



(11) **EP 3 650 136 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
13.05.2020 Bulletin 2020/20

(51) Int Cl.:
B21D 37/10 (2006.01)

(21) Application number: **18913306.9**

(86) International application number:
PCT/CN2018/099317

(22) Date of filing: **08.08.2018**

(87) International publication number:
WO 2019/192114 (10.10.2019 Gazette 2019/41)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **Xinjingrui Tungsten Steel (Xiamen) Co., Ltd.**
Xiamen, Fujian 361000 (CN)

(72) Inventor: **LI, Jingda**
Xiamen, Fujian 361000 (CN)

(74) Representative: **Gong, Jinping**
CocreatelP
Eggenfeldenerstraße 56
81929 München (DE)

(30) Priority: **03.04.2018 CN 201810303648**
09.07.2018 CN 201810741651

(54) **CEMENTED CARBIDE SCREW NUT MOLD HAVING MULTI-LAYER GRADED STRUCTURE AND MANUFACTURING METHOD THEREFOR**

(57) Disclosed is a cemented carbide screw nut mold with multi-layered gradient structure and manufacturing method thereof, comprising a tough material matrix and a wear resistant layer, wherein the tough material matrix has a central through-hole structure, an upper surface of the tough material matrix is provided with a first wear-resistant material layer, and an inner surface of the central through-hole structure is provided with a second wear-resistant material layer. The tough material matrix has good impact toughness, while the wear-resistant material layer

has a high hardness as well as a good wear resistance, so that with the wear-resistant material layer provided on the surface of the central through-hole structure, the forging function of the screw nut mold is realized. At the same time, the wear-resistant material layer provided on the upper surface of the tough material matrix protects the interface between the layers below it, so that the high-performance cemented carbide screw nut mold with multi-layered gradient structure has long service life and saves cemented carbide material.

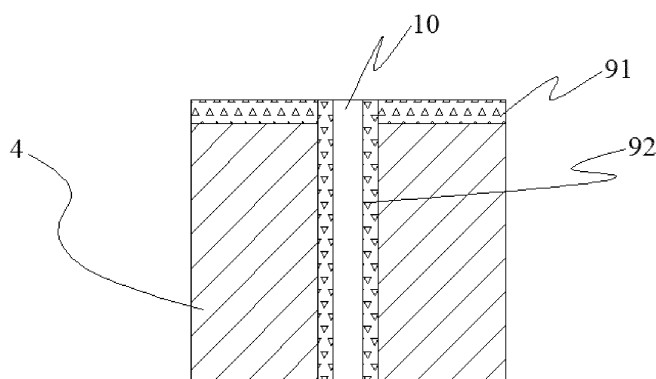


Fig. 4

EP 3 650 136 A1

Description**TECHNICAL FIELD**

5 **[0001]** The disclosure relates the technical field of cemented carbide, in particular, to a cemented carbide screw nut mold with multi-layered gradient structure and manufacturing method thereof.

BACKGROUND

10 **[0002]** Cemented carbide is a material with high hardness, high strength and high wear-resistance, which has been widely used in many fields of modern industry. For the processing of hardware such as screws and nuts, a mold made of cemented carbide is usually used to punch metal bars to obtain hardware products. The wear-resistance of the working surface of the cemented carbide mold determines the service life of the entire mold. Traditional cemented carbide screw nut mold is made of cemented carbide material with high wear-resistance. After the end of the service of the mold, the entire mold material is scrapped. However, actually, only the surface layer of the stamping surface of the mold is damaged, so a waste of resource is caused if the material and the mold body are discarded together.

15 **[0003]** Employing a technical solution of using a gradient cemented carbide mold can save a lot of cemented carbide resources. Only the surface layer of the stamping surface of the mold is made of high wear-resistant cemented carbide material, and the mold body is made of cemented carbide material with high toughness, so that for the mold, the bearing surface has high hardness, good wear-resistance, and the mold body material has good impact toughness. The wear-resistance and toughness of the carbide are well coordinated, so that the comprehensive performance and service life of the cemented carbide are improved, and the contradiction between the wear-resistance and toughness in the traditional cemented carbide with uniform structure is better solved. However, the material properties of the blanks made of tough mixtures and wear-resistant mixtures vary greatly. How to press the tough and wear-resistant mixtures into a screw nut mold blank requires effective molding methods to achieve.

20 **[0004]** Chinese Patent No. CN103817150 disclosed a gradient-structural cemented carbide roller ring, including a roller ring outer layer and a roller ring core, wherein the roller ring outer layer is configured at an outer surface of the roller ring core, a mutual melting layer is formed between the roller ring outer layer and the roller ring core, a composition gradient is formed between the roller ring outer layer and the roller ring core, and the composition of the roller ring outer layer and the roller ring core are different. A wax-dried ball-milled mixture of roller ring outer layer and a wax-dried ball-milled mixture of roller ring core are layered and laminated with powder, cold-pressed into a roller ring blank, and sintered to obtain a final product. The disadvantage is: for the roller-ring structure of this technical solution, the composition gradient is only formed in a radial direction of the roller ring, and no wear-resistance layer is disposed on upper and lower surfaces of the roller ring, so that the shear force on the surfaces may exert a peeling force on the interface of the radial composition during use of the roller ring, leading to limited service life of the roller ring. In view of this, the disclosure provides a cemented carbide screw nut mold with multi-layered gradient structure and manufacturing method thereof.

SUMMARY

40 **[0005]** An object of the disclosure is to provide a cemented carbide screw nut mold with multi-layered gradient structure and manufacturing method thereof. Specifically, the technical solutions are:

A cemented carbide screw nut mold with multi-layered gradient structure and manufacturing method thereof, including a tough material matrix, a first wear resistant material layer, a central through-hole structure, and a second wear resistant material layer, wherein the tough material matrix has a cylindrical shape, an upper surface of the tough material matrix is provided with the first wear-resistant material layer, the central through-hole structure penetrates through the tough material matrix and the first wear resistant material layer, and the central through-hole structure is provided inside with the second wear-resistant material layer.

50 A maximum size of a cross-sectional outer contour of the first wear-resistant material layer is equal to a cross-sectional diameter of the tough material matrix.

An outer contour of a cross section of the second wear-resistant material layer is circular, or polygonal, or is surrounded by straight lines and arcs, or is surrounded by straight lines and curves, or is surrounded by a plurality of segments of arcs, or is surrounded by arcs and curves, or is a plurality of segments of curves, or is surrounded by straight lines, arcs and curves.

55 A longitudinal cross-sectional contour of an interface between the second wear-resistant material layer and the tough material matrix is a plurality of segments of straight lines, or is constituted by straight lines and arcs, or is constituted by straight lines and curves, or is constituted by a plurality of segments of arcs, or is constituted by arcs and curves, or is a plurality of segments of curves, or is constituted by straight lines, arcs and curves.

A maximum size of an outer contour of a cross-section of the first wear-resistant material layer is smaller than a cross-sectional diameter of the tough material matrix; the outer contour of the cross section of the first wear-resistant material layer is circular, or polygonal, or is surrounded by straight lines and arcs, or is surrounded by straight lines and curves, or is surrounded by a plurality of segments of arcs, or is surrounded by arcs and curves, or is a plurality of segments of curves, or is surrounded by straight lines, arcs and curves.

[0006] The first wear-resistant material layer is disposed on a top surface of the tough material matrix, or on both the top surface and a bottom surface of the tough material matrix.

[0007] A manufacturing method for cemented carbide screw nut mold with multi-layered gradient structure, including steps of:

(1) blank forming of tough material matrix: placing a first mold sleeve from a bottom opening of an annular outer mold into an interior of the annular outer mold, and ensuring that bottom ends of the two are flush; inserting a first core rod into a center hole of the first mold sleeve, and ensuring that bottom ends of the two are flush; weighing a tungsten cemented carbide toughness mixture composed of WC powder Co powder and Cr_3C_2 powder and having a particle size of WC powder of 6-16 μm to fill into a space between an inner wall of the annular outer mold and the first core rod, then shaking, so that the tungsten cemented carbide toughness mixture is evenly filled; placing a second mold sleeve from the top opening of the annular mold into the annular mold, and letting the first core rod pass through a center hole of the second mold sleeve; applying pressure from a top of the second mold sleeve and pressurizing it to 2Mpa for 2 to 3 seconds, then depressurizing to atmospheric pressure, then pressurizing to 10MPa for 2 to 3 seconds, and depressurizing to atmospheric pressure again; taking out the second mold sleeve, and keeping the first core rod, the first mold sleeve, and the formed tough material matrix blank in the annular outer mold.

(2) forming of first wear-resistance material layer: weighing a tungsten cemented carbide wear-resistance mixture composed of WC powder Co powder and VC powder and having a particle size of WC powder of 0.6-6 μm to fill into a space between an upper surface of the toughness material blank and the first core rod, then shaking, so that the tungsten cemented carbide wear-resistance mixture is evenly filled; placing a second mold sleeve from the top opening of the annular mold into the annular mold, and letting the first core rod pass through a center hole of the second mold sleeve; applying pressure from a top of the second mold sleeve and pressurizing it to 4 to 5 Mpa for 5 to 3 seconds, then depressurizing to atmospheric pressure, then pressurizing to 4 to 5 MPa for 2 to 3 seconds and depressurizing to atmospheric pressure, and then pressurizing to 4 to 5 MPa for 2 to 3 seconds and depressurizing to atmospheric pressure again; taking out the first mold sleeve, applying pressure from the top of the second mold sleeve, abutting the first core rod and the whole blank from the annular outer mold at one time, pulling the first core rod out from a center hole of the blank, to obtain a first formed blank.

(3) placing of the second wear-resistance material layer: placing the tungsten cemented carbide wear-resistance mixture of the second wear-resistance material layer into the central through-hole structure of the first formed blank, and grinding and smoothing the upper surface.

(4) sintering, including a plurality of stages of heat-preservation sintering processes, which are:

pre-sintering and degreasing: sintering for 3 to 5 hours in a temperature range of 250 °C to 450 °C;
sintering: sintering for 5 to 8 hours in a temperature range of 450 °C to 1200 °C;
sintering and stable-forming: sintering for 1 to 2 hours in a temperature range of 1400 °C to 1500 °C.

[0008] Further, preferably, the sintering includes a plurality of stages of heat-preservation sintering processes, which are:

pre-sintering and degreasing: sintering for 3 to 5 hours in a temperature range of 250 °C to 450 °C;
primary stage of sintering: sintering for 3 to 5 hours in a temperature range of 450 °C to 800 °C;
sintering and contraction forming: sintering for 2 to 3 hours in a temperature range of 1000 °C to 1200 °C;
sintering and stable-forming: sintering for 1 to 2 hours in a temperature range of 1400 °C to 1450 °C.

[0009] For the preferred sintering solution, organic matters in tungsten cemented carbide wear-resistant mixture are fully decomposed and discharged, so that the final product has higher density and higher mechanical properties.

[0010] The technical solution of the disclosure has the following advantages:

The tough material matrix has good impact toughness, while the wear-resistant material layer has a high hardness as

well as a good wear resistance, so that with the wear-resistant material layer provided on the surface in the central through-hole structure, the forging function of the screw nut mold is realized. At the same time, the wear-resistant material layer provided on the upper surface of the tough material matrix protects the interface between the layers below it, so that the cemented carbide screw nut mold with multi-layered gradient structure has long service life and saves material for wear-resistance material layer.

mold model code	prior art product		product of the disclosure	
	fracture toughness (KIC)	mold life (times)	fracture toughness (KIC)	mold life (times)
AD mold	14	586000	21	3483000
AD2 mold	17	1086000	21	5625000
BQ mold	20	60000	24	200000
BQ2 mold	20	70000	27	210000

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Fig. 1 is a view showing blank forming of a tough material matrix of Embodiment 1 of the disclosure.

Fig. 2 is a view showing forming of a first wear-resistant material layer of Embodiment 1 of the disclosure.

Fig. 3 is a view of a first blank of Embodiment 1 of the disclosure.

Fig. 4 is a longitudinal section view of a cemented carbide screw nut mold with multi-layered gradient structure of Embodiment 1 of the disclosure.

Fig. 5 is a cross-section view of a cemented carbide screw nut mold with multi-layered gradient structure of Embodiment 1 of the disclosure.

Fig. 6 is a cross-section view of a cemented carbide screw nut mold with multi-layered gradient structure of Embodiment 2 of the disclosure.

Fig. 7 is a longitudinal section view of a cemented carbide screw nut mold with multi-layered gradient structure of Embodiment 2 of the disclosure.

Fig. 8 is a cross-section view of a cemented carbide screw nut mold with multi-layered gradient structure of Embodiment 3 of the disclosure.

Fig. 9 is a longitudinal section view of a cemented carbide screw nut mold with multi-layered gradient structure of Embodiment 3 of the disclosure.

Fig. 10 is a cross-section view of a cemented carbide screw nut mold with multi-layered gradient structure of Embodiment 4 of the disclosure.

Fig. 11 is a cross-section view of a cemented carbide screw nut mold with multi-layered gradient structure of Embodiment 5 of the disclosure.

Fig. 12 is a longitudinal section view of a cemented carbide screw nut mold with multi-layered gradient structure of Embodiment 5 of the disclosure.

Fig. 13 is a cross-section view of a cemented carbide screw nut mold with multi-layered gradient structure of Embodiment 6 of the disclosure.

Fig. 14 is a longitudinal section view of a cemented carbide screw nut mold with multi-layered gradient structure of Embodiment 6 of the disclosure.

Fig. 15 is a longitudinal section view of a cemented carbide screw nut mold with multi-layered gradient structure of Embodiment 7 of the disclosure.

Fig. 16 is a top view of a cemented carbide screw nut mold with multi-layered gradient structure of Embodiment 7 of the disclosure.

Fig. 17 is a cross-section view of a cemented carbide screw nut mold with multi-layered gradient structure of Embodiment 8 of the disclosure.

Fig. 18 is a longitudinal section view of a cemented carbide screw nut mold with multi-layered gradient structure of Embodiment 9 of the disclosure.

DETAILED DESCRIPTION

[0012] The following embodiment is used for illustrating the invention but limiting the scope thereof.

Embodiment 1

[0013] With reference to Figs. 1 to 5, a cemented carbide screw nut mold with multi-layered gradient structure and manufacturing method thereof includes a tough material matrix 4, a first wear resistant material layer 91, a central through-hole structure 10, and a second wear resistant material layer 92, wherein the tough material matrix 4 has a cylindrical shape, an upper surface of the tough material matrix 4 is provided with the first wear-resistant material layer 91, the central through-hole structure 10 penetrates through the tough material matrix 4 and the first wear resistant material layer 91, and the central through-hole structure 10 is provided inside with the second wear-resistant material layer 92.

[0014] The first wear-resistant material layer 91 and the second wear-resistant material layer 92 have a thickness of 2mm.

[0015] An outer contour of a cross section of the second wear-resistant material layer 92 is circular. An outer contour of a cross section of the first wear-resistant material layer 91 is circular, and a diameter thereof is equal to a diameter of a cross section of the tough material matrix 4.

[0016] A longitudinal cross-sectional contour of an interface between the second wear-resistant material layer 92 and the tough material matrix 4 is a straight line.

[0017] A manufacturing method for cemented carbide screw nut mold with multi-layered gradient structure, including steps of:

(1) blank forming of tough material matrix: placing a first mold sleeve 5 from a bottom opening of an annular outer mold 1 into an interior of the annular outer mold 1, and ensuring that bottom ends of the two are flush; inserting a first core rod 3 into a center hole of the first mold sleeve 5, and ensuring that bottom ends of the two are flush; weighing a tungsten cemented carbide toughness mixture composed of WC powder, Co powder and Cr_3C_2 powder and having a particle size of WC powder of $11\ \mu\text{m}$ to fill into a space between an inner wall of the annular outer mold 1 and the first core rod 3, then shaking, so that the tungsten cemented carbide toughness mixture is evenly filled; placing a second mold sleeve 2 from the top opening of the annular mold 1 into the annular mold 1, and letting the first core rod 3 pass through a center hole of the second mold sleeve 2; applying pressure from a top of the second mold sleeve 2 and pressurizing it to 2Mpa for 2 ± 1 seconds, then depressurizing to atmospheric pressure, then pressurizing to 10MPa for 2 ± 1 seconds, and depressurizing to atmospheric pressure again; taking out the second mold sleeve 2, and keeping the first core rod 3, the first mold sleeve 5, and the formed tough material matrix blank in the annular outer mold.

(2) forming of first wear-resistance material layer: weighing a tungsten cemented carbide wear-resistance mixture composed of WC powder Co powder and VC powder and having a particle size of WC powder of $3\ \mu\text{m}$ to fill into a space between an upper surface of the toughness material blank and the first core rod 3, then shaking, so that the tungsten cemented carbide wear-resistance mixture is evenly filled; placing a second mold sleeve 2 from the top opening of the annular mold 1 into the annular mold 1, and letting the first core rod 3 pass through a center hole of the second mold sleeve 2; applying pressure from a top of the second mold sleeve 2 and pressurizing it to 4 ± 1 Mpa for 2 ± 1 seconds, then depressurizing to atmospheric pressure, then pressurizing to 4 ± 1 MPa for 2 ± 1 seconds and depressurizing to atmospheric pressure, and then pressurizing to 10MPa for 5 seconds and depressurizing to atmospheric pressure again; taking out the first mold sleeve 5, applying pressure from the top of the second mold sleeve 2, abutting the first core rod 3 and the whole blank from the annular outer mold 1 at one time, pulling the first

core rod 3 out from a center hole of the blank, to obtain a first formed blank.

(3) placing of the second wear-resistance material layer: inserting the tungsten cemented carbide wear-resistance mixed blank of the preformed concentric cylindrical second wear-resistance material layer into the central through-hole structure of the first formed blank, and grinding and smoothing the upper surface.

(4) sintering, including a plurality of stages of heat-preservation sintering processes, which are:

pre-sintering and degreasing: sintering for 5 hours in a temperature of 250 °C;

sintering: sintering for 8 hours in a temperature of 1200 °C;

sintering and stable-forming: sintering for 2 hours in a temperature of 1500 °C.

Embodiment 2

[0018] With reference to Figs. 6 to 7, the present embodiment differs from Embodiment 1 in that the first wear-resistant material layer 91 and the second wear-resistant material layer 92 have a maximum thickness of 8mm, the outer contour of the cross section of the second wear-resistant material layer 92 is polygonal, a longitudinal cross-sectional contour of an interface between the second wear-resistant material layer 92 and the tough material matrix 4 is a plurality of segments of straight lines, and the placing of the second wear-resistance material layer 92 is performed by inserting the second wear-resistance material layer with central through holes performed by the tungsten cemented carbide wear-resistance mixture into the first blank. The tungsten cemented carbide toughness mixture is composed of WC powder Co powder and Cr_3C_2 powder, and has a particle size of WC powder of 6 μm ; the tungsten cemented carbide wear-resistance mixture is composed of WC power, Co powder and VC powder, and has a particle size of WC powder of 0.6 μm .

[0019] The sintering includes a plurality of stages of heat-preservation sintering processes, which are:

pre-sintering and degreasing: sintering for 3 hours in a temperature of 450°C;

sintering: sintering for 5 hours in a temperature of 1200 °C;

sintering and stable-forming: sintering for 1 hour in a temperature of 1400 °C.

[0020] The rest is the same.

Embodiment 3

[0021] With reference to Figs. 8 to 9, the present embodiment differs from Embodiment 1 in that the first wear-resistant material layer 91 and the second wear-resistant material layer 92 have a maximum thickness of 5mm, the outer contour of the cross section of the second wear-resistant material layer 92 is surrounded by straight lines and arcs, a longitudinal cross-sectional contour of an interface between the second wear-resistant material layer 92 and the tough material matrix 4 is composed of straight lines and arcs; the placing of the second wear-resistance material layer 92 is performed by: inserting the second core rod into the central through hole of the first blank and ensuring that its center symmetry line coincides with the central through hole of the first blank, filling the second wear-resistant material layer of tungsten cemented carbide wear-resistant mixture powder between the central through hole of the first blank and the second core rod and compacting, and then pulling out the second core rod. The tungsten cemented carbide toughness mixture is composed of WC powder Co powder and Cr_3C_2 powder, and has a particle size of WC powder of 16 μm ; the tungsten cemented carbide wear-resistance mixture is composed of WC power, Co powder and VC powder, and has a particle size of WC powder of 6 μm .

[0022] The sintering includes a plurality of stages of heat-preservation sintering processes, which are:

pre-sintering and degreasing: sintering for 5 hours in a temperature of 250 °C;

primary stage of sintering: sintering for 5 hours in a temperature of 800 °C;

sintering and contraction forming: sintering for 3 hours in a temperature of 1000 °C.

sintering and stable-forming: sintering for 2 hours in a temperature of 1450°C.

The rest is the same.

Embodiment 4

[0023] With reference to Fig. 10, the present embodiment differs from Embodiment 1 in that the first wear-resistant material layer 91 and the second wear-resistant material layer 92 have a maximum thickness of 4mm, and the outer contour of the cross section of the second wear-resistant material layer 92 is surrounded by straight lines and curves.

The tungsten cemented carbide toughness mixture is composed of WC powder Co powder and Cr_3C_2 powder, and has a particle size of WC powder of $14\text{ }\mu\text{m}$; the tungsten cemented carbide wear-resistance mixture is composed of WC powder, Co powder and VC powder, and has a particle size of WC powder of $1\text{ }\mu\text{m}$.

[0024] The sintering includes a plurality of stages of heat-preservation sintering processes, which are:

pre-sintering and degreasing: sintering for 4 hours in a temperature of 350°C ;
sintering: sintering for 7 hours in a temperature of 750°C ;
sintering and stable-forming: sintering for 1.5 hours in a temperature of 1450°C .
The rest is the same.

Embodiment 5

[0025] With reference to Figs. 11 to 12, the present embodiment differs from Embodiment 1 in that the first wear-resistant material layer 91 and the second wear-resistant material layer 92 have a maximum thickness of 5mm, the outer contour of the cross section of the second wear-resistant material layer 92 is surrounded by a plurality of segments of arcs, a longitudinal cross-sectional contour of an interface between the second wear-resistant material layer 92 and the tough material matrix 4 is composed of straight lines and curves; the placing of the second wear-resistance material layer 92 is performed by: inserting the second core rod into the central through hole of the first blank and ensuring that its center symmetry line coincides with the central through hole of the first blank, filling the second wear-resistant material layer of tungsten cemented carbide wear-resistant mixture powder between the central through hole of the first blank and the second core rod and compacting, and then pulling out the second core rod. The tungsten cemented carbide toughness mixture is composed of WC powder Co powder and Cr_3C_2 powder, and has a particle size of WC powder of $7\text{ }\mu\text{m}$; the tungsten cemented carbide wear-resistance mixture is composed of WC powder, Co powder and VC powder, and has a particle size of WC powder of $5\text{ }\mu\text{m}$.

[0026] The sintering includes a plurality of stages of heat-preservation sintering processes, which are:

pre-sintering and degreasing: sintering for 3 hours in a temperature of 450°C ;
primary stage of sintering: sintering for 3 hours in a temperature of 600°C ;
sintering and contraction forming: sintering for 2 hours in a temperature of 1200°C .
sintering and stable-forming: sintering for 1 hour in a temperature of 1400°C .
The rest is the same.

Embodiment 6

[0027] With reference to Figs. 13 to 14, the present embodiment differs from Embodiment 1 in that the first wear-resistant material layer 91 and the second wear-resistant material layer 92 have a maximum thickness of 5mm, the outer contour of the cross section of the second wear-resistant material layer 92 is surrounded by straight lines, arcs and curves, a longitudinal cross-sectional contour of an interface between the second wear-resistant material layer 92 and the toughness material matrix 4 is composed of straight lines, arcs and curves, and the first wear-resistant material layer 91 is placed on upper and lower surfaces of the toughness material matrix 4; the placing of the second wear-resistance material layer 92 is performed by: inserting the second core rod into the central through hole of the first blank and ensuring that its center symmetry line coincides with the central through hole of the first blank, filling the second wear-resistant material layer of tungsten cemented carbide wear-resistant mixture powder between the central through hole of the first blank and the second core rod and compacting, and then pulling out the second core rod.

[0028] The rest is the same. The tungsten cemented carbide toughness mixture is composed of WC powder Co powder and Cr_3C_2 powder, and has a particle size of WC powder of $15\text{ }\mu\text{m}$; the tungsten cemented carbide wear-resistance mixture is composed of WC powder, Co powder and VC powder, and has a particle size of WC powder of $2\text{ }\mu\text{m}$.

[0029] The sintering includes a plurality of stages of heat-preservation sintering processes, which are:

pre-sintering and degreasing: sintering for 4 hours in a temperature range of 350°C ;
primary stage of sintering: sintering for 4 hours in a temperature of 700°C ;
sintering and contraction forming: sintering for 2.5 hours in a temperature of 1150°C .
sintering and stable-forming: sintering for 1.5 hours in a temperature of 1400°C .

Embodiment 7

[0030] With reference to Figs. 15 to 16, the present embodiment differs from Embodiment 1 in that the outer contour of the cross section of the second wear-resistant material layer 91 has a maximum size smaller than the outer diameter

of the toughness material matrix 4, and the outer contour of the cross section of the first wear-resistance material layer 91 is polygonal. The tungsten cemented carbide toughness mixture is composed of WC powder Co powder and Cr_3C_2 powder, and has a particle size of WC powder of $9\text{ }\mu\text{m}$; the tungsten cemented carbide wear-resistance mixture is composed of WC powder, Co powder and VC powder, and has a particle size of WC powder of $1\text{ }\mu\text{m}$.

[0031] The rest is the same.

Embodiment 8

[0032] With reference to Fig. 17, the present embodiment differs from Embodiment 1 in that the inner surface of the cross section of the second wear-resistance material layer 92 has a polygonal contour. The rest is the same.

Embodiment 9

[0033] With reference to Fig. 18, the present embodiment differs from Embodiment 1 in that the cemented carbide screw nut mold with multi-layered gradient structure has an outer contour of round platform structure, and a trapezoidal outer contour of the longitudinal section; the first wear-resistant material layer 91 is disposed on the top surface of the round platform. The rest is the same.

[0034] Although the disclosure has been described in detail with the general description and the specific embodiments, it is obvious to those skilled in the art that some modifications or improvements can be made based on the present disclosure. Therefore, these modifications or improvements made without departing from the spirit of the present disclosure belong to the scope of protection of the present disclosure.

Claims

1. A cemented carbide screw nut mold with multi-layered gradient structure and manufacturing method thereof, comprising a tough material matrix, a first wear resistant material layer, a central through-hole structure, and a second wear resistant material layer, wherein the tough material matrix has a cylindrical shape, an upper surface of the tough material matrix is provided with the first wear-resistant material layer, the central through-hole structure penetrates through the tough material matrix and the first wear resistant material layer, and an inner wall of the central through-hole structure is provided with the second wear-resistant material layer.
2. The cemented carbide screw nut mold with multi-layered gradient structure according to claim 1, wherein a maximum size of a cross-sectional outer contour of the first wear-resistant material layer is equal to a cross-sectional diameter of the tough material matrix.
3. The cemented carbide screw nut mold with multi-layered gradient structure according to claim 1, wherein an outer contour of a cross section of the second wear-resistant material layer is circular, or polygonal, or is surrounded by straight lines and arcs, or is surrounded by straight lines and curves, or is surrounded by a plurality of segments of arcs, or is surrounded by arcs and curves, or is a plurality of segments of curves, or is surrounded by straight lines, arcs and curves.
4. The cemented carbide screw nut mold with multi-layered gradient structure according to claim 1, wherein a longitudinal cross-sectional contour of an interface between the second wear-resistant material layer and the tough material matrix is a plurality of segments of straight lines, or is constituted by straight lines and arcs, or is constituted by straight lines and curves, or is constituted by a plurality of segments of arcs, or is constituted by arcs and curves, or is a plurality of segments of curves, or is constituted by straight lines, arcs and curves.
5. The cemented carbide screw nut mold with multi-layered gradient structure according to claim 1, wherein a maximum size of an outer contour of a cross-section of the first wear-resistant material layer is smaller than a cross-sectional diameter of the tough material matrix; the outer contour of the cross section of the first wear-resistant material layer is circular, or polygonal, or is surrounded by straight lines and arcs, or is surrounded by straight lines and curves, or is surrounded by a plurality of segments of arcs, or is surrounded by arcs and curves, or is a plurality of segments of curves, or is surrounded by straight lines, arcs and curves.
6. The cemented carbide screw nut mold with multi-layered gradient structure according to any one of claims 1 to 5, wherein the first wear-resistant material layer is disposed on a top surface of the tough material matrix, or on both the top surface and a bottom surface of the tough material matrix.

7. A manufacturing method for cemented carbide screw nut mold with multi-layered gradient structure, comprising steps of:

(1) blank forming of tough material matrix: placing a first mold sleeve from a bottom opening of an annular outer mold into an interior of the annular outer mold, and ensuring that bottom ends of the two are flush; inserting a first core rod into a center hole of the first mold sleeve, and ensuring that bottom ends of the two are flush; weighing a tungsten cemented carbide toughness mixture composed of WC powder Co powder and Cr_3C_2 powder and having a particle size of WC powder of 6-16 μm to fill into a space between an inner wall of the annular outer mold and the first core rod, then shaking, so that the tungsten cemented carbide toughness mixture is evenly filled; placing a second mold sleeve from the top opening of the annular mold into the annular mold, and letting the first core rod pass through a center hole of the second mold sleeve; applying pressure from a top of the second mold sleeve and pressurizing it to 2Mpa for 2 to 3 seconds, then depressurizing to atmospheric pressure, then pressurizing to 10MPa for 2 to 3 seconds, and depressurizing to atmospheric pressure again; taking out the second mold sleeve, and keeping the first core rod, the first mold sleeve, and the formed tough material matrix blank in the annular outer mold.

(2) forming of first wear-resistance material layer: weighing a tungsten cemented carbide wear-resistance mixture composed of WC powder Co powder and VC powder and having a particle size of WC powder of 0.6-6 μm to fill into a space between an upper surface of the toughness material blank and the first core rod, then shaking, so that the tungsten cemented carbide wear-resistance mixture is evenly filled; placing a second mold sleeve from the top opening of the annular mold into the annular mold, and letting the first core rod pass through a center hole of the second mold sleeve; applying pressure from a top of the second mold sleeve and pressurizing it to 4 to 5 Mpa for 5 to 3 seconds, then depressurizing to atmospheric pressure, then pressurizing to 4 to 5 MPa for 2 to 3 seconds and depressurizing to atmospheric pressure, and then pressurizing to 4 to 5 MPa for 2 to 3 seconds and depressurizing to atmospheric pressure again, then pressurizing to 10MPa for 5 seconds and depressurizing to atmospheric pressure again; taking out the first mold sleeve, applying pressure from the top of the second mold sleeve, abutting the first core rod and the whole blank from the annular outer mold at one time, pulling the first core rod out from a center hole of the blank, to obtain a first formed blank.

(3) placing of the second wear-resistance material layer: placing the tungsten cemented carbide wear-resistance mixture of the second wear-resistance material layer into the central through-hole structure of the first formed blank, and grinding and smoothing the upper surface.

(4) sintering: sintering for 3 to 5 hours in a temperature range of 250 °C to 450 °C; heating to a temperature range of 450 °C to 1200 °C, and sintering for 5 to 8 hours; then continuously heating to a temperature range of 1400 °C to 1500 °C, and sintered for 1 to 2 hours.

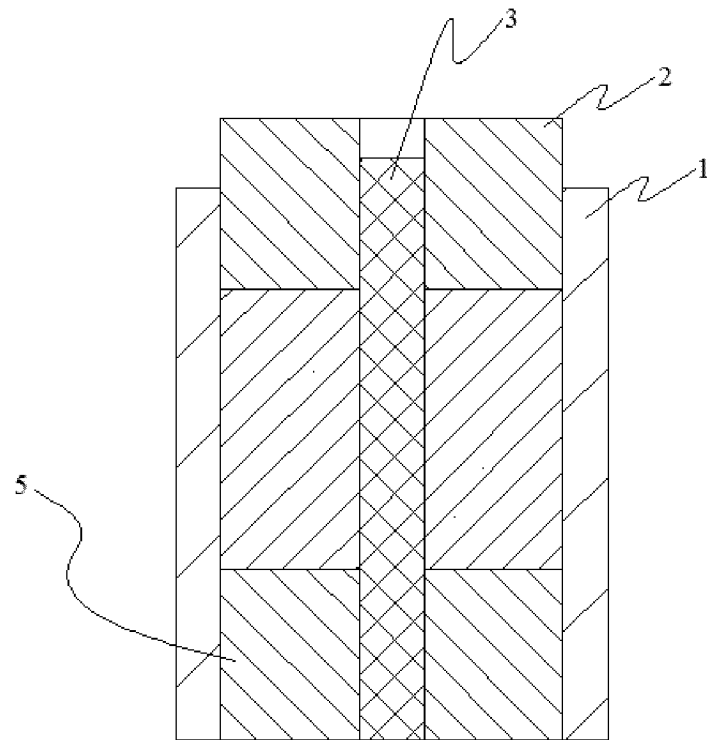


Fig. 1

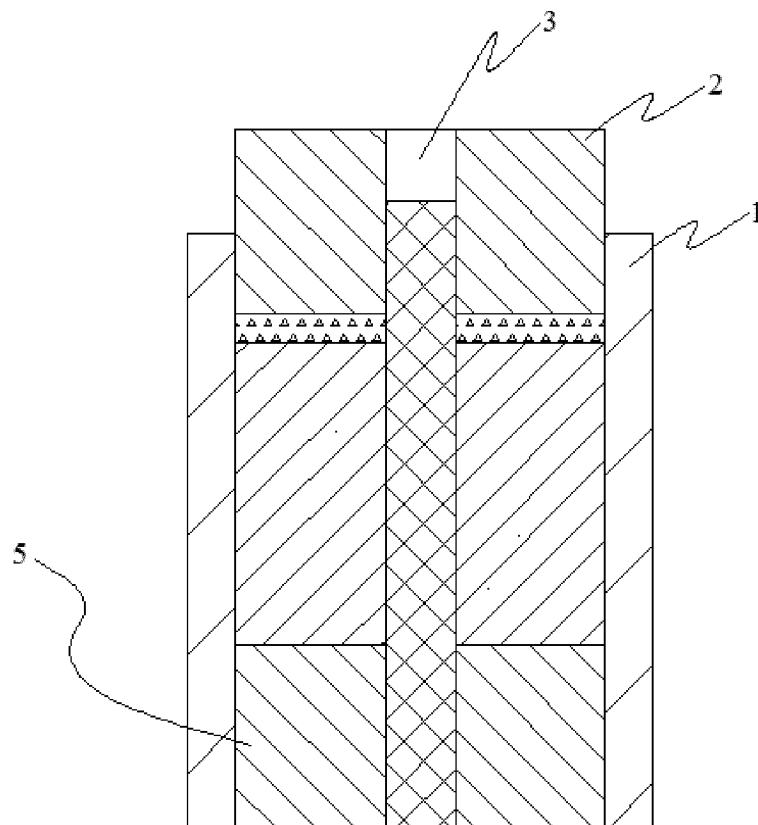


Fig. 2

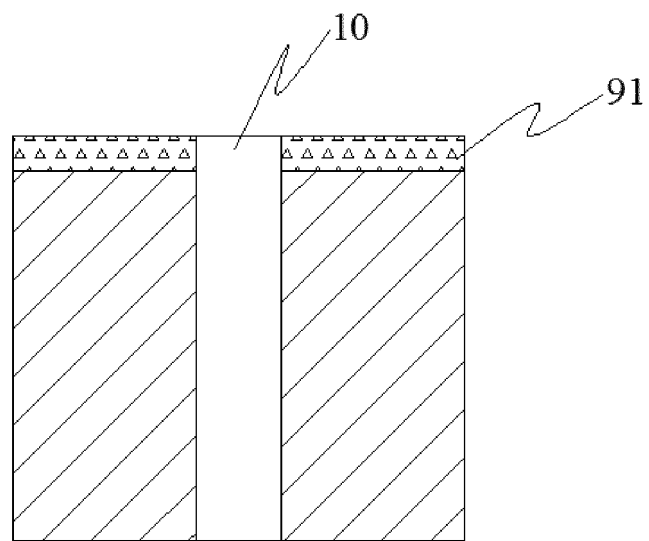


Fig. 3

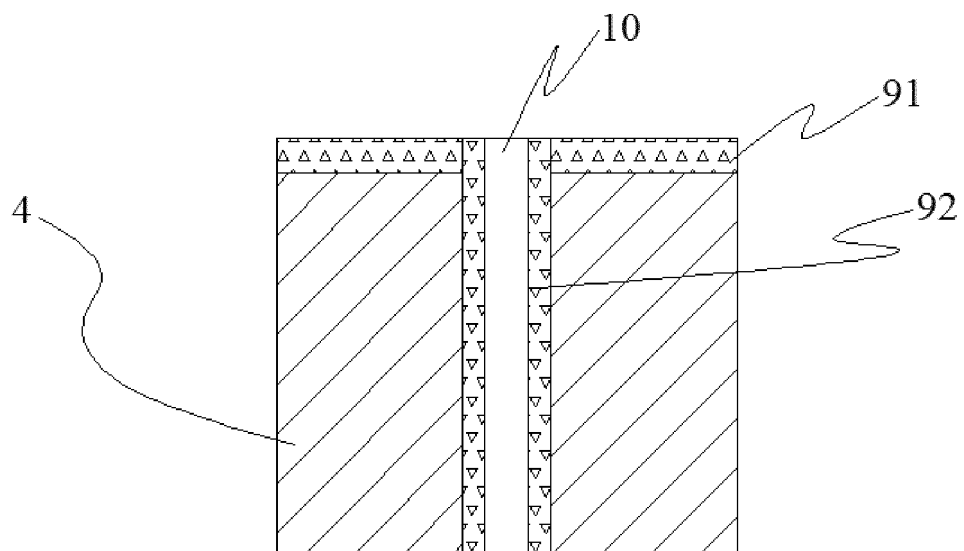


Fig. 4

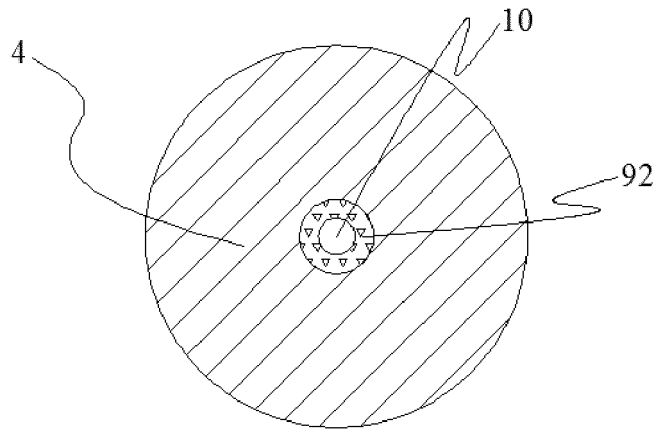


Fig. 5

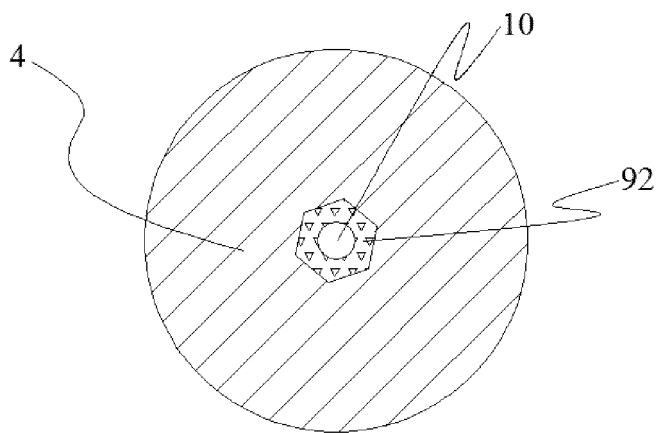


Fig. 6

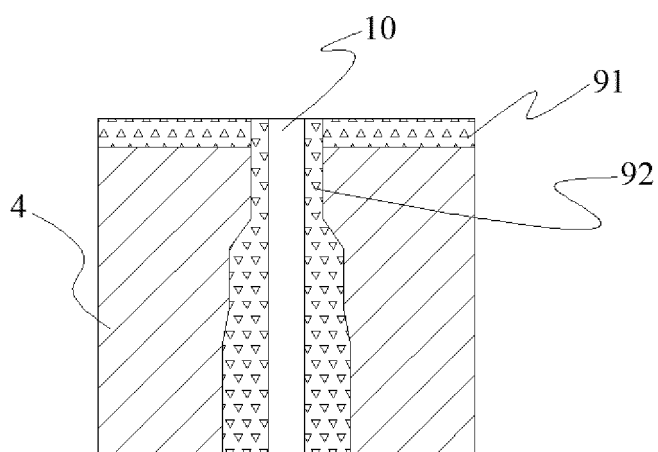


Fig. 7

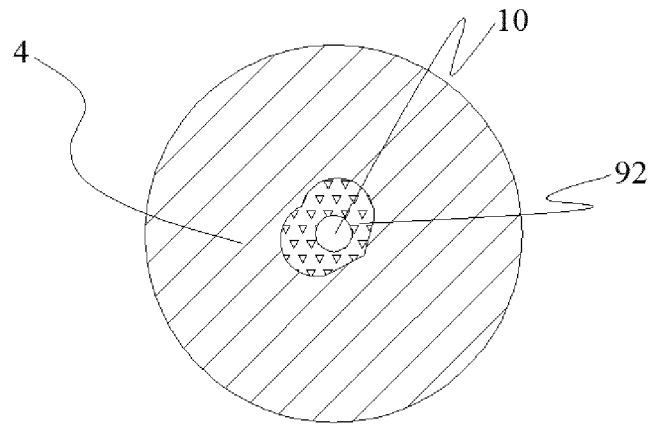


Fig. 8

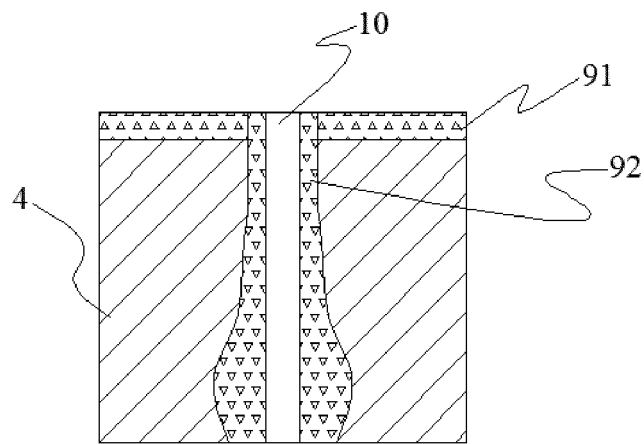


Fig. 9

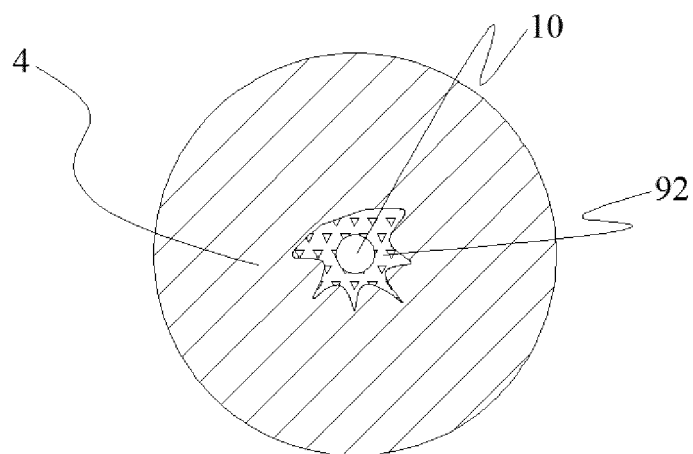


Fig. 10

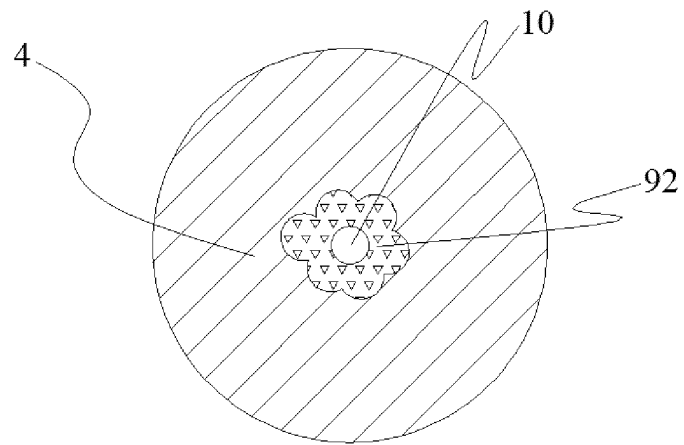


Fig. 11

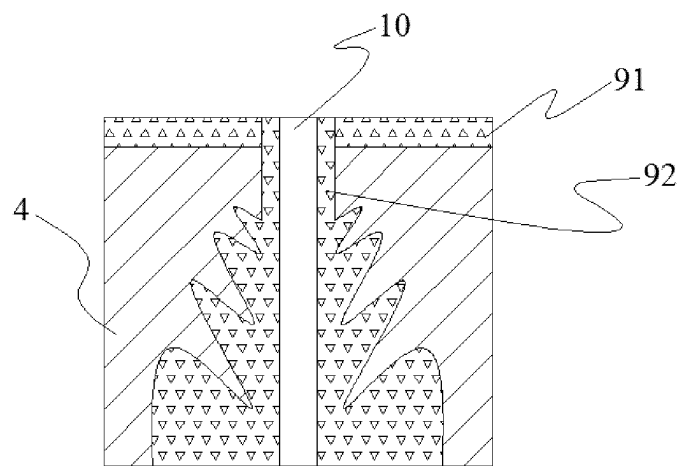


Fig. 12

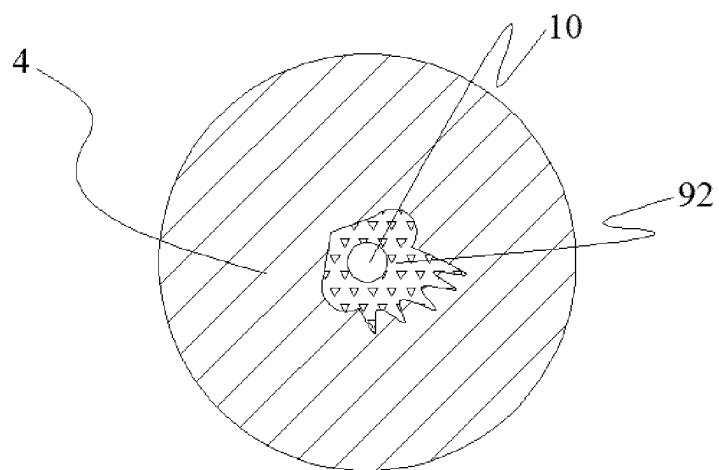


Fig. 13

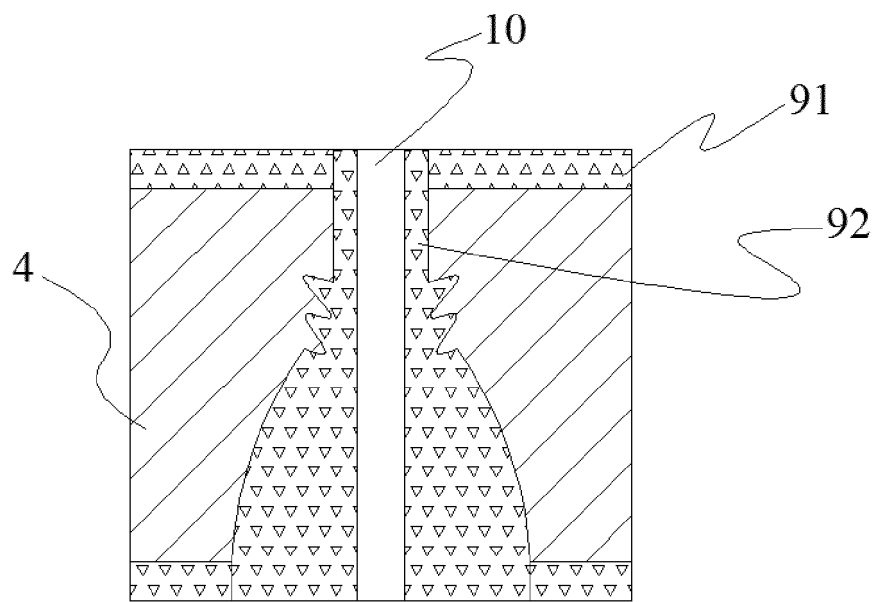


Fig. 14

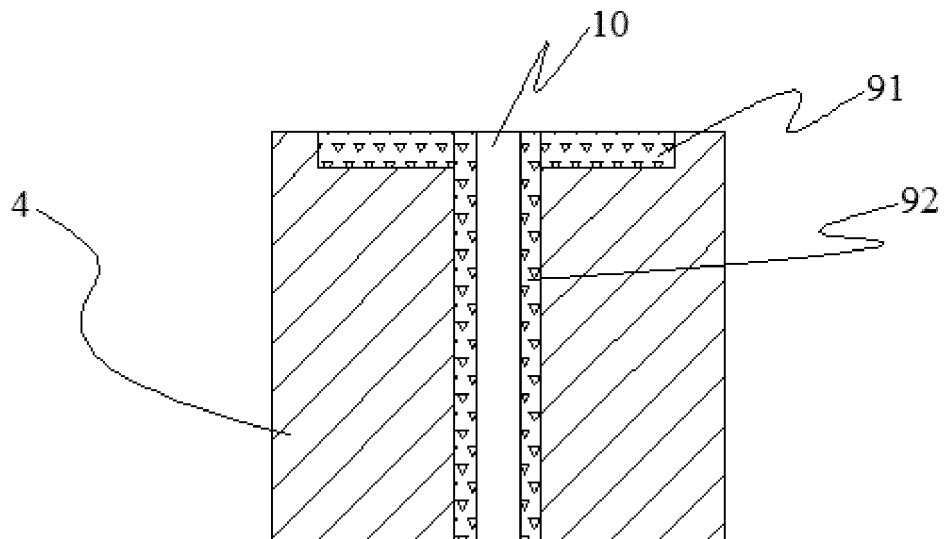


Fig. 15

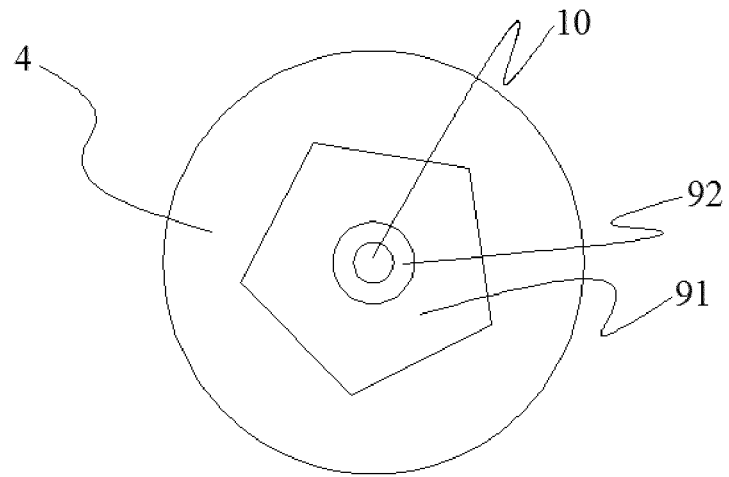


Fig. 16

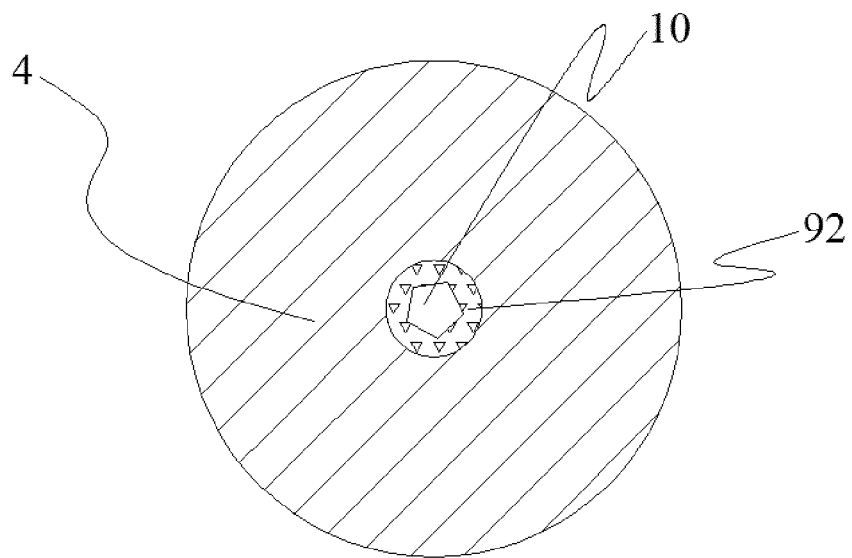


Fig. 17

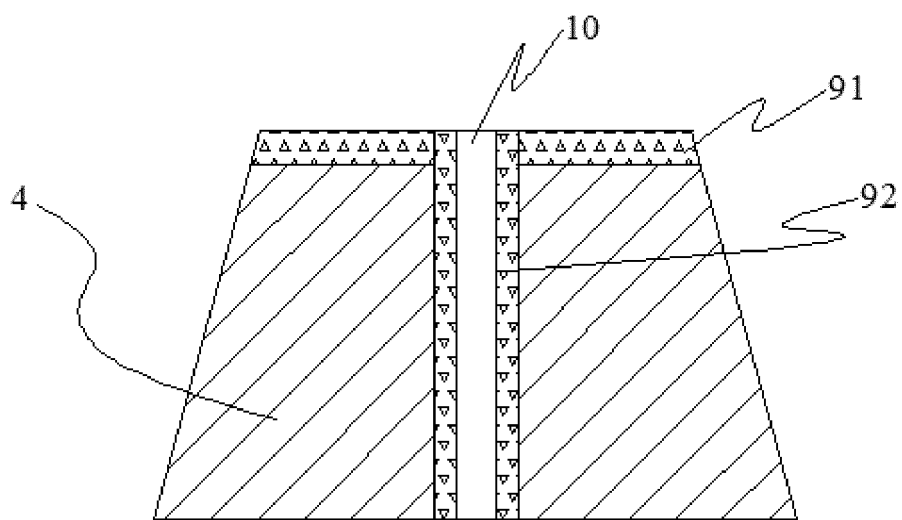


Fig. 18

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2018/099317

5	A. CLASSIFICATION OF SUBJECT MATTER B21D 37/10(2006.01)i According to International Patent Classification (IPC) or to both national classification and IPC		
	B. FIELDS SEARCHED		
10	Minimum documentation searched (classification system followed by classification symbols) B21D B22F B23P B21C		
	Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
15	Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) CNABS, CNTXT, CNKI, VEN: 模具, 螺母, 螺帽, 螺丝, 梯度, 复合, 硬质合金, 耐磨, 磨损, 层, 芯, 孔, 烧结, 腔, mo?ld, die, screw, nut, gradient, composite, hard, alloy, wear+, abrasion, abrasive, layer, film, core, hole, sinter, cavity		
	C. DOCUMENTS CONSIDERED TO BE RELEVANT		
20	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	X	CN 206838934 U (XINJINGRUI TUNGSTEN STEEL (XIAMEN) CO., LTD.) 05 January 2018 (2018-01-05) see description, paragraphs [0009]-[0014], and figure 1	1-6
25	A	CN 104057271 A (FUJIAN JINXIN TUNGSTEN CO., LTD.) 24 September 2014 (2014-09-24) see description, paragraphs [0007]-[0028], and figures 1-4	7
	A	CN 102773371 A (TZE PING PRECISION MACHINERY CO., LTD.) 14 November 2012 (2012-11-14) see entire document	1-7
30	A	CN 103817150 A (HUNAN TIANYI HIGH-TECH MATERIALS MANUFACTURE CO., LTD.) 28 May 2014 (2014-05-28) see entire document	1-7
	A	CN 104588500 A (SUZHOU OUMEIKE CARBIDE TOOL CO., LTD.) 06 May 2015 (2015-05-06) see entire document	1-7
35	A	CN 202877359 U (PHOENIX INTERNATIONAL CO., LTD.) 17 April 2013 (2013-04-17) see entire document	1-7
	☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
40	* Special categories of cited documents: “A” document defining the general state of the art which is not considered to be of particular relevance “E” earlier application or patent but published on or after the international filing date “L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) “O” document referring to an oral disclosure, use, exhibition or other means “P” document published prior to the international filing date but later than the priority date claimed		
45	“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention “X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone “Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art “&” document member of the same patent family		
	Date of the actual completion of the international search		Date of mailing of the international search report
	12 September 2018		28 September 2018
50	Name and mailing address of the ISA/CN		Authorized officer
	State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088 China		
	Facsimile No. (86-10)62019451		Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2018/099317

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 5656735 A (INOUE JAPAX RES) 18 May 1981 (1981-05-18) see entire document	1-7
A	JP 2005342744 A (SANALLOY INDUSTRY CO., LTD.) 15 December 2005 (2005-12-15) see entire document	1-7

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2018/099317

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Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	206838934	U	05 January 2018	None			
CN	104057271	A	24 September 2014	CN	104057271	B	18 May 2016
CN	102773371	A	14 November 2012	None			
CN	103817150	A	28 May 2014	CN	103817150	B	01 July 2015
CN	104588500	A	06 May 2015	None			
CN	202877359	U	17 April 2013	None			
JP	5656735	A	18 May 1981	None			
JP	2005342744	A	15 December 2005	None			

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 103817150 [0004]