(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 380 715 A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 89101505.9

(51) Int. Cl.5: C22C 1/10, B22D 19/08

(22) Date of filing: 28.01.89

(43) Date of publication of application:
08.08.90 Bulletin 90/32

(84) Designated Contracting States:
BE DE ES FR GB IT

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(54) Abrasion resistant composite casting and production method thereof.

(57) The invention provides an abrasion resistant composite casting, suitable for use in equipment operating under severe abrasive conditions. The composite material consists of small particles or grains of cemented carbide embedded in a matrix of alloy white cast iron: at least 70 % of the total amount of said particles has a grain size between 2 and 15 mm.

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Abrasion Resistant Composite Casting and Production Method Thereof

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates to an abrasion resistant material having large abrasion resistance under severe abrasion condition in which abrasive particles run into surface or move scraping the surface.

2. Prior art:

Heretofore, components or parts which are mounted on a machine or equipment and exposed to severe abrasion condition have been made of a certain material having high abrasion resistance such as 12% Mn steel (Hadfield's manganese steel), 27% Cr cast iron or the like.

Users of such machine or equipment have still required to have their machine or equipment more endurable, and to meet such requirement manufacturers have been engaged in developing a composite material having higher abrasion resistance. Several promising composites have been proposed in this respect, and among which an invention titled "A composite including sintered carbide and cast iron" disclosed in Japanese Patent Publication (examined) No. 60-11096 is worthy to note as a typical prior art.

According to this prior art, a composite is made of a cemented carbide and a cast iron and featured in that although the cast iron itself includes a graphite cast iron having a rather low abrasion resistance and hardness, its carbon equivalent is adjusted to 2.5 to 6.0, an intermediate alloy phase or a transition zone is formed between the cemented carbide and cast iron, and 20 - 80% of the cemented carbide is located in the transition zone. The prior art disclosed several examples for optimum operating conditions. It is described therein that a remarkable superiority was achieved when the composite is applied to a liner of coal crusher, a bit or bit holder of 3 inch rock drill and a die for molding head under normal temperature, as compared with the conventional abrasion resistant material such as hard martensite cast iron, manganese steel, the conventional bit holder of high quality fatigue resistant steel or such steel bit itself and the conventional die of ball bearing steel, respectively.

It is also described that such superiority is achieved because transition and continuous variation taking place between the hard cemented carbide and soft graphite cast iron perform desirable action against strong impact. It is further described therein that when applying the composite to a bit holder of a rock drill for example, dynamic strain is reduced and decentralized due to low Young's modulus and large damping capacity, eventually resulting in avoidance of concentration of impact load.

Figure 2 is a microphotograph of the metallic structure of said prior art obtained as a result of test carried out by the applicant. This photograph of 50 magnifications shows a composite of three phases, i.e., nodular graphite cast iron, intermeidate layer and cemented carbide from left to right each being adjacent one another forming a layer. It is easily understood that the intermediate layer absorbs strong shock and prevents rupture and peeling.

A problem, however, exists in that it will be impossible to coat completely the entire surface to be exposed to abrasion with the cemented carbide of high hardness, and particularly when graphite cast iron infiltrates into particles and comes out on the surface, there is a possibility of deterioration depending on the operating conditions due to low hardness and low abrasion resistance of the graphite cast iron. The problem is more serious when the composite is confronted with such abrasion as scratching, beating, scraping brought about by hard particles. The graphite cast iron infiltrated into the boundary of the cemented carbide can absorb strong shock and hold the carbide, but will not be able to resist the abrasion and be immediately worn out by such abrasion, whereby the cemented carbide will soon peel off without exhibiting its excellent performance of abrasion resistance.

It is certainly possible to thicken the layer of cemented carbide for the purpose of extending the life or durability thereof, but such counter-measure is not always practical in view of considrable increase of cost and technical difficulty in infiltrating the cast layer into the whole particle layer. Another problem exists in that indeed large amount of intermediate layer in the foregoing prior art is effective in improving the low hardness of graphite cast iron, but the intermediate layer diminishes high hardness of the cemented carbide, eventually resulting in reduction of abrasion resistance. There is a further problem of substitution of cobalt largely applied to the cemented carbide resulting in formation of brittle phase.

SUMMARY OF THE INVENTION

The present invention was made to solve the above-discussed problems and has an object of providing a composite casting having large resistance to abrasion.

To accomplish the foregoing object, the composite casting of high abrasion resistance according to the invention comprises fine pieces of cemented carbide, and a white cast iron which forms a required configuration by combining said fine pieces.

It is preferable that the fine pieces of cemented carbide are in any of such form as crushed pieces, grain particles or compressively molded compacts or combination of them and that at least 70% of total amount of the pieces are in a range of 2 - 15 mm in grain size.

It is also preferable that the white cast iron is mainly composed of a complex carbide to which alloy element is added, and in which carbon is included in a range of 2.5% to 4.0% and chromium/carbon (Cr%/C%) is in a range of 1 to 12.

The composite casting is preferably produced in such a manner that, establishing an average layer thickness of the fine pieces of cemented carbide as T (cm), casting temperature of molten cast iron fed to the fine pieces is higher than the melting point (°C) of the cast iron by 50 T(°C) to 180 (1.75 + T) (°C).

As compared with graphite cast iron, the white cast iron can be a material of high hardness being composed of cementite and martensite. To improve abrasion resistance of such cast iron, it is well known that an alloy element such as chromium is added and melted so that a complex carbide of iron and chromium is precipitated on a matrix as a structure after solidification, whereby hardness of the matrix itself is also improved. In this respect, according to the invention, it is defined as mentioned above that carbon is most preferably included in a range of 2.5% to 4.0%, while ratio of chromium/carbon (Cr%/C%) being in a range of 1 to 12. If the ratio is less than 1, precipitation of complex carbide is poor and matrix hardness is low resulting in precipitation.of graphite. On the other hans, if the ratio is more than 12, C needed for production of carbide is so insufficient that C is taken from the cemented carbide resulting in formation of brittle phase on the boundary between the cast iron and cemented carbide.

Furthermore, in order to infiltrate completely the molten white cast iron into small gaps formed among cemented carbide particles, casting temperature of the molten white cast iron should be higher than the melting point 0(°C) thereof by at least 50 T(°C) where the thickness of the particle layer is T cm. In addition, in order to avoid the cemented carbide from excessive solution into the white cast iron, the temperature of molten white cast iron should also be in the range of melting point thereof to 180 (1.75 + T) (°C).

Concerning the particles, if grain size thereof is too small, gaps formed among the cemented carbide particles are also too small to infiltrate the white cast iron into the gaps among the particles even though raising the casting temperature. Moreover, if raising the casting temperature too high, solution amount of the cemented carbide into the white cast iron increases considerably. On the other hans, if the grain size is too large, not only volume ratio of the cemented carbide is reduced, but also average distance among the particles in which the white cast iron matrix is cut by abrasive particles is increased, thereby reducing the performance of abrasion resistance. Accordingly, it is preferable that at least 70% of the particles is in a range of 2 - 15 mm in grain size.

As mentioned above, the composite casting according to the invention exhibits excellent resistance to abrasion without impact or abrasion with low impact, in particular to such abrasion as resulting in scrutching, sliding, scraping on the surface caused by hard fine particles (of ore, coal, coke, abrasive grain, soil fraction, etc.). In the composite casting according to the invention, high abrasion resistance proper to the cemented carbide which is a high hard alloy is kept and supported by the white cast iron serving as matrix, and in which the surface is hardly worn or abrased owing to high abrasion resistance rendred by these two components mated with each other, thereby achieving excellent durability or long life. In particular, by producing a composite casting considering preferable C%, Cr/C ratio, grain size of cemented carbide and preferable casting temperature of molten cast iron, the composite casting of sufficiently long life can be attained as shown in six examples described later.

Other objects, features and advantages of the invention will becomes apparent in the course of the following description with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a microphotograph of the metallic structure according to an embodiment of the present invention; and

Figure 2 is amicrophotograph of the metallic structure according to the prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Example 1:

Three plates, i.e., (1) a plate made of 2.6% C - 26% Cr white cast iron and, (2) a plate made of alumina sintered plate and (3) a composite plate made of cemented carbide particle layer of 10 mm in thickness and nodular graphite cast iron matrix, were respectively prepared as comparative examples, while preparing (4) a composite plate including cemented carbide layer of 6 mm in thickness and matrix of 2.8%C - 24% Cr - Ni - Mo according to the invention. These four plates were then put in use each as a shooting liner incorporated in a conveyor line for conveying sintered ore installed in an iron mill.

As a result of this comparative experiment, it was found that lifes of the four liners were as follows:

(1) liner of 2.6% C - 26% Cr white cast iron	30 days
(2) liner of alumina sintered plate	40 days
(3) liner of cemented carbide layer and nodular graphite matrix	150 days
(4) liner according to the invention	500 days

In this manner, according to the invention, a significant improvement in abrasion resistance of the matrix among cemented carbide particles was achieved, in spite of reduction of amount of expensive cemented carbide by half as compared with the liner (3).

Example 2:

Two plates, i.e., (1) a plate made of 2.7% C - 28% Cr white cast iron and (2) another plate made of hard facing material were prepared as comparative examples, while preparing (3) a composite plate including cemented carbide particle layer of 15 mm in thickness and matrix of 3.2% C - 2.5% Cr - 4% Ni according to the invention. These three plates were put in use as crushing plates each incorporated in a machine for crushing sintered ores. Life of each crushing plate was as follows:

(1) plate of 2.7% C - 28% Cr white cast iron	60 days
(2) plate of hard facing	45 days
(3) plate according to the invention	240 days

Figure 1 is a microphotograph (200 magnifications) of the metal structure around the boundary between the white cast iron and cemented carbide (WC - Co) of the composite produced in this Example 2. In the photograph, the cast iron is seen on the left side and the cemented carbide on the right side, and a very thin intermediate layer is barely found in the boundary.

Example 3:

(1) A plate made of 2.7% C - 28% Cr white cast iron was prepared as a comparative example, while preparing (2) a composite plate including cemented carbide particle layer of 15 mm in thickness and a matrix of 3.2% C - 2.5% Cr - 4% Ni according to the invention. These two plates were put in use each as a

liner incorporated in a section for gyrationally shooting materials of a blast furnace installed in an iron mill under the same conditions. Life of each liner was as follows:

(1) liner of 2.7% C - 28% Cr white cast iron liner	1 month
(2) liner according to the invention	8 months

Example 4:

(1) A plate made of alumina sintered plate and (2) another plate made of hard facing material of 5.5% C - 22% Cr - 7% Mo - 8% Nb - 2% W were prepared as comparative examples, while preparing (3) a composite plate including cemented carbide particle layer of 8 mm in thickness and matrix of 2.6% C - 27% Cr - Ni - Mo according to the invention. These three plates were put in use as liners incorporated in skip car of a blast furnace. Life of each liner was as follows:

(1) liner of alumina sintered plate	90 days
(2) liner of hardening and thickening material	270 days
(3) liner according to the invention	not less than 720 days

Example 5:

(1) A plate made of 3.0% C - 26% Cr white cast iron was prepared as a comparative example, while preparing (2) a composite plate including cemented carbide particle layer of 8 mm in thickness and a matrix of 2.7% C - 25% Cr - Mo according to the invention. The two plates were put in use each as a liner of inlet part of a mixer for shooting sintered ore materials. Life of each liner was as follows:

(1) liner of 3.0% C - 26% Cr white cast iron	45 days
(2) liner according to the invention	not less than 650 days

Example 6:

(1) A plate made of 3.2% C - 15% Cr - 3% Mo white cast iron was prepared as a comparative example, while preparing (2) a composite plate including cemented carbide particle layer of 8 mm in thickness and matrix of 2.8% C -25% Cr white cast iron according to the invention. The two plates were put in use each as side liner of conveying line of sintered ores. Life of each liner was as follows:

(1) liner of 3.2% C - 15% Cr - 3% Mo white cast iron	90 days
(2) liner according to the invention	not less than 980 days

Claims

1. An abrasion resistant composite casting including fine pieces of cemented carbide, and a white cast

iron which combines said fine pieces to give a required form.

2. An abrasion resistant composite casting according to claim 1, wherein the fine pieces of cemented carbide are in any form of crushed particle, grain particle or compressively molded compact or combination of them and that at least 70% of total amount of the pieces are in a range of 2 - 15 mm in grain size.

3. An abrasion resistant composite casting according to claim 1, wherein the white cast iron is mainly composed of a complex carbide to which alloy element is added, and in which carbon is included in a range of 2.5% to 4.0% and chromium/carbon (Cr%/C%) is in a range of 1 to 12.

4. An abrasion resistant composite casting according to claim 2, wherein the white cast iron is mainly composed of a complex carbide to which alloy element is added, and in which carbon is included in a range of 2.5% to 4.0% and chromium/carbon (Cr%/C%) is in a range of 1 to 12.

5. A method for producing an abrasion resistant composite casting comprising a step of casting a molten cast iron whose structure after solidification is white cast iron to a cemented carbide layer of T cm in thickness, and in which temperature of the casting molten cast iron is higher than the melting point thereof by 50 T °C to 180 (1.75 + T) °C.

Fig. 1

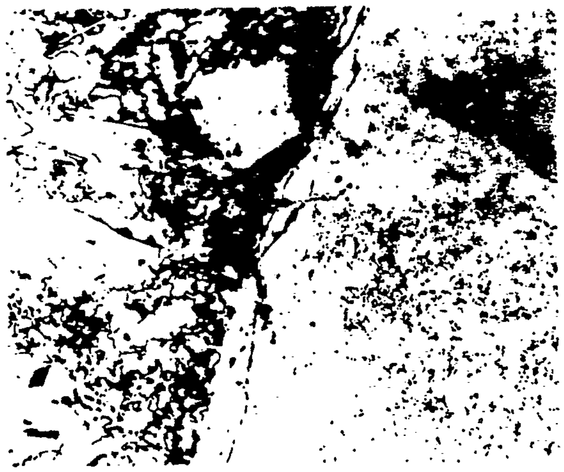

Fig. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 10 1505

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	GB-A-1 582 574 (PERMANENCE CORP.) * Claims 1,3,4; page 4, lines 107-119 * ---	1	C 22 C 1/10 B 22 D 19/08
Y	EP-A-0 130 626 (COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION) * Claims 1,3,4 * ---	1,3	
Y	GB-A- 183 063 (AMERICAN ABRASIVE METALS CO.) * Whole document * ---	1	
Y	US-A-3 941 181 (STOODY) * Claims 1,8; figure 2; column 3, lines 24-38 * ---	1	
Y	METALS HANDBOOK, 9th edition, vol. 1: "Properties and Selection: Irons and Steels", pages 3-5,75-76,81-82, American Society for Metals, Metals Park, Ohio, US * Pages 3-5: "White cast iron"; pages 75-76 and 81-82: "Alloy cast iron" * -----	1,3	TECHNICAL FIELDS SEARCHED (Int. Cl.5) C 22 C B 22 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27-09-1989	LIPPENS M.H.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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