United States Patent Office 3,496,682 Patented Feb. 24, 1970

3,496,682

COMPOSITION FOR PRODUCING CUTTING AND/OR WEARING SURFACES

Joseph F. Quaas, Island Park, and John P. Broderick, Bayside, N.Y., assignors to Eutectic Welding Alloys Corporation, Flushing, N.Y., a corporation of New York

No Drawing. Filed May 5, 1964, Ser. No. 365,160
Int. Cl. C04b 31/16; C09c 1/68; C08h 17/12
U.S. Cl. 51—309 9 Claims

This invention relates to powder compositions useful in producing cutting and/or wearing surfaces on parent materials and a method of producing such deposits. More particularly the invention relates to a powdered metal alloy composition containing diamond bort and a method of depositing such composition on a parent material by means of the flame spray technique whereby outstanding cutting and/or wearing surfaces are produced.

Diamond bort has been found useful when incorporated in a metal matrix for producing cutting surfaces in various industries. Thus in the oil industry, for example, diamond cutting tools are used in drilling operations. These cutting tools are extremely expensive but in view of their outstanding properties and recovery techniques the tools have found widespread acceptance.

Diamond cutting tools generally consist of fragmented bort entrapped within a matrix, this matrix in turn firmly attached to a parent material. Needless to say, in view of the high cost of diamond tools it is essential that the tool have a long life span. The diamond itself, which is the most expensive portion of the tool, never wears out. The life span of the tool is dictated by the amount of erosion during service life occurring in the matrix alloy which entraps the diamond. After a certain amount of erosion has occurred, the matrix alloy is worn away from the diamond particles and the diamonds tend to fall out of the cutting tool and are lost unless proper precautions are taken.

Since the diamonds themselves constitute the primary expense in such cutting tools, it is customary to calculate the expected time in which sufficient erosion has occurred for the diamonds to loosen and fall out of the tool. The industry has developed calculations depending on the matrix alloy utilized to determine when the diamonds will be so loosened and the tool is then removed from service before the diamonds fall out and are lost. The bit is sent to a refinisher having specialized and expensive equipment who recovers the diamonds and rebuilds the tool by replacing the diamonds in a new metal matrix. In this manner, diamond cutting tools may be rebuilt a number of times.

The hardness of the metal matrix and its ability to both initially entrap the diamond securely and to resist erosion during use determines the life span of the tool. It is, therefore, necessary to use a matrix alloy composition which provides maximum resistance to wear and most intimate contact with the diamond particles to securely bind them in the matrix.

The harder the matrix alloy, the more it is wear resistant. It has been found, however, that there are certain difficulties in using metal matrix alloys of high hardness with diamond bort. Generally, the harder a matrix alloy, also the higher is its melting temperature. Diamond bort is generally insensitive to temperatures up to about 2400° F. Above 2400° F. the diamond particles begin to oxidize and crack making them useless in cutting tools. Additionally, if the diamond particle is heated at about 2400° F. for a substantial period of time, it will oxidize and crack. Thus, while the art recognizes that high hardness is desirable in matrix alloys used to entrap the diamond particles, it has been unable to utilize hard matrix alloys because their relatively high melting temperatures are incompatible with diamond bort.

Another factor which prevented the use of high hardness matrix alloys is that generally the harder the alloy the less tendency the molten alloy has to intimately contact the diamond during entrapment. Diamond bort consists of highly irregular sized diamond particles. Unless these particles are intimately contacted over a substantial portion of their irregular surface by the molten matrix alloy, they will not be securely entrapped. This results in the diamonds loosening and falling out of the matrix alloy while the tool is still in service. In such a case the life span of the tool is shortened and the diamond is completely lost.

As a result of the above discussed limitations, the art has been restricted to relatively soft matrix alloys with resulting tools of relatively short life spans.

It is an object of this invention to provide a matrix alloy composition containing diamond bort and a method of depositing such a composition which produce cutting surfaces having a long service life. It is another object to produce such method and compositions which will prevent oxidation and/or cracking of the diamond particles during deposition. It is a further object to provide such compositions and method which will produce a deposit wherein the diamond particles are securely entrapped within the matrix alloy. It is also an object to provide such a method and composition which utilize a matrix alloy of high hardness. It is yet another object to produce such compositions and method which may be utilized to produce cutting surfaces with simple and economical equipment having maximum portability. It is lastly an object to provide such compositions and method which may be used to produce new cutting tools or to refinish and rebuild such tools after they have become worn.

These and other objects are attained according to the invention by flame spraying a matrix alloy system incorporating diamond bort whose melting point is below 2400° F. A particularly effective such matrix system has a nickel, cobalt, or copper base, while being essentially self fluxing and highly fluid when molten and containing from 10 to 80 percent by weight of diamond bort. A flame spraying torch deposits such a composition uniformly without damage to the diamond particles.

By diamond bort is meant fragmented diamond particles normally used in industry. This material comprises diamonds too badly flawed or too off-color to be used in jewelry. The particle size of the bort used in this invention is generally between —20 and +325 mesh.

The diamond bort is mechanically mixed with a matrix base alloy in an amount between 10 to 80 percent by weight bort to 10 to 90 percent powdered matrix alloy. Suitable ranges of diamond bort and powdered matrix alloy are as follows:

	Weight Percent		
Constituents	Broad	Preferred	Example
Diamond bort	10 to 80	30 to 50	40
Matrix alloy	10 to 90	40 to 70	60

It is generally preferred to maintain an excess of matrix alloy compared to the diamond bort on a weight basis.

It has been found desirable for certain applications to use a mixture of diamonds and refractory carbides such as tungsten, titanium, chromium, zirconium, molybdenum carbides and the like. Generally from 1 to 50 percent carbides on a weight basis may be included.

Matrix alloy powders found particularly useful according to the invention include the nickel, cobalt and copper base alloys. The alloys may contain minor

amounts of such additional agents as silicon, boron, chromium or tin. It is preferred to use boron in the composition to provide self fluxing properties and high fluidity so that the irregular surfaces of the diamond particles are intimately contacted and securely entrapped. The particle size of the matrix alloy should in general be maintained below 20 and preferably below 150 mesh. The matrix alloy powder used must melt below 2400° F. so that the diamond particles will not be damaged during deposition. Suitable nickel base alloys include those containing silicon and boron, with or without chromium. Cobalt base alloy systems containing minor additions of boron and copper base alloys of the copper-silicon and copper-tin type may be utilized.

The following examples represent particularly useful alloy mixtures which may be used according to the invention. These alloys are specifically designed to combine the features of melting below 2400° F., high fluidity, self fluxing, lack of fuming, wear resistance and hardness so that the cutting and/or wearing surfaces produced have the longest possible service life, hold the diamond particles tightly entrapped and cause no physical or chemical changes in the diamond bort during deposition.

NICKEL BASE MATRIX ALLOY

Constituent	Weight Percent	
	Range	Example
Silicon	1.5–5.0	3.0
Boron	1.5–5.0	2.0
Chromium	0–20	1.0
Molybdenum	0–7	0.2
Nickel	Balance	Balance

This nickel base alloy matrix provides the most outstanding characteristics of low melting, high wear resistance and hardness and is the particularly preferred alloy.

COBALT BASE MATRIX ALLOY

Constituent	Weight Percent	
	Range	Example
Nickel	1.0–5.0	3.0
Chromium	26.0–32.0	28.0
Silicon	0.5–3.0	1.0
Boron	1.0–3.0	2.0
Carbon	0.8–2.0	4.5
Tungsten	3.5–7.5	3.0
Molybdenum	0.0–5.0	57.5
Cobalt	Balance	Balance

COPPER BASE MATRIX ALLOY (COPPER-SILICON TYPE)

Constituents	Weight Percent		
	Broad Range	Intermediate Range	Example
Nickel	15.0–40.0	20.0–25.0	23.0
Silicon	1.0–5.0	3.0–4.0	3.45
Boron	0.15–2.50	0.25–0.5	0.47
Manganese	0.20–2.00	0.5–1.0	0.75
Copper	Balance	Balance	Balance

COPPER BASE MATRIX ALLOY (COPPER-TIN TYPE)

Constituents	Weight Percent	
	Broad Range	Preferred Range
Nickel	1 to 10	1 to 3.
Chromium	0 to 2	0 to 0.6.
Silicon	0 to 0.4	.05 to 0.15.
Boron	.03 to 0.5	.05 to 0.10.
Phosphorus	0.1 to 0.6	0.20 to .35.
Tin	4 to 12	6 to 9.
Iron	1.01 to 0.5	0.02 to 0.3.
Copper	Balance	Balance.

In view of the known properties of diamonds, it was most unexpected to find that the present method and such high melting temperature compositions could be used to effectively deposit the diamonds without deleteriously affecting them. In view of the known properties of diamonds it was likewise unexpected to achieve intimate contact between the molten alloy and the diamond particle during deposition.

Diamond bort generally cannot be subjected to temperatures above 2400° F. due to unacceptable changes in physical and chemical properties. Furthermore, extensive heating at temperatures about 2400° F. will tend to cause cracking and/or oxidation which renders the particles unfit for use in producing cutting or/and wearing surfaces. Refractory carbides, for example tungsten carbide on the other hand are far less prone to oxidation.

The flame spray technique involves the use of an oxy-fuel mixture such as oxy-acetylene, oxy-propane, etc., as a source of heat. These oxy-fuel mixtures burn at temperatures which far exceed 2400° F. and it is, therefore, highly unexpected that the diamonds do not suffer undesirable changes in physical or chemical characteristics when sprayed at such high temperatures. For example, an oxy-acetylene flame can produce temperatures in the range of 5550 to 6000° F. depending on the ratio of oxygen to acetylene. A neutral flame normally used in the flame spray process produces a temperature of 5850° F. The reason that the diamonds did not undergo any chemical or physical changes during flame spraying may result from its subjecting them to the high temperature of the oxy-fuel flame for only a brief period of time. Thus in normal operation the diamond particles pass from the torch tip to the workpiece in a matter of micro seconds. In this short period of time, the diamond, even though traveling through a temperature zone within the oxy-fuel flame far exceeding 2400° F., is not physically or chemically changed. This short travel time is accomplished at high effieciency with a flame spray process in which the matrix alloy powder is entrained by an oxy-fuel gas mixture and sprayed at substantially equal velocity wit the gas mixture upon the surface being coated.

It is also known in the art that diamond particles unlike particles of for example refractory carbides are not yet by molten alloys. Tungsten carbide for example is wet by molten alloys and, therefore, can be entrapped solidly within a matrix alloy. Diamonds, however, are so highly refractory that no wetting can occur. Therefore, it is highly unexpected that by utilizing the flame spray technique diamonds are intimately contacted with the molten alloy to an extent sufficient to hold them firmly within the matrix. This is particularly true when one considers the extremely irregular shape and surface area of the particles. It was unexpectedly found that by providing a matrix alloy composition of high fluidity and utilizing the flame spray technique intimate contact of the molten alloy with substantially all the surface area of the individual particles could be obtained. This appears to be helped by a combination of matrix alloys having high fluidity and the thrust provided by the particles striking the workpiece.

In the flame spraying of alloy compositions according to this invention, the matrix alloy powder containing diamond bort is mixed with the fuel gas and/or oxygen gas, passed through a tip in the torch wherein the gases are burned and sprayed onto the heated parent material. Entraining the powder in the gas mixture and spraying it at substantially equal velocity with it efficiently performs the method of the invention. The diamond particles are unchanged both physically and chemically during deposition. The matrix alloy powder is melted or plasticized during its travel through the flame and upon hitting the preheated workpiece it is substantially molten. The molten matrix carries the bort and flows on the parent metal to provide a uniform coating over the workpiece. As the melt solidifies it mechanically entraps the diamond bort.

The process and compositions of the present invention find particular utility in resurfacing and rebuilding worn-out cutting tools such as those tools used in the oil drilling industry. Calculations can be used to predict when the service life of the tool has been sufficiently long to cause erosion of the matrix alloy to the point wherein the diamonds may be lost. The normal procedure has been to remove the cutting tool from service and ship

it to a rebuilder. This rebuilder normally resurfaces the tool by a method known as infiltration. In this system, the tool is placed in a mold conforming to the desired outside characteristics of the rebuilt tool. A mixture of matrix, diamonds, flux and, if desired, refractory carbides is then placed around the tool inside the mold. By use of induction heat the mold, tool, and alloy mixture are heated at high temperatures for long periods of time to insure complete infiltration of the matrix into the tool.

The above prior art process of rebuilding the worn tools is greatly simplified according to the invention. Infiltration requires the use of expensive equipment. The molds used are quite expensive and generally the mold is destroyed when the rebuilt workpiece is removed. Furthermore, the infiltration process requires expensive heating equipment and complex contol equipment for regulating the temperature. The present process on the other hand does not require expensive equipment of this nature. Furthermore, all equipment used in the inventive process is highly portable. The rebuilding of the tool can thus be done at the job site and the time and expense of shipping the tool to a refinisher is obviated.

The process of the present invention furthermore allows utilization of metal matrix alloys which produce harder deposits. In the infiltration process, the alloy matrix must not only be melted but it must be superheated in order to obtain fluidity. It further must be maintained at a high temperature for a long period of time to insure infiltration. Since the melting temperature of matrix alloys generally increases as the hardness of the matrix increases and since diamonds suffer adverse physical and chemical changes at high temperature extended heating, the infiltration process has been generally limited to matrix alloys of low melting temperature and low hardness. The present process allows utilization of alloy mixtures melting up to 2400° F. This is particularly true since superheating and long periods of heating are not required. Thus the diamond bort may be entrapped in an alloy of high hardness in the process according to the invention without adverse physical or chemical changes resulting.

Another area wherein the present process and compositions find particular utility is in the production of wear strips on cutting tools. In drilling, for example, it is required that the drill hole have a uniform diameter throughout its entire length. Drillers generally know the exact size of the drill bit, and all subsequent materials (e.g., pipe, fishing tools, pumps, etc.) that are sent down the drill hole have a size corresponding to the drill bit. A drill bit is normally subject to wear not only on its cutting surface but also around its sides. This is caused by constant contact and friction with the sides of the drill hole and the spoil passing by. The bit, therefore, tends to wear and the diameter of the bit lessens, gradually decreasing the diameter of the drilled hole. As a result, pipes, tools, etc., subsequently sent down the drill hole, may become jammed or lodged in the drill hole. These pipes, tools, etc., may become so firmly jammed as to cause total abandonment of the drill hole and jammed equipment all at considerable expense.

It has, therefore, become common to place wear strips around the circumference of the drill bit. These wear strips may consist of diamond particles entrapped in a matrix alloy. These wear strips prevent the diameter of the drilled hole from decreasing.

The wear strips have previously been applied, after infiltration, by heating the tool so as to sweat the surface around the circumference and the diamond particles are then placed by hand one by one into the softened or sweated surface. Normally a small suction tool is utilized to pick up the diamond particles and to drop them onto the surface where they become entrapped.

The present process allows direct application of the wear strip in a far simpler and more economical manner. The matrix alloy-diamond bort mixture is merely flame sprayed onto the circumference. The particles are not placed on one by one by hand and since the equipment used is highly portable, the wear strips may be applied to the tool in the field.

The present process and compositions may, of course, be used whenever a cutting surface is desired. The invention provides far greater versatility and flexibility of application and allows on-the-job repairs and production of custom tools. The invention provides a simple method of producing heterogeneous facings without the need for specialized heat sources, molds, induction furnaces, temperature control, etc.

The process and compositions of the present invention further provide a uniform distribution of diamond bort in matrix alloy. There is no danger of the diamond particles settling out in a highly fluid, thick coating of molten alloy. Thick coverings of diamond-matrix alloy are built up by successive passes with the flame spray torch and the diamonds remain uniformly distributed within the coating.

The composition and method of the present invention further insure that the degree of contact between the irregular surface of each diamond particle and the matrix is high. The particularly advantageous matrix alloy has inherently high fluidity and insures intimate contact and, as such, the diamond is less susceptible to dislodgement and loss. The alloy compositions are further self-fluxing and, therefore, no flux need be additionally added. The compositions are further not subject to fuming since they do not contain zinc. The combination of thrust from the flame spray process and the fact that the molten matrix is highly fluid helps account for the exceptional flow and coverage of a larger area of the parent material as compared with other methods of deposition.

The composition and method further insure that the diamond particles will not be adversely changed in either physical or chemical properties. The alloy mixture is so chosen to melt below 2400° F. Only a short application of heat is required. No extensive heat control apparatus is required.

The deposits produced by the composition and method of the present invention are hard and wear resistant. The matrix is less susceptible to wear during use and, as such, the diamond particles do not loosen or dislodge as quickly. The service life of a tool to which this invention is applied is thereby remarkably extended.

We claim:

1. An alloy composition suitable for flame spraying comprising from 10 to 80 percent by weight diamond bort and from 10 to 90 percent by weight of a powdered matrix alloy melting below 2400° F. said matrix alloy being selected from the group consisting of nickel base alloys containing minor amounts of silicon, boron and chromium, cobalt base alloys containing minor amounts of boron, copper base alloys containing minor amounts of silicon and copper base alloys containing minor amounts of tin.

2. The alloy composition of claim 1 wherein the diamond bort has a particle size between —20 and +325 mesh.

3. The alloy composition of claim 1 wherein the diamond bort is present in an amount between 30 and 50 percent by weight and the powdered matrix alloy is present in an amount between 40 and 70 percent by weight.

4. The alloy composition of claim 1 wherein the powdered matrix alloy comprises the following constituents in the following percents by weight.

Constituents:	Wt. percent
Silicon	1.5–5.0
Boron	1.5–5.0
Chromium	0–20
Molybdenum	0–7
Nickel	Balance

5. The alloy composition of claim 1 wherein the powdered matrix alloy comprises the following constituents in the following percents by weight.

Constituents:	Wt. percent
Nickel	1.0–5.0
Chromium	26.0–32.0
Silicon	0.5–3.0
Boron	1.0–3.0
Carbon	0.8–2.0
Tungsten	3.5–7.5
Molybdenum	0.0–5.0
Cobalt	Balance

6. The alloy composition of claim 1 wherein the powdered matrix alloy comprises the following constituents in the following percents by weight.

Constituents:	Wt. percent
Nickel	15.0–40.0
Silicon	1.0–5.0
Boron	0.15–2.50
Manganese	0.20–2.00
Copper	Balance

7. The alloy composition of claim 1 wherein the powdered matrix alloy comprises the following constituents in the following percents by weight.

Constituents:	Wt. percent
Nickel	20.0–25.0
Silicon	3.0–4.0
Boron	0.25-0.5
Manganese	0.5–1.0
Copper	Balance

8. The alloy composition of claim 1 wherein the powdered matrix alloy comprises the following constituents in the following percents by weight.

Constituents:	Wt. percent
Nickel	1–10
Chromium	0–2
Silicon	0–0.4
Boron	.03–0.5
Phosphorous	0.1–0.6
Tin	4–12
Iron	0.01–0.5
Copper	Balance

9. The alloy composition of claim 1 wherein the powdered matrix alloy comprises the following constituents in the following percents by weight.

Constituents:	Wt. percent
Nickel	1–3
Chromium	0–0.6
Silicon	.05–0.15
Boron	.05–0.10
Phosphorous	0.20–.35
Tin	6–9
Iron	0.02–0.3
Copper	Balance

References Cited

UNITED STATES PATENTS

2,175,223	10/1939	Silliman	75—160
2,240,829	5/1941	Bevillard	51—309 X
2,562,587	7/1951	Swearingen	117—22
2,786,779	3/1957	Long et al.	117—22
2,864,696	12/1958	Foreman	117—105 X
2,866,698	12/1958	Kuzmick	51—309 X
2,868,667	1/1959	Bowles	117—105 X
2,880,109	3/1959	Current et al.	117—22
2,961,312	11/1960	El Baum	117—105 X
3,035,934	5/1962	Cape	117—22
3,141,746	7/1964	De Lai	51—309 X
3,230,097	1/1966	Fischer	117—22 X
3,238,060	3/1966	Quaas et al.	117—22 X
3,248,189	4/1966	Harris	51—309 X
3,293,029	12/1966	Broderick et al.	75—154 X
3,313,633	4/1967	Longo	106—1

FOREIGN PATENTS

907,355	10/1962	Great Britain.

WILLIAM D. MARTIN, Primary Examiner

PAUL F. ATTAGUILE, Assistant Examiner

U.S. Cl. X.R.

51—293; 75—153, 160, 170, 171; 106—1; 117—22, 105.2