A grinding wheel for the grinding of curved surface portions (0) consists basically of a carrying body (2, 12) and an abrasive (3, 13, 23) applied to the carrying body. The carrying body (2, 12) has a circumferential surface (4), of which the section relative to a radial plane (R) has a curvature. The abrasive (3, 13, 23) is arranged on the carrying body (2, 12), at least in the region of the circumferential surface (4). The abrasive thereby likewise has, in section, relative to the radial plane (R), a curvature which corresponds essentially to the curvature of the circumferential surface (4).
The invention relates to a grinding wheel for the grinding of curved surface portions and also to an intermediate product and to a method for the production of such a grinding wheel, having the features of the preamble of the independent claims.

Various types of grinding wheels are known. The grinding of flat surfaces, for example, sheetlike wheels are used, to one or both sides of which an abrasive is applied.

It is known from U.S. Pat. No. 5,722,881, to apply abrasive flaps to the outside of a disk-shaped carrier.

EP 911 116 discloses grinding wheels, in which abrasives are arranged next to one another in segments, so as to overlap, on both surfaces.

These known grinding wheels are suitable for the grinding of essentially flat surfaces. In specific applications, however, it is desirable to grind radii, for example in the case of weld seams which connect sheetlike parts to one another. Above all with regard to applications where there are stringent hygiene requirements or where corrosion is to be avoided, it is important that the surface of the weld seam is smooth, in particular has no depressions or pores. Such concavely curved surfaces can be ground with relatively poor quality by means of conventional grinding wheels.

An object of the present invention is, therefore, to avoid the disadvantages of the known prior art, in particular, therefore, to provide a grinding wheel which is suitable for the grinding of curved concave surfaces. The grinding wheel is to be capable of being produced in a simple way and is to have long service life.

These objects are achieved, according to the invention, by means of a grinding wheel having the features of the characterizing part of claim 1.

The grinding wheel consists basically of a carrying body and of abrasive applied to the carrying body. By “abrasive” is meant in this connection, in particular, a sheetlike carrier which is provided with abrasive, that is to say, typically, a grinding belt or sections from a grinding belt or a flat grinding wheel. It is also conceivable, however, to apply abrasive directly, and without a carrier, to the carrying body, in particular to glue abrasive material directly to the carrying body.

The grinding wheel is rotatable about an axis, for example by means of a grinding machine. The carrying body has a circumferential surface which, in section in a radial plane, has at least partially a concave curvature. A radial plane is a plane which runs through the axis of rotation. The abrasive is arranged on the carrying body, at least in the region of the circumferential surface. The abrasive therefore likewise has, in section, relative to the radial plane, a curvature which corresponds approximately to the curvature of the circumferential surface.

The grinding wheel according to the invention is of approximately rotationally symmetrical design. Of course, as seen in the circumferential direction, the outer surface of the carrying body has a curvature. Here and hereafter, by the “curvature of the circumferential surface” is meant the curvature of the circumferential surface in a radial plane.

Since the carrying body is provided with a convex circumferential surface and the abrasives are applied to the carrying body, at least in the region of the circumferential surface, concave surface portions can be ground in a simple way.

Since, according to the invention, an abrasive is applied to a carrying body having a predetermined shape with a curvature, the shape of the abrasive is at all times defined exactly by the carrying body. In contrast to bound abrasives, in which the shape of the grinding surface may change in the course of time due to the removal of the abrasive, the curved grinding surface according to the invention remains defined over the lifetime of the grinding wheel.

According to a first exemplary embodiment, the carrying body is designed as a ring. Designing the carrying body as a ring has various advantages. Thus, the carrying body can be produced at a relatively low outlay in terms of material. Moreover, a carrying body designed as a ring can be fastened in a simple way to a grinding machine by means of a fastening device, such as is described, for example, in EP 911 116.

In an alternative exemplary embodiment, the carrying body is designed as a disk. One advantage of this construction is that the disk can be fastened directly to the grinding machine.

In a preferred embodiment, the abrasive is clamped on the carrying body by means of a clamping device. The sheetlike flexible abrasive is curved around the curvature of the circumferential surface of the carrying body and is clamped laterally. Such a clamping device reliably ensures that the abrasive does not come loose even at high loads.

Moreover, the clamping device may be designed as a holding means for fastening the grinding wheel to a grinding machine. The clamping device in this case serves at the same time for holding the grinding wheel and for fastening the abrasive.

According to an alternative exemplary embodiment, the abrasive is glued to the carrying body. Gluing is simpler than clamping, since a specific clamping device can be dispensed with. Of course, gluing can also be combined with clamping. For this purpose, the abrasive is glued to the carrying body in a first step. To increase the resistance, the abrasive is at the same time also clamped.

In a further exemplary embodiment, the abrasive is formed from segments which are arranged next to one another on the carrying body so as to overlap in the circumferential direction. The abrasive is fastened to one side of a carrying body in a similar way to EP 911 116. In contrast to EP 911 116, however, the carrying body has a curved outer surface, over which the abrasive is applied in a curved manner. Individual segments can be adapted to the curvature of the circumferential surface in a particularly simple way.

The segments are particularly advantageously of almond-shaped design. In this connection, “almond-shaped” means that the segments have rounded side edges which narrow toward both ends of the segment. This shape reduces the thickening of the layer consisting of the segments which is caused by the overlapping.
According to an alternative exemplary embodiment, the abrasive is designed as a belt which, as seen in the circumferential direction, is wound in coils on the carrying body designed as a ring. This type of fastening is particularly advantageous, because the belt, as it were, fastens itself to the carrier on account of the coils. Since only a one-piece abrasive is applied, the outlay in terms of production is reduced.

The overlapping of the segments or of the coils is in this case advantageously designed in such a way that the distance of the front end of the segments or coils, as seen in the direction of rotation, from the axis of rotation is greater than the distance of the rear end. Overlapping of this type leads to an advantageous self-renewing effect and consequently to an increase in service lives. During operation, the rear end of the segments or coils which is furthest on the outside is removed first.

According to a further exemplary embodiment, the abrasive is designed as a belt which, as seen in the circumferential direction, is applied to the circumferential surface. The belt is applied as a closed belt to the circumferential surface and is bent around along its side edges toward the surfaces of the carrying body. The advantage of this exemplary design is that, in contrast to overlaps, the grinding surface is essentially flat, that is to say has no steps.

In order to make it easier for the edges of the closed belt to be folded round, the belt may be provided along its edges with indentations or cutouts. The segments formed between indentations or cutouts can be folded onto the surfaces of the carrying body and at the same time slightly overlap one another. A corrugation of the sheetlike abrasive is thereby avoided.

According to a further exemplary embodiment, the abrasive in the form of abrasive material (abrasive grain) is glued directly to the surface of the carrying body by means of a binder. Fastening and deformation of abrasive on a substrate are therefore unnecessary.

The radius of curvature of the circumferential surface is typically adapted to the curved surface to be ground. The radius is preferably between 3 mm and 8 mm. The carrying body of the grinding wheel is advantageously formed from glass-fiber-reinforced plastic. The abrasive can be glued especially permanently to such a carrying body. It is also conceivable, however, in particular, to manufacture a carrying body designed as a ring, for example, from aluminum or from plastic. The curved portion of the circumferential surface of the carrying body advantageously extends over an angle of more than 180°, that is to say the carrying body has a ringlike outer circumference. A particularly large actively usable grinding surface is thereby made available.

The invention is explained in more detail below in exemplary embodiments and with reference to the drawings in which:

FIG. 1 shows a section through a surface to be ground and through part of a grinding wheel according to the invention,

FIG. 2 shows a top view of a first exemplary embodiment of a grinding wheel according to the invention,

FIG. 3 shows a cross section through the exemplary embodiment according to FIG. 2,

FIG. 4 shows an enlarged illustration of abrasives according to the exemplary embodiment from FIG. 2,

FIG. 5 shows a top view of a second exemplary embodiment of the invention,

FIG. 6 shows a cross section through a grinding wheel according to the exemplary embodiment from FIG. 5,

FIG. 7 shows a top view of an intermediate product for the production of a grinding wheel according to the invention,

FIG. 8 shows a cross section through part of the intermediate product according to FIG. 7 and a grinding wheel produced from it,

FIG. 9 shows a top view of a third exemplary embodiment of the grinding wheel according to the invention,

FIG. 10 shows a top view of the abrasive for a grinding wheel according to the exemplary embodiment from FIG. 9, and

FIG. 11 shows a cross section through a fourth exemplary embodiment of a grinding wheel.

FIG. 1 shows schematically the use of a grinding wheel according to the invention in cross section. The grinding wheel serves, for example, for the grinding of radii into the surface O of a weld seam which, for example, joins together two metal parts M1, M2.

A grinding wheel 1 is fastened rotatably about an axis A. The grinding wheel 1 has a carrying body which, according to the following exemplary embodiments, may be designed as a ring 2 or as a disk 12. FIG. 1 shows a section through the grinding wheel 1 along a radial plane R (see FIG. 2). Planes running through the axis A are designated as radial planes. The carrying body of the grinding wheel 1 has a circumferential surface 4. This circumferential surface 4 is the surface defining the circumference of the grinding wheel 1. The circumferential surface 4 is curved convexly, in section, relative to the radial plane R. In the region of the circumferential surface 4, the carrying body of the grinding wheel 1 is provided with an abrasive which, according to the following exemplary embodiments, may be designed as a segment or as a belt or as abrasive grain applied to the carrying body by means of a binder. On account of the convex curvature of the circumferential surface 4, the abrasive, for example a segment 3, applied to the circumferential surface 4 also acquires a convex shape. The radius can be ground into the surface O of the weld location S by means of the curved abrasive.

A first exemplary embodiment of the grinding wheel according to the invention is shown in FIGS. 2 to 4. FIG. 2 shows a top view of the grinding wheel 1. The grinding wheel 1 according to this exemplary embodiment has a carrying body designed as a ring 2. The ring 2 is formed from aluminum, steel or nylon or from a glass-fiber-reinforced plastic. Along the outer circumferential surface 4, the ring 2 is curved convexly in a radial sectional plane R. Mutually overlapping segments 3 lying next to one another and consisting of a flexible abrasive are arranged on the ring 2. Typically, abrasive segments with a carrying material consisting of fabric (cotton or polyester), on which desired abrasive grain is held by means of a binder, are used.
Segments 3 are glued to the underside and top side of the ring 2 by means of an adhesive, for example a polyurethane adhesive. In addition, the segments 3 are clamped by means of a clamping device (see FIG. 3). The clamping device consists of an upper part 5 and a lower part 6 which are held together, for example, by means of screws 10 and thus clamp the ring 2 together with the segments 3. Moreover, the clamping device consisting of the parts 5, 6 may be provided with a holding device 7 (illustrated by broken lines), by means of which the grinding wheel 1 can be fastened to a grinding machine (not illustrated).

[0041] The overlapping of the segments 3 is selected such that the distance d of the front end 8 of the segments 3 in the direction of rotation D, from the axis of rotation A of the grinding wheel 1 is shorter than the distance of the rear end 9 of the segment 3, as seen in the direction of rotation D, from the axis of rotation A. This results in a softer grinding action. At the same time, during operation the rear end 9 is removed, so that the grinding wheel 1 is self-renewing.

[0042] As shown in FIG. 3 the circumferential surface 4 is provided, in a radial sectional plane R, with a radius of curvature r. The circumferential surface 4 does not need to run exactly along a circle, that is to say the radius of curvature of the circumferential surface is not constant. The radius of curvature r is selected according to the type of grinding location to be treated. It is typically 3 mm to 8 mm.

[0043] When the grinding wheel 1 is worn away, the clamping device consisting of the parts 5, 6 can be released and the ring 2 replaced. Owing to the clamping device, it is not necessary for the holding device 7 connected to the clamping device 5, 6 to be replaced.

[0044] FIG. 4 shows a preferred shape of the segments 3. The segments 3 are of almond-shaped design. That is to say, the segments have the greatest width in a middle region 15. The middle region 15 bears against the ring 2 along an outer circumferential line 16. The segments 3 narrow away from the center line 15, the front end 8 and the rear end 9 being of curved design. This shape of the segments 3 takes into account the desired curvature of the segments 3. The problem of thickening due to additional material in the region of the fastening of the segments 3 on the ring 2 thereby avoided.

[0045] FIGS. 5 and 6 show an alternative exemplary embodiment of the grinding wheel 1 according to the invention. As in FIGS. 2 to 4, the carrying body is designed as a ring 2. In contrast to the preceding exemplary embodiment, the abrasive is designed as a belt 13 which is wound in coils 14 around the ring 2. The coils 14 are arranged, in a similar way to the segments 3, such that the distance of the front end 8 of the coils, as seen in the direction of rotation, from the axis of rotation A is greater than the distance of the rear end 9 of the coils 14. One advantage of the winding is that individual segments do not have to be fastened to the ring. A gluing of the abrasive to the ring 2 may be dispensed with. The clamping device, evident in FIG. 6, consisting of an upper and a lower part 5, 6 serves for pressing the grinding belt 13 onto the ring 2. The ring 2 is provided on its top side and underside with a concave pressing region 17. The parts 5, 6 press the grinding belt 13 into the concave region 17. This leads to a tensioning of the grinding belt 13 in the region of the curved circumferential surface 4.

[0046] FIG. 7 shows a top view of an intermediate product of a grinding wheel which is constructed in a similar way to the exemplary embodiment according to FIGS. 2 to 4. In contrast to the exemplary embodiment according to FIGS. 2 to 4, according to FIG. 7 the carrying body is designed as a continuous disk 12. The disk 12 consists, for example, of glass-fiber-reinforced plastic. To produce a grinding wheel according to this exemplary embodiment, first, segments 3 are glued to a surface of the disk 12, so that an inner end 11a is glued to the surface and an outer end 11b of the segments projects (see the cross section in FIG. 8) beyond the outer circumferential line 16 of the disk 12 to an extent such that the projecting end 11b can subsequently be curved downward and likewise be glued to the underside 12 of the disk 12. In this case, the segment 3 assumes the convex shape of the circumferential surface 4.

[0047] Of course, a grinding wheel according to FIG. 2 to 4 having a ring-shaped carrying body can also be produced by means of the production method thus illustrated.

[0048] FIGS. 9 and 10 show a further exemplary embodiment of the invention. The carrying body is designed as a ring 2 in a similar way to the exemplary embodiment according to FIGS. 2 to 4. The abrasive is designed as a belt 23 which is applied to the ring 2 in the circumferential direction U along the outer circumferential line 16. The belt 23 is intrinsically flat. So that the belt 23 acquires a curved surface, the edges 24 of the belt 23 are folded onto the top side and underside of the wheel 2 and fastened, for example glued and/or clamped, thereto. So that the belt 23 is not corrugated when the edges 24 are folded round, the belt is provided with indentations 25 extending from the edges 24 toward the middle 26 of the belt 23. The belt 23 overlaps itself in the region of the indentations 25 on the top side and underside of the wheel 2 (see FIG. 9). FIG. 10 shows a top view of a detail of the belt 23. The middle 26 of the belt is laid onto the wheel 12 along the outer circumferential line 16. FIG. 10 illustrates cutouts 25. The size of the cutouts 25 may be selected according to the degree of curvature. Indentations are also conceivable in which no material is removed from the belt 23. The exemplary embodiment according to FIGS. 9 and 10 can be implemented both with a carrying body as a ring 2 and with a disk-shaped carrying body 12. The grinding belt 23 is a conventional grinding belt. The grinding belt can be glued along the outer circumferential line 16 and to the top side and underside of the carrying body and/or be clamped by means of a clamping device in a similar way to the preceding exemplary embodiments.

[0049] FIG. 11 shows a cross section through a fourth exemplary embodiment of the invention. A carrying body designed as a ring 2 is formed as an injection molding, in which the ends 11a, 11b of the segments 3 are anchored. Such anchoring is, of course, also conceivable in connection with a continuous disk, according to the exemplary embodiment in FIG. 7 and 8, and with a belt applied in the circumferential direction, according to FIGS. 9 and 10. The parts of the fastening device 5, 6 for all the exemplary embodiments shown can be manufactured, for example, from aluminum. Plastic injection moldings may, however, also be envisaged.

[0050] In the exemplary embodiments according to FIGS. 1, 3, 6, and 11, the curved circumferential surface extends over an angle β of more than 180°. That is to say, a circumferential portion of at least 180° can be used for
grinding. The carrying body has in this case a region of greatest thickness in the axial direction. The thickness of the carrying body decreases radially inward from this region, so that a drop-shaped cross section is obtained. The abrasive is applied to the carrying body radially inward over and beyond the region of greatest thickness.

[0051] According to a further exemplary embodiment not illustrated in the figures, the abrasive is applied, without substrate, directly to the carrying body, for example a ring, as shown in FIG. 2 and 3. For this purpose, abrasive grain is applied by means of a binder (for example, epoxy resin) to the surface of the ring 2 (for example, consisting of aluminum, steel or plastic).

1. A grinding wheel for grinding curved surface portions comprising a carrying body and an abrasive applied to the carrying body, wherein the carrying body has a circumferential surface which has, in section in a radial plane, at least partially a convex curvature, and wherein the abrasive is arranged on the carrying body, at least in the region of the circumferential surface, so that the abrasive has, in section, relative to the radial plane R, a curvature which corresponds approximately to the curvature of the circumferential surface.

2. A grinding wheel of claim 1, wherein the carrying body is designed as a ring.

3. A grinding wheel of claim 1, wherein the carrying body is designed as a disk.

4. A grinding wheel of claim 1, wherein the abrasive is clamped on the carrying body by means of a clamping device.

5. A grinding wheel of claim 1, wherein the clamping device is provided with a holding means for fastening the grinding wheel to a grinding machine.

6. A grinding wheel of claim 1, wherein the abrasive is glued to the carrying body.

7. A grinding wheel of claim 1, wherein the abrasive consists of segments which are arranged on the carrying body preferably so as to overlap in the circumferential direction.

8. A grinding wheel of claim 7, wherein the segments are of almond-shaped design.

9. A grinding wheel of claim 2, wherein the abrasive is designed as a belt which is wound in coils on the ring preferably so as to overlap, as seen in the circumferential direction.

10. A grinding wheel of claim 7, wherein the overlap is designed in such a way that the distance of the front end of the segments respectively the coils, in the direction of rotation, from the axis of rotation is shorter than the distance of the rear end, in the direction of rotation, from the axis of rotation.

11. A grinding wheel of claim 1, wherein the abrasive is designed as a belt which, as seen in the circumferential direction, is applied to the carrying body at least on an outer circumferential line of the circumferential surface.

12. A grinding wheel of claim 11, wherein the belt is provided along its edges with indentations or cutouts.

13. A grinding wheel of claim 1, wherein the circumferential surface has a radius of curvature of 3 mm to 8 mm.

14. A grinding wheel of claim 1, wherein the carrier consists of glass-fiber-reinforced plastic.

15. An intermediate product for the production of a grinding wheel of claim 7, wherein the segments are fastened with an inner end to the carrying body and wherein the outer end of the segments projects beyond the outer, circumferential line of the carrying body.

16. A method of making a grinding wheel of claim 7, comprising steps of

providing an intermediate product comprising abrasive segments arranged on a carrying body so as to overlap in a circumferential direction, the segments having an outer end fastened to the carrying body and an outer end projecting beyond an outer circumferential line of the carrying body,

bending of the outer ends of the segments around the curved circumferential portion and

fastening of the outer ends to the carrying body.

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