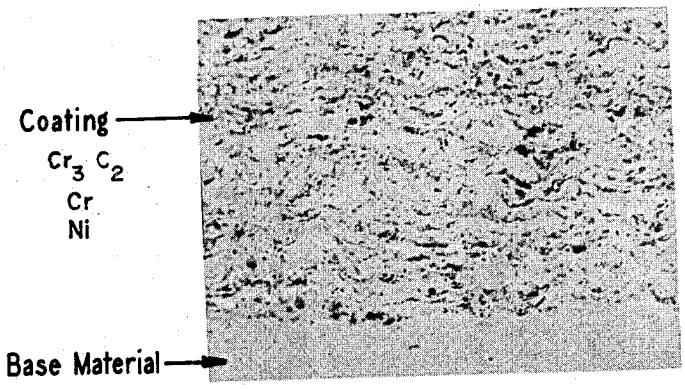
Sept. 29, 1964 J. F. PELTON ETAL 3,150,938

COATING COMPOSITION METHOD OF APPLICATION AND PRODUCT THEREOF

Filed June 9, 1960



INVENTORS
JOHN F. PELTON
JOHN M. KOFFSKEY, JR.
BY Dominic J. Terminello
ATTORNEY

United States Patent Office 3,150,938 Patented Sept. 29, 1964

3,150,938

COATING COMPOSITION, METHOD OF APPLICATION, AND PRODUCT THEREOF

John F. Pelton and John M. Koffskey, Jr., Indianapolis, Ind., assignors to Union Carbide Corporation, a corporation of New York

Filed June 9, 1960, Ser. No. 34,871
5 Claims. (Cl. 29—194)

This invention relates to a specific coating composition, to a method for applying same, and to the coated article so obtained. More particularly, it relates to such a composition capable of producing a coating having excellent high temperature wear and oxidation resistance.

There is a need in industry for coating materials that can withstand severe wear conditions at high temperatures. In particular, the aircraft industry requires coatings to protect wear surfaces in turbo-jet engines. The turbine blades, for example, undergo some distortion due to temperature expansion and contraction as well as to high velocity conditions. This distortion creates severe wear conditions on the contact surfaces between turbine blade spacers. Prior wear resistant coating materials, such as tungsten carbide with cobalt binder, have been unable to give adequate protection in this area. The prior coatings could not stand up under the high temperature wear and oxidizing conditions. An aluminum oxide coating, for example, is able to withstand the high temperature oxidizing conditions but its wear resistance is not quite high enough, especially when mating with itself. It also is too brittle and does not have sufficient bond strength.

It is accordingly the object of the present invention to provide a powder composition suitable for application by flame-plating techniques which result in coatings having good resistance at high temperatures to wear and oxidation.

The sole figure in the drawing is a photomicrograph at 500 diameter magnification showing the base material with the wear and oxidization resistant coating bonded thereto.

The objects of this invention are accomplished in general by a coating composition which comprises between about 70 and 90 weight percent chromium carbide (Cr_3C_2 and lower carbides) and between about 30 and 10 weight percent of a nickel-chromium alloy (80 percent nickel–20 percent chromium). This material can be applied as a coating to various base materials by means of the detonation plating process disclosed in United States Patent No. 2,714,563 or by other high temperature high velocity coating processes, such as the arc torch or jet burner disclosed in application Serial No. 706,099 and now abandoned, filed December 30, 1957, by Gage et al., and in Patent No. 2,861,900, filed May 2, 1955, by G. H. Smith et al. The actual composition of the resulting coating will be somewhat different from the above starting composition due to changes brought about by heating during the coating process. For example, the coatings of this material applied by the detonation process, when using a starting composition of about 85 weight percent chromium carbide and about 15 weight percent of a nickel-chromium alloy (80 percent Ni–20 percent Cr) and an oxygen/carbon atomic ratio of 1.2 and nitrogen dilution of 46 volume percent have a general composition of about 10 weight percent Cr_3C_2, 15 weight percent nickel-chromium alloy, and the remainder a mixture of chromium carbides, chromium oxides, and chromium metal.

The advantages of these new coating compositions in resisting wear are shown in the following table which compares relative wear of several coating combinations under high temperature high load conditions. These tests were run to determine the resistance to gross wear caused by galling and scoring. Test conditions were: 500 p.s.i.g. pressure on samples; relative rubbing speed between the

samples of 10 feet per minute; with no lubricant; temperature at test piece as indicated.

TABLE I

Comparative Wear for Combinations of Coatings in Mating Relation

Test No.	Mating Materials	Temperature at Test Piece	Loss in Coating Thickness 10^{-6} inches/hr.
1	Cr_3C_2–(Ni–Cr)	1,300	7.2
	Cr_3C_2–(Ni–Cr)		7.6
2	Cr_3C_2–(Ni–Cr)	1,300	8.2
	Al_2O_3		5.3
3	WC–Cr_3C_2–Ni	1,300	36
	Al_2O_3		5.2
4	Al_2O_3	1,200	104
	Al_2O_3		42
5	WC–Co	1,000	53
	WC–Co		40

It can be seen from the above table that prior coating combinations of aluminum oxide, tungsten carbide-cobalt, and tungsten carbide-chromium carbide-nickel have excessive total wear at high temperatures and high load. The novel coating of the present invention has comparatively low total wear when mating with aluminum oxide and especially when mating with itself. This last property is quite important since it is most desirable to coat similar mating surfaces with the same material to simplify fabrication and replacement procedures.

This novel coating has also withstood severe oxidizing conditions up to at least 1800° F. without failure. Prior wear resistant coatings, such as tungsten carbide-cobalt fail due to oxidation above 1000° F.

The coating starting material is usually prepared by blending chromium carbide and nickel-chromium alloy powders of desired size suitable for coating (about 325 mesh and finer). A chromium and nickel powder mixture could be sustituted for the nickel-chromium alloy. The particular method of powder preparation used would depend primarily upon economic factors, such as availability of particular raw materials.

The following examples describe the application of this novel coating composition to a baseplate by the detonation plating process.

EXAMPLE I.—APPLICATION OF AN 85 PERCENT CHROMIUM CARBIDE 15 PERCENT NICKEL-CHROMIUM ALLOY COATING

Acetylene at 1.5 c.f.m., oxygen at 1.8 c.f.m., and nitrogen at 2.2 c.f.m. were introduced to a detonation gun to form a detonable mixture having an oxygen/carbon atomic ratio of 1.2. Finely divided coating powder having a composition of 85 weight percent chromium carbide and 15 weight percent nickel-chromium alloy (80 percent nickel–20 percent chromium) suspended in a nitrogen carrier gas stream of 0.6 c.f.m. was introduced at a rate of 30–32 gram/min. to the barrel of the detonation gun. The detonable mixture thus surrounding the coating particles contained about 46 volume percent nitrogen. The detonation mixture was ignited at a rate of about four times per second and the coating powder was impinged on a metal baseplate to form a dense adherent coating composed of irregular shaped microscopic leaves interlocking and overlapping with each other. The coating has an average hardness of 800–850 VPN as measured with a 300 gram load and a modulus of rupture of 75,000 p.s.i.

EXAMPLE II.—APPLICATION OF A 75 PERCENT CHROMIUM CARBIDE 25 PERCENT NICKEL-CHROMIUM ALLOY COATING

Acetylene at 1.13 c.f.m., oxygen at 1.35 c.f.m. and nitrogen at 3.02 c.f.m. were introduced to a detonation

gun to form a detonatable mixture having an oxygen/carbon atomic ratio of 1.2. Finely divided coating powder having a composition of 75 weight percent chromium carbide and 25 weight percent nickel-chromium alloy (80 percent nickel–20 percent chromium) suspended in a nitrogen carrier gas stream of 0.6 c.f.m. was introduced at a rate of 32 grams per minute to the barrel of the detonation gun. The detonatable mixture thus surrounding the coating particles contained about 60 volume percent nitrogen. The detonatable mixture was ignited at a rate of about four times per second, and the coating powder was impinged on a metal baseplate to form a dense adherent coating about 0.005–0.006 inch thick composed of irregular shaped microscopic leaves interlocking and overlapping with each other. The coating had an average hardness of 775–825 VPN as measured with a 300 gram load. The coating has a modulus of rupture of about 82,000 p.s.i. The final coating product has a general composition of about 30 weight percent Cr_3C_2, 30 weight percent nickel-chromium alloy, and the remainder a mixture of chromium carbides, chromium oxides and chromium metal.

It is noted that the above Example II employed a nitrogen content of about 60 volume percent in the detonation gun barrel. This is the preferred operating condition for applying the high binder content composition on turbine blades since the resulting lower flame temperature aids in retaining an increased amount of binder in the coating product. The high binder content composition of the latter example results in a more impact resistant coating and also in a higher modulus of rupture and would be used for applications where those qualities were of paramount importance.

The above examples illustrate the use of the instant novel coating compositions with a detonation gun; however, it should be reiterated that the said compositions can be used with equal success with other flame-plating processes such as the arc torch and the jet burner. The specific coating composition ratios by weight of chromium carbide, chromium, and nickel disclosed represent a definite advance in the art of coatings which have high temperature wear and oxidation resistance.

It is to be understood that the novel coating composition may contain between about 70–90 weight percent chromium carbide and between about 10–30 weight percent of a nickel-chromium alloy (80 percent nickel–20 percent chromium) without affecting the utility of the coating as disclosed. However, the ratios set forth in

the above examples represent the preferred embodiments.

This application is a continuation-in-part application of our application Serial No. 738,299, filed May 28, 1958, and now abandoned.

What is claimed is:

1. A coating composition which comprises between about 70 and 90 percent by weight of powdered chromium carbide, between about 8 and 24 percent by weight of powdered nickel and the remainder being powdered chromium.

2. A coating composition which comprises about 85 percent by weight of powdered chromium carbide, 12 percent by weight of powdered nickel and the remainder being powdered chromium.

3. A coating composition which comprises about 75 percent by weight of powdered chromium carbide, 20 percent by weight of powdered nickel and 5 percent by weight of powdered chromium.

4. A method of applying a high temperature wear and oxidation resistant coating which comprises introducing a finely divided powder comprising about 75 percent by weight of powdered chromium carbide, about 20 percent by weight of powdered nickel and about 5 percent by weight of powdered chromium into a detonation gun, surrounding such composition with a detonable fuel-oxidant mixture having an oxygen/carbon atomic ratio of about 1.2 and containing about 60 volume percent nitrogen; igniting such detonable mixture to form a detonation, and impinging the coating composition onto a body to be coated by means of the high temperature high velocity gas stream and shock wave attendant with such detonation.

5. An article of manufacture made according to claim 4 wherein the coating in such body has a lamellar structure of interlocking and overlapping microscopic leaves bonded to each other and to said body.

References Cited in the file of this patent

UNITED STATES PATENTS

2,067,166	Balke	Jan. 12, 1937
2,128,146	Hinnuber	Aug. 23, 1938
2,581,252	Goetzel et al.	Jan. 1, 1952
2,714,563	Poorman et al.	Aug. 2, 1955
2,753,621	Wellborn	July 10, 1956

FOREIGN PATENTS

318,524	Switzerland	Feb. 28, 1957