

## Description

### Copending applications

Copending EP-A1-0 143 342 and copending EP-A1-0 143 344, both filed on even date herewith, disclose and claim subject matter which is related to the present application.

### Technical field

The present invention relates to wear and corrosion resistant coatings and to a method for producing such coatings. More particularly, the invention relates to a new family of W-Co-Cr-C coatings having improved strength and wear resistance.

### Background art

Coatings of W-Co-Cr-C are used in those applications where both superior wear and corrosion resistance are required. A typical composition for these coatings comprises about 8 to 10 weight percent cobalt, about 3 to 4 weight percent chromium, about 4.5 to 5.5 weight percent carbon and the balance tungsten. These coatings can be successfully applied to various substrates, e.g. iron base alloy substrates, using known thermal spray techniques. Such techniques include, for example, detonation gun (D-Gun) deposition as disclosed in U.S. Patent Nos. 2,714,563 and 2,950,867, plasma arc spray as disclosed in U.S. Patent Nos. 2,858,411 and 3,016,447 and other so-called "high velocity" plasma or "hypersonic" combustion spray processes.

Although coatings of W-Co-Cr-C have been employed successfully in many industrial applications over the past decade or more, there is an ever increasing demand for even better coatings having superior wear resistance. In the textile industry, for example, there is a need for special coatings of this type for use on crimper rolls subjected to extraordinary conditions of abrasive wear.

As is generally known, these coatings derive their wear resistance from the presence of complex carbides of W, Co and Cr. It is also known that the wear resistance of the coating usually increases with any increase in the volume fraction of carbides. Therefore, it has been previously thought by those skilled in the art that a relatively high carbon content is necessary in order to obtain optimum wear resistance.

### Summary of the invention

It has now been surprisingly discovered in accordance with the present invention that reducing the carbon content of the W-Co-Cr-C coatings described above to about 4.0 weight percent or less with the proper proportions of Co and Cr actually increases the wear resistance contrary to the teachings of the prior art. It has been found, however, that when too low a carbon content is employed, i.e., less than about 3.0 weight percent, then the resulting coatings are difficult, if not impossible, to grind to a smooth finish.

A coating composition applied to a substrate by a thermal spray process in accordance with the present invention consists of from 6.5 to 9.0 weight percent cobalt, from 2.0 to 4.0 weight percent chromium, from 3.0 to 4.0 weight percent carbon and the balance tungsten and incidental impurities.

A method for coating a substrate wherein a powdered coating material is suspended within a high temperature, high velocity gaseous stream and heated to a temperature at least close to the melting point thereof, said gaseous stream being directed against a surface of said substrate to deposit said powdered coating material and form a coating thereon, in conformity with the present invention, is characterized in that a powdered coating material having a composition such that the coating deposited onto said substrate consists of from 6.5 to 9.0 weight percent cobalt, from 2.0 to 4.0 weight percent chromium, from 3.0 to 4.0 weight percent carbon and the balance tungsten and incidental impurities, is used.

A powdered coating composition for applying a wear and corrosion resistant coating to a substrate by a thermal spray process in accordance with the present invention consists of from 6.5 to 9.0 weight percent cobalt, from 2.0 to 4.0 weight percent chromium, from 3.0 to 4.0 weight percent carbon and the balance tungsten and incidental impurities.

### Description of the preferred embodiments

The coatings of the present invention can be applied to a substrate using any conventional thermal spray technique. The preferred method of applying the coating is by detonation gun (D-Gun) deposition. A typical D-Gun consists essentially of a water-cooled barrel which is several 30 cm (feet) long with an inside diameter of about 25 mm (1 inch). In operation, a mixture of oxygen and a fuel gas, e.g., acetylene, in a specified ratio (usually about 1:1) is fed into the barrel along with a charge of powder to be coated. The gas is then ignited and the detonation wave accelerates the powder to about 730 m/sec. (2400 ft./sec.) while heating the powder close to or above its melting point. After the powder exits the barrel, a pulse of nitrogen purges the barrel and readies the system for the next detonation. The cycle is then repeated many times a second.

The D-Gun deposits a circle of coating on the substrate with each detonation. The circles of coating are about 25 mm (1 inch) in diameter and a few microns (ten thousandths of an inch) thick. Each circle of coating is composed of many overlapping microscopic splats corresponding to the individual powder particles. The overlapping splats interlock and mechanically bond to each other and to the substrate without substantially alloying at the interface thereof. The placement of the circles and the coating deposition are closely controlled to build up a smooth coating of uniform thickness and to minimize substrate heating and establishment of residual stresses in the applied coating.

The powder used in producing the coating of the present invention may be essentially the same powder composition as heretofore employed in depositing W—Co—Cr—C coatings of the prior art. However, in this instance, the oxygen-fuel gas ratio employed in the D-Gun process is increased from a value of about 1.0 to a value of between about 1.1 and 1.2. Under these conditions, changes during the coating process result in the desired coating composition. It is also possible to use other operating conditions with a D-Gun and still obtain the desired coating composition if the powder composition is adjusted accordingly. Moreover, other powder compositions may be used with other thermal spray coating devices to compensate for changes in composition during deposition and obtain the desired coating composition of this invention.

The powders used in the D-Gun for applying a coating according to the present invention are preferably sintered products. However, other forms of powder such as cast and crushed powder can also be used. Generally, the size of the powder should be about 0.044 mm or smaller (—325 mesh). Powders produced by other methods of manufacture and with other size distributions may be used according to the present invention with other thermal spray deposition techniques if they are more suited to a particular spray device and/or size.

As indicated above, it is preferred to use essentially the same powder composition as heretofore employed in depositing W—Co—Cr—C coatings of the prior art. This powder composition consists of about 10 weight percent cobalt, about 4 weight percent chromium, about 5 weight percent carbon and the balance tungsten. With this powder, the feed rate of both oxygen and fuel gas (e.g., acetylene) should be adjusted to provide an oxygen-fuel gas ratio of between about 1.1 and 1.2. This ratio is higher than that usually used heretofore with the same powder composition and provides an oxidizing mixture which reduces the carbon content of the applied coating.

At oxygen-fuel gas ratios close to about 1.1, the conventional powder composition using the D-Gun process will produce coatings having a carbon content of about 3.5 weight percent. Conversely, at oxygen-fuel gas mixtures close to about 1.2, this same powder will produce coatings having a lower carbon content of about 3.1 weight percent.

Alternatively, the coating of the present invention can be applied to a substrate by plasma arc spray or other thermal spray techniques. In the plasma arc spray process, an electric arc is established between a non-consumable electrode and a second non-consumable electrode spaced therefrom. A gas is passed in contact with the non-consumable electrode such that it contains the arc. The arc-containing gas is constricted by a nozzle and results in a high thermal content effluent. Powdered coating material is injected into the high thermal content effluent from the nozzle and is deposited onto the surface to be

coated. This process, which is described in U.S. Patent No. 2,858,411, supra, produces a deposited coating which is sound, dense and adherent to the substrate. The applied coating also consists of irregularly shaped microscopic splats or leaves which are interlocked and mechanically bonded to one another and also to the substrate.

In those cases where the plasma arc spray process is used to apply the coatings of the present invention, powders fed to the arc torch may have essentially the same composition as the applied coating itself. With some plasma arc or other thermal spray equipment, however, some change in composition is to be expected and, in such cases, the powder composition may be adjusted accordingly to achieve the coating composition of the present invention.

The coatings of the present invention may be applied to almost any type of substrate, e.g., metallic substrates such as iron or steel or non-metallic substrates such as carbon, graphite and polymers, for instance. Some examples of substrate material used in various environments and admirably suited as substrates for the coatings of the present invention include, for example, steel, stainless steel, iron base alloys, nickel, nickel base alloys, cobalt, cobalt base alloys, chromium, chromium base alloys, titanium, titanium base alloys, aluminum, aluminum base alloys, copper, copper base alloys, refractory metals, and refractory-metal base alloys.

Although the composition of the coatings of the present invention may vary within the ranges indicated above, the preferred coating composition consists of from 7.0 to 8.5 weight percent cobalt, from 2.5 to 3.5 weight percent chromium, from 3.0 to 4.0 weight percent carbon and the balance tungsten and incidental impurities. Such coatings are ideally suited for industrial valves, mechanical seals, bushings and the like. They are also ideally suited for use in the textile industry as crimper rolls, for example.

The microstructure of the coatings of the present invention are very complex and not completely understood. However, it is believed that the major portion of the coatings consist essentially of a mixture of WC and (W, Cr, Co)<sub>2</sub>C with other metal carbides and possibly metallic phases. Despite the lower volume fraction of carbides present as compared to similar coatings of the prior art, the coatings of the present invention surprisingly exhibit improved wear resistance without sacrificing other desirable characteristics such as hardness, toughness, etc. Typical hardness values for coatings of the present invention exceed about 900 DPH<sub>300</sub>.

The following examples will serve to further illustrate the practice of the present invention.

#### Example I

Specimens of AISI 1018 steel were cleaned and prepared for coating as follows. The surface on one side of each specimen was ground smooth and parallel to the opposite side. The surface was then grit blasted with 0.25 mm (60 mesh) Al<sub>2</sub>O<sub>3</sub> to

a surface roughness of about 3  $\mu\text{m}$  (120 micro-inch) RMS. All the specimens were then coated according to the prior art using a detonation gun (D-Gun) and a sintered powder of the following composition: 10 weight percent Co, 4 weight percent Cr, 5.2 weight percent C and the balance W. The size of the powders was about 0.044 mm or smaller (-325 mesh). Acetylene was used as the fuel gas. The oxygen-fuel gas ratio was 0.98.

A chemical analysis of the coating showed the following composition: 8 weight percent Co, 3.2 weight percent Cr, 4.7 weight percent C and the balance W. The chemical analysis was carried out principally by two methods. Carbon was analyzed by a combustion analysis technique using a Leco Carbon Analyzer and volumetric determination of gaseous output. Cobalt and chromium were analyzed by first fusing the sample in  $\text{Na}_2\text{O}_2$  and separating the cobalt and chromium, then determining the amount of each potentiometrically.

Abrasive wear properties of the applied coating were determined using the standard dry sand/rubber wheel abrasion test described in ASTM Standard G65-80, Procedure A. In this test, the specimen was loaded by means of a lever arm against a rotating wheel with a chlorobutyl rubber rim around the wheel. An abrasive (i.e. 0.21 mm to 0.30 mm (50-70 mesh) Ottawa Silica Sand) was introduced between the specimen and the rubber wheel. The wheel was rotated in the direction of abrasive flow. The test specimen was weighed before, after and periodically during the test, and its weight loss was recorded. Because of the wide differences in the densities of different materials tested, the mass loss is normally converted to volume loss to evaluate the relative ranking of materials. The average volume loss for these specimens (conventional W-Co-Cr-C coating) was 1.7  $\text{mm}^3$  per 1000 revolutions.

The hardness of these specimens was also measured by standard methods. The average hardness was found to be 1100 DPH<sub>300</sub>. The specimens were also easily ground to a smooth finish using the normal method of finishing wear resistant coating with a diamond grinding wheel and an infeed of 13  $\mu\text{m}$  (0.0005 inch) per pass.

#### Example II

Specimens of AISI 1018 steel were prepared in the same manner as described in Example I. The specimen surfaces were then coated using a D-Gun and the same sintered powder, i.e., 10 weight percent Co, 4 weight percent Cr, 5.2 weight percent C and the balance W. The powder size was also identical, i.e., 0.044 mm or smaller (-325 mesh). Acetylene was also used as the fuel gas. In this instance, however, the oxygen-fuel gas ratio in the D-Gun was 1.1 according to the present invention.

A chemical analysis of the coating showed the following composition: 7.6 weight percent Co, 2.9 weight percent Cr, 3.5 weight percent C and the balance W.

Abrasive wear tests were also carried out using the ASTM Standard G65-80, Procedure A. The

average volume loss for the specimens was 1.1  $\text{mm}^3$  per 1000 revolutions. This represents a significant improvement in wear resistance over the specimens of Example I.

The hardness of the specimens was also measured and found to be 1150 DPH<sub>300</sub>. The specimens were also easily ground to a smooth finish using the normal method as in Example I.

#### Example III

Specimens of AISI 1018 steel were prepared in the same manner as described in Example I. The specimen surfaces were then coated with a D-Gun and the same sintered powder, i.e., 10 weight percent Co, 4 weight percent Cr, 5.2 weight percent C and the balance W. The powder size was also identical, i.e., 0.044 mm or smaller (-325 mesh). Acetylene was also used as the fuel gas. However, the oxygen-fuel gas ratio used in this instance was 1.2 according to the present invention.

A chemical analysis of the coating showed the following composition: 7.8 weight percent Co, 2.9 weight percent Cr, 3.1 weight percent C and the balance W.

Abrasive wear tests were also carried out on one specimen using the ASTM Standard G65-80. The volume loss for this specimen was 1.1  $\text{mm}^3$  per 1000 revolutions. This also represents a significant improvement in wear resistance over the specimens of Example I.

The hardness of the specimen was also measured and found to be 1080 DPH<sub>300</sub>. The specimen was ground to a smooth but somewhat rougher finish using the normal method as in Example I.

#### Example IV

Specimens of AISI 1018 steel were prepared in the same manner as described in Example I. The specimen surfaces were then coated with a D-Gun and the same sintered powder; i.e., 10 weight percent Co, 4 weight percent Cr, 5.2 weight percent C and the balance W. The powder size was also identical, i.e., 0.044 mm or smaller (-325 mesh). Acetylene was also used as the fuel gas. However, the oxygen-fuel gas mixture used in this instance was 1.3.

A chemical analysis of the coating showed the following composition: 7.6 weight percent Co, 2.7 weight percent Cr, 2.6 weight percent C and the balance W.

The hardness of this type of coating is about 1125 DPH<sub>300</sub>. Abrasive wear tests were carried out on this coating as in Example I, II, and III with a volume loss of 1.5  $\text{mm}^3$  per revolution. However, attempts to grind the coating to a smooth finish were unsuccessful using the normal method as described in Example I.

#### Example V

Specimens of AISI 1018 steel were prepared in the same manner as described in Example I. The specimen surfaces were then coated using a plasma spray torch and the same sintered pow-

der; i.e., 10 weight percent Co, 4 weight percent Cr, 5.2 weight percent C and the balance W. The powder size was also 0.044 mm or smaller (-325 mesh).

A chemical analysis of the coating showed the following composition: 9.2 weight percent Co, 3.5 weight percent Cr, 5.0 weight percent C and the balance W. The cobalt and carbon content of this coating was higher than that of the coatings of the present invention.

Abrasive wear tests were also carried out using the ASTM Standard G65-80, Procedure A. The average volume loss for the coated specimen was 9.3 mm<sup>3</sup> per 1000 revolutions. The wear properties of this coating were poor even when compared against the wear properties of the conventional D-Gun coatings of Example I. This is to be expected in the case of plasma spray coatings which do not wear as well as D-Gun coatings.

The hardness of the specimen was also measured and found to be 687 DPH<sub>300</sub>.

#### Example VI

Specimens of AISI 1018 steel were prepared in the same manner as described in Example I. The specimen surfaces were then coated using a plasma spray torch and a sintered powder of the following composition: 10.9 weight percent Co, 4.3 weight percent Cr, 3.8 weight percent C and the balance W. The powder size was 0.044 mm or smaller (-325 mesh).

A chemical analysis of the coating showed the following composition: 8.6 weight percent Co, 3.6 weight percent Cr, 3.4 weight percent C and the balance W. This coating composition was within the scope of the present invention.

Abrasive wear tests were also carried out using the ASTM Standard G65-80, Procedure A. The average volume loss for this coating specimen was 4.1 mm<sup>3</sup> per 1000 revolutions. The wear rate for this coating was less than half the wear rate for the plasma spray coating of the previous example using a conventional powder.

The hardness of the coated specimen was also measured and found to be 830 DPH<sub>300</sub>.

Although the powder and coating compositions have been defined herein with certain specific ranges for each of the essential components, it will be understood that minor amounts of various impurities may also be present. Iron is usually the principal impurity in the coating resulting from grinding operations and may be present in amounts up to about 1.5 and in some cases 2.0 weight percent of the composition.

Although the foregoing examples include only D-Gun and plasma spray coatings, it will be understood that other thermal spray techniques such as "high velocity" plasma, "hypersonic" combustion spray processes or various other detonation devices may be used to produce coatings of the present invention.

#### Claims

1. A coating composition applied to a substrate by a thermal spray process which consists of from 6.5 to 9.0 weight percent cobalt, from 2.0 to 4.0 weight percent chromium, from 3.0 to 4.0 weight percent carbon and the balance tungsten and incidental impurities.
2. A coating composition according to Claim 1 consisting of from 7.0 to 8.5 weight percent cobalt, from 2.5 to 3.5 weight percent chromium, from 3.0 to 4.0 weight percent carbon and the balance tungsten and incidental impurities.
3. A coating composition according to Claim 1 or 2 having a hardness value in excess of about 900 DPH<sub>300</sub>.
4. A coating composition according to any one of Claims 1 to 3 wherein the substrate is a metallic material selected from the group consisting of steel, stainless steel, iron base alloys, nickel, nickel base alloys, cobalt, cobalt base alloys, chromium, chromium base alloys, titanium, titanium base alloys, aluminum, aluminum base alloys, copper, copper base alloys, refractory metals, and refractory-metal base alloys.
5. A coating composition according to any one of Claims 1 to 3 wherein the substrate is a non-metallic material selected from the group consisting of carbon, graphite, and polymers.
6. A method for coating a substrate wherein a powdered coating material is suspended within a high temperature, high velocity gaseous stream and heated to a temperature at least close to the melting point thereof, said gaseous stream being directed against a surface of said substrate to deposit said powdered coating material and form a coating thereon, characterized in that, a powdered coating material having a composition such that the coating deposited onto said substrate consists of from 6.5 to 9.0 weight percent cobalt, from 2.0 to 4.0 weight percent chromium, from 3.0 to 4.0 weight percent carbon and the balance tungsten and incidental impurities, is used.
7. A method according to Claim 6 wherein the powdered coating material has a composition such that the coating deposited onto said substrate consists of from 7.0 to 8.5 weight percent cobalt, from 2.5 to 3.5 weight percent chromium, from 3.0 to 4.0 weight percent carbon and the balance tungsten and incidental impurities.
8. A method according to Claim 6, wherein the powdered coating material has a composition consisting of from 6.5 to 9.0 weight percent cobalt, from 2.0 to 4.0 weight percent chromium, from 3.0 to 4.0 weight percent carbon and the balance tungsten and incidental impurities.
9. A method according to any one of Claims 6 to 8 wherein the powdered coating material is suspended within a high temperature, high velocity gaseous stream produced by a detonation device.
10. A method according to Claim 9 wherein a mixture of oxygen and a fuel gas is fed into the barrel of a detonation gun along with the powdered coating material; and the oxygen fuel gas mixture is ignited to produce a detonation wave

der; i.e., 10 weight percent Co, 4 weight percent Cr, 5.2 weight percent C and the balance W. The powder size was also 0.044 mm or smaller (-325 mesh).

A chemical analysis of the coating showed the following composition: 9.2 weight percent Co, 3.5 weight percent Cr, 5.0 weight percent C and the balance W. The cobalt and carbon content of this coating was higher than that of the coatings of the present invention.

Abrasive wear tests were also carried out using the ASTM Standard G65-80, Procedure A. The average volume loss for the coated specimen was 9.3 mm<sup>3</sup> per 1000 revolutions. The wear properties of this coating were poor even when compared against the wear properties of the conventional D-Gun coatings of Example I. This is to be expected in the case of plasma spray coatings which do not wear as well as D-Gun coatings.

The hardness of the specimen was also measured and found to be 687 DPH<sub>300</sub>.

#### Example VI

Specimens of AISI 1018 steel were prepared in the same manner as described in Example I. The specimen surfaces were then coated using a plasma spray torch and a sintered powder of the following composition: 10.9 weight percent Co, 4.3 weight percent Cr, 3.8 weight percent C and the balance W. The powder size was 0.044 mm or smaller (-325 mesh).

A chemical analysis of the coating showed the following composition: 8.6 weight percent Co, 3.6 weight percent Cr, 3.4 weight percent C and the balance W. This coating composition was within the scope of the present invention.

Abrasive wear tests were also carried out using the ASTM Standard G65-80, Procedure A. The average volume loss for this coating specimen was 4.1 mm<sup>3</sup> per 1000 revolutions. The wear rate for this coating was less than half the wear rate for the plasma spray coating of the previous example using a conventional powder.

The hardness of the coated specimen was also measured and found to be 830 DPH<sub>300</sub>.

Although the powder and coating compositions have been defined herein with certain specific ranges for each of the essential components, it will be understood that minor amounts of various impurities may also be present. Iron is usually the principal impurity in the coating resulting from grinding operations and may be present in amounts up to about 1.5 and in some cases 2.0 weight percent of the composition.

Although the foregoing examples include only D-Gun and plasma spray coatings, it will be understood that other thermal spray techniques such as "high velocity" plasma, "hypersonic" combustion spray processes or various other detonation devices may be used to produce coatings of the present invention.

#### Claims

1. A coating composition applied to a substrate by a thermal spray process which consists of from 6.5 to 9.0 weight percent cobalt, from 2.0 to 4.0 weight percent chromium, from 3.0 to 4.0 weight percent carbon and the balance tungsten and incidental impurities.

2. A coating composition according to Claim 1 consisting of from 7.0 to 8.5 weight percent cobalt, from 2.5 to 3.5 weight percent chromium, from 3.0 to 4.0 weight percent carbon and the balance tungsten and incidental impurities.

3. A coating composition according to Claim 1 or 2 having a hardness value in excess of about 900 DPH<sub>300</sub>.

4. A coating composition according to any one of Claims 1 to 3 wherein the substrate is a metallic material selected from the group consisting of steel, stainless steel, iron base alloys, nickel, nickel base alloys, cobalt, cobalt base alloys, chromium, chromium base alloys, titanium, titanium base alloys, aluminum, aluminum base alloys, copper, copper base alloys, refractory metals, and refractory-metal base alloys.

5. A coating composition according to any one of Claims 1 to 3 wherein the substrate is a non-metallic material selected from the group consisting of carbon, graphite, and polymers.

6. A method for coating a substrate wherein a powdered coating material is suspended within a high temperature, high velocity gaseous stream and heated to a temperature at least close to the melting point thereof, said gaseous stream being directed against a surface of said substrate to deposit said powdered coating material and form a coating thereon, characterized in that, a powdered coating material having a composition such that the coating deposited onto said substrate consists of from 6.5 to 9.0 weight percent cobalt, from 2.0 to 4.0 weight percent chromium, from 3.0 to 4.0 weight percent carbon and the balance tungsten and incidental impurities, is used.

7. A method according to Claim 6 wherein the powdered coating material has a composition such that the coating deposited onto said substrate consists of from 7.0 to 8.5 weight percent cobalt, from 2.5 to 3.5 weight percent chromium, from 3.0 to 4.0 weight percent carbon and the balance tungsten and incidental impurities.

8. A method according to Claim 6, wherein the powdered coating material has a composition consisting of from 6.5 to 9.0 weight percent cobalt, from 2.0 to 4.0 weight percent chromium, from 3.0 to 4.0 weight percent carbon and the balance tungsten and incidental impurities.

9. A method according to any one of Claims 6 to 8 wherein the powdered coating material is suspended within a high temperature, high velocity gaseous stream produced by a detonation device.

10. A method according to Claim 9 wherein a mixture of oxygen and a fuel gas is fed into the barrel of a detonation gun along with the powdered coating material; and the oxygen fuel gas mixture is ignited to produce a detonation wave



along the length of said barrel which accelerates said powdered coating material in said high temperature, high velocity gaseous stream.

11. A method according to Claim 10 wherein the ratio of oxygen to fuel gas in said mixture is approximately 1.0.

12. A method according to Claim 10 wherein the ratio of oxygen to fuel gas in said mixture is between about 1:1.1 and 1:1.2.

13. A method according to Claim 12 wherein the powdered coating material has a composition consisting of about 10 weight percent cobalt, about 4 weight percent chromium, about 5.2 weight percent carbon and the balance tungsten and incidental impurities.

14. A method according to Claim 6 wherein the powdered coating material is suspended within a high temperature, high velocity gaseous stream produced by a plasma arc torch.

15. A method according to Claim 11 or 14 wherein the powdered coating material has a composition which is substantially the same as the composition of said coating.

16. A powdered coating composition for applying a wear and corrosion resistant coating to a substrate by a thermal spray process consisting of from 6.5 to 9.0 weight percent cobalt, from 2.0 to 4.0 weight percent chromium, from 3.0 to 4.0 weight percent carbon and the balance tungsten and incidental impurities.

17. A powdered coating composition according to Claim 16 consisting of from 7.0 to 8.5 weight percent cobalt, from 2.5 to 3.5 weight percent chromium, from 3.0 to 4.0 weight percent carbon and the balance tungsten and incidental impurities.

18. A powdered coating composition according to Claim 16 or 17 consisting of sintered powders.

#### Patentansprüche

1. Auf ein Substrat mittels eines thermischen Sprühprozesses aufgebraute Beschichtungszusammensetzung, die aus 6,5 bis 9,0 Gewichtsprozent Kobalt, 2,0 bis 4,0 Gewichtsprozent Chrom, 3,0 bis 4,0 Gewichtsprozent Kohlenstoff, Rest Wolfram und beiläufige Verunreinigungen, besteht.

2. Beschichtungszusammensetzung nach Anspruch 1 bestehend aus 7,0 bis 8,5 Gewichtsprozent Kobalt, 2,5 bis 3,5 Gewichtsprozent Chrom, 3,0 bis 4,0 Gewichtsprozent Kohlenstoff, Rest Wolfram und beiläufige Verunreinigungen.

3. Beschichtungszusammensetzung nach Anspruch 1 oder 2 mit einem HärteWert von über etwa 900 DPH<sub>300</sub>.

4. Beschichtungszusammensetzung nach einem der Ansprüche 1 bis 3, wobei das Substrat ein metallischer Werkstoff ist, der aus der aus Stahl, rostfreiem Stahl, Eisenbasislegierungen, Nickel, Nickelbasislegierungen, Kobalt, Kobaltbasislegierungen, Chrom, Chrombasislegierungen, Titan, Titanbasislegierungen, Aluminium, Aluminiumbasislegierungen, Kupfer, Kupferbasislegierungen, feuerfesten Metallen und Feuerfestmetall-

Basislegierungen bestehenden Gruppe ausgewählt ist.

5. Beschichtungszusammensetzung nach einem der Ansprüche 1 bis 3, wobei das Substrat ein nichtmetallischer Werkstoff ist, der aus der aus Kohlenstoff, Graphit und Polymeren bestehenden Gruppe ausgewählt ist.

6. Verfahren zum Beschichten eines Substrats, bei dem ein pulverförmiges Beschichtungsmaterial in einem Hochtemperatur-Hochgeschwindigkeits-Gasstrom suspendiert und auf eine mindestens nahe seinem Schmelzpunkt liegende Temperatur erhitzt wird, und der Gasstrom gegen eine Oberfläche des Substrats gerichtet wird, um das pulverförmige Beschichtungsmaterial abzulagern und auf der Oberfläche eine Beschichtung auszubilden, dadurch gekennzeichnet, daß ein pulverförmiges Beschichtungsmaterial solcher Zusammensetzung verwendet wird, daß die auf dem Substrat abgelagerte Beschichtung aus 6,5 bis 9,0 Gewichtsprozent Kobalt, 2,0 bis 4,0 Gewichtsprozent Chrom, 3,0 bis 4,0 Gewichtsprozent Kohlenstoff, Rest Wolfram und beiläufige Verunreinigungen, besteht.

7. Verfahren nach Anspruch 6, wobei das pulverförmige Beschichtungsmaterial eine solche Zusammensetzung hat, daß die auf dem Substrat abgelagerte Beschichtung aus 7,0 bis 8,5 Gewichtsprozent Kobalt, 2,5 bis 3,5 Gewichtsprozent Chrom, 3,0 bis 4,0 Gewichtsprozent Kohlenstoff, Rest Wolfram und beiläufige Verunreinigungen, besteht.

8. Verfahren nach Anspruch 6, wobei das pulverförmige Beschichtungsmaterial eine Zusammensetzung bestehend aus 6,5 bis 9,0 Gewichtsprozent Kobalt, 2,0 bis 4,0 Gewichtsprozent Chrom, 3,0 bis 4,0 Gewichtsprozent Kohlenstoff, Rest Wolfram und beiläufige Verunreinigungen, hat.

9. Verfahren nach einem der Ansprüche 6 bis 8, wobei das pulverförmige Beschichtungsmaterial in einem Hochtemperatur-Hochgeschwindigkeits-Gasstrom suspendiert wird, der mittels einer Detonationsvorrichtung erzeugt wird.

10. Verfahren nach Anspruch 9, wobei ein Gemisch aus Sauerstoff und einem Brenngas in die Trommel einer Detonationspistole zusammen mit dem pulverförmigen Beschichtungsmaterial eingeführt wird und das Sauerstoff-Brenngas-Gemisch gezündet wird, um entlang der Trommel eine Detonationswelle zu erzeugen, welche das pulverförmige Beschichtungsmaterial in dem Hochtemperatur-Hochgeschwindigkeits-Gasstrom beschleunigt.

11. Verfahren nach Anspruch 10, wobei das Verhältnis von Sauerstoff zu Brenngas in dem Gemisch näherungsweise 1,0 beträgt.

12. Verfahren nach Anspruch 10, wobei das Verhältnis von Sauerstoff zu Brenngas in dem Gemisch zwischen etwa 1:1,1 und 1:1,2 liegt.

13. Verfahren nach Anspruch 12, wobei das pulverförmige Beschichtungsmaterial aus etwa 10 Gewichtsprozent Kobalt, etwa 4 Gewichtsprozent Chrom, etwa 5,2 Gewichtsprozent Kohlenstoff, Rest Wolfram und beiläufige Verunreinigungen, besteht.



14. Verfahren nach Anspruch 6, wobei das pulverförmige Beschichtungsmaterial in einem mittels eines Plasmalichtbogenbrenners erzeugten Hochtemperatur-Hochgeschwindigkeits-Gasstrom suspendiert wird.

15. Verfahren nach Anspruch 11 oder 14, wobei das pulverförmige Beschichtungsmaterial im wesentlichen die gleich Zusammensetzung wie die Beschichtung hat.

16. Pulverförmige Beschichtungszusammensetzung zum Aufbringen einer verschleiß- und korrosionsbeständigen Beschichtung auf ein Substrat durch einen thermischen Sprühprozeß, bestehend aus 6,5 bis 9,0 Gewichtsprozent Kobalt, 2,0 bis 4,0 Gewichtsprozent Chrom, 3,0 bis 4,0 Gewichtsprozent Kohlenstoff, Rest Wolfram und beiläufige Verunreinigungen.

17. Pulverförmige Beschichtungszusammensetzung nach Anspruch 16 bestehend aus 7,0 bis 8,5 Gewichtsprozent Kobalt, 2,5 bis 3,5 Gewichtsprozent Chrom, 3,0 bis 4,0 Gewichtsprozent Kohlenstoff, Rest Wolfram und beiläufige Verunreinigungen.

18. Pulverförmige Beschichtungszusammensetzung nach Anspruch 16 oder 17 bestehend aus gesinterten Pulvern.

#### Revendications

1. Composition de revêtement appliquée sur un substrat par un procédé de projection thermique qui est constituée de 6,5 à 9,0% en poids de cobalt, de 2,0 à 4,0% en poids de chrome, de 3,0 à 4,0% de carbone et le reste de tungstène et d'impuretés accidentelles.

2. Composition de revêtement selon la revendication 1, constituée de 7,0 à 8,5% en poids de cobalt, de 2,5 à 3,5% en poids de chrome, de 3,0 à 4,0% en poids de carbone et le reste de tungstène et d'impuretés accidentelles.

3. Composition de revêtement selon la revendication 1 ou 2, ayant une valeur de dureté supérieure à environ DPH<sub>300</sub>.

4. Composition de revêtement selon l'une quelconque des revendications 1 à 3, dans laquelle le substrat est en une matière métallique choisie dans le groupe constitué de l'acier, de l'acier inoxydable, d'alliages à base de fer, de nickel, d'alliages à base de nickel, de cobalt, d'alliages à base de cobalt, de chrome, d'alliages à base de chrome, de titane, d'alliages à base de titane, d'aluminium, d'alliages à base d'aluminium, de cuivre, d'alliages à base de cuivre, de métaux réfractaires et d'alliages à base de métaux réfractaires.

5. Composition de revêtement selon l'une quelconque des revendications 1 à 3, dans laquelle le substrat est en une matière non métallique choisie dans le groupe constitué du carbone, du graphite et de polymères.

6. Procédé pour revêtir un substrat, dans lequel une matière de revêtement en poudre est mise en suspension dans un courant gazeux à haute température, grande vitesse, et chauffée à une température au moins proche de son point de

fusion, ledit courant gazeux étant dirigé contre une surface dudit substrat pour déposer ladite matière de revêtement en poudre sur cette surface et y former un revêtement, caractérisé en ce qu'il est utilisé une matière de revêtement en poudre ayant une composition telle que le revêtement déposé sur ledit substrat est constitué de 6,5 à 9,0% en poids de cobalt, de 2,0 à 4,0% en poids de chrome, de 3,0 à 4,0% en poids de carbone, le reste de tungstène et d'impuretés accidentelles.

7. Procédé selon la revendication 6, dans lequel la matière de revêtement en poudre présente une composition telle que le revêtement déposé sur ledit substrat est constitué de 7,0 à 8,5% en poids de cobalt, de 2,5 à 3,5% en poids de chrome, de 3,0 à 4,0% en poids de carbone et le reste de tungstène et d'impuretés accidentelles.

8. Procédé selon la revendication 6, dans lequel la matière de revêtement en poudre présente une composition constituée de 6,5 à 9,0% en poids de cobalt, de 2,0 à 4,0% en poids de chrome, de 3,0 à 4,0% en poids de carbone et le reste de tungstène et d'impuretés accidentelles.

9. Procédé selon l'une quelconque des revendications 6 à 8, dans lequel la matière de revêtement en poudre est mise en suspension dans un courant gazeux à haute température, grande vitesse, produit par un dispositif à détonation.

10. Procédé selon la revendication 9, dans lequel un mélange d'oxygène et d'un gaz combustible est introduit dans le canon d'un pistolet à détonation en même temps que la matière de revêtement en poudre; et le mélange d'oxygène et de gaz combustible est mis à feu pour produire une onde de détonation parcourant la longueur dudit canon, qui accélère ladite matière de revêtement en poudre dans ledit courant gazeux à haute température, grande vitesse.

11. Procédé selon la revendication 10, dans lequel le rapport de l'oxygène au gaz combustible dans ledit mélange est d'environ 1,0.

12. Procédé selon la revendication 10, dans lequel le rapport de l'oxygène au gaz combustible dans ledit mélange est compris entre environ 1:1,1 et 1:1,2.

13. Procédé selon la revendication 12, dans lequel la matière de revêtement en poudre présente une composition constituée d'environ 10% en poids de cobalt, d'environ 4% en poids de chrome, d'environ 5,2% en poids de carbone et le reste de tungstène et d'impuretés accidentelles.

14. Procédé selon la revendication 6, dans lequel la matière de revêtement en poudre est mise en suspension dans un courant gazeux à haute température, grande vitesse, produit par une torche à arc sous plasma.

15. Procédé selon la revendication 11 ou 14, dans lequel la matière de revêtement en poudre présente une composition qui est sensiblement la même que celle dudit revêtement.

16. Composition de revêtement en poudre pour l'application d'un revêtement résistant à l'usure et à la corrosion sur un substrat par un procédé de projection thermique, constituée de 6,5 à 9,0% en poids de cobalt, de 2,0 à 4,0% en poids de



(15)

chrome, de 3,0 à 4,0% en poids de carbone et le reste de tungstène et d'impuretés accidentelles.

17. Composition de revêtement en poudre selon la revendication 16, constituée de 7,0 à 8,5% en poids de cobalt, de 2,5 à 3,5% en poids

de chrome, de 3,0 à 4,0% en poids de carbone et le reste de tungstène et d'impuretés accidentelles.

18. Composition de revêtement en poudre selon la revendication 16 ou 17, constituée de poudres frittées.

5

10

15

20

25

30

35

40

45

50

55

60

65

8

