US 20130280995A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2013/0280995 A1
(43) Pub. Date: Oct. 24, 2013
Dopp et al.

(54) **ABRASIVE MATERIAL AND ABRASIVE WHEEL**

(71) Applicants: **Stephan Dopp**, Hamburg (DE); **Dirk-Olaf Damrau**, Pinneberg (DE)

(72) Inventors: **Stephan Dopp**, Hamburg (DE); **Dirk-Olaf Damrau**, Pinneberg (DE)

(73) Assignee: **Hermes Schleifmittel GmbH & Co. KG**, Hamburg (DE)

(21) Appl. No.: **13/864,626**

(22) Filed: **Apr. 17, 2013**

(30) **Foreign Application Priority Data**

Apr. 20, 2012 (EP) 12002759.4

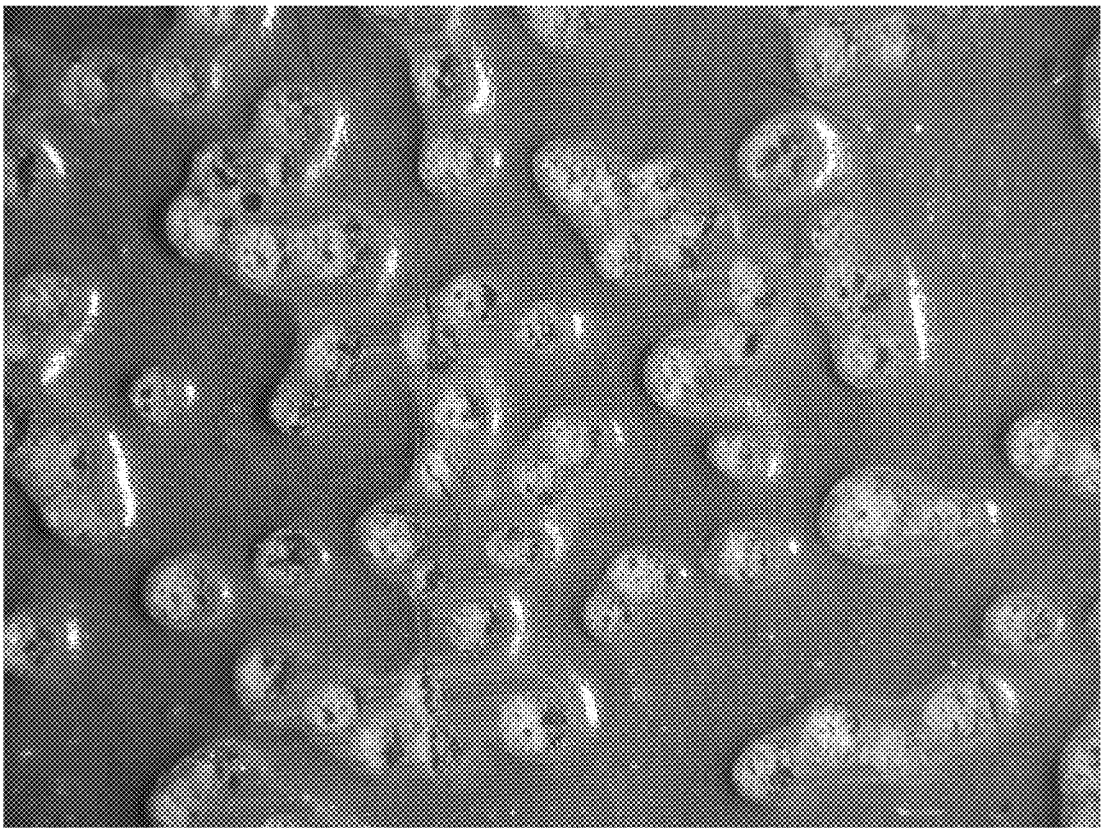
Publication Classification

(51) **Int. Cl.**
B24D 3/00 (2006.01)

(52) **U.S. Cl.**
CPC *B24D 3/00* (2013.01)
USPC **451/540**; 51/307; 51/309

(57) **ABSTRACT**

The invention relates to an abrasive having a base body and abrasive particles applied to the surface of the base body, characterized in that the base body has a multicellular structure. The invention further relates to a process for producing this abrasive and to a grinding tool based on this abrasive.



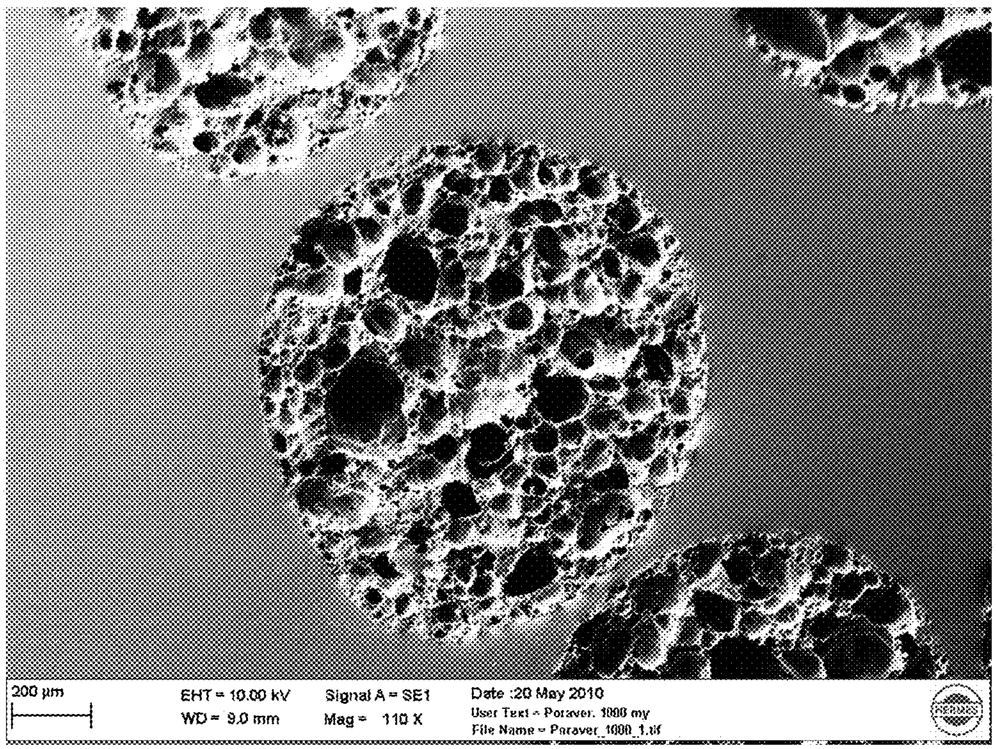

200 µm
EHT = 10.00 kV
WD = 9.0 mm
Signal A = SE1
Mag = 110 X
Date :20 May 2010
User Text = Poraver, 1000 my
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Fig. 1

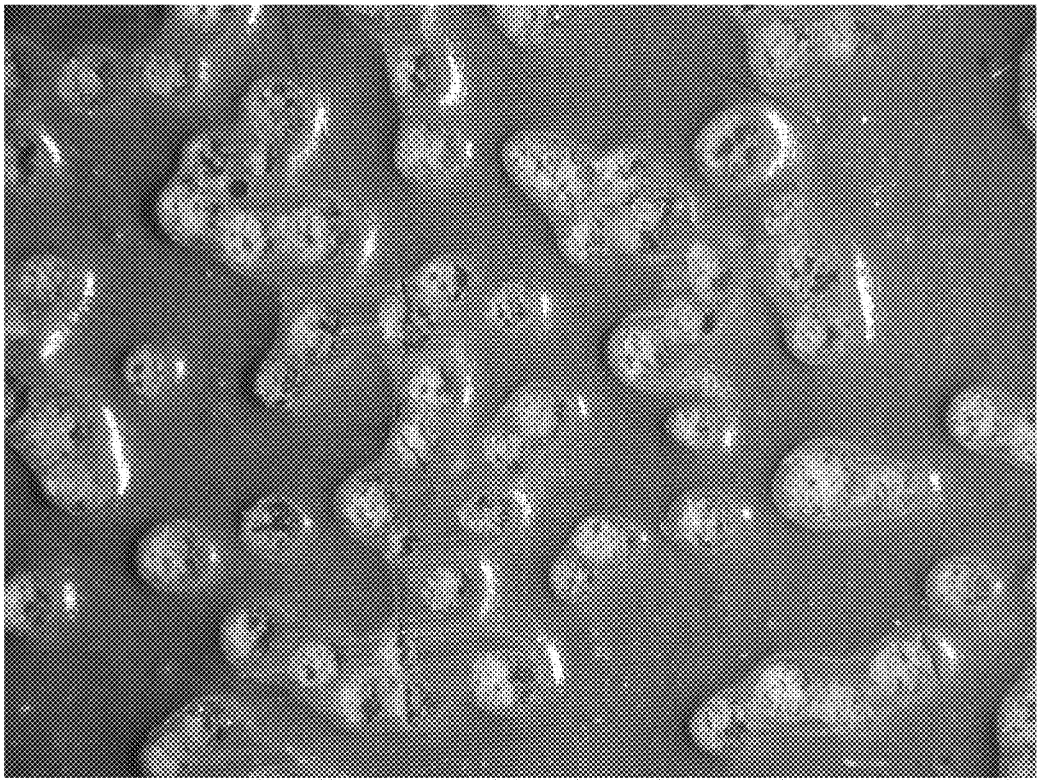

Fig. 2

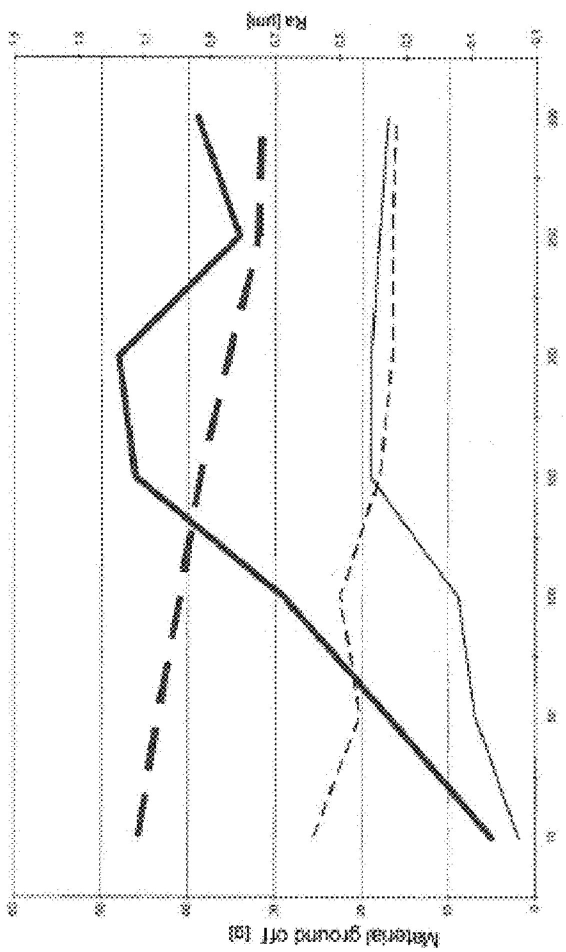

Fig. 3

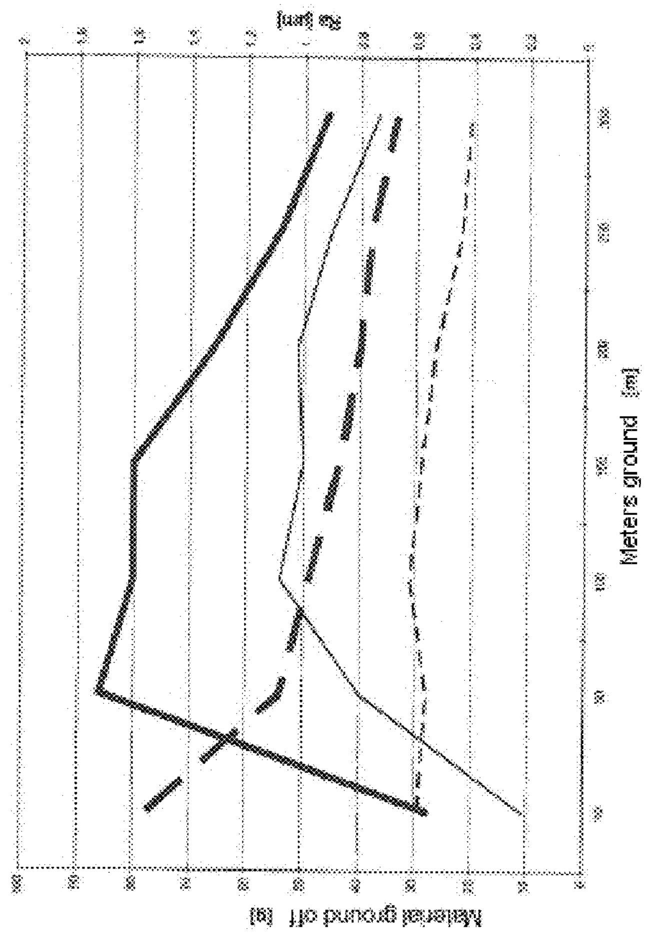

Fig. 4

ABRASIVE MATERIAL AND ABRASIVE WHEEL

[0001] The invention relates to an abrasive having a base body and abrasive particles applied to the surface of the base body. The invention further relates to a process for producing such an abrasive and also a grinding tool in which the abrasive according to the invention is used

[0002] Abrasives on a substrate are subject to wear during use, which limits the operating life. A critical factor here is the decreasing sharpness of the grinding tool. The cause is primarily a change in the cutting geometry, for example caused by breaking-off of abrasive particles, breaking out of abrasive particles from the binder or wear of the abrasive particles in the form of continuous removal of material (plateau formation) and also clogging of the abrasive coating by deposits of material. When the grinding tool is used, this wear becomes apparent by decreasing removal of material, and increasing evolution of heat but also by a changing ground surface. The wear can be compensated for by a limited extent by adaptation of the process parameters, so that a sufficiently constant machining quality can be achieved in many applications. However, independently thereof, the end of the operating life of the tool is reached when the cutting edges/points become blunted. Particularly in industrial machining processes, the tool change which is then necessary results in a considerable decrease in the process efficiency. This applies particularly to machining processes by means of which a defined surface structure and roughness are to be obtained.

[0003] There have in the past been various attempts to delay the bluntening of the grinding tool, for example by means of a tool structure which provides a plurality of layers of abrasive particles which are used stepwise over time.

[0004] This principle has been realized in various ways. Thus, for example, a plurality of layers of binder and abrasive particles have been applied on top of one another on a substrate. A disadvantage of this structure is the high percentage contact areas, with the associated evolution of heat, which are formed after the first layer of particles has worn away. The comparatively flat surface structure also has no free spaces for chips, so that compaction of abraded material and clogging of she tool surface are promoted. This not only limits the operating life of the tool but also reduces the surface quality of the workpiece through to surface defects.

[0005] Another process provides for agglomerates consisting of a plurality of abrasive particles to be applied to the substrate. Compared to the first-named process, this process has the advantage that fresh abrasive particles found in the agglomerate are continually engaged during the course of the grinding process without a binder layer having to be removed over a large area. A similar approach is followed by grinding tools which are structured in a defined way, in the case of which the abrasive particles are embedded in a binder matrix.

[0006] It is also known (DE-A. 23 48 338) that a hollow sphere on she outer surface of which a layer of abrasive particles fixed by means of a binder is situated, can, instead of abrasive particles or an agglomerate, be sprinkled onto the substrate. While the abrasive particles fixed on the top on the hollow sphere are initially engaged at the commencement of use, the sphere opens during further use and is continually removed. The abrasive particles bound to the outer surface are used in succession as a consequence of this process. An advantage of this tool structure is not only the vertically single-layer structure. The opening of the hollow sphere brings about an approximately constant percentage contact area during use. As a consequence, grinding can be carried out with approximately constant removal of material, constant evolution of heat and a constant surface result over a long period of time using a hollow sphere grinding tool. The cutting geometry thus displays comparable features over the entire operating life of the tool. The hollow sphere can, according to this prior art, be obtained by expansion of vinyl chloride-ethylene copolymers. A further process is likewise known. Here, polystyrene spheres are coated with a mixture of binder and abrasive particles, with the binder consisting of a high-temperature-stable, inorganic material. This makes it possible to heat the spheres to temperatures of about 500° C. and thus subject the polystyrene core to a pyrolysis with predominantly volatile reaction products. In a subsequent step, the binder has to be cured at even higher temperatures. As a result, a hollow sphere particle having a hard fired surface and abrasive particles bound therein is obtained.

[0007] It is an object of the invention to provide an abrasive of the type mentioned at the outset which can be produced simply and be used in a versatile manner.

[0008] The invention achieves this object by the base body of the abrasive having a multicellular structure.

[0009] Firstly, some terms used in the context of the invention will be explained.

[0010] An abrasive serves to remove material by cutting from a workpiece being machined. The base body bears the abrasive particles which bring about the actual removal of material.

[0011] According to the invention, the base body has a multicellular structure. This means that the volume enclosed thereby is permeated by many walls or wall structures which divide this volume into smaller hollow spaces (pores or cells). The individual cells can partly be completely closed, and can partly be connected to adjacent cells because of only partly closed wall structures.

[0012] The invention has recognized that such a base body has a series of advantages. The cell structure firstly gives the body its strength, in particular in the process for coating with binder, but also stabilizes de abrasive particles during the grinding process, in particular when the bodies do not experience any significant additional stabilization due to a multiple coating and/or a heat treatment. The microporous base bodies have a comparatively low density due to the size and type of the pores, so that continuous vertical removal of material with the aim of exposing as yet unused abrasive particles can be achieved without problems. Accordingly, the percentage contact area and thus the evolution of heat of/by the grinding tool increases only insignificantly after opening of the body.

[0013] The invention has also recognized that the use of a multicellular base body has a series of further advantages over the use of hollow spheres as per the prior art (DE-A 23 48 338).

[0014] The hollow spheres, of the prior art are opened in an early stage of the grinding operation. It has been found that although the opened hollow spheres do not increase the percentage contact area of the tool surface and generate free space for chins, the chips cannot be removed from the half-opened hollow body. Rather, these compact during the course of the grinding process in such a way that the percentage contact area of the tool surface is increased and marks having the quality of surface defects can be formed on the workpiece surface.

[0015] In addition, damage to the abrasive particle hollow body can occur in the production process and in the further course of production lead to filling of these hollow bodies with the regluing system used. In the grinding process, the hollow body which has been filled in this way can no longer open and causes surface defects and/or a premature end to the operating life.

[0016] The multicellular structure used according to the invention avoids these disadvantages. A base body which has been opened at the beginning of the grinding process does not have space for accommodating chips and abraded material because of its porous structure.

[0017] According to the invention, the base body is preferably made of a glass; in particular, it can be a foamed glass body. Suitable glasses are, for example, soda-lime silicate glasses. A person skilled in the art will be familiar with the production of such a preferably essentially spherical, base body and the production thereof is described, for example, in DE 39 41 732 A1, DE 195 22 460 A1, DE 103 60 819 A1, EP 484 643 A1 and ED 1 723 087 B1. These documents are incorporated by reference into the present disclosure. Suitable base bodies composed of glass having a multicellular structure are commercially available, for example from Dennert Poraver GmbH under the trade name Poraver®.

[0018] The use of such glass base bodies for the purposes of the Invention has the further advantage that environmentally friendly production of the abrasive is possible. The production of hollow vinyl chloride-ethylene spheres known in the prior art requires a high outlay for occupational hygiene and environmental protection because of the processing of vinyl chloride. The same (elaborate occupational hygiene and environmental protection) applies to the production of hollow spheres based on polystyrene, in particular in the pyrolysis of the polystyrene core with the volatile pyrolysis products formed.

[0019] The average size of the abrasive bodies is, according to the invention, preferably from 0.1 to 2 mm, more preferably from 0.2 to 1 mm, more preferably from 0.3 to 0.5 mm. The invention makes it possible, in particular, to provide abrasive bodies having small sizes (for example about 300 μm or 300-500 μm) which are required for the grinding tools having a coating thickness in the order of magnitude of 600 μm, for which there is increasing demand. Multicellular base bodies can readily be produced in any desired size and are commercially available. In contrast, the production of such small abrasive bodies is not readily possible in the prior art (based on hollow spheres). In the production of vinyl chloride-ethylene copolymer spheres, the size of these cannot be controlled with sufficient precision by the process conditions in the prior art, the spheres obtained therefore have to be sieved and only the part having the appropriate size range can be used. Furthermore, very small hollow spheres require, for reasons of stability, a comparatively thick binder layer for the application of abrasive particles, but this thick binder layer makes breaking-open during the course of the grinding process difficult. On the other hand, the multicellular base bodies of the present invention have an inherently higher stability and therefore require, even at a small size, only a correspondingly thinner binder layer.

[0020] The pore size of the base body is preferably in the range from 1 to 200 μm (determined on scanning electron micrographs of polished sections). The density of the base body is preferably in the range from 0.1 to 1 g/cm^3. This density range firstly makes it possible to achieve sufficient strength, particularly in the production of the abrasive, during application to a grinding tool and in use and secondly allows continuous removal of material from the porous base body during the course of the grinding process, so that as yet unused abrasive particles continually come into contact with the workpiece surface. Furthermore, at a density in this range, the percentage contact area and thus the evolution of heat of/from the grinding tool increase only inconsequentially after opening of the abrasive body and during the course of continuous removal thereof.

[0021] The compressive strength of an individual base body (before coating thereof with abrasive particles) is preferably from 0.2 to 6 N. Base bodies having a relatively small size, for example in the size range from 0.25 to 0.5 mm, can, according to the invention, have a compressive strength of from 0.2 to 1.6 N and correspondingly larger base bodies, for example in the size range from 1 to 2 mm, can have a compressive strength of from 1.1 to 6 N.

[0022] To determine the compressive strength of the individual base body, a single base body is placed on a steel plate. The granule is compressed to fracture using a punch placed on top by means of a testing press. The force required for this is reported as the compressive strength of the base body in [N]. The data reported represent the average of 30 individual measurements.

[0023] According to the invention, sufficient stability, in particular in the further processing of base bodies to give abrasives and abrasives to give a grinding tool, can depend on the compressive strength of the bed of base bodies. The compressive strength of such a bed of base bodies is, according to the invention, preferably in the range from 1 to 4 N/mm^2, more preferably from 1.5 to 3 N/mm^2. Here too, it can once again be preferred that the compressive strengths vary as a function of the size of the base bodies. In the case of base bodies in she range from 0.1 to 0.3 mm, a compressive strength of the bed of, for example, about 2.8 N/mm^2 can be preferred, in the case of a size range from 0.25 to 0.5 mm about 2.6 N/mm^2, in the case of a size range from 0.5 to 1 mm about 2 N/mm^2 and in the case of a size range from 1 to 2 mm about 1.6 M/mm^2. The compressive strength of the bed is determined by a method based on DIN EN 1355-2. To determine the compressive strength of the bed, 1 liter of the base body is introduced into a steel cylinder and compacted. The granular material is compressed by 20 mm in this cylinder using a punch placed on top by means of a testing press. The force required for this is reported as the compressive strength of the bed in [N/mm^2].

[0024] The abrasive particles on the surface of the base bodies can preferably consist of a size fraction in the range from P40 to P2500, preferably from P60 to P180 or from P180 to P500 (FEPA standard). The values mentioned can be combined in any way to form ranges according to the invention. As abrasive particles, it is possible to use, for example, α-alumina or silicon carbide.

[0025] The shape of the abrasive is determined primarily by the shape of the multicellular base body. This is due to the fact that the base body has a significantly larger volume compared to the abrasive particles and the abrasive particles are applied to the enveloping surface of the body and can thus not bring about any significant change in the shape of the abrasive. The size ratio of the diameters (abrasive particles/base bodies) is preferably less than 1:6. In the determination, the average abrasive particle diameter dk50 is determined in accordance with the FEPA standard 43-D-1984 and divided by the diameters of the multicellular base body. The diameters of the multicellular base body are derived from the classification by the manufacturer (Dennert Poraver GmbH).

[0026] The invention further provides a process for producing an abrasive according to the invention, which comprises the steps:

[0027] a) provision of the multicellular base body,

[0028] b) coating of the base body with binder,

[0029] c) coating of the base body with ti abrasive particles.

[0030] As binder, it is possible to use suitable organic or inorganic binders of the prior art.

[0031] According to the invention, drying can be carried out after coating of the base body with abrasive particles. Preference is given to heating to temperatures above 200° C., preferably temperatures of from 100 to 1000° C., more preferably from 800 to 1000° C., beyond drying. Here, the binder is strengthened further, in particular burnt, and attains its maximum strength. The grinding particles are firmly bound to the surface of the base body, and strengthened binder can contribute to the resistance of the finished abrasive body to compressive and shear stresses.

[0032] During the course of such a thermal treatment, a thermally induced change in the multicellular structure in the interior of the base body may occur. The use of base bodies composed of an appropriately heat-resistant material makes it possible to maintain the stability of the multicellular structure even at these high temperatures. This is useful in the case of abrasives for use with high grinding forces.

[0033] The invention further provides a grinding cool having a substrate, a binder for abrasive and an abrasive according to the invention. The substrate can comprise a woven or knitted fabric or paper. A covering binder can be additionally applied to the abrasive. The grinding tool can be, for example, a grinding tape, abrasive paper or the like.

[0034] Working examples of the invention are described below.

[0035] The figures show:

[0036] FIG. **1** a photomicrograph of a base body having a multicellular structure;

[0037] FIG. **2** a photomicrograph of a grinding tool according to the invention after a period of use which corresponds to about half the operating life;

[0038] FIGS. **3** and **4** grinding power (material removed) and peak-to-valley height of grinding tools according to the invention.

EXAMPLES 1-4

Production of Abrasive Bodies

[0039] The production of the abrasive bodies according to the invention is carried out by coating a multicellular base body with binder and abrasive particles. As base bodies, use is made of Poraver® glass bodies from Dennert Poraver GmbH. FIG. **1** shows a photomicrograph of such a base body having a multicellular structure. The size ranges used are indicated in Tab. 1 which indicates the constituents of the abrasive bodies.

TABLE 1

	Example 1	Example 2	Example 3	Example 4
Poraver base bodies from Dennert [kg]	30 (d = 0.7-1.0 mm)	30 (d = 0.7-1.0 mm)	30 (d = 0.5-1.0 mm)	30 (d = 0.5-1.0 mm)
Binder CM 025 [kg]	33 (3 × 11)*	33 (3 × 11)*	33 (3 × 11)*	33 (3 × 11)*
Abrasive particles NK P400 [kg]	90 (3 × 30)*	90 (3 × 30)*		
Abrasive particles SiC P180 [kg]			90 (3 × 30)*	90 (3 × 30)*
Drying*	3 × 20 min, 176° C.	3 × 20 min, 176° C.	3 × 20 min, 176° C.	3 × 20 min, 176° C.
Curing	—	10 min, 920° C.	—	10 min, 920° C.

*a three-stage coating operation was selected.

[0040] Tab. 2 describes the composition of organic and inorganic binders. The binder of the type CM 025 serves to apply abrasive particles to the base body. The binder GL 414 is used to apply abrasive to a substrate for producing a grinding tool (see examples below). The binder NL 592 serves as covering binder for the grinding tool. Organic binders, e.g. binders based on phenolic, epoxy, melamine or polyurethane resins can also be used instead of an inorganic binder to anchor abrasive particles on the multicellular base body.

TABLE 2

Type	CM 025	GL 414	NL 592
Refractory binder FFB 32 [kq]	64.4		
Clay GWE [kg]	33.9		
Emulan A [kg]	1.79	0.253	0.6
Phenolic resin SF [kg]		50.505	60.0
Omyacarb 4-BG [kg]		26.936	50.0
Calcium carbonate type 442 [kg]		16.835	25.0
IRON OXIDE BLACK 316 [kg]			4
Water [kg]		5.471	25.5

	In-house type designation	Description	Source
(1)	Refractory binder FFB 32	Monoaluminum phosphate solution	Chemetall GmbH
(2)	Clay GWE	Chamotte	Adolf Gottfried Tonwerke GmbH
(3)	Emulan A	Nonionic emulsifier	BASF SE
(4)	Phenolic resin SF	Aqueous resol	Momentive GmbH
(5)	Omyacarb 4-BG	Ground chalk	Omya GmbH
(6)	Calcium carbonate type 442	Precipitated chalk	Magnesia GmbH
(7)	IRON OXIDE BLACK 316	Fe304 color pigment	Bayer AG

[0041] To produce the abrasive, base bodies and binder CM 025 are firstly mixed with one another. A mechanical mixer 'Zyklos" from Schwelm is used here. As soon as the base bodies are completely wetted, the abrasive particles are added and homogeneously distributed. The product is dried at about 176° C. by means of a belt dryer. After drying, the product is classified by means of a longitudinal vibrating sieve. The upper sieve has a mesh opening of 1600 μm, and the lower sieve has a mesh opening of 840 μm. The residue on the lower sieve is subjected two further times to This coating process and in each case dried. Separate, sprinklable and free-flowing abrasive spheres are obtained. Curing by heating (examples 2 and 4) is carried out merely once after the last coating operation.

[0042] The abrasives differ in the use of different abrasive particles, namely standard α-alumina particle size fraction P400 (examples 1 and 2) and silicon carbide (examples 3 and 4). The abrasives of examples 1 and 3 are merely dried, while those of examples 2 and 4 are additionally strengthened by heat treatment (fired).

EXAMPLES 5-8

Production of Grinding Tapes

[0043] Table 3 below shows the constituents of grinding tapes according to the invention.

	Example 5	Example 6	Example 7	Example 8
Support	Paper (300 g/m^2)	Paper (300 g/m^2)	X2623/1 (310 g/m^2)	X2623/1 (310 g/m^2)
Base binder	GL 414 (85 g/m^2)	GL 414 (93 g/m^2)	GL 414 (160 g/m^2)	GL 414 (150 g/m^2)
Abrasive	Example 2 (122 g/m^2)	Example 1 (106 g/m^2)	Example 4 (220 g/m^2)	Example 3 (191 g/m^2)
Covering binder	NL 592 (245 g/m^2)	NL 592 (245 g/m^2)	NL 592 (360 g/m^2)	NL 592 (328 g/m^2)

EXAMPLE 5

[0044] A paper support (width 400 mm, 300 g/m^2) was coated with the base binder GL 414 and subsequently sprinkled with the abrasive from example 2. The velocity of travel was 5 m/min and the mass of base binder applied per unit area was 85 g/m^2, and that of the abrasive was 122 g/m^2.

[0045] After a residence time of 90 minutes in a loop dryer at 90° C., the regluing (covering binder) of the type NL 592 was applied at a mass per unit area of 245 g/m^2 (velocity of travel 5 m/min). After drying in a loop dryer (180 min, 130° C.) and flexing (flexing unit from IM&T, transverse flexing with smoothing rod, 1.5 bar, 15 m/min), grinding tapes having dimensions of 150 mm×2500 mm (straight sheet butt joint, 70° C.) were made.

EXAMPLE 6

[0046] The procedure of example 5 was repeated with the following modifications:

[0047] An abrasive from example 1 is sprinkled on in an amount of 106 g/m^2; the base binder GL 414 is applied in an amount of 93 g/m^2 and the covering binder NL 592 is applied in an amount of 245 g/m^2.

EXAMPLE 7

[0048] The procedure of example 5 was repeated with the following modifications:

[0049] A woven cotton fabric X2623/1 (from Holsteinische Textilveredelung, twilled cotton fabric having a thread count of 32.5/19.0 (warp/weft) threads/cm^2 having a thread thickness of 50/36 (warp/weft) TEX, consolidated by means of a finish composed of a leather glue/latex mixture, (310 g/m^2) is used as substrate. An abrasive from example 4 is sprinkled on in an amount of 220 g/m^2; the base binder GL 414 is applied in an amount of 160 g/IT and the covering binder NL 592 is applied in an amount of 360 g/m^2.

EXAMPLE 8

[0050] The procedure of example 5 was repeated with the following modifications:

[0051] A woven cotton fabric X2623/1 (310 g/m^2) is used as substrate. An abrasive from example 3 is sprinkled on in an amount of 191 g/m^2; the base binder GL 414 is applied in an amount of 150 g/m^2 and the covering binder NL 592 is applied in an amount of 328 g/m^2.

EXAMPLE 9

[0052] Grinding tests are carried out using the grinding tapes of examples 5 and 6 under the following conditions:

[0053] Grinding machine: Flat grinding machine from Niederberger, Type NCS-P Support disk: grooved, hardness 60' Shore

[0054] Power drawn: 2 A

[0055] Tape velocity: 26 m/s

[0056] Workpiece advance: 10 m/min

[0057] Workpiece: Flat steel, material number 1.4301 in accordance with DIN 17007 (3 mm×50 mm×1000 mm)

[0058] FIG. **2** shows the surface of a grinding tape according to the invention after a period of use corresponding to about half the operating life. Opened particle-coated bodies, in this case abrasive, having a porous internal structure, but no accumulation of abraded material, can be seen.

[0059] FIG. **3** shows the result of the grinding tests. It can be seen that the removal of material is significantly higher for a grinding tape according to the invention of example 5 in which the abrasive was additionally heat-treated after drying. The bold lines are for example 5 and the thin lines for example 6.

[0060] Grinding tests using the grinding tapes of examples 7 and 8 are carried out under the same conditions, except that titanium (material number 3.7164 in accordance with DIN 17007, dimensions: 4 mm×100 mm×1000 mm) is used as workpiece. FIG. **4** shows the result of the grinding tests. It can be seen that the removal of material is significantly higher for a grinding tape according to the invention of example 7 in which the abrasive was additionally heat-treated after drying. The bold lines are for example 7 and the thin lines for example 8.

1. Abrasive having a base body and abrasive particles applied to the surface of the base body, characterized in that the base body has a multicellular structure.

2. Abrasive according to claim **1**, characterized in that the base body is a foamed glass body.

3. Abrasive according to claim **1**, characterized in that the base body is essentially spherical.

4. Abrasive according to claim **1**, characterized in that the average size of the abrasive bodies is 0.1-2 mm, preferably 0.2-1 mm, more preferably 0.3-0.5 mm.

5. Abrasive according to claim **1**, characterized in that the pore size of the base body is in the range from 1 to 200 μm.

6. Abrasive according to claim **1**, characterized in that the density of the base body is in the range from 0.3 to 1 g/cm3.

7. Abrasive according to claim **1**, characterized in that the compressive strength of a base body is 0.2-6 N.

8. Abrasive according to claim **1**, characterized in that the compressive strength of a bed of the base bodies is 1-4 N/mm2, preferably 1.5-3 N/mm2.

9. Abrasive according to claim **1**, characterized in that the abrasive particles consist of a particle size fraction in the range from P150 to P1000, preferably from P180 to P500.

10. Abrasive according to claim **1**, characterized in that the abrasive particles comprise α-alumina or silicon carbide.

11. Process for producing an abrasive according to claim **1**, characterized by the following steps:

d) provision of the multicellular base bodies,

e) coating of the base body with binder,

f) coating of the base body with abrasive particles.

12. Process according to claim **11**, characterized in that the abrasive is heat-treated, preferably at temperatures of 400-1000° C., preferably 800-1000° C.

13. Grinding tool having a substrate, a binder for abrasive and an abrasive, wherein the substrate preferably comprises a woven fabric, a knitted fabric or paper, film or nonwoven, characterized in that it comprises abrasive according to claim **1**.

14. Bonded grinding tool, characterized in that it comprises binder and abrasive according to claim **1**.

15. Grinding tool according to claim **13**, characterized in that it additionally has a covering binder.

* * * * *