GRINDING WHEEL HAVING AN ANTIMONY OR BISMUTH TRIOXIDE BOND

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The present invention relates to an abrasive element, such as a grinding wheel or the like.

The useful life of abrasive elements such as grinding wheels is an exceedingly significant factor. All wheels wear as they are being used. The greater the wear, the shorter is the effective life of the grinding wheel. The problem of wear is particularly significant when the object being machined is exceptionally resistant to abrasion, as is the case of tungsten carbide parts. Industrial grinding operations are performed on tungsten carbide parts, but the cost of such machining operations is quite high because of the resistance to abrasion which tungsten carbide exerts. This resistance reflects itself in a low rate of carbide removal, necessitating long operating times, and in a relatively rapid rate of grinding wheel wear, resulting in the necessity for frequent replacement of worn grinding wheels with new ones.

It is the prime object of the present invention to devise a grinding wheel which will in large measure ameliorate the problems set forth and which will be capable of grinding hard materials such as tungsten carbide considerably more rapidly than has heretofore been considered possible, and which will wear less on the grinding wheel. The magnitude of the improvement in functioning characteristic of the grinding wheel of the present invention is made apparent when the efficiency ratio of the devices of the present invention is compared with the efficiency ratio of comparable prior art devices (the efficiency ratio is defined as the ratio between the volumetric parts of carbide removed and the volumetric parts of the grinding wheel material which are worn away). Whereas for dry grinding of carbide an efficiency ratio of 40—50:1 has been considered good, and whereas the efficiency ratio can be raised to about 325:1 in the case of wet grinding with a wheel having a vitrified bond, devices made in accordance with the present invention in a dry grinding procedure have an efficient ratio of approximately 1400:1.

For grinding carbides and other comparable materials the abrasive particles employed are usually diamonds. The problem in a grinding wheel is largely to hold the diamond particles in place for an optimum period of time and to prevent them from becoming broken or degenerated. The exact mechanism which permits a bonded material to perform its function is not accurately known, although many theories have been advanced. The selection of a particular type of bonding material, or a particular composition or combination of compositions within a given type of material, is a more or less empirical matter.

I have found that grinding wheels having surprisingly improved dry grinding characteristics can be produced if, as a major component of the bonding material, there is employed either antimony trioxide or bismuth trioxide or mixtures of the two. The trioxide bonding material, in the form of small granules or particles, is thoroughly mixed with the abrasive particles, preferably synthetic diamonds, and the mixture is then compacted and sintered under pressure and temperature to form an end product in which the diamond particles are securely held by a matrix of the trioxide material. When the precise action of the trioxide bonding material in imparting to the end product the greatly improved properties which are characteristic thereof is not fully known, it is believed that the trioxide bond-
If desired, a filler material may be incorporated into the abrasive unit. Any standard filler known to be suitable for use in grinding wheels can be used, provided that its softening point is well above the forming temperatures (1100–1300°F) for the products here disclosed. Silicon carbide, alumina oxide, silica and cryolite are typical of appropriate fillers. The amount of filler may be varied widely, up to approximately 50% by weight of the total constituents of the end product.

While the applicability of the bonding material here disclosed is not limited thereto, it has been found particularly effective when hard abrasive particles are in the form of diamond, and especially synthetic diamonds. Synthetic diamond particles used for abrasive purposes have a shape and a rough surface such that they are apparently anchored in place extremely firmly by the trioxide bond here disclosed. Natural diamonds have been used successfully in combination with the bond of the present invention, but with inferior results when compared to the use of synthetic diamonds. When, however, the surfaces of the natural diamonds are roughened by etching before being mixed with the bonding material, the performance characteristics of the end product are greatly improved, and approach those of grinding wheels using synthetic diamonds.

While it is possible to make an entire grinding wheel from the composition here disclosed, it is usually uneconomical to do so, and excellent results can be achieved by forming the abrasive composition of the present invention as a rim on a preformed core. The nature of the core may be widely varied. I have found that a standard vitrified grinding wheel functions quite well in that regard, since it is strong enough to withstand the forming temperatures and pressures to which the abrasive composition of the present invention is subjected. A vitrified core comprising 4% by weight of a glass which melts at approximately 1800°F and five parts by weight of aluminum oxide also produces a desirable core. In general, any material of suitable structural strength which will not soften when subjected to the formation temperatures and pressures of the composition of the present invention will be satisfactory.

A typical formulation for the bonding material is as follows:

**Example I**

<table>
<thead>
<tr>
<th>Parts by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimony trioxide (−230 mesh)</td>
</tr>
<tr>
<td>Barium aluminum borate glass (−230 mesh)</td>
</tr>
<tr>
<td>Carbon</td>
</tr>
<tr>
<td>1000 mesh silicon carbide (filler)</td>
</tr>
</tbody>
</table>

A second typical formulation is as follows:

**Example II**

<table>
<thead>
<tr>
<th>Parts by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bismuth trioxide (−230 mesh)</td>
</tr>
<tr>
<td>Glass frit (−230 mesh)</td>
</tr>
<tr>
<td>1000 mesh silicon carbide (filler)</td>
</tr>
<tr>
<td>Pure carbon</td>
</tr>
</tbody>
</table>

The above ingredients are ball-milled for a period of 24 hours in order to ensure that all of the ingredients are thoroughly mixed. Thereafter the abrasive particles are mixed therewith. The amount of diamond particles can be varied widely, and as many as 80 carats of diamonds per cubic inch of wheel can be used. The normal commercial concentrations, which usually range between 18 to 22 carats of diamond per cubic inch of wheel, are also appropriate. The bonding material here disclosed is capable of carrying both high and low diamond concentrations, ranging, for purposes of exemplification and not limitation, from 18 carats per cubic inch to 144 carats per cubic inch.

The mixture of bonding material and abrasive particles is then placed in an appropriate mold, preferably of the high density graphite type, together with the supporting core if such a core is used. By way of specific example, in order to produce a grinding wheel having a 5" outer diameter a core having an outer diameter of 4.875 inches may be used. The radially outer surface of that core may be pretreated in known fashion for better adhesion to the rim of abrasive material to be formed thereon. The mold, in such a case, has an internal diameter of approximately 5 inches, and the space between the mold and the core is filled with the mixture of bonding material and abrasive particles.

In filling the space between the mold and the 4.875 inches diameter core in order to produce a 5" diamond grinding wheel, the following proportions of bonding material and abrasive particles are exemplary:

**Example III**

<table>
<thead>
<tr>
<th>Carats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimony trioxide bonding material mixture</td>
</tr>
<tr>
<td>Synthetic diamond particles 80–100 mesh</td>
</tr>
<tr>
<td>Synthetic diamond particles 100–120 mesh</td>
</tr>
</tbody>
</table>

**Example IV**

When the bonding material comprises bismuth trioxide instead of antimony trioxide the proportions are the same as in Example I, except that the trioxide bonding material is present in the amount of 180 carats.

After the mold has been filled, it is closed and then subjected to the simultaneous action of heat and pressure. The pressure may be exerted by a hydraulic press, to approximately 1500 p.s.i. Heat may be applied in any appropriate manner, as through the use of induction coils or electrically heated plates. The temperature is raised to 1100°F when antimony trioxide alone is involved or to 1200°F when bismuth trioxide is used. These mold temperatures should, for best results, be held to within a few percent, and preferably 1-2%, of the values specified. The heat and pressure is continued for approximately 15 minutes, after which the heat is removed and the mold and its contents are permitted to cool approximately 300°F before the pressure is released. Thereafter the mold is permitted to cool in air and the finished product is removed therefrom.

The vastly improved abrasive action of the devices here disclosed, when compared with the prior art, may be seen from the following test results. 5" x 1/4" diamond wheel having a diamond abrasive rim portion formed in accordance with the present invention was rotated at 2700 r.p.m. in a commercial grinding machine having a downfeed of .001 inch per pass, a cross feed of .042 inch per pass, and a table speed of 50 feet per minute. The work object was a 6" x 3" piece of No. 44A tungsten carbide. The total downfeed (a measure of the depth of carbide removed) was 100 inch. The total wheel wear could not even be measured by a micrometer, so small was it, and highly accurate measuring techniques indicated that the radius of the wheel decreased only .000325 inch. This made for an efficiency ratio of 1392.6:1. This is to be compared with efficiency ratios of 40–50:1 for dry grinding of tungsten carbide with resinoid bonded diamond wheels, and it is even more times greater than the efficiency ratios of 200:1 and 325:1 which are considered good for wet grinding of tungsten carbide with prior art resin bonded and vitrified bonded diamond wheels. It may be noted that with the composition here disclosed the finish produced on the tungsten carbide work object was better than normal, and no overheating occurred.

A 4" cup-type wheel having an abrasive area made in accordance with this disclosure was, in a dry grinding procedure, rotated at 3600 r.p.m., with a downfeed of .001 inch per pass and a traverse of 250 inches per minute. The workpiece was a 4 x 1/2 inch piece of carborundum. The total downfeed was 250 inch. The wheel wear, measured along the radius of the wheel, was only .000275 inch. This made for an efficiency ratio of 409.6:1. This is to be compared with an efficiency ratio...
of 20-30 parts by weight for each 100 parts by weight of said trioxide.

9. The grinding wheel of claim 3, in which said bonding composition comprises particles of high purity carbon in proportions between 5-1 part by weight for 100 parts by weight of said trioxide, and further comprises a filler material having a softening point above around 1200° F. or 1300° F. when used with antimony trioxide or bismuth trioxide respectively, said filler material being present in amounts between 20-30 parts by weight for each 100 parts by weight of trioxide.  

10. The grinding wheel of claim 2, in which said bonding composition comprises particles of high purity carbon in proportions between 5-1 part by weight for 100 parts by weight of said trioxide.

11. The grinding wheel of claim 2, in which said bonding composition comprises a filler material having a softening point above around 1200° F. or 1300° F. when used with antimony trioxide or bismuth trioxide respectively, said filler material being present in an amount between 20-30 parts by weight for each 100 parts by weight of trioxide.

12. The grinding wheel of claim 2, in which said bonding composition comprises particles of high purity carbon in proportions between 5-1 part by weight for 100 parts by weight of said trioxide, and further comprises a filler material having a softening point above around 1200° F. or 1300° F. when used with antimony trioxide or bismuth trioxide respectively, said filler material being present in amounts between 20-30 parts by weight for each 100 parts by weight of trioxide.

13. The grinding wheel of claim 2, in which said trioxide is present in proportions of 100 parts by weight and said glass is present in proportions of 10-30 parts by weight.

14. The grinding wheel of claim 13, in which said bonding composition comprises particles of high purity carbon in proportions of 5-1 part by weight for 100 parts by weight of said trioxide.

15. The grinding wheel of claim 13, in which said bonding composition comprises a filler material having a softening point above around 1200° F. or 1300° F. when used with antimony trioxide or bismuth trioxide respectively, said filler material being present in amounts between 20-30 parts by weight for each 100 parts by weight of trioxide.

16. The grinding wheel of claim 13, in which said bonding composition comprises particles of high purity carbon in proportions between 5-1 part by weight for 100 parts by weight of said trioxide, and further comprises a filler material having a softening point above around 1200° F. or 1300° F. when used with antimony trioxide or bismuth trioxide respectively, said filler material being present in amounts between 20-30 parts by weight for each 100 parts by weight of trioxide.

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