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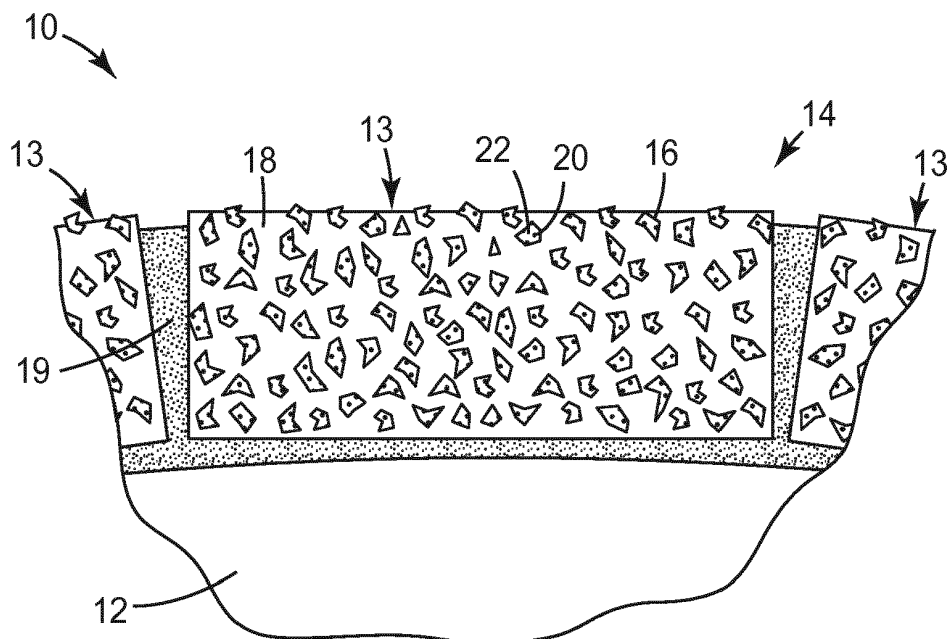
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(54) **ABRASIVE ARTICLE COMPRISING AGGLOMERATES AND METHOD OF MAKING THEREOF**

(57) The invention relates to an abrasive article comprising a carrier body as well as an abrasive layer, wherein the abrasive layer comprises agglomerates with superabrasive particles bound in a first vitrified bond (bond I) as well as a second vitrified bond (bond II) bonding the

agglomerates, wherein the hemisphere point of the first vitrified bond is higher or the same than the hemisphere point of the second vitrified bond. The invention also relates to a method of making an abrasive layer for an article according to the invention.

**FIG. 2****EP 3 663 042 A1**

Description

[0001] The invention relates to an abrasive article as well as to a method of making an abrasive layer for an abrasive article.

[0002] Abrasive articles comprising an abrasive layer are used to grind, abrade, finish and/or polish a wide variety of materials, commonly referred to as workpiece, in a wide variety of applications. These applications range from for example high surface finish level to high level of parallelism of metal to finish camshafts. In the context of this patent application abrading or grinding is used for any kind of surface modification or material removal of a workpiece. Abrasive process or grinding process is used to describe any kind of removing process of material of a workpiece or modification process of a surface of a workpiece.

[0003] Abrasive articles comprising agglomerates are well known and are usually used in abrasive wheels as well as in abrasive belts. Agglomerates usually comprise abrasive particles as well as a binder. Common binders that may be used for agglomerates are inorganic binders as well as organic binders, wherein vitrified or ceramic materials may be used as inorganic binders and phenolic resins may be used as organic binders.

[0004] An advantage of abrasive agglomerates is that small and medium sized abrasive particles may be used to build up a relatively large agglomerate. The agglomerates provide a completely different abrasive behaviour compared to abrasive particles of a comparable size. They can be useful for providing abrasive articles that can exhibit unexpected extended life and stable cut-rates over that extended life when compared to state-of-the art monolayer constructions.

[0005] One example of an abrasive article with shaped agglomerates is for example disclosed in WO 2018/017695 A1. According to this publication abrasive agglomerate particle including fused aluminium oxide mineral bonded in a vitreous matrix are known.

[0006] Abrasive articles comprising agglomerates with superabrasive particles bonded in a glass powder or respectively bonded in a vitrified matrix are also known. According to WO 2004/094110 A1 those abrasive articles may be used in continuous belts, abrasive tapes or resin bonded disks.

[0007] In view of the prior art cited above, there is still a need for an abrasive article with high cut rates, an extended life time and at the same time low damaging of the ground surface.

[0008] Surprisingly it has been found that an abrasive article comprising:

- a carrier body as well as
- an abrasive layer, wherein the abrasive layer comprises
 - agglomerates with superabrasive particles bound in a first vitrified bond (bond I) as well as
 - a second vitrified bond (bond II) bonding the agglomerates, wherein the temperature of the hemisphere point measured according to DIN 51730 (2007-09-00) of the first vitrified bond (bond I) is higher or the same than the temperature of the hemisphere point measured according to DIN 51730 (2007-09-00) of the second vitrified bond (bond II)

provides extremely good life time properties as well as extremely stable cut-rates compared to abrasive articles known in the prior art.

[0009] A carrier body of the abrasive article according to the invention may have any known shape of carrier bodies for abrasive articles, such as a disk like shape, a cylindrical shape etc. In most of the cases they are shaped such that they may be used on machines comprising a rotary drive. The carrier body of the abrasive article according to the invention may comprise any kind of known material usually used for carrier bodies of abrasive articles, such as metals, ceramics or polymers like for example steel, aluminium or stainless steel, ceramics, polyamide, phenolic based compound filled with particles, carbon reinforced fiber etc. or a combination thereof.

[0010] Abrasive articles further provide at least one abrasive layer that is arranged on a surface of the carrier body. The abrasive layer is the layer of the abrasive article that is used for abrading or grinding a workpiece. The abrasive layer may be continuous, or it may comprise segments that build the abrasive layer. If the carrier body is a disk, they may be arranged on at least one of the two parallel surfaces of the carrier body. When the carrier body is cylindrically shaped, the abrasive layer may also be arranged on the circumferential surface of the carrier body. Any other known shapes of an abrasive layer are possible as well.

[0011] The abrasive article according to the invention provides an abrasive layer, wherein the abrasive layer comprises agglomerates. The agglomerates according to the invention comprise superabrasive particles that are bound in a first vitrified bond (so called bond I). The abrasive layer further comprises a second vitrified bond (so called bond II) that bonds the agglomerates to a layer. According to the invention the vitrified bonds of the agglomerates and of the abrasive layer (bond I and bond II) are selected such that the temperature of the hemisphere point measured according to DIN 51730 (2007-09-00) of the first vitrified bond (bond I) used in the agglomerates is higher or the same than the temperature of the hemisphere point measured according to DIN 51730 (2007-09-00) of the second vitrified bond (bond II) bonding

the agglomerates.

[0012] The vitrified bond may comprise glass (powder) or glass-ceramic. Various types of glass and glass-ceramics may be useful to make the vitrified bond. It may be produced from a precursor composition comprising a mixture or combination of one or more raw materials that when heated to a high temperature melt and/or fuse to form an integral vitreous matrix phase. The vitrified bond may be formed, for example from a frit. A frit is a composition that has been pre-fired before its employment in the precursor composition for forming the vitrified bond of the agglomerate particle and/or of the abrasive layer. As used herein, the term frit is a generic term for a material that is formed by thoroughly blending a mixture comprising one or more frit forming components, followed by heating (also referred to as pre-firing) the mixture to a temperature at least high enough to melt it; cooling the resulting glass, and crushing it. The crushed material can then be screened to a very fine powder.

[0013] Examples of suitable glasses for the vitrified bonds and the frit for making it include silica glass, silicate glass, borosilicate glass, and combinations thereof. A silica glass is typically composed of 100 percent by weight of silica. In some embodiments, the vitreous matrix is a glass that includes metal oxides or oxides of metalloids, for example aluminium oxide, silicon oxide, boron oxide, magnesium oxide, sodium oxide, manganese oxide, zinc oxide, calcium oxide, barium oxide, lithium oxide, potassium oxide, titanium oxide, metal oxide that can be characterized as pigments (e.g., cobalt oxide, chromium oxide, and iron oxide), and mixtures thereof.

[0014] The superabrasive particles used in the agglomerates of the invention, may be any kind of known superabrasive particles. Superabrasive particles generally have a Mohs hardness of greater than 8. The superabrasive particles include cubic boron nitride (CBN) and diamonds or a combination thereof. They can be either shaped (i.e. rod, triangle, or pyramid) or unshaped (i.e. irregular).

[0015] The superabrasive particles may be present in the abrasive layer in a range from 20 to 50 vol. % based on the volume of the abrasive layer. The superabrasive particles may be preferably present in the abrasive layer in a range from 30 to 40 vol. %. When the vol. % is higher than 50% the abrasive article will be too hard. Also, if the vol. % is above the mentioned threshold and if too much abrasive is inside of the abrasive article the specific pressure between the abrasive layer and the workpiece in the grinding process might be too high. On the other hand, if the vol. % is smaller than 20 % the lifetime of the abrasive article will be too short.

[0016] The first vitrified bond may be present in the abrasive layer in a range from 5 to 20 vol. % based on the volume of the abrasive layer. It may preferably be present in the abrasive layer in a range from 6 to 12 vol. %.

[0017] The second vitrified bond may be present in the abrasive layer in a range from 5 to 20 vol. % based on the volume of the abrasive layer. It may preferably be present in the abrasive layer in a range from 7 to 15 vol. % based on the volume of the abrasive layer. If the second vitrified bond is present in an amount outside of the mentioned range it is either not enough or too much "adhesive" or bonding material in the abrasive layer.

[0018] According to one embodiment of the invention, the abrasive layer may comprise pores in a range from 35 to 55 vol. % based on the volume of the abrasive layer. A structure with a certain number of pores comprises an open structure, which is good for grinding and provides a lower risk of grinding burn.

[0019] The agglomerates in the abrasive layer of the abrasive article according to the invention may have an average equivalent circle diameter of 0.4 to 1.3 mm. The equivalent circle diameter may be optically measured with a Keyence Microscope VHX 5000 (Version 1.3.2.4, System Version 1.03) (commercial available from Keyence Deutschland GmbH, 63263 Neu-Isenburg, Germany).

[0020] The superabrasive particles in the agglomerates may have an average size between US 400/500 mesh to US 60/80 mesh measured according to ANSI B74.12-2012.

[0021] For the invention it is possible to use agglomerates of irregular shape or agglomerates of precise shape. If the agglomerates comprise a precise shape, they may for example have a cubical shape, a pyramidal shape, a truncated pyramidal shape, a spherical shape or a combination of the before mentioned.

[0022] The invention is also related to a method of making an abrasive layer for an abrasive article according to the invention, wherein the method comprises the steps of:

- providing agglomerates with superabrasive particles bound in a first vitrified bond (bond I)
- providing a frit for generating a second vitrified bond (bond II)
- optionally providing other components like additives
- mixing the agglomerates, the frit as well as the optional components to a homogeneous mixture;
- bringing this mixture in the form of an abrasive layer or in the form of segments or pellets for building an abrasive layer;
- sintering the formed mixture at a temperature that is lower than the temperature used for sintering the agglomerates.

[0023] The agglomerates of the present invention can be prepared by the following procedure. Abrasive particles are mixed with a temporary binder and a permanent binder in solution to form a slurry. Generally, the mixture is agitated to disperse the abrasive particles. Specific examples of temporary binders include dextrin in water.

[0024] After the mixing steps is complete, the slurry is moved into a mold, for example, a tooling bearing multiple

cavities. The cavities in the tooling can have many different shapes, for example, a truncated pyramid. Excess slurry is removed, resulting in discrete molds filled with the slurry. The slurry is then solidified by drying, for example, at room temperature for about 15 to about 20 hours. Solidification results from removal of the liquid from the mixture. The dried particles are agglomerate precursors, held together by the temporary binder. The agglomerate precursors are then removed from the tooling. The temporary binder materials bind the agglomerates before final firing but would generally be removed when the permanent binder is activated, for example the temporary binder would burn away in a firing step.

[0025] This is generally accomplished by heat to fuse the permanent binder, or by radiation to activate a solidification process. For example, the agglomerate precursors, with a glass permanent binder, are fused by heating an oven in a first step at about 330 °C for about 1 hour, in a second step at about 420 °C for 1 hour and then the temperature is raised to the temperature of the hemisphere point of the vitrified bond within about 80 °C of the hemisphere point of the glass for about 3 hours. The two steps at 330 and 420 °C are necessary to ensure a complete burning out of the temporary binder.

[0026] The difference between the sintering temperature of the first vitrified bond (bond I) and the sintering temperature of the above mentioned process may be between 20 and 300 °C. The difference in temperature may be preferably between 30 and 200 °C.

[0027] The optional other components mentioned in the above method may be additives like temporary binders (e.g. polycarboxylic acid or polyethylenglykol or dextrin).

[0028] The invention will now be described in more detail with reference to the following figures exemplifying particular embodiments of the invention:

Fig. 1 is three-dimensional view of an abrasive article of the present invention and

Fig. 2 is a cross sectional view of the detail A in Figure 1 of the abrasive article of the present invention.

[0029] Herein below various embodiments of the present invention are described and shown in the drawings wherein like elements are provided with the same reference numbers.

[0030] Fig. 1 is a three-dimensional view of an abrasive article 10, a peripheral grinding wheel, of the present invention. The abrasive article 10 comprises a carrier body 12 and an abrasive layer 14. The abrasive layer 14 consists of several segments 13 building the abrasive layer 14.

[0031] Fig. 2 illustrates the detail A of Figure 1 of the abrasive article 10 according to the invention. The abrasive article 10 comprises a carrier body 12 and an abrasive layer 14. The abrasive layer 14 comprises segments 13 glued on the carrier body 12 by an adhesive 19. The segments 13 comprises agglomerates 16 as well as a vitrified bond 18 (bond II) holding the agglomerates 16. The agglomerates 16 comprise superabrasive particles, Cubic Boron Nitride (CBN), 20 as well as a vitrified bond 22 (bond I).

Examples

[0032] The invention is further illustrated by the following examples that are not intended to limit the scope of the invention. These examples are merely for illustrative purposes only and are not meant to be limiting on the scope of the appended claims.

Example 1: B126 standard grinding wheel (comparative example)

Example 2: B126 grinding wheel according to the invention

[0033] Example 1: the reference grinding wheel is J10B.000.947 350-10-4-B126-VZ150R-411-127 T20 14A1 (commercial available from 3M Deutschland GmbH, 41453 Neuss, Germany).

[0034] Manufacturing of Example 2, the grinding wheel according to the invention (with the agglomerates in the abrasive layer)

Preparation of the agglomerates

[0035] The agglomerates of the present invention can be prepared by the following procedure. Abrasive particles as specified below are mixed with a temporary binder as specified below and a permanent binder as also specified below in solution to form a slurry. The mixture is agitated to disperse the abrasive particles. Specific examples of temporary binders include dextrin in water.

[0036] First step of preparation the mixture for the agglomerates is to prepare the temporary binder according Tab. 1. This binder offered adequate green strength of the agglomerates before firing and burns off clearly during the firing process.

Tab. 1: Temporary Binder for Mineral

Dextrin	25,0g	Commercial available from Carl Roth GmbH & Co. KG, 76185 Karlsruhe, Germany
De-ionized Water	75,0g	
Total	100,0g	

Tab. 2: Slurry Formulation for Mineral in weight percent

Weight %		Material	Supplier
9,4	Vitrified bond I	Glass Frit BP 10613	Reimbold + Strick GmbH 51149 Köln Germany
62,9	Abrasive particles	CBN AMA B126	World Wide Superabrasive 33426 Boynton Beach, Florida, USA
25,2	Temp. binder	25 % Dextrin in Water	see Tab. 1
1,9	Additive	Aerosol AY 50 (50% MEK)	Dow Corning Cooperation Midland, MI, USA
0,6	Additive	Defoamer Dow 62	Dow Corning Cooperation Midland, MI, USA
100		Total	

[0037] The slurry was thoroughly mixed by stirring in an open beaker system for five minutes followed by an ultrasonic bath for a period of 30 minutes. After the mixing step is complete, the slurry is moved into a mold, for example, a Polypropylene tooling bearing multiple cavities. The cavities in the tooling can have many different shapes, for example, a truncated pyramid. Excess slurry is removed, resulting in discrete molds filled with the slurry. The slurry is then solidified by drying, for example, at room temperature for about 15 to about 20 hours. Solidification results from removal of the liquid from the mixture. The dried particles are agglomerate precursors, held together by the temporary binder. The agglomerate precursors are then removed from the tooling. The temporary binder materials bind the agglomerates before final firing but would generally be removed when the permanent binder is activated, for example the temporary binder would burn away in a firing step.

[0038] This is generally accomplished by heat to fuse the permanent binder, or by radiation to activate a solidification process.

[0039] The agglomerate precursors, with a glass permanent binder, are fused by heating an oven in a first step at about 330 °C for about 1 hour, in a second step at about 420 °C for 1 hour and then the temperature is raised to the temperature of the hemisphere point of the vitrified bond within about 80 °C of the hemisphere point of the glass for about 3 hours. The two steps at 330 and 420 °C are necessary to ensure a complete burning out of the temporary binder. The sintering cycle is according to the data in Tab. 3.

[0040] The agglomerates are sintered under a controlled reduced atmosphere in a LH120/13 furnace (commercial available from Nabertherm GmbH, 28865 Lilienthal, Germany).

Tab. 3: Sintering cycle for the agglomerates

	Step 1	Step 2	Step 3	Step 4
Heating rate (°C/hour)	80	80	60	50
Temperature (°C)	330	420	970	20
Holding time (minutes)	60	60	180	0

Preparation of the abrasive layer

[0041] A mixture of several raw materials as specified below is pressed into segments to build up the abrasive layer of the test wheel B.

[0042] The recipe to produce the mixture and to press the segments:

Tab. 4 Formulation for Mixture to build up the Abrasive Layer

Weight in g		Material	Supplier
100,85	Abrasive particles	Agglomerates	Described above
1,82	Additive	Acrodur 950L	BTC Europe GmbH 40789 Monheim, Germany
1,00	Additive	Polyethylenglykol 400	Carl Roth GmbH & Co. KG 76185 Karlsruhe Germany
7,94	Additive	Water	
15,28	Vitrified bond II	Glass Frit BP 10613	Reimbold + Strick GmbH 51149 Köln Germany
4,97	Temporary binder	Scotch Weld SW4235I	3M Deutschland GmbH 41453 Neuss Germany

[0043] The materials (see above) are mixed by hand in a porcelain mortar with a spoon. After drying this mixture at room temperature for app. 10 hours, the mixture is sieved through a 1mm sieve. Next step is to press the mixture into segments. 2,09g are filled in to a cavity of a pressing mold. Each segment has a volume of 1.138,5mm³. The pressed segments have the following dimensions 11,5mm x 22mm x 4,5mm. The pressed green parts have a volume of 1.138,5 mm³ and a weight of 2,09g.

[0044] After the above described pressing process the segments are sintered in a LH120/13 furnace (commercial available from Nabertherm GmbH, 28865 Lilienthal, Germany). The sintering cycle is shown in Tab 5.

Tab. 5: Sintering cycle for the segments

	Step 1	Step 2	Step 3	Step 4
Heating rate (°C/hour)	80	80	60	50
Temperature (°C)	330	420	930	20
Holding time (minutes)	60	60	180	0

[0045] The sintered segments are now glued on a commercially available steel body (carrier body). The used adhesive is Scotch-Weld 9323 B/A (commercial available from 3M Deutschland GmbH, 41453 Neuss, Germany).

[0046] Figure 1 shows the final configuration of a grinding wheel with an abrasive layer according to the invention.

Grinding tests

[0047] All here described grinding tests are running on a grinding machine Junker Lean Selection Speed # 80038 (commercial available from Erwin Junker Maschinenfabrik GmbH, 77787 Nordrach, Germany).

Plunge Grinding Test

[0048] First test cycle, used to evaluate the grinding ability of the abrasive article, is a plunge grinding test related to the damage of the workpiece surface after the grinding process.

[0049] All tests are started with a dressing process to eliminate an out of the round of the mounted grinding wheel on the spindle of the grinding machine. The diamond dressing disc is U75B.003.053 IS 170 8 75 3.28467 R=0,3 / 40° LAP (commercial available from 3M Deutschland GmbH, 41453 Neuss, Germany). The dressing disc and the grinding wheel are turning in same direction. The peripheral speed of the grinding wheel is 80 m/s and the peripheral speed of the dressing disc is 64m/s. The completely infeed of the dressing process is 12µm and is done in 3 steps by 4µm.

[0050] The grinding test itself is done with six steel plates (dimensions, outside diameter of 105mm, inside diameter of 6mm and a thickness of 8mm) and the steel quality is bearing steel type 100CR6 (1.3505) with a hardness of HRC 62 +2 measured according DIN EN ISA 6508-1:2016 (commercial available from Carl Pohle GmbH & Co. KG, 41238 Monchengladbach, Germany). After two grinding steel plates the above described dressing process was performed.

[0051] To evaluate the quality of the workpiece surface after the grinding process the Barkhausen values are measured.

[0052] The Barkhausen value (Barkhausen noise) is an approved measuring technique in the quality control of grinding processes. The Barkhausen measurement is to detect the magnetism of the lateral face of a workpiece, to control the resulting damage of the workpiece surface after the grinding process. This measurement detects modifications in the

workpiece generate by burning (overheating when grinding) during the grinding process. The Barkhausen measurement is a popular test in the automotive and bearing industry to control the quality of grinding operations by steel parts. A lower Barkhausen value indicates a better surface quality.

[0053] The following equipment is used for the measurement of the Barkhausen value during the described grinding tests. Analyser Stresstech Rollscan 350, device to mount the workpiece; Stresstech Shaftscan 100, measuring sensor Stresstech S1-15-32-02 and software Stresstech view scan V.4.3 (all this equipment is commercial available from Stresstech GmbH, 56477 Rennerod, Germany).

[0054] Each grinding wheel is tested with three runs - each run grinding the wheel to a smaller diameter - with respectively two steel plates. Each steel plate has an outside diameter of 105mm at the beginning, after grinding down to an outside diameter of 88,9mm (first run) and then the Barkhausen value is measured, after that grinding to an outside diameter of 68,9mm (second run) the Barkhausen value is measured and then the last Barkhausen value is measured at an outside diameter of 40,0mm (third run) of the steel plate.

[0055] The grinding and measuring of the second steel plate is the same procedure as described before, but without the dressing process. After the first test run with two steel plates six Barkhausen values are measured.

[0056] After three test runs of the six steel plates 18 Barkhausen values are measured and the Barkhausen values listed in the table 5 are an arithmetic average of these 18 values. For each example (Example 1 and Example 2) six steel plates are grinded.

[0057] This grinding test to evaluate the Barkhausen value runs with peripheral speed of the grinding wheel of 80 m/s. The speed ratio between the grinding wheel and the steel plate is constant 94 m/s during the test. The peripheral speed of the steel plate is constant 0,85m/s. The grinding wheel and the steel plate are turning in the same direction.

[0058] Each test run for example the first run to grind the outside diameter from 105mm down to 88,9mm runs in three different grinding operations. First grinding operation, the roughing grinding, is with a constant Q'_w of 60mm³/mm * s. Second grinding operation, the pre-finishing, is with an infeed of 20μm and with a constant Q'_w of 8mm³/mm * s. Third grinding operation, the finishing, is with an infeed of 2μm and with a constant Q'_w of 2mm³/mm * s.

[0059] Q'_w is the stock removal rate in a grinding process. Another term for Q'_w is Q-prime.

$$Q'_w = \frac{a_e \times v_w}{60}$$

a_e = depth of cut per pass in mm

v_w = workpiece feed-rate in mm per min

[0060] The used coolant is for all grinding tests Houghten Cut-Max-902-10 (commercial available from Houghton Deutschland GmbH, 44319 Dortmund, Germany). The coolant pump for the cooling nozzle has 10bar on the pressure side of the pump. The coolant pump for the cleaning nozzle has 60bar on the pressure side of the pump.

[0061] The arithmetic average of the Barkhausen values are shown in Tab. 2

Tab. 6: Averages of Barkhausen values

Example	Barkhausen value (average of 18 values)
Example 1	100
Example 2	54

[0062] The test results of Example 2 are better than the results of Example 1, the Barkhausen value is much lower of the parts which are grinded with Example 2. This result stands for a lower surface damage during the grinding process by Example 2.

Peel Grinding Test

[0063] Second test cycle is the peel grinding test, which is used to evaluate the grinding ability of the two grinding wheels in relation to their lifetime.

[0064] All peel grinding tests start with a dressing process to eliminate an out of the round of the mounted grinding wheel on the spindle of the grinding machine. The diamond dressing disc is U75B.003.053 IS 170 8 75 3.28467 R=0,3 / 40° LAP (commercial available from 3M Deutschland GmbH, 41453 Neuss, Germany). The dressing disc and the grinding wheel are turning in same direction. The peripheral speed of the grinding wheel is 120 m/s and the peripheral

speed of the dressing disc is 96m/s. The completely infeed of the dressing process is 12µm and is done in 4 steps by 3µm.

[0065] The peel grinding test itself is done with a steel tube (outer diameter 45mm, inner diameter 28mm, length 330mm) and the steel quality is bearing steel type 100CR6 (1.3505) with a hardness of HRC 62 +2 measured according DIN EN ISA 6508-1:2016 (commercial available from Carl Pohle GmbH & Co. KG, 41238 Monchengladbach, Germany).

[0066] To evaluate the cutting performance of the grinding wheels related to the ware resistance the G-ratio is commonly used. The G-ratio mentioned in this patent application is defined as the volume of stock removed of the workpiece divided by the volume of abrasive tool lost.

$$G - Ratio = \frac{V_W}{V_A}$$

V_W = the volume of stock removed of the workpiece in mm³

V_A = the volume of abrasive tool lost in mm³

[0067] Each grinding wheel is tested with two runs with respectively two steel tubes. Each steel tube has an outside diameter of 45mm at the beginning, after grinding down an outside diameter of 32mm. The grinding test to evaluate the G-ratio runs with a peripheral speed of the grinding wheel of 120 m/s. The speed ratio between the grinding wheel and the steel tube is constant 53 during the test. The peripheral speed of the steel tube is constant 2,26m/s. The grinding wheel and the steel tube are turning in counter rotation. The stock removal rate in this grinding cycles is constant and is 50 mm³/sec.

[0068] Each peel grinding step in axial direction along the length of the steel tube has an infeed of 0,1mm in radial direction, all peel grinding test runs start at the same position in axial direction. After the grinding of two steel tubes for each grinding wheels, the ground volumes of the steel tubes are divided by the lost abrasive volumes of the grinding wheels. The results are the G-ratios for both grinding wheels in this test (Tab. 6). The volumes are calculated. Lost weights of the steel tubes divided by the density of the steel and lost weights of the grinding wheels divided by the density of abrasive layers.

[0069] The results of the G-ratio of Example 1 and Example 2 are summarized in Table 7.

Tab. 7: Averages of G-ratios

Example	G-ratio
Example 1	38.000
Example 2	63.000

[0070] The used coolant for all peel grinding tests is Houghten Cut-Max-902-10 (commercial available from Houghton Deutschland GmbH, 44319 Dortmund, Germany). The coolant pump for the cooling nozzle has 10bar on the pressure side of the pump. The coolant pump for the cleaning nozzle has 60bar on the pressure side of the pump.

[0071] The test results of Example 2 are better than the results of Example 1, the G-ratio is much higher of Example 2. This result stands for a better live time of Example 2.

[0072] Thus, the abrasive article according to the invention (Example 2) provides a surprisingly better lifetime as the comparative example (Example 1) as well as a significant better behavior regarding surface damage.

Claims

1. An abrasive article comprising:

- a carrier body as well as
- an abrasive layer, wherein the abrasive layer comprises

- agglomerates with superabrasive particles bound in a first vitrified bond (bond I) as well as
- a second vitrified bond (bond II) bonding the agglomerates, wherein temperature of the hemisphere point measured according to DIN 51730 (2007-09-00) of the first vitrified bond (bond I) is higher or the same than the temperature of the hemisphere point measured according to DIN 51730 (2007-09-00) of the second

vitrified bond (bond II).

2. The abrasive article according to claim 1, wherein the superabrasive particles comprise cubic boron nitride (CBN) and/or diamonds.

3. The abrasive article according to claim 1 or 2, wherein the superabrasive particles are present in a range from 20 to 50 vol. % based on the volume of the abrasive layer, preferably in a range from 30 to 40 vol. % based on the volume of the abrasive layer.

4. The abrasive article according to any of the preceding claims, wherein the first vitrified bond I is present in a range from 5 to 20 vol. % based on the volume of the abrasive layer, preferably in a range from 6 to 12 vol.% based on the volume of the abrasive layer.

5. The abrasive article according to any of the preceding claims, wherein the second vitrified bond II is present in a range from 5 to 20 vol. % based on the volume of the abrasive layer, preferably in a range from 7 to 15 vol. % based on the volume of the abrasive layer.

6. The abrasive article according to any of the preceding claims, wherein the abrasive layer comprises pores in a range from 35 to 55 vol. % based on the volume of the abrasive layer.

7. The abrasive article according to any of the preceding claims, wherein the agglomerates have an average equivalent circle diameter of 0.4 to 1.3 mm.

8. The abrasive article according to any of the preceding claims, wherein the superabrasive particles in the agglomerate have an average size between US 400/500 mesh to US 60/80 mesh measured according to ANSI B74.12-2012.

9. The abrasive article according to any of the preceding claims, wherein the agglomerates are irregularly shaped or have a precise shape.

10. The abrasive article according to any of the preceding claims, wherein the agglomerates have a precise shape, for example a cube, pyramid, truncated pyramid or a sphere.

11. A method of making an abrasive layer for an article according to any of the claims 1 to 10, the method comprising the steps of:

- providing agglomerates with superabrasive particles bound in a first vitrified bond (bond I)
- providing a frit for generating a second vitrified bond (bond II)
- optionally providing other components like additives
- mixing the agglomerates, the frit as well as the optional components to a homogeneous mixture;
- bringing this mixture in the form of an abrasive layer or in the form of segments or pellets for building an abrasive layer;
- sintering the formed mixture at a temperature that is lower than the temperature used for sintering the agglomerates.

12. The method according to any of the claims 11 to 13, wherein the difference between the sintering temperature of the first vitrified bond (bond I) and the sintering temperature of the above method is between 20 and 300 °C.

13. The method according to claim 11 or 12, wherein the optional other components may be additives like temporary binders as polycarboxylic acid, polyethylenglykol, dextrin.

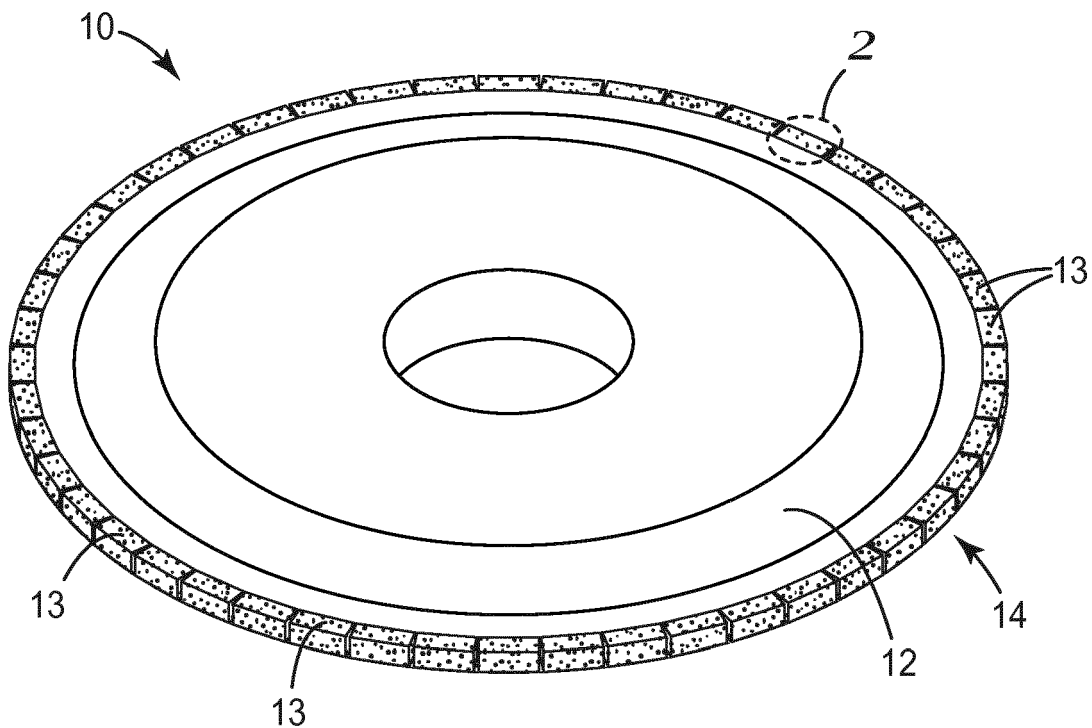


FIG. 1

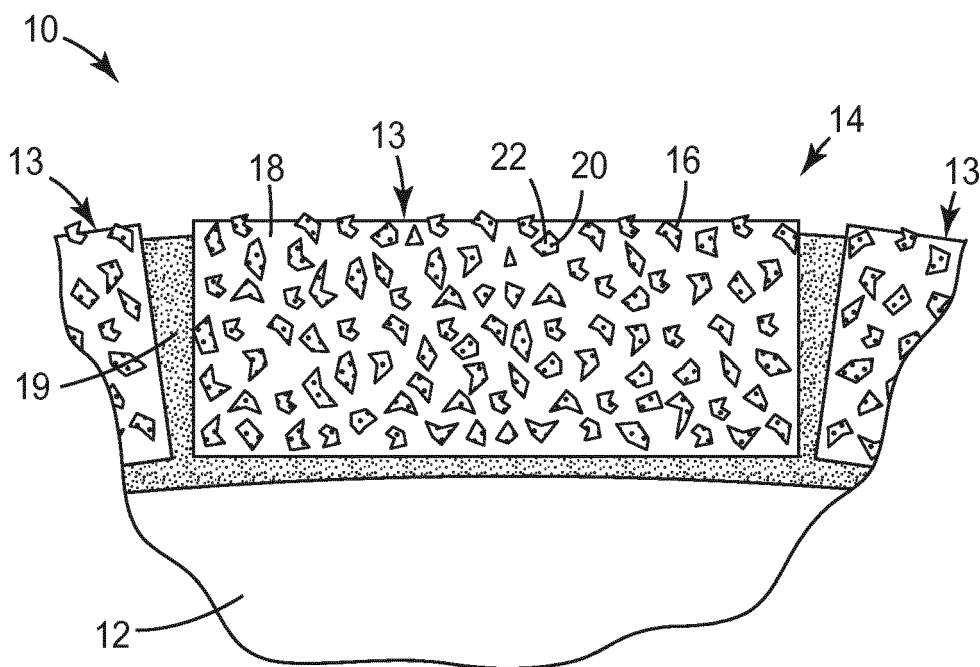


FIG. 2



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Place of search Munich		Date of completion of the search 6 February 2019	Examiner Arhire, Irina
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