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ABRASIVE ARTICLE CONTAINING ZIRCONIUM TETRAFLUORIDE FILLER

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This invention relates to the manufacture of abrasive articles such as grinding wheels and more particularly to grinding wheels incorporating a novel and improved filler.

One widely used type of grinding wheel is essentially composed of abrasive grains bonded in a matrix comprising a synthetic resin, commonly a phenolic resin, having an inorganic filler in powder form dispersed therethrough. It is known that fillers of this type give stability to the molded product during cure and are also a necessary component of a high-strength bond, particularly in the case of hard, dense grinding wheels.

It has been generally accepted that fillers possessing special properties are required on severe dry grinding operations, especially when the grinding of highly corrosion-resistant metals is involved. Billet snagging and cutting off operations typify cases in which special fillers are required.

While several possible mechanisms have been suggested to account for the improved performance obtained when fillers are incorporated in the bond, it is not possible to demonstrate conclusively which if any of these proposed mechanisms is in fact responsible for the improved results obtained. In general the utility of particular fillers or classes of fillers must be established by experiment. This is especially true of blends of different fillers, which in some cases have been found to exhibit a synergistic effect. Accordingly empirical criteria have been found to be essential in evaluating such fillers.

In the present specification, two empirical criteria will be used for indicating the relative effectiveness of the various filler materials referred to, namely, grinding ratio and metal removal rate. Grinding ratio is expressed as the number of cubic inches of metal removed for each cubic inch of wheel wear. For example, if in the course of a grinding operation, 25 cubic inches of metal is removed from the piece of metal being ground and at the same time 5 cubic inches of the grinding wheel is worn away, the grinding ratio will be 5.0. Metal removal rate is expressed in cubic inches per minute. If for example 25 cubic inches of metal is removed from the piece of metal being ground over a period of five minutes, the metal removal rate is 5.0. It is evident that grinding ratio and metal removal rate as thus defined will vary as a function of both grinding wheel properties and the nature of the metal being ground. Hence valid comparisons can be achieved only by grinding a particular metal stock under standardized conditions.

It is an object of the present invention to provide a resin-bonded abrasive article having improved grinding properties. It is another object of the invention to provide a resin-bonded abrasive grinding wheel containing a novel filler that confers improved grinding properties on the wheel, especially when the wheel is used for severe dry grinding operations such as billet snagging and cut-off operations. It is still another object of the invention to provide a resin-bonded abrasive grinding wheel which exhibits an improved grinding ratio and/or metal removal rate. It is a still further object of the invention to provide a grinding wheel that is free from the phenomenon known as "loading," i.e., a wheel that does not accumulate particles of ground metal at the grinding surface thereof. Other objects of the invention will be in part obvious and in part pointed out hereafter.

The present invention is predicated upon the discovery that the compound zirconium tetrafluoride (ZrF_4) possesses exceptionally useful properties as a filler in resinoid grinding wheels. This compound can be used alone as a filler, or it can be blended in various proportions with other known fillers as described more fully hereafter. When incorporated as the sole filler in resin-bonded wheels to be used on severe dry grinding operations, it provides wheels that exhibit substantial improvement in metal removal rate over wheels containing conventional fillers such as cryolite, pyrite and zinc sulfide.

It has been further found that zirconium tetrafluoride can be added to and blended with formulations containing conventional fillers to produce wheels that exhibit grinding ratios and/or metal removal rates that are superior to those obtained when either zirconium tetrafluoride or a conventional filler is used alone. The effect of the zirconium tetrafluoride on conventional fillers when mixed therewith makes it possible for the less expensive conventional fillers to be used as a relatively high percentage of the total filler and still maintain attractive performance levels.

When zirconium tetrafluoride is used as the sole filler, it has been found to be operative over a fairly wide range of proportions, i.e., 5% to 45% of the volume of the bond. When the zirconium tetrafluoride is blended with conventional fillers such as cryolite, iron sulfide (pyrite), zinc sulfide and the like, it is desirably used to the extent of at least 5% by volume of the total filler. Since zirconium tetrafluoride can be used alone as a filler, there is no upper limit to the amount that can be used in blended fillers. In other words, the zirconium tetrafluoride can vary from 5% to 100% of the total filler in the wheel.

In order to point out more fully the nature of the present invention, the following example is given of an illustrative embodiment of a grinding wheel incorporating the invention and a method of making such a grinding wheel:

A number of snagging wheels were made up as described herein incorporating various fillers as specified in Table 1 below. For purposes of comparison, the data of Table 1 include values for a number of conventional fillers, e.g., cryolite (Na_3AlF_6), pyrite (FeS_2), and zinc sulfide. These snagging wheels were tested in accordance with the method described herein to determine grinding ratio and metal removal rate and the values are set forth in Table 1. The formulation employed in making these grinding wheels was as follows:

58.63 parts by volume of Al_2O_3 abrasive grain (⅓ each, 12 grit, 14 grit, 16 grit)
8.67 parts by volume of liquid resin (50% Varcum 8121, 50% furfural)
1.53 parts by volume calcium oxide
17.96 parts by volume of powdered phenolic resin (Varcum 3034)
13.22 parts by volume of filler

The abrasive grain was mixed with the liquid resin in a mixer to cause the liquid resin to coat the abrasive. The powdered phenolic resin, calcium oxide and filler were separately blended in a mixer and the wetted abrasive was then added to and mixed with the blended powders to uniformly coat each particle of abrasive with the blended powdered materials.

The resulting mixture was cold-molded into a wheel ¼" thick at a presure of about 2 tons per square inch to give the wheel a grain density of 36.41 grams per cubic inch. Wheel density varied with specific gravity of the filler material and ranged from 48.0 grams per cubic inch to 53.0 grams per cubic inch. The molded wheel was cured in a convection oven to a top temperature of 365° F.

Grinding tests to evaluate these wheels were conducted

on a cut-off machine, cutting off one inch square bar stock of 430 stainless steel. The machine was operated at a constant presure of 690 pounds per inch of wheel width and wheel speed was 9500 surface feet per minute. The time required per cut and the wheel wear in inches on the diameter of the wheel were measured. Since a known volume of metal was removed in each cut, the metal removal rate in terms of cubic inches per minute and the grinding ratio in volume of metal removed per volume of wheel wear could be determined from these data. The results are given in Table 1 below.

In Table 1, the values are based upon cryolite as a standard filler. That is to say, the cryolite filler is assumed to have a unit grinding ratio and a unit metal removal rate. Thus the values given are relative rather than absolute. In the case of the blends the percentages given are by volume.

TABLE 1

Filler	Grinding Ratio	Metal Removal Rate
Cryolite	1.00	1.00
Pyrite	.98	.91
Zinc sulfide	.97	.93
ZrF_4	.97	1.25
ZrF_4 (50%)—Pyrite (50%)	1.43	1.25
ZrF_4 (20%)—Pyrite (80%)	1.68	1.06
ZrF_4 (5%)—Pyrite (95%)	1.30	1.04

The data of the foregoing table show the improvement in metal removal rate achieved by using zirconium tetrafluoride in place of conventional fillers such as cryolite, pyrite and zinc sulfide. They also show the synergistic improvement in grinding ratio that is obtained when zirconium tetrafluoride is blended with pyrite.

From the foregoing description and data it is apparent that the present invention provides an economic means of improving the performance of grinding wheels incorporating a relatively large proportion of inexpensive filler. The improvement achieved by utilizing relatively small amounts of the zirconium tetrafluoride of the present invention in a blended filler is, under suitable conditions, considerably more than proportional to its concentration in the blend. In at least some cases the performance obtained with the blended fillers is superior to that obtained with either filler alone. Moreover, it has been found that when the present fillers are used, there is much less tendency for the surface of the wheel to become loaded with metal particles. This low loading property is especially important in the working of aluminum and its

alloys which are particularly difficult to grind because of the wheel loading problem.

It is of course to be understood that the foregoing examples are intended to be illustrative only and that numerous changes can be made in the ingredients and proportions described therein without departing from the spirit of the invention as defined in the appended claims.

I claim:

1. In an abrasive article essentially composed of abrasive grains bonded with a synthetic resin bond having a filler dispersed therethrough, the improvement which comprises utilizing a filler containing zirconium tetrafluoride.

2. In an abrasive article essentially composed of abrasive grains bonded with a synthetic resin bond having a filler dispersed therethrough, the improvement which comprises using a filler containing at least 5% by volume of zirconium tetrafluoride.

3. In an abrasive article essentially composed of abrasive grains bonded with a synthetic resin bond having a filler dispersed therethrough, the improvement which comprises incorporating in said filler from 5% to 100% by volume of zirconium tetrafluoride.

4. In an abrasive article essentially composed of abrasive grains bonded with a synthetic resin bond having a filler dispersed therethrough, the improvement which comprises using as said filler a mixture of iron sulfide and zirconium tetrafluoride containing at least 5% by volume of said tetrafluoride.

5. A grinding wheel essentially composed of abrasive grains bonded with a synthetic resin bond having an inorganic filler dispersed therethrough, said filler containing at least 5% by volume of zirconium tetrafluoride.

6. A grinding wheel essentially composed of abrasive grains bonded with a synthetic resin bond having a filler dispersed therethrough, said filler being a mixture of at least 5% by volume of zirconium tetrafluoride, the remainder of said filler being iron sulfide.

7. A grinding wheel according to claim 6 and wherein said synthetic resin bond is a phenolic resin bond.

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