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(54) Bond-coating alloys for thermal spraying.

(57) An alloy, suitable for flame spraying in powder form onto a metal substrate to provide a bond-coat thereon, which contains, by weight, from 2 to 30% aluminium, from 2 to 25% chromium, from 0 to 8% silicon, from 0 to 4% boron and from 0 to 6% iron, the balance, apart from impurities, being copper and/or nickel. The alloys are useful for repairing and building up metal surfaces by metal coating, for restoration or finishing purposes, and for acting as a bond-coat for the application of a ceramic coating.

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BOND-COATING ALLOYS
FOR THERMAL SPRAYING

This invention relates to bond-coating alloys for thermal spraying and particularly to an alloy suitable for flame spraying in powder form onto a metal substrate to provide a bond-coat thereon.

In the application of metal coatings by thermal spraying it is necessary for the surface of the metal substrate to be roughened in order to provide a key for satisfactory adhesion of the coating. Such roughening is carried out on substrates made from materials having a hardness of less than about 300 DPN, by mechanical means such as, for example, by grit-blasting or by rough-machining techniques. However, such roughening treatment is ineffective on substrate materials having a hardness greater than 300 DPN and it is then necessary to apply an intermediate bond coat to the substrate upon which bond-coat the metal or ceramic coating may be thermally sprayed.

Additionally bond-coats are required if the substrate is in the form of a thin section which would be distorted by grit-blasting or rough-machining. Such bond-coats bond metallurgically to the substrate and are capable of repeated coating applications although they need be used in all cases for repeated coating applications. In this aspect they differ from so-called "self-bonding coatings" which are normally intended as single deposit coatings which show some measure of metallurgical bonding to a metallic substrate but are not necessarily suitable for use as bond-coats on metal substrates such as hardened steels. This specification is only concerned with bond-coats.

Such a bond-coat, sprayed on as a thin adherent layer, provides attachment for a subsequent, thicker, sprayed deposit. To be effective the bond-coat material must be capable of adhering with sufficient strength to a, smooth machined surface of a substrate and this conventionally is achieved by ensuring that the temperature of the bond-coat particles issuing from the spraying apparatus remains high until they meet the substrate surface. The additional heat necessary may be provided by an exothermic reaction between the bond coat material and oxygen in the spray flame in the case, for example, of an exothermic bond coat material such as molybdenum. When molybdenum is sprayed from a wire-spray gun it reacts with oxygen either in the air or in the flame to form a volatile oxide. This reaction is accompanied by the evolution of heat and the particles which reach the substrate thus are at a high temperature and are free from surface oxidation. However, it has been thought that flame spraying molybdenum in powder form produces a bond-coat which has inferior adhesion to that produced by spraying molybdenum in wire form.

Composite materials containing or comprising nickel and aluminium, such as nickel coated aluminium powders, agglomerated nickel/aluminium powders and composite wires have been proposed for use as bond-coat materials but such materials are costly and/or in short supply. These materials, when sprayed, react to form nickel aluminide with the evolution of heat sufficient to promote metallurgical bonding at the interface. Powdered materials such as the above have been used also in association with other alloy powders to provide "self bonding" coatings, but such mixtures are not normally advocated as bond-coats.

There is thus a need for a material of lower cost for a bond-coat which can be manufactured by simple alloying from readily obtainable raw materials.

Whilst it has been proposed to use aluminium-bronze as a bond-coat obtained by wire spraying, it has been noted that only limited adhesion is obtainable when the material is sprayed in powder form.

Surprisingly it has now been discovered that the addition of sufficient chromium to an alloy of copper and/or nickel containing aluminium provides a bond strength when sprayed onto a smoothly machined surface which is sufficient to enable the material to be used as a bond-coat.

Accordingly the invention provides an alloy, suitable for flame spraying in powder form onto a metal substrate to provide a bond-coat thereon, which contains, by weight, from 2 to 30% aluminium, from 2 to 25% chromium, from 0 to 8% silicon, from 0 to 4% boron and from 0 to 6% iron, the balance, apart from impurities, being copper and/or nickel.

Preferably the alloy contains from 2 to 15% aluminium. Advantageously the alloy contains not less than 5% chromium. More preferably the alloy contains 6.0% aluminium, 8.5% chromium, 4.6% silicon and 49.0% copper, the balance, apart from impurities, being nickel.

An advantageous combination of properties is exhibited by a preferred alloy containing, by weight, 5% aluminium, 10% chromium, 5% silicon, and 45% copper, the balance, apart from impurities, being nickel. A further preferred alloy contains, by weight, 8% aluminium, 4% chromium, 2% silicon, and 15% nickel, the balance, apart from impurities, being copper.

In the following, bond-coats were tested by means of a scratch test in which the bond-coatings where applied to steel samples approximately 50 mm x 50 mm x 10 mm in size and adhesion of the bond-coat was judged by observing the effects of scribing, down to the substrate, two lines approximately 3 mm apart. The test samples were used in the as machined condition after degreasing with an organic solvent immediately prior to spraying. The samples were preheated only sufficiently to prevent condensation of moisture on their surfaces and each material was sprayed in a rapid series of overlapping passes, two layers being applied, with the second being at right angles to the first to give a deposit thickness of approximately 0.25 mm.

Molybdenum powder sprayed with an oxidising flame produced a bond-coat with good cohesion and adhesion but spraying with a neutral or reducing flame gave a coating having virtually no adhesion.

Nickel aluminium composite proprietary powders were flame sprayed to produce bond-coatings with good cohesion and adhesion whereas nickel aluminium pre-alloyed powders when flame sprayed gave a coating with good cohesion but reduced adhesion.

A 90% copper, 10% aluminium alloy in pre-alloyed form provided a flame sprayed coating with adequate adhesion and best results were obtained with an oxidising flame.

Bond-coatings were then produced from an alloy of the invention in powder form. Satisfactory bonding and adhesion characteristics were obtained with alloys containing, by weight, from 2 to 30%, preferably from 2 to 15%, aluminium, from 2 to 25%, preferably from 5 to 25%, chromium, from 0 to 8% silicon, from 0 to 4% boron and 0 to 6% iron, the balance, apart from impurities, being copper and/or nickel. Optimum qualities were achieved with alloy compositions containing aluminium in the range of from 2.5 to 8% and preferred alloy compositions, according to the invention, contained by weight, 5% aluminium, 10% chromium, 5% silicon, 45% copper, balance, apart from impurities, being nickel, and contained, by weight, 8% aluminium, 4% chromium, 2% silicon, 15% nickel, balance, apart from impurities, being copper. A further preferred alloy composition according to the invention contained 6.0% aluminium, 8.5% chromium, 4.5% silicon and 49.5% copper, the balance, apart from impurities, being nickel.

Such alloys according to the invention produced bond-coatings with bond strengths comparable to that of unreacted nickel-aluminium composites but superior to that of well sprayed molybdenum or aluminium bronze materials.

Further tests were carried out in which further coatings were applied to the intial bond-coat. Tor this test the initial bond-coat was applied to a steel bar which had been grit-blasted in order to ensure, as far as possible, that on subsequent testing any failure would be at the bond-coat build-up interface.

Two samples were prepared, one using aluminium bronze as the bond-coat and one using the alloy according to the invention. The build-up coating in each case was a proprietary nickel base alloy. The samples, prepared as above, were subjected to hammering until failure and it was observed that the coating applied with the use of the aluminium bronze bond-coat failed at the bond-coat/substrate interface whereas the sample carrying a bond-coat according to the invention withstood greater hammering and ultimately failed at the bond-coat/build-up coat interface thus demonstrating the superior adhesion of the bond-coat alloy of the invention.

Additional tests were carried out to ascertain the resistance of an alloy according to the invention to corrosion in a marine or similar corrosive environment, in comparison with that of a conventional nickel/aluminium bond-coat alloy. Accordingly two samples were prepared by spraying layers of the alloy on to stainless steel test panels, one sample using a conventional nickel/aluminium bond-coat alloy having a nominal composition, by weight, of 95% nickel and 5% aluminium and the other sample using a bond-coat alloy according to the invention having a nominal composition, by weight, of 6.0% aluminium, 8.5% chromium, 4.6% silicon, 31.9% nickel and 49.0% copper. Both samples were weighed and immersed in 3% sodium chloride solution. The samples were removed at fixed intervals from the solution, weighed and the results recorded. After six days all the conventional nickel/aluminium coating had been removed from the immersed area of the respective sample whereas the coating of the alloy according to the invention showed an initial attack equivalent to 2.75 milligrams per square decimetre per day during the first six days of immersion, after which no further weight loss was noted. Thus the alloy according to the present invention was found to have greatly superior resistance to marine corrosion than the conventional nickel/aluminium alloy.

An alloy according to the invention, having the nominal composition given in the foregoing example, was used as a bond-coat for applying a coating of COLMONOY C290 (Trade Mark) having a nominal composition, by weight, of 13.3% chromium, 1.5% boron, 2.5% silicon, 0.4% carbon 37.0% nickel, with the balance, apart from impurities, being iron, to electric motor shafts and to an hydraulic ram. The shafts were satisfactorily repaired in this way. The ram was rough threaded to increase the coating contact area, sprayed with the bond-coat of the alloy of the invention to a thickness of 0.1 mm on which a further coating of the COLMONOY C 290 alloy was built up to a thickness sufficient to machine back to the original ram size.

Thus it can be seen that bond-coats produced from an alloy according to the invention possess very good properties of adhesion to the substrate, sufficient even to withstand the severe test of subsequent machining. These good adhesion properties enable a bond-coat produced from an alloy of the invention to be used for reclamation of areas of components which have been mismachined to dimensions below the minimum required dimensions. Such areas may be bond-coated and subsequently machined or ground to the required dimensions without the need for roughening or undercutting of the substrate area to be reclaimed.

Moreover alloys according to the present invention may be used as bond-coats for the application of ceramic deposits, such as alumina (nominal composition by weight, 94.0% aluminium oxide, 2.5% titanium oxide, 2.0% silicon dioxide, plus usual impurities) or TITANIA (Trade Mark) (nominal composition, by weight, 50% aluminium oxide, 50% titanium dioxide) to a metal substrate. In the latter case the bond-coat may be applied directly onto a machined and degreased substrate without grit-blasting being necessary.

CLAIMS

1. An alloy, suitable for flame spraying in powder form onto a metal substrate to provide a bond-coat thereon, which contains, by weight, from 2 to 30% aluminium, from 2 to 25% chromium, from 0 to 8% silicon, from 0 to 4% boron and from 0 to 6% iron, the balance, apart from impurities, being copper and/or nickel.

2. An alloy according to claim 1, containing from 2 to 15% aluminium.

3. An alloy according to claim 1 or claim 2, containing not less than 5% chromium.

4. An alloy according to any one of claims 1 to 3, containing 6.0% aluminium, 8.5% chromium, 4.6% silicon and 49.0% copper, the balance, apart from impurities, being nickel.

5. An alloy according to any one of claims 1 to 3, containing 5% aluminium, 10% chromium, 5% silicon and 45% copper, the balance, apart from impurities, being nickel.

6. An alloy according to claim 1 or claim 2, containing 8% aluminium, 4% chromium, 2% silicon and 15% nickel, the balance, apart from impurities, being copper.

7. An alloy, suitable for flame spraying in powder form onto a metal substrate to provide a bond-coat thereon, substantially as hereinbefore described.

European Patent Office

EUROPEAN SEARCH REPORT

0035377

Application number

EP 81 30 0805

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	GB - A - 843 423 (METALLIZING ENG. COMP.) * Claims 2,5 and 9 *	1-3
	US - A - 3 869 779 (M. GEDWILL) * Claims 4 and 5 *	1-3
	US - A - 4 019 875 (F. DITTRICH) * Claim 18 *	1-3
A	US - A - 3 736 130 (F. UISANIE) * Claims 1 and 4 *	4
A	DE - A - 2 703 246 (METALLGESELLSCHAFT) * Claim 1 *	
A	THIN SOLID FILMS, vol. 53, 1978 LAUSANNE (CH) I. KVERNES et al.: "Use of corrosion-resistant plasma-sprayed coatings in diesel engines", pages 259-269 * Table 1, sample GA-B, 10 *	

☑ The present search report has been drawn up for all claims

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

C 23 C 7/00
C 22 C 19/05
C 22 C 9/06

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

C 23 C 7/00
B 23 K 35/00
C 22 C 19/05
C 22 C 9/06

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

Place of search	Date of completion of the search	Examiner
The Hague	25.05.1981	RIES