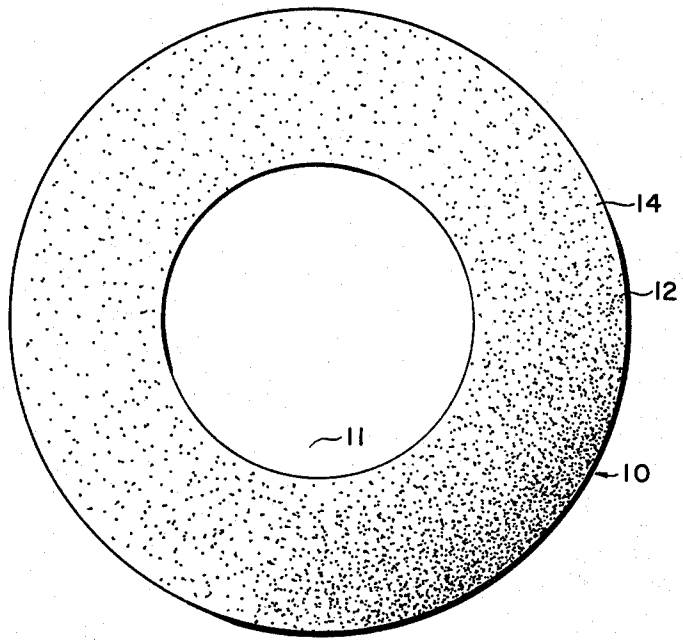
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MIXTURE OF FUSED ALUMINA AND FUSED ZIRCONIA GRANULES IN BONDED ABRASIVE ARTICLES

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MIXTURE OF FUSED ALUMINA AND FUSED ZIRCONIA GRANULES IN BONDED ABRASIVE ARTICLES

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This invention relates generally to bonded abrasive bodies, particularly to improved bonded abrasive wheels composed of a mixture of fused alumina and fused zirconia granules. More particularly, the invention relates to heavy duty grinding wheels, such as snagging wheels, that can be used effectively in the rough grinding of stainless steel, such as, for example, the grinding of billets and cutting off the gates and risers on castings.

This application is a continuous-in-part of my copending application Serial Number 26,576, filed May 3, 1960, now abandoned.

The bonded abrasive wheels, that are ordinarily used for grinding stainless steel billets, and for other rough work on stainless steel, are made form bonded crushed fused alumina grain. These wheels are characterized by efficient performance in cutting through surface scale; however, wheels of this type are characterized by relatively poorer performance, by comparison, when grinding the metal itself.

Recently, bonded wheels made with crushed fused zirconia grain have been made and used for grinding stainless steel billets. Wheels of this type are characterized by relatively poor performance for grinding scale from stainless steel, but grinding performance on the metal itself is good. Comparative testing has indicated that fused zirconia is superior to fused alumina as an abrasive for heavy duty grinding wheels. However, the crushed fused zirconia grain, despite its superior performance, has not been untilized extensively due to the high cost of the grain. The superior performance does not justify the greater cost of the bonded abrasive wheel. Moreover, the high pressures which must be used with wheels made with fused zirconia grain makes such wheels unsuitable for manual operation.

It is therefore an object of the present invention to provide a bonded abrasive body that is characterized by superior grinding effectiveness and efficiency.

Another object of the invention is to provide grinding wheels useful for most grinding operations where wheels having alumina or ziconia grains are currently used but giving results superior to those given by such alumina or zirconia-containing wheels.

Another object of the invention is to provide a bonded abrasive wheel composed of a mixture of fused alumina and fused zirconia granules and characterized by superior performance, as compared to wheels previously available, for the rough grinding of stainless steel.

A further object of the invention is to provide a snagging wheel that can be manufactured at a competitive manufacturing cost and that is characterized by superior performance for the rough grinding of stainless steel, and that is relatively easy to employ in manual grinders.

Various other objects and advantages will appear from the following description of an embodiment of the invention, and the novel features will be particularly pointed out hereinafter in connection with the appended claims.

I have found that superior performance, for the grinding of stainless steel and the like, can be obtained from a bonded abrasive body, such as a snagging wheel, that is made from a bond and a grain mixture of crushed fused alumina grain and crushed fused zirconia grain. Although it would normally be expected that wheels composed of a combination of fused alumina and fused zirconia grains would have properties intermediate to the properties of wheels composed essentially of the individual components, I have found that abrasive wheels composed of a combination of the two grains have performance characteristics superior to wheels made either of fused alumina or fused zirconia alone. This surprising and unexpected functional benefit resulting from the joint use of fused alumina grain and fused zirconia grain in admixture in the same bonded brasive body offers the distinct advantage of lowering the cost of the abrasive article by reducing the amount of zirconia in the article without detracting, and in fact, enhancing its performance characteristics when all factors of use are collectively considered.

The reasons for this surprising result are not fully understood. However, it appears that zirconia wheels are very efficient in grinding the solid base metal due to lack of chemical affinity for the base metal, but due to low hardness are poor in penetrating hard surface scale. Alumina wheels, on the other hand, penetrate scale well but are not as efficient on the base metal. Apparently, the combination of the two grains, in admixture in the same bonded abrasive body, provides a balanced composition which effectively penetrates scale and efficiently grinds the base metal.

While my invention may be utilized in various forms of grinding wheels, in the accompanying drawing, I have shown a side elevation of one form of grinding wheel embodying my invention. Reference numeral **10** designates generally a grinding wheel composed of abrasive particles **12** that are held together by a bonding material **14**. Arbor hole **11** provides a means for mounting the wheel on a rotating shaft not shown.

Abrasive bodies made in accordance with my invention can readily be made from commercially available grains. The crushed fused alumina grain is the commercially available product of a regular alumina electric furnace, crushed and screened for size. Either stabilized or unstabilized zirconia grain may be used; however, unstabilized grain is generally preferred, since it is less expensive than the stabilized grain and the temperature range in which the abrasive bodies are used does not necessitate the stabilized grain.

In general, the grain size will range from No. 8 grit to about No. 220 grit, in accordance with the use to which the bonded abrasive body is to be put.

The relative proportions of the grains in abrasive bodies made according to my invention will vary according to the use to which they are put. I prefer a composition of 50 percent alumina, by volume, and 50 percent zirconia, by volume. I have obtained excellent results with bodies having a composition of 25 percent zirconia, by volume and 75 percent alumina, by volume. In general it is desirable that at least 15 percent, by volume of each type of grain be included.

The mixture of crushed fused alumina grain and crushed fused zirconia grain is bonded with any thermosetting resinoid bond of the type that is conventionally used in the manufacture of bonded abrasive products. Thermosetting resinoid bonds suitable for use in my invention include, for example, bonds that are based on phenolic resins and amine formaldehyde resins. Natural rubber, synthetic rubbers such as butadiene-acrylonitrile and butadiene-styrene polymers, and shellac bonds may be used for high-speed wheels, but are not as satisfactory as resin bonds. Therefore, their use in wheels embodying my invention is limited.

Bonded abrasive bodies embodying my invention may be made by the various standard procedures for making bonded abrasive wheels. Where the bond is a phenol formaldehyde resin, the bond, with or without fillers or

modifiers may be thoroughly admixed with the grain and after thorough admixture, the mix may be placed in a mold and hot pressed according to the standard procedures employed in the manufacture of resinoid bonded wheels.

Alternatively, the abrasive bodies can be made by pressing the mixture of abrasive grains and bond, with or without a filler or modifier, in a mold at room temperature to form an abrasive article of the desired shape, followed by the subjection of the molded article to heat treatment to cure or mature the bond.

The following examples will serve to illustrate the superior results obtained by abrasive wheels made according to my invention.

EXAMPLE I

Snagging wheels embodying my invention have been made as set forth below.

Wheel mix:	Percent by weight
Abrasive grain (50% by vol. alumina/50% by vol. zirconia)	79
Phenolic resin	8
FeS_2	6
Cryolite	6
CaO	1

The abrasive grain, a mixture of equal parts of Nos. 10, 12, 14 and 16 grit, were wet with furfural in the amount of 55 cc. of furfural per kilogram of resin. The abrasive grain wet with furfural was placed in a mixer and thoroughly admixed with the powdered phenolic resin, pyrites and cryolite fillers and CaO modifier. The mixture was then molded in a hot press at about 325° F. for 1 hour and then cured at 350° F. The wheels thus made had a porosity of about 3.5%.

EXAMPLE II

To provide a comparison between the operating characteristics of bonded abrasive wheels embodying my invention, and prior art wheels, three groups of bonded abrasive wheels were made with three different types of grain, the wheels having the same grit size and binder. One group of bonded abrasive wheels was made using crushed fused alumina grain; a second group with crushed fused zirconia grain; and a third group with a mixture of grains containing substantially equal parts by volume of crushed fused alumina and crushed fused zirconia granules.

In order to provide comparative results, a standard procedure was followed for making all of the bonded abrasive wheels. That is, the non-abrasive ingredients and the standard wheel making technique were kept constant for all the bonded abrasive wheels. The grain size was kept constant and was uniform for all the wheels. Thus, three identical sets of wheels were made, that is, identical except that one set had fused alumina abrasive, another set had fused zirconia abrasive, and the third set had an abrasive mixture composed of 50% by volume fused alumina grain and 50% by volume fused zirconia grain.

The abrasive grains in each case were first wet with a plasticizer, furfural, and the wet abrasive grain then thoroughly mixed with the bond, a heat-hardenable powdered phenolic resin and a filler, cryolite. The wet abrasive grain was mixed with the mixture of bond and filler until the abrasive had picked up substantially all the powdered resin. This mixture was then molded in a hot press at about 330° F. for 45 minutes, according to standard procedure used in the manufacture of resinoid-bonded abrasive wheels.

The wheels thus made were 24" in diameter and 3" thick and had a 12" diameter arbor hole. An equal number of wheels of each type was employed in a mechanical grinder, grinding stainless steel billets under uniform operating conditions until the wheel diameters were reduced from 24" to 20". The results observed are tabulated below.

Table I

Wheel	Hours of Useful Life	Wheel Wear, Cubic Inches Per Hour W	Total Material Removed (in pounds)	Material Removed, Pounds Per Hour M	Quality, M^2/W	Efficiency, M/W
100% Alumina	2.8	148	430	153.6	159	1.04
100% Zirconia	4.3	96.5	440	102.3	108	1.06
50% Alumina, 50% Zirconia	3.2	129	495	154.7	186	1.20

Two factors govern the performance of a heavy duty grinding wheel. These are the amount of metal removed per unit time and the wheel loss per unit time. Two units have been used by the industry to judge the performance of a grinding wheel based on these two interrelated factors. The first ratio is the ratio of the metal removed per cubic inch of wheel wear, M/W. This ratio represents the relative value of the wheel without taking into consideration the operators' pay or the overhead in the mill where the wheel is used. To take into account the labor costs and overhead, a second factor has been utilized which weights the metal removed more heavily than the wheel wear. This quality factor is the ratio of the square of the metal removed to the wheel loss M^2/W. This quality factor is a true indication of the value of the wheel. By both comparisons, it will be seen that the wheels having a mixture of alumina and zirconia grains were superior to wheels having only alumina grains or zirconia grains as the abrasive.

EXAMPLE III

To provide a further basis of comparison between wheels made in accordance with my invention and the bonded alumina wheels now widely used, a second test was made in which an equal number of alumina wheels and alumina-zirconia wheels, made and operated as described in connection with Example II, were reduced to a stub diameter of 16". At this point the wheels are considered to have no further useful life. The non-abrasive ingredients and standard wheel making technique were kept constant for both wheel groups. An equal number of wheels of each type was employed in a mechanical grinder, grinding stainless steel billets under uniform operating conditions. The results are tabulated in Table II.

Table II

Wheel	Hours of Useful Life	Wheel Wear, Cubic Inches Per Hour W	Total Material Removed (in pounds)	Material Removed, Pounds Per Hour M	Quality, M^2/W	Efficiency, M/W
100% Alumina	5.3	142	746	149.7	139	.99
50% Alumina, 50% Zirconia	8.58	88	1,090	127	183	1.45

It will be seen that both the quality factor, M^2/W, and the efficiency factor, M/W, of the wheels embodying my invention were superior to wheels having only alumina grains as the abrasive.

EXAMPLE IV

A test similar to those described above was made comparing the standard fused alumina wheel with a wheel made according to my invention having a composition of alumina, 75% by volume, and zirconia, 25% by volume. Both types of wheels were made and operated as described in connection with Example II, the non-abrasive ingredients and the standard wheel making technique being kept constant for both wheel groups. These wheels were 24" in diameter and 2½" thick. An equal number of wheels of each type was employed in a mechanical

grinder, grinding stainless steel billets under uniform operating conditions until the wheels were reduced to a stub diameter of 16". The results of the test are compiled in Table III.

Table III

Wheel	Hours of Useful Life	Wheel Wear, Cubic Inches Per Hour W	Total Material Removed (in pounds)	Material Removed, Pounds Per Hour M	Quality, M^2/W	Efficiency, M/W
100% Alumina	3.73	168	558	149.6	133	.89
75% Alumina, 25% Zirconia	4.7	134	660	140.4	147	1.05

The wheels made according to my invention again demonstrated superior performance.

The foregoing examples indicate clearly the surpising results obtained by wheels embodying my invention. In each instance, the wheels have an abrasive body composed of a mixture of alumina and zirconia grains had a quality factor and efficiency factor higher than that of wheels utilizing either alumina or zirconia grains alone. Thus, my invention provides an abrasive body which gives superor performance to known abrasive bodies at a cost less than the cost of the best known abrasive bodies.

In the manufacture of snagging wheels and other bonded abrasive bodies, in accordance with this invention, it will be understood that standard manufacturing procedures for making bonded abrasive bodies are followed. Accordingly, grit size, the specific thermosetting bond, and the proportion of grit in relation to the bond, may be varied in accordance with the particular application for which the bonded abrasives are intended.

While the invention probably will find greatest application in the manufacture of snagging wheels for use in the rough grinding of stainless steel, such as, for example, the grinding of billets and cutting off the gates and risers on castings, the invention can also be applied to the manufacture of other bonded abrasive bodies.

While the invention has been described in connection with a specific embodiment thereof, it will be understood

that it is capable of further modification, and this application is intended to cover any variations, uses or adaptations of the invention. It will therefore be recognized that the invention is not to be considered as limited to the precise embodiments shown and described but it is to be interpreted as broadly as permitted by the appended claims.

I claim:

1. An abrasive body consisting essentially of abrasive grain and a thermosetting resinoid bond therefor, said grain consisting essentially of a mixture of about 85% to about 15% by volume fused alumina grain and about 15% to about 85% by volume of fused zirconia grain.

2. An abrasive body consisting essentially of abrasive grain bonded thermosetting resinoid bond, said grain consisting essentially of a mixture of about 75% to about 25% by volume fused alumina grain and about 25% to about 75% by volume fused zirconia grain.

3. An abrasive body consisting essentially of thermosetting resinoid bonded abrasive grain, said grain consisting essentially of a mixture of about 50% by volume fused alumina grain and 50% by volume fused zirconia grain.

4. An abrasive body according to claim 3 in which the resinoid bond is a phenolic resin.

5. A grinding wheel consisting essentially of abrasive grain bonded with a thermosetting resinoid bond, said grain consisting essentally of a mixture of about 75% to about 50% by volume fused alumina grain and about 25% to about 50% by volume fused zirconia grain.

6. A grinding wheel comprising abrasive grain bonded with a thermosetting resinoid bond, said grain consistng essentally of a mixture of about 50% by volume fused alumina grain and about 50% by volume fused zirconia grain.

7. A grinding wheel according to claim 6 in which the thermosetting resinoid bond is a phenolic resin.

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