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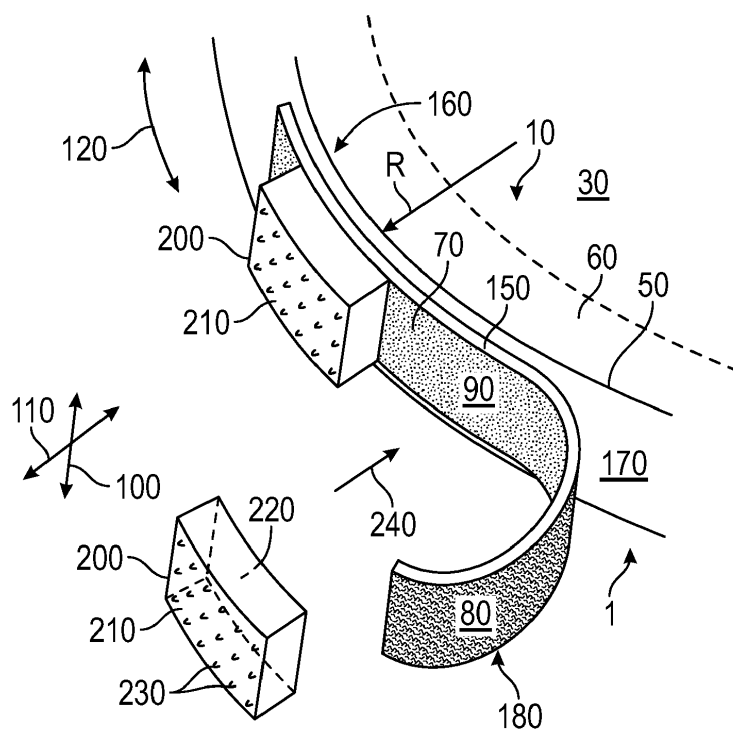
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(54) GRINDING WHEEL, ASSEMBLIES AND PROCESSES FOR ASSEMBLING A GRINDING WHEEL

(57) Abrasive elements can be secured to a perimeter of a base disk using doublesided adhesive tape, thereby forming an abrasive grinding wheel.



Description

[0001] The present disclosure relates to grinding wheels, to processes for assembling such grinding wheels and to assemblies useful in such processes. In one particular aspect, the present disclosure relates to segmented grinding wheels and to processes and assemblies for assembling those.

[0002] Certain grinding wheels (also referred to herein as "segmented grinding wheels") include a base disk and a plurality of abrasive elements which have respective abrasive surfaces, and which are attached, via attachment surfaces, to the base disk whose center corresponds to the axis of rotation of the grinding wheel. In other grinding wheels, such as in certain so-called outer diameter grinding wheels or peripheral grinding wheels, a single ring-shaped, non-segmented abrasive element is attached at the perimeter of the base disk. In a grinding operation with such grinding wheels, the base disk is rotated about the axis, so that a workpiece can be ground by the abrasive surface of each abrasive element.

[0003] In some traditional grinding wheels, the abrasive elements were attached at the perimeter of the base disk via a liquid adhesive or glue. Where there were two or more abrasive elements, they were attached side by side along the perimeter. Such a grinding wheel is described, for example, in the international patent application published as WO 99/38648 A1, in which the abrasive segments are cemented to a core with an adhesive such as epoxy cement. In traditional processes liquid adhesive was chosen to be sufficiently low in viscosity to enter into surface irregularities and small cavities of the abrasive element, thereby increasing the contact surface between the adhesive and the abrasive element. After curing and hardening of the adhesive the increased contact surface resulted in a strong bond between the adhesive and the abrasive element, and in a low risk of the element coming off the base disk at high rotational speeds.

[0004] Liquid adhesives are, however, difficult to apply with a high degree of precision. To ensure a maximum contact area, usually more liquid adhesive is applied than necessary, often resulting in overspill of excess liquid adhesive and in some excess liquid adhesive covering sides of the abrasive elements, thereby forming adhesive-filled gaps between two adjacent abrasive elements and preventing adjacent elements from contacting each other. Such gaps could result in undesired vibration of the wheel, as stated in the U.S. patent application published as US 2002/0119742 A1.

[0005] Excess adhesive may also end up on the abrasive surface of the abrasive element to be attached, or of an adjacent abrasive element. For cleanly removing this adhesive, a thin layer of the abrasive surface is removed together with the excess adhesive, thereby reducing the thickness of the abrasive element by a bit. The reduced thickness of the abrasive element results in a shorter usable life of the abrasive element and of the entire grinding wheel.

[0006] Applying a liquid adhesive on a peripheral surface of the base disk or on a surface of an abrasive element at an even thickness is demanding. Where the liquid adhesive is applied as a layer of uneven thickness, e.g. varying along the circumference of the base disk, adjacent abrasive elements may end up being attached at slightly different distances from the base disk, so that one abrasive element protrudes further from the base disk than its neighbor. To obtain an even diameter of the grinding wheel, protruding portions must be removed, which reduces the thickness - and thereby the usable life - of some abrasive elements.

[0007] In an attempt to address these problems, the present disclosure provides, in a first aspect, a method of assembling an abrasive grinding wheel for rotating about an axis of rotation, comprising the steps of:

(a) providing a base disk, axially symmetric about the axis of rotation of the abrasive grinding wheel, the axis of rotation defining axial directions parallel thereto and radial directions orthogonal thereto, and a radially outermost circumferential portion of the base disk defining a perimeter portion of the base disk,

providing a first abrasive element having an abrasive surface for grinding a workpiece, and a major attachment surface for attaching the first abrasive element to the base disk at the perimeter portion; and

providing a double-sided adhesive tape comprising a major first adhesive surface, an opposed major second adhesive surface, and a first layer of adhesive forming the major first adhesive surface;

(b) adhering the major first adhesive surface to the base disk at the perimeter portion;

(c) before or after step (b), adhering the major second adhesive surface to the attachment surface of the first abrasive element.

[0008] Double-sided adhesive tapes have a layer of adhesive of an even thickness. Employing a double-sided adhesive tape to attach abrasive elements to a perimeter of a base disk avoids overspilling of excess adhesive and the propagation of adhesive to the sides and to the abrasive surface of the abrasive elements. Due to the even thickness of their adhesive layer, an abrasive element will not protrude further from the base disk than an adjacent abrasive element. Therefore, when the abrasive grinding wheel is prepared for use, less abrasive material needs to be removed from the abrasive elements for them to form a perimeter of an even radius, suitable for grinding. This prolongs the useable lifetime of the abrasive grinding wheel.

[0009] The axis of rotation of the abrasive grinding wheel defines axial directions. Radial directions are di-

rections orthogonal to the axis of rotation. Circumferential directions are directions orthogonal to both the axis of rotation and to radial directions. Circumferential directions are directions parallel to the perimeter of the grinding wheel and parallel to the perimeter of the base disk.

[0010] The base disk is axially symmetric about an axis of rotation about which the grinding wheel rotates when in use. The base disk has two opposed major surfaces, i.e. an upper and a lower major surface, spaced from each other in a thickness direction of the base disk. These opposed major surfaces may be flat or curved. Flat major surfaces may be parallel to each other, e.g. parallel to each other within $\pm 10^\circ$.

[0011] In most embodiments the base disk has a generally circular shape, e.g. a shape centered around the axis of rotation, in which case the perimeter portion is an annular portion of the base disk. In certain other embodiments, however, the base disk may have a polygonal shape, such as a square, triangular, hexagonal or octagonal shape, for example. The polygonal shape may be centered around the axis of rotation. A polygonal base disk may also be centered around the axis of rotation. In these other embodiments the perimeter portion is shaped like a set of straight portions where each straight portion is connected with adjacent straight portions at its ends, forming an angle at the connection. In certain other embodiments the base disk has an irregular shape.

[0012] The base disk may comprise, or be made from, metal, a polymeric material or any other suitable material.

[0013] The present disclosure may be particularly useful for abrasive grinding wheels that have an abrasive surface at their outer diameter, next to a perimeter or circumference of the grinding wheel. These wheels are sometimes also referred to as outer diameter grinding wheels, cylindrical external grinding wheels, cylindrical internal grinding wheels, surface grinding wheels or centerless grinding wheels. Hence in certain embodiments the abrasive grinding wheel is an outer diameter grinding wheel.

[0014] However, other types of grinding wheels (such as those where an abrasive surface is located radially inward from the outer diameter) can benefit from the advantages of the disclosure.

[0015] The perimeter of the base disk delimits the base disk in a direction away from the axis of rotation, so that the base disk is the body radially inward from the perimeter. The perimeter may be a circular perimeter. A circular perimeter corresponds to a circular shape of the base disk. Alternatively, the perimeter may be a polygonal perimeter. The perimeter thus corresponds to a polygonal shape of the base disk. The perimeter may have any other suitable shape.

[0016] The perimeter portion of the base disk is the portion of the base disk at the perimeter and in the vicinity of the perimeter, radially inward of the perimeter. In other words, a radially outermost circumferential portion of the base disk defines a perimeter portion of the base disk. The perimeter portion of a circular base disk may com-

prise, for example, the portion of the base disk located radially between 30 percent of the radius of the perimeter and 100 percent of the radius of the perimeter, or the portion of the base disk located radially between 50 percent of the radius of the perimeter and 100 percent of the radius of the perimeter, or the portion of the base disk located radially between 80 percent of the radius of the perimeter and 100 percent of the radius of the perimeter, or the portion of the base disk located radially between 90 percent of the radius of the perimeter and 100 percent of the radius of the perimeter. A percentage of the radius is measured from the axis of rotation, where a larger percentage of the radius refers to a portion radially further outward from the axis.

[0017] Therefore, in certain embodiments of the methods, the assemblies and the devices according to the present disclosure the perimeter portion is the portion of the base disk located radially between thirty percent (30%) of the radius of the perimeter and hundred percent (100%) of the radius of the perimeter of the base disk.

[0018] Where the base disk is not circular, the perimeter portion is the portion of the base disk located radially between thirty percent (30%) of the radius of the perimeter and hundred percent (100%) of the greatest radius of the perimeter of the base disk, measured at any circumferential position of the perimeter of the base disk.

[0019] The perimeter portion can have different shapes or profiles. A profile can be seen in a sectional view through the rotational axis. Generally, the perimeter portion will have a generally rectangular profile, formed by a top surface (an "upper perimetral surface") of the base disk, an opposed bottom surface (a "lower perimetral surface") of the base disk, and a lateral surface ("perimetral face") of the base disk. A surface normal of the upper perimetral surface may be generally (e.g. within an angle of $\pm 10^\circ$) parallel to the axis of rotation. A surface normal of the opposed lower perimetral surface may be generally (e.g. within $\pm 10^\circ$) antiparallel to the axis of rotation. A surface normal of the perimetral face may generally be pointing away from the axis of rotation. The surface normal of the perimetral face may be orthogonal (e.g. within $\pm 10^\circ$) to the axis of rotation.

[0020] An abrasive element, e.g. the first abrasive element and/or, where present, a second abrasive element and/or, where present, any further abrasive element, has at least one abrasive surface for grinding the workpiece which the grinding wheel is supposed to grind. An abrasive element may comprise a second abrasive surface.

[0021] An abrasive surface is an exposed surface which is adapted to abrade a workpiece. An abrasive surface (i.e. a first, a second or any further abrasive surface of an abrasive element) may comprise a surface structure suitable for grinding a workpiece. The surface structure may comprise, for example, exposed portions of abrasive particles. An abrasive element may, for example, comprise abrasive particles such as diamonds or CBN particles, and a binder, wherein a plurality of the abrasive particles is exposed, at least partially, on the

abrasive surface such as to contact and abrade the work-piece in a grinding process. Abrasive elements may, for example, be formed from vitreous or resin bonded particles of aluminum oxide, silicon oxide, iron oxide, molybdenum oxide, vanadium oxide, tungsten carbide, silicon carbide and the like.

[0022] The abrasive surface, and any abrasive surface, of an abrasive element may be flat. Alternatively, the abrasive surface, and any abrasive surface, of an abrasive element may be curved. It may be curved in one direction. A curvature in one direction may be considered similar to the curvature of the curved surface of a cylinder. Alternatively, it may be curved in two directions. A curvature in two directions may be considered similar to the curvature of the surface of a sphere or of an ellipsoid. Where the abrasive surface is curved, a radius of its curvature may correspond to the radius of curvature of the perimeter of the base disk. The radius of its curvature may be equal to the radius of curvature of the perimeter of the base disk within ± 5 centimeters (cm) or within ± 1 centimeter.

[0023] An abrasive element has an attachment surface for attaching the abrasive element to the base disk at the perimeter portion. The attachment surface may be located opposite to the abrasive surface. In other words, an abrasive element may have an abrasive surface and an opposed major attachment surface. However, the attachment surface may be not opposed to the abrasive surface. It may be, for example, be oriented orthogonally to the abrasive surface, so that their respective surface normals are orthogonal to each other, e.g. within an angle of $\pm 10^\circ$.

[0024] The attachment surface is a major surface of the abrasive element. The attachment surface may be flat. Alternatively, the attachment surface may be curved. It may be curved in one direction. Alternatively, it may be curved in two directions. Where the attachment surface is curved in one or two directions, a radius of its curvature may correspond to the radius of curvature of the perimeter of the base disk. Identical or similar radii of curvature facilitate attaching an abrasive element to the perimetral portion of the base disk.

[0025] An attachment surface of an abrasive element may be generally parallel to an abrasive surface of the abrasive element. An attachment surface of an abrasive element may be generally concentric with an abrasive surface of the abrasive element.

[0026] A radius of curvature of the attachment surface may be equal to the radius of curvature of the perimeter of the base disk within ± 5 cm. A radius of its curvature may be equal to the radius of curvature of the perimeter of the base disk. A radius of curvature of the attachment surface being equal to, or close to, the radius of the radius of curvature of the perimeter of the base disk may facilitate attachment of the abrasive element to the base disk at the perimeter portion.

[0027] In methods and assemblies according to the present disclosure a double-sided adhesive tape is used

to attach an abrasive element to a base disk. The long direction of such a double-sided adhesive tape defines a length direction of the tape and of its layer(s) of adhesive. The first layer of adhesive defines a thickness direction extending in a thickness direction of the first layer of adhesive and of the tape, the thickness direction being a direction orthogonal to the length direction. A width direction of the layer of adhesive is a direction orthogonal to the length direction and to the thickness direction.

[0028] As used herein, a double-sided adhesive tape comprises a major first adhesive surface, an opposed major second adhesive surface and a first layer of adhesive, wherein the first layer of adhesive forms the first adhesive surface.

[0029] The opposed major second adhesive surface may be parallel to the major first adhesive surface, e.g. before the double-sided adhesive tape is applied or thereafter.

[0030] The first layer of adhesive may form the second adhesive surface. The first layer of adhesive may form the first and the second adhesive surface.

[0031] A double-sided adhesive tape may comprise a second layer of adhesive. The second layer of adhesive may extend parallel to the first layer of adhesive. The second layer of adhesive may be arranged adjacent in thickness direction to the first layer of adhesive. The second layer of adhesive may thus be arranged on the first layer of adhesive. The second layer of adhesive may form the second adhesive surface.

[0032] In certain embodiments, the first layer of adhesive forms the major first adhesive surface, and the second layer of adhesive forms the major second adhesive surface.

[0033] As used herein the term "adhering an adhesive surface to" a substrate refers to bringing the adhesive surface and the substrate in a surface contact such that the adhesive surface sticks to the substrate.

[0034] A double-sided adhesive tape comprising a first and a second layer of adhesive may further comprise a carrier layer. The carrier layer may enhance the mechanical stability (such as rigidity or tear resistance) of the double-sided adhesive tape. The carrier layer may extend parallel to the first layer of adhesive and to the second layer of adhesive. The carrier layer may be arranged adjacent in thickness direction to the first layer of adhesive and adjacent to the second layer of adhesive. The carrier layer may be arranged in thickness direction between the first layer of adhesive and the second layer of adhesive.

[0035] The double-sided adhesive tape comprises a first layer of adhesive. A layer of adhesive, such as the first layer of adhesive or the second layer of adhesive, may be a layer of solid adhesive. A solid adhesive, as referred to herein, is an adhesive which has a viscosity of greater than 10^7 Pa.s at 25°C and atmospheric pressure.

[0036] As used herein, a layer of adhesive of a double-sided adhesive tape does not comprise liquid or semi-

solid adhesive. As used herein, a liquid or semisolid adhesive is an adhesive that has a viscosity of 10^7 Pa.s or less at 25°C and atmospheric pressure.

[0037] Before use, the double-sided adhesive tape may be protected by a liner covering the major first adhesive surface or the major second adhesive surface. The liner may protect the respective major adhesive surface against contamination and/or stabilize the double-sided adhesive tape. The liner is removed before the respective major adhesive surface can be adhered to a substrate, e.g. to a base disk or to the attachment surface of an abrasive element.

[0038] A method of assembling an abrasive grinding wheel as described herein may, before the step of adhering the first adhesive surface to the base disk, comprise a step of removing a liner from the first adhesive surface. A method of assembling an abrasive grinding wheel as described herein may, before performing any of steps (b) or (c), comprise a step of removing a liner from the major first adhesive surface or from the major second adhesive surface.

[0039] Certain steps of the methods of assembling an abrasive grinding wheel according to the present disclosure can be performed by a robot. Robots have been used in the past to apply adhesive tapes to curved surfaces, e.g. Kuka (Kuka AG, Augsburg, Germany) industrial robots applying an adhesive sealing tape to certain door openings in the automotive industry. This can save time and cost for human labor and may result in a more reliable and more precise abrasive grinding wheel.

[0040] Therefore, in certain embodiments, the step (b) of adhering the first adhesive surface to the base disk at the perimeter portion is performed by a robot. In other embodiments, the step (c) of adhering the second adhesive surface to the attachment surface of the first abrasive element is performed by a robot. In some of these embodiments step (b) is performed by a robot and step (c) is performed by a robot or by the robot. Generally, step (b) and/or step (c) may be performed by a robot.

[0041] In certain embodiments a method of assembling an abrasive grinding wheel described herein comprises, after adhering an adhesive surface of the double-sided tape to a base disk and/or to an attachment surface, the additional step of enhancing the adhesion between the adhesive surface and the base disk and/or the attachment surface. Enhancing the adhesion between the adhesive surface and the base disk and/or the attachment surface may comprise applying pressure to the adhesive, or applying pressure to the base disk and/or the attachment surface, and/or it may comprise curing the layer of adhesive via heat or via irradiation. Pressure helps establish a more intimate contact between the layer of adhesive and the base disk, or between the layer of adhesive and the attachment surface, which typically results in a better adhesion.

[0042] The first layer of adhesive, and any layer of adhesive, of the double-sided adhesive tape may comprise a curable adhesive. "Curing" as used herein refers to

crosslinking polymers in the adhesive and/or to hardening the adhesive. Known curing methods include, for example, applying heat to the layer of adhesive, or irradiating the layer of adhesive with UV radiation or with an electron beam. A cured curable adhesive comprised in the layer of adhesive may result in a stronger, more reliable bond between the double-sided adhesive tape and the base disk or the first abrasive element.

[0043] Heat may be applied to the first layer of adhesive or to a second layer of adhesive by electromagnetic induction. Inductive heating can deliver a desired amount of heat in a precisely defined location for a precisely determined time. An inductive heater is typically based on a current flowing through an induction coil. Such an inductive heater can be integrated into a "hand" of a robot, which allows for an automated computer-controlled curing. Automation and computer control may provide for more a consistent curing of the adhesive and more reliable adhesion as well as for faster curing, thus reducing manufacturing time and cost.

[0044] Therefore, in certain embodiments, the method of assembling an abrasive grinding wheel according to the present disclosure further comprises, after steps (b) and (c), a step of (d) curing the first layer of adhesive by applying heat to the first layer of adhesive. This further step (d) may comprise curing the first layer of adhesive by applying heat to the first layer of adhesive by electromagnetic induction.

[0045] Inductive heating can provide large flow of heat into the first or second layer of adhesive. For certain adhesives, curing times of 90 seconds or more at 200 °C can result in a full cure, while a comparable curing in an oven at about the same temperature requires about 20 minutes. Inductive curing can thus provide for a shorter cycle time in manufacturing.

[0046] Hence, in certain embodiments in which the first layer of adhesive is cured by applying heat to it, heat is applied to the first layer of adhesive by electromagnetic induction for 60 seconds or longer. Similarly, in certain embodiments in which the first or second layer of adhesive is cured by applying heat to it, heat is applied to the first and/or to the second layer of adhesive by electromagnetic induction for 60 seconds or longer.

[0047] In certain embodiments heat is applied to the first layer of adhesive (and/or to the second layer of adhesive, where present) by electromagnetic induction for 240 seconds or less. In certain of these embodiments heat is applied to the first layer of adhesive (and/or to the second layer of adhesive, where present) by electromagnetic induction for 180 seconds or less. In certain of these embodiments heat is applied to the first layer of adhesive (and/or to the second layer of adhesive, where present) by electromagnetic induction for 120 seconds or less.

[0048] A heating time of at least 60 seconds was found to provide thorough curing for certain curable adhesives, resulting in a reliable adhesion and permanent securing of abrasive elements to a base disk. A heating time of less than 240 seconds was found to provide thorough

curing for certain curable adhesives, sufficient for a reliable adhesion and permanent securing of abrasive elements to a base disk.

[0049] According to the present disclosure, abrasive elements may be applied to one of the (upper or lower) major surfaces of the base disk at its perimeter portion, or to the perimetral face.

[0050] The methods of the present disclosure are suitable to assemble grinding wheels sometimes referred to as "face and fine grinding wheels" or "cup wheels": In certain embodiments of the methods disclosed herein, the perimeter portion comprises an upper perimetral surface whose surface normal is parallel, within an angle of $\pm 10^\circ$, to the axis of rotation, an opposed lower perimetral surface whose surface normal is antiparallel, within an angle of $\pm 10^\circ$, to the axis of rotation, and wherein step (b) comprises adhering the major first adhesive surface to the upper perimetral surface or to the lower perimetral surface.

[0051] In certain embodiments, the perimeter portion of the base disk comprises an upper perimetral surface whose surface normal is generally (within $\pm 10^\circ$) parallel to the axis of rotation, an opposed lower perimetral surface whose normal is generally (within $\pm 10^\circ$) antiparallel to the axis of rotation, and a perimetral face whose surface normal is generally orthogonal, within an angle of $\pm 20^\circ$, to the axis of rotation, and step (b) comprises adhering the first adhesive surface to the upper perimetral surface or to the lower perimetral surface.

[0052] For such base disks the methods described herein can provide for a more even profile of the abrasive grinding wheel and can help reduce the height of axially protruding portions of abrasive elements that would have to be removed in dressing. The usable life of the abrasive grinding wheel may thereby be prolonged.

[0053] In certain embodiments, the perimeter portion comprises a perimetral face whose surface normal is orthogonal, within an angle of $\pm 20^\circ$, to the axis of rotation, and wherein step (b) comprises adhering the major first adhesive surface to the perimetral face. The perimetral face may be a surface extending along the perimeter of the base disk.

[0054] In certain of these embodiments, the perimeter portion of the base disk comprises an upper perimetral surface whose surface normal is generally (within an angle of $\pm 10^\circ$) parallel to the axis of rotation, an opposed lower perimetral surface whose normal is generally (within an angle of $\pm 10^\circ$) antiparallel to the axis of rotation, and a perimetral face whose surface normal is generally orthogonal, within an angle of $\pm 20^\circ$, to the axis of rotation, and step (b) comprises adhering the major first adhesive surface to the perimetral face.

[0055] For such base disks the methods described herein can provide for an even profile of the abrasive grinding wheel and can help reduce the height of radially protruding portions of abrasive elements that would have to be removed in dressing. The usable life of the abrasive grinding wheel may thereby be prolonged.

[0056] Further to a method of assembling an abrasive grinding wheel, the present disclosure also provides, in a second aspect, an abrasive element assembly comprising

- a) an abrasive element having an abrasive surface for grinding a workpiece, and a major attachment surface for attaching the abrasive element to a base disk at a perimeter portion of the base disk; and
- b) a double-sided adhesive tape comprising a major first adhesive surface, adapted to adhere to the perimeter portion, an opposed major second adhesive surface, and a first layer of adhesive forming the major first adhesive surface, wherein the major second adhesive surface is adhered to the major attachment surface of the abrasive element.

[0057] The abrasive element and the double-sided adhesive tape applied to its attachment surface, can be pre-assembled to form the abrasive element assembly independently from the availability of any base disk. The abrasive element assembly and the base disk can thus be manufactured and stored independently. Also, the base disk does not need to be provided with double-sided adhesive tape, which may be difficult for base disks of certain sizes. Instead, the (typically much smaller) abrasive elements can be provided with double-sided adhesive tape to form abrasive element assemblies, which can be adhered to various types of base disks when and where desired.

[0058] In certain embodiments of the abrasive element assembly described above, the major attachment surface is a curved surface. The major attachment surface may be, for example, a surface curved in two dimensions. It may be, for example, a cylindrically curved surface.

[0059] Curved attachment surfaces facilitate reliable adhesion of the abrasive element to corresponding curved surfaces of the base disk, such as the perimetral face. Preferably, the curved major attachment surface of the abrasive element assembly has a curvature radius equal or similar to the curvature radius of the corresponding curved surfaces of the base disk, e.g. the curved surface of the perimetral face to which the abrasive element is to be attached. Equal or similar radii help obtain a particularly well-fitting and hence reliable attachment.

[0060] In other embodiments of the abrasive element assembly described above, the major attachment surface is a flat surface.

[0061] A flat attachment surface facilitates reliable adhesion of the abrasive element to corresponding flat surfaces of the base disk, such as a flat upper perimetral surface or a flat lower perimetral surface.

[0062] Further to the method of assembling an abrasive grinding wheel and to the abrasive element assembly described above, the present disclosure also provides, in a third aspect, a base disk assembly. Such as base disk assembly may be considered a base disk with a double-sided adhesive tape applied to the base disk

via which tape abrasive elements can be attached to the base disk.

[0063] A base disk assembly according to the present disclosure comprises

a) a base disk axially symmetric about an axis of rotation, the axis of rotation defining axial directions parallel thereto and radial directions orthogonal thereto, the base disk comprising a radially outermost circumferential portion defining a perimeter portion of the base disk; and

b) a double-sided adhesive tape comprising i) a major first adhesive surface, ii) a first layer of adhesive forming the major first adhesive surface, and iii) an opposed major second adhesive surface, adapted to be adhered to a major attachment surface of an abrasive element, wherein the major first adhesive surface is adhered to the base disk at the perimeter portion.

[0064] The major first adhesive surface may be adhered to the base disk at a perimetral upper surface or at a perimetral lower surface of the perimeter portion. Alternatively, the major first adhesive surface may be adhered to the base disk at a perimetral face of the perimeter portion.

[0065] A base disk assembly as described herein can be pre-assembled independently from the availability of any abrasive elements by adhering the double-sided adhesive tape to the perimeter portion of the base disk. Abrasive elements can be adhered to the base disk via the tape at a later time to form an abrasive grinding wheel. The abrasive elements and the base disk assembly can thus be manufactured and stored independently. Also, the abrasive elements do not need to be provided with double-sided adhesive tape before attaching them to the base disk. Instead of providing many abrasive elements with double-sided adhesive tape, the single base disk is provided with double-sided adhesive tape to form the base disk assembly. Different suitable types of abrasive elements can thereafter be adhered to a base disk assembly as, when and where desired.

[0066] Performing the methods disclosed herein may result in obtaining an abrasive grinding wheel in which an abrasive element is adhered to a perimeter portion of a base disk. The present disclosure therefore also provides, in a fourth aspect, an abrasive grinding wheel for rotating about an axis of rotation, comprising:

a) a base disk axially symmetric about an axis of rotation of the abrasive grinding wheel, the axis of rotation defining axial directions parallel thereto and radial directions orthogonal thereto, and a radially outermost circumferential portion of the base disk defining a perimeter portion of the base disk;

b) an abrasive element having an abrasive surface for grinding a workpiece, and a major attachment surface for attaching the abrasive element to the

base disk at the perimeter portion; and

c) a double-sided adhesive tape comprising i) a major first adhesive surface, ii) a first layer of adhesive forming the first adhesive surface, iii) an opposed major second adhesive surface,

wherein the major first adhesive surface is adhered to the perimeter portion of the base disk, and wherein the major second adhesive surface is adhered to the major attachment surface of the abrasive element, wherein the abrasive element is secured to the perimeter portion by the double-sided adhesive tape.

[0067] Such an abrasive grinding wheel according to the present disclosure may have a longer useable life than traditional grinding wheels in which abrasive elements are secured to a base disk by a traditional, liquid adhesive. Also, it may have a reduced risk of vibration than traditional grinding wheels in which abrasive elements are secured to a base disk by a liquid adhesive which might create gaps between adjacent abrasive elements. An abrasive grinding wheel as described herein may also be more cost-effective to manufacture, as a tape may be easier to apply and quicker to cure than a liquid adhesive.

[0068] In certain embodiments of the methods, devices and assemblies described herein the first layer of adhesive comprises an epoxy-based adhesive or an acrylic adhesive or a polyurethane adhesive. Epoxy-based adhesives and acrylic adhesives can provide particularly strong and durable bonding of the double-sided adhesive tape to abrasive elements and to surfaces of typical base disks.

[0069] In certain embodiments the double-sided adhesive tape is a structural adhesive tape, such as, for example, 3M™ Structural Adhesive Tape SAT1010, available from 3M Company, St. Paul, Minnesota, U.S.A.. In other embodiments the double-sided adhesive tape may be, for example, a 3M™ VHB™ Tape such as 3M™ VHB™ Tape 4949. The structural adhesive tape may have a thickness of between 0.05 millimeters (mm) and 1.00 mm.

[0070] The double-sided adhesive tape used in the methods, devices and assemblies described herein may be a single-layer double-sided adhesive tape, i.e. a tape in which the first layer of adhesive forms the first major adhesive surface and the second major adhesive surface. Alternatively, the double-sided adhesive tape used in the methods, devices and assemblies described herein may be a multilayer double-sided adhesive tape, i.e. a tape in which the first layer of adhesive forms the first major adhesive surface and a second layer of adhesive forms the second major adhesive surface. Hence generally, in certain embodiments of the methods, devices and assemblies described herein the double-sided adhesive tape further comprises a second layer of adhesive forming the major second adhesive surface.

[0071] This may be advantageous in that the first layer of adhesive can be tailored for adequate adhesion to the

base disk, while the second layer of adhesive can be tailored for adequate adhesion to an abrasive element. The first layer of adhesive may comprise, for example, a pressure-sensitive adhesive and the second layer of adhesive may comprise, for example, a curable adhesive. The first layer of adhesive may comprise, for example, a curable adhesive and the second layer of adhesive may comprise, for example, a pressure-sensitive adhesive.

[0072] The first layer of adhesive and the second layer of adhesive may be arranged adjacent, in a thickness direction of the double-sided adhesive tape, to each other, or they may be arranged spaced from each other in a thickness direction of the double-sided adhesive tape. Generally, cohesion between the layers of the double-sided adhesive tape must be adequate for the tape to attach abrasive elements reliably to a base disk and for the resulting abrasive grinding wheel to grind a workpiece reliably.

[0073] In certain embodiments of the methods, devices and assemblies according to the present disclosure the first layer of adhesive comprises a curable adhesive. In certain embodiments in which a second layer of adhesive exists, the second layer of adhesive may comprise a curable adhesive. In certain of these embodiments the first layer of adhesive comprises a heat-curable adhesive or a UV-curable adhesive or an electron-beam-curable adhesive. In certain of these embodiments, where a second layer of adhesive exists, the second layer of adhesive may comprise a heat-curable adhesive or a UV-curable adhesive or an electron-beam-curable adhesive. In certain embodiments, both the first layer of adhesive and the second layer of adhesive comprise a respective heat-curable adhesive.

[0074] The use of curable adhesives may generally be advantageous in that their bond after curing may be particularly strong and durable, while before curing they may, for example, allow for repositioning. Curable adhesives may thus facilitate controlled activation of strong adhesion. This may make assembly of a grinding wheel or of abrasive element assemblies or of base disk assemblies as described herein easier and more cost-effective.

[0075] In certain methods according to the present disclosure it may be desirable to secure an abrasive element to a base disk in two steps: in a first step, the abrasive element is adhered on the perimeter portion of the base disk and held in its position by a first portion (a first strip) of the first layer of adhesive. In a second step the abrasive element is secured to the base disk by curing a second portion (a second strip) of the first layer of adhesive. The first portion and the second portion may be arranged side-by-side in the same plane of the first layer of adhesive of the double-sided adhesive tape. Such a two-step process may provide time for an operator or a robot to change tools between the first and the second step, e.g. from a positioning tool to a curing tool. The resulting grinding wheel may have a stronger bond and a more precise position and orientation of the abrasive elements on the

base disk.

[0076] The first portion may comprise a pressure-sensitive adhesive. The second portion may comprise a curable adhesive, such as a curable acrylic adhesive or a curable epoxy-based adhesive as described above.

[0077] The first portion and the second portion may extend, in their length directions, in a length direction of the double-sided adhesive tape. They may be arranged next to each other in a width direction of the double-sided adhesive tape.

[0078] The first adhesive layer strip may comprise a first type of adhesive, such as, for example, a curable adhesive. The first type of adhesive may be operable to provide a strong permanent adhesion after the adhesive is cured. Curable adhesives are, for example, heat-cured adhesives, ultraviolet-cured adhesives, or electron beam cured adhesives.

[0079] The first type of adhesive may be operable to provide a strong permanent adhesion after the adhesive is activated. Such activatable adhesives are, for example, hotmelt adhesives. Hotmelt adhesives bond after being adequately heated and after subsequent cooling to ambient temperature.

[0080] The second adhesive layer strip may comprise a second type of adhesive, such as, for example, a pressure-sensitive adhesive. The second type of adhesive may be operable to provide an immediate adhesion. Immediate adhesion is adhesion that does not require activation or curing. The second type of adhesive may be useful in holding an abrasive element in place on the base disk until the first type of adhesive of the first adhesive layer strip is activated and/or cured.

[0081] So generally, in certain embodiments of the methods, devices and assemblies according to the present disclosure, an extension of the first layer of adhesive in a width direction of the double-sided adhesive tape defines a layer width, and the first layer of adhesive comprises an elongated first adhesive layer strip and an elongated second adhesive layer strip, arranged adjacent to each other in a width direction of the double-sided adhesive tape, and each of the first and second adhesive layer strips has a width smaller than the layer width, with a length direction of each adhesive layer strip being oriented parallel to a length direction of the double-sided adhesive tape, and wherein the first adhesive layer strip comprises a pressure-sensitive adhesive, and the second adhesive layer strip comprises a curable adhesive.

[0082] The layer of adhesive may thus comprise a first adhesive layer strip and a second adhesive layer strip. The first adhesive layer strip and the second adhesive layer strip may be arranged next to each other in a width direction of the layer of adhesive. A first portion of the width (i.e. extension in width direction) of the layer of adhesive may thus be occupied by the first adhesive layer strip, while a second portion of the width of the double-sided adhesive tape may be occupied by the second adhesive layer strip.

[0083] A double-sided adhesive tape may comprise a

layer of adhesive comprising a first adhesive layer strip, a second adhesive layer strip and a third adhesive layer strip. The first adhesive layer strip, the second adhesive layer strip and the third adhesive layer strip may be arranged next to each other in a width direction of the layer of adhesive. The second adhesive layer strip may be arranged, in the width direction, between the first adhesive layer strip and the third adhesive layer strip. A first portion of the width (i.e. extension in width direction) of the layer of adhesive may thus be occupied by the first adhesive layer strip, a second portion of the width of the double-sided adhesive tape may be occupied by the second adhesive layer strip, and a third portion of the width of the double-sided adhesive tape may be occupied by the third adhesive layer strip.

[0084] The first adhesive layer strip and the third adhesive layer strip may comprise a first type of adhesive, such as, for example, a curable adhesive. The first type of adhesive may be operable to provide a strong permanent adhesion after the adhesive is cured.

[0085] The first type of adhesive may be operable to provide a strong permanent adhesion after the adhesive is activated. The first type of adhesive may be operable to provide a strong permanent adhesion after the adhesive is activated.

[0086] The second adhesive layer strip may comprise a second type of adhesive, such as, for example, a pressure-sensitive adhesive. The second type of adhesive may be operable to provide an immediate adhesion. The second type of adhesive may be useful in holding an abrasive element in place until the first type of adhesive is activated and/or cured.

[0087] An arrangement of the second adhesive layer strip between the first and the third adhesive layer strip may help provide a more symmetric permanent attachment by the first and third adhesive layer strips, and an attachment in two width positions of an abrasive element, potentially resulting in a more stable permanent attachment.

[0088] Embodiments of the present disclosure will now be described in more detail with reference to the following Figures exemplifying particular embodiments of the disclosure:

- Fig. 1 Perspective view of a base disk as useable in methods and assemblies according to the present disclosure;
- Fig. 2 Perspective view of a first abrasive grinding wheel as being assembled via a method according to the present disclosure;
- Fig. 3 Perspective view of a second abrasive grinding wheel as being assembled via a method according to the present disclosure ;
- Fig. 4 Perspective view of a first abrasive element and a double-sided adhesive tape useable in methods and assemblies according to the present disclosure;
- Fig. 5 Perspective view of a second abrasive element

and a double-sided adhesive tape useable in methods and assemblies according to the present disclosure;

- Fig. 6 Perspective view of a double-sided adhesive tape, useable in methods, devices and assemblies according to the present disclosure, having a single layer of adhesive;
- Fig. 7 Perspective view of a double-sided adhesive tape, useable in methods, devices and assemblies according to the present disclosure, having two layers of adhesive;
- Fig. 8 Perspective view of a double-sided adhesive tape, useable in methods, devices and assemblies according to the present disclosure, having two adhesive layer strips; and
- Fig. 9 Perspective view of a further double-sided adhesive tape, useable in methods, devices and assemblies according to the present disclosure, having three adhesive layer strips.

[0089] Figure 1 is a perspective view of a circular base disk 10 on which abrasive elements 200 can be adhered so that the base disk 10 and the abrasive elements 200 form an abrasive grinding wheel. The base disk 10 is a metal disk 10 and is axially symmetric about an axis 20 of rotation of the abrasive grinding wheel, which is also the axis 20 of rotation of the base disk 10. In use, when grinding a workpiece, the abrasive grinding wheel rotates about the axis 20 of rotation.

[0090] The axis 20 of rotation defines axial directions 100 which are directions parallel to the axis 20, radial directions 110 orthogonal to the axis 20, and circumferential directions 120 around the axis 20.

[0091] The base disk 10 has an upper major surface 30 and an opposite lower major surface 40 (not visible in Figure 1). The major surfaces 30, 40 are flat and spaced from each other in a thickness direction of the base disk 10, i. e. in an axial direction 100.

[0092] A perimeter 50 of the base disk 10 delimits the base disk 10 in a radial direction 110 pointing away from the axis 20 of rotation, so that the base disk 10 is a body radially inward from the perimeter 50. A radius R of the perimeter 50 is the radial distance between the axis 20 and the perimeter 50. For circular base disks 10 radius R is the radius of curvature of the perimeter 50 of the base disk 10. For non-circular base disks the radius R may be different for different positions along a circumference of the base disk.

[0093] A perimeter portion 60 of the base disk 10 is the portion 60 of the base disk 10 at the perimeter 50 and in the vicinity of the perimeter 50, radially inward of the perimeter 50. In other words, a radially outermost circumferential portion of the base disk 10 defines a perimeter portion 60 of the base disk 10. In the embodiment shown in Figure 1, the perimeter portion 60 of the base disk 10 comprises the portion 60 of the base disk 10 located radially between about 75 percent of the radius R of the perimeter 50 and 100 percent of the radius R of the pe-

rimeter 50.

[0094] The portion of the upper major surface 30 located in the perimeter portion 60 is referred to as upper perimetral surface 130, the corresponding portion of the lower major surface 40 located in the perimeter portion 60 is referred to as lower perimetral surface 140. The lateral surface of the base disk 10, i.e. the surface connecting the upper perimetral surface 130 and the lower perimetral surface 140 will be referred to as the perimetral face 170 of the base disk 10.

[0095] In assembly methods according to the present disclosure an abrasive element can be adhered to the upper perimetral surface 130, the lower perimetral surface 140, or to the perimetral face 170 of the base disk 10 by a double-sided adhesive tape, as will be explained below.

[0096] Figure 2 illustrates, in a perspective view, a method of assembling an abrasive grinding wheel 1 according to the present disclosure. The abrasive grinding wheel 1 comprises the base disk 10 and abrasive elements 200 attached thereto. A section of the first base disk 10 of Figure 1 is shown, with a double-sided adhesive tape 70 adhered to the perimetral face 170 of the base disk 10 at its perimeter portion 60. Abrasive elements 200 are secured to the perimeter portion 60 via the double-sided adhesive tape 70.

[0097] Looking first at the double-sided adhesive tape 70, the tape 70 has a layer of adhesive 150 forming a major first adhesive surface 80 and an opposed major second adhesive surface 90, parallel to the major first adhesive surface 80. The layer of adhesive 150 comprises a pressure-sensitive adhesive.

[0098] The first adhesive surface 80 is adhered to the base disk 10 at the perimeter portion 60, namely to the perimetral face 170. While a left-hand portion 160 the tape 70 is shown adhered to the perimeter portion 60, a right-hand portion 180 of the tape 70 is shown before being adhered to the perimeter portion 60 of the base disk 10.

[0099] Once the tape 70 is fully adhered to the base disk 10 the length direction of the tape 70 is the circumferential direction 120, the width direction of the tape 70 is an axial direction 100, and a thickness direction of the tape 70 is a radial direction 110. In the embodiment of Figure 2 a width of the double-sided adhesive tape 70 is slightly smaller than the axial extension or height of the perimetral face 170. In many alternative embodiments, however, the width of the tape 70 is identical to the height of the perimetral face 170, in order to maximize adhesive contact area and thereby the adhesive power.

[0100] The double-sided adhesive tape 70 extends in circumferential direction 120 along only a portion of the perimeter 50. A plurality of double-sided adhesive tapes 70 can be applied next to each other in order to cover the entire perimetral face 170 in circumferential directions 120.

[0101] Turning to the abrasive elements 200, a rear (in Figure 2) abrasive element 200 is shown adhered to the

second adhesive surface 90 of the double-sided adhesive tape 70. A front (in the Figure) abrasive element 200 is shown before being adhered to the second adhesive surface 90 of the double-sided adhesive tape 70. For adhering it, it is moved in the radial direction towards the axis 20 of rotation indicated by arrow 240, is brought into surface contact with the second adhesive surface 90 such that a major attachment surface 220 of the abrasive element 200 sticks to the second adhesive surface 90 of the double-sided adhesive tape 70.

[0102] After adhering, adhesion may be enhanced by pressing the abrasive element 200 radially towards the perimeter 50 of the base disk 10 for an adequate time.

[0103] Each abrasive element 200 has a curved abrasive surface 210 which contacts and grinds a workpiece when the abrasive grinding wheel 1 is assembled and in use, and a curved major attachment surface 220, opposed to the abrasive surface 210. Abrasive particles 230 are exposed on the abrasive surface 210. Once the abrasive elements 200 are secured to the base disk 10, the abrasive surfaces 210 of the abrasive elements 200 point radially away from the axis 20 of rotation.

[0104] Via the tape 70, each abrasive element 200 is adhered to the perimetral face 170 of the base disk 10. Further abrasive elements 200 (not shown) are adhered to the second adhesive surface 90 of the double-sided adhesive tape 70, so that eventually the entire perimetral face 170 is covered with abrasive elements 200, secured to the base disk 10 by a plurality of double sided adhesive tapes 70.

[0105] When grinding a workpiece, the base disk 10 with the abrasive elements 200 secured to it rotates at high speed, causing a considerable centrifugal force on the abrasive elements 200. The adhesive power and internal cohesion of the double-sided adhesive tape 70 must be carefully selected so that the tape 70 can withstand the centrifugal forces and keep the abrasive elements 200 secured to the base disk 10.

[0106] The base disk 10 with double-sided adhesive tape 70 adhered to its perimetral face 170, and before attaching any abrasive elements 200, can be considered a base disk assembly that is prepared for later attachment of abrasive elements 200 to the perimetral face 170 via the tape 70.

[0107] In the embodiment of the present disclosure illustrated in a perspective view in Figure 3, an abrasive grinding wheel 1 is shown during assembly. A double-sided adhesive tape 70 is adhered with its first major adhesive surface 80 to an upper perimetral surface 130 of the perimeter portion 60 of a base disk 10, and abrasive elements 200 are being adhered to a second major adhesive surface 90 of the tape 70. While a left-hand portion 160 of the tape 70 is shown adhered to the upper perimetral surface 130, a right-hand portion 180 of the tape 70 is shown before being adhered to the upper perimetral surface 130 of the base disk 10.

[0108] The double-sided adhesive tape 70 is similar to the tape 70 described in the context of Figure 2 and will

thus not be described again. Once the tape 70 is adhered to the base disk 10 the length direction of the tape 70 is a circumferential direction 120, the width direction of the tape 70 is a radial direction 110, and a thickness direction of the tape 70 is an axial direction 100. In the embodiment of Figure 3 the double-sided adhesive tape 70 extends, in radial direction 110, up to the perimeter 50 of the base disk, leaving no gap between the perimeter 50 and the lateral edge of the tape 70. In alternative embodiments the double-sided adhesive tape 70 extends, in radial direction 110, almost up to the very perimeter 50 of the base disk 10, leaving a radial gap, or it extends radially even beyond the perimeter 50. Such arrangements can help maximize adhesive contact area and adhesive power for securing abrasive elements 200 to the base disk 10. Portions of tape 70 protruding radially beyond the perimeter 50 may or may not be removed before using the abrasive grinding wheel 1.

[0109] The double-sided adhesive tape 70 extends in circumferential direction 120 along only a portion of the perimeter 50. A plurality of double-sided adhesive tapes 70 can be adhered next to each other on the upper perimetral surface 130 in order to cover the full circumference of the upper perimetral surface 130.

[0110] A rear (in Figure 3) abrasive element 200 is shown adhered to the second adhesive surface 90 of the double-sided adhesive tape 70. A front (in the Figure) abrasive element 200 is shown before being adhered to the second adhesive surface 90 of the double-sided adhesive tape 70. For adhering it, it is moved in the axial direction 100 indicated by arrow 240 towards the second adhesive surface 90. It is brought into a surface contact with the second adhesive surface 90 such that a major attachment surface 220 of the abrasive element 200 sticks to the second adhesive surface 90 of the double-sided adhesive tape 70.

[0111] After adhering, adhesion may be enhanced by pressing the abrasive element 200 axially towards the upper perimetral surface 130 of the base disk for an adequate time.

[0112] In the embodiment of Figure 3 each abrasive element 200 has a flat abrasive surface 210 which contacts and grinds a workpiece when the abrasive grinding wheel 1 is assembled and in use, and a flat major attachment surface 220, opposed to the abrasive surface 210. Abrasive particles 230 are exposed on the abrasive surface 210. Once the abrasive elements 200 are secured to the base disk 10, the abrasive surfaces 210 of the abrasive elements 200 point in an axial direction 100, parallel to the axis 20 of rotation.

[0113] Via the tape 70, each abrasive element 200 is adhered to the upper perimetral surface 130 of the base disk 10. Further abrasive elements 200 (not shown) are adhered to the second adhesive surface 90 of the double-sided adhesive tape 70, side by side in circumferential direction 120 and adjacent to each other, so that eventually the entire circumference of the upper perimetral surface 130 is covered with abrasive elements 200, se-

cured to the base disk 10 by the double-sided adhesive tape 70.

[0114] Once the abrasive elements 200 are secured to the base disk 10, the abrasive surfaces 210 of the abrasive elements 200 point axially upwards, their surface normals being oriented parallel to the axis 20 of rotation.

[0115] The base disk 10 with the double-sided adhesive tape 70 adhered to its upper perimetral surface 130, and before attaching any abrasive elements 200, can be considered a base disk assembly that is prepared for later attachment of abrasive elements 200 to the upper perimetral surface 130 via the tape 70.

[0116] In the embodiments of Figure 2 and Figure 3 the double-sided adhesive tape 70 is adhered to the perimeter portion 60 of the base disk 10 before the abrasive elements 200 are adhered to the tape 70. This order may be reversed.

[0117] Figure 4 is a perspective view of an abrasive element assembly 300 which comprises an abrasive element 200 similar to the abrasive elements 200 of Figure 2 and a double-sided adhesive tape 70. The abrasive element assembly 300 is useable in methods and devices described herein. The abrasive element 200 has an abrasive surface 210 (not visible in Figure 4) and an opposed major attachment surface 220, generally parallel to, and concentric with the abrasive surface 210. Both the abrasive surface 210 and the major attachment surface 220 are curved, their respective curvature radius being about the same as the curvature radius R of the perimetral face 170 of the base disk 10 to which the abrasive element 200 is to be secured. The attachment surface 220 has the same curvature radius as the perimetral face 170, because it is designed to be secured to that perimetral face 170.

[0118] The entire major attachment surface 220 is covered with a double-sided adhesive tape 70, similar to the tape 70 of Figure 2. The adhesive tape 70 comprises a first layer 150 of a curable adhesive. For illustrative purposes the tape 70 is shown partially cut away, although the tape 70 covers the attachment surface 220 completely. In alternative embodiments the tape 70 covers the attachment surface 220 only partially. The first adhesive surface 80 of the tape 70 is exposed, while the opposed second adhesive surface 90 is adhered to the attachment surface 220 of the abrasive element 200, and therefore not visible in Figure 4.

[0119] For securing the abrasive element assembly 300 to a perimetral face 170 of a base disk 10, such as the perimetral face 170 of the base disk 10 of Figures 2 or 3, the exposed first adhesive surface 80 is first adhered to the perimetral face 170 by bringing the first adhesive surface 80 and the perimetral face 170 in surface contact with each other such that the first adhesive surface 80 sticks to the perimetral face 170. The layer 150 of adhesive is then cured to establish a strong bond between the layer 150 of adhesive and the perimetral face 170 of the base disk 10.

[0120] Figure 5 is a perspective view of a further abrasive element assembly 301. It comprises an abrasive element 200 similar to the abrasive elements 200 of Figure 3. The abrasive element 200 has a flat abrasive surface 210 (not visible in Figure 5) and an opposed flat major attachment surface 220, generally parallel to the abrasive surface 210. Both the abrasive surface 210 and the major attachment surface 220 are flat. The attachment surface 220 is flat because it is to be secured to the flat upper perimetral surface 130 of a base disk 10 like the base disk 10 of Figure 3.

[0121] The major attachment surface 220 is completely covered with a double-sided adhesive tape 70, similar to the tape 70 of Figure 2. The double-sided adhesive tape 70 has a layer 150 of a curable adhesive. For illustrative purposes the tape 70 is shown partially cut away, although the tape 70 covers the attachment surface 220 completely. In alternative embodiments the tape 70 covers the attachment surface 220 only partially. The first adhesive surface 80 of the tape 70 is exposed, while the opposed second adhesive surface 90 is adhered to the attachment surface 220 of the abrasive element 200, and therefore not visible in Figure 5.

[0122] For securing the abrasive element assembly 301 to an upper perimetral surface 130 of a base disk 10, such as the upper perimetral surface 130 and the base disk 10 of Figures 2 or 3, the exposed first adhesive surface 80 is first adhered to the upper perimetral surface 130 by bringing the first adhesive surface 80 and the upper perimetral surface 130 in surface contact with each other such that the first adhesive surface 80 sticks to the upper perimetral surface 130. Adhesion is then enhanced by heat-curing the layer 150 of curable adhesive by inductive heating, using an inductive heating coil (not shown) and bringing it in the vicinity of the layer 150 of adhesive. During the curing process the abrasive element 200 is pressed onto the upper perimetral surface 130 of the base disk 10.

[0123] Figures 6 to 9 are perspective views of various types of double-sided adhesive tapes that are useable in methods, devices and assemblies described herein.

[0124] Figure 6 illustrates a double-sided adhesive tape 70 that has a single layer 150 of a single adhesive. The layer 150 of adhesive forms a major first adhesive surface 80, adapted for adhering to a base disk of an abrasive grinding wheel, and an opposed major second adhesive surface 90, parallel to the major first adhesive surface 80, and adapted to adhere to an attachment surface 220 of an abrasive element 200. The layer 150 of adhesive is a layer 150 of a pressure-sensitive adhesive or of a curable adhesive.

[0125] Figure 7 illustrates a further double-sided adhesive tape 71 that has a first layer 150 of a first adhesive and a second layer 152 of a second adhesive. The first layer 150 of adhesive forms a major first adhesive surface 80, adapted for adhering to a base disk 10 of an abrasive grinding wheel 1, and an opposed major second adhesive surface 90, parallel to the major first adhesive sur-

face 80, and adapted to adhere to an attachment surface 220 of an abrasive element 200. The first layer 150 of adhesive is a layer 150 of a pressure-sensitive adhesive or of a curable adhesive.

[0126] For greater mechanical stability the double-sided adhesive tape 71 comprises a carrier layer 290, arranged in a thickness direction 280, between the first layer 150 and the second layer 152 of adhesive.

[0127] Figure 8 illustrates a further double-sided adhesive tape 72 that has a single layer 150 of adhesive. The layer 150 of adhesive forms a major first adhesive surface 80, adapted for adhering to a base disk 10 of an abrasive grinding wheel 1, and an opposed major second adhesive surface 90, parallel to the major first adhesive surface 80, and adapted to adhere to an attachment surface 220 of an abrasive element 200.

[0128] The layer 150 of adhesive comprises a first adhesive layer strip 260 and a second adhesive layer strip 270, both elongated in a length direction 310 of the tape 72. The first adhesive layer strip 260 and the second adhesive layer strip 270 are arranged next to each other in a width direction 250 of the layer 150 of adhesive. A first portion of the width (i.e. of the extension in width direction 250) of the layer 150 of adhesive is occupied by the first adhesive layer strip 260, while a second portion of the width of the layer 150 of adhesive is occupied by the second adhesive layer strip 270.

[0129] The first adhesive layer strip 260 comprises a pressure-sensitive adhesive, while the second adhesive layer strip 270 comprises a heat-curable adhesive. When assembling an abrasive grinding wheel 1 according to certain methods described herein, the first adhesive surface 80 of the double-sided adhesive tape 72 is adhered to the perimetral portion 60 of the base disk 10 using the immediate adhesion provided by the first adhesive layer strip 260 with its pressure-sensitive adhesive. Abrasive elements 200 are then adhered with their respective major attachment surfaces 220 to the major second adhesive surface 90 of the double-sided adhesive tape 72. The abrasive elements 200 are held in place by the immediate adhesion provided by the first adhesive layer strip 260 with its pressure-sensitive adhesive until several or all abrasive elements 200 have been positioned on the base disk 10.

[0130] The second adhesive layer strip 270 with its curable adhesive is then cured by applying heat to the double-sided adhesive tape 72 until the curable adhesive is fully cured. The fully cured adhesive of the second adhesive layer strip 270 then provides a strong, permanent and durable bond between the abrasive elements 200 and the base disk 10.

[0131] Figure 9 illustrates a further double-sided adhesive tape 73 that has a single layer 150 of adhesive. The layer 150 of adhesive forms a major first adhesive surface 80, adapted for adhering to a base disk 10 of an abrasive grinding wheel, and an opposed major second adhesive surface 90 (not visible in Figure 9), parallel to the major first adhesive surface 80, and adapted to ad-

here to an attachment surface 220 of an abrasive element 200.

[0132] The layer 150 of adhesive comprises a first adhesive layer strip 260, a second adhesive layer strip 270, and a third adhesive layer strip 271. All three adhesive layer strips 260, 270, 271 are elongated in a length direction 310 of the tape 73. The first adhesive layer strip 260, the second adhesive layer strip 270 and the third adhesive layer strip 271 are arranged next to each other in a width direction 250 of the layer 150 of adhesive, with the first adhesive layer strip 260 being arranged between the second adhesive layer strip 270 and the third adhesive layer strip 271. A first portion of the width (i.e. of the extension in width direction 250) of the layer 150 of adhesive is thus occupied by the first adhesive layer strip 260, a second portion of the width of the layer 150 of adhesive is occupied by the second adhesive layer strip 270, and a third portion of the width of the layer 150 of adhesive is occupied by the third adhesive layer strip 271.

[0133] The first adhesive layer strip 260 comprises a pressure-sensitive adhesive, while the second and third adhesive layer strip 270, 271 each comprise a heat-curable adhesive. When assembling an abrasive grinding wheel 1 according to certain methods described herein, the first adhesive surface 80 of the double-sided adhesive tape 72 is adhered to the perimetral portion 60 of the base disk 10 using the immediate adhesion provided by the first adhesive layer strip 260 with its pressure-sensitive adhesive. Abrasive elements 200 are then adhered with their respective major attachment surfaces 220 to the major second adhesive surface 90 of the double-sided adhesive tape 72. The abrasive elements 200 are held in place by the immediate adhesion provided by the first adhesive layer strip 260 with its pressure-sensitive adhesive until several or all abrasive elements 200 have been positioned on the base disk 10.

[0134] The second and third adhesive layer strips 270, 271 with their curable adhesive are then cured by applying heat to the double-sided adhesive tape 73 until the curable adhesive is fully cured. The fully cured adhesive of the second and the third adhesive layer strips 270, 271 then provides a strong, permanent and durable bond between the abrasive elements 200 and the base disk 10.

[0135] The permanent bond may be stronger in the tape 73 of Figure 9 than in the tape 72 of Figure 8 because a greater portion (about two thirds) of the width of the adhesive layer 150 is occupied by the curable adhesive which provides in particular for a stronger permanent bond than in the tape 72 of Figure 8.

Claims

1. A method of assembling an abrasive grinding wheel (1) for rotating about an axis (20) of rotation, comprising the steps of:

(a) providing a base disk (10), axially symmetric

about the axis (20) of rotation of the abrasive grinding wheel (1),

the axis (20) of rotation defining axial directions (100) parallel thereto and radial directions (110) orthogonal thereto, and a radially outermost circumferential portion of the base disk (10) defining a perimeter portion (60) of the base disk (10),

providing a first abrasive element (200) having an abrasive surface (210) for grinding a workpiece, and a major attachment surface (220) for attaching the first abrasive element (200) to the base disk (10) at the perimeter portion (60); and

providing a double-sided adhesive tape (70, 71, 72, 73) comprising a major first adhesive surface (80), an opposed major second adhesive surface (90), and a first layer (150) of adhesive forming the major first adhesive surface (80);

(b) adhering the major first adhesive surface (80) to the base disk (10) at the perimeter portion (60);

(c) before or after step (b), adhering the major second adhesive surface (90) to the attachment surface (220) of the first abrasive element (200).

2. Method according to claim 1, wherein step (b) and/or step (c) is performed by a robot.

3. Method according to claim 1 or claim 2, further comprising, after steps (b) and (c), a step of (d) curing the first layer (150) of adhesive by applying heat to the first layer (150) of adhesive.

4. Method according to any one of the preceding claims, wherein the perimeter portion (60) is the portion of the base disk (10) located radially between 30 percent of the radius of the perimeter (50) and 100 percent of the radius of the perimeter (50) of the base disk (10).

5. Method according to any one of the preceding claims, wherein the perimeter portion (60) comprises an upper perimetral surface (130) whose surface normal is parallel, within $\pm 10^\circ$, to the axis (20) of rotation, an opposed lower perimetral surface (140) whose surface normal is antiparallel, within $\pm 10^\circ$, to the axis (20) of rotation, and wherein step (b) comprises adhering the major first adhesive surface (80) to the upper perimetral surface (130) or to the lower perimetral surface (140).

6. Method according to any one of claims 1 to 4, where-

in the perimeter portion (60) comprises a perimetral face (170) whose surface normal is orthogonal, within $\pm 20^\circ$, to the axis (20) of rotation, and wherein step (b) comprises adhering the major first adhesive surface (80) to the perimetral face (170).

7. Abrasive element assembly (300, 301) comprising

a) an abrasive element (200) having an abrasive surface (210) for grinding a workpiece, and a major attachment surface (220) for attaching the abrasive element (200) to a base disk (10) at a perimeter portion (60) of the base disk (10); and
b) a double-sided adhesive tape (70, 71, 72, 73) comprising a major first adhesive surface (80), adapted to adhere to the perimeter portion (60), an opposed major second adhesive surface (90), and a first layer (150) of adhesive forming the major first adhesive surface (80),

wherein the major second adhesive surface (90) is adhered to the major attachment surface (220) of the abrasive element (200).

8. Abrasive element assembly (300) according to claim 7, wherein the major attachment surface (220) is a curved surface.

9. Abrasive element assembly (301) according to claim 7, wherein the major attachment surface (220) is a flat surface.

10. Base disk assembly (1) comprising

a) a base disk (10) axially symmetric about an axis (20) of rotation, the axis (20) of rotation defining axial directions (100) parallel thereto and radial directions (110) orthogonal thereto, the base disk (10) comprising a radially outermost circumferential portion defining a perimeter portion (60) of the base disk (10); and
b) a double-sided adhesive tape (70, 71, 72, 73) comprising

i) a major first adhesive surface (80),
ii) a first layer of adhesive (150) forming the major first adhesive surface (80), and
iii) an opposed major second adhesive surface (90), adapted to be adhered to a major attachment surface (220) of an abrasive element (200),

wherein the major first adhesive surface (80) is adhered to the base disk (10) at the perimeter portion (60).

11. Abrasive grinding wheel (1) for rotating about an axis (20) of rotation, comprising:

a) a base disk (10) axially symmetric about an axis (20) of rotation of the abrasive grinding wheel (1), the axis (20) of rotation defining axial directions (100) parallel thereto and radial directions (110) orthogonal thereto, and a radially outermost circumferential portion of the base disk (10) defining a perimeter portion (60) of the base disk (10);

b) an abrasive element (200) having an abrasive surface (210) for grinding a workpiece, and a major attachment surface (220) for attaching the abrasive element (200) to the base disk (10) at the perimeter portion (60); and

c) a double-sided adhesive tape (70, 71, 72, 73) comprising

i) a major first adhesive surface (80),
ii) a first layer (150) of adhesive forming the first adhesive surface (80),
iii) an opposed major second adhesive surface (90),

wherein the major first adhesive surface (80) is adhered to the perimeter portion (60) of the base disk (10), and wherein the major second adhesive surface (90) is adhered to the major attachment surface (220) of the abrasive element (200), wherein the abrasive element (200) is secured to the perimeter portion (60) by the double-sided adhesive tape (70, 71, 72, 73).

12. Method according to any one of claims 1 to 6, or abrasive element assembly (300, 301) according to any one of claims 7 to 9, or base disk assembly (1) according to claim 10, or abrasive grinding wheel (1) according to claim 11, wherein the first layer (150) of adhesive comprises an epoxy-based adhesive or an acrylic adhesive or a polyurethane adhesive.

13. Method according to any one of claims 1 to 6 or 12, or abrasive element assembly (300, 301) according to any one of claims 7 to 9 or 12, or base disk assembly (1) according to claim 10 or claim 12, or abrasive grinding wheel (1) according to any one of claims 11 or 12, wherein the double-sided adhesive tape (71) further comprises a second layer (152) of adhesive forming the major second adhesive surface (90).

14. Method according to any one of claims 1 to 6, 12 or 13, or abrasive element assembly (300, 301) according to any one of claims 7 to 9 and 12 to 13, or base disk assembly (1) according to any one of claims 10, 12 and 13, or abrasive grinding wheel (1) according to any one of claims 11 to 13, wherein the first layer (150) of adhesive comprises a heat-curable adhesive or a UV-curable adhesive or an electron-beam-curable adhesive.

15. Method according to any one of claims 1 to 6 and 12 to 14, or abrasive element assembly (300, 301) according to any one of claims 7 to 9 and 12 to 14, or base disk assembly (1) according to any one of claims 10 and 12 to 14, or abrasive grinding wheel (1) according to any one of claims 11 to 14, 5

wherein an extension of the first layer (150) of adhesive in a width direction (250) of the double-sided adhesive tape (72, 73) defines a layer width, 10

wherein the first layer (150) of adhesive comprises an elongated first adhesive layer strip (260) and an elongated second adhesive layer strip (270, 271), arranged adjacent to each other in the width direction (250) of the double-sided adhesive tape (72, 73), 15

wherein each of the first and second adhesive layer strips (260, 270, 271) has a width smaller than the layer width, with a length direction of each adhesive layer strip (260, 270, 271) being oriented parallel to a length direction (310) of the double-sided adhesive tape (72, 73), 20

and wherein the first adhesive layer strip (260) comprises a pressure-sensitive adhesive, and the second adhesive layer strip (270, 271) comprises a curable adhesive. 25

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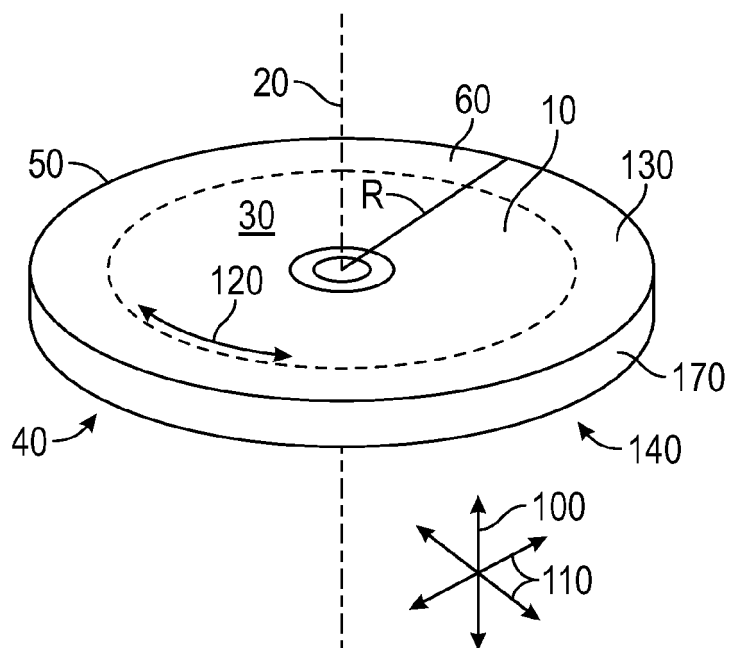


FIG. 1

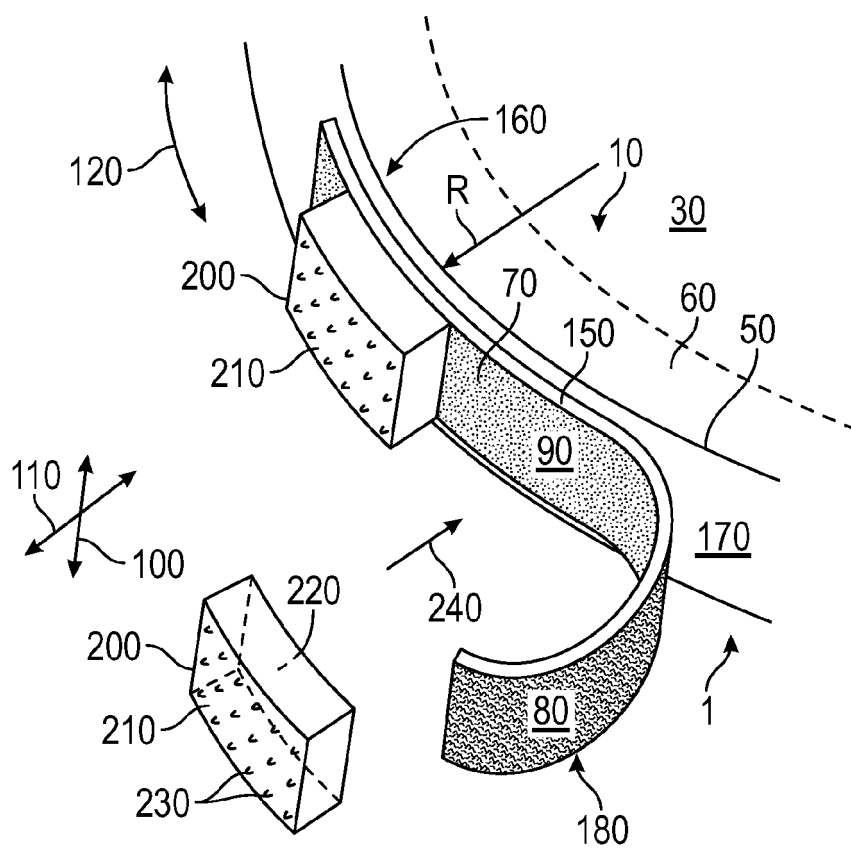


FIG. 2

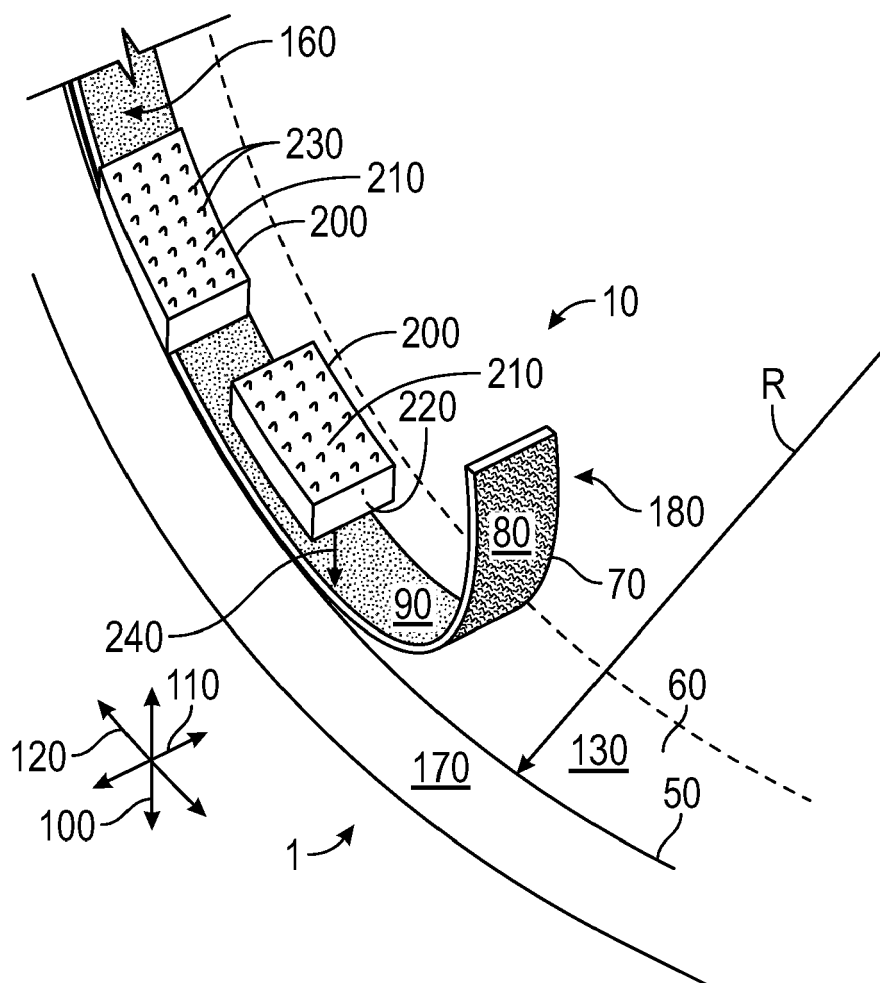


FIG. 3

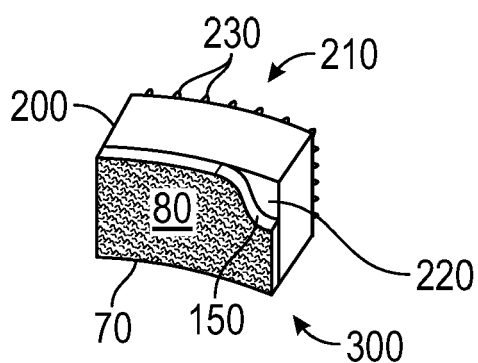


FIG. 4

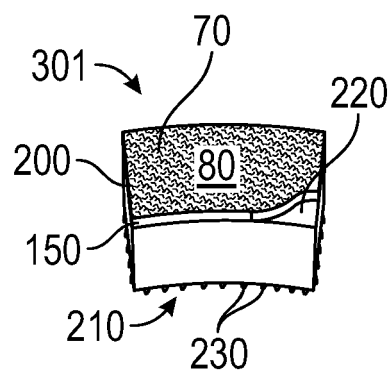


FIG. 5

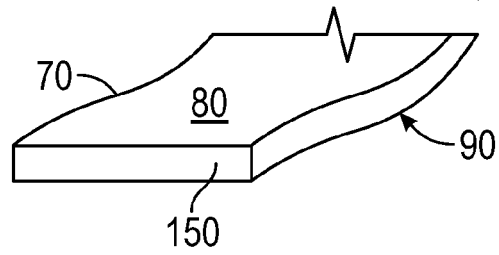


FIG. 6

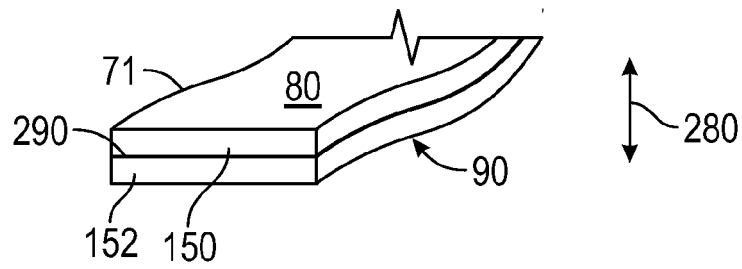


FIG. 7

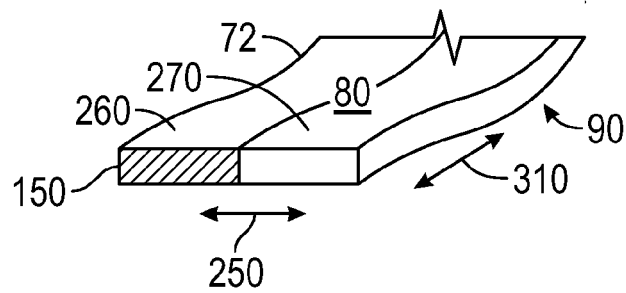


FIG. 8

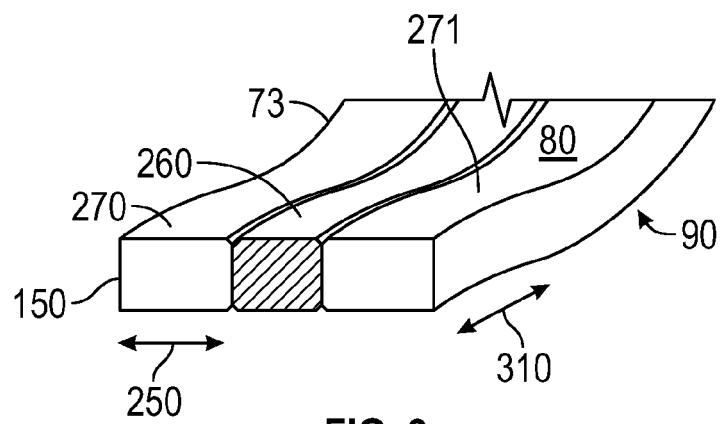


FIG. 9



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Place of search Munich		Date of completion of the search 23 August 2022	Examiner Arhire, Irina
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