United States Patent [19]

Bauer

[54] METHOD OF MAKING DIE CASTINGS HAVING MULTI-LAYER COATED SURFACES

- [75] Inventor: Alfred F. Bauer, Toledo, Ohio
- [73] Assignee: NL Industries, Inc., New York, N.Y.
- [22] Filed: Nov. 27, 1972
- [21] Appl. No.: 309,753
- [52] U.S. Cl..... 29/527.3, 29/527.6, 164/9,
- 164/33, 164/132, 164/46

 [51]
 Int. Cl.
 B22d 19/08

 [58]
 Field of Search
 164/9, 14, 33, 46, 58, 164/59, 132, 138, 95, 111, 112; 29/527.6, 527.3, 447, 423

[56] References Cited

UNITED STATES PATENTS

2,074,007	3/1937	Wissler 29/527.6 X
3,083,424	4/1963	Bauer 164/112
3,099,869	8/1963	Piper 164/69

[11] **3,797,101**

[45] Mar. 19, 1974

3,401,736	9/1968	Imagawa 164/95
3,433,284	3/1969	Webbere et al 164/33 X
3,689,986	9/1972	Takahashi et al 29/527.6

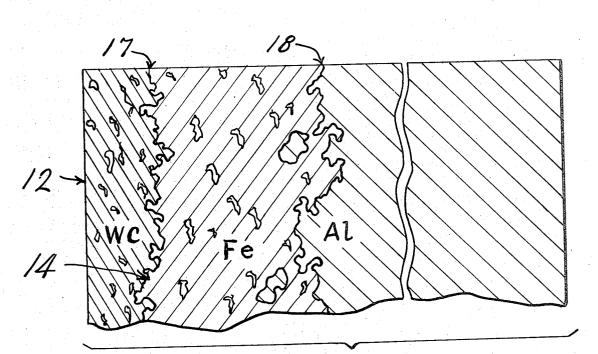
Primary Examiner-R. Spencer Annear

Attorney, Agent, or Firm-Allen Owen; John C. Purdue

[57] ABSTRACT

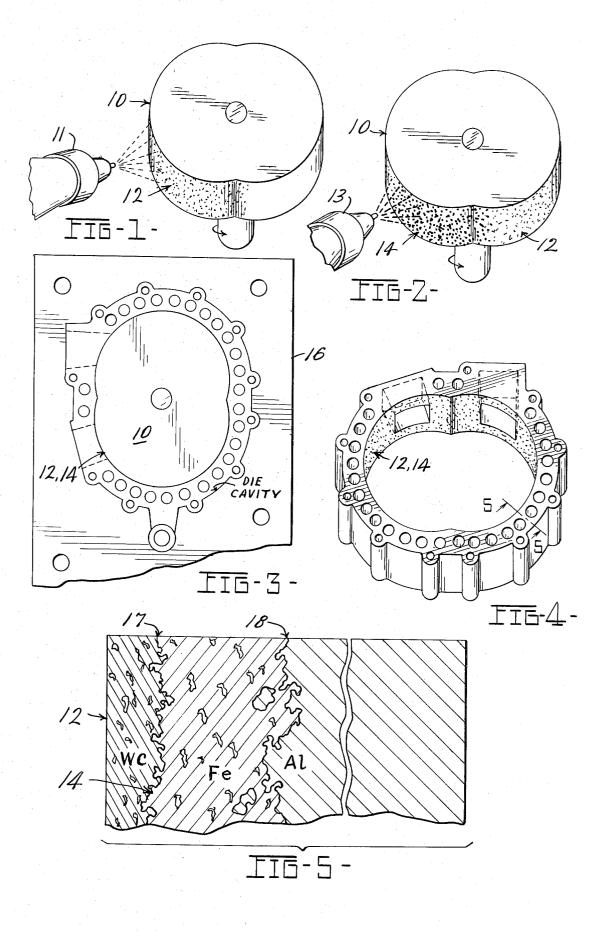
This invention relates to a method for producing coated die castings, for example, die cast cylinders or housings for rotary or reciprocating internal combustion engines. The method is particularly directed to the production of a casting having a multiple layer coating wherein the layer exposed to the working surface of the cylinder or housing is of a material which will provide a very hard, wear resistant layer, and the underlayer, between the die casting and the wear resistant layer is of a softer, less expensive, highly adherent and physically strong material.

7 Claims, 5 Drawing Figures



PATENTED MAR 1 9 1974

3,797,101



5

METHOD OF MAKING DIE CASTINGS HAVING MULTI-LAYER COATED SURFACES

The method of the present invention is an improvement of the method disclosed in my U.S. Pat. No. 3,083,424, issued Apr. 2, 1963.

BACKGROUND OF THE INVENTION

In my prior patent, there is disclosed a method of making a coated cylinder or housing for an internal combustion engine in which the die casting process is 10 used and which produces, for example, an aluminum cylinder or housing having a wear resistant layer of a metal of much higher melting point than the aluminum and exhibiting improved wear resistant properties. The technique has become known in the art as the "trans- $^{15}\,$ plant coat" process. In the prior patent the suggested wear resistant layer comprised stainless steel or other predominantly iron alloys. The coating thickness suggested and disclosed in the prior patent was from 0.015 20 inch to about 0.025 inch, although thicker coatings could readily be used. Briefly stated, the former process consists of spraying, with a metalizing gun, or otherwise depositing on a cylindrical core portion of a die, a body of metal having a higher melting point than the body of the cylinder or housing of which the casting was to be made. Subsequently, the sprayed or coated core was inserted into a die casting machine and the aluminum or other metal of lower melting point was cast under high pressure around the coated core. Upon $_{30}$ removal of the completed casting from the machine the core was separated from the casting by differential expansion, in the preferred embodiment, leaving a taperfree coated housing or casting of a high degree of accuracy and smoothness which requires only a simple hon- 35 ing operation on the interior of the casting to produce a smooth, accurately dimensioned, wear resistant surface suitable for internal combustion engines either of the reciprocating or rotary type.

While the iron alloy coating was sufficient for many 40 applications, the more advanced engine cylinders and housings have been improved by the application of a hard metal layer, such as chromium, plated onto the iron alloy.

It has also been known to apply a tungsten carbide 45 layer directly onto the interior wearing surface of an engine cylinder or housing after the cylinder or housing has been cast and machined. It is extremely difficult to accomplish good adhesion between such a tungsten carbide layer and the machined aluminum casting. In addition, this method is a time-consuming, wasteful process because the layer must be made initially quite thick and subsequently ground down to the final dimensions, configuration and degree of smoothness. 55 Grinding a tungsten carbide layer is difficult in itself. In addition, it has been found that a very thin tungsten carbide layer is undesirable because the compressive force exerted thereon under service conditions at an operating temperature of about 400°F. will frequently cause a separation between the tungsten carbide layer and the aluminum of the casting. However, such separation can be prevented even when the tungsten carbide layer is very thin by employing a comparatively thick backing layer of an iron alloy. The tungsten carbide material is quite expensive, currently selling for approximately \$20.00 a pound while the iron layer previously used sells for only about \$.40 a pound. Eco-

nomically, therefore, the composite or dual layer coating of the present invention has a distinct advantage.

BRIEF STATEMENT OF THE INVENTION

Briefly stated, the present invention includes a method for producing a coated die casting by depositing a thin layer of very hard material such as tungsten or titanium carbide, on a die casting core, then applying a second, thicker backing layer of metal, such as steel on top of the hard metal layer and adhered thereto by the roughness of the exterior of the deposited hard metal layer. The coated core is then placed in a die casting machine and the cylinder or housing is cast around it as in the previously explained transplant coat process. The coating adheres to the metal of the die casting by interlocking of the casting metal with the rough exterior surface of the backing layer. The bond between the backing layer and the die casting is extremely good.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings

FIG. 1 is a diagrammatic elevational view of a die casting core suitable for use in the manufacture of the
housing for rotary engine showing the spray application of an initial hard layer such as tungsten or other metallic carbide on the core;

FIG. 2 is a view similar to FIG. 1 showing the application of a layer of a second metal backing the first hard layer;

FIG. 3 is a diagrammatic view of the core in place in a die casting die, the core bearing both of the previously applied coatings;

FIG. 4 is an elevational view of a completed casting with the core removed, leaving the coatings in place in the casting; and

FIG. 5 is an enlarged, fragmentary sectional view through the wall of the completed casting taken on the line 5-5 of FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As indicated in the accompanying drawings, the present invention is most useful in the manufacture of trochoid housings for rotary engines. As used herein the words "cylinder" and "housing" indicate cylinders for reciprocating engines and housings for rotary engines inter-changeably.

FIG. 1 of the drawings indicates diagrammatically at 10 a core for the manufacture of a housing for a rotary engine. The core 10 is preferably taper-free so as to minimize the machining required to finish the final cast housing. The core 10 is mounted for rotation on a lathe-like machine and a metalizing gun 11 is mounted adjacent the machine to spray a layer 12 of a hard material, such as tungsten carbide, silicon carbide, boron carbide, titanium carbide, chromium carbide or any of several borides, usually associated with a binder such as cobalt, nickel, or the like. The layer 12 can also be 60 of a ceramic material, e.g., zirconia or alumina, which can be applied without a binder, or can be an alloy or a pure metal such as chromium, or molybdenum. Hereinafter, the various carbides, borides and the like are generically referred to as "hard metal"; it is to be un-65 derstood that this term encompasses the carbide and borides per se as well as in a particulate form dispersed in a binder such as nickel. The layer 12 can be formed by spraying, for example, a Metco 438 or 439 tungsten carbide nickel aluminide blend from the gun 11. In the preferred embodiment, the thickness of the hard metal layer 12 is from 0.003 to 0.020 inch, most desirably from 0.005 to 0.015 inch. Thicker coatings are equally 5 operable but for economic reasons the thinnest possible coating requiring the minimum machining is desired. The hard metal layer adheres somewhat to the core 10 but is not bonded thereto. If desired, the core lease agent such as talc or sodium bicarbonate prior to spraying on the initial hard metal layer. In an even more preferred embodiment an initial thin separation layer of softer material, for example, of a ferrous or non-ferrous metal or alloy, is first deposited on the 15 of a release layer of iron alloy or the like the casting is core. This separation layer can be iron, aluminum, zinc, tin or an alloy thereof and can be applied with a gas or electric metalizing gun. Such a separation layer exhibits much less tendency to adhere to the core than does the hard metal layer. This thin initial separation layer may 20 be only from 0.001 inch to 0.003 inch thick, but it serves as an effective release layer with respect to the core 10.

As shown in FIG. 2, the core having been coated with the hard metal layer 12 as in FIG. 1 is then subjected 25to spraying from a second gun indicated at 13 which deposits a thicker layer 14 of a material such as steel or a chromium-iron alloy such as is sold under the trade name Metco No. 2. The layer 14 preferably has a thickness from 0.010 to 0.065 inch, most desirably from $^{\rm 30}$ 0.015 to 0.060 inch. The exterior of the hard metal layer 12 sprayed on as in FIG. 1 is rough and pitted and the steel layer 14 applied as in FIG. 2 from the gun 13 adheres thereto by entering into the interstices of the rough and pitted surface of the exterior of the hard ³⁵ metal layer 12. This coating 14 itself exhibits on its exterior a rough and pitted surface as explained in my prior U.S. Pat. No. 3,083,424. The gun 13 can be a common gas or electric metalizing gun.

40 The coated core 10, bearing both of the sprayed on layers 12 and 14 deposited as in FIGS. 1 and 2, is then inserted into an appropriate die in a die casting machine diagrammatically indicated at 16 in FIG. 3. The die 16 has a cavity of an appropriate shape surrounding the core 10. The metal of the housing is cast into the cavity of the die 16 under normal die casting pressures which may run from 2000 psi. to 15,000 psi. The high pressure exerted on the casting metal causes this metal to enter into the interstices of the rough, pitted surface 50 of the exterior of the layer 14 of steel or other iron alloy. The completed casting is then permitted to solidify in the die 16 and is subsequently removed with the core 10 still in place. The bond exhibited between the casting metal, which is preferably aluminum, and the coat-55 ing 14 has a greater strength of adherence than the bond between the initially deposited hard metal layer 12 and the core 10. Thus, when the core 10 is removed from the solidified casting, as by a differential expansion, the coatings 12 and 14 will adhere to the casting $_{60}$ and not to the core. Attempts to remove the core from the casting by sheer physical force may result in a destruction of the coating 12 because of the adherence of some of the hard metal particles to the core which would then either score the remainder of the coating or cause its destruction for practical use.

Once the casting has been removed from the die casting machine and the core 10 removed from the casting,

a section through the wall of the casting is essentially as shown in FIG. 5. FIG. 5 is, of course, an enlarged fragmentary view and shows the relatively thin internal hard metal layer 12 and the relatively thicker backing layer 14 of the iron alloy interlocked to the hard metal layer at the interface 17. The aluminum or casting metal is interlocked as at 18 to the backing layer 14 of the iron alloy. In each instance the bond between the layers, at 17 and 18, is only by reason of the interlock-10 may be coated with a solution or dispersion of a re- 10 ing of the material of each layer with its neighboring material in the rough, pitted surface which forms the exterior of the layer after the spray coating application. There appears to be no chemical bonding.

> If the technique has included the primary application then subjected to a machining operation, usually grinding, to expose the hard metal layer 12 which is desired for the working surface of the housing.

> The coated casting is then ground to its final finish and dimensions. Even though the hard metal layer may be ground down to a thickness of only a few microns in some areas it will not spall off or crack because the physical strength imparted by the backing layer of iron alloy is such that even though the aluminum of the casting (having a higher coefficient of thermal expansion) tends to expand radially away from the coatings upon heating during engine operation adequate strength of the composite layers is such that cracking does not occur.

I claim:

1. A method for producing a die casting which comprises applying to a die casting core a relatively thin hard metal coating having a rough and pitted exposed surface, applying to the hard metal coating, and into interlocking engagement with the rough and pitted surface thereof, a relatively thicker backing coating of a metal which is strong, highly adherent, and softer than said hard metal having a rough and pitted exposed surface, positioning the coated core in a die, introducing under die casting pressure a metal having a lower melting temperature than that of either of the coatings into the die and into interlocking engagement with the rough and pitted surface of the metal coating on the core, solidifying the introduced metal, and separating the core from the hard metal layer whereby the interior of the die casting exhibits the hard wear resistant character of the thin initial coating.

2. A method as claimed in claim 1 wherein the thickness of the hard metal coating on the core is controlled to one sufficiently thin that absent the metal backing coating, a given compressive force applied thereto when the finished casting is heated causes separation of the hard metal coating and the die cast metal, and the thickness of the metal backing coating is controlled to one at which the given compressive force applied to the hard metal layer when the finished casting is heated does not cause separation.

3. A method as claimed in claim 1 wherein a dry particulate release agent is applied to the die casting core prior to application thereto of the layer of a hard metal.

4. A method as claimed in claim 1 wherein a metal coating is applied to the die casting core as a separation 65 layer prior to application thereto of the layer of a hard metal.

5. A method as claimed in claim 1 wherein a thin coating of a metal is first applied to the die casting core,

said metal having a lower melting temperature than that of the hard metal, and the hard metal coating is then applied to the metal coating.

6. A method as claimed in claim 5 wherein, after separation of the core from the casting, the metal coating 5 that was first applied to the core is removed by a ma-

chining operation to expose the hard metal coating.

7. A method as claimed in claim 4 wherein, after separation of the core from the casting, the metal coating that was first applied to the core is removed by a machining operation to expose the hard metal coating.

* * * * *

15

20

25

30

35

40

45

50

55

10

60