United States Patent Office 3,030,198 Patented Apr. 17, 1962

3,030,198

ABRASIVE ARTICLE

Harry S. Kibbey, Morrow, Ohio, assignor to The Cincinnati Milling Machine Co., Cincinnati, Ohio

No Drawing. Filed May 18, 1960, Ser. No. 29,813
10 Claims. (Cl. 51—298)

This invention relates to the manufacture of abrasive articles such as grinding wheels, and more particularly to a grinding wheel 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 it is difficult to demonstrate conclusively, the mechanism by which fillers contribute to improved wheel operation, several possible mechanisms have been suggested to account for the improved results obtained. Thus in cases where the melting point of the filler is less than the surface temperature of the abrasive grit at the area of contact between the wheel and the metal being cut, the filler will melt to form a liquid that coats the surface of the abrasive grit. If the filler is properly selected, the molten filler serves as a lubricant at the area of contact between the chip and abrasive.

Another possible mechanism may be the reaction of the chip with the filler to form a non-adhesive film. The freshly cut metal surface of the chip is highly reactive at the temperature and pressure achieved during the grinding process. If the filler is reactive with any component of the metal or alloy being ground and is present near the abrasive-chip interface, it may be expected to corrode the surface of the chip. The product of this reaction, in the case of certain fillers, is a non-adhesive film that prevents reaction of the chip with the abrasive and also prevents rewelding of the chip to the base metal.

In accordance with a third possible mechanism, the freshly cut metal surface may react with the filler to produce a product in the form of a lubricating film. This film may have a shear strength low enough to act as a solid film lubricant that provides a means of lubricating the area of contact between the chip and abrasive.

It is evident that a particular filler may perform in accordance with more than one of the above described mechanisms. Also combinations of fillers may be used to provide improved performance over either material used alone. While the mechanisms outlined above provide some general guidance for the selection of useful fillers, it is in general not possible to predict accurately the utility of a particular filler. 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 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. 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 potassium hexafluorophosphate (KPF_6) possesses exceptionally useful properties as a filler in resinoid grinding wheels. This compound can be used alone as the filler, or it can be blended in various proportions with other known fillers as described more fully hereafter. When incorporated in resin-bonded wheels to be used on severe dry grinding operations it provides wheels that exhibit improvement in both grinding ratio and metal removal rate over the fillers commonly used for wheels intended for this type of operation.

Potassium hexafluorophosphate has a sufficiently low melting point (575° C.) to provide liquid lubrication during grinding. At temperatures above its melting point it decomposes to produce products including phosphorous pentafluoride having a corrosive effect on both stainless steel and low carbon mild steel. The decomposition of KPF_6 at temperatures above its melting point furnishes a corrosive material to provide the beneficial corrosion of the surface of the chip as described above. Thus two beneficial effects, that is, liquid lubrication and corrosion at the contact area, are furnished by this single material.

It has been found that small percentage additions of KPF_6 to formulations containing other materials as fillers give significant improvement in grinding ratio and metal removal rate over similar formulations containing no KPF_6. Addition of KPF_6 in small percentages permits inexpensive fillers that impart high strength to resin-bonded snagging formulations to be used as a high percentage of the total filler and still maintain attractive performance levels. It further appears that small percentage additions to KPF_6 to other fillers which give attractive metal removal rates but low grinding ratios increase these grinding ratios significantly with no decrease in metal removal rate.

As indicated above, KPF_6 may be used as the sole filler and when so used has been found to be operative over a relatively wide range, e.g., 5% to 45% by volume of the volume of the bond. It may also be blended with other known fillers, such as cryolite, iron sulfide (pyrite), zinc sulfide and the like. In such blends the amount of KPF_6 may be varied widely, for example in some cases as little as 1% by volume of KPF_6 in the blended filler will produce a significant improvement in grinding properties. On the other hand, since KPF_6 can be used alone as the filler, the upper limit of the amount of KPF_6 used in such blends is 100%, that is, the KPF_6 content of the blended fillers may vary from 1% to 100%.

In order to point out more fully the nature of the present invention, the following examples are given of illustrative embodiments of grinding wheels incorporating the invention.

EXAMPLE I

A number of snagging wheels were made up as described herein incorporating various fillers as specified in Table I below. For purposes of comparison, the data of Table I 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 I. 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 mold-molded into a wheel ¼ inch thick at a pressure 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 pressure 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 I below.

In Table I, 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 I

Filler	Grinding Ratio	Metal Removal Rate
Cryolite	1.00	1.00
Pyrite	.98	.91
Potassium Hexafluorophosphate (KPF_6)	1.41	1.17
Zinc Sulfide (ZNS)	1.16	0.81
50% Pyrite, 50% KPF_6	1.38	1.29
80% Pyrite, 20% KPF_6	1.52	1.18
90% Pyrite, 10% KPF_6	1.75	1.07
50% Cryolite, 50% KPF_6	1.43	1.21
50% ZnS, 50% KPF_6	1.25	1.14
80% ZnS, 20% KPF_6	1.38	1.02

The data of Table I clearly show that potassium hexafluorophosphate, whether used alone or blended with other fillers, provides a substantial advantage over conventional fillers such as cryolite, zinc sulfide and pyrite. Also these data bring out the fact that mixtures of KPF_6 with other fillers exhibit a synergistic effect.

EXAMPLE II

Another series of snagging wheels was made up generally in accordance with the method of claim 1 except that the proportions of ingredients were changed as indicated by the following formulation:

63.16 parts by volume of abrasive grain
8.17 parts by volume liquid phenolic resin
0.92 part by volume calcium oxide
15.99 parts by volume powdered phenolic resin
11.76 parts by volume of filler

The snagging wheels of this example were molded in such manner as to provide a composition containing about 11% pore volume as compared with about 4% pore volume in the relatively dense wheels of Example I.

Table II

Filler	Grinding Ratio	Metal Removal Rate
Cryolite	1.00	1.00
50% Pyrite, 50% KPF_6	1.05	1.39
80% Pyrite, 20% KPF_6	1.01	1.36
90% Pyrite, 10% KPF_6	1.16	1.25

The data of Table II show that mixtures of KPF_6 and Pyrite may be used to improve significantly the metal removal rate of wheels having a pore volume substantially greater than that of the wheels of Example I.

From the foregoing description 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 KPF_6 in a blended filler is, under suitable conditions, considerably more than proportional to its concentration in the blend. 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 potassium hexafluorophosphate.

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 1% by volume of potassium hexafluorophosphate.

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 1% to 100% by volume of potassium hexafluorophosphate.

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 cryolite and potassium hexafluorophosphate containing at least 1% by volume of said hexafluorophosphate.

5. 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 zinc sulfide and potassium hexafluorophosphate containing at least 1% by volume of said hexafluorophosphate.

6. 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

potassium hexafluorophosphate containing at least 1% by volume of said hexafluorophosphate.

7. 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 pyrite and potassium hexafluorophosphate containing at least 1% by volume of said hexafluorophosphate.

8. A grinding wheel essentially composed of abrasive grains bonded with a synthetic resin bond having a filler dispersed therethrough, said filler containing at least 1% by volume of potassium hexafluorophosphate.

9. 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 1% by volume of potassium hexafluorophosphate, with the remainder of said filler being selected from the group consisting of cryolite, zinc sulfide and iron sulfide.

10. A grinding wheel according to claim 9 and wherein said synthetic resin bond is a phenolic resin bond.

References Cited in the file of this patent

UNITED STATES PATENTS

2,216,135	Rainier	Oct. 1, 1940
2,408,319	Kistler	Sept. 24, 1946