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COATED ALUMINUM CYLINDER WALL AND A METHOD OF MAKING

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This invention relates to wear-resistant materials and more particularly to flame-sprayed coatings of powdered metal mixtures for improving the wear resistance.

Many metals have highly desirable properties which would make them quite useful for a number of applications were it not for their exceedingly poor wear resistance. Aluminum and aluminum alloys, for example, generally have the necessary strength-to-weight ratios for application in many component parts of an internal combustion engine in addition to excellent thermal conductivity for dispersion of heat. However, the inherently poor wear resistance of aluminum makes it unsuitable for use in moving component parts where cast iron or steel have heretofore been used.

It is a primary object of this invention to provide an improved wear-resistant material which can be applied as an adherent, useful, anti-wear coating on metals having poor wear resistance. Another object of the invention is to provide an improved method of forming a wear-resistant coating on the surface of metals, such as aluminum. A further object of the invention is to provide a flame-sprayed, highly wear-resistant coating on the cylinder wall of an aluminum internal combustion engine.

These and other objects of the invention are obtained by the flame spraying of a mixture of powdered aluminum and powdered iron onto the surface of a part so as to form a highly wear-resistant adherent coating. Other objects, features and advantages of this invention will appear more clearly from the following description of specific embodiments thereof.

The part is generally formed sufficiently undersize to permit a substantial thickness of the coating to remain on the surface of the part after finish machining.

As is customary in the art, the surface of the part preferably is suitably prepared to receive the flame-sprayed coating. The part is preferably thoroughly cleaned, such as by degreasing in trichlorethylene or perchlorethylene vapor at about 230° F. Then the surface to be coated is roughened or etched by means of an abrasive blast.

Ordinarily it is preferred that the surface of the metal part be etched by an abrasive blast to provide a surface which is of a uniform, gray-white, metallic color. The surface, when viewed without magnification, should be found free of visible mill scale, rust, corrosion, oxides, paint and other foreign matter. The depth of the etch by the abrasive blast can be varied to some extent, but a heavy etch is usually desirable. The bond between the base and the flame-sprayed coating is primarily a mechanical bond which is enhanced by a heavy etch on the underlying base metal.

The metal part can be abraded or etched using natural silica sand, crushed chat or steel grit. Steel grit is preferably used since it has excellent angularity and leaves substantially no grit deposit on the surface of the part. In etching the part the surface can be grit blasted with an air stream which is preferably normal to the surface being abraded. Highly satisfactory results are obtained when etching metals, such as aluminum, with SAE 18 hard steel grit.

It has been found that exceptionally adherent metallic coatings are obtained when the surface being coated has been preheated. Among other things the preheating inhibits condensation of moisture from the oxy-acetylene flame on the surface being sprayed. It appears that such condensation is detrimental to the formation of a strongly bonded coating. Although it is generally preferred that the surface which is to be coated be preheated to a temperature of at least about 475° F., satisfactory results are generally obtainable when the surface is preheated to a temperature of at least 325° F. In some instances, satisfactory bonds are obtainable when the part is preheated at temperatures as low as 200° F. The preheating of the part, however, should not be to such a high temperature as to cause a melting thereof or of the flame-sprayed coating which is subsequently applied.

The powdered metal mixture of the invention is flame sprayed onto the prepared surface of the part in the known and accepted manner of flame spraying powdered metals. A metallizing gun, such as is known and used in the art for flame spraying powdered materials, can be used. One such gun is schematically shown in "Metal Spraying—Development and Application" by S. J. Oechsle, Jr., Metal Finishing, December 1957. In a powdered metal flame-spray gun the powdered metal is aspirated into an air stream which propels it through a flame area, generally oxy-acetylene flames, oxy-propylene flames or the like, onto a prepared surface. The part is generally positioned between 4 inches to 10 inches away from the nozzle of the gun and the metal stream usually is projected normal to the surface being coated. Of course, the coating should be applied uniformly so as to deposit a coating of substantially equal thickness throughout.

Generally even extremely thin coatings formed in accordance with the invention contribute to improved wear resistance. The maximum thickness which is preferred is dependent upon the specific use of the article coated and the thermal expansion coefficient of the base metal. Coating thicknesses above about 0.045 inch tend to exhibit poor adherence to the base metal if the base metal has a different thermal expansion coefficient than the sprayed coating. In most instances coating thicknesses up to 0.045 inch on any base metal provide generally satisfactory results.

After the wear-resistant material is sprayed onto the surface of the part, the part can be finish machined, such as by turning, grinding, honing and the like. If the coated part is to be finish machined, the sprayed layer should be oversprayed by an amount sufficient to allow for finishing the part to the required dimensions while leaving a final coating of the desired thickness. The desired final thickness, of course, will vary depending upon the article being coated and its use.

A sufficient thickness of the coating should be initially applied to accommodate approximately 0.004 inch to 0.006 inch to be removed in finishing operations. Thus, when a finish coating thickness of approximately 0.002 inch is desired, an initial thickness of 0.006 inch to 0.008 inch should be applied. The preferred thickness of the applied coating is dependent upon the desired final thickness of the coating, the thickness reduction in finishing operations and differences in thermal expansion coefficients of the base metal and the sprayed coating.

For example, when coating a cylinder wall of an internal combustion engine, a finish thickness of approximately 0.001 inch to 0.002 inch of the sprayed coating is desired. Since finish machining operations generally remove up to 0.004 inch to 0.006 inch, the sprayed coating should be applied in an initial thickness of approximately 0.005 inch to 0.008 inch. However, for other applications, such as in forming wear-resistant surfaces on braking surfaces of brake drums, a final coating thickness as high as 0.015 inch to 0.020 inch can be used. Therefore, initial coating thicknesses should be about 0.019 inch to 0.026 inch to accommodate for finish machining operations to the desired final thicknesses.

In a specific example of the invention, an aluminum cylinder liner can be made more wear-resistant by applying a flame-sprayed metal coating. An annular, cylindrical sleeve is machined to an oversized inner diameter of about 3.8785 inches. The inner diameter of the sleeve is formed larger by twice the thickness of the final spray coating desired. The cylinder liner is degreased in trichlorethylene vapor at a temperature of about 230° F. The inner diameter of the sleeve is grit blasted with SAE 18 sharp steel grit impinging normal to the surface being abraded. The grit is passed through a 3/16 inch opening in a grit blasting nozzle by an air stream under a pressure of approximately 65 pounds per square inch.

After the grit blasting, the liner is heated to a temperature of 475° F. and while at this temperature a mixture of 90% powdered aluminum and 10% iron is uniformly sprayed onto the inner diameter of the liner. The particle size of the powdered metals in the mixture is about minus 80 to plus 200 mesh. After applying the coating to a thickness of about 0.007 inch, the interior of the liner is ground and honed to finish machine the inner diameter to 3.8745 inches.

The mixtures which are flame-sprayed in accordance with the invention are powdered metal mixtures containing, by weight, approximately 92% to 78% powdered aluminum and 8% to 22% powdered iron. The addition of the powdered iron to the flame-sprayed aluminum considerably improves the wear resistance of the powdered aluminum but such improvement is not appreciably found below about 3% powdered iron. Although beneficial effects are obtained by additions of powdered iron above 3%, by weight, at least 8%, by weight, is usually required to obtain the optimum wear resistance and mechanical properties. However, in some instances, proportions of powdered iron as low as 3%, by weight, may be preferred. Moreover, relative amounts of powdered iron in excess of 22%, by weight, increase wear resistance and can be used in many applications. However, amounts of powdered iron above about 45%, by weight, tend to make the coating undesirably porous, brittle and poorly adherent for general purposes.

It is contemplated that the beneficial results of this invention are equally obtainable with powdered aluminum base alloys, those alloys containing at least 50% aluminum, as are obtainable employing powdered aluminum. Accordingly, the term "aluminum" is used herein to include alloys containing at least 50%, by weight, aluminum in addition to pure aluminum. Similarly, the advantages of the instant invention are not only obtained with pure powdered iron but also with powdered ferrous base alloys. Therefore, ferrous base alloys, those alloys containing at least 50%, by weight, iron are encompassed by the term "iron" as used herein, as well as pure iron.

The particle size of the powdered metals which are used in the mixture can vary to some extent but generally should not be greater than approximately 80 mesh size. Particles larger than about 80 mesh size may give adequate wear resistance but tend to make the deposit undesirably coarse, rough and porous. On the other hand, the powdered metals preferably are of a particle size which is greater than approximately a 200 mesh size since smaller particle sizes tend to cause poor adherence of the coating to the base metal.

In general, powdered metal particle sizes which are about minus 80 mesh size to plus 200 mesh size are preferred. The phrase "about minus 80 mesh size to plus 200 mesh size" refers to mixtures in which the particles will pass through about an 80 mesh standard screen and be substantially retained by about a 200 mesh standard screen.

Various types of metal powders can be employed, such as aluminum flake or aluminum powder formed by atomizing molten aluminum. The atomized type powders are generally more desirable than the flake powders, as the atomized powders contain lesser amounts of aluminum oxide and therefore fuse more readily during the spraying to form a more satisfactory coating. It is also contemplated that such powders can be compacted into a rod or wire form for use in the subject invention.

Although this invention has been described in connection with certain specific examples thereof, no limitation is intended thereby except as defined in the appended claims.

We claim:

1. In an internal combustion engine, an aluminum cylinder wall having a wear-resistant coating of a flame-sprayed metal mixture comprising, by weight, approximately 78% to 92% powdered aluminum and 8% to 22% powdered iron, said coating having a thickness of approximately 0.001 inch to 0.002 inch.

2. The method of forming a wear-resistant coating on a surface of an aluminum article which comprises etching a surface of an aluminum article, heating said article so that said surface is at a temperature of at least 200° F. and flame spraying onto said heated surface a powdered metal mixture containing, by weight, about 78% to 92% powdered aluminum and about 8% to 22% powdered iron, said powdered metal in said mixture having a particle size of approximately minus 80 mesh to plus 200 mesh.

3. The method of forming a wear-resistant coating on a surface of an aluminum article which comprises preparing a surface of an aluminum article to receive a flame-sprayed metal coating, heating said article so that said surface is at a temperature of at least 200° F. and flame spraying onto said heated surface a powdered metal mixture containing, by weight, about 55% to 97% powdered aluminum and 3% to 45% powdered iron, said powdered metal in said mixture having a particle size of approximately minus 80 mesh to plus 200 mesh.

4. The method of forming a wear-resistant coating on the surface of an aluminum cylinder wall which comprises cleaning the surface of an aluminum cylinder wall of an internal combustion engine, grit blasting said surface, preheating said surface to a temperature of at least 200° F. and flame spraying onto said surface a powdered metal mixture consisting essentially of, by weight, about 78% to 92% powdered aluminum and about 8% to 22% powdered iron, said powdered metals having a particle size of about minus 80 mesh to approximately plus 200 mesh and said coating having a thickness lesser than about 0.045 inch.

5. In an internal combustion engine, an aluminum cylinder wall having a wear-resistant coating of a flame sprayed metal mixture comprising, by weight, about 55% to 97% powdered aluminum and 3% to 45% powdered iron, the thickness of said coating being lesser than about 0.045 inch.

6. The method of forming a wear-resistant coating on the surface of an aluminum cylinder wall which comprises cleaning the surface of an aluminum cylinder wall of an internal combustion engine, grit blasting said surface, preheating said surface to a temperature of at least about 200° F. and flame spraying onto said surface a powdered metal mixture consisting essentially of, by weight, about 55% to 97% powdered aluminum and 3% to 45% powdered iron, said powdered metals having a particle size of about minus 80 mesh to approximately plus 200 mesh and said coating having a thickness lesser than about 0.045 inch.

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