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(54) Title: STUDS FOR HIGH PRESSURE GRINDING ROLLERS

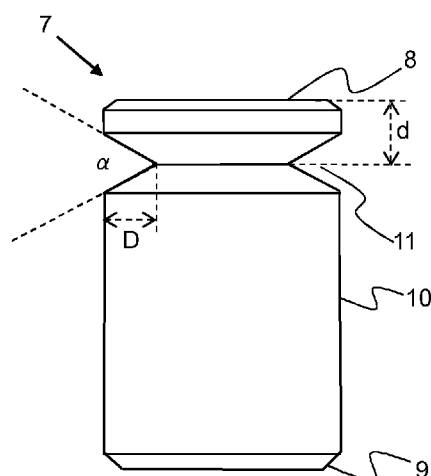


Figure 4

(57) Abstract: A reconditionable high pressure grinding roller stud is provided. The stud is substantially cylindrical and comprises a grinding surface; an attachment end configured to attach to a roller; and a side wall connecting the grinding surface to the attachment end. The side wall comprises a recess extending around a circumference of the side wall. The recess enables easy reconditioning of the stud such that the worn grinding surface can be removed to expose a second grinding surface.

STUDS FOR HIGH PRESSURE GRINDING ROLLERS

FIELD

5 The invention relates to the field of studs for high pressure grinding rollers and methods of using such studs.

BACKGROUND

10 High pressure grinding roller (HPGR) milling is becoming a popular route for crushing rocks and mineral. As shown in Figure 1, HPGR apparatus includes a first roller 1 and a second roller 2 with a gap between them. In use, the first and second rollers counter-rotate. A feed of material 3 is allowed to fall from a hopper through a gap between the first and second rollers 1, 2.

15 The first roller 1 is allowed to move linearly in a direction normal to the direction of the material feed. The first roller is usually biased to a particular position relative to the second roller by springs or hydraulic cylinders

20 As the material feed passes through the gap between the first and second rollers 1, 2, compression causes the particles of the feed material 3 to fracture, and the resultant material 4 has a much reduced particle size. The use of counter-rotating rollers 1, 2 allows the particle size reduction to be a continuous operation rather than a batch operation.

25 The rollers 1, 2 may have a flat surface, but in some examples (such as that shown in Figure 2) the rollers have a plurality of studs disposed on the surface. Studs have the advantage of increasing the pressure where they contact the feed material and protecting the roller itself. The studs are typically made from a hard material such as cemented tungsten carbide and provide an effective roller surface.

30 After continuous use for a period of time, the studs show signs of wear. The feed material 3 usually falls through the gap at the middle of the rollers, as shown in Figure 3. This leads to uneven wear and the gap between the effective roller surfaces at the middle of the rollers becomes larger than the gap towards the ends of the rollers. The same situation occurs where studs are not used (as shown in Figure 3, with the gap 6 between the rollers being

larger towards the middle). This reduces the efficiency of the rollers. In cases where studs are not used, the entire roller must be replaced. In cases where studs are used, the studs must be either be replaced, or selectively ground down towards the ends of the rollers to ensure that the effective rollers surface becomes flat again. Either way, this is a time-consuming and expensive operation.

SUMMARY

It is an object to provide a more effective way of mitigating against wear on a high pressure grinding rollers apparatus that uses studs on the roller surface.

10

According to a first aspect, there is provided a reconditionable high pressure grinding roller stud. The stud is cylindrical and comprises a grinding surface, an attachment end configured to attach to a roller, and a side wall connecting the grinding surface to the attachment end, the side wall comprising a recess. The recess extends around a circumference of the side wall. An advantage of the recess is that it allows a controlled volume of the stud between the recess and the grinding surface to be removed without the need for grinding down to recondition the stud.

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20

As an option, the recess extends fully around a circumference of the side wall. In this embodiment, the recess extends circumferentially a full 360 degrees around the stud.

As an option, the stud comprises a cemented metal carbide material.

25

The grinding surface optionally has a diameter selected from any of between 12 and 30 mm, between 14 and 25 mm, and between 16 and 20 mm.

The recess optionally has a depth selected from between 1 and 6 mm. As a further option, the recess has a depth selected from between 2 and 4 mm.

30

As an option, the recess forms an angle between 40 and 80°. As a further option, the recess forms an angle between 50 and 70°.

A stud optionally comprises a plurality of recesses, allowing a volume to be removed a plurality of times.

The attachment end is optionally configured to attach to the roller by any of gluing, brazing, press-fitting, shrink fitting, threaded connection, and mechanical connection.

- 5 According to a second aspect, there is provided a high pressure grinding roller comprising a cylindrical roller having a circumferential surface and a plurality of high pressure grinding rollers studs according to any one of claims 1 to 10 attached to the circumferential surface.

As an option, the high pressure grinding roller comprises:

- 10 a first plurality of high pressure grinding roller studs, each stud of the first plurality of high pressure grinding roller studs having a recess located a first distance from the grinding surface, the first plurality of high pressure grinding studs being located at a first location on the circumferential surface; and
- a second plurality of high pressure grinding roller studs, each stud of the first
- 15 second plurality of high pressure grinding roller studs having a recess located a second distance from the grinding surface, the second plurality of high pressure grinding studs being located at a second location on the circumferential surface.

As a further option, the high pressure grinding roller comprises:

- 20 a third plurality of high pressure grinding roller studs, each stud of the further plurality of high pressure grinding roller studs having a recess located a third distance from the grinding surface, the third plurality of high pressure grinding studs being located at a third location on the circumferential surface.

- 25 It will be appreciated that further pluralities of studs may be provided with the location of the recess set according to the position of the studs on the roller to compensate for expected wear.

- As an option, each high pressure grinding roller stud is attached to the roller by any of
- 30 gluing, brazing, press-fitting, shrink fitting, threaded connection, and mechanical connection.

According to a third aspect, there is provided a method of reconditioning a high pressure grinding roller as described above in the second aspect. For at least a portion of the

plurality of high pressure grinding roller studs, a volume of each stud between the recess and the grinding surface is removed to expose a new, second grinding surface.

As an option, the volume is removed by applying a shear force at the recess.

5

As an option, the volume is removed by using any of a hammer and a chisel.

As an alternative option, the volume is removed during a grinding operation.

10 BRIEF DESCRIPTION OF THE DRAWINGS

Non-limiting embodiments will now be described by way of example and with reference to the accompanying drawings in which:

Figure 1 illustrates schematically a known high pressure grinding roller apparatus;

15

Figure 2 shows rollers comprising studs;

Figure 3 illustrates schematically a plan view of a pair of rollers after use;

20 Figure 4 is a side elevation view of a first exemplary high pressure grinding roller stud;

Figure 5 is a schematic cross-section view of an exemplary high pressure grinding roller;

Figure 6 is a schematic cross-section view of a high pressure grinding roller showing wear;

25

Figure 7 is a side elevation view of the first exemplary high pressure grinding roller stud after removing a volume between a circumferential recess and a grinding surface;

Figure 8 is a schematic side view of a high pressure grinding roller after reconditioning;

30

Figure 9 is a flow diagram showing exemplary steps for reconditioning a high pressure grinding roller;

Figure 10 shows a side elevation view of a second exemplary high pressure grinding roller stud;

5 Figure 11 illustrates schematically a first test for removing a volume of a high pressure grinding roller stud;

Figure 12 illustrates schematically a second test for removing a volume of a high pressure grinding roller stud;

10 Figure 13 is a photograph showing a new exposed grinding surface after a volume between the circumferential recess and the grinding surface has been removed; and

Figure 14 shows a side elevation view of a third exemplary high pressure grinding roller stud.

15

DETAILED DESCRIPTION

Referring to Figure 4, a high pressure grinding roller stud 7 is provided. The stud 7 has a grinding surface 8 arranged to contact the material to be ground. An attachment end 9 is located at an end opposite to the grinding surface 8. The grinding surface 8 and the attachment end 9 are connected by a side wall 10. The stud is substantially cylindrical except for a circumferential recess 11 extending around the side wall 10, having a deepest point at a predetermined distance d from the grinding surface 8. The circumferential recess 11 defines an angle α and has a depth D .

20 The stud 7 is unitary and has a cylindrical body comprising first and second body portions which interface at the recess 11. The first body portion includes the grinding surface 8, whereas the second body portion includes the attachment end 9. The stud 7 is reconditionable in that the first body portion is removable from the second body portion at the recess 7, and only by virtue of the recess 7, to expose a further grinding surface, as
30 will be explained in more detail below.

The stud 7 is attached to a high pressure grinding roller toward the attachment end 9 by any suitable means, such as gluing, brazing, shrink fitting, press fitting and so on. A plurality of studs is attached to the grinding roller such that the grinding surface 8 of each stud 7 is

at a desired height, and the plurality of grinding surfaces 8 forms an effective roller surface, as shown in Figure 5. The circumferential recess 11 of each stud 7 is located below the steel surface of the roller 12. The studs located towards the centre of the roller 14 need not have a circumferential recess 11, as these studs will be subject to more wear when in use. The effective surface of the roller is shown by dashed line 13.

As discussed above, after a period of use, the studs towards the middle of the grinding roller are likely to have been subjected to more wear than the studs towards the ends of the grinding roller, and so the effective grinding surface is no longer flat (or the desired shape profile). This is illustrated in Figure 6. The studs 14 towards the centre of the roller have experience more wear than the studs at either end of the roller, and so the effective surface is no longer flat and resembles the surface shown in Figure 3. In addition to stud wear, the steel roller 12 also experiences wear and the circumferential recess 11 of a stud becomes exposed. The exposure of the circumferential recess 11 of certain studs can be used as an indicator to inform an operator that an unacceptable degree of wear has occurred and the roller 12 requires reconditioning.

Note that to compensate for uneven wear along the length of the roller, the distance of the circumferential recess from the grinding surface of each stud may vary according to the stud's position on the roller; a stud towards the middle of the roller 12 may have a shorter distance between the circumferential recess 11 and the grinding surface than a stud towards the end of the grinding roller. Indeed a stud towards the middle of the grinding roller may not be provided with a circumferential recess at all, but the studs towards the ends of the roller are provided with a recess to compensate for uneven wear.

Once the amount of wear has become unacceptable, for selected studs, a volume of the stud 7 between the circumferential recess 11 and the grinding surface 8 is removed to expose a new grinding surface 15, as shown in Figure 7.

As shown in Figure 8, the new grinding surface 15 of each stud 7 forms a new effective roller surface 16 and the new effective roller surface 16 is once more uniform. As mentioned above, the distance of the recess 11 to the grinding surface for an individual stud varies according to the position of the stud on the roller 12. This ensures that after reconditioning, all studs provide an approximately flat effective surface. The studs towards

the centre 14 of the roller 12 are not provided with a recess because they are subjected to the maximum wear and so form a baseline for the effective roller surface.

5 Note that while the effective roller surface 16 is shown as being substantially flat and parallel to the axis of rotation of the roller 12, the distance d of the circumferential recess 11 can be selected according to the position of the stud 7 on the roller 12. In this way a profile effective grinding surface can be achieved.

10 Turning now to Figure 9, the process of reconditioning a roller 12 is summarized. The following numbering corresponds to that of Figure 9:

S1. An HPGR roller is provided that has an effective surface made up of studs, at least some of the studs having a circumferential recess located on a side wall of the stud.

15 S2. The roller is used until there is an unacceptable amount of wear on the studs, meaning that the roller requires reconditioning.

20 S3. Each stud with a circumferential has a volume removed between the circumferential recess and the grinding surface of the stud. This exposes a new, second grinding surface.

As mentioned above, studs have previously been reconditioned by grinding them back to a desired shape. However, this is a time-consuming and expensive operation. An advantage of using studs with a circumferential recess is that the circumferential recess provides a
25 weak point in the stud allowing the volume of the stud above the circumferential recess to be quickly and easily removed. There are various ways this volume can be removed, for example by an operator shearing off the volume with a hammer or chisel. Alternatively, the recess design can be engineered such that when the recess is exposed from the steel, it is removed automatically during a grinding process from impact with the material being
30 ground.

Examples

In order to test how easily the volume between the initial grinding surface 8 and the circumferential recess 11 can be moved, different studs were manufactured with different circumferential recess depths and tested using different conditions.

Example 1, as illustrated in Figure 4, had a circumferential recess 11 with a depth d of 4 mm, an angle a of 60° and the diameter of the stud at the deepest point of the recess was 11.2 mm. This means that the cross-sectional diameter, at the weakest point, was 98.5 mm².

Example 1 was made from a cemented tungsten carbide comprising 15% Co with a hardness of 1050 HV30. It will be appreciated that other hard materials may be used. Cemented tungsten carbide grades having between 8 and 20% Co and a hardness range of 850 to 1300 HV30 are examples of suitable materials.

Example 2 shown as part 17 in Figure 10, had a circumferential recess 11 with a depth d of 2 mm, an angle a of 60° and the diameter of the stud at the deepest point of the recess was 16.0 mm. This means that the cross-sectional diameter, at the weakest point, was 201.1 mm², twice that of Example 1. Example 2 was also made from a cemented tungsten carbide comprising 15% Co with a hardness of 1050 HV30.

The samples were tested using two different tests as follows:

Test 1, illustrated in Figure 11 using Example 1, used a vertical impact applied with a 2000 g hammer struck directly onto the grinding surface 8 along a main central axis of the stud 7.

Test 2, illustrated in Figure 12 using Example 1, used a horizontal impact wedge 18 placed in the circumferential recess 11, and the impact wedge was then impacted with a 2000 g hammer at a direction normal to the main central axis of the stud 7.

Example 1 undergoing test 1 broke under impact from the 2000 g hammer to leave a clean, second grinding surface 15, as shown in Figure 13.

Example 2 undergoing test 1 showed no damage after several impacts from the 2000 g hammer.

5 Example 1 undergoing test 2 sheared off after a few strokes of the 2000 g hammer to leave a clean, second grinding surface 15.

Example 2 undergoing test 2 sheared off after a few strokes of the 2000 g hammer to leave a clean, second grinding surface 15.

10 It will be appreciated that various factors will affect how easily the volume between the circumferential recess 11 and the grinding surface 8 can be removed. These include:

- the hardness and toughness of the material used for the stud;
- the angle of the recess
- the depth of the recess
- 15 • the geometry of the recess
- the cross-sectional area of the stud at the narrowest point

The skilled person will be aware that the weak point at the circumferential recess must not be so weak that the volume between the circumferential recess 11 and the grinding surface 8 breaks off during normal operation until the recess 11 becomes exposed as the steel
20 wears away, and the stud is configured to have a volume removed during the normal grinding operation.

For the cemented tungsten carbide material referred to above, it has been found that a circumferential recess with a depth between 1 and 6 mm for a 20 mm diameter stud is
25 suitable, and a recess angle of between 40° and 80°.

Note that the examples above show a stud with a single circumferential recess 11. Referring to Figure 14, there is shown a further embodiment in which a second circumferential recess 19 is provided. This allows the stud 19 to be shortened multiple
30 times. The skilled person will appreciate that further circumferential recesses may also be provided.

The invention as set out in the appended claims has been shown and described with reference to embodiments. However, it will be understood by those skilled in the art that various changes in form and detail may be made without departing from the scope of the invention as defined by the appended claims. For example, other types of material could
5 be used, such as hardened steel, and the stud may have a shape other than cylindrical as described in the examples. Furthermore, the examples describe a recess that extends all the way around the circumference of the side wall of a cylindrical stud, but it will be appreciated that the recess may not extend all the way around. For example, if the stud has a substantially square cross-sectional shape, the recess may be applied on one, two, three or
10 four of the sides. The main function of the recess is to create a weakened area that allows a predetermined volume of the stud to be removed when necessary.

CLAIMS:

1. A high pressure grinding roller stud, the stud being substantially cylindrical and comprising:
5 a grinding surface;
an attachment end configured to attach to a roller; and
a side wall connecting the grinding surface to the attachment end, the side wall comprising a recess extending around a circumference of the side wall.
- 10 2. The stud according to claim 1, wherein the recess extends fully around the circumference of the side wall.
3. The stud according to claim 1 or 2, wherein the stud comprises a cemented metal carbide material.
15
4. The stud according to any one of claims 1 to 3, wherein the grinding surface has a diameter selected from any of between 12 and 30 mm, between 14 and 25 mm, and between 16 and 20 mm.
- 20 5. The stud according to any one of claims 1 to 4, wherein the recess has a depth selected from between 1 and 6 mm.
6. The stud according to any one of claims 1 to 5, wherein the recess has a depth selected from between 2 and 4 mm.
25
7. The stud according to any one of claims 1 to 6, wherein the recess forms an angle between 40 and 80°.
8. The stud according to any one of claims 1 to 7, wherein the recess forms an angle
30 between 50 and 70°.
9. The stud according to any one of claims 1 to 8, comprising a plurality of recesses.

10. The stud according to any one of claims 1 to 9, wherein the attachment end is configured to attach to the roller by any of gluing, brazing, press-fitting, shrink fitting, threaded connection, and mechanical connection.

5 11. A high pressure grinding roller comprising a cylindrical roller having a circumferential surface and a plurality of high pressure grinding rollers studs according to any one of claims 1 to 10 attached to the circumferential surface.

12. The high pressure grinding roller according to claim 11, comprising:

10 a first plurality of high pressure grinding roller studs, each stud of the first plurality of high pressure grinding roller studs having a recess located a first distance from the grinding surface, the first plurality of high pressure grinding studs being located at a first location on the circumferential surface; and

15 a second plurality of high pressure grinding roller studs, each stud of the first second plurality of high pressure grinding roller studs having a recess located a second distance from the grinding surface, the second plurality of high pressure grinding studs being located at a second location on the circumferential surface.

13. The high pressure grinding roller according to claim 12, comprising:

20 a third plurality of high pressure grinding roller studs, each stud of the further plurality of high pressure grinding roller studs having a recess located a third distance from the grinding surface, the third plurality of high pressure grinding studs being located at a third location on the circumferential surface.

25 14. The high pressure grinding roller according to any one of claims 11 to 13, wherein each high pressure grinding roller stud is attached to the roller by any of gluing, brazing, press-fitting, shrink fitting, threaded connection, and mechanical connection.

30 15. A method of reconditioning a high pressure grinding roller according to any one of claims 11 to 14, the method comprising:

for at least a portion of the plurality of high pressure grinding roller studs, removing a volume of each stud between the recess and the grinding surface to expose a new, second grinding surface.

16. The method according to claim 14, wherein the volume is removed by applying a shear force at the recess.
17. The method according to claim 15 or 16, wherein the volume is removed by using
5 any of a hammer and a chisel.
18. The method according to any one of claims 15 to 17, wherein the volume is removed during a grinding operation.

1/7

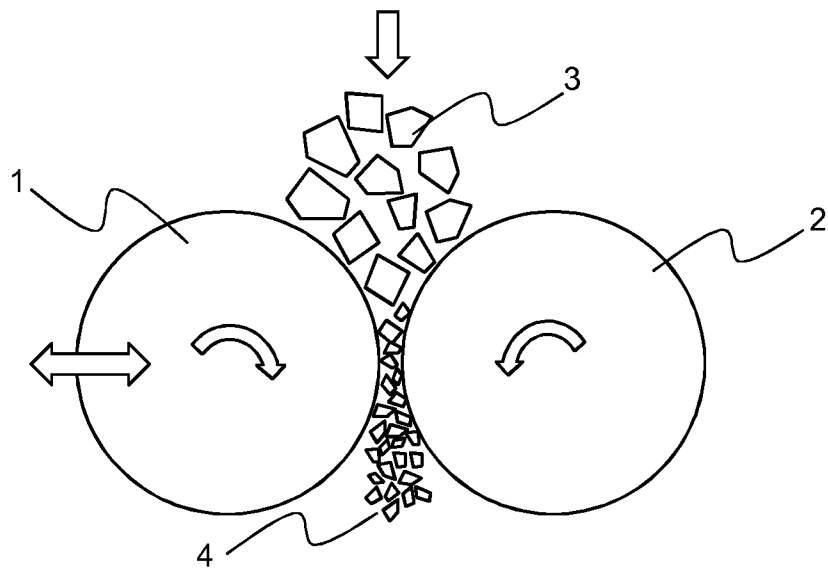


Figure 1
(Prior Art)

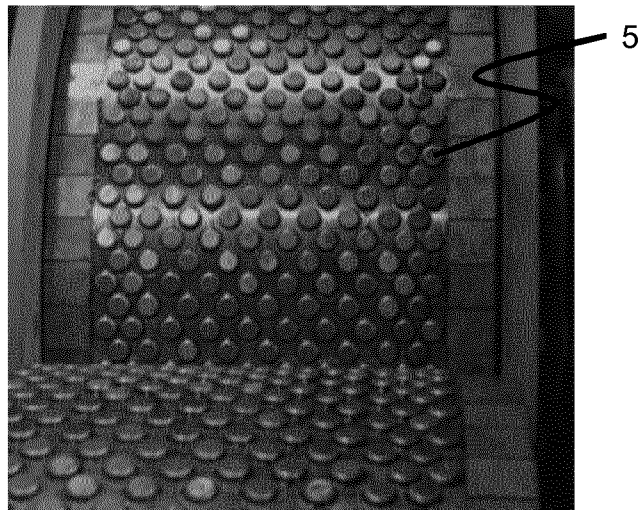


Figure 2
(Prior Art)

2/7

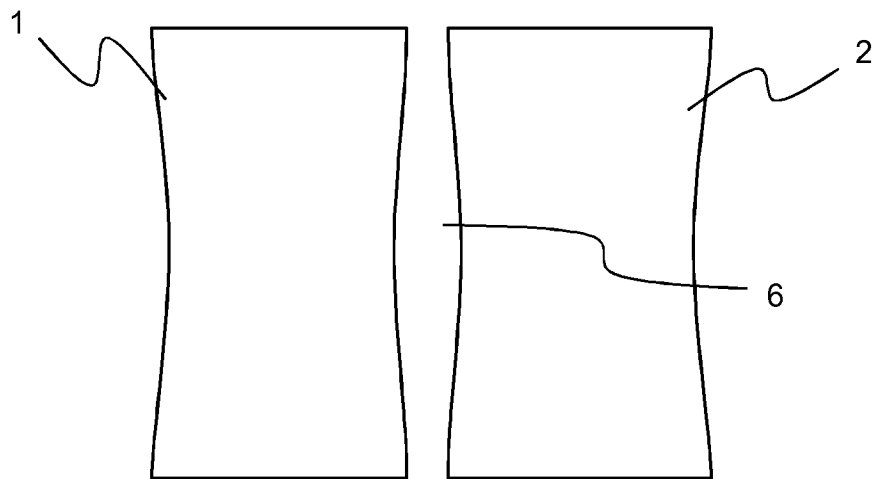


Figure 3
(Prior Art)

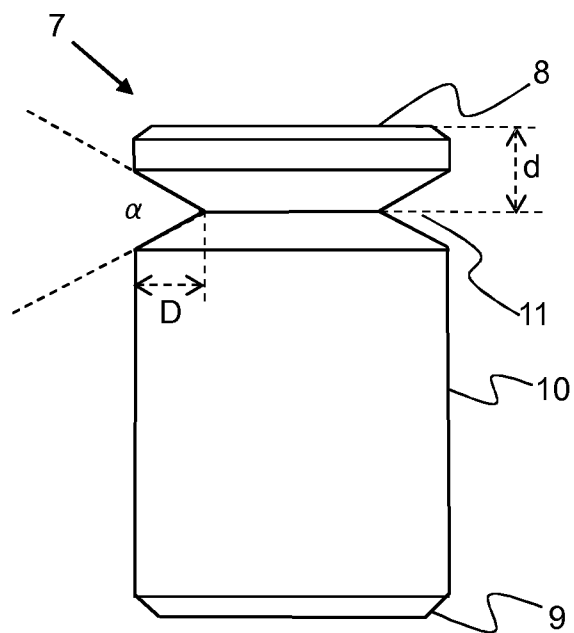


Figure 4

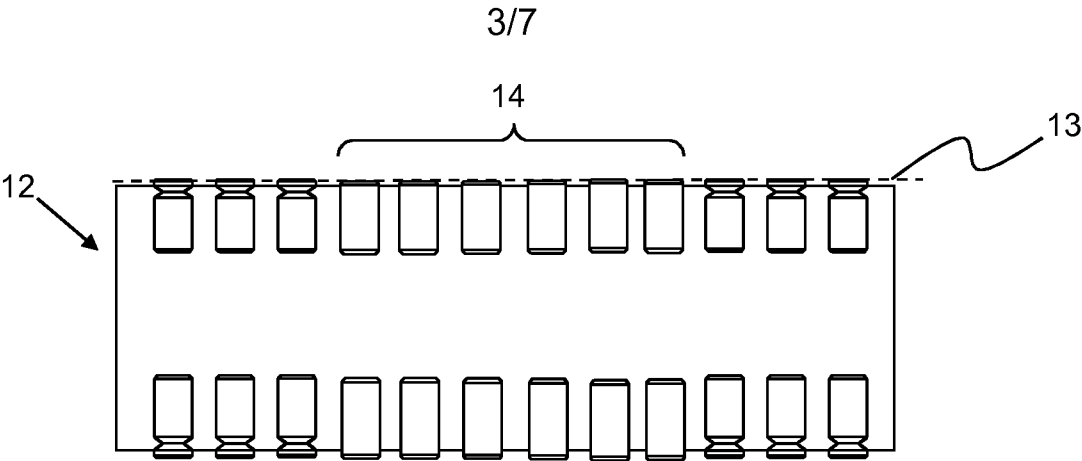


Figure 5

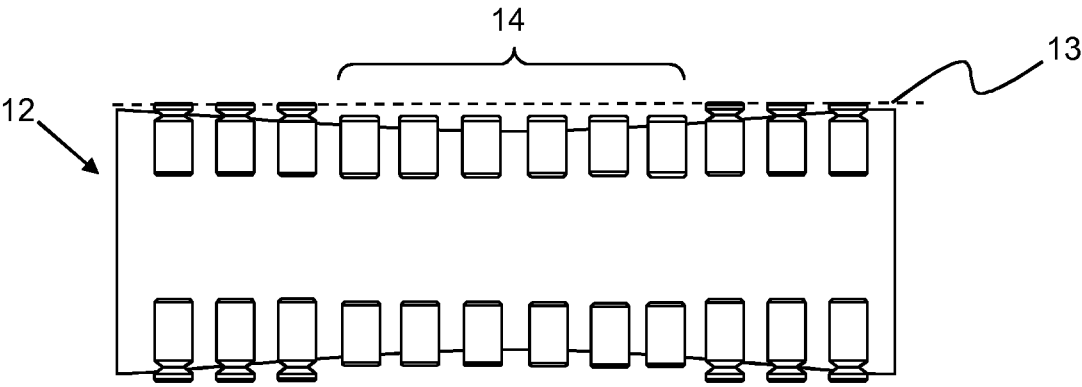


Figure 6

4/7

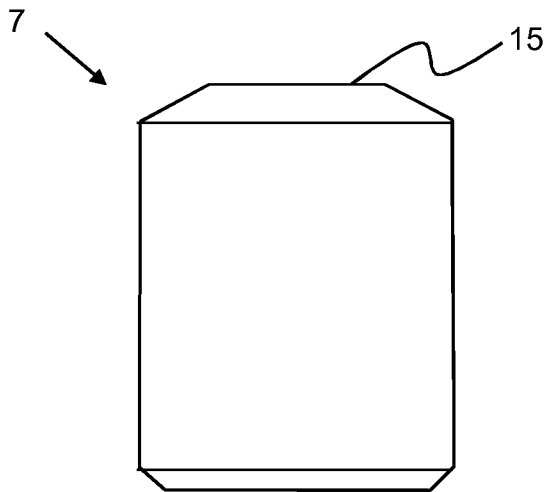


Figure 7

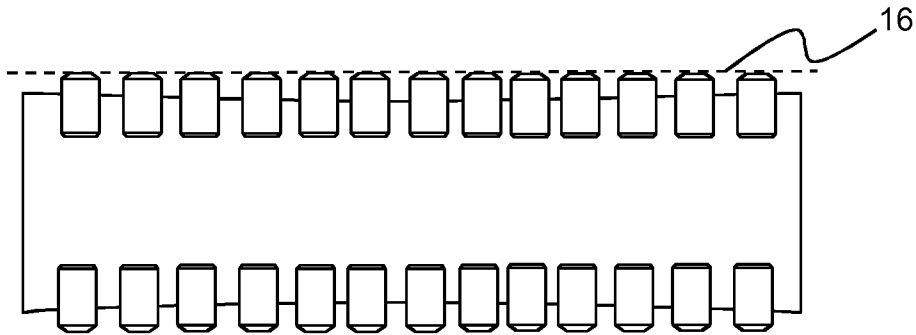


Figure 8

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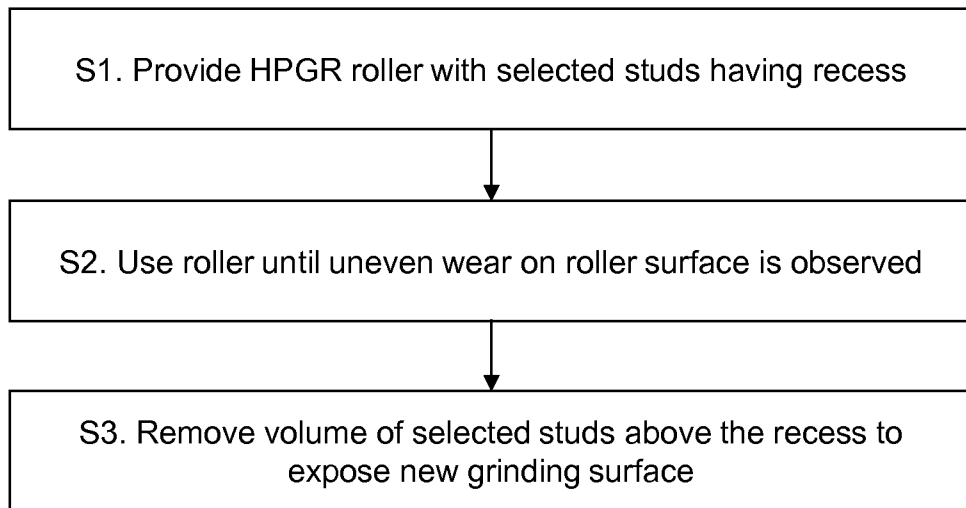


Figure 9

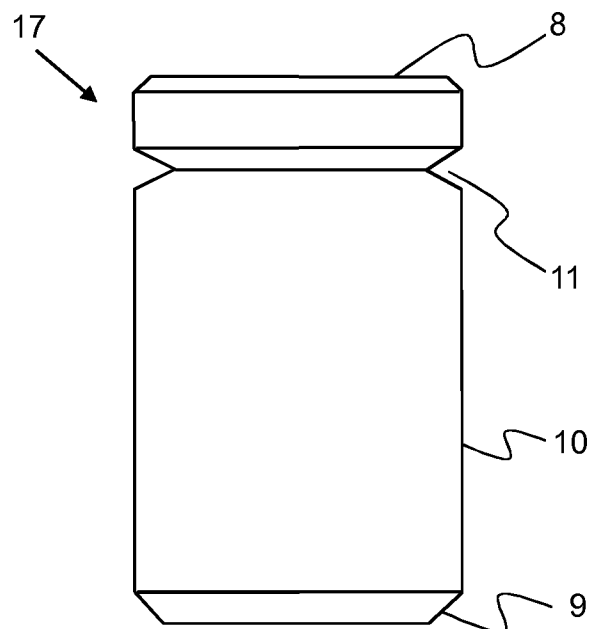


Figure 10

6/7

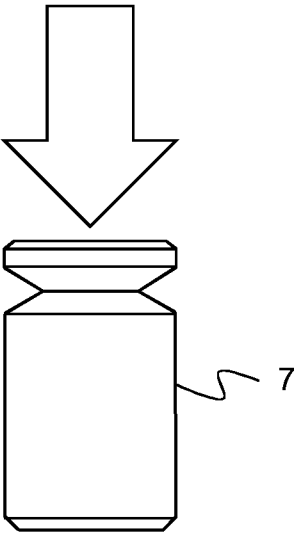


Figure 11

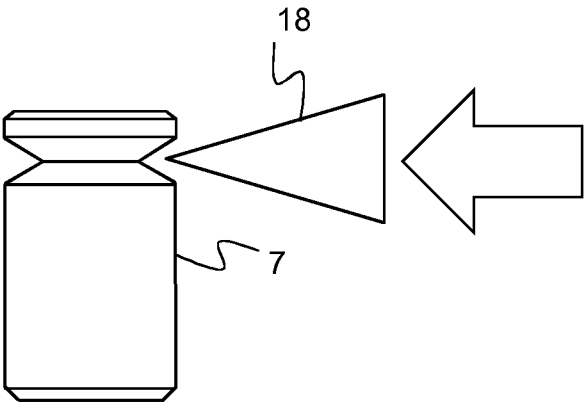


Figure 12

7/7

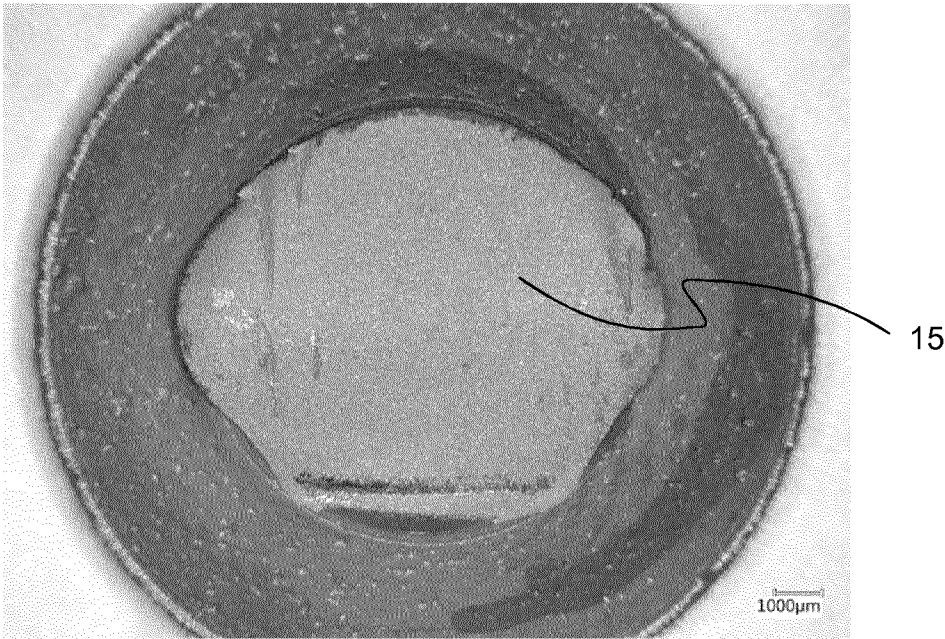


Figure 13

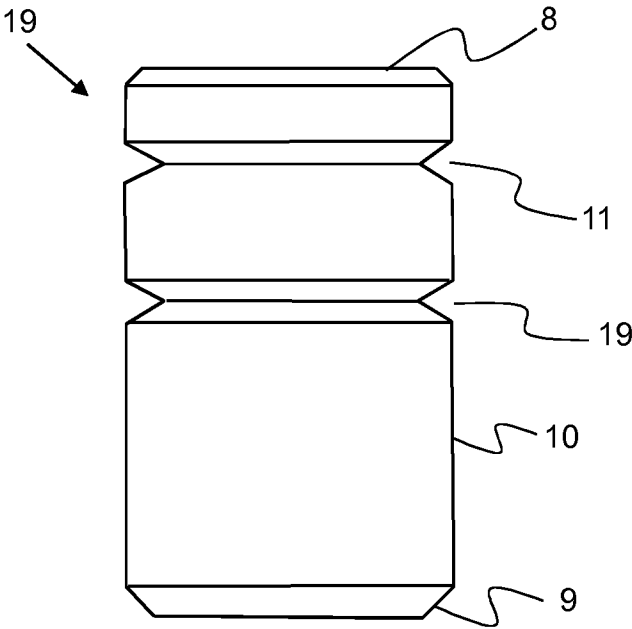


Figure 14

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/058134

A. CLASSIFICATION OF SUBJECT MATTER
INV. B02C4/30
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B02C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2016/318024 A1 (FRANGENBERG MEINHARD [DE] ET AL) 3 November 2016 (2016-11-03)	1-3, 10, 11
Y	paragraphs [0008] - [0012], [0015], [0019], [0023], [0025], [0032]; figures 1-3	4-9, 12-18
Y	----- WO 2011/048226 A1 (SIEMPELKAMP GIESSEREI GMBH [DE]; KLEINKROEGER WOLFGANG [DE]; MIKOLEIZI) 28 April 2011 (2011-04-28) page 8, lines 4-10; figure 4 page 12, lines 16-24	4-9, 12-18
A	----- US 2013/299618 A1 (SHARMAN DAVID [US]) 14 November 2013 (2013-11-14) paragraphs [0111], [0112], [0104], [0105]; figures 1, 5, 10a-10g	1-18



Further documents are listed in the continuation of Box C.



See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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