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LOW SMOKING NICKEL ALUMINUM FLAME SPRAY POWDER

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This invention relates to a low smoking nickel aluminum flame spray powder. The invention more particularly relates to a nickel aluminum composite flame spray powder which may be flame-sprayed to form a self-bonding coating with the generation of considerably less smoke than the previously known self-bonding nickel aluminum flame spray powders or other self-bonding flame spray materials.

In flame spraying the surface or base, such as the metal surface or base being coated by the flame spray technique, must generally have a special surface preparation such as a severe mechanical roughening in order to ensure a satisfactory bond of the sprayed coating. Certain materials, as for example molybdenum, will however adequately bond to a clean surface without this special surface preparation and of course subsequently applied sprayed layers will adequately bond to the initially applied sprayed coating as one flame-sprayed layer bonds to a previously applied layer without difficulty. Materials, such as molybdenum, which will bond to a base without the conventional surface preparation, are referred to in the flame spray art as self-bonding. A further self-bonding flame spray material is a composite composed of nickel and aluminum which will exothermically react when flame-sprayed, forming a nickel aluminide intermetallic.

The known self-bonding flame spray materials generate a considerable amount of smoke during spraying and this presents a problem if adequate ventilating facilities are not provided, as for example where special exhausting facilities, such as an exhaust booth, are not available.

It has been found that the amount of smoke generated by the nickel aluminum composites may be reduced by reducing the percentage of the aluminum in the composite, but this results in a corresponding reduction of the bond strength of the coating formed, and it has not been possible to reduce the smoke to a tolerable level while retaining a satisfactory bond strength.

One object of this invention is a self-bonding flame spray powder which will generate substantially less smoke when sprayed than the prior art powders and still retain a high bond strength.

A further object of this invention is an aluminum coated nickel flame spray powder which is self-bonding when sprayed and which will generate substantially less smoke than the conventional nickel aluminum composite powders while retaining a high bond strength.

These and still further objects will become apparent from the following description:

In accordance with the invention I have discovered that a particular form of a nickel aluminum composite flame spray powder containing a specific additive will produce substantially less smoke when sprayed than the other known nickel aluminum composite flame spray powders and will retain high bond strength or even show increased bond strength.

The composite flame spray powder in accordance with the invention comprises nickel particles coated with 2½ to 6% by weight of aluminum and ½ to 2% by weight nickel boron, based on the total of aluminum, nickel boron and nickel in the particles.

The composite of aluminum and nickel boron coated nickel particles should have the general over-all shape and size of conventional flame spray powders and thus, for

example, should have a size between —60 mesh and +3 microns, and preferably —140 mesh and +10 microns, the mesh sizes being U.S. Standard Screen Mesh sizes. Most preferably the powder should be as uniform as possible in grain size, with the individual grains not varying by more than 240 microns and preferably 75 microns.

The initial nickel particles which constitute the core or nucleus of the composite powders in accordance with the invention should have a size and shape approximating that desired in the end powders as described above. The nickel core or nucleus particles are then coated with the aluminum and nickel boron, the coating being effected by any known coating process, as for example described in copending application Ser. No. 343,705, filed Feb. 10, 1964.

Preferably the aluminum and the nickel boron are deposited in finely divided form in a binder on the nickel particles.

The aluminum and nickel boron, preferably in as finely divided form as possible, as for example a size of —325 mesh, are mixed in the required proportions with a binder or lacquer so as, in effect, to form a paint in which the aluminum and nickel boron particles correspond to the pigment. The paint is then used to coat the nickel core particles and allowed to set or dry.

The binder material may be any known or conventional binder material which may be used for forming a coating or for bonding particles together or to a surface. The binder is preferably a varnish containing a resin as the varnish solids, and may contain a resin which does not depend on solvent evaporation in order to form a dried or set film. The varnish may thus contain a catalyzed resin as the varnish solids. Examples of binders which may be used include the conventional phenolic, epoxy, or alkyd varnishes, varnishes containing drying oils, such as tuna oil and linseed oil, rubber and latex binders and the like.

The coating of the nickel core component with the "paint" containing the aluminum and nickel boron may be effected in any known or desired manner, and it is simply necessary to mix the two materials together and allow the binder to set or dry, which will result in a fairly free-flowing powder consisting of the nickel core coated with cladding of the aluminum and nickel boron.

The nickel boron powder may be any known powder comprising an alloy of nickel and boron containing for example, from 5–95% boron, and preferably from 7–25% by weight of boron, and most preferably about 18% by weight boron. The nickel boron powder most preferably is used in a particle size range between —20 and +1 micron.

The powders are sprayed in the conventional manner, using a powder type flame spray gun, though it is also possible to combine the same in the form of a wire or rod, using plastic or a similar binding, as for example polyethylene which decomposes in a heating zone of the gun. When formed as wires, the same may have conventional sizes and accuracy tolerances for flame spray wires and thus, for example, may vary in size between ¼" and 20 gauge.

The spraying is in all respects effected in the conventional manner previously utilized for self-bonding flame spray material, and in particular nickel aluminum composites. Due to the self-bonding characteristics, special surface preparation other than a good cleaning is not required though, of course, conventional surface preparation may be utilized if desired. The powder in accordance with the invention may be flame-sprayed as a bonding coat for subsequently applied flame spray material or any purposes where it is desired to form the nickel aluminide coating. The composites may furthermore be sprayed in

conjunction with, or in addition to, other flame spray materials conventionally used in the art.

When sprayed, the nickel and aluminum exothermically react, forming a nickel aluminide intermetallic.

The following examples are given by way of illustration and not limitation:

EXAMPLE 1

Finely divided aluminum powder (—325 mesh) was admixed with 20% by weight of nickel boron powder based on aluminum, consisting of a foundry alloy containing 18% by weight of boron and having a particle size between about 1–20 microns. The powder blend was then admixed with a conventional phenolic varnish having approximately 10% solid contents so as to form a mixture having the consistency of heavy syrup and containing about 60% by weight of the metal particles. 100 grams of the varnish powder mixture is then added to about 900 grams of nickel powder having a size between about 200–325 mesh and the two are thoroughly mixed, with the mixing continued until the varnish dries leaving a fairly free-flowing powder in which all of the nickel core particles are clad with a dry film which contains the aluminum particles and nickel boron particles. The powder is then warmed to about 250° F. to ensure complete drying. The powder is then screened and hand-milled to reduce the same to a —100 mesh powder. The end powder consists approximately of 5% aluminum, 1% nickel boron, the balance nickel. The powder is flame-sprayed on a mild steel plate which has been surface cleaned by smooth grinding. The spraying is effected at a distance of 6" from the plate, using a powder type flame spray gun as described in U.S. Patent 2,961,335 of Nov. 22, 1960 and sold by Metco, Inc., of Westbury, N.Y., under the trade name "Thermospray" powder gun. The spraying is effected at a rate of 5 to 10 lbs. of powder per hour, using acetylene gas as the fuel, at a pressure of 10 lbs. p.s.i. gauge and a flow rate of 25 cu. ft./hr., and oxygen as the oxidizing gas at a pressure of 12 lbs. p.s.i. gauge and a flow rate of 35 cu. ft./hr. During the spraying very little smoke is generated and a coating layer is built up to a thickness of between .003" and .005". The coating is self-bonded, has excellent oxidation resistant characteristics even at high temperatures, and can be used as an intermediate bonding coat.

EXAMPLE 2

Example 1 was repeated except that three batches of powder were made up containing 3, 4 and 5% by weight of aluminum, respectively, each containing 1% by weight of nickel boron. Each of the powder batches was sprayed as described in Example 1 and the amount of smoke generated was determined on the basis of the amount of time it took for the smoke to fill a booth having a volume of 36 cu. ft. The bond strength of the coatings produced for each of the batches was also tested in the conventional manner by spraying on the end face of a mild steel rod of approximately 1" diameter, grinding the sprayed coating smooth, and cementing a second, similar rod to the ground steel and pulling the two rods apart in tension and determining the force necessary to lift the coating.

Table I below indicates the results:

TABLE I

Aluminum Content (percent)	Bond Strength (p.s.i.)	Smoke, time to fill 36 cu. ft. volume (sec.)
3	2,360	No smoke
4	3,010	15–20
5	3,550	8–10

EXAMPLE 3

Example 2 was repeated exactly except that in each case the flame spray powder was formed without the nickel boron. The results obtained are shown in Table II below:

TABLE II

Aluminum Content (percent)	Bond Strength* (p.s.i.)	Smoke, time to fill 36 cu. ft. volume (sec.)
3	2,175	8–9
4	2,650	6
5	3,050	4–5

*These figures are averages of 6 or more tests.

EXAMPLE 4

Example 1 may be repeated, using in place of the nickel boron foundry alloy, nickel boron alloys containing from 5–95% and preferably 7–25% boron.

While the invention has been described in detail with reference to certain specific embodiments, various changes and modifications which fall within the spirit of the invention and scope of the appended claims, will become apparent to the skilled artisan. The invention is, therefore, only intended to be limited by the appended claims or their equivalents wherein I have endeavored to claim all inherent novelty.

I claim:

1. A flame spray powder comprising particles having a nickel core coated with aluminum and nickel boron.

2. A flame spray powder comprising particles having a nickel core coated with about 2½% to 6% by weight of aluminum and ½ to 2% nickel boron based on the total of nickel, aluminum and nickel boron.

3. A flame spray powder according to claim 2 in which said nickel boron is present in amount of about 1% by weight.

4. A flame spray powder comprising particles having a nickel core coated with a binder containing aluminum particles and nickel boron particles, said aluminum particles being present in amount of 2½ to 6% by weight based on the total of aluminum, nickel and nickel boron, said nickel boron particles being present in amount of about ½ to 2% by weight based on the total of the aluminum, nickel and nickel boron.

5. A flame spray powder according to claim 4 in which said binder is a varnish.

6. A flame spray powder according to claim 5 in which said nickel boron is present in amount of about 1% by weight.

7. A flame spray powder according to claim 6 in which said aluminum is present in amount of about 5% by weight.

8. In the flame spray process, the improvement which comprises spraying a flame spray powder comprising particles having a nickel core coated with a minor amount of aluminum and nickel boron.

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