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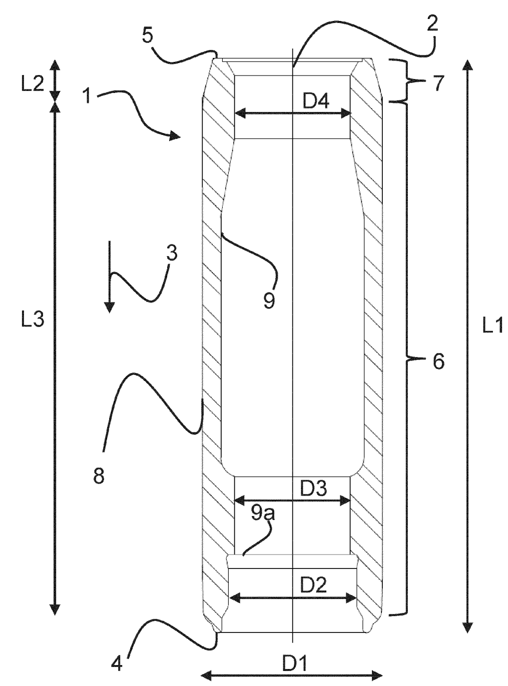
(54) **PUNCH SLEEVE**

(57) Punch sleeve (1) made from a sintered material comprising the following components: 10 to 35 weight percent tungsten carbide, 50 to 60 weight percent in total of one or more selected from titanium carbide, titanium carbonitride and titanium nitride, 35 to 5 weight percent in total of one or more selected from cobalt and nickel, 1.5 to 0 weight percent chromium, 2.5 to 0 weight percent molybdenum, 1 to 0 weight percent in total of other additions, wherein the sum in weight percentages of said components is 95 to 100 weight percent.

Fig. 1



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Description

[0001] The present invention relates to a punch sleeve, a punch apparatus, a use of said punch sleeve and a method for drawing a metal blank into a can body.

[0002] EP 2 746 413 A1 shows a punch for manufacturing of metal beverage.

[0003] A typical process for manufacturing beverage cans starts typically by cutting a circular metal blank out of a sheet of metal, typically made from an aluminium alloy or steel. Then the metal blank is typically placed into a cupping press, where the blank is drawn into the shape of a cup. Subsequently a punch sleeve, mounted onto a ram thereby forming a punch, is pushed swiftly, typically within a fraction of a second, and typically continuously against the then cup shaped metal blank through typically a drawing die and typically several ironing dies. The cup shaped metal blank is thus deep drawn, i.e., reduced in diameter and increased in height, and subsequently ironed, i.e., foremost increased further in height by stretching and thinning cup walls, creating a beverage can body. These two steps are typically called drawing and ironing.

[0004] The objective of the present invention is to provide a punch sleeve which can increase productivity and decrease downtimes and energy consumption during manufacturing of beverage cans.

[0005] The objective is solved by the punch sleeve according to claim 1. Advantageous embodiments of the invention are disclosed in the dependent claims, which can be combined freely amongst each other and with claim 1, and in further embodiments of this disclosure, including enclosed Figs. 1 and 2 and the corresponding description thereof.

[0006] The punch sleeve is made from a sintered material which comprises the following components: 10 to 35 weight percent tungsten carbide, 50 to 60 weight percent in total of one or more selected from titanium carbide, titanium carbonitride and titanium nitride, 35 to 5 weight percent in total of one or more selected from cobalt and nickel, 1.5 to 0 weight percent chromium, 2.5 to 0 weight percent molybdenum, 1 to 0 weight percent in total of other additions, wherein the sum in weight percentages of said components is 95 to 100 weight percent.

[0007] The term "weight precent" and the like is to be understood throughout the present disclosure, unless stated otherwise, as the weight precent and the like of any of said components and optionally further components of the sintered material in relation to the total weight of the sintered material.

[0008] Regarding said components of the sintered material a sum S1 = (said tungsten carbide + said titanium carbide + said titanium carbonitride + said titanium nitride) in weight percentages can range from 60 to 95 weight percent, a sum S2 = (said cobalt + said nickel) in weight percentages can range from 35 to 5 weight percent, and a sum S3 = (said chromium + said molybdenum + said other additions) can range from 0 to 5 weight percent, such that a sum S = S1 + S2 + S3 can range from 95 to 100 weight percent; if the sintered material consists of said components, which is possible and conceivable, S = 100 weight percent.

[0009] "in total of one or more selected from titanium carbide, titanium carbonitride and titanium nitride" is to be understood, unless stated otherwise, that the sum of weight percentages of said titanium carbide, said titanium carbonitride and said titanium nitride, to the extent that these components are present, is calculated, and that at least one (titanium carbide, titanium nitride, titanium carbonitride), two (titanium carbide and titanium nitride, titanium carbide and titanium carbonitride, titanium nitride and titanium carbonitride) or all three (titanium carbide and titanium carbonitride and titanium nitride) of these components is/are present in the sintered material according to their weight percentages disclosed in the present disclosure.

[0010] It is possible and conceivable that said sintered material is essentially or completely free of said titanium nitride, i.e., that said titanium carbide and/or said titanium carbonitride is/are present, essentially without or without said titanium nitride, respectively. Thus, "in total of one or more selected from titanium carbide, titanium carbonitride and titanium nitride" is then replaced by "in total of one or more selected from titanium carbide and titanium carbonitride" regarding the definition of the composition of the sintered material.

[0011] "in total of one or more selected from cobalt and nickel", is to be understood, unless stated otherwise, that the sum of weight percentages of said cobalt and said nickel to the extent that said cobalt and said nickel are present, is calculated, and that one (cobalt, nickel) or both (cobalt and nickel) are present in the sintered material according to their weight percentages disclosed in the present disclosure.

[0012] The term "other additions" is to be understood throughout the present disclosure, unless stated otherwise, in view of an industrial scale production process of the sintered material, meaning that these "other additions" are introduced, e.g., by use of recycled raw materials, pressing and sintering a green body, unavoidable impurities and/or in order to achieve specific properties.

[0013] In that the punch sleeve is a sleeve, it can be slid and thereby mounted onto a ram, preferably by a nut screwed onto a threaded part of said ram such that said nut abuts an axial forward facing shoulder of the punch sleeve under radial clearance to the punch sleeve. Thus, the punch sleeve is a hollow and open-ended body, preferably open ended at both ends sides. The punch sleeve can be a one-piece body or a two or more-piece body. The punch sleeve helps distribute forces more evenly and can be replaced and maintained better over a monolithic ram used for direct punching.

[0014] An optimum balance between weight reduction, wear resistance and toughness is achieved in that the punch sleeve is made from the sintered material comprising said following components: 10 to 35 weight percent tungsten carbide, 50 to 60 weight percent in total of one or more selected from titanium carbide, titanium carbonitride and titanium nitride, 35 to 5 weight percent in total of one or more selected from cobalt and nickel, 1.5 to 0 weight percent chromium, 2.5 to 0 weight percent molybdenum, 1 to 0 weight percent in total of other additions, wherein the sum in weight percentages of said components is 95 to 100 weight percent. In other words, the optimum balance between titanium carbide, titanium nitride and/or titanium carbonitride for weight reduction on the one side and tungsten carbide on the other side for wear resistance has been found combined with an optimum binder content, formed by said cobalt and/or nickel for toughness improvement; said titanium carbide, titanium nitride and/or titanium carbonitride have each a relatively low mass density of on average about 5 g/cm^3, whereas the mass density of tungsten carbide is about 15.6 g/cm^3 and thus is on a volume basis heavier; the invention is not bound to any peculiarities related to the precise calculation of these densities.

[0015] Said weight reduction is achieved by the relatively large total content in relatively low mass density of titanium carbide, titanium nitride and/or titanium carbonitride, enabled for by the presence of at least said relatively heavy tungsten carbide and said toughness enhancing cobalt and/or nickel. Due to said weight reduction, implemented by said composition of the sintered material, the punch sleeve can put less stress on the entire punch-die-system, expanding the lifespan of the die and other parts of related equipment as well, lowers operating costs, since less energy is required to move the punch sleeve, which is especially advantageous for high volume beverage can production operations, enhance precision during punching, and improve operator safety, since a lighter punch sleeve is easier to handle.

[0016] Said sintered material has a microstructure formed predominantly by grains made from said titanium carbide, titanium nitride and/or titanium carbonitride, depending on which of these components is present, due to their relatively low mass density, i.e., high specific volume, in comparison to a higher mass density of said tungsten carbide.

[0017] The tungsten carbide has typically a stoichiometry of WC. Titanium carbide, if present, has typically a stochiometric composition of $(Ti_{1-r}, W_r)C$, wherein r ranges from 0 to smaller 0.5, preferably from 0 to 0.15, i.e., some tungsten can be present in said titanium carbide. Titanium carbonitride, if present, has typically a stochiometric composition of $(Ti_{1-x},W_x)(C_{1-y},N_y)$, wherein x ranges from 0 to smaller 0.5, preferably from 0 to 0.15, and y ranges from greater 0 to smaller 1, i.e., some tungsten can be present in said titanium carbonitride. Titanium nitride, if present, has typically a stoichiometry of TiN.

[0018] When titanium carbide and titanium carbonitride are selected from titanium carbide, titanium carbonitride and titanium nitride, titanium carbide can be present as essentially pure titanium carbide, i.e., TiC (r = 0), together with titanium carbonitride having some tungsten, i.e., $(Ti_{1-x},W_x)(C_{1-y},N_y)$ with x from greater 0 to smaller 0.5, preferably from greater 0 to 0.15, and y ranges from greater 0 to smaller 1. Thus, when titanium carbide and titanium carbonitride are present together with these stoichiometries, individual "titanium carbide grains" and "titanium carbonitride grains" can be identified in the microstructure of the sintered material, typically by EBSD (electron back-scatter diffraction) images, where said "titanium carbide grains" typically appear as almost black grains and said "titanium carbonitride grains" appear in a brighter, grey shading, typically larger in size on average than said "titanium carbide grains".

[0019] The source for said molybdenum, if present, can typically be molybdenum powder and/or molybdenum carbide powder added to a powder mixture which can be pressed and sintered to manufacture said sintered material.

[0020] The source for said chromium, if present, can typically be chromium powder and/or chromium carbide powder added to a powder mixture which can be pressed and sintered to manufacture said sintered material.

[0021] Preferably said sintered material consists of said following components: 10 to 35 weight percent tungsten carbide, 50 to 60 weight percent in total of one or more selected from titanium carbide, titanium carbonitride and titanium nitride, 35 to 5 weight percent in total of one or more selected from cobalt and nickel, 1.5 to 0 weight percent chromium, 2.5 to 0 weight percent molybdenum, 1 to 0 weight percent in total of other additions, wherein the sum in weight percentages of said components is 100 weight percent.

[0022] Preferably said sintered material consists of said following components: 10 to 35 weight percent tungsten carbide, 50 to 60 weight percent in total of one or more selected from titanium carbide, titanium carbonitride and titanium nitride, 35 to 5 weight percent in total of cobalt and nickel, wherein the content in cobalt is larger than 0 weight percent, wherein the content in nickel is larger than 0 weight percent, 1.5 to 0 weight percent chromium, 2.5 to 0 weight percent molybdenum, 1 to 0 weight percent in total of other additions, wherein the sum in weight percentages of said components is 100 weight percent. Thus, the composition of the sintered material comprises then cobalt and nickel.

[0023] Preferably said sintered material consists of said following components: 10 to 35 weight percent tungsten carbide, 50 to 60 weight percent in total of one or more selected from titanium carbide and titanium carbonitride, 35 to 5 weight percent in total of one or more selected from cobalt and nickel, 1.5 to 0 weight percent chromium, 2.5 to 0 weight percent molybdenum, 1 to 0 weight percent in total of other additions, wherein the sum in weight percentages of said components is 100 weight percent. Thus, the composition of the sintered material is then free of titanium nitride.

[0024] Preferably said sintered material consists of said following components: 10 to 35 weight percent tungsten carbide, 50 to 60 weight percent in total of one or more selected from titanium carbide and titanium carbonitride, 35 to 5 weight percent in total of cobalt and nickel, wherein the content in cobalt is larger than 0 weight percent, wherein the content in nickel is larger than 0 weight percent, 1.5 to 0 weight percent chromium, 2.5 to 0 weight percent molybdenum, 1 to 0 weight percent in total of other additions, wherein the sum in weight percentages of said components is 100 weight percent. Thus, the composition of the sintered material is then free of titanium nitride and comprises cobalt and nickel.

[0025] According to a further embodiment of said punch sleeve the content in total of the one or more selected from titanium carbide, titanium carbonitride and titanium nitride is 52 to 56 weight percent. It has been found that within this narrower range of the titanium carbide, titanium carbonitride and titanium nitride, which can be used to replace any broader range of the titanium carbide, titanium carbonitride and/or titanium nitride in the present disclosure where the sintered material comprises or consists of said components, the punch sleeve has an improved tool lifetime, including the cases where the composition of the sintered material is free of titanium nitride.

[0026] According to a further embodiment of said punch sleeve the tungsten carbide content is 27 to 33 weight percent. It has been found that within this narrower range of the tungsten carbide, which can be used to replace any broader range of the tungsten carbide in the present disclosure where the sintered material comprises or consists of said components, the punch sleeve has an improved tool lifetime, including the cases where the composition of the sintered material is free of titanium nitride.

[0027] According to a further embodiment of said punch sleeve the nickel content is 1 to 6 weight percent. It has been found that when the nickel content is in the range from 1 to 6 weight percent, which can be used to replace any broader range of nickel in the present disclosure where the sintered material comprises or consists of said components, the punch sleeve has an improved tool lifetime, including the cases where the composition of the sintered material is free of titanium nitride; the nickel has been found to improve at least corrosion resistance.

[0028] According to a further embodiment of said punch sleeve the nickel content is 2 to 4 weight percent. It has been found that when the nickel content is in the narrower range from 2 to 4 weight percent, which can be used to replace any broader range of nickel in the present disclosure where the sintered material comprises or consists of said components, the punch sleeve has an improved tool lifetime, including the cases where the composition of the sintered material is free of titanium nitride.

[0029] According to a further embodiment of said punch sleeve the chromium content is 0.3 to 1.5 weight percent, preferably 0.5 to 1.3 weight percent. It has been found that within this narrower range of the chromium, which can be used to replace any broader range of the chromium in the present disclosure where the sintered material comprises or consists of said components, the punch sleeve has an improved tool lifetime, including the cases where the composition of the sintered material is free of titanium nitride; the chromium has been found to at least reduce the mean grain size of the tungsten carbide.

[0030] According to a further embodiment of said punch sleeve the molybdenum content is 0.5 to 2.5 weight percent. It has been found that within this narrower range of the molybdenum, which can be used to replace any broader range of the molybdenum in the present disclosure where the sintered material comprises or consists of said components the punch sleeve has an improved tool lifetime, including the cases where the composition of the sintered material is free of titanium nitride; it has been found that the molybdenum increases the hot deformation resistance.

[0031] According to a further embodiment of said punch sleeve the titanium carbonitride has a stochiometric composition of $(Ti_{1-x},W_x)(C_{1-y},N_y)$, wherein x ranges from greater 0 to 0.15 and y ranges from greater 0 to smaller 1. It has been found that the stochiometric composition of $(Ti_{1-x},W_x)(C_{1-y},N_y)$, wherein x ranges from greater 0 to 0.15 and y ranges from greater 0 to smaller 1, improves the wear resistance achieved by said titanium carbonitride, in that a relatively small, limited by x smaller or equal to 0.15, amount of tungsten, W, is present in said titanium carbonitride, without making said titanium carbonitride too heavy, i.e., without compromising the weight reduction achievable by said titanium carbonitride. It has been found that the wear resistance improves even further, when the titanium carbonitride has the stochiometric composition of $(Ti_{1-x},W_x)(C_{1-y},N_y)$, wherein x ranges from greater 0 to 0.15 and y ranges from greater 0 to smaller 1, and is present together with titanium carbide having the stochiometric composition of TiC, i.e., essentially pure titanium carbide.

[0032] According to a further embodiment of said punch sleeve the tungsten carbide has a mean grain size in the range from 0.2 μm to 3 μm, preferably from 1 μm to 3 μm. It has been found that when the mean tungsten carbide grain size is in the range from 0.2 μm to 3 μm, preferably from 1 μm to 3 μm, that the punch sleeve has an improved tool lifetime.

[0033] The mean grain size of said tungsten carbide grains is to be measured as "linear intercept length" according to the international standard ISO 4499-2:2008(E), unless stated otherwise. EBSD micrographs (EBSD, electron back-scatter diffraction) of sintered samples are to be used as a basis, unless stated otherwise. The measurement methodology for such micrographs is described, for example, in: K. P. Mingard et al., "Comparison of EBSD and conventional methods of grain size measurement of hard metals", Int. Journal of Refractory Metals & Hard Materials 27 (2009) 213-223, unless stated otherwise.

[0034] According to a further embodiment the punch sleeve has a nose positioned on one end of the punch sleeve, a trailing edge positioned opposite to the nose on a second end of the punch sleeve and a cylindrical portion between the nose and the trailing edge. The nose is preferably rounded since this enables for a smooth first contact with said metal blank during drawing.

[0035] According to a further embodiment the punch sleeve has an internal abutment shoulder on parts of the nose. Said abutment shoulder is typically formed by a section of the punch sleeve having a reduced internal diameter over a larger internal diameter on parts of the second end and over a larger internal diameter further towards the nose outside of said section. Said abutment shoulder is designed for abutment of a fastening element, typically screwed onto a threaded section of a ram, wherein said ram is typically slid into said section such that a threaded part of the ram protrudes out off said section on parts of said nose and such that the fastening element abuts said shoulder section when screwed onto said threaded section.

[0036] The objective is also solved by a punch apparatus according to claim 13.

[0037] The punch apparatus comprises a ram and a punch sleeve according to any of the thereto related claims, including claim 1, and/or embodiments, including enclosed Figs. 1 and 2 and the corresponding description thereof, wherein the punch sleeve is slid and mounted onto the ram. The advantages of the punch apparatus are the same as the ones disclosed for the punch sleeve. The punch apparatus has due to said punch sleeve a reduced movable weight, improved wear resistance and toughness, thus the ram can reciprocate faster with an improved alignment, less energy consumption, and a longer apparatus lifetime. The apparatus can also comprise one or more dies designed such that the punch sleeve can be moved through said dies to allow for deep drawing of a metal blank into a can body.

[0038] The objective is also solved by a use of a punch sleeve punch sleeve according to claim 14.

[0039] The use of the punch sleeve according to any of the thereto related claims, including claim 1, and/or embodiments, including enclosed Figs. 1 and 2 and the corresponding description thereof, for drawing a metal blank into a can body. The advantages of this use are the same as the ones disclosed for the punch sleeve.

[0040] The objective is also solved by a method for drawing a metal blank into a can body according to claim 15.

[0041] The method for drawing a metal blank into a can body comprises the steps: a) providing a punch sleeve according to any of the thereto related claims, including claim 1, and/or embodiments, including enclosed Figs. 1 and 2 and the corresponding description thereof, or a punch apparatus according to any of the thereto related claims, including claim 13, and/or embodiments, including enclosed Figs. 1 and 2 and the corresponding description thereof, b) providing a metal blank, c) drawing the metal blank of step b) into a can body by moving the punch sleeve of step a) and the metal blank of step b) against each other. Preferably, the metal blank is already drawn into a cup shaped body and provided as such in step b). Typically, one or more dies are provided in step c) through which the punch sleeve is moved in a continuous stroke to draw the metal blank or cup shaped can body, respectively.

[0042] The Figures show:

Fig. 1: a schematic drawing of a punch sleeve in a longitudinal section, and

Fig. 2: a schematic drawing of a punch apparatus in a longitudinal section.

[0043] Fig. 1 shows a punch sleeve 1 in a longitudinal section along a longitudinal axis 2, along which the punch sleeve 1 is movable in a reciprocating motion.

[0044] The punch sleeve 1 is a one-piece body made from a sintered material consisting exemplary of the following components: 53.5 weight percent in total of titanium carbide and titanium carbonitride, 30 weight percent tungsten carbide, 12 weight percent cobalt, 3 weight percent nickel and 1.5 weight percent chromium; the sum of said components is 100 weight percent and the sum of cobalt and nickel is 15 weight percent.

[0045] It is possible and conceivable, that the contents of said components are chosen differently according to the corresponding embodiments of the present disclosure, and/or that the sintered material comprises one or more further components selected from molybdenum and the other additions according to the corresponding embodiments of the present disclosure, such that the sum of the weight percentages of the components is 100 weight percent.

[0046] The tungsten carbide has a mean grain size of 2.3 μm, representative for each of the mean grain size ranges 0.2 μm to 3 μm and 1 μm to 3 μm. The mean grain size of said tungsten carbide grains is measured as "linear intercept length" according to the international standard ISO 4499-2:2008(E). EBSD micrographs (EBSD, electron back-scatter diffraction) of sintered samples haven been used as a basis. The measurement methodology for such micrographs is described, for example, in: K. P. Mingard et al., "Comparison of EBSD and conventional methods of grain size measurement of hard metals", Int. Journal of Refractory Metals & Hard Materials 27 (2009) 213-223.

[0047] The punch sleeve 1 is designed to draw metal blanks into a can body by a single stroke parallel to the longitudinal axis 2 along the direction 3 and is rotational symmetric with respect to the longitudinal axis 2. The punch sleeve 1 has a nose 4 positioned on one end and a trailing edge 5 positioned opposite to the nose 4 on a second end. The nose 4 is rounded and designed for a first contact with said metal blank. The punch sleeve 1 has further a cylindrical portion 6 between the nose 4 and the trailing edge 5 connected to a tapered trailing section 7 tapering from an outer diameter D1 of the cylindrical portion 6 to a smaller diameter proximate to the trailing edge 5.

[0048] The punch sleeve 1 has further an outer surface 8, an inner surface 9 and an internal abutment shoulder 9a on parts of the nose 4. The abutment shoulder 9a has thus a surface perpendicular to the longitudinal axis 2 and facing towards the nose 4.

[0049] The abutment shoulder 9a is designed for abutment with a fastening element axially securing the punch sleeve 1 to ram to which further reference is made in the description of Fig. 2.

[0050] The punch sleeve has a total length L1 measured parallel to the longitudinal axis 2 and from the nose 4 to the trailing edge 5. The total length L1 is exemplarily 184 mm but can equally well range from 180 mm to 190 mm, or any other length, though 180 mm to 190 mm is preferred for making so-called sleek cans where drawing with a lightweight and wear resistant sleeve is specifically advantageous.

[0051] Said trailing section 7 has a length L2 measured analogously to the length L1. L2 is exemplarily 12.4 mm but can equally well range from 10 mm to 15 mm or any other length, though 10 mm to 15 mm is preferred for drawing so-called sleek cans.

[0052] The cylindrical section 6 has a length L3 measured analogously to the length L1. The length L3 is exemplarily 164.6 mm but can equally well range from 160 mm to 170 mm or any other length, though 160 mm to 170 mm is preferred for drawing so-called sleek cans.

[0053] The punch sleeve 1 has further an inner diameter D2 proximate to the nose 4 and further a smaller inner diameter D3 located behind the abutment shoulder 9a. D2 is exemplarily 41 mm but can equally well range from 35 mm to 45 mm or any other diameter, though 35 mm to 45 mm is preferred for drawing so-called sleek cans. D3 is exemplarily 37 mm but can equally well range from 35 mm to 40 mm or any other value as long as D3 is smaller than D2. D1 is exemplarily 57 mm but can equally range from 55 mm to 60 mm or any other value, though 55 mm to 60 mm is preferred for drawing so-called sleek cans.

[0054] The punch sleeve 1 has further an inner diameter D4 on parts of the tapered section 7 which is equal to the inner diameter D3. D3 and D4 are designed to match the outer diameter of a ram inserted into the punch 1 sleeve and contacting the inner surface 9 where the inner diameters D3 and D4 are defined.

[0055] Fig. 2 shows the same longitudinal section of punch sleeve 1 as Fig. 1. In Fig. 2 the punch sleeve 1 is slid and mounted onto a ram 10. A punch apparatus 11 comprises the punch sleeve 1 and the ram 10. The ram 10 is a cylindrical body made from a steel and rotational symmetric with respect to the longitudinal axis 2 and axially secured by a nut 14, being a fastening element, in threading engagement with a threaded part of the ram 10 such that the nut 14 abuts the abutment shoulder 9a, as evident by comparing Figs. 1 and 2. The nut 14 as radial clearance to the inner surface 9 such that the nut 14 can be screwed onto the ram 10.

[0056] Fig. 2 depicts further a metal blank 12 already drawn by a cupping press into a cup shaped body having an inner diameter D4 larger than the diameter D1 and further having a wall thickness D5 and a height L4 measured analogously to the length L1. D4 is exemplarily 83 mm but can equally well be selected from a different diameter suitable for interacting with the punch sleeve 1. L4 is exemplarily 37 mm but can equally well be selected from a different height suitable for interacting with the punch sleeve 1.

[0057] According to a use of the punch sleeve 1 and a use of the punch apparatus 11 the metal blank 12 is drawn by a stroke of the punch sleeve 1 against the metal blank 12 and into a ring die 13; it is possible and conceivable to have more than one ring die, each placed below the die 13.

[0058] By this stroke the diameter D4 of the metal blank 12 is reduced to a smaller diameter equal to the diameter D1, and the height L4 is increased, e.g., by a factor of 1.5 or more.

[0059] According to a method for drawing the metal blank 12 into a can body, the following steps are carried out: a) the punch sleeve 1 or the punch apparatus 11 are provided, b) the metal blank 12 is provided, c) the metal blank 12 is drawn by moving the punch sleeve 1 and the metal blank 12 against each other, wherein the punch sleeve 1 is moved into the die 13.

[0060] The punch sleeve 1 and thereby the punch apparatus 12 are light weighted and wear resistant having thereby in view drawing metal blanks into can bodies: a longer lifetime, lower energy consumption and lesser maintenance need. Said light-weightiness is predominantly due to that the sintered material comprises from 50 to 60 weight percent in total of titanium carbide and titanium carbonitride, being an example for in total of one or more selected from titanium carbide, titanium carbonitride and titanium nitride, in the presence of a wear resistance improving lower tungsten carbide content from 10 to 35 weight percent, and a toughness improving binder content of from 35 to 5 weight percent cobalt and nickel.

[0061] The present invention is not limited to the design of the punch sleeve 1. In other embodiments, the dimensions of the punch sleeve 1, especially the dimensions L1, L2, L3, D1, D2 and D3, can be changed relatively and/or in absolute values in view of a desired can body design and/or in view of a differently designed ram 10.

Experiments

[0062] A reference punch sleeve, named hereafter punch sleeve A, was made from a sintered material consisting of the following components: 88 weight percent tungsten carbide and 12 weight percent cobalt. The sintered material of punch sleeve A had an approximate density of 14.3 g/cm^3.

[0063] A further reference punch sleeve, named hereafter punch sleeve B, was made from a sintered material consisting of the following components: 38 weight percent in total of titanium carbide, 30 weight percent tungsten carbide, 24 weight percent cobalt, 6 weight percent nickel and 2 weight percent chromium. The sintered material of punch sleeve B had an approximate density of 8.0 g/cm^3.

[0064] A punch sleeve according to the invention, named hereafter punch sleeve Inv., was made from a sintered material consisting of the following components: 53.5 percent tungsten carbide, 30 weight percent titanium carbide, 12 weight percent cobalt, 3 weight percent nickel and 1.5 weight percent chromium. The sintered material of punch sleeve B had an approximate density of 7.0 g/cm^3.

[0065] Five samples from each punch sleeve A, B and Inv. were taken and subjected to the same wear test for determining sliding wear under a linear reciprocating ball-on-sample contact in terms of a wear track depth, ASTM G133-22 (Standard Test Method for Linearly Reciprocating Ball-on-Flat Sliding Wear, Publication year 2022) can be taken as reference for conducting such wear tests. In each sintered material one wear track was made under the same pressing force and surface condition until a given number of ball-on-sample reciprocations was reached; the average wear track depth was calculated from said five samples.

[0066] These and further wear test results regarding further compositions based on the sintered material of punch sleeve Inv. are discussed in the following part of the disclosure on a relative basis which suffices for the person skilled in the art to reproduce and confirm the trends and influences identified. The person skilled in the art knows how to conduct a wear test for a sintered material, naturally she/he uses the same test parameters when she/he compares the wear behaviour of different sintered materials.

[0067] The wear tracks were deepest in the sintered material of punch sleeve A. In the sintered material of punch sleeve B the wear tracks were 13 % flatter (less deep) compared to the wear track depth in the sintered material of punch sleeve A. In the sintered material of punch sleeve Inv. the were tracks were 21 % flatter (less deep) compared to the wear track depth in the sintered material of punch sleeve A and 9 % flatter (less deep) compared to the wear track depth in the sintered material of punch sleeve B.

[0068] Thus, the following trends were identified: the presence of 53.5 weight percent titanium carbide combined with 30 weight precent tungsten carbide in the sintered material of punch sleeve Inv. yields not only a significantly lighter punch sleeve but also a better wear resistance than the presence of 88 weight tungsten carbide without titanium carbide, as in the sintered material of punch sleeve A having a more than two-times higher density.

[0069] The presence of 53.5 weight percent titanium carbide combined with 30 weight precent tungsten carbide in the sintered material of punch sleeve Inv. yields not only an even lighter punch sleeve but also a better wear resistance than the presence of a lower titanium carbide content of 38 weight percent combined with the same tungsten carbide content of 30 weight percent, as in the sintered material of punch sleeve B.

[0070] Consequently, it was found that the inventive punch sleeve had not only a longer tool life due to an improved wear resistance in said method for drawing the metal blank 12, but also requires less energy to be moved due to its lower density.

[0071] Further similar wear tests were conducted regarding the sintered material, hereafter named "further sintered materials", unless stated otherwise, of further punch sleeves. The composition of the sintered materials of the further punch sleeves is based on the composition of the sintered material punch sleeve Inv. was made from, but each time with a systematic variation of one or more components.

[0072] It was found that the range of titanium carbide from 52 to 56 weight percent in the further sintered materials improves the wear resistance over being outside of this range, for which the sum S1 = (said tungsten carbide + said titanium carbide) in weight percentages was kept constant at 83 weight percent and the total content of nickel and cobalt was kept constant at 17 weight percent to yield 100 weight percent.

[0073] It was found that the range of nickel and cobalt in total from 5 to 35 weight percent in the further sintered materials improves the wear resistance over being outside of this range, for which the total content of tungsten carbide and titanium carbide was adapted accordingly within 65 to 95 weight percent to yield 100 weight percent.

[0074] It was found that the nickel content in the range from 1 to 4 weight percent in the further sintered materials improves the wear resistance over being outside of this range, for which the total content of nickel and cobalt was kept constant at 15 weight percent and the total content of titanium carbide and tungsten carbide was kept constant and 85 weight percent to yield 100 weight percent.

[0075] It was found that the additional presence of chromium in the further sintered material in the range from 0.3 to 1.5 weight percent improves the wear resistance over being outside of this range, for which the total content of titanium carbide and tungsten carbide was kept constant at 85 weight percent with 53 weight percent titanium carbide and for which the total content of nickel and cobalt was adapted accordingly to yield 100 weight percent.

[0076] It was found that the presence of molybdenum in the further sintered materials in the range from 0.5 to 2.5 weight percent improves the wear resistance over being outside this range, for which the total content of titanium carbide and tungsten carbide was kept constant at 85 weight percent with 53 weight percent titanium carbide and for which the total content of nickel and cobalt was adapted accordingly to yield 100 weight percent.

[0077] It was found that the presence of other additions up to 1 weight is acceptable for punch sleeve applications.

[0078] It was found that the mean grain size of the tungsten carbide in the range from 1 μm to 3 μm improves the wear resistance over being outside of this range, for which the sintered material of punch sleeve Inv. was used. This trend was confirmed for any of the further sintered materials.

[0079] In the sintered material of punch sleeve Inv. titanium carbide and titanium carbonitride were selected from titanium carbide, titanium carbonitride and titanium nitride. Based on further prepared sintered materials having the same composition as the sintered material of punch sleeve Inv. but either only titanium carbide selected from titanium carbide, titanium carbonitride and titanium nitride or only titanium nitride selected from titanium carbide, titanium carbonitride and titanium nitride, it was found that the presence of titanium carbide with titanium carbonitride improves the wear resistance, especially, when the titanium carbide is essentially pure, i.e., TiC, and the titanium carbonitride has some tungsten, i.e., for example $(Ti_{0.85},W_{0.15})(C_{0.8},N_{0.2})$, $(Ti_{0.90},W_{0.10})(C_{0.8}\ N_{0.2})$, $(Ti_{0.95},W_{0.05})(C_{0.8},N_{0.2})$, $(Ti_{0.85},W_{0.15})(C_{0.5},N_{0.5})$, $(Ti_{0.90},W_{0.10})(C_{0.5},N_{0.5})$, $(Ti_{0.95},W_{0.05})(C_{0.5},N_{0.5})$, $(Ti_{0.85},W_{0.15})(C_{0.2},N_{0.8})$, $(Ti_{0.90},W_{0.10})(C_{0.2},N_{0.8})$, $(Ti_{0.95},W_{0.05})(C_{0.2},N_{0.8})$.

[0080] In further prepared sintered materials having the composition of the sintered material of the punch sleeve Inv. only titanium carbide was selected from titanium carbide, titanium carbonitride and titanium nitride.

[0081] In further prepared sintered materials having the composition of the sintered material of the punch sleeve Inv. only titanium carbonitride was selected from titanium carbide, titanium carbonitride and titanium nitride.

[0082] In further prepared sintered materials having the composition of the sintered material of the punch sleeve Inv. only titanium nitride was selected from titanium carbide, titanium carbonitride and titanium nitride.

[0083] In further prepared sintered materials having the composition of the sintered material of the punch sleeve Inv. titanium carbide and titanium nitride were selected from titanium carbide, titanium carbonitride and titanium nitride.

[0084] In further prepared sintered materials having the composition of the sintered material of the punch sleeve Inv. titanium carbonitride and titanium nitride were selected from titanium carbide, titanium carbonitride and titanium nitride.

[0085] In further prepared sintered materials having the composition of the sintered material of the punch sleeve Inv. titanium carbide, titanium carbonitride and titanium nitride were selected from titanium carbide, titanium carbonitride and titanium nitride.

Claims

1. Punch sleeve (1) made from a sintered material comprising the following components:

10 to 35 weight percent tungsten carbide,
50 to 60 weight percent in total of one or more selected from titanium carbide, titanium carbonitride and titanium nitride,
35 to 5 weight percent in total of one or more selected from cobalt and nickel,
1.5 to 0 weight percent chromium,
2.5 to 0 weight percent molybdenum,
1 to 0 weight percent in total of other additions, wherein
the sum in weight percentages of said components is 95 to 100 weight percent.

2. Punch sleeve (1) according to claim 1, wherein the content in total of the one or more selected from titanium carbide, titanium carbonitride and titanium nitride is 52 to 56 weight percent.

3. Punch sleeve (1) according to any of the preceding claims, wherein the tungsten carbide content is 27 to 33 weight percent.

4. Punch sleeve (1) according to any of the preceding claims, wherein the nickel content is 1 to 6 weight percent.

5. Punch sleeve (1) according to claim 4, wherein the nickel content is 2 to 4 weight percent.

6. Punch sleeve (1) according to any of the preceding claims, wherein the chromium content is 0.3 to 1.5 weight percent.

7. Punch sleeve (1) according to any of the preceding claims, wherein the molybdenum content is 0.5 to 2.5 weight percent.

8. Punch sleeve (1) according to any of the preceding claims, wherein the titanium carbonitride has a stochiometric composition of $(Ti_{1-x},W_x)(C_{1-y},N_y)$, wherein x ranges from greater 0 to 0.15 and y ranges from greater 0 to smaller 1.

9. Punch sleeve (1) according to any of the preceding claims, wherein the tungsten carbide has a mean grain size in the range from 0.2 μm to 3 μm.

10. Punch sleeve (1) according to claim 9, wherein the tungsten carbide has a mean grain size in the range from 1 μm to 3 μm.

11. Punch sleeve (1) according to any of the preceding claims, wherein the punch sleeve (1) has a nose (4) positioned on one end of the punch sleeve (1), a trailing edge (5) positioned opposite to the nose (4) on a second end of the punch sleeve (1) and a cylindrical portion (6) between the nose (4) and the trailing edge (5).

12. Punch sleeve (1) according to claim 11, wherein the punch sleeve (1) has an internal abutment shoulder (9a) on parts of the nose (4).

13. Punch apparatus (11), comprising a ram (10) and a punch sleeve (1) according to any of the preceding claims, wherein the punch sleeve (1) is slid and mounted onto the ram (10).

14. Use of a punch sleeve (1) according to any of claims 1 to 12 for drawing a metal blank (12) into a can body.

15. Method for drawing a metal blank (12) into a can body, comprising the steps:

a) providing a punch sleeve (1) according to any one of claims 1 to 12 or a punch apparatus according to claim 13,
b) providing a metal blank (12),
c) drawing the metal blank (12) of step b) into a can body by moving the punch sleeve (1) of step a) and the metal blank (12) of step b) against each other.

Fig. 1

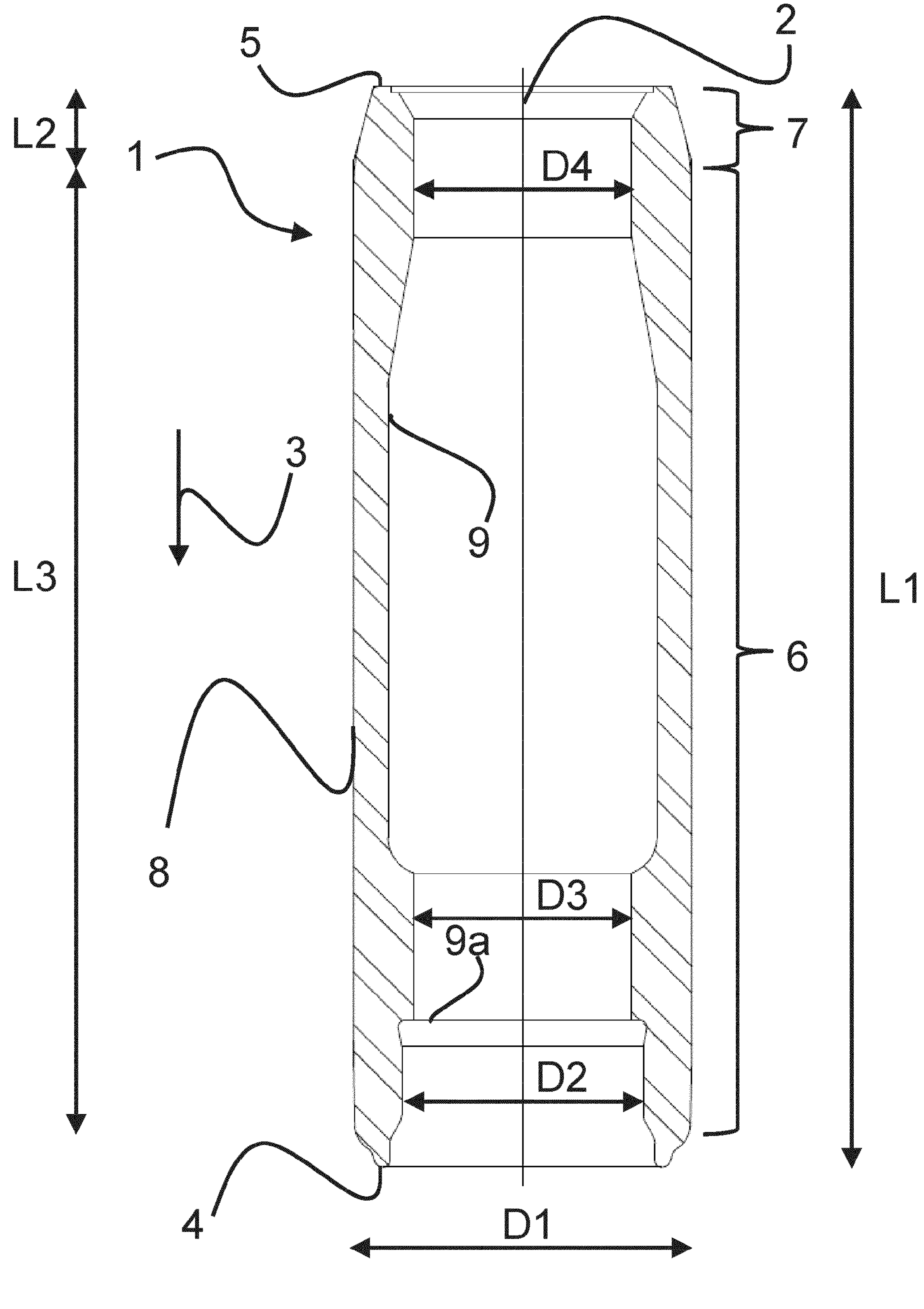
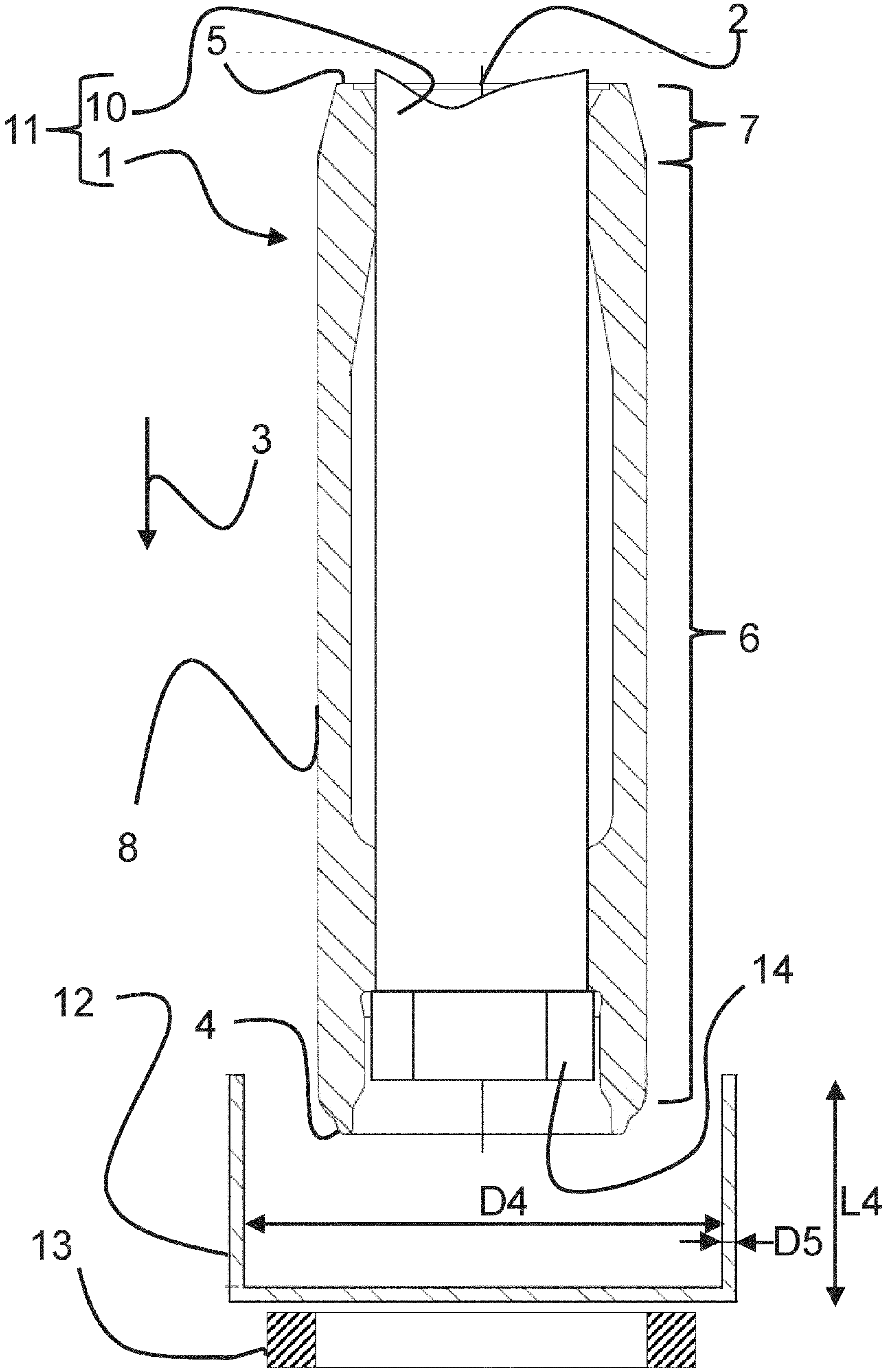


Fig. 2



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EUROPEAN SEARCH REPORT

Application Number
EP 23 20 0731

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	US 5 736 658 A (MIRCHANDANI PRAKASH K [US] ET AL) 7 April 1998 (1998-04-07) * column 3; lines 38-42 * * columns 4-5; lines 66-16 * * claims 1,14,22; figure 5 * * column 3; lines 51-53 * * column 2; lines 40-47 * -----	1-15	INV. B22F5/10 B21D51/26 C22C1/051 C22C29/04 C22C29/10 C22C29/16 B21D37/01 ADD. C22C29/00 C22C29/06

TECHNICAL FIELDS SEARCHED (IPC)

B22F
B21D
C22C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	16 February 2024	Momeni, Mohammad

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CATEGORY OF CITED DOCUMENTS

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16-02-2024

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US 5736658 A	07-04-1998	NONE	

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

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- **K. P. MINGARD et al.** Comparison of EBSD and conventional methods of grain size measurement of hard metals. *Int. Journal of Refractory Metals & Hard Materials*, 2009, vol. 27, 213-223 **[0033] [0046]**