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MANUFACTURE OF ABRASIVE PRODUCTS

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This invention relates to the manufacture of abrasive products such as grinding wheels, discs, segments and the like, and particularly to such products bonded with a synthetic resin.

The objects of this invention are to produce abrasive products of greatly improved durability and having little or no tendency to load, and consequently possessing the qualities of cutting more effectively and freely, and producing less heat in the work being ground or cut.

The value of lubrication during abrading or grinding action is well known. So-called cutting oils are commonly used when grinding is done wet. In dry grinding, lubrication has been resorted to even in such a crude manner as having the operator occasionally smear the abrading surface of the grinding wheel with grease or oil. Another more positive method for providing lubrication is by filling or impregnating the pores or voids in grinding wheels with resins, waxes, or pitches, which fluidize and exude during grinding as the result of generated heat.

In U. S. Patent No. 2,258,774 of October 14, 1941, there is set forth the limitations of these conventional methods of lubrication of grinding and cutting wheels during use, and there is disclosed the advantages derived from the incorporation in the bonding material of powdered or granulated metals or alloys having melting points in the range of the grinding temperatures of the abrasive product.

We have now found that similar self-lubricating qualities result from the incorporation of antimony sulphide in the bond, and particularly where the bond comprises a resinoid. We have further found that synthetic resin bonded abrasive wheels containing powdered or granulated antimony sulfide show practically no tendency to load, i. e., no tendency for metal being ground or cut to be "picked-up" at the grinding surface. As a result of this important characteristic the wheel will continue to cut freely, and with less generation of heat in the work being ground.

When antimony sulfide, as, for example, the naturally occurring mineral stibnite, is heated, a number of changes occur. The mineral melts at 550° C. At this, and higher temperatures, decomposition also takes place. When air is present, antimony sulfide, when heated to temperatures in the neighborhood of its melting point, readily oxidizes. The products of this oxidation are antimony trioxide (Sb_2O_3) and sulfur dioxide (SO_2), which latter in the presence of water vapor normally present in the atmosphere produces some sulfurous acid (H_2SO_3).

Now, when antimony sulfide is incorporated as a powder or in a granulated form in the bond of a grinding or cutting wheel, the heat developed at the area of grinding contact causes these recited changes to occur. First, some of the antimony sulfide fuses, and provides a lubricating effect exactly where and when it is needed—permitting cooler grinding or cutting, with less heating of both grinding wheel and metal being cut or ground. Also, the products of the decomposition appear to have an effect upon the surfaces of metal chips as they are cut from

the metal being ground or cut. The result is that surface changes are produced either on the surfaces of the newly cut chips, or on the wheel surface, or both; and the consequence of such changes is a virtually complete elimination of the tendency of the wheel to load.

Example I

The following is an example of making a snagging type of wheel according to our invention. In all of the following examples the parts referred to are by weight.

We first prepare a dry powdery mix, by taking 100 parts (by weight) of a potentially reactive synthetic resin in the pulverized state (in this case a phenol-formaldehyde resin known as Varcum resin No. 1930) into which is mixed 40 parts of stibnite (antimony sulfide) in a pulverized form of average mesh size, and 50 parts of pulverized cryolite, the latter acting as a filler.

In another container we take 800 parts of fused alumina abrasive containing equal proportions of Nos. 10, 12, 14 and 16 grit, to which we add 50 parts of a liquid mixture containing 25 parts of a liquid phenol-formaldehyde resin (in this case Varcum resin No. 8141), 8⅓ parts of cresylic acid, and 16⅔ parts of furfural.

The abrasive and liquid resin are mixed until the individual abrasive particles are thoroughly and uniformly coated, and to this mass, while being agitated, is added the said previously commingled dry pulverized resin and stibnite. The entire mass is stirred until the pulverized resin and antimony sulfide are uniformly suspended on the wetted abrasive particles, forming a loose granular mix. The resultant granular mix is poured and leveled in a mold of desired dimensions and molded under pressure—cold or hot. The formed wheel is removed from the molds and baked in an oven to harden or cure the bond, at temperatures ranging from 175° F. to 320° F.

While curing temperatures up to 350° F. and higher are commonly used in baking resin-bonded abrasive products, we have found that particularly in the case of relatively dense wheels containing antimony sulfide, such higher temperatures should be avoided, since they tend to produce swelling or bloating of the wheels. This is apparently due to the partial tendency for stibnite, in admixture with synthetic resin in such a bond, to decompose and/or oxidize at temperatures well below its melting point.

A grinding wheel made as above described, showed, in a grinding test on stainless steel, a removal of 723 lbs. of steel for 540 cubic inches of usable abrasive material, or a ratio of .74 cubic inch of wheel per pound of stainless steel removed. A similar standard wheel not embodying the incorporation of stibnite showed a removal of 167 lbs. of the same steel for 540 cubic inches of usable abrasive material, or a ratio of 3.2 cubic inches of wheel per pound of stainless steel removed. The wheel made as described above showed no sign of "loading," and retained its free-cutting ability throughout the test, while the standard wheel showed definite "loading," developed considerably more heat, and did not show uniform retention of cutting ability.

Example II

The following is another example of making a snagging wheel.

The dry powdery mix is first obtained as described with Example I, using the following ingredients and ingredient proportions:

	Parts
Analine formaldehyde resin (powder)	100
Stibnite	60
Cryolite	60

The abrasive-liquid mix is obtained, using the following ingredients and proportions:

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	Parts
The abrasive of Example I	625
Furfural	22

The further procedure described for Example I is then followed, except that in this case, after pouring the granular mix in the molds and leveling, the filled molds are heated to a temperature between 225° F. and 250° F. and pressed at in that temperature range, after which the product is cured.

Example III

The following is an example of making a cut-off wheel.

The dry powdery mix is first obtained, using the following ingredients and proportions:

	Parts
Phenol formaldehyde resin (Varcum 1364)	100
Stibnite	20
Litharge powder	100
Asbestos floats	20

The abrasive-liquid mix is obtained using parts of alumina abrasive containing equal proportions of Nos. 20, 24 and 30 grit to which is added 42 parts of a liquid mix containing three parts of a liquid phenol formaldehyde resin and one part of furfuryl alcohol.

The further procedure described for Example I is then followed.

A cut-off wheel made according to the example, showed, in a test in cutting a standard steel pipe, a ratio of wheel wear to amount of metal cut of 0.135 while a similar standard wheel not embodying the incorporation of stibnite showed a ratio of 0.26 (and thus a 100% increase in metal cut for the wheel embodying the present invention) and also exhibited a considerable increase in freedom of the cut.

Example IV

The following is another example of making a cut-off wheel.

The dry powdery mix is first obtained, using the following ingredients and proportions:

	Parts
Melamine-formaldehyde resin (powder)	40
Phenol-formaldehyde resin (powder)	40
Stibnite	100
Cryolite	40

The abrasive-liquid mix is obtained using 600 parts of alumina abrasive containing equal proportions of Nos. 24, 30 and 36 grit and from 16 to 20 parts of furfuryl alcohol. The further procedure described for Example I is then followed.

We have found that in place of the dry powdered resins of the phenol-formaldehyde, cresol-formaldehyde, melamine-formaldehyde, etc. types we may use such resins modified by additions of such additives as Hycar OR types of synthetic rubber or vinyl polymers such as polyvinyl butyral, etc. Such additives have a tendency to increase the toughness of the bond, and their presence in no way interferes with the effectiveness of our invention.

We have also found that other methods of forming resin-bonded abrasive products may be used to advantage in carrying our our invention. For example, we may make a snagging wheel in accordance with our U. S. Patent No. 2,448,985, granted September 7, 1948, incorporating stibnite in place of, or in addition to, the other filler used.

Example V

As an example of the manufacture of a snagging wheel, applying our invention to this method, we proceed as follows:

We take 100 parts by weight of copolymer of butadiene and acrylic-acid nitrile (Hycar OR–15), and after a five minute "break-down" on a rubber mill, slowly add 75 parts of a meta-para cresol resin of low viscosity. After the addition of the resin is complete we transfer the batch to an internal mixer of the Werner-Pfleiderer type, and while continuing mixing slowly add 175 more parts of the resin, obtaining a smooth viscous mix. We transfer this mix to a dough-type mixer and add 4,400 parts of abrasive grain of suitable mesh size. During mixing we add the following ingredients: 200 parts of a pulverized solid "A" stage phenol-formaldehyde resin, 250 parts of pulverized stibnite, 100 parts of cryolite, 20 parts of slaked lime, 35 parts of sulfur, and one part of a vulcanization accelerator such as Grasselerator 808. Mixing is continued until thorough dispersion of the ingredients is effected, and the abrasive grains substantially uniformly coated. The batch is then removed, formed in molds as by conical rollers, pressed in the mold at, for example, 1,500 lbs. p. s. i. of wheel surface, and cured by any of the known methods employed for rubber-bonded or resin-bonded abrasive products.

Example VI

As another example of the manufacture of an abrasive wheel of modified-resin bond, utilizing our present invention, we proceed as follows:

In a dough-type mixer we place 500 parts of a cresol-hexamethylene tetramine resin of low viscosity, and 100 parts of a powdered or flake form of polyvinyl butyral. These ingredients are mixed for a few minutes and then allowed to stand for some hours, e. g., overnight, until the butyral has swelled and essentially dissolved in the fluid resin. We then add 8,000 parts of abrasive grain of suitable mesh size, 50 parts of water-tar-pitch, 350 parts of a pulverized phenol-formaldehyde resin, and 1,000 parts of powdered stibnite. The batch is then mixed until a uniform plastic mass is obtained. This mass is transferred to suitable molds and formed, as by conical rollers. The formed wheels, still in the molds, are then pressed at, for example, 1,200 lbs. p. s. i. of wheel surface, either warm or cold, and cured in the molds under some pressure and at temperatures starting at about 175° F. and gradually rising to about 320° F.

While we prefer the mineral stibnite in a pulverized or granular form, we are not limited to the antimony sulfide in this form. For example, there are various forms of artificially prepared or precipitated antimony sulfides, such as the "Golden Antimony" and "Crimson Antimony" long known to the rubber trade. There are precipitated forms of antimony sulfide, the former probably antimony trisulfide mixed with varying proportions of free or uncombined sulfur. The latter is probably antimony pentasulfide mixed with varying proportions of other materials such as free sulfur and calcium sulfate. While these materials can be used to advantage in accordance with this invention, we find the presence of the free sulfur and other materials detrimental, particularly in resin-bonded wheels. For example, resin-bonded abrasive products containing appreciable amounts of free sulfur have a tendency to blow, or bloat, during baking—with a resultant formation of "shells" in the wheels, as will be well understood by those conversant with the art. We prefer to use a relatively pure form of stibnite, because of its relative freedom from uncombined sulfur and other extraneous material.

Some forms of naturally occurring stibnite ore contain a fairly large proportion of foreign material. We can use such ores in their pulverized form, but since the foreign material acts essentially as common mineral filler, and is without the beneficial effects of the stibnite, we prefer the purer forms.

The proportion of stibnite (Sb_2S_3) used varies according to the type of wheel being produced, the grade, and the degree of porosity desired. We have found antimony sulfide as little as 10% of the weight of the resin to produce beneficial results, and have used as much as 200% of the resin weight, although we usually prefer to use from 50% to 100% of the resin weight. While the range of particle size in the pulverized stibnite or

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antimony sulfide is wide or substantial, we have found that best results are obtained when this range is from particles passing an 80 mesh screen to particles passing a 300 mesh screen, and finer. In normal crushings of stibnite, because of its brittleness, a wide range of particle sizes is usually obtained.

While the particular examples given show the embodiment of the invention applied to the making of heavy duty snagging wheels (used, for instance, in the grinding of steel billets under heavy pressure) and in thin, cut-off wheels, where the invention exhibits the greatest advantages, other types of abrasive wheels may be made embodying the invention, and particularly those used where high temperatures and shock have to be withstood.

The method of making abrasive products embodying the present invention, the physical characteristics and the resulting products and the methods and advantages of their use will in the main be fully apparent from the above-detailed description thereof.

The principal advantages secured in the use of the abrasive products are greatly increased durability and considerably enhanced cutting ability due to the action of the stibnite as a lubricant and loading inhibitor. It will be further apparent that while we have set forth preferred examples of bonds, ingredients, proportions, etc., that these have been given merely as examples without departing from the broader principles of the invention as defined in the following claims.

We claim:

1. An abrasive product comprising abrasive particles bonded with an organic bond selected from the class consisting of synthetic resins and synthetic rubbers, the said abrasive product having incorporated and distributed therein antimony sulfide particles, the antimony sulfide being in the proportion of from 10% to 200% by weight of the organic bond, the antimony sulfide particles acting within the range of grinding temperatures of the abrasive product as a lubricant and a loading inhibitor.

2. The abrasive product of claim 1 in which the antimony sulfide comprises stibnite.

3. The abrasive product of claim 1 in which the antimony sulphide is incorporated and distributed in the organic bond.

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