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METHOD OF MANUFACTURING GRAPHITE-BOND GRINDING WHEELS FOR PRECISION GRINDING

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ABSTRACT OF THE DISCLOSURE

Graphite-bond grinding wheels for precision grinding having a low coefficient of friction, high thermal conductivity and high bending strength are obtained by molding and then sintering a mixture of abrasive grinding grains, graphite and a bonding material composed of 30–70% by weight of kaolin and 70–30% by weight of montmorillonite. The resultant sintered wheel has microspores and is desirably impregnated with a lubricating agent.

This invention relates to grinding wheels and more particularly to a new method for producing graphite-bond grinding wheels having highly desirable characteristics for precision grinding.

In precision grinding, the grinding heat generated not only gives rise to affected layers (deteriorated layers) and residual stress in the work being ground but also becomes a cause in many cases of occurrence of serious defects such as grinding cracks. This grinding heat is generated by friction, most of the grinding work or energy being used for friction work, that is, for overcoming friction between glazed grains and the workpiece being ground and friction between the bond material and the chips. Consequently, even when a large quantity of cooling fluid is used, cooling of local parts where heat is generated is grossly inadequate, whereby various defects are caused. Thus, grinding heat has been a serious problem in precision grinding.

Among the grinding wheels known heretofore, there are vitrified wheels wherein clays are vitrified for the bond material, resinoid wheels wherein synthetic resins are used, metal bond wheels wherein metals such as copper, nickel, and iron are used, and wheels in which other bond materials are used. In all of these wheels, however, the coefficients of friction of the bond material are high, and, moreover, the wear of the bond material which influences the self-sharpening characteristic of the abrasive grains in each case is both advantageous and disadvantageous. Accordingly, together with blunting due to attrition wear of the cutting edges of the abrasive grains, the generation of grinding heat increases.

Particularly in the case of a diamond wheel, the generation of grinding heat and the irregular discharge of chips cause the cutting edges of the abrasive grains of diamond to be blunted by chemical action, whereby the grinding performance is greatly impaired. Furthermore, the abrasive grains are shed or ploughed by the discharged chips and fall off. This is a serious disadvantage and makes the grinding of various heat-treated steels which produce flow type chips impossible.

In precision grinding, therefore, it is vitally important

to reduce the generation of grinding heat as much as possible, cause smooth discharge of chips, prevent occurrence of deteriorated layers and residual stress, reduce the roughness of finished surfaces, and maintain accuracy of the order of microns.

In order to reduce greatly the generation of grinding heat, cause smooth discharge of chips, and facilitate self-sharpening of the abrasive grains through suitable micro-wear of the bond material, a bond material having a low coefficient of friction, high lubricity, high thermal conductivity, and high bending strength is required.

It is an object of the present invention to provide a bond material having the above stated properties.

An ultimate object of the invention is to provide grinding wheels of high performance and other desirable characteristics for precision grinding.

Another object of the invention is to provide a method for producing grinding wheels of the above stated character.

More specifically, the present invention contemplates the production of vitrified grinding wheels by bonding various grinding abrasive grains with a bonding material having the constitution of a hard graphite pencil and having essential conditions such as touch and slip, point strength, and suitable micro-wear steps.

According to the present invention, briefly stated, there is provided a method for producing graphite-bond grinding wheels for precision grinding, characterized by the steps of: thoroughly mixing a bond material composed of 30–70% of kaolin and 70–30% of montmorillonite clays and 40–60% of fine powdery graphite, having the constitution of a hard graphite pencil, with selected grinding abrasive grains; adding 3–10% of water to the resulting mixture; pressure moulding the resulting material to specified dimensions and shape to form a green wheel; heating and sintering the green wheel in a graphite saggar in a neutral or reducing atmosphere at a temperature of from 850 to 950 degrees C. thereby to produce a sintered wheel having micropores; and impregnating said mocripores with a lubricative treatment agent such as stearic acid.

A bond material having the constitution of a hard graphite pencil has not only a bending strength which is two to three times that of conventionally used bond materials, irrespective of the kind of abrasives used, but also many other desirable features.

For example, by impregnating the micro-pores of this bond material with a lubricative treatment agent such as stearic acid, the necessity of using cooling fluid is obviated, and dry grinding can be accomplished with a grinding wheel produced with this bond material with only a very low generation of heat whereby local temperatures can be maintained below 270 degrees C. As a result, the grinding process can be continued, without occurrence of defects such as deterioration of ground surface, residual stress, and grinding cracks, with the emission of a regular and clear sound as the original colour and lustre of the workpiece material is retained, and fresh flow type chips are smoothly discharged, the cutting edges of the abrasive grains being self-sharpened by the suitable wear of the grinding wheel.

In accordance with the present invention, the bond materials having hardnesses corresponding to that of various hard graphite pencils have compositions as exemplified in Table 1 and physical properties as indicated in Table 2 and are prepared by sintering and then impregnating the

micropores thereof with a treatment agent such as stearic acid thereby to increase their strength and lubricity.

TABLE 1.—COMPOSITIONS, PERCENT

	Degree of Hardness [1]		
	5H	7H	9H
Composition in percent by weight:			
Amorphous graphite	19	17	15
Crystalline graphite	29	27	25
Bond material	52	56	60
Bond material composition percent by weight:			
Kaolin clay	45	55	60
Montmorillonite A	45	40	37
Montmorillonite B	10	5	3

[1] The hardness (H) degrees, 5H, 7H, 9H correspond respectively to hardnesses 5H, 7H, and 9H respectively of graphite pencils.

TABLE 2.—PHYSICAL PROPERTIES

	Degree of Hardness [1]		
Physical Property	5H	7H	9H
Coeff. of friction (J.I.S.) [2]	0.223	0.225	0.228
Specific gravity	2.35	2.40	2.43
Water absorption, percent	16.2	15.6	14.8
Stearic acid impregnation, percent	7.41	7.13	6.82
Bending strength, kg./cm.^{2}	785	862	948

[1] The hardness (H) degrees, 5H, 7H, 9H correspond respectively t hardnesses 5H, 7H, and 9H respectively of graphite pencils.
[2] As defined by Japan Industrial Standards.

In Table 1, mixtures of amorphous graphite, crystalline graphite and bond material in the percent by weight indicated in each vertical column yields an object having the hardness set forth at the head of the columns, and the physical properties indicated in Table 2. It is to be noted that for each composition, the bond material is made up of specified percentages by weight of kaolin clay, montmorillonite A and montmorillonite B as shown in the bottom half Table 1.

In order to indicate more fully the nature of the present invention, the following example of its embodiment is set forth, it being understood that this example is presented as illustrative only, and that it is not intended to limit the scope of the invention.

Bond materials of the compositions indicated in Table 1 are selected in accordance with the indicated degrees of the grinding wheel and respectively mixed intimately with grinding abrasive grains of grain ratios of from 15 to 48 percent. From 3 to 5 percent of water is mixed uniformly with each resulting mixture, and a metal mould of specified form for a grinding wheel filled with the resulting mixture, which is moulded under pressure until the predetermined bulk density is attained.

Each green wheel of the specified dimensions thus moulded is removed from the mould and then dried at a temperature of 80 degrees C. The dried green wheels are next placed in respective saggars and heated in a neutral atmosphere or a reducing atmosphere at a temperature of from 850 to 950 degrees C. to sinter the bond materials.

The sintered wheels so obtained are left standing to cool naturally and then, after being preheated at 100 degrees C., are immersed in molten stearic acid to cause suitable quantities of stearic acid to be adsorbed in the micro-pores of the wheels, which are thereupon completed.

In the case of a diamond grinding wheel, a layer of a thickness of from 2 to 5 mm. containing diamond abrasive grains is bonded adhesively to a base structure in the form of a disk of the bond material according to the invention containing a suitable quantity of silicon carbide grains, a disk of a light alloy, or a disk of synthetic resin, whereupon the grinding wheel is completed.

In order to indicate the utility of the present invention the following example of actual use and grinding performance of a grinding wheel according to the invention is presented.

Grinding was carried out with the following equipment and under the following conditions.

Grinder: Horizontal surface grinder manufactured by Okamoto Machine Tool Mfg. Co., Ltd., Japan.

Grinding wheel—

Dimensions: 205 mm. diameter; 19.5 mm. thickness; 51.5 mm. hole diameter.

Particulars: #80 SA grains; 25% grain ratio; 2.17 bulk density.

Workpiece: Special tool steel (Japan Industrial Standards designation SKS 2) [1]; hardness, Rockwell C64.

Grinding conditions—

Wheel peripheral speed _____metres/min__ 1,750
Table speed _____do____ 10
Depth of out per pass _____microns__ 10
Type of grinding, dry.

The following results were obtained.

Grinding ratios

	Quantity of workpiece ground (mm.^{3})	Quantity of wheel wear (mm.^{3})	Grinding ratio
Cumulative number of passes:			
0-100	675	6.28	107
100-200	640	6.28	102
200-300	646	6.28	103
300-400	648	6.28	103

Finished surface roughness, as measured by contact needle type instrument:

	Roughness, microns
No crossfeed, no spark out	1.2
No crossfeed, full spark out	0.95
Crossfeed, spark out, 1 pass	0.8
Crossfeed, full spark out	0.75

Measurement of temperatures due to generated grinding heat (measured with constantan-iron thermocouples):

	Electromotive force, mv.	Temperature,° C.
Distance from surface, mm.:		
0.01	11.5	250
0.02	10.0	Successively
0.03	7.5	lower
0.07	6.5	thereafter.
0.09	6.0	
0.12	5.0	
0.14	5.0	
0.16	4.0	
0.20	3.0	
0.22	2.5	

As indicated by the results set forth above, the grinding wheel according to the invention has excellent performance.

Since it is obvious that many changes and modifications can be made in the above described details without departing from the nature and spirit of the invention, it is to be understood that the invention is not to be limited to the details described herein except as set forth in the appended claims.

What I claim is:

1. A method for producing a graphite-bond grinding wheel for precision grinding which comprises: throughly mixing a bonding material composed of 30–70% by weight of kaolin and 70–30% of montmorillonite clays and 40–60% of fine powdery graphite with selected grinding abrasive grains, adding 3–10% by weight of water to the resulting mixture; pressure moulding the resulting material to specified dimensions and shape to form a green wheel; heating and sintering the green wheel in a graphite saggar in an inert atmosphere at a temperature of from 850 to 950 degree C thereby to produce a sintered wheel having micropores.

2. The method according to claim 1 and the further step of impregnating the microspores of said sintered wheel with stearic acid.

3. In a method for producing a graphite-bond grinding

[1] Chemical content (percent) of special tool steel SKS2: 1.00–1.10 C; 0.35 (max.) Si; 0.80 (max,) Mn; 0.030 (max,) P; 0.030 (max.) S; 0.50–1.00 Cr; 1.00–1.50 W.

wheel for precision grinding by mixing graphite and a bonding material with abrasive grinding grains, shaping and then sintering the mixture, the improvement which comprises mixing 40–60% by weight of fine powdery graphite and a bonding material composed of 30–70% by weight of kaolin, 70–30% by weight of montmorillonite clays with selected grinding abrasive grains.

References Cited

UNITED STATES PATENTS

1,479,107	1/1924	Ohman	51—308
1,483,507	2/1924	Brockbank	51—308
1,546,115	7/1925	Beecher	51—308
1,844,064	2/1932	Hartmann	51—295
2,132,005	10/1938	Milligan et al.	51—308
2,281,526	4/1942	Milligan et al.	51—308
3,321,287	5/1967	Hunsberger et al.	51—295

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51—296, 308