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WEAR RESISTANT COBALT BONDED TUNGSTEN CARBIDE COMPOSITE

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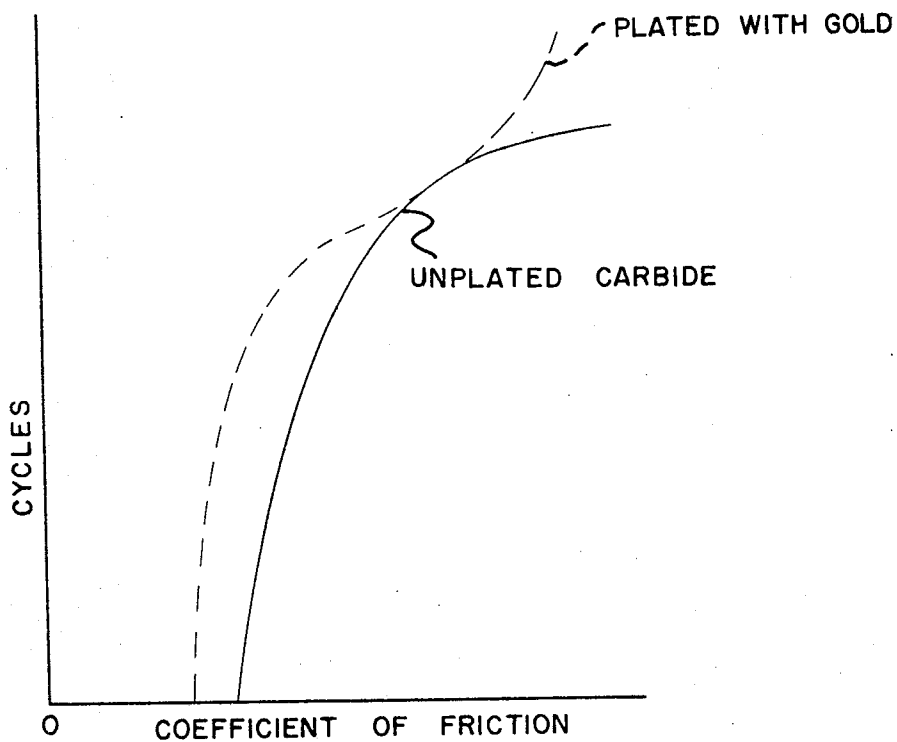


FIG. 1

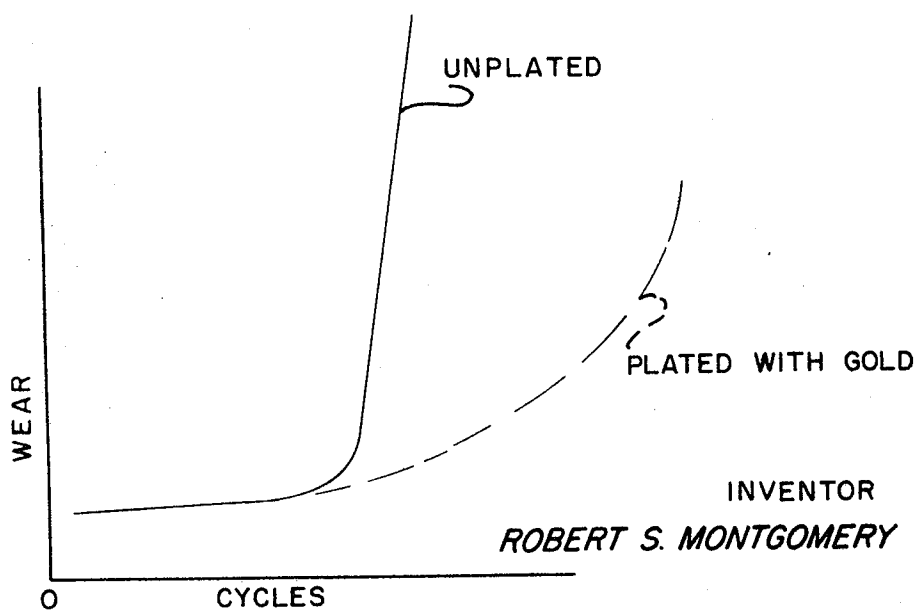


FIG. 2

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WEAR RESISTANT COBALT BONDED TUNGSTEN CARBIDE COMPOSITE

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6 Claims

ABSTRACT OF THE DISCLOSURE

The wear resistance of cobalt bonded tungsten carbide composites is improved by coating the surface of the composite with a thin layer of either gold, tin, manganese, titanium or silver.

This invention relates to improvements in the wear resistance of cemented carbide bodies and more particularly to tungsten carbide composites.

Cemented carbide bodies or tungsten carbide composites are made up of a plurality of tungsten carbide granules which are bonded together by cobalt or a material primarily made up of cobalt. It has been found that when cemented carbide bodies of this type are subjected to repeated surface stresses, such as provided by sliding or rolling contact, after a few cycles the cobalt binder pulls away from the tungsten carbide granules. There is a failure of the bonding between the cobalt and tungsten carbide granules. This allows large flakes of the carbide composite to break away from the body. When enough of these flakes break away, the body is no longer usable for its intended purpose. Large pits are formed in the surface of the body thus increasing the coefficient of friction and eventually resulting in complete failure. Because failure occurs after a few cycles, the use of cemented carbides wherever cyclic stresses of great numbers are encountered has been limited. The strength of tungsten carbide composites would be advantageous in many more applications where cyclic stresses occur such as in high pressure compressors where pistons and cylinders are in sliding and sealing contact with each other if the stability of composites subjected to cyclic stresses could be increased.

It is the principal object of this invention to provide an improved wear resistant material.

It is another object of this invention to provide a wear resistant material with increased stability when subjected to repeated cyclic stresses.

It is another object of this invention to provide a method of improving the wear resistance of cemented carbide bodies.

In general, these objects are carried out by coating a cemented carbide body with a material selected from the group consisting of gold, tin, titanium, manganese and silver.

The foregoing and other objects will become apparent from the following description and drawings in which:

FIG. 1 is a graph showing the coefficient of friction of this invention where the ordinate axis is a logarithmic scale and abscissa axis is a lineal scale; and

FIG. 2 is a graph showing the improved wear qualities of this invention where both the ordinate and the abscissa are logarithmic scales.

By this invention it has been discovered that the amount of surface fatigue on a tungsten carbide composite can be reduced over a prolonged number of cyclic stresses by coating the composite with a thin layer of a material containing a metal selected from the group consisting of gold, tin, manganese, titanium and silver.

The base material is a standard tungsten carbide com-

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posite usually made up of tungsten carbide particles or granules bonded together with cobalt. The cobalt may be in the range of three to twenty-five percent by weight of the composite with the grain size of the tungsten carbide varying according to desired hardness and strength.

The composite is then coated by a suitable method such as electroplating which per se is well known or by vapor deposition. Vapor deposition usually involves placing the tungsten carbide composite in a vacuum and evaporating the coating metal onto the carbide. This process is per se old and is used for achieving thin coatings of materials which do not lend themselves to electroplating. Because vapor deposition may be used for all of the coating metals, it is a preferred method of coating. When deposition is used, the coating is not firmly fixed to the base but the results achieved by the end product are the same as if firmly fixed. It is intended that other methods of plating are within the scope of this invention, and in some cases, it may be possible to simply paint the coating material on the carbide.

The coating thickness is important to the extent that if it is too thin, it will give no improved results whereas if it is too thick, the excess will merely wear away giving no improved wear until a thin coating is achieved. The coating material, by itself, has poor wear qualities so that a thick coat actually decreases wear qualities until it has worn away. With tin it was found that a coating thickness of one-half microinch failed to achieve any improved wear qualities in the carbide composite while a coating of 2 microinches worked well in improving wear qualities. With gold, a .8 microinch coating was found to be effective. Although these thicknesses are difficult to measure, it is believed that about one-half microinch is the thinnest effective coating. A thickness of .0001 inch was found to be the upper limit. In some applications this may be too thick while in other applications a thicker coating may be desirable.

If the end product is to be used where size is a critical factor, a thinner coating is preferred. For example, if a tungsten carbide composite is to be used for the piston of a high pressure compressor, size is critical as there must be a seal achieved between the piston and cylinder walls. If a thick coating is used which wears away quickly before the increased wear qualities are apparent, the sealing between the piston and cylinder will be lost. The loss of sealing between the piston and cylinder due to wear of the carbide composite is one of the reasons coating is necessary. Therefore, if the seal is lost due to too thick a coating, no advantage is achieved.

In tests performed it was shown that the tendency of the carbide to fail was greatly decreased when the coating was used. In all tests the carbide used was a particular grade of General Electric carbide. The differences in grade result from different tungsten carbide grain size with all grades tested having about six percent by weight cobalt as a binder.

The tests were performed by using a General Electric grade 895 carbide flat plate. The flat was securely mounted and a hemispherical carbide rider of either General Electric 895 carbide or General Electric 883 carbide was used. A reciprocating wear machine was used which applied a load of 33.2 pounds and the rider moved over the flat at an average speed of one foot per second. The actual distance of travel in a complete cycle was 8 inches with a time of travel of $\frac{3}{4}$ second. The temperature of the working surface was maintained at 65° C.

In a pilot test using an unplated General Electric grade 895 flat and a General Electric grade 895 rider, it was found that the coefficient of friction was about .2. After 100 cycles, the coefficient of friction was .3 and at 600 cycles, the coefficient of friction was about .45. This is shown generally on FIG. 1 with a solid line.

The wear increased greatly as the number of cycles increased. Wear, in this test, is a measure of the amount of material removed from the hemispherical rider in cubic millimeters. In the pilot test using a General Electric 895 flat and the same material rider, the wear gradually increased until about 500 cycles and then the material experienced complete failure. This is shown by the solid line on FIG. 2.

In general, the coatings of this invention do not improve the coefficient of friction. As indicated on FIG. 2, when the carbide was plated with gold, the coefficient of friction was slightly improved until about 500 cycles. At this point the coefficient of friction became about the same as the uncoated carbide. After the point where the unplated carbide fails, the coefficient of friction of the coated carbide remains substantially constant. This is simply because of lack of failure and not per se due solely to the coating as would be the case if the coating acted simply as a solid lubricant. The coating thickness was .0001 inch.

When the flat was coated with gold containing 2-4% cobalt, the wear qualities of the composite improved greatly. Until about 500 cycles, the wear of the plated material is the same as that of the unplated material. However, from that point, as shown on FIG. 2, the wear continues to be gradual rather than abrupt. At 10,000 cycles complete failure has still not occurred whereas, at 500 cycles the unplated material has completely failed. Pure gold produced test results substantially similar to the gold with cobalt added but it was found that the addition of cobalt to the gold increased hardness and was easier to work with and more readily obtainable.

The remainder of the coating materials produced similar results with similar curves. However, some of the coating material tried did not work. While tin worked, indium, which in most cases is similar to tin, did not work. If the coating acted as a solid lubricant, if tin worked, indium would also work. However, the wear qualities decreased and failure occurred faster than without the coating. Other factors, besides the general lack of improvement of the coefficient of friction other than after failure occurred, which indicated that the coating was not acting as a solid lubricant are the fact that thinner coatings are used in this invention than would work with solid lubricants. What materials will improve wear qualities is not predictable to the extent that the effectiveness of solid lubricants is predictable.

Those materials which worked in addition to gold were tin, titanium, manganese, and silver which all delayed failure until approximately 10,000 cycles and in some cases, failure never occurred. Silver works to the extent that it delayed complete failure until about 10,000 cycles, but in the region of mild wear, the wear was greater than the unplated tungsten carbide composite. If desired, cobalt may be added to the other coating metals but this was found not as useful as in the case of gold.

It has been found that those metals which do achieve the desired result are all soluble in cobalt with the exception of silver. Each of the metals tends to stabilize the alpha phase cobalt. As is known at higher temperatures cobalt has one crystalline structure usually designated the alpha phase. When pure cobalt is cooled to about 600° C. it changes to a second crystalline structure. By stabilizing the alpha phase, the coatings of this invention lowers the temperature at which the crystalline structure changes. This is believed to be one reason why the subject metals improve the wear qualities of tungsten carbide composites. A corollary to this theory is that the coating relieves the stresses in the outer surface of the cemented carbide.

Silver is different from the other metals which work. Unlike the other metals, silver is not soluble in cobalt. In the region of mild wear, the wear is not improved yet failure is prevented. The lack of improved wear in the

region of few cycles is attributed to the lack of solubility of silver in cobalt.

Each of the metals that work has an atom size which is larger than cobalt and each is softer than cobalt. Not all metals whose atom size is larger than cobalt will work. In addition to larger atom size, it is believed that the metal must be soluble in cobalt, with silver as an exception. Although aluminum conformed to these requirements, it did not work probably owing to its reactivity toward oxygen.

It has also been found that those metals which work or increase the wear qualities may be alloyed with metals which do not have this effect and the overall wear qualities are increased. By the term "alloys of those metals," I do not intend to limit myself to interalloys of the five metals that work but include alloys of the preferred metals with other metals that do not work. Even though the materials that work are combined with other materials, those that work still coat the carbide composite to an extent sufficient to improve wear. For example, it was found that bronze, a tin containing alloy of copper, worked. The metals that do work may be alloyed with each other and work. Although all tests were carried out using tungsten carbide, it is contemplated that this coating will improve wear when used with other carbides of heavy metals such as titanium.

From the foregoing it can be seen that an improved tungsten carbide composite has been provided by coating its surface with a material selected from the group consisting of gold, tin, titanium, manganese and silver and alloys thereof.

It is intended that the foregoing be merely that of a preferred embodiment and that the invention be limited only by that which is within the scope of the appended claims.

I claim:

1. A wear resistant material comprising tungsten carbide granules bonded together with cobalt; the surface of the composite formed by said granules and cobalt being coated with a material soluble in cobalt.

2. A wear resistant material according to claim 1 wherein the coating material is softer than cobalt.

3. The material of claim 1 wherein the coating material has a thickness of between .0000005 inch and .0001 inch.

4. A wear resistant material comprising a plurality of granules of a carbide of a heavy metal bonded together with cobalt; the surface of the composite formed by said granules and cobalt being coated with a material selected from the group consisting of gold, titanium, tin, manganese and alloys of those metals.

5. The material of claim 4 wherein the coating material has a thickness of at least .0000005 inch.

6. A wear resistant material comprising a plurality of granules of a carbide of a heavy metal bonded together with cobalt; the surface of the composite formed by said granules and cobalt having a coating of silver less than .0001 inch thick.

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