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PROCESS FOR FORMATION OF NON-ABRASIVE REFRACTORY
RUBBING SURFACE HAVING HIGH THERMAL
CONDUCTIVITY BY CASTING

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FIG.1

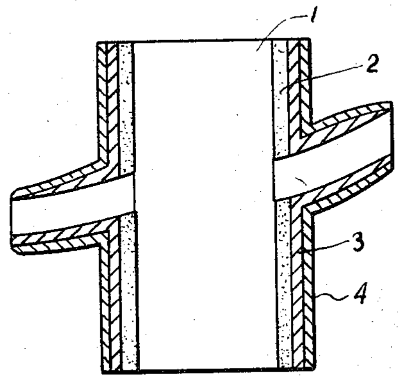


FIG.2

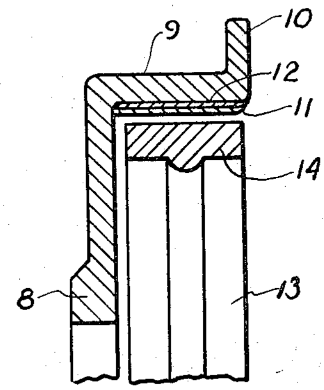


FIG.3

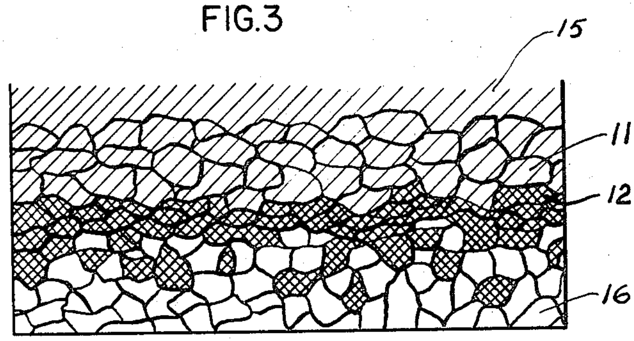
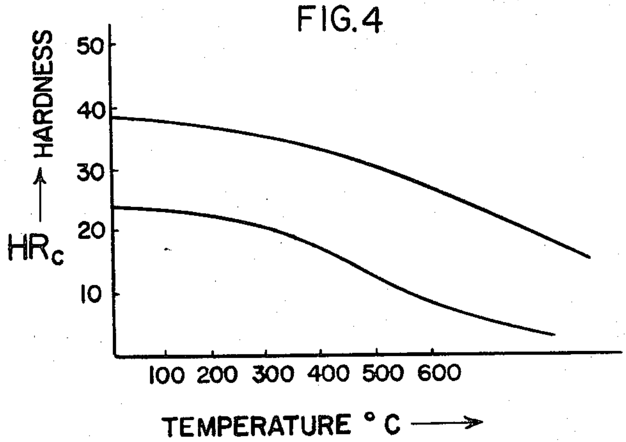


FIG.4



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PROCESS FOR FORMATION OF NON-ABRASIVE REFRACTORY RUBBING SURFACE HAVING HIGH THERMAL CONDUCTIVITY BY CASTING

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5 Claims. (Cl. 164—95)

ABSTRACT OF THE DISCLOSURE

A method of coating a metal article having a layer of non-abrasive heat-resistant metal on a body of high thermal conductivity metal comprises spraying a first porous layer of a lower melting point metal on a sand core, spraying a second porous layer of higher melting point non-abrasive heat-resistant metal on the first layer, positioning the core in a casting mold, and pouring molten high thermal conductivity metal into the mold and over the core, the porosity of said layers permitting venting of entrapped air and gases therethrough and providing a good bond between the body and the layers. After separating the casting from the core, the first layer may be removed to expose the layer of non-abrasive heat-resistant metal.

This invention relates to a process for the formation of a non-abrasive and heat-resistant metal layer on a body formed of a substance having refractory surface having high thermal conductivity which is applicable to frictional surfaces of relatively moving machine parts, such, for instance, as those of a high speed brake hub drum of vehicles or cylinder and piston of internal combustion engines.

The general object of the invention is to provide an improved process of forming a non-abrasive and heat resistant surface on a high thermal conductivity body of the relatively moving machine parts by casting.

A further object of the invention is to provide a very strong core capable of enduring rough handling and heat shock.

The inside surface of a machine part such as a cylinder of an internal combustion engine, in particular, an aluminum cylinder of an automobile or frictional surface of a brake evolving an extremely large amount of heat when exposed to a high temperature condition, such as damping hub drum must have a good heat resistance as well as a good thermal conductivity, otherwise, heat of friction is accumulated to cause over-heating, which results in an accident such as abrasion sticking of the frictional surface.

In carrying out the invention in one way, a light metal having a high thermal conductivity, such as aluminum or aluminum alloy, is used as a base material for the machine parts by casting using a core prepared from synthetic resin-coated casting sands for shell holding. At first, a non-abrasive and heat resistant metal layer is formed initially on the outer surface of the said core by spraying, and then the coated core is set in a casting mold and a melt of the above mentioned base material is poured in the mold and bonded to the non-abrasive and heat resistant metal layer, and the latter is transferred to the surface of the article made of the base metal.

In a further improvement according to the invention, prior to applying a non-abrasive and heat resistant layer wear resisting metal on the outer surface of the core by a metal spray, a low melting point metal or alloy, such as zinc aluminum, or an alloy thereof is applied as a 1st layer on the outer surface of the said core by metal spraying process, that is, by an electrically heated molten metal spraying process, and a non-abrasive and heat resistant metal which forms the frictional surface of the article is, as a 2nd layer, applied on the 1st layer by a molten metal spraying process by utilizing the fine irregularities of the surface of the 1st layer as holding means.

By using such a low melting point metal or alloy in the formation of the 1st layer, the thermal shock applied to the core is very low since the melt spray of the lower melting point metal has a small heat capacity so that the damage and the thermal deformation of the core can be positively prevented without necessity of great skill and large care as in the case of the direct spraying of the non-abrasive and heat resistant metal layer. Moreover, the core is reinforced such that it can sufficiently stand heat stress caused by the thermal shock at the spraying of metal for the 2nd layer and local heating by the metal spray, whereby the core is mechanically protected against rough handling which frequently happens in mass production, and the surface state of the 1st layer is an extremely effective layer of fine particles for welding of the 2nd layer by spraying, therefore, a desired metal can be coated as the 2nd layer easily with a uniform thickness and non-abrasive and heat resistant metal and wear resisting layer can be easily formed.

A 3rd layer of aluminum is, if necessary, formed by the molten metal spray on the 2nd layer on the surface of the treated core and the core is then set in a casting mold. Then, a molten metal having high thermal conductivity such as aluminum or an aluminum alloy is poured in the mold and as the 2nd layer and the 3rd layer also have porous surface structures consisting of fine particles of spray metal, the poured base metal is very firmly adhered to the 3rd layer, the boundary layer forms an uneven structure and the combining surface areas are enlarged, which results in increasing the thermal conductivity between layers. Also, since the surface of the core is only covered by the metal spray layers, gases can be easily vented in case of casting through the porous layers.

By then breaking finally the core, the layer fused onto the outer surface of the core is formed on the surface of the cast product and by removing the 1st layer having a low melting point from thus obtained surface, the 2nd layer of the non-abrasive and heat resistant metal layer can be obtained for use as a non-abrasive surface.

For a better understanding of the invention reference is taken to the accompanying drawings, in which,

FIG. 1 shows a cross-sectional view of a core for casting light metal cylinder of an internal combustion engine by the method of the invention;

FIG. 2 is a partial sectional view of a brake hub drum for use in automobiles;

FIG. 3 shows a microscopic structure of non-abrasive and heat resistant metal layer; and

FIG. 4 is a characteristic diagram wherein the hub drum according to the invention is compared with a conventional hub drum and shows that the decrease of hardness accompanied by the temperature rise of hub drum and a high performance can be expected over a wide temperature range.

Referring to FIG. 1, reference numeral **1** represents a baked core prepared from synthetic resin-coated casting sands for shell molding by a conventional means.

The core **1** has a substantial strength but is liable to be damaged if violently handled and is deformed if it is subject to a sudden thermal shock locally.

According to the invention, a low melting point metal or alloy such as zinc, aluminum or an alloy thereof is applied on the outer surface of the core **1** by a metal spraying process, to form the 1st layer **2**. The core **1** is reinforced by the 1st layer **2** and its strength is increased, thereby enabling to resist even considerably violent handling and succeeding mechanical working without being damaged.

Moreover, since the melting point of the material used in the formation of the 1st layer is low and the heat capacity necessary for instant melting of the spraying material and that of the sprayed metal are small, the core **1** is not subjected to a large thermal shock as in the case of metal spraying for the 1st layer, hence the 1st layer **2** is easily formed without causing deformation.

The thickness of the 1st layer **2** in this example is 1.5 mm.

The core **1** reinforced by the 1st layer **2** can sufficiently endure the mechanical operation of a continuous melt spraying device.

As a second step, a non-abrasive and heat resistant metal such as wear resisting steel or wear resisting alloy is applied on the outer surface of the 1st layer **2** by a metal spray to form a 2nd layer **3**. A suitable composition of steel as the material for the 2nd layer is illustrated in Table 1.

TABLE 1

	Percent
C	0.80
Mn	0.70
P	<0.04
S	<0.04
Fe	98.42

The thickness of the 2nd layer **3** is also 1.5 mm.

In this case, as the 2nd layer **3** is thoroughly interconnected by means of the porous uneven surface of the 1st layer **2**, the former may have sufficient thickness and can be well adhered to the latter, and as the heat of molten metal spray is not directly applied to the core **1** by the presence of the 1st layer **2** having a high thermal conductivity, the damage and the thermal deformation of the core **1** can be positively prevented.

The above molten metal spray process can be effectively applied to the case of casting a core having a complicated shape as the core is sufficiently reinforced. Further, if necessary, a light metal or a light alloy may be applied on the outer surface of the 2nd layer **3** by a melt spray process to form 3rd layer **4**.

The thickness of the 3rd layer **4** may be about 0.5–1.0 mm. for effectively strengthening weldability of a poured metal with the base material but in the case of applying a heat-treatment as after-treatment to diffuse the base material into the material of the 2nd layer **3** and to form an alloyed intermediate layer, the formation of such a 3rd layer **4** is not always necessary. However, more complete fusing or combination can be obtained by further applying the heat-treatment in the case of forming the 3rd layer **4** also.

The core **1** having thus sprayed layers is set in a casting mold for making a cylinder and a melt of base metal is poured in the mold to cast the cylinder body containing the 2nd layer **3** and the 3rd layer **4**. As the outer sprayed layer **5** of the core **1** has the fine porous uneven surface, the poured base material is interconnected with the sprayed layer at the boundary and is combined strongly thereto.

Preferred examples of compositions of aluminum alloys suitable as the base material of the cylinder are shown in Table 2.

TABLE 2

Si	Cu	Fe	Mg	Mn	Al
7.54%	0.64%	0.40%	<0.33%	<0.02%	Balance
10.10%	0.20%	<0.8%	<0.30%	----------	Balance
12.00%	2.0–4.0%	<1.5%	<0.30%	<0.02%	Balance

When the process of the invention is applied to the making of cylinders, there is an advantage that a treatment similar to a so-called porous treatment in a chromium plated cylinder liner can be obtained inevitably without any effort since the porous portions and recesses are impregnated with lubricant, and also the porous portions form a vent passage for gases during casting, which improve the quality of cast product.

As, in the process of the invention as mentioned above, the 1st layer **2** of a low melting point alloy or metal is first formed on the outer surface of the core **1** by molten metal spraying process and then the 2nd layer **3** of a non-abrasive and heat resistant material is formed on the surface of the 1st layer **2**, the damage and the deformation of the core by external force, thermal shock and heat stress caused by the melt spray of the 2nd layer **3** can be extremely reduced, which makes the mass production of such a kind of casting operation possible and increases largely the production efficiency. Also, the presence of the 1st layer **2** particularly facilitates the formation of the non-abrasive and heat resistant metal layer as the 2nd layer **3** on the surface of the core **1** and protects the core **1** from damage during the pouring time of a molten metal thereon. In addition to serving as the non-abrasive and heat resistant metal layer, the second layer is strongly joined with the poured base metal, heat is effectively transferred from the 2nd layer **3** to the base material through the intimately combined portion and the heat is positively radiated.

Another embodiment of the invention as applied to a brake hub drum of automobiles will be explained with reference to FIG. 2 where **8** designates a hub drum made of aluminum or its alloy shown in partial section, **9** is its rim portion, **10** a flange, **11** is the surface layer of a high heat resistant and non-abrasive material coated to the inner peripheral surface of the rim **9**, and **12** is an intermediate layer of base material aluminum, that is, which firmly bonds alloy-like the surface layer **11** to said rim portion made of base metal. **13** represents a brake shoe, **14** a brake lining.

Examples of the composition of a heat resistant and non-abrasive material which constitutes the surface hardening layer and of the aluminum alloy as drum material are shown as in Tables 3 and 4.

TABLE 3

Sample Number	Chemical compositions, percent								
	C	Mn	Si	P	S	Cr	Ni	Fe	Hardness
1. Chromium steel	0.32	0.50	0.05	<0.02	<0.02	13.5	------	85.14	HRc 29.
2. High carbon steel	0.80	0.70	------	<0.04	<0.04	------	------	98.42	HRc 36.
3. Ni-Cr-Mn steel	0.04	2.00	(1)	<0.03	<0.03	1.5	4.00	(2)	HRc 25.
4. Mo-steel alloy	Mo—Above 99%.								HRc 38.

[1] Mo 1–3%. [2] Remaining.

TABLE 4

Sample Number	Chemical compositions, percent					
	Si	Mg	Cu	Mn	Fe	Al
1. Al-alloy	7.54	0.33	0.64	0.02	0.40	Remaining.
2. Al-alloy	10.10	0.30	0.20	------	<0.8	Do.
3. Al-alloy	12.00	0.30	2.0–4.0	0.02	<1.5	Do.

According to the invention, the heat resistant and non-abrasive material as mentioned in Table 3 is sprayed to a thickness of 0.5 to 1 mm. on the surface of the shell molding core, which forms the inner periphery of the rim **9**, to form the surface layer **11** (FIGS. 2 and 3) and an intermediate layer **12** of aluminum is sprayed thereon, the core is then put in a casting mold, a melt of an alloy of base material as exemplified in Table 4 is cast by a die-casting or conventional casting process and the coated layers on the core surface are cast together in the molten base metal or alloy.

In this case, the intermediate layer **12** of aluminum serves as a binder which fuses and firmly bonds the base material **16** and the surface layer **11** and fills the fine gaps between the coating particles of surface layer **11** to adhere perfectly.

Since the thickness of the surface layer **11** is thin and the layer is bonded tightly by the intermediate layer **12** alloyed to the base material, the friction heat when produced is transmitted immediately to the base material **16** to produce no substantial temperature difference between both layers and the thermal expansion of the surface layer **11** is substantially equal to that of the base material **16**. The friction heat generated on sliding contact surface of hub drum is thus immediately dissipated without causing any trouble in the thin coated layer and defects as in the previous method owing to the accumulation of heat would never occur.

When the core is broken easily after casting the hub drum, the surface layer **11**, which forms a brake sliding contact surface, appears, the surface layer requires only a direct grinding processing without special machining operation and thus a hub drum of high performance can be produced without the increase in operating steps.

What I claim is:

1. The method in accordance with claim **5** in which the nonabrasive and heat resistant metal coating comprises steel.

2. The method in accordance with claim **5** in which said lower melting point metal is selected from the group consisting of zinc, aluminum and an alloy thereof.

3. The method in accordance with claim **5** in which said metal having a high thermal conductivity comprises aluminum alloy.

4. The method in accordance with claim **5** which includes the step of applying a coating of aluminum over said coating of nonabrasive and heat resistant metal.

5. The method for forming a non-abrasive and heat resistant surface on a surface of a body cast from material having high thermal conductivity comprising the steps of

forming a core from casting sand containing a synthetic resin binder to the desired shape and size and to define the surface of said body cast over said core, coating at least said surface defining portion of said core by spraying thereon a lower melting point metal in the form of molten particles prior to and followed by coating said sprayed surface with a porous layer of non-abrasive and heat resistant higher melting point metal by spraying said metal thereon in the form of molten particles, positioning said core in a casting mold, pouring molten metal having a high thermal conductivity into said mold and over said core to cast said body, and during casting to vent entrapped air and gases through said porous layer to permit said poured metal to penetrate into the interstices of said porous layer and to bond said metal of high thermal conductivity to said porous layer by said penetration, and separating said core from said cast body and leaving said cast body which is integrally bonded to said non-abrasive and heat resistant layer.

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