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RESIN BONDED ABRASIVE WHEELS CONTAINING
FIBROUS AND NON-FIBROUS FILLERS
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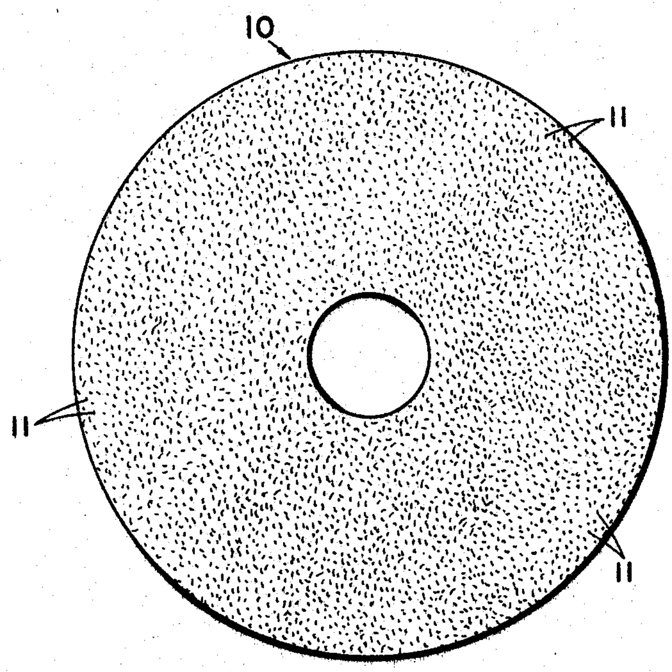

FIG. 1

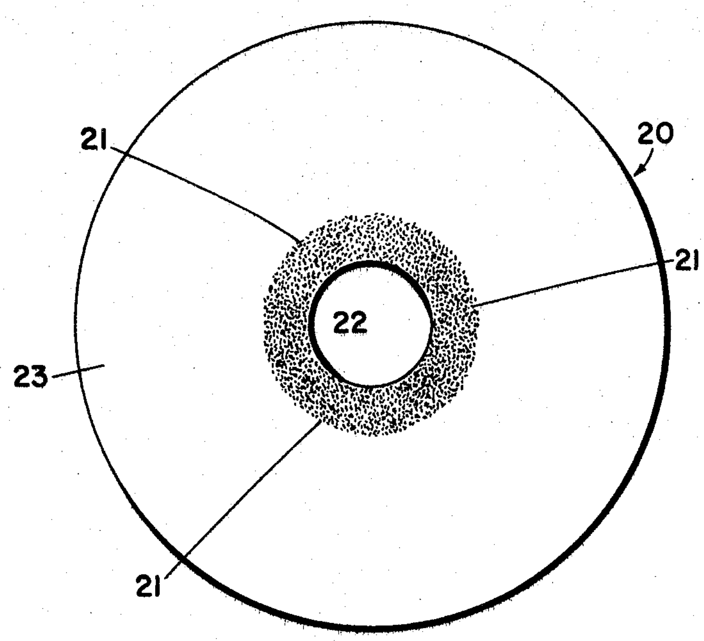

FIG. 2

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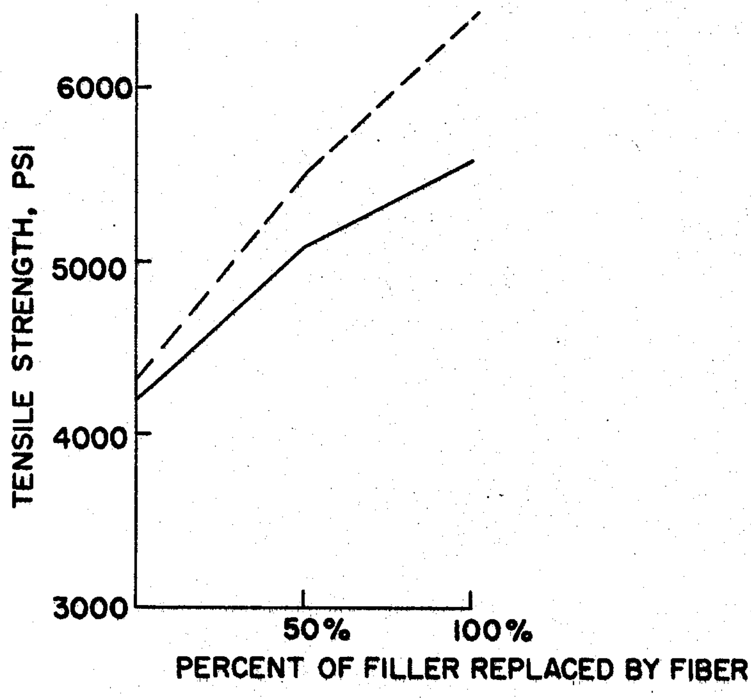

FIG. 3

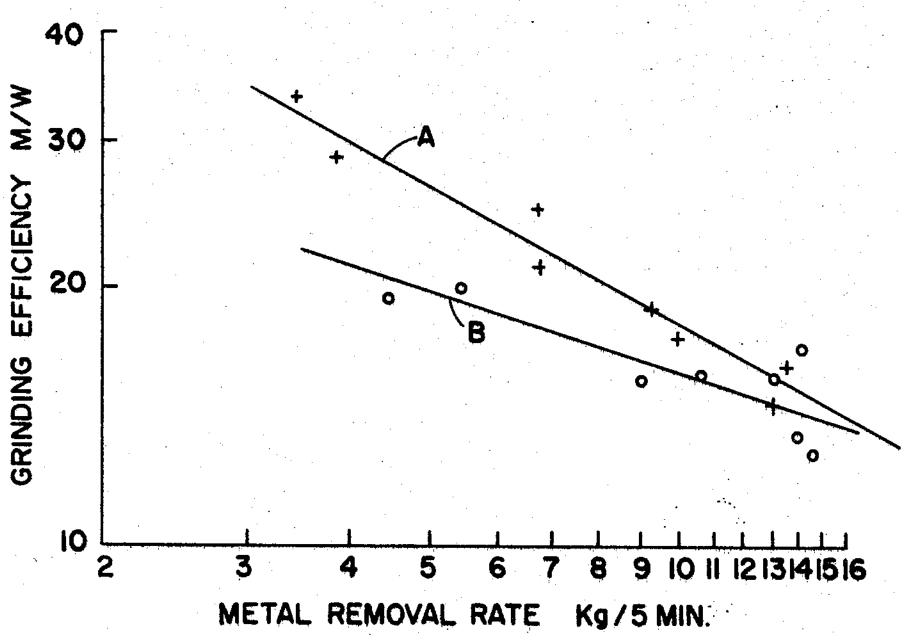

FIG. 4

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RESIN BONDED ABRASIVE WHEELS CONTAINING FIBROUS AND NON-FIBROUS FILLERS

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U.S. Cl. 51—298 7 Claims

ABSTRACT OF THE DISCLOSURE

A bonded abrasive article incorporating in the bond a filler material, at least 10 volume percent of said filler consisting of ceramic fibers having a length to diameter ratio of between 3:1 and 500:1 and an average length of 5 mm. or less. The fibers may be distributed uniformly throughout the bonded abrasive article or may be distributed only in areas of high stress, such as about the arbor of a bonded abrasive wheel.

BACKGROUND OF THE INVENTION

This invention relates to bonded abrasive articles and more particularly to bonded abrasive articles wherein the bond contains a filler, at least a portion of which filler consists of fibers of controlled length to diameter ratio.

Abrasive articles and more particularly bonded abrasive grinding wheels are often provided with a reinforcing member or reinforcing material in order to improve the strength and increase the bursting speed of the article. Such is often the case for heavy-duty grinding wheels which incorporate coarse abrasive grit, 6–24 grit, since wheels having coarse abrasive grit generally have lower strengths and lower bursting speeds than wheels using the same bonding material but having fine grit abrasive. Wheels containing still coarser grit could probably be reinforced more efficiently with short glass fibers because of reduced processing problems. Reinforcing materials are also used in wheels designed for high speed grinding operations since such wheels must have high strength to withstand the high speeds at which they are operated.

Various means for reinforcing abrasive articles have been employed in prior art abrasive articles such as wire mesh, resin impregnated cloth and ceramic fibers in the form of woven fabric, yarns, felted pads and individual fibers and the like. Such reinforcing means are, however, subject to several disadvantages. First of all, their use in bonded abrasive articles requires special manufacturing techniques which raise the cost of producing reinforced bonded abrasive articles. Further, when using fibers as reinforcing means in dense abrasive articles, which are normally produced by the application of both heat and pressure, the abrasive particles often cut the fibers thus reducing the effectiveness of the reinforcing material.

Accordingly it is an object of this invention to provide a reinforcing material which can be readily incorporated in bonded abrasive articles without the need for special manufacturing techniques.

Another object of this invention is to provide improved resin bonded abrasive articles having higher strength and improved bursting speeds as well as improved grinding efficiencies.

These and other objects and advantages will appear from the following description of several embodiments of the invention, and the novel features will be particularly pointed out in connection with the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of an abrasive article made according to this invention showing fibers uniformly distributed throughout the article.

FIG. 2 is a side view of an embodiment of this invention showing fibers distributed in an area of high stress.

FIG. 3 shows the improvement in tensile strength with increased amount of fiber in the bond.

FIG. 4 shows improved grinding efficiency of an abrasive article containing fibers according to this invention compared to an abrasive article similar in all respects except the bond contain no fiber.

SUMMARY OF THE INVENTION

The novel bonded abrasive articles of this invention comprise abrasive grains united by a resin bond wherein said bond includes fibers having a length to diameter ratio of between 3:1 and about 500:1.

DESCRIPTION OF THE INVENTION

It has been discovered that when fibers of controlled length to diameter ratio, between 3:1 and 500:1 and preferably between about 10:1 and 200:1, are incorporated in the bond of a bonded abrasive article there is achieved an improvement in grinding efficiency and improved tensile strength and bursting speed.

Abrasive articles made according to this invention comprise abrasive grain united by a resin bond into an integral body. The abrasive grain may be any abrasive material, for example, silicon carbide, alumina, glass, garnet, quartz, diamond or mixtures thereof. The grit size may be varied in accordance with the usual practice in order to achieve specific types of abrasive articles.

Various types of resins are used as the bond to unite the abrasive grains and the selection of a particular resin depends, among other things, on the nature of the material to be ground, wheel speed, type of grinding machine, and other factors well-known to one skilled in the art. Among the resins used are natural and synthetic rubber, shellac, phenolic resins, epoxy resins, and others well-known in the industry as a suitable bond for abrasive articles.

In accordance with the present invention the bond is improved by the addition of fibers having a length to diameter ratio of between 3:1 and 500:1 to the resin. It is preferred that the fibers range in length from between about 100 microns to about 1 mm. although fibers that range in length from 30 microns up to about 5 mm. have been used.

The fibers, which either occur naturally or are produced by well-known methods such as spinning or drawing, are produced from materials which form relatively high strength fibers able to withstand the temperatures encountered during production of the abrasive article and the temperatures and conditions encountered during use of the article. Among such materials are silica, glass, mineral wool, quartz, silicates such as aluminum silicate, asbestos and mixtures thereof. Fibers used in this invention normally range from about 8 to about 40 microns in diameter. They may be formed from staple fibers, i.e. fibers having a length to diameter ratio greater than 500:1, by such means as ball milling to reduce the length to diameter ratio of the fibers to the desired range of between 3:1 to 500:1.

In formulating abrasive articles according to this invention, the fibers in the bond are considered as a filler material and, as is well-known in the abrasive field, proportions of filler may vary widely depending on application and the bonding used in forming the abrasive article. The fibers may be used in conjunction with non-fibrous filler materials such as pyrites, cryolite, common salt, calcium oxide and the like. The fibers may be uniformly distributed throughout the abrasive article as is shown in FIG. 1 wherein a bonded abrasive grinding wheel **10** is shown having fibers **11** of a length to diameter ratio of between 3:1 and 500:1, said fibers being uniformly distributed throughout said wheel, in the bond thereof.

For certain applications the presence of fibers in the working area of the abrasive article may be undesirable while fiber reinforcement around areas of high stress is desired. In such cases reinforcement of the article at high stress areas, such as around the arbor hole, is accomplished by modifying the bond around such high stress area with fibers in accordance with this invention while the bond of the remaining portion of the article contains no filler or only a nonfibrous filler.

Such an embodiment of this invention is shown in FIG. 2. An abrasive wheel **20** is shown wherein the fibers **21** are distributed in the bond around arbor hole **22**. The outer portion **23** of the wheel contains no fiber.

Abrasive articles may be made according to this invention by commonly known methods of manufacture such as cold pressing or hot pressing. One such method of producing abrasive articles according to this invention comprises the steps of distributing the fiber in a resin, forming a mixture of said fiber-including resin and abrasive grain and molding said mixture under compression and at a sufficient temperature to cure the resin and unite the abrasive grain. It is important to obtain an even distribution of the fiber in resin and it has been found that for best results the fiber should be mixed with the resin while the latter is maintained slightly above its melting point. Adequate mixing of fiber and resin, however, is also achieved by mixing the fibers and resin in a mill, such as a hammer mill.

As a further aid in insuring uniform mixing of fiber and resin it is preferred that the average length of the fibers be 5 mm. or less.

It has been found that when a substantial portion of the fibers are in excess of about 5 mm. in length it is very difficult to obtain good distribution of the fiber in the resin and that further problems, such as difficulty in obtaining uniform density and grain distribution, may be encountered in forming the finished abrasive article without the use of special techniques of manufacture.

The following specific examples describe the manner in which the novel abrasive articles of the present invention can be prepared. These examples are given for illustrative purposes only, it not being intended to limit the invention to the specific proportions and uses set forth below.

Example 1

A standard abrasive wheel, 12 inches in diameter, 1 inch thick and having an arbor hole 2 inches in diameter (12" x 1" x 2½") was made from the following raw batch.

	Vol. percent
Abrasive (8 grit fused Al_2O_3 containing 10% ZrO_2)	54
Bond	46

The bond consisted of the following materials:

	Vol. percent
Resin (non-modified phenolic Novolac identified as Varcum 3030)	62
Filler:	
Pyrites (325 mesh)	20
K_2SO_4	8
NaCl	7
CaO	3

The resin, filler and abrasive were mixed to form a raw batch. The raw batch was charged into a mold and compression molded at a pressure of 3500 p.s.i. and a temperature of 171° C. for one hour.

A test wheel was made in the same manner and using the same materials and proportions as is the standard wheel except that about 50 volume percent of the nonfibrous filler was replaced by glass fibers having a length to diameter ratio of between 3:1 and 500:1. The average length of the fibers was 0.793 mm.

In forming the raw batch, the resin and fibers were first mixed while the resin was in a melted condition. This was accomplished by mixing the resin and fibers on heated rolls of a two roll mill. The resin temperature was maintained at about 110° C. which is slightly above the resin melting temperature of 98° C.–104° C. After mixing, the resin-fiber mix was allowed to cool and then crushed. The crushed resin-fiber mix was combined with the filler and abrasive grain to form a raw batch which was then compression molded in the same manner as for the standard abrasive wheel.

The bursting speeds of the standard abrasive wheel and the test abrasive wheel containing fiber made according to the above procedure were determined. The standard wheel had a bursting speed of 21,600 r.p.m. while the test wheel containing fibers had a bursting speed of 25,700 r.p.m., which represented a 17 percent improvement in bursting strength over the standard wheel which contained no fibers.

The following example demonstrates the effect of incorporating fibers in the bond of abrasive articles on the grinding efficiency of such articles.

Example 2

Two standard 12" x 1" x 2½" abrasive wheels and two test wheels of the same dimensions as the standard wheels were produced as in Example 1. The filler of the test wheels including about 50 volume percent of glass fibers. The wheels were tested for grinding efficiency on a rotary tester using type 304 stainless steel billets as the material to be ground. The wheels were run at 9500 s.f.p.m. The wheels were tested at grinding pressures of 450 lbs., 550 lbs., 650 lbs. and 750 lbs. The results of the grinding tests are shown in Table A.

Grinding efficiency is reported as M/W where M represents kg./5 min. of material removed and W represents kg./5 min. of wheel loss.

FIG. 4 is a plot of grinding efficiency M/W vs. metal removal rate kg./5 min. as taken from Table A. The test wheel results are plotted as crosses while the standard wheel results are plotted as circles. Line A is a straight line fit to the plot of the test wheel results; line B represents a straight line fit to the standard wheel test results.

From FIG. 4 it can be seen that the abrasive articles containing fibers in the filler had improved grinding efficiencies over the standard abrasive wheel, particularly at lower metal removal rates.

Example 3

To determine the effect of increasing percentages of fiber on bond strength a series of 8" x 1" x 1" bars consisting of 52 volume percent 8 grit sintered bauxite abrasive and 48 volume percent bond were made. Control bars were produced having the following two bond formulas:

	Formula 1, vol. percent	Formula 2, vol. percent
Resin (as in Example 1)	70	60
Filler:		
Pyrites	15	22
K_2SO_4	7	8
NaCl	5	7
CaO	3	3

TABLE A

	Grinding pressure											
	450 lbs.			550 lbs.			650 lbs.			750 lbs.		
	M [1]	W [2]	M/W	M	W	M/W	M	W	M/W	M	W	M/W
Control wheel	5.40	.25	20.2	10.6	.68	15.7	13.9	1.1	13.0	11.4	.68	16.6
(Filler contained no fiber)	4.6	.23	19.8	9.1	.58	15.7	13.7	1.0	13.7	10.9	.71	15.6
Test wheel	3.45	.106	32.6	6.6	.31	21.0	9.9	.57	17.3	13.3	.79	16.7
(Filler contained 50 vol. percent glass fiber)	3.75	.134	28.0	6.6	.28	23.7	9.2	.48	18.9	13.0	.84	15.4

[1] M is kg./5 min. of stainless steel removed by abrasive wheel. [2] W is kg./5 min. of wheel loss.

The bars were compression molded at 171° C. at a pressure of 2700 p.s.i.

Test bars having 25 volume percent, 50 volume percent, 75 volume percent and 100 volume percent of the nonfibrous filler replaced by glass fibers of the type used in Example 1 were made in the same manner as the control bars from each of Formulae 1 and 2.

The control and test bars were tested for tensile strength by the internal split method. This method comprises supporting the bar to be tested by appropriate means between opposed knife-edge jaws running across the width of the bar. The jaws are urged together with increasing force thereby setting up internal tensile stress in the bar. Force on the jaws is increased until the bar fails. The results are reported as tensile strength in pounds per square inch.

The test results are shown in FIG. 3 which is a plot of tensile strength vs. volume percent fiber present in the filler. The solid line represents Formula 1 bond composition while Formula 2 bond compositions are represented by the dashed line.

Similar increases in bond strength are achieved when aluminum silicate or mineral wool fibers are used as a filler in the bond and it is within the scope of this invention to use any fibrous ceramic material as a filler in abrasive articles made according to this invention.

As has been shown, the fibers may constitute the entire filler of the bond or may be used in conjunction with nonfibrous fillers. When used with nonfibrous fillers it has been found that best results are achieved when at least 10 volume percent of the filler consists of fibers.

Although the examples of this specification show the use of ceramic fibers to reinforce hot pressed articles, it should be clear that it is within the scope of this invention to use ceramic fibers of controlled length to diameter ratio in cold pressed and sintered articles as well.

While the invention has been described in connection with specific embodiments thereof, it will be understood that it is capable of further modifications and this application is intended to cover any variation, uses or adaptations of the invention following the principles of the invention and including such departures from the present disclosure as come within known or customary practice in the art to which the invention pertains and as may be applied to the essential features hereinbefore set forth or as fall within the scope of the appended claims.

I claim:

1. A bonded abrasive grinding wheel consisting of abrasive grains united into an integral body, at least a part of the grinding wheel being united by a bond comprising a resin selected from the group consisting of natural and synthetic rubber, shellac, phenol aldehyde resins and epoxy resins and a filler consisting essentially of from 0% to about 90% by volume of the total amount of filler of nonfibrous filler selected from the group consisting of pyrites, cryolite, sodium chloride, calcium oxide, potassium sulfate and mixtures thereof, and from 100% to about 10% by volume of the total amount of filler of fibrous filler consisting of fibers selected from the group consisting of silica, glass, mineral wool, quartz, aluminum silicate, asbestos and mixtures thereof, having a length to diameter ratio of between about 3:1 and 500:1 and an average length of between about 100 microns and about 1 millimeter.

2. The bonded abrasive grinding wheel of claim 1 wherein at least 10 volume percent of the total amount of filler consists of glass fibers.

3. The bonded abrasive grinding wheel of claim 1 wherein the fibrous filler comprises from about 30 to about 60 volume percent of the total amount of filler.

4. The bonded abrasive grinding wheel of claim 1 wherein the fibrous filler comprises about 100 volume percent of the total amount of filler.

5. A raw batch suitable for producing a bonded abrasive grinding wheel comprising a resin selected from the group consisting of natural and synthetic rubber, shellac, phenol aldehyde resins and epoxy resins, abrasive grain and a filler consisting essentially of from 0% to about 90% by volume of the total amount of filler of nonfibrous filler selected from the group consisting of pyrites, cryolite, sodium chloride, calcium oxide, potassium sulfate and mixtures thereof, and from 100% to about 10% by volume of the total amount of filler of fibrous filler comprising fibers selected from the group consisting of silica, glass, mineral wool, quartz, aluminum silicate, asbestos and mixtures thereof, having a length to diameter ratio of between about 3:1 and about 500:1, the fibers ranging in length from about 100 microns to about 1 millimeter.

6. The bonded abrasive grinding wheel of claim 1 wherein the fibers are distributed substantially uniformly throughout the grinding wheel.

7. A process for producing the bonded abrasive grinding wheel of claim 1 comprising the steps of forming a raw batch consisting essentially of a resin selected from the group consisting of natural and synthetic rubber, shellac, phenol aldehyde resins and epoxy resins, abrasive grains, and a filler consisting essentially of from 0% to about 90% by volume of the total amount of filler of nonfibrous filler selected from the group consisting of pyrites, cryolite, sodium chloride, calcium oxide, potassium sulfate and mixtures thereof, and from 100% to about 10% by volume of the total amount of filler of fibrous filler consisting of fibers selected from the group consisting of silica, glass, mineral wool, quartz, aluminum silicate, asbestos and mixtures thereof, having a length of between about 100 microns and about 1 millimeter and a length to diameter ratio of between 3:1 and 500:1, and forming the bonded abrasive grinding wheel from the raw batch by the application of pressure and heat.

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