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Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) Wear-resistant roll and method of making it

(57) Roll (1,2) for a roller press comprises a cylindrical press roll having an outer cylindrical pressing surface for use with an opposing roll, and a plurality of wear-resistant surface members (studs) (6), whereby the studs are fixed to the roll and the free ends of the studs protrude radially from the surface of the roll, and whereby the spaces between the studs are filled with a matrix material (12) being softer than the hardest material of which the studs are made. According to the invention the matrix material is a composite material comprising a non-metallic, organic binding mass. The roll is therefore easy and cost-effective producible and allows the application of long studs and can furthermore easily be repaired on-site without using sophisticated process equipment. The final roll surface is smooth.

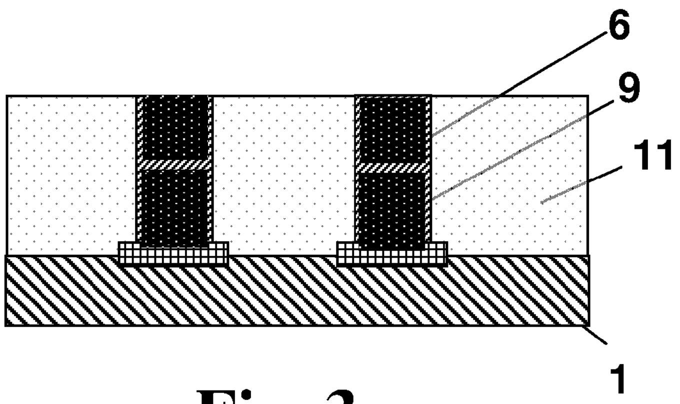

Fig. 3

EP 2 572 790 A1

Description

[0001] The present invention relates to an improved roll construction for a roller press, comprising a cylindrical press roll having an outer cylindrical pressing surface for use with an opposing roll, and a plurality of wear-resistant surface members (studs), whereby the studs are fixed to the roll and the free ends of the studs protrude radially from the surface of the roll, and whereby the spaces between the studs are filled with a matrix material being softer than the hardest material of which the studs are made.

[0002] Furthermore, the present invention relates to a method of manufacturing a roll for a roller press comprising the steps: forming a cylindrical press roll having an outer cylindrical pressing surface for use with an opposing roll, fixing a plurality of wear resistant surface members (studs) to the roll surface at spaced intervals having a hardness greater than the roll surface, so that free ends of the studs protrude radially from the surface of the roll, and filing the spaces between the studs with a matrix material, whereby the matrix material comprising a binding mass being softer than the hardest material of which the studs are made.

Technical background

[0003] In the mineral and cement industries hard particles need to be ground to small fractions. A number of methods exist and a leading and growing method is <u>H</u>igh <u>P</u>ressure <u>R</u>oller <u>G</u>rinding (HPRG).

[0004] This method is characterized by two coated counter-rotating rollers which are pushed firmly together. The material to be ground is fed between these rollers while their rotating motion pushes it through the small gap between them. Equipment availability and the overall cost of grinding facilities utilizing roller presses are significantly influenced by the service life of wear parts, in particular the durability of the grinding rollers.

[0005] There is a need in design for a coating on the rollers to protect them against wear. In the past this was simple weld overlay with FeCr alloys. To increase the wear resistance, it was realized that there must be a move from weld overlay to harder materials and several systems were developed.

[0006] One system is the HEXADUR® process, which provides a highly abrasion resistant material for wear protection for grinding rollers. The name HEXADUR® has been derived from the shape and arrangement of hard metal hexagons which are fixed by hot isostatic pressed (HIP) on to a base metal via a matrix.

[0007] The disadvantages are the expense, limited size of the parts that can be produced, as well as lack of possibilities for repairing on-site.

[0008] A second system is the "Polycom process" which focused on placing studs in holes drilled into the surface of the roll. The basic idea is that the stud surface is raised above the surface of the roller. The ground stone/cement then fills in the space between the studs and acts as an auto protection for the studs.

[0009] In EP 2 239 058 A1 an improved, wear-resistant roll for use in a roller press as well as a method for the production of such a roll is described. The roll comprises a cylindrical press roll with plurality of wear resistant studs on the outer surface of said role. The studs are welded on the roll and serve as a holding fixture for hard particles or metal inserts. In the exemplary embodiment the spaces between the studs are filled with a matrix material consisting of an alloy based on Ni or Fe. The surrounding matrix material is achieved by deposition from wire, electrode, power deposition by usual methods like welding, PTA, brazing or spraying. This device is capable of operating under extremely high forces with markedly reduced wear of the grinding surface.

[0010] However, wear resistant rolls with a metallic matrix material have several disadvantages. For example, the deposition of the metallic matrix material generally includes a melting process which requires a large heat input and therefore raises the production costs. The studs cannot be replaced on-site without the need for processes that involve heat. There is a limit to the thickness of the studs and if long studs are applied, the matrix material has to be made up of several layers, with all interface problems and additional costs.

Object of the invention

[0011] An object of the invention is to provide an improved, easy and cost-effective producible pressing roll for a roller press which allows the application of long studs and can furthermore easily be repaired on-site without using sophisticated process equipment.

[0012] It is a further object of the invention to provide a fast, less sensitive and cost-effective method for manufacturing a roll for a roller press with high reliability.

Summary of the invention

[0013] With respect to the roll for a roller press, starting from the above mentioned roll, this object is achieved according to the invention in that the matrix material is a composite material with a non-metallic, organic binding mass.

[0014] The basic idea is to fill the spaces between the studs with a softer, but still wear resistant material which is easy to apply and which ensures an excellent bonding of this material to the studs as well as to the roll.

[0015] The matrix is a composite material based on a non-metallic, organic binding mass. Prior to a hardening or solidifying process the binding mass is a liquid or paste-like substance. Several process techniques known in the art, like spraying, electrostatically supported spraying, flooding, flinging, immersion, pressing or spreading, are generally suited for applying such fluid substances to the roll and filling the space between the studs.

[0016] The composite material is made of the non-metallic binding mass as well as of at least one constituent. A special wear resistant material is achieved, if the additional constituents have different physical or chemical properties to enhance the properties of the composite matrix.

[0017] The wear resistant studs are welded to the roller base. The studs serve as a replacement for hard particles, preferably made of WC, or metal insert members as known in the prior art.

[0018] The matrix material can be applied in a single layer with a thickness up to 50 mm or in multi-layers. The application of single layers with a thickness up to 50 mm allows the processing of longer studs avoiding interface problems and additional costs.

[0019] The studs are stabilized by the matrix material and additionally - with operation for grounding material - by the ground material itself. The reason for that is that as a result of wear of the softer matrix material the studs will protrude from the matrix as to form pockets between adjacent studs, and the pockets will be filled with ground material. Therefore, shortly after beginning of the operation for grounding material, nearly the whole outer surface of the roll is covered with the grounded material having the same hardness as the material to be grounded. The grounded material is best suited for stabilizing the studs and protecting the softer matrix material from further wear.

[0020] Furthermore, the matrix material with a non-metallic, organic binding mass can easily be repaired on-site. Even for the repair, a low heat process is applied which reduces the need for sophisticated process equipment as well as the maintenance costs.

[0021] In a preferred modification of the present invention the outer surface of the studs and the surface formed by the composite material have the same level.

[0022] If the outer surface of the studs and the surface formed by the composite material have the same surface level, a roll with a smooth, uniform outer surface is obtained as well as the studs are stabilized by the composite material. Studs that are completely stabilized by composite material can withstand higher forces.

[0023] Good results were achieved by using a non-metallic, organic binding mass made of epoxy.

[0024] In the prior art as cited above for processing the matrix material heat is applied to the matrix material to melt it. Especially, metallic matrices often show a high melting temperature, requiring also a high processing temperature. In contrast to this, the processing temperature for melting non-metallic binding masses made of organic compounds according to the present invention is comparatively low. Therefore, the application of the matrix can be conducted at lower temperatures, thereby reducing production costs.

[0025] Furthermore, non-metallic binding masses made of an organic compound are known which can be hardened in a curing process at low temperature in a non-melting process. These binding masses usually have a liquid or paste-like consistency at room temperature.

[0026] Epoxy is a duroplastic organic with high stability and chemical resistance. Epoxy is formed by reaction of epoxy resin with a hardener. A matrix material based on epoxy is easy to use. The epoxy resin can be hardened after filling the spaces between the studs.

[0027] Preferably, the composite material comprises hard particles, whereby the hard particles are dispersed in the matrix in an amount in the range of 15 wt% to 80 wt%, preferably in the range between 20 and 40 wt%, based on the entire composite material.

[0028] By addition of hard particles to the composite material an especially wear resistant matrix material is provided. If the amount of hard particles in the composite material is lower than 20 wt%, especially if it is lower than 15 wt%, the wear resistance of the composite material is only slightly improved. If the amount of hard particles is higher than 40 wt%, especially if it is higher than 80 wt%, a paste-like material is obtained which is difficult to process.

[0029] In a preferred modification of the present invention, the hard particles are made of Al_2O_3, WC and/or SiC

[0030] Hard particles made of Al_2O_3, WC and/or SiC are commercially available in different grain sizes and characterized by high mechanical resistance and stability.

[0031] Preferably, the composite material comprises armouring means, preferably in form of fibres.

[0032] Armouring means increase the tensile strength, the stability, dimensional stability and the mechanical resistance of the composite material. Preferably, armouring means in form of fibres are used. Fibres are well suited to absorb tensile forces. Preferably, the armouring means are organic fibres. The non-metallic, organic binding mass and the organic fibres show similar thermal expansion coefficients.

[0033] Good results were achieved when the armouring means are made of a synthetic plastic material, preferably the armouring means are aramid fibres, and when the armouring means are dispersed in the matrix in an amount in the range of 5 wt% to 20 wt% based on the entire composite material.

[0034] Armouring means made of synthetic plastic material can be easily and cost-effectively produced. Preferably, the armouring means are aramid fibres. Aramid fibres show high tensile strength, solidity and chemical stability and can absorb tensile forces. Furthermore, aramid fibres are heat-resistant up to 400 °C. If the amount of armouring means in the composite material is lower than 5 wt%, only a slight effect on the tensile strength of the composite material can be observed. If the amount of armouring means is higher than 20 wt% a paste-like material is obtained which is difficult to process.

[0035] In a preferred modification of the present invention the spaces between the studs are filled by a low heat, non-melting process, using a liquid or paste-like precursor substance of the composite material which after hardening forms the composite material.

[0036] Liquid or paste-like precursor substances can be easily filled in the spaces between the studs. Finally, the precursor substance can be hardened by polymerization or polycondensation, for example, by application of low heat, radiation or by a chemical hardener which is added to the precursor substance. A non-melting process is advantageous because the process can be conducted at low temperature. Thereby, the production costs are reduced and the on-site repair is made dramatically easier.

[0037] Preferably, the composite material can sustainably withstand temperatures of at least 250°C.

[0038] During the grinding process of a roller press generally heat is generated. Therefore, the thermostability of the composite material is an important parameter. Composite parameters that can withstand temperatures of at least 250 °C can be used in roller presses without the necessity of a special cooling system.

[0039] With respect to the method of manufacturing a roll for a roller press the above object, starting from the method mentioned above, is achieved according to the invention in that for filling the spaces between the studs as matrix material a composite material comprising a non-metallic, organic binding mass is applied.

[0040] Prior to a hardening or solidifying process, the binding mass is a liquid or paste-like substance. The basic idea is to use as matrix material such fluid substances which are easy to apply to the space between the studs and which, after hardening or solidifying, ensure an excellent bonding of the material to the studs as well as to the roll. Such fluid substances can easily be applied to spaces between the studs using several process techniques known in the art, like spraying, electrostatically supported spraying, flooding, flinging, immersion, pressing or spreading, are generally suited for applying such a substance to the roll and filling the space between the studs.

[0041] The wear resistant studs are welded to the roller base. Fixing of the studs by welding is a fast and reliable low cost process. The studs are additionally stabilized by the matrix material and additionally - with operation for grounding material - by the ground material itself as explained above.

[0042] In a preferred modification of the method, the filling of the spaces between the studs is performed by a low heat, non-melting process.

[0043] Filling the spaces between the studs by a low heat, non-melting process is advantageous because the process can be conducted at low temperature. Thereby, the production costs are reduced.

[0044] In a further preferred modification of the method, for filling the spaces between the studs a liquid or paste-like precursor substance of the composite material is applied which after hardening forms the composite material.

[0045] A liquid or paste-like precursor substance can be easily filled in the spaces between the studs. Finally, the precursor substance can be hardened by polymerization or polycondensation, for example, by application of low heat, radiation or by a chemical hardener which is added to the precursor substance.

[0046] Preferably, for the filling of the spaces between the studs a composite material is applied comprising a non-metallic binding mass made of epoxy.

[0047] In the prior art as cited above for processing the matrix material heat is applied to the matrix material to melt it. Especially, metallic matrices often show a high melting temperature, requiring also a high processing temperature. In contrast to this, the processing temperature for melting non-metallic binding masses made of organic compounds according to the present invention is comparatively low. Therefore, the application of the matrix can be conducted at lower temperatures, thereby reducing production costs.

[0048] Furthermore, non-metallic binding masses made of epoxy, are known which can be hardened at low temperature in a non-melting process. These binding masses usually have a liquid or paste-like consistency at room temperature. Filling the space between the studs and hardening the material is fast and less energy consuming process.

[0049] In a preferred modification of the present invention the composite material used comprises hard particles which are dispersed in the composite material in an amount in the range of 15 wt% to 80 wt%, preferably in the range between 20 and 40 wt%, based on the entire composite material.

[0050] By addition of hard particles to the composite material an especially wear resistant matrix material is provided. If the amount of hard particles in the composite material is lower than 20 wt%, especially if it is lower than 15 wt%, the wear resistance of the composite material is only slightly improved. If the amount of hard particles is higher than 40 wt%, especially if it is higher than 80 wt% a paste-like material is obtained which is difficult to process.

[0051] Good results were achieved by using a composite material which comprises hard particles made of Al_2O_3, WC and/or SiC.

[0052] Hard particles made of Al_2O_3, WC and/or SiC are commercially available in different grain sizes and characterized by high mechanical resistance and stability.

[0053] Good wear resistance was achieved by using a composite material that comprises armouring means, preferably in form of fibers, which are dispersed in the composite material in an amount in the range of 5 % wt% to 20 wt% based on the entire composite material.

[0054] Armouring means increase the tensile strength, the stability, dimensional stability and the mechanical resistance of the composite material. Preferably, armouring means in form of fibres are used. Fibres are well suited to absorb tensile forces.

[0055] If the amount of armouring means in the composite material is lower than 5 wt%, only a slight effect on the tensile strength of the composite material can be observed. If the amount of armouring means is higher than 20 wt% a paste-like material is obtained which is difficult to process.

Preferred embodiments

[0056] In the drawings schematically shows

Fig.1 a plan view of opposed grinding rolls of a two roller machine employing a composite matrix material with a non-metallic binding mass in accordance with the principles of the invention,

Fig. 2 to Fig. 4 process steps for making the rolls of Fig. 1 according of the method of the invention.

[0057] **Fig. 1** illustrates a two roller press for comminution of granular material by interparticle crushing. The press is formed between cylindrical rolls 1 and 2 which form a press nip 3 therebetween. The rolls are suitably supported on high force bearings 4 with means for adjusting the nip width and pressure to obtain the nip forces required for interparticle crushing. Granular material is supplied from above the nip by a suitable product delivery shaft. End plates 5 positioned at the end of the nip 3 for aiding in retaining material and preventing it from exiting axially out the ends of the nip 3. A suitable receiving means is provided beneath the nip for receiving the comminuted material.

[0058] In a partial view a plurality of wear-resistant studs 6 are shown, which are welded to the cylindrical surface of the rolls 1, 2. The place between the studs is filled with hardened polymer composite material 12 (MECATEC®A5 HT; Castolin GmbH, Germany).

[0059] The studs 6 are made of a wear resistant core made of a Fe-based alloy, surrounded by a metal stud casing made of a tough steel and a base made of low cost steel. Such studs are known from DE 20 2004 007 809 U1 which is incorporated into this patent application by reference.

[0060] **Fig. 2 to 4** show a preferred process for manufacturing the rolls 1, 2. The studs 6 are welded to the surface of the roll 1 by bold welding. Then, the space between the studs 6 is filled with a paste-like precursor material 11 (MECATEC® A5 HT, Castolin GmbH, Germany) by using a spatula. This material consists of a bulkpolymer and hardening reagent. The bulkpolymer comprises a binding mass, armouring means and hard particles. The binding mass is made of epichlorohydrin, bisphenol A and bisphenol F. In the binding mass armouring means made of aramid fibres are dispersed. The hard particles are a mix of Al_2O_3 ceramic particles and SiC particles. The hardening reagent is triethylenetetramine.

[0061] In an alternative embodiment, the precursor material 11 is MECATEC® 101 F or MECATEC® 101 P. As a result, the studs 6 are completely embedded in the composite material having the same height as the stud top (Fig. 3). The surface of the roller is then smooth. After a hardening step, the precursor material rapidly solidifies and polymerises completely at ambient temperatures forming a thermosetting polymer with a three-dimensionally cross linked network structure and forms the composite matrix material 12 as shown in Fig. 4. The obtained composite material 12 is wear resistant, but still softer than the casing 9 of the studs 6 and can withstand temperatures up to 250 °C

Claims

1. A roll for a roller press, comprising a cylindrical press roll having an outer cylindrical pressing surface for use with an opposing roll, and a plurality of wear-resistant surface members (studs), whereby the studs are fixed to the roll and the free ends of the studs protrude radially from the surface of the roll, and whereby the spaces between the studs are filled with a matrix material being softer than the hardest material of which the studs are made, **characterised in that** the matrix material is a composite material comprising a non-metallic, organic binding mass.

2. A roll according to claim 1, **characterized in that** the outer surface of the studs and the surface formed by the composite material have the same level.

3. A roll according to claim 1 or 2, **characterized in that** the non-metallic, organic binding mass is made of epoxy.

4. A roll according to any of the preceding claims, **characterized in that** the composite material comprises hard particles, whereby the hard particles are dispersed in the matrix in an amount in the range of 15 wt% to 80 wt%, preferably in the range between 20 and 40 wt% based on the entire composite material.

5. A roll according to claim 4, **characterized in that** the hard particles are made of Al_2O_3, WC and/or SiC.

6. A roll according to any of the preceding claims, **characterized in that** the composite material comprises armouring means, preferably in form of fibres.

7. A roll according to claim 6, **characterized in that** the armouring means are made of a synthetic plastic material, preferably the armouring means are aramid fibres, and that the armouring means are dispersed in the matrix in an amount in the range of 5 wt% to 20 wt% based on the entire composite material.

8. A roll according to any of the preceding claims, **characterized in that** the spaces between the studs are filled by a low heat, non-melting process, using a liquid or paste-like precursor substance of the composite material which after hardening forms the com-

posite material.

9. A roll according to any of the preceding claims, **characterized in that** the composite material can sustainably withstand temperatures of at least 250 °C

10. The method of manufacturing a roll for a roller press comprising the steps:

forming a cylindrical press roll having an outer cylindrical pressing surface for use with an opposing roll, fixing a plurality of wear resistant surface members (studs) to the roll surface at spaced intervals having a hardness greater than the roll surface, so that free ends of the studs protrude radially from the surface of the roll, and filing the spaces between the studs with a matrix material, whereby the matrix material comprising a binding mass being softer than the hardest material of which the studs are made, **characterized in that** for filling the spaces between the studs as matrix material a composite material comprising a non-metallic binding mass is applied.

11. Method according to claim 10, **characterized in that** the filling of the spaces between the studs is performed by a low heat, non-melting process.

12. Method according to claims 10 or 11, **characterized in that** for filling the spaces between the studs a liquid or paste-like precursor substance of the composite material is applied which after hardening forms the composite material.

13. Method according to any of the preceding claims 10 to 12, **characterized in that** for filling the spaces between the studs a composite material is applied comprising a non-metallic binding mass made of epoxy.

14. Method according to any of the preceding claims 10 or 13, **characterized in that** a composite material is used comprising hard particles, preferably made of Al_2O_3, WC and/or SiC, which are dispersed in the composite material in an amount in the range of 15 wt% to 80 wt%, preferably in the range between 20 and 40 wt%, based on the entire composite material.

15. Method according to any of the preceding claims 10 to 14, **characterized in that** a composite material is used that comprises armouring means, preferably in form of fibers, which are dispersed in the composite material in an amount in the range of 5 wt% to 20 wt% based on the entire composite material.

Amended claims in accordance with Rule 137(2) EPC.

1. A roll for a roller press, comprising a cylindrical press roll (1) having an outer cylindrical pressing surface for use with an opposing roll (2), and a plurality of wear-resistant surface members, namely studs (6), whereby the studs (6) are fixed to the roll (1, 2) and the free ends of the studs (6) protrude radially from the surface of the roll (1, 2), and whereby the spaces between the studs (6) are filled with a matrix material being softer than the hardest material of which the studs (6) are made, **characterised in that** the matrix material is a composite material (12) comprising a non-metallic, organic binding mass, whereby the non-metallic, organic binding mass is made of epoxy, and whereby the composite material (12) comprises armouring means.

2. A roll according to claim 1, **characterized in that** the outer surface of the studs (6) and the surface formed by the composite material (12) have the same level.

3. A roll according to claim 1 or 2, **characterized in that** the composite material (12) comprises hard particles, whereby the hard particles are dispersed in the matrix in an amount in the range of 15 wt% to 80 wt%, preferably in the range between 20 and 40 wt% based on the entire composite material (12).

4. A roll according to claim 3, **characterized in that** the hard particles are made of Al_2O_3, WC and/or SiC.

5. A roll according to any of the preceding claims, **characterized in that** the composite material comprises armouring means in form of fibres.

6. A roll according to claim 5, **characterized in that** the armouring means are made of a synthetic plastic material, preferably the armouring means are aramid fibres, and that the armouring means are dispersed in the matrix in an amount in the range of 5 wt% to 20 wt% based on the entire composite material (12).

7. The method of manufacturing a roll for a roller press comprising the steps:

forming a cylindrical press roll (1) having an outer cylindrical pressing surface for use with an opposing roll (2), fixing a plurality of wear resistant surface members (studs) (6) to the roll surface at spaced intervals having a hardness greater than the roll surface, so that free ends of the studs (6) protrude radially from the surface of the roll (1, 2), and filing the spaces between the studs (6) with a matrix material, whereby the matrix material comprising a binding mass being softer than the hardest material of which the studs (6) are made, **characterized in that** for filling the spaces between the studs (6) as matrix material a composite material (12) is applied comprising a non-metallic binding mass made of epoxy, and whereby a composite material (12) is used that comprises armouring means.

8. Method according to claim 7, **characterized in that** the filling of the spaces between the studs (6) is performed by a low heat, non-melting process.

9. Method according to claims 7 or 8, **characterized in that** for filling the spaces between the studs (6) a liquid or paste-like precursor substance of the composite material (12) is applied which after hardening forms the composite material (12).

10. Method according to any of the preceding claims 7 to 9, **characterized in that** a composite material (12) is used comprising hard particles, preferably made of Al_2O_3, WC and/or SiC, which are dispersed in the composite material (12) in an amount in the range of 15 wt% to 80 wt%, preferably in the range between 20 and 40 wt%, based on the entire composite material (12).

11. Method according to any preceding claims 7 to 10, **characterized in that** a composite material is used that comprises armouring means in form of fibers.

12. Method according to any of the preceding claims 7 or 11, **characterized in that** the armouring means are dispersed in the composite material (12) in an amount in the range of 5 wt% to 20 wt% based on the entire composite material (12).

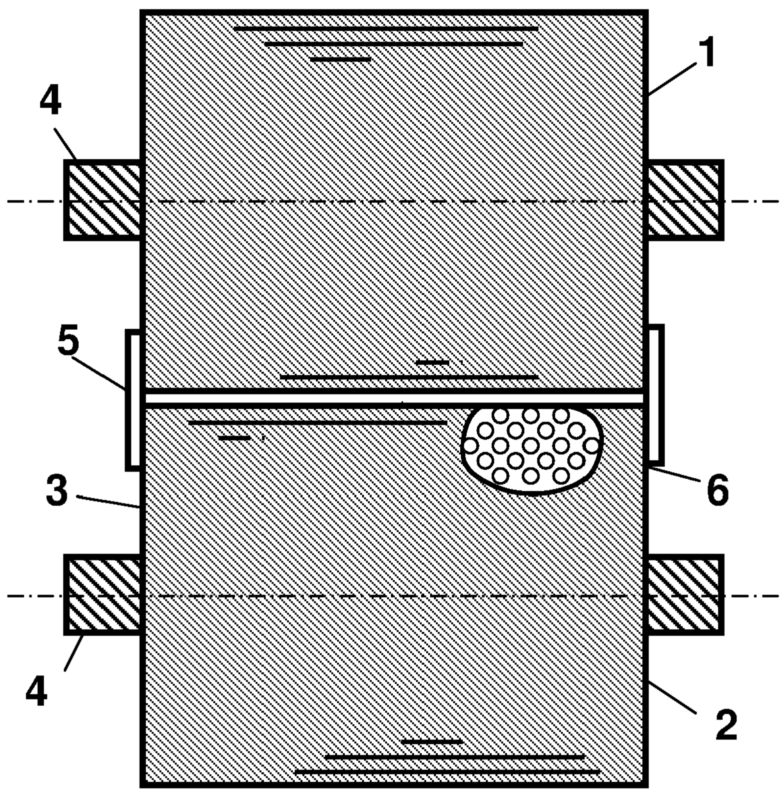

Fig. 1

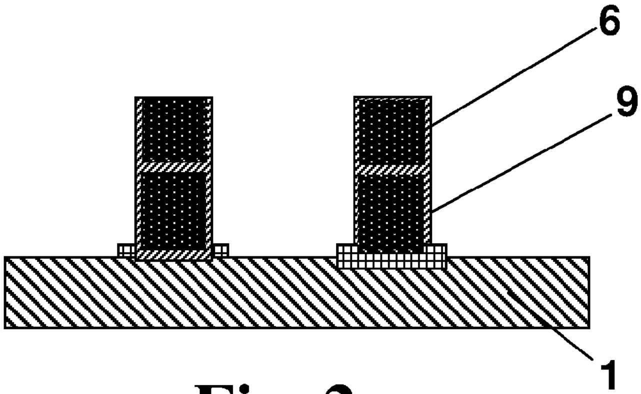

Fig. 2

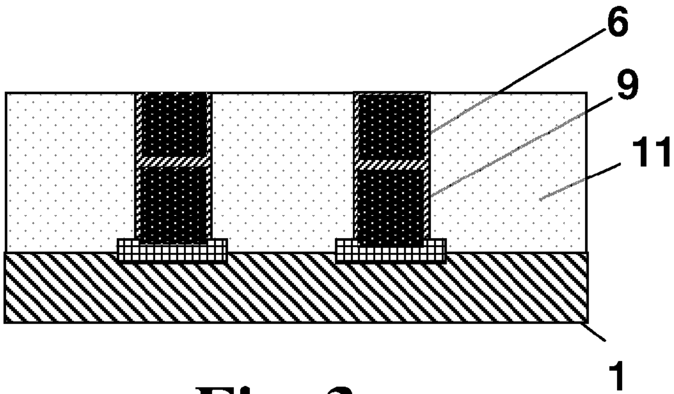

Fig. 3

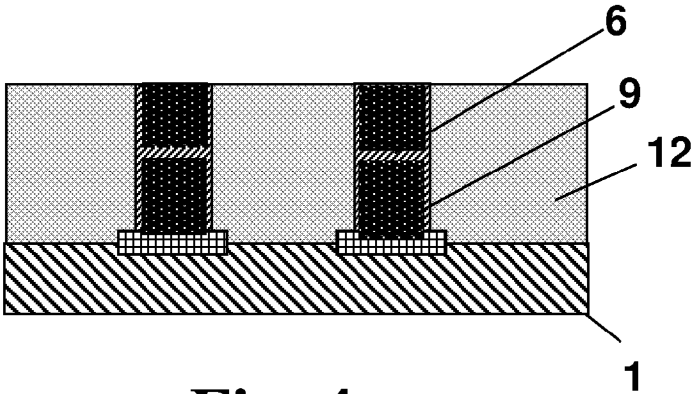

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 11 18 2178

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 0 516 952 A1 (KLOECKNER HUMBOLDT DEUTZ AG [DE]) 9 December 1992 (1992-12-09) * column 4, line 34 - column 5, line 5; figure 6 * -----	1-15	INV. B02C4/30
A,D	EP 2 239 058 A2 (MEC HOLDING GMBH [DE]) 13 October 2010 (2010-10-13) * paragraph [0012] - paragraph [0015]; figures 1-6 * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

B02C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 February 2012	Swiderski, Piotr

1

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 18 2178

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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16-02-2012

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EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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- DE 202004007809 U1 **[0059]**