PROCESS TO ENHANCE BRAZABILITY OF CARBIDE BITS

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ABSTRACT

The present invention teaches a method in which a cemented carbide product is prepared such that the ease and quality of brazing is improved. The process involves a controlled heat treatment such that the surface of the carbide is enriched with cobalt from the carbide matrix. This cobalt surface enhances the wettability and flow during brazing and provides for improved bond strength.
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CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not Applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not Applicable

BACKGROUND OF INVENTION

[0003] Cemented carbide, or ‘carbide’, is a mixture of very hard tungsten carbide (WC) particles in a matrix of cobalt (Co). Carbide is typically manufactured in a process in which WC and Co powders are blended, pressed and sintered. During sintering, Co melts and wets the WC, resulting in a material that combines high strength, toughness and hardness. Carbide is widely used for cutting tools and in wear resistant applications. There are several grades of carbide, distinguished by grain size and ancillary alloying element additions.

[0004] A particularly useful application of carbide is as a tool bit for cutting, milling, turning, etc. For these applications, the carbide bit is customarily brazed onto the tool body, for example in carbide-tipped steel saw blades. In this way, the carbide comprises the working surfaces of the tools, where wear resistance and hardness is particularly important, and the body of the tool, often steel, has important attributes such as machinability, toughness, and is economical. Besides the individual properties of the carbide tip and the tool body, a critical factor for a durable tool is the bond strength of the braze.

[0005] While there are many methods of brazing, the present invention discloses a method in which the surface of the carbide is prepared in such a manner that the quality of the braze is improved. Basically, the present invention utilizes a vacuum heat treatment procedure to enrich the surface of the carbide with cobalt, thus providing an integral metal surface upon which the braze metal can form a strong bond. The cobalt surface layer effectively improves capillary action between the braze metal and the carbide and allows Co to diffuse into the braze, improving bond strength. It also allows for a sound braze due to the good wettability and flow characteristics of the braze on the carbide surface layer.

[0006] There are several methods used to enhance the surface of carbides in preparation for brazing. Each of these methods, however, has serious drawbacks that the present invention eliminates. In the process taught by U.S. Pat. No. 2,979,811, carbide is processed through a number of steps involving molten salt bath heat treatments and chemical exposure. The process is used to wick a thin layer of pure Co from the bulk carbide binder phase to the surface of the carbide. While effective, this method, and the various methods derived from this basic procedure have some practical negative consequences. The multiple steps required cause these processes to be inherently labor intensive, and thus costly. If not carefully monitored, open molten salt bath furnaces can be dangerous and if not properly controlled and maintained, they can produce noxious smoke and environmentally hazardous Barium byproducts. In addition, the nesting of the carbide parts that is used to allow a high packing density of parts per furnace run can result in a cosmetically uneven surface. Finally, care must be given during the quench step that is used to chill the carbides so as not to result in high residual stresses, which can result in cracking or shortened tool life, especially of harder carbide grades.

[0007] Since a metal surface layer results in an improved braze over the carbide surface layer, many methods of directly depositing metal on to carbides have been used with varying degrees of success. Plating a metal directly onto a carbide has been demonstrated, but the plated metal/carbide interface is typically inconsistent and can separate. Pre-timing, or coating the carbide surface with braze material prior to brazing also is inconsistent if done directly on an untreated carbide. Therefore, instead of directly plating or pre-timing, many processes utilize an alternative approach. This involves a multi-step procedure in which etching is used to remove the binder phase near the surface to give an irregular, high surface area substrate, onto which a metallic coating or braze material can be applied to in preparation for brazing. In general, these procedures are complex because of the multiple steps and the use of hazardous chemicals.

[0008] One method of preparing a surface for a metallic coating is taught in U.S. Pat. No. 6,322,871 in which a ceramic part is in preparation for brazing. This process utilizes a sodium hydroxide cleaning step, followed by acid etching and the application of a metallic coating. Although it is not clear if this method would be effective for carbides in addition to ceramic parts, the process involves the use of both highly caustic and highly acidic chemicals. Similarly, U.S. Pat. No. 5,058,799 describes a metallized ceramic substrate having enhanced bond strength between the ceramic substrate and a metal layer.

[0009] While not specifically used to enhance the braze joint between a carbide and a tool body, some carbide manufacturers create concentration gradients of cobalt such that the surface of a carbide is many times richer in Co than the interior. This gradient can be formed during the initial sintering of the Co and WC powder performs or during a heat treatment process under a controlled furnace atmosphere. Enriching the surface with Co enhances the toughness of the surface, and the interior, with less Co, has high deformation resistance. The surface of these products, however, still only contains perhaps up to 20% Co, which although is much higher than a typical 6% Co interior, is still not the pure metal layer needed for enhancing the brazed joint integrity.

BRIEF SUMMARY OF THE INVENTION

[0100] The present invention provides for a process in which the brazability and braze joint strength of a carbide part is enhanced. This process involves the simple application of a controlled vacuum heat treatment followed by a nitrogen gas quench. The invention further provides for a method in which no dangerous chemicals, or dangerous molten salt furnaces are utilized. The invention further provides for parts that are produced with minimal residual stresses. Further advantages of this invention over the prior art include the ability to process parts without the need for sand- or grit-blasting and the much reduced labor costs due to the simplicity and reduced number of steps of the process. These advantages also lead to a more consistent product.
BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

DETAILED DESCRIPTION OF THE INVENTION

According to the present invention, carbide parts are arranged on metal racks and inserted into a vacuum heat treatment furnace. A preheat is applied to the parts and a partial vacuum is applied to the furnace chamber. The temperature of the furnace is then ramped to over 2000°F and held for several minutes. The power is then shut off and Nitrogen gas is introduced into the furnace chamber to effect a rapid quenching of the parts, which are then removed and air cooled the rest of the way to room temperature.

EXAMPLE 1

1850 pieces of tungsten carbide wear parts are treated. Part dimensions are 1.25×1.00×0.125-inches and each weighs 39 grams. The total weight of the charge is approximately 72.15 kg.

Step 1: The parts are loaded in baskets and placed in the furnace chamber.

Step 2: The parts are preheated to 1500°F and a partial vacuum of 30% of atmospheric pressure is applied to the furnace chamber.

Step 3: The parts are heated to 2200°F at a rate of between 25°F-30°F per minute.

Step 4: The parts are held at 2200°F, under partial vacuum for 12 minutes.

Step 5: Nitrogen gas is introduced into the furnace chamber, effectively quenching the parts to a temperature of 200°F. Parts are then removed and air cooled to room temperature.

Once this process is performed, the tungsten carbide parts can be readily brazed to a tool body with a high quality bond.

The example above is non-limiting and given for illustration purposes. The actual temperatures and temperature heat-up ramp rates may vary somewhat depending upon the amount and density of the loaded parts. Average production loads will vary depending upon the size and characteristics of each particular furnace. In general, a total cycle time of 2 to 3 hours per batch is expected, however different cycles may be just as effective. In addition, a continuous operation instead of a batch operation may also be utilized for this process.

It is possible that the present invention may be practiced directly following the sintering operation that is used in the carbide fabrication process. The sintering operation is typically performed under vacuum at a much higher temperature. Therefore, the sintering furnace would need to be ramped down to the holding temperature (e.g., 2200°F as taught by Example 1) and held, followed by a quench.

While the example specifies a partial vacuum be applied, other means to exclude oxygen from the furnace environment may be employed. These may include the filling of the furnace with an inert gas or the mechanical encapsulation of the parts, such as by wrapping with a foil or by the application of a suitable high temperature paint or suspension. In addition, alternative quench media, such as other gas mixtures may be used.

It is recognized that while the present invention has been described with reference to preferred embodiments, various details of the invention can be changed without departing from the scope of the invention. Furthermore, no limitations are intended to the details of the process shown, other than as described in the claims below.

1. A method for treating cemented carbide products comprising the steps of:
   a. heat treatment in a furnace at a temperature of 1800°F to 2500°F under a partial or complete vacuum for 1 to 60 minutes,
   b. quenching, or rapidly cooling said products, whereby the surface of said cemented carbide becomes enriched with the metal or alloy from the matrix of the cemented carbide.

2. The method of claim 1 wherein said cemented carbide products primarily consist of a composite of tungsten carbide and cobalt and optionally, additional elements and carbides.

3. The method of claim 1 wherein said enrichment of the surface of the carbide product is by the metal cobalt, or by an alloy that comprises at least in part cobalt, which is contained in the matrix of the cemented carbide.

4. The method of claim 1 wherein said heat treatment is directly preceded by an initial lower temperature heat treatment step.

5. The method of claim 1 wherein a higher temperature sintering operation directly precedes said heat treatment.

6. The method of claim 1 wherein said heat treatment is performed at a temperature of 2000°F to 2200°F, under a 30% partial vacuum for 12 minutes.

7. The method of claim 1 wherein said quenching is achieved through the introduction of nitrogen gas into the furnace chamber.

8. The method of claim 1 wherein said enrichment of the surface of the cemented carbide is used to enhance the brazing ability of the carbide.

9. The method of claim 1 wherein said enrichment of the surface of the cemented carbide is used to enhance the wear resistance and service life of the carbide.

10. A method for treating cemented carbide products comprising the steps of:
   a. pre-heating in a furnace at a temperature of 1500°F,
   b. evacuating the furnace resulting in at least a partial vacuum or reduction of atmospheric pressure,
   c. increasing the temperature of the furnace at a rate of 5°F-50°F per minute until a temperature of 1800°F to 2500°F is attained,
   d. holding the parts in the furnace for a period of 1 to 60 minutes,
   e. quenching, or rapidly cooling said products via the introduction of nitrogen gas into the furnace, whereby the surface of said cemented carbide becomes enriched with cobalt from the matrix of the cemented carbide.
11. The method of claim 10 wherein said cemented carbide products primarily consist of a composite of tungsten carbide and cobalt and optionally, additional elements and carbides.

12. The method of claim 10 wherein said heat treatment is performed under a 20-60% of atmosphere, partial vacuum.

13. The method of claim 10 wherein said enrichment of the surface of the cemented carbide is used to enhance the brazing ability of the carbide.

14. The method of claim 10 wherein said enrichment of the surface of the cemented carbide is used to enhance the wear resistance and service life of the carbide.

15. A method for treating cemented carbide products comprising the steps of:

a. heat treatment in a furnace at a temperature of 1800° F. to 2500° F. while excluding oxygen from the surface of the products for 1 to 60 minutes,

b. quenching, or rapidly cooling said products,

whereby the surface of said cemented carbide becomes enriched with the metal or alloy from the matrix of the cemented carbide.

16. The method of claim 15 wherein said cemented carbide products primarily consist of a composite of tungsten carbide and cobalt and optionally, additional elements and carbides.

17. The method of claim 15 wherein said enrichment of the surface of the carbide product is by the metal cobalt, or by an alloy that comprises at least in part cobalt, which is contained in the matrix of the cemented carbide.

18. The method of claim 15 wherein said heat treatment is directly preceded by an initial lower temperature heat treatment step.

19. The method of claim 15 wherein a higher temperature sintering operation directly precedes said heat treatment.

20. The method of claim 15 wherein said exclusion of oxygen is achieved by introducing an inert gas into the furnace chamber.

21. The method of claim 15 wherein said exclusion of oxygen is achieved by mechanically encapsulating the product, such as in a metal foil or by a paint or suspension that seals the surface of the product.

22. The method of claim 15 wherein said quenching is achieved through the introduction of a gas into the furnace chamber.

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