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3,087,803

DIAMOND GRINDING WHEEL AND COMPOSITIONS THEREFOR

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This invention relates to improved compositions for making diamond grinding wheels and to improved diamond grinding wheels made therefrom.

Diamond grinding wheels are extensively used in the metal working industries for grinding hard materials such as tungsten carbide and the like. Diamond grinding wheels generally include diamond grit, filler materials, and a matrix or bonding agent. Those in present industrial use fall in one of three different classes depending upon the type of bonding agent used, the most widely used type being the so-called resinoid bonded type, which include resinous bonding agents. The two other principal types in present day use are metal bonded and vitrified bonded wheels. The present invention pertains especially to diamond grinding wheels of the resinoid bonded type.

Primarily because of the extremely high cost of diamonds, relative to silicon carbide and aluminum oxide, the use of diamonds as abrasives in grinding wheels has been confined to special applications. These applications include, normally, the necessity to grind materials of such hardness that only diamonds are capable of efficient grinding, and sufficient commercial value of the ground article to justify the cost of grinding with diamonds. Such applications ordinarily fall in the finish grinding category where light cuts and low pressure between the wheel and article being ground are employed. Even though unusual care is exercised in the use of the diamond grinding wheel, diamonds are lost or dislodged from the cutting face of the wheel before the full grinding ability of the diamond particle has been realized. It is commonly recognized and understood that the bond which holds the diamond particles in the wheel is the most important single factor in regulating and controlling the length of the useful life of the wheel and thus the overall cost of grinding with diamond wheels. Various attempts have been made through the years to provide improved bonds and greater holding power for the diamond particles. Such considerations led to both the metal bonded and vitrified bonded diamond wheels. While a metal bond provides excellent holding power for the diamond particles, the presence of the metal is detrimental to the free grinding action as the result of the rubbing between the metal bond and the surface being ground. Moreover, the processing to obtain uniform distribution of the diamond particles in the metal bond is complicated and expensive so that their field of use is limited. The vitrified bond also has good holding power for the diamond particles, but the selection of vitrifiable materials which can be vitrified without incurring detrimental heat effects on the diamond particles is difficult and the manufacture requires close control and is expensive.

Resinoid bonded diamond wheels are less expensive than either metal bonded or vitrified bonded wheels. Heretofore, however, the wear life of resinoid diamond

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wheels has not been as high as the metal or vitrified bonded wheels, generally speaking, and improvement in this characteristic has long been sought.

Accordingly, one important object of the present invention is to improve resinoid bonded diamond grinding wheels.

Other objects are: to provide improved compositions for making diamond grinding wheels; to provide an improved resinoid bonded diamond grinding wheel having exceptionally long wearing characteristics; to provide an improved resinoid bonded diamond grinding wheel in which the matrix supporting the diamond grit wears away at approximately the optimum wear rate of the diamond grit itself thereby maximizing the life of the wheel and minimizing the loss of relatively unworn diamond particles from the matrix while still maintaining diamond grit exposed on the working surface of the wheel for proper cutting action; to provide an improved resinoid bonded diamond grinding wheel having improved grinding characteristics and wearing qualities relative to previously available diamond grinding wheels of this type; and in general to provide an improved diamond grinding wheel of over-all greatly superior characteristics.

During grinding with a diamond grinding wheel there is contact between the extreme outer ends of the diamond particles and the surface being ground and substantial quantities of heat are developed thereby. Some of this heat is dissipated by radiation into the air or other coolant which is being used but a large proportion of it is conducted through the diamond particle to its base portion and is given up to the bond. As the heat increases, both the diamond particle and the bond expand, at different rates, and the bond tends to soften and ultimately the force on the outer end of the diamond particle exceeds the adhesive holding power of the bond and the particle becomes dislodged. The present invention is based on the discovery that the holding power of conventional resinoid bonds for diamond particles is greatly enhanced, not by modifying the bond, per se, but rather by modifying the constituency of the abrasive composition.

In accordance with this invention it has been found that the above and related objects are completely realized by making diamond grinding wheels from a composition containing controlled proportions of diamonds, a resin, a tough, abrasion-resistant, heat-absorptive filler and at least one additional hard abrasive particulate material capable of grinding the intended work. The tough filler, while abrasive to certain soft materials including steel is merely abrasion resistant to the hard materials normally ground with diamond wheels, such as cemented carbides and the like. The tough filler appears to function to modify the adhesive holding power for the diamond particles by aiding in absorbing and distributing throughout the body of the wheel the heat conducted to the bond through the base of the diamond particle. The additional hard, abrasive particles modify the grinding load on the diamond particles by doing a part of the grinding themselves, whereas the diamond particles serve to protect the other hard abrasive and prevent its fracture and breakdown at its ordinary rate. It appears that the combination of this invention allows the diamond particles to function in the manner best suited to its natural capabilities, namely extremely low-pressure light cuts under moderate temperature conditions, and by

virtue of the elimination of localized hot spots in the bonding resins the diamonds are retained in the wheel until maximum wear life is obtained.

The abrasive composition of this invention is the following:

Constituent	Useful range, percent by weight	Preferred range, percent by weight
Diamonds-----	10-30	20-25
Resin-----	7-15	8-12
Tough filler-----	10-55	25-40
Hard abrasive-----	5-55	20-35
Other fillers-----	0-40	0-20

The sum of the tough filler and the hard abrasive should not exceed 75% and preferably does not exceed 50%.

The tough, abrasion-resistant and heat absorptive filler which is suitable for use in the compositions of this invention is a fused oxidic material. The material may be a fused mixture of partly reduced zirconia and titania, or may be a fused mixture in which zirconia and titania are present as solid solutions in one another and include dissolved therein about 3% to about 20% of other oxides from the group consisting of the oxides of silicon, iron, chromium and aluminum. These fused materials are complex and the exact proportions of titanium, zirconium, silicon or other reduced metal is not known, but some free metal and some oxide of the metal is desired in the complex. The complexes are produced by fusion in an electric arc furnace, in the presence of a controlled proportion of carbon, of titania and zirconia or ores which are high in titania and zirconia but also containing a smaller amount of one or more of the above named oxide materials. The mol ratio of titanium to zirconium may vary within the range of 1:9 to 9:1, or when other oxides are present, the ratio of titanium oxide to zirconium oxide may vary within the range of 2:8 to 8:2 with the other oxides constituting from 3% to 20% of the total. Particularly good results have been achieved when using, as the filler material, a fused reduced titania-zirconia product of the following approximate analysis, expressed in terms of non-reduced oxides:

	Percent
SiO ₂ -----	4.2
ZrO ₂ -----	86.3
Fe ₂ O ₃ -----	1.5
TiO ₂ -----	9.1
Al ₂ O ₃ -----	0.9

The composition exists in a chemically reduced form, as indicated by the analysis total of 102%, and it is believed that the principal element of the composition existing in a reduced state is the titanium. The product is manufactured by the Titanium Alloy Manufacturing Division of the National Lead Company, Niagara Falls, New York, and is commercially available under the trade name of TAM 85/15. It has a diamond pyramid hardness value of about 950 to 1200 which is much lower than the hardness values that have been reported for complexes consisting of the fused oxides of only zirconia and titania since these values may be as high as 2100. Materials of the above generally described type are inclusive of the specific materials which are described in greater detail in U.S. Patents 2,653,107 and 2,877,104, and any of the products of these patents are satisfactory for the purposes of this invention.

The use of the tough filler of this invention as the abrasive particles in resin bonded grinding wheels has been proposed for grinding relatively soft materials, such as steel, stainless steel and the like. Using wheels containing these tough filler particles as the only abrasive in the wheel the grinding efficiency, such as in snag grinding of stainless steel, is improved to within the range

of 2-4 times, and usually 3-4 times that obtained with conventional resinoid bonded aluminum oxide grinding wheels. It has also been suggested that the tough filler particles, of this invention could be used in conjunction with aluminum oxide or silicon carbide particles in conventional grinding wheels and the results of such addition improve the results obtained with the alumina or silicon carbide wheel, but do not equal in grinding efficiency the results obtained with the wheel containing the tough filler particles of this invention as the sole abrasive grit. When, for example, a combination wheel is made to contain 40% of the tough filler particles of this invention and 60% aluminum oxide particles, the snag grinding efficiency is about 1.8 times as good as that obtained with a wheel containing only aluminum oxide grit, and a wheel containing 70% of the tough filler particles of this invention and 30% of aluminum oxide particles produces a wheel having a grinding efficiency of about 2.6 times as good as the results obtained from a wheel containing only aluminum oxide grit, the efficiency being measured in conventional terms, that is the ratio of the pounds of metal removed per hour to the cubic inches of wheel loss per hour. In comparison, the addition of the tough filler of this invention to a diamond grinding wheel containing hard abrasive particles, in the proportions above stated, produces increases in efficiency, relative to a standard resinoid bonded diamond wheel, as high as 15 to 18 times, as is indicated in greater detail in the examples set forth hereinafter.

The hard abrasive particles which are suitable for use in the wheels of this invention are relatively hard materials having a Knoop scale hardness value of about 1800 or higher and specifically including titanium carbide, silicon carbide, tungsten carbide, zirconium carbide, tantalum carbide, chromium carbide, boron carbide, titanium nitride, and aluminum oxide. The use of relatively hard filler materials, such as silicon carbide, in conjunction with diamonds in a diamond grinding wheel of the resinoid bonded type has been previously suggested as, for example in the U.S. Patent 2,051,558, issued in 1936 to Voegli-Jaggi, and it is common practice to include such relatively hard filler materials in many conventional diamond grinding wheel compositions. The unexpected and surprising improvement achieved in the practice of the present invention is apparently not due to the hardness of the hard abrasive material, but rather to the combination functioning of those hard abrasive particles together with the tough, abrasion-resistant filler material which serves to improve the heat distribution in the bonding material and maximize the retention time of the diamonds in the wheel.

It has heretofore been known that the inclusion of relatively large proportions of hard filler materials, such as titanium nitride, titanium carbide and tantalum carbide, and the like, tends to reduce the cutting efficiency of conventional resinoid bonded diamond grinding wheels, and if too great a proportion of such a hard material is included in the wheel composition, the wheel becomes glazed during service, overheats, and its cutting action is seriously reduced. Characteristics of the tough filler material of the present invention, however, are such that it improves the tolerance of the wheel for the hard abrasive material or materials and strongly resists the tendency of the wheel to become glazed and, even though the wheel may be compounded so that it is an extremely "hard" wheel, it nevertheless runs clean and does not tend to become "loaded" or glazed. While the hard abrasive particles and the tough filler particles, when present in the minimum concentrations indicated above, produce diamond grinding wheels having increased efficiencies relative to a diamond grinding wheel containing neither of these particles, much better results are obtained when the proportions of the hard abrasive and the tough filler fall within the preferred ranges set forth.

The best results are obtained when approximately equal quantities, by weight, of the hard abrasive and the tough filler in the diamond grinding wheels are used. As the proportion of tough filler is increased toward its maximum, in the presence of any quantity of the hard abrasive, within the range specified, the grinding efficiency increases. Similarly, in the presence of any proportion of the tough filler, within the range disclosed, the increase of the hard abrasive from its minimum toward its maximum tends to increase the grinding efficiency.

The diamond abrasive may be either synthetic or natural and satisfactorily may have a particle size in the range of about 80 to 320 Tyler screen mesh, and preferably 100 to 120 Tyler screen mesh. Somewhat improved results are obtained when the diamond particles are selected so as to contain a predominant proportion of particles having a needle shape or a thin flat plate shape rather than a cubic or block-like shape. In order to achieve the desired contact between the diamond particles and the tough filler and hard abrasive particles, the size of the tough filler and hard abrasive particles should in all cases be as small as, and preferably smaller than the diamond particles which are present. Good results have been obtained from wheels containing 100 grit diamond particles and tough filler and hard abrasive particles having a size in the range of 220 to 325 Tyler screen mesh and finer. When using such materials, the tough filler and hard abrasive particles tend to orient themselves around and to lie in direct contact with each other and the diamond particles, so that maximum efficiency is obtained in distributing high quantities of heat throughout the entire body of the wheel which would otherwise be absorbed by the bond in a localized area. The high heat conductivity of the tough filler material serves this function relative to both the diamond particles and the hard abrasive particles and thus tends to prevent decrease in the abrasive holding power of the bond for each of these particles.

The wheels of this invention may also include other conventional fillers such as cryolite, barium zirconium silicate, titanium dioxide, etc., in the proportions above specified. In many instances, it is preferred that the wheels contain a quantity of such other conventional filler to aid in controlling the desired properties of wheel hardness, water resistance, and the like, according to well-known principles of grinding wheel design.

The particular bonding resin selected to constitute the resinoid bond is relatively unimportant and a large variety of suitable resins which are available on the market may be satisfactorily employed. The phenol aldehyde resins, particularly phenol formaldehyde resins, are entirely satisfactory. The selected resin preferably contains at least a proportion of a so-called "low flow" resin to optimize the distribution of the abrasive grit and the filler materials throughout the wheel. Particularly good results have been obtained from the use of phenol-formaldehyde bonding resins consisting of a mixture of 25% of Resinox 795 and about 75% of Resinox RI 5028 and a mixture of 50% of Resinox 755 and 50% of Resinox 795, these resins being available from Monsanto Chemical Company.

The diamond grinding wheels of this invention may be made in accordance with conventional manufacturing procedures. It is only necessary to uniformly admix the diamond particles, the powdered resin bond, the tough filler particles and the hard abrasive particles and other filler, when present, and this may be done by rotating these materials in a mechanical blender or a ball mill. When a ball mill is used it is desirable to exclude the diamond particles from the mix and to add them after the blending of the other components. The mixed material may be formed into solid wheels or more conventionally may be applied in the form of thin layers of about $\frac{1}{16}$ " up to about $\frac{1}{4}$ " deep on the working surface of a preliminarily formed plastic hub. In either case, the resin

bond is cured, and for phenol formaldehyde bonds this is satisfactorily accomplished by slowly raising the temperature to about 320° F. and maintaining this temperature from about 8 to about 18 hours.

Typical diamond grinding wheel compositions according to the present invention are listed in the following table:

Ingredient	Composition							
	1	2	3	4	5	6	7	8
Diamond	28	28	28	28	28	28	28	28
Resin	16	16	16	16	16	14	16	42
Tough filler (TAM 85/15)	30	52	36	44	26	37½	18	28
Hard abrasive (TIC)	30	44	44	72	32	16½	60	7
Cryolite	6	4	4	—	6	2½	6	14
BaZrSiO ₄	5	—	—	—	5	—	—	—
TiO ₂	5	—	8	—	5	7	—	—
Total	120	144	144	160	118	112	128	119
Character ¹	MS	MS	S	VH	MS	S	EH	H
Ratio A ² , percent	100	85	122	164	123	44	333	25
Ratio B ³ , percent	63	69	69	73	63	63	66	41
Ratio C ⁴ , percent	25	36	25	28	22	33	14	24

¹ Character designation: S, soft; MS, medium soft; H, hard; VH, very hard; EH, extremely hard.

² Ratio A is the weight ratio of the hard to the tough filler.

³ Ratio B is the weight ratio of the total filler to the total mass.

⁴ Ratio C is the weight ratio of the tough filler to the total mass.

NOTE.—Ingredient proportions are given as parts by weight.

The compositions listed in the table range from soft to very hard in their hardness characteristics. These variations in hardness are achieved through appropriate selections of filler materials and proportions, and by resin identity and proportion. If, for example, the hard filler, titanium carbide is increased in proportion as in Example No. 8, the wheel is relatively hard. On the other hand, in Examples Nos. 4 and 7, the titanium carbide concentration is relatively low and the wheel is soft. The composition of Example No. 1 produces a wheel characterized as hard since the resin proportion is relatively low.

All of the compositions listed in the table are based on a 100 concentration diamond grit (based on the industry accepted standard of 72 carats of diamond per cubic inch of diamond section in the finished wheel for 100 concentration) but it has been found that the diamond concentration may be reduced substantially, down to about 50 concentration, while still maintaining cutting and wear characteristics superior to other previously available 100 concentration diamond grinding wheels. The practice of the invention therefore permits the achievement of improved economy either by prolonging the service life of diamond grinding wheels having a standard diamond concentration or by reducing the diamond concentration substantially without sacrificing the previously available service life. This characteristic is more specifically illustrated in some of the specific examples which follow.

The following examples illustrate in greater detail the comparative grinding efficiencies which are achieved by the combination of hard abrasive particles and the tough filler in diamond wheels but it is to be understood that the specific proportions and specific ingredients which are employed are illustrative only and do not set forth the definitive limits of this invention which have been set forth herein above.

Example I

A number of 4" x $\frac{1}{4}$ " x $\frac{1}{4}$ " diamond grinding wheels having a $\frac{1}{8}$ " layer of the improved composition of this invention on the periphery of a plastic hub were made by blending 5.48 grams of 100 grit natural diamond, 2.8 grams of a 50%-50%, by weight, admixture of phenol-formaldehyde powdered resins designated commercially as Resinox #755 and Resinox #795, 7.66 grams of 325 mesh low free carbon grade titanium carbide, 1 gram of cryolite and 7.66 grams of TAM 85/15. The uniformly blended batch was placed in a conventional diamond

wheel die around a plastic hub, placed under pressure and preliminarily cured for about one-half hour. The wheel was then removed from the die and positioned in an oven in which the temperature was slowly raised to 320° F. and maintained for fourteen hours at that temperature. This produced 100 diamond concentration wheels containing 22.3% diamonds, 11.4% resin, 31.1% titanium carbide, 4.1% cryolite and 31.1% TAM 85/15. After curing, the wheels were trued and balanced and subjected to the following grinding test.

The wheels were placed on a commercial surface grinder which was operated at approximately 5,000 surface feet per minute and used to grind cemented tungsten carbide in the form of blocks having a size of 2½" x ¾" x 1¼". The grinding was done with a down-feed of 0.0005 inch to remove 0.100 inch, a down-feed of 0.001 inch to remove 0.200 inch, a down-feed of 0.002 inch to remove 0.200 inch and a down feed of 0.005 inch to remove 0.100 inch. The grinding efficiency was measured by the ratio of the tungsten carbide loss in cubic inches to the wheel loss in cubic inches. The average grinding efficiency for the wheels was determined to be 72.1 as compared to a grinding efficiency of 7.1 for a commercially purchased 100 concentration diamond grinding wheel of standard type and the same size which was tested on the same machine under the same conditions.

Example II

Another diamond wheel of similar size was made in accordance with the procedure described in Example I to produce a diamond wheel containing 22.3% selected natural diamond having a grit size in the range of 80 to 100 screen mesh and containing predominantly needle and flat plate shaped particles, 11.4% of the resin described in Example I, 31.1% of 325 mesh titanium carbide, 4.1% cryolite and 31.1% of 220 mesh and finer TAM 85/15.

When this wheel was subjected to the grinding test detailed in Example I the average grinding efficiency was found to be 79.8.

Example III

A grinding wheel was made to contain the identical percentage of each component as that specified in Example II with the only difference being that the diamonds present in the wheel were selected natural diamonds having a grit size between 80 and 120 screen mesh. These wheels were subjected to the grinding tests detailed in Example I. The average grinding efficiency was found to be 110.1.

Example IV

A diamond grinding wheel was prepared by using the procedures outlined in Example I to contain 10.9% of 100 grit natural diamonds, 11.2% of the resin specified in Example I, 30.5% 325 mesh titanium carbide, 43.3% 220 mesh and finer TAM 85/15 and 3.9% cryolite. This wheel is approximately a 50 concentration diamond wheel.

When this wheel was subjected to the grinding test detailed in Example I the average grinding efficiency was found to be 34.1.

Example V

A diamond grinding wheel was prepared, with the procedures of Example I, to contain 22.3% natural diamond, 11.4% of the resin specified in Example I, 17.5% 220 mesh TAM 85/15, 40.3% of 325 mesh titanium carbide, 1.5% of heavy grade titanium dioxide, 1.5% barium zirconium silicate, 1.5% rutile and 4.1% cryolite, all of the fillers other than TAM 85/15 being 325 mesh or finer. This wheel contains approximately 2½ times as much TAM 85/15 as titanium carbide. When these wheels were subjected to the grinding test specified in Example I, the average grinding efficiency was found to be 40.5

Example VI

A diamond grinding wheel of the same type specified in Example I was made by using the procedures set forth in Example I to contain 24.6% 100 grit natural diamond, 12.6% resin bond of the type described in Example I, 23.8% 325 mesh and finer silicon carbide, 34.4% 220 mesh and finer TAM 85/15 and 4.5% cryolite.

When this wheel was tested in accordance with the procedure of Example I, the average grinding efficiency was found to be 121.

Example VII

A diamond grinding wheel of the same type specified in Example I was made by using the procedures there set forth to contain 23.1% 100 grit natural diamond, 11.8 %resin bond of the type described in Example I, 28.6% 320 mesh aluminum oxide, 32.3% TAM 85/15 and 4.2% cryolite.

When this wheel was tested in accordance with the procedure of Example I, the average grinding efficiency was found to be 53.7.

Other compositions in accordance with this invention which are satisfactory are the following:

Example VIII

	Percent by weight
100 grit natural diamond	14.2
Phenol-formaldehyde resin	7.3
Tungsten carbide (325 mesh)	55.9
TAM 85/15	19.9
Cryolite	2.6

Example IX

100 grit natural diamond	16.9
Phenol-formaldehyde resin	8.6
Tantalum carbide (325 mesh)	47.8
TAM 85/15	23.6
Cryolite	3.1

Example X

100 grit natural diamond	24.6
Phenol-formaldehyde resin	12.6
Silicon carbide	12.8
Aluminum oxide	11.0
TAM 85/15	34.4
Cryolite	4.5

Example XI

100 grit natural diamond	22.3
Phenol-formaldehyde resin	11.4
Titanium carbide (325 mesh)	17.5
TAM 85/15	4.5
Heavy grade titanium dioxide	13.4
Berium zirconium silicate	13.4
Rutile	13.4
Cryolite	4.1

This application is a continuation-in-part of my application Serial No. 790,359, filed January 2, 1959, and now abandoned.

What is claimed is:

1. A resinoid bonded diamond grinding wheel composition consisting essentially of about 10% to about 30% diamonds, about 7% to about 15% of a phenol-aldehyde resinous bonding agent, about 10% to about 55% of a tough filler and about 5% to about 55% of a hard abrasive selected from the group consisting of titanium carbide, silicon carbide, tantalum carbide, tungsten carbide, zirconium carbide, chromium carbide, boron carbide, titanium nitride and aluminum oxide, said tough filler comprising a partly reduced fused mixture of zirconia and titania in which the mol. ratio of titania to zirconia is within the range of 1:9 to 9:1, the sum of said tough filler and said hard abrasive not exceeding about 75%.

2. A resinoid bonded diamond grinding wheel com-

position consisting essentially of about 10% to about 30% diamonds, about 7% to about 15% of a phenol-aldehyde resinous bonding agent, about 10% to about 55% of a tough filler and about 5% to about 55% of a hard abrasive selected from the group consisting of titanium carbide, silicon carbide, tantalum carbide, tungsten carbide, zirconium carbide, chromium carbide, boron carbide, titanium nitride and aluminum oxide, said tough filler being a partly reduced fused mixture of zirconia and titania in which the mol. ratio of titania to zirconia is within the range of 2:8 to 8:2 and which fused mixture contains from about 3% to about 20% of at least one oxide selected from the group consisting of the oxides of silica, iron, chromium and aluminum, the sum of said tough filler and the said hard abrasive not exceeding about 50%.

3. A resinoid bonded diamond grinding wheel composition comprising about 20% to about 25% diamonds, about 8% to about 12% of a phenol-aldehyde resinous bonding agent, about 25% to about 40% of a tough filler and about 20% to about 35% of a hard abrasive selected from the group consisting of titanium carbide, silicon carbide, tantalum carbide, tungsten carbide, zirconium carbide, chromium carbide, boron carbide, titanium nitride and aluminum oxide, said tough filler comprising a partly reduced fused mixture of zirconia and titania in which the mol. ratio of titania to zirconia is within the range of 1:9 to 9:1, the sum of said tough filler and said hard abrasive not exceeding about 75%.

4. A resinoid bonded diamond grinding wheel composition consisting essentially of about 20% to about 25% diamonds, about 8% to about 12% of a phenol-aldehyde resinous bonding agent, about 25% to about 40% of a tough filler and about 20% to about 35% of a hard abrasive selected from the group consisting of titanium carbide, silicon carbide, tantalum carbide, tungsten car-

bide, zirconium carbide, chromium carbide, boron carbide, titanium nitride and aluminum oxide, said tough filler being a partly reduced fused mixture of zirconia and titania in which the mol. ratio of titania to zirconia is within the range of 2:8 to 8:2 and which fused mixture contains from about 3% to about 20% of at least one oxide selected from the group consisting of the oxides of silica, iron, chromium and aluminum, the sum of said tough filler and the said hard abrasive not exceeding about 50%.

5. A resinoid bonded diamond grinding wheel composition in accordance with claim 1 wherein said tough filler is a material having an approximate analysis based on the non-reduced oxides of:

	Percent
SiO ₂ -----	4.2
ZrO ₂ -----	86.3
Fe ₂ O ₃ -----	1.5
TiO ₂ -----	9.1
Al ₂ O ₃ -----	0.9

6. A resinoid bonded diamond grinding wheel composition in accordance with claim 1 wherein the ratio of said tough filler to said hard abrasive is about 1 to 1.

7. A resinoid bonded diamond grinding wheel composition in accordance with claim 1 wherein said hard abrasive is silicon carbide.

8. A resinoid bonded diamond grinding wheel composition in accordance with claim 1 wherein said hard abrasive is titanium carbide.

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