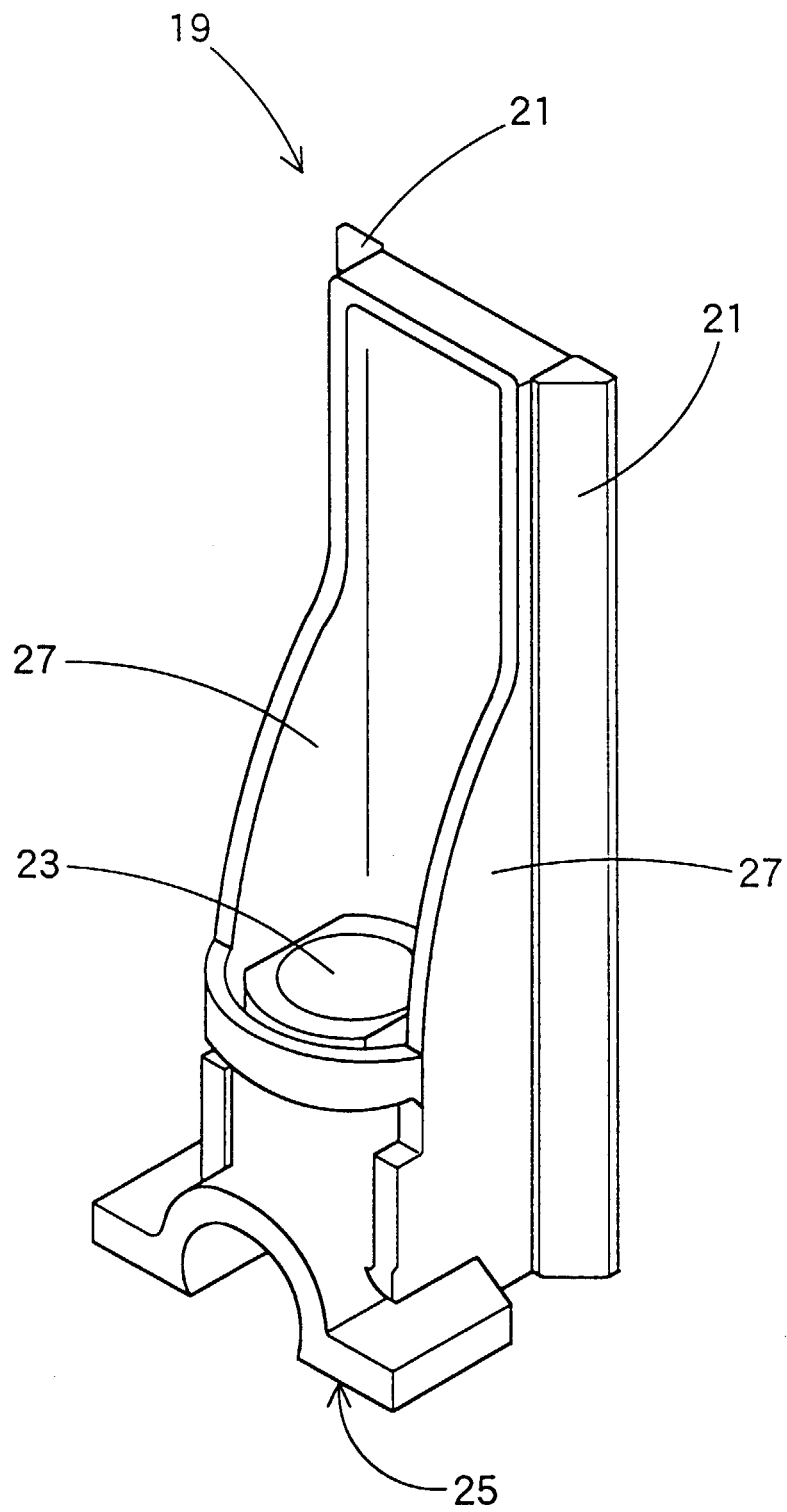


Fig. 4

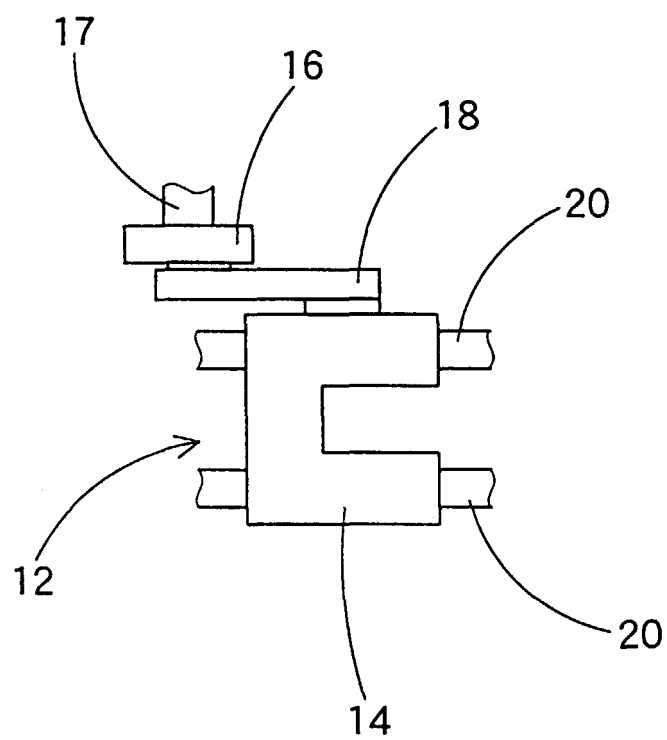


Fig. 5

