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(54) **A device for manufacturing a cutting insert green body and a method of compacting powder into a cutting insert green body by means of said device**

(57) A device for manufacturing a cutting insert green body by compacting a powder, said device comprising: a die (7) for receiving said powder, at least one punch for compacting said powder received by said die (7), and a powder-filling device (12) for filling powder into the die (7), wherein, in an upper surface (13) of at least one part of the die (7), the die (7) comprises an upper opening (14) through which said powder is introduced into the die (7) and through which or towards which said punch may be forwarded into the die (7) for the purpose of compacting powder introduced into the die (7), wherein said upper opening (14) is defined by an edge (15) that presents a

curvature other than planar. The upper surface (13) of the die (7) presents a path that, at least in on direction (x), extends rectilinearly from a laterally offset point on said upper surface (13) to said upper opening (14) and covers said upper opening (14) and intersects said edge (15) that defines said upper opening (14), wherein said path has a predetermined non-planar profile in a cross section perpendicularly to said direction (x), and the powder-filling device (12) has a bottom surface that at least partially presents a profile corresponding to said non-planar profile of said path.

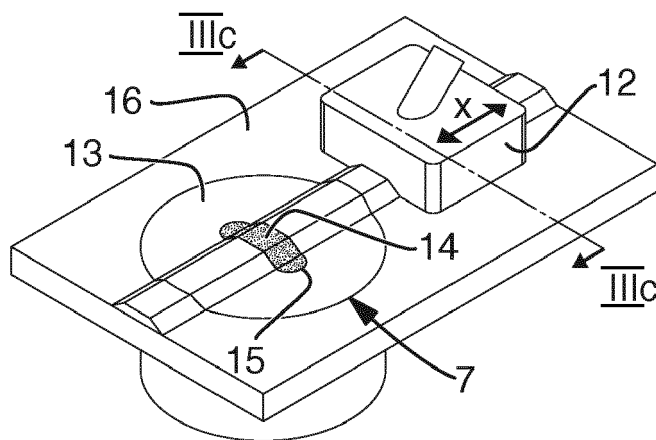


Fig 3a

Description

TECHNICAL FIELD

[0001] The present invention relates to a device for manufacturing a cutting insert green body by compacting a powder, said device comprising: a die for receiving said powder; at least one punch for compacting said powder received by said die, and; a powder-filling device for filling powder into the die, wherein, in an upper surface of at least one part of the die, the die comprises an upper opening through which said powder is introduced into the die and through which or towards which said punch may be forwarded into the die for the purpose of compacting powder introduced into the die, and wherein said upper opening is defined by an edge that presents a curvature other than planar.

[0002] The invention also relates to a method of compacting powder into a cutting insert green body, by means of a device according to the invention.

BACKGROUND OF THE INVENTION

[0003] In connection to the compacting of powder into cutting insert green bodies to be sintered into cutting inserts for the cutting of metals, it may be of interest to purposively affect the distribution of the non-compacted powder filled into a die in order to suppress predetermined density variations within the compacted green body to be formed.

[0004] Accordingly, it is of interest to be able to press a powder into a green body with a uniform density distribution in order to, for example, minimize the upcoming of cracks during the pressing operation or to avoid unintentional shape distortions during the subsequent sintering operation. In connection to the pressing of green bodies with a multi-level appearance (varying height) using only one upper punch, one lower punch and a standard filling shoe, the green body will per definition obtain a non-uniform density distribution.

[0005] One way of solving the above-mentioned problem of non-uniform density, or at least suppressing/reducing such non-uniformity, would be to adapt the top surface of the column of powder filled into a die to the shape of the green body to be compacted. This can be achieved by providing the die with an upper opening through which powder is filled into the die, wherein said opening is defined by an edge that presents a curvature other than planar. Powder is filled into the die to such a level that it is in alignment with the edge that defines said opening.

[0006] EP 2 164 657 discloses a device and a method for manufacturing an end mill, in which there is formed a down-stepped portion on an upper surface of the die for the purpose of affecting the density distribution of the compacted green body to be formed in said die. As a result of the provision of said down-stepped portion, a part of the die that will define a part of the compacted

green body that will have a smaller thickness is filled with a smaller amount of powder. EP 2 164 657 does not mention how a powder filling device would be adapted to the non-planar configuration of the upper surface of the die, but is very clear on the point that there is needed a specific means for eliminating remaining powder from the top surface of the die, thereby indicating that there is a remaining problem related to the filling of powder, namely how to prevent excessive powder from being left on the top surface of the die in the area of the down-stepped portion.

THE OBJECT OF THE INVENTION

[0007] It is an object of the present invention to present a device and a method for the compaction of a powder into a cutting insert green body which either enables a less complicated press tool design or enables a control of the density distribution in the compacted green body by adaption of the curvature of an opening into which powder is filled into the die by letting the edge, that defines said opening, present a non-planar curvature, wherein the device and method presents a solution to the problem of how to prevent powder from being left on the upper surface of the die, in the area affected by the non-planar curvature, in connection to the filling of the die with powder.

SUMMARY OF THE INVENTION

[0008] The object of the invention is achieved by means of the invention according to claim 1, characterised in that the upper surface of the die presents a path that, in one direction, extends rectilinearly from a laterally offset point on said upper surface to said upper opening and covers said upper opening and intersects said edge that defines said upper opening, wherein said path has a predetermined non-planar profile in a cross section perpendicularly to said direction, and that the powder-filling device has a bottom surface that at least partially presents a profile corresponding to said non-planar profile of said path. In said bottom surface, the powder-filling device has an opening through which powder is discharged into the die. As a result of the inventive design, the upper surface of the column of powder that is provided in the die will present a profile corresponding to said non-planar profile. The non-planar profile of the upper surface of the powder column is adapted to the geometry of the green body to be formed. Said profile may, but must not necessarily, resemble the shape of the upper surface of the green body to be shaped. The non-planar profile may be designed so as to accomplish a more uniform density distribution in the green body to be compacted, or so as to accomplish a predetermined symmetry of the density distribution of the green body to be compacted. However, in specific press designs, the provision of the non-planar profile on an upper surface of a die part may primarily be to achieve other advantages, such as simplification of

the die design rather than affecting the uniformity or symmetry of the density distribution of the green body.

[0009] According to the present disclosure, the powder-filling device is enabled to be rectilinearly moved on and along said path in continuous contact with the upper surface of the die to and from said opening in said direction, and to overlap said opening. When the powder-filling device has been removed from the upper opening of the die, an upper surface of the powder that has been introduced into the die will, preferably, be in alignment with said path and edge, of the upper surface of the die.

[0010] According to one embodiment, the powder-filling device has a bottom surface with a path that extends rectilinearly in one direction x and which has a profile in a cross-section perpendicular to said direction x that corresponds to the predetermined non-planar profile of said path of the upper surface of the die. The path of the bottom surface of the powder-filling device is wide enough and long enough to be able to fully overlap the upper opening in the upper surface of the die. Thereby, the powder-filling device will be able of sliding along said path on the upper surface of the die and to fully overlap (cover) the upper opening in the latter, while being in alignment with the part of the path of the die that encloses said opening. Any excessive powder in the region of said upper opening on the upper surface of the die part after powder-filling will be effectively removed by the returning powder-filling device.

[0011] According to one embodiment, at the bottom surface thereof, the powder-filling device has a bottom opening for discharge of powder into the die, wherein said path of the bottom surface covers said bottom opening. The opening in the bottom of the powder-filling device will overlap the upper opening of the die when the powder-filling device is in a position in which filling of powder is executed.

[0012] According to one embodiment, in at least a direction perpendicular to said direction x , the bottom opening of the powder-filling device has a size that is larger than the size of the upper opening in the die.

[0013] According to an alternative embodiment, in at least a direction perpendicular to said direction x , the bottom opening of the powder-filling device has a size that is equal to or smaller than the size of the upper opening in the die.

[0014] According to yet another embodiment, a region around said bottom opening in the bottom surface of the powder-filling device has a curvature corresponding to the curvature of the edge that defines the upper opening in the upper surface of the die, such that the bottom surface of the powder-filling device will be in sealing relation with said edge of the opening in the upper surface of the die when the powder-filling device is in an operative position on the die in which powder is filled into the die.

[0015] According to one embodiment, the powder-filling device is arranged so as to slide above and along said path of the upper surface of the die in said direction x in which said path of the upper surface of the die extends

rectilinearly from said laterally offset point to said upper opening and to overlap said opening, wherein said path of the powder-filling device is arranged opposite to the path of the upper surface of the die and extends rectilinearly in the direction x in which the path of the upper surface of the die extends rectilinearly.

[0016] According to one embodiment, the path of the powder-filling device is arranged so as to be in supporting contact with said path of the die in connection to said sliding of the powder-filling device on the upper surface of the die. As an alternative, if there is no such supporting contact, the distance between the path of the powder filling device and the path of the die should be kept so small that it prevents powder from leaking into the space between said paths.

[0017] The non-planar profile of said path, which is also adopted by the upper surface of the powder column residing in the die after powder-filling and removal of the powder-filling device, may be adapted to the of the green body to be compacted in order to achieve, or at least promote, uniform density distribution or symmetric density distribution of the green body to be compacted and may correspond to or resemble the shape of the upper surface of the green body to compacted.

[0018] According to one embodiment, the curvature of said edge that defines the upper opening in the upper surface of the die and intersects with said path corresponds to a curvature of an upper edge of a green body to be compacted in said die. An upper edge of the green body is referred to as an upper lateral edge formed in the region in which the upper punch is as closest to an inner peripheral surface of the die. Typically, said edge corresponds to a cutting edge of the cutting insert to be formed by sintering of the green body. The curvature of said edge that defines said opening is not necessarily exactly identical to the curvature of said edge on the green body. It could, for example, have larger amplitude than the latter, in order to compensate for the fact that the green body at high elevation sections of the curvature, obviously representing sections of the green body with larger height, requires proportionally more powder when compared to low elevation sections in order to achieve/promote a uniform density distribution of the green body after compaction.

[0019] According to another embodiment, said punch comprises an abutment surface for abutment with the powder to be compacted, and an outer peripheral surface, and a punch edge at the intersection between the abutment surface and the outer peripheral surface, wherein the punch edge extends with a predetermined curvature around the circumference of the punch, which curvature corresponds the curvature of the edge that defines the opening in the upper surface of the die and intersects with said path. This may be regarded as another way of expressing the same characteristic as defined in the previous paragraphs, but by connecting the shape of said edge to the shape of the punch rather than to the shape of a green body to be formed. The edge that

defines said opening is not necessarily exactly identical to the curvature of said punch edge in order to enable the formation of said path and/or it could have a larger amplitude than the punch edge.

[0020] Alternatively the curvature of the edge that defines the opening in the upper surface of the die and, thereby, the profile of the path may be adapted to and resemble the shape of the abutment surface of the punch rather than just the curvature of the punch edge, for the purpose of accomplishing a more uniform or symmetric density distribution in the green body.

[0021] The profile of said path may deviate substantially from the shape of the upper surface of the green body to be compacted due to several reasons. For example, in cases in which a press tool member by means of its mere presence and/or geometry obstructs powder from flowing freely to all regions in the die cavity to be filled, and in those cases when the obstructed regions might be poorly filled, the profile of said path, and the curvature of said edge that defines the upper opening of the upper surface of the die may differ substantially from the shape of the upper surface of the green body to be compacted and from the curvature of the upper edge of the green body to be compacted, since the profile of said path and of the edge that defines said opening are designed in order to compensate for the poor filling caused by the obstructing press tool member.

[0022] According to one embodiment, said die is subdivided into a first lower die part and a second upper die part, and said upper surface of the die that comprises said path is an upper surface of the second upper die part.

[0023] According to one embodiment, the lower die part may be the die part that, together with an abutment surface of the upper punch and, preferably, an abutment surface of a lower punch, introduced into the lower die from a position below the lower die, defines the cavity that determines the geometry of the green body. Said upper die part is provided with said path in an upper surface thereof. During powder-filling, the die parts are contiguously arranged and the powder is introduced into the die through an upper opening covered by said path in the upper die part and up to the level defined by the edge that defines the upper opening of the upper die part. After compaction, the upper die part may be removed from the lower die part for the purpose of facilitating removal of the compacted green body out of the first die part. According to an alternative embodiment, the lower die part, the upper die part, provided with said path, an upper punch and a lower punch define the cavity that determines the geometry of the green body to be compacted. Typically, the green body will have a waist, of larger dimension than the rest of the green body and that is defined by the intersection between the lower die part and the upper die part. During powder-filling, the die parts are contiguously arranged and the powder is introduced into the die through the upper opening covered by said path in the upper die part and up to the level defined by an edge that defines said upper opening.

[0024] According to an alternative embodiment, the die is subdivided into a first lower die part and a second upper die part that are removable from each other, wherein said upper surface of the die that comprises said path is an upper surface of the first lower die part. The lower die part may be the die part that, together with an abutment surface of the upper punch and an abutment surface of a lower punch, introduced into the lower die from a position below the lower die, defines the cavity that determines the geometry of the compacted green body. During powder-filling, the die parts are separated and the powder is introduced by means of a powder-filling device as previously disclosed into the die through an upper opening covered by said path of the lower die part and up to the level defined by the edge that defines the upper opening of the lower die part. The upper die part may have a corresponding path on its lower surface, such that it may be in alignment with the lower die part and contiguously arranged in relation thereto during the subsequent compaction procedure. The die parts are joined such that they are contiguously arranged and the compaction is effected by displacement of the upper punch downwards through the upper die part and into the lower die part. A lower opening of the upper die part may be smaller than the upper opening of the lower die part, such that, during compaction, a thin rim formed by a lower surface of the upper die part overlaps said upper opening of the lower die part around said upper opening. The edge that defines said upper opening of the lower die part may have a curvature corresponding to the curvature of an upper edge of the green body. Typically, the inner peripheral surface of the lower die part widens towards said upper opening thereof. During compaction the upper punch is forwarded only a very short distance into the lower die part until a punch edge of the punch is very close to the inner peripheral surface of the lower die part. After compaction, the upper die part may be removed from the lower die part for the purpose of facilitating removal of the compacted green body out of the first die part. In this case, an important advantage of the invention is the enablement of a less complicated press tool design, possibly combined with the advantage of promoting improved density distribution and/or density distribution symmetry in the green body.

[0025] According to yet another alternative, in which the die is subdivided into a first lower die part and a second upper die part that are removable from each other, wherein said upper surface of the die that comprises said path is an upper surface of the first lower die part, the green body will have a waist of larger dimension than the rest of the green body, said waist being defined by the intersection between the lower die part and the upper die part when these are contiguously arranged.

[0026] During powder-filling, the die parts are separated and the powder is introduced into the die through said upper opening covered by said path of the lower die part and up to the level defined by the edge that defines the upper opening of the lower die part covered by said path.

A lower opening of the upper die part comprises an edge with a curvature corresponding to the curvature of the edge that defines the upper opening in the upper surface of the lower die part. The upper die part may have a corresponding path on its lower surface, such that it may be in alignment with the lower die part and contiguously arranged in relation thereto during the subsequent compaction procedure.

[0027] If profile filling in accordance with the teaching of the invention is not being applied as suggested here, filling the upper opening covered by said path of the lower die part will result in leakage of powder and obstruct the die parts from being contiguously arranged. The powder filling could also be performed through an upper opening of the upper die part, something that may necessitate a more complicated press tool design.

[0028] The object of the invention is also achieved by a method of compacting powder into a cutting insert green body, comprising the steps of,

- providing a device according to the invention, as defined hereinbefore or hereinafter,
- positioning the powder-filling device at said laterally offset position on the upper surface of the die such that said profile of the path of the bottom surface of the powder-filling device is in alignment with said predetermined non-planar profile of the path of the die,
- forwarding the powder-filling device to the upper opening of the die by way of sliding along said path of the upper surface of the die, filling powder into the die,
- removing the powder-filling device from said upper opening by way of sliding along said path of the die, and
- compacting the powder in the die by means of said punch.

[0029] According to one embodiment, the die is subdivided in a first lower die part and a second upper die part that are removable from each other, and said upper surface of the die that comprises said path is an upper surface of the first lower die part, wherein the method comprises the further steps of removing the second upper die part from the first lower die part before filling powder into the first lower die part, and placing the second upper die part on the first lower die part before compacting the powder by means of said punch.

[0030] Further features and advantages of the present invention will be presented in the following detailed description and the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

[0031] Embodiments of the present invention will now be described more in detail with reference to the annexed drawing, on which:

Fig. 1a is a cross section of parts of a device for

compaction of powder into cutting insert green bodies, according to prior art,

Fig. 1b a view from above of a cutting insert green body produced by means of the device shown in fig. 1a,

Fig. 2 is a cross section corresponding to that of fig. 1, showing parts of a compaction device according to an embodiment of the invention,

Fig. 3a is a perspective view of parts of a compaction device according to one embodiment of the invention,

Fig. 3b is a cross-section of parts of the device shown in fig. 3a, separated from each other,

Fig. 3c is a cross-section corresponding to IIIc-IIIc in fig. 3a

Fig. 4a, is a perspective view of parts of a compaction device according to one embodiment of the invention,

Fig. 4b is a cross-section of parts of the device shown in fig. 4a, separated from each other,

Fig. 4c is a cross-section corresponding to IVc-IVc in fig. 4a,

Fig. 5 is cross section corresponding to that of fig. 2, but showing a modified version of the embodiment shown in fig. 2,

Fig. 6 is a cross section corresponding to that of figs. 1a, 2 and 5, but showing a further embodiment of the invention,

Figs. 7 and 8 and 9 are an alternative embodiment of a compaction device according to the invention shown in perspective and/or cross section views,

Fig. 10a shows a cross section of a further alternative embodiment of a compaction device according to the invention,

Fig. 10b is a representation of a green body compacted by means of the compaction device shown in fig. 10a,

Fig. 11 shows a cross section of another embodiment of a compaction device according to the invention,

Fig. 12a shows the compaction device shown in fig. 11 in a position ready for filling of powder into the die thereof,

Fig. 12b is a representation of a green body compacted by means of the compaction device shown in fig. 11, and

Fig. 13 shows the principle of how to adapt the orientation of the die cavity geometry in order to enable profile filling in accordance with the teaching of the present disclosure for a specific green body geometry

DETAILED DESCRIPTION OF THE INVENTION

[0032] Fig. 1a shows essential parts of a compaction device according to prior art, suitable for the pressing of powder into cutting insert green bodies. The compaction device comprises a die 1, an upper punch 2 and a lower punch 3. The die 1 defines a hollow space into which the upper punch 2 is introduced from above and the lower punch 3 is introduced from below. When powder, here indicated with 5, is introduced into the die 1, this is usually done by means of a powder-filling device (not shown) which slides on an upper surface of the die 1 to a position above an upper opening therein and fills a die cavity defined by the die 1 and the lower punch 3 up to the level of the upper surface of the die 1, as shown in fig. 1a. In fig. 1a there is also indicated the geometry of a green body, here indicated with 6, and the position that the latter will take in the die 1 when the powder 5 is compacted through a downward motion of the upper punch 2 and upward motion of the lower punch 3 from the respective positions thereof shown in fig. 1a. Before introduction of the upper punch into the die 1, the lower punch 3 is normally retracted slightly downwards, such that the upper surface of the column of powder is lowered in relation to an upper surface of the die 1. The geometry of the green body shown in fig. 1a, is further shown in fig. 1b.

[0033] In this specific example shown in fig. 1a the ratio between the total height of the powder columns at section A and B (H) and the final height of the compacted green body at A and B (h_A , h_B) varies approximately from 2.5 at A ($H/h_A=2.5$) to 1.7 at B ($H/h_B=1.7$). Section A will thus obtain a relative high density and section B a relative low density, all because the powder-filling device leaves a powder column with a flat top surface behind after filling the die cavity.

[0034] The present invention suggests a way of reducing/suppressing the density variations of prior art upon compaction of powder into a cutting insert green body by using a filling method and device hereinafter named a *profile filling method and device*. By using the profile filling method by means of a custom designed powder-filling device, die table (optional) and die, the powder can be shaped into a specific profile using standard filling movements of a press. The profile can be chosen in such a way that the powder columns at section A, B and anywhere else along the insert obtain the same or similar compaction ratio, thereby significantly uniforming the density distribution in the green body.

[0035] Fig. 2 shows a cross section of essential parts of a compaction device according to an embodiment of the present invention, aimed for the pressing of powder into cutting insert green bodies. The shown parts may be identical to those shown in fig 1a in the sense that they are able of forming a green body of corresponding shape. The characterising difference is the design of the upper surface of the die, which however only reveals itself in fig. 2 by the fact that the column of powder shown therein has a different shape than in fig. 1a. However, in order to clarify that the parts shown in fig. 2 belong to a device according to the present disclosure, they are given other numbers. Thus, there is a die 7, an upper punch 8 and a lower punch 9. As can be seen, the powder 10 is shaped into a predetermined profile. The profile is chosen such that each of the sections A, B and anywhere else along the insert obtain the same or similar compaction ratios ($H_A/h_A=H_B/h_B=2.5$). Crucial for the generation of the predetermined shape of the powder column is the shape of the upper surface of the die, as will be seen in fig. 3a. The green body 11 may have the same geometry as the green body 6 shown in fig. 1a, since the inner peripheral surface of the die 7 that, together with the upper punch 8 and the lower punch 9, defines the cavity which defines the shape of the green body 11 is the same as the one shown in fig. 1a.

[0036] Fig. 3a is another figure showing essential parts of the compaction device according to an embodiment of the invention shown in fig. 2. The device presents features that make it suitable for forming the profile of the powder shown in fig. 2. Accordingly, the compaction device shown in figs. 2 and 3a-c comprises a die 7 for receiving powder 10, at least one punch (here at least the upper punch 8) for compacting said powder 10 received by said die 7 (the punches are though not shown in fig. 3a-c), and a powder-filling device 12 for filling powder into the die 7. In an upper surface 13 thereof, the die 7 comprises an upper opening 14 through which said powder 10 is introduced into the die 7 and through which said punch 8 shown in fig. 2 may be forwarded into the die 7 for the purpose of compacting powder 10 introduced into the die 7. The opening 14 is defined by an edge 15 that presents a curvature other than planar. The upper surface 13 of the die 7 presents a path that, at least in one direction x, extends rectilinearly from a laterally offset point on said upper surface 13 to said upper opening 14 and covers said upper opening 14 and intersects said edge 15 that defines said upper opening 14, wherein said path has a predetermined non-planar profile in a cross section perpendicularly to said direction x, and wherein the powder-filling device 12 has a bottom surface that at least partially presents a profile corresponding to said non-planar profile. At least a part of said path may be defined by a rim or the like, as shown in fig. 3a, that extends in said direction x and may be removable from the upper surface of the die 7, for possible exchange thereof. In fig. 3a, there is also shown a die table 16 that surrounds the die 7 and works as a further support sur-

face for the powder-filling device 12. Preferably, the upper surface of the table 16 is in alignment with the upper surface 13 of the die 7. The table 16 presents an extension of said path on the upper surface 13 of the die 7, thereby enabling further sliding of the powder-filling device 12 away from the die 7. Depending on the design of the die 7, the presence of the table 16 is optional.

[0037] The powder-filling device 12 has a bottom surface 17 (see fig. 3b) with a path that extends rectilinearly in one direction and which has a profile in a cross-section perpendicular to said direction that corresponds to the predetermined non-planar profile of said path of the upper surface 13 of the die 7. The powder-filling device 12 has a bottom opening 18 for discharge of powder into the die 7, and said path of the bottom surface 17 covers said bottom opening 18.

[0038] When powder is to be filled into the die 7 through the upper opening 14 thereof, the powder-filling device 12 is positioned on the path of the die 7 such that the path of the bottom surface 17 of the powder-filling device 12 overlaps and is in alignment with the path of the die 7 in said direction x (see fig. 3c). The powder-filling device 12 is slid along the path of the die 7 in said direction x to a position in which the opening 18 in the bottom surface 17 thereof overlaps the upper opening 14 of the die 7, and powder is filled into said upper opening at least to the level of the edge 15 that defines said upper opening. Then the powder filling device 12 is removed from the upper opening 14 of the die by means of sliding along said path on the upper surface of the die 7, either backwards towards the offset position from which it started or forwards, if the path on the upper surface 13 of the die 7 continues beyond the upper opening 14. The powder-filling device 12 leaves behind it an upper surface 13 of the die 7 that is practically free from powder, except for the opening 14, which is has powder up to a level that is in alignment with said path on the upper surface 13 of the die 7. Thus the powder column will have an upper surface with a profile corresponding to the profile of said path, which may be the profile shown fig. 2. The upper opening 14 of the die is now exposed for introduction of the upper punch 8 from above for the purpose of compacting powder. Before the upper punch 8 is introduced into the upper opening 14, a lower punch introduced from below into the die may be retracted downwards such that the powder in the die is displaced downwards, and the upper surface of powder is lowered to a position not in alignment but below the level of said path of the upper surface of the die. Thereby, the upper punch is enabled to enter the die without immediately pressing powder out of the die. However, the above-mentioned profile of the upper surface of the powder is maintained after said lowering thereof.

[0039] Traditionally, the bottom opening of the powder-filling device 12 would have a size that is larger than the size of the upper opening in the die, at least in a direction perpendicular to said direction x. However, in order to further suppress the risk of having remaining powder on

the upper surface 13 of the die 7 after removal of the powder-filling device 12 from the filling position thereof to a laterally offset position, it is also suggested, as an alternative, that, at least in a direction perpendicular to the direction x, the bottom opening 18 of the powder-filling device 12 has a size that is equal to or smaller than the size of the upper opening 13 in the die 7 (see fig. 3b and 3c). It is preferred that a region around said bottom opening 18 in the bottom surface 17 of the powder-filling device 12 has a curvature corresponding to the curvature of the edge 15 that defines the upper opening 14 in the upper surface 13 of the die 7, such that the bottom surface 17 of the powder-filling device 12 will be in sealing relation with said edge 15 of the opening 14 in the upper surface 13 of the die 7 when the powder-filling device 12 is in an operative position on the die 7 in which powder is filled into the die 7.

[0040] Figs. 4a-4c shows an alternative embodiment for the compaction of an alternative green body (not shown) of the compaction device shown in figs. 3a-c, in which said edge that defines the opening in the upper surface of the die, the path of the upper surface of the die and the path of the lower surface of the powder-filling device have a different profile than in the embodiment shown in figs. 3a-c, such that the profile of upper surface of the column of powder after powder-filling will be different from the one shown in fig. 2. However, since the components, apart from that difference, are identical to those shown in figs. 3a-c, they are given the same reference numbers as those in figs. 3a-c added with the symbol '.

[0041] In practice, it is probably not possible to give the whole profile of the upper surface of the power column the theoretically correct shape due to complex green body design features, collapse of steep profile slopes, collapse of sharp profile corners, etc. However, a modified profile, compensated for the possible issues mentioned above, should still give a significant improvement regarding density distribution. Fig. 5 is a representation of an alternative to the profile shown in fig. 2. The punches are identical to those shown in fig. 2, and are thus given the same reference numbers as those in fig. 2. The die is however different from the die 7 shown in fig. 2 in that it has an edge that defines an upper opening thereof that is different from that of fig. 1 in the respect that it has a curvature that will result in the profile shown in fig. 5. The die is therefore given the reference number 19. The path in the upper surface of the die has profile perpendicularly to said direction x that corresponds to the profile of the upper surface of the powder column shown in fig. 5, and the powder-filling device has a path on its bottom surface with a corresponding profile, all in accordance with the essential teaching of the invention.

[0042] Fig. 6 shows a further embodiment in which the die is subdivided into a first lower die part 7a and a second upper die part 7b, and said upper surface 13 of the die that comprises said path is an upper surface 13 of the

second upper die part 7b. The reasons for using a die subdivided into a lower die part and an upper die part may be diverse and the upper die part may be arranged so as to be displaced relative to the lower die part during the pressing operation or not. One reason may be as follows: The length of the upper negative section of a compaction tool for positive inserts is here indicated with HvN. It is of interest to be able to change this length, because a fixed length could limit the possibility to optimize the press cycle for powders with different filling properties that result in relatively large fill heights. In the case of profile filling, the relatively cheap wear plate that forms an upper die part 7b of the die potentially could be manufactured in a variety of heights (HvP), giving the possibility to optimize the HvN dimension.

[0043] There may be further and other reasons for using a die which is subdivided into a lower die part and an upper die part. Figs. 7 and 8 and 9 show an embodiment of such a device which comprises a die comprised by a lower die part 20 and an upper die part 21. There is also provided a lower punch 22 and an upper punch 23. The upper die part 21 comprises an upper surface 24 which comprises an opening 25 defined by an edge 26 which is non-planar. On the upper surface 24 there is provided a path which extends rectilinearly in direction x and has a predetermined non-flat profile perpendicular to said direction. The path overlaps the upper opening 25 and intersects the edge 26. In accordance with the teaching of the invention, the device should be provided with a powder-filling device (not shown) that has a lower surface with a path with a profile corresponding to the profile of the upper surface 24 of the upper die part 21, such that it can fit into the path of the upper surface 24 of the upper die part 21. Powder is introduced into the die by means of the powder-filling device in accordance with the teaching already described. In connection to compaction of powder introduced into a cavity defined by the lower punch 22, the lower die part 20 and the upper die part 21, the upper punch 23 is introduced into the upper die part 21 through the opening 25 and forwarded such a distance into the lower die part 20 that a lower edge of the upper punch 23 is so close to the sloping inner peripheral surface of the lower die part 20 that the green body is defined by an upper surface of the lower punch 22, the inner peripheral surface of the lower die part 20 and a lower surface of the upper punch 23. Above the level to which the lower lateral edge 27 of the upper punch 23 is forwarded there will be a space which is not occupied by the green body but will have the function of a release portion that permits lateral expansion of the green body as the latter is taken out of the lower die part. Before taking out the green body from the lower die part 20, the upper die part 21 is removed from the lower die part 20, such that the green body only has to pass a release portion defined by the inner peripheral surface of the lower die part 20 above said level, and not pass through a punch channel provided in the upper die part 23.

[0044] Figs. 9 is a further view of the device for compaction of powder to a green body shown in figs. 7 and 8.

[0045] Fig. 10a shows an embodiment according to which, as an alternative to powder-filling through an upper opening in the upper flat surface of an upper die part which can be flat enabling filling with a standard filling device with a lower flat surface, powder-filling may be done through an upper opening 28 in the upper surface 29 of the lower die part 30. A path in accordance with the general teaching of the present invention is then arranged in the upper surface 29 of the lower die part 30, and the device comprises a powder-filling device 31 with a lower surface that presents a corresponding path or cross-section in accordance with the general teaching of the present invention and is arranged to be slid from a laterally offset position to a powder filling position along said path of the lower die part 30. An upper die part 32 may, preferably, have a corresponding path on its lower surface, such that it may be in alignment with the lower die part 30 and contiguously arranged in relation thereto during the subsequent compaction procedure in which an upper punch 33 is forwarded through the upper die part 32 into the lower die part 30. The upper die part 32 is removable from the lower die part 30, and removed from the latter during said powder-filling, and contiguously arranged in relation thereto during compaction. During powder-filling, a lower punch is retracted downwards in order to enable receipt of the amount of powder needed for the subsequent compaction. Prior to the compaction, the lower punch is forwarded upwards to transfer some of the powder into the upper die part 32 before the powder is compacted by both the upper punch 33 and the lower punch.

[0046] After compaction, the upper die part 32 is once again removed from the lower die part 30 in order to enable ejection of the compacted green body, indicated with 34 in fig. 10b, from the lower die part 32 through the upper opening 28 in the upper surface 29 thereof. The compacted green body 34 has an upper lateral edge 35 that has a curvature corresponding to the curvature of an edge that defines the upper opening 28 in the upper surface 29 of the lower die part 30.

[0047] In accordance with the teaching of figs. 11, 12a and 12b the present invention may also be applied to cases in which the die is subdivided into a lower die part 36 and an upper die part 37 and in which the cavity 38 that defines the shape of the compacted green body is defined by an upper surface of a lower punch 39, the lower surface of an upper punch 40 and the inner peripheral surfaces of both the lower and the upper die parts 36, 37. Typically, the intersection line 41 between an upper opening in the lower die part and a lower opening in the upper die part defines a waist of maximum width of the green body 42 to be compacted. The compacted green body 42 is shown in fig. 12b. An upper surface 43 of the lower die part 36 is provided with an opening 44 through which powder is introduced into the die by means of a powder-filling device 45. A path in accordance with

the general teaching of the invention defined hereinbefore is provided in said upper surface 43, as well as an upper opening 44. A powder-filling device 45 according to the teaching of the present invention is arranged for the filling of powder into said opening. During powder-filling, the upper die part 37 is separated from the lower die part 36 to enable the powder-filling device 45 to slide on and along said path to its powder-filling position above the opening 44 in upper surface 43. The lower punch 39 is temporarily retracted downwards to enable receipt of the amount of powder necessary for the subsequent compaction. Prior to the compaction the lower punch 39 is forwarded upwards to transfer some of the powder into the upper die part 37 before the powder is compacted by both the upper punch 40 and the lower punch 39.

[0048] After completed powder-filling, the powder-filling device 45 is removed from said opening 44 by sliding along said path, and the upper die part 37 is positioned contiguously on top of the lower die part 36. During compaction, the upper punch 33 is moved towards the upper opening 44 in the lower die part 36 and towards the space that will define said cavity 38.

[0049] As a further alternative, said path could instead be arranged in the upper surface of the upper die part, and the powder-filling device could be arranged to fill powder into the die from an opening in the upper surface of the upper die part, provided that the upper punch is able to be removed sufficiently upwards to enable such powder-filling.

[0050] Fig. 13 shows a cutting insert produced from a green body, such as the green body by way of sintering, wherein it is obviated that the invention, in order to be realised, may require a specific positioning of said path on the upper surface of the die in relation to a specific geometry of a green body which is defined by an inner peripheral surface of the die. Initially it may not be obvious that the insert shown in fig. 13 is a candidate for the filling method according to the present invention. However, by changing the orientation of the insert (i.e. the cavity that defines the geometry of the green body to be produced in the die) with approximately 60 degrees it is apparent that this geometry could benefit from profile filling (see figure 13).

Claims

1. A device for manufacturing a cutting insert green body (6, 11) by compacting a powder (10), said device comprising:

- a die (7; 7'; 7a, 7b; 19; 20, 21) for receiving said powder (10)
- at least one punch (8; 23) for compacting said powder (10) received by said die (7; 7'; 7a, 7b; 19; 20, 21), and
- a powder-filling device (12; 12') for filling powder (10) into the die (7; 7'; 7a, 7b; 19; 20, 21),

- wherein, in an upper surface (13; 13'; 24) of at least one part of the die (7; 7'; 7a, 7b; 19; 20, 21), the die comprises an upper opening (14; 14'; 25) through which said powder (10) is introduced into the die (7; 7'; 7a, 7b; 19; 20, 21) and through which or towards which said punch (8; 23) may be forwarded into the die (7; 7'; 7a, 7b; 19; 20, 21) for the purpose of compacting powder (10) introduced into the die (7; 7'; 7a, 7b; 19; 20, 21),

- wherein said upper opening (14; 14'; 25) is defined by an edge (15; 15'; 26) that presents a curvature other than planar, **characterised in that** the upper surface (13; 13'; 24) of the die (7; 7'; 7a, 7b; 19; 20, 21) presents a path that, in one direction (x), extends rectilinearly from a laterally offset point on said upper surface (13; 13'; 24) to said upper opening (14; 14'; 25) and covers said upper opening (14; 14'; 25) and intersects said edge (15; 15'; 26) that defines said upper opening (14; 14'; 25), wherein said path has a non-planar profile in a cross section perpendicularly to said direction (x), and that the powder-filling device (12; 12') has a bottom surface (17, 17') that at least partially presents a profile corresponding to said non-planar profile of said path.

2. A device according to claim 1, **characterised in that** the powder-filling device (12; 12') has a bottom surface (17, 17') with a path that extends rectilinearly in said direction (x) and which has a profile in a cross-section perpendicular to said direction (x) that corresponds to the predetermined non-planar profile of said path of the upper surface (13; 13'; 24) of the die (7; 7'; 7a, 7b; 19; 20, 21).

3. A device according to claim 2, **characterised in that**, in the bottom surface (17, 17') thereof, the powder-filling device (12; 12') has a bottom opening for discharge of powder (10) into the die (7; 7'; 7a, 7b; 19; 20, 21), and that said path of the bottom surface (17, 17') covers said bottom opening.

4. A device according to claim 3, **characterised in that**, at least in a direction perpendicular to said direction x, the bottom opening of the powder-filling device (12; 12') has a size that is larger than the size of the upper opening (14; 14'; 25) in the die (7; 7'; 7a, 7b; 19; 20, 21).

5. A device according to claim 3, **characterised in that**, at least in a direction perpendicular to said direction x, the bottom opening of the powder-filling device (12; 12') has a size that is equal to or smaller than the size of the upper opening (14; 14'; 25) in the die (7; 7'; 7a, 7b; 19; 20, 21).

6. A device according to claim 5, **characterised in that** a region around said bottom opening in the bottom surface (17, 17') of the powder-filling device (12; 12') has a curvature corresponding to the curvature of the edge (15; 15'; 26) that defines the upper opening (14; 14'; 25) in the upper surface (13; 13'; 24) of the die (7; 7'; 7a, 7b; 19; 20, 21), such that the bottom surface (17, 17') of the powder-filling device (12; 12') will be in sealing relation with said edge (15; 15'; 26) of the opening in the upper surface (13; 13'; 24) of the die (7; 7'; 7a, 7b; 19; 20, 21) when the powder-filling device (12; 12') is in an operative position on the die (7; 7'; 7a, 7b; 19; 20, 21) in which powder (10) is filled into the die (7; 7'; 7a, 7b; 19; 20, 21).
7. A device according to any one of claims 2-6, **characterised in that** the powder-filling device (12; 12') is arranged so as to slide above and along said path of the upper surface (13; 13'; 24) of the die (7; 7'; 7a, 7b; 19; 20, 21) in said direction (x) in which said path of the upper surface (13; 13'; 24) of the die (7; 7'; 7a, 7b; 19; 20, 21) extends rectilinearly from said laterally offset point to said upper opening (14; 14'; 25) and to fully overlap said opening, wherein said path of the powder-filling device (12; 12') is arranged opposite to the path of the upper surface (13; 13'; 24) of the die (7; 7'; 7a, 7b; 19; 20, 21) and extends rectilinearly in the direction (x) in which the path of the upper surface (13; 13'; 24) of the die (7; 7'; 7a, 7b; 19; 20, 21) extends rectilinearly.
8. A device according to claim 7, **characterised in that** the path of the powder-filling device (12; 12') is arranged so as to be in supporting contact with said path of the die (7; 7'; 7a, 7b; 19; 20, 21) in connection to said sliding of the powder-filling device (12; 12') on the upper surface (13; 13'; 24) of the die (7; 7'; 7a, 7b; 19; 20, 21).
9. A device according to any one of claims 1-8, **characterised in that** the curvature of said edge (15; 15'; 26) that defines the upper opening (14; 14'; 25) in the upper surface of the die (7; 7'; 7a, 7b; 19; 20, 21) corresponds to a curvature of an upper edge of a green body (6) to be compacted in said die (7; 7'; 7a, 7b; 19; 20, 21).
10. A device according to any one of claims 1-9, **characterised in that** said punch (8; 23) comprises an abutment surface for abutment with the powder (10) to be compacted, and an outer peripheral surface, and a punch edge at the intersection between the abutment surface and the outer peripheral surface, wherein the punch edge extends with a predetermined curvature around the circumference of the punch (8; 23), which curvature corresponds to the curvature of the edge (15; 15'; 26) that defines the upper opening (14; 14'; 25) in the upper surface (13; 13'; 24) of the die (7; 7'; 7a, 7b; 19; 20, 21).
11. A device according to any one of claims 1-10, **characterised in that** said die (7; 20, 21) is subdivided into a first lower die part (7a; 20) and a second upper die part (7b, 21), and said upper surface of the die that comprises said upper opening and said path is an upper surface of the second upper die part (7b; 21).
12. A device according to claim 11, **characterised in that** said die is subdivided into a first lower die part (30; 36) and a second upper die part (32; 37) that are removable from each other, and said upper surface of the die part that comprises said path is an upper surface (29; 43) of the first lower die part (30; 36).
13. A method of compacting a powder (10) into a cutting insert green body (6), comprising the steps of,
- providing a device according to any one of claims 1-14,
 - positioning the powder-filling device (12; 12') at said laterally offset position on the upper surface (13; 13'; 24) of the die (7; 7'; 7a, 7b; 19; 20, 21) such that said profile of the path of the bottom surface (17, 17') of the powder-filling device (12; 12') is in alignment with said predetermined non-planar profile of the path of the die (7; 7'; 7a, 7b; 19; 20, 21),
 - forwarding the powder-filling device (12; 12') to the upper opening (14; 14'; 25) of the die (7; 7'; 7a, 7b; 19; 20, 21) by way of sliding along said path of the upper surface (13; 13'; 24) of the die (7; 7'; 7a, 7b; 19; 20, 21),
 - filling powder (10) into the die (7; 7'; 7a, 7b; 19; 20, 21),
 - removing the powder-filling device (12; 12') from said upper opening (14; 14'; 25) by way of sliding along said path of the die (7; 7'; 7a, 7b; 19; 20, 21), and
 - compacting the powder (10) in the die (7; 7'; 7a, 7b; 19; 20, 21) by means of said punch (8; 23).
14. A method according to claim 13, **characterised in that** the die is subdivided in a first lower die part (30; 36) and a second upper die part (32; 37) that are removable from each other, and that said upper surface (29; 43) of the die part that comprises said path is an upper surface (29; 43) of the first lower die part (30; 36), wherein the method comprises the further steps of removing the second upper die part (32; 37) from the first lower die part (32; 36) before filling powder into the first lower die part (30; 36), and placing the second upper die part (32; 37) on the first lower die part (30; 36) before compacting the powder by

means of said punch (33; 40).

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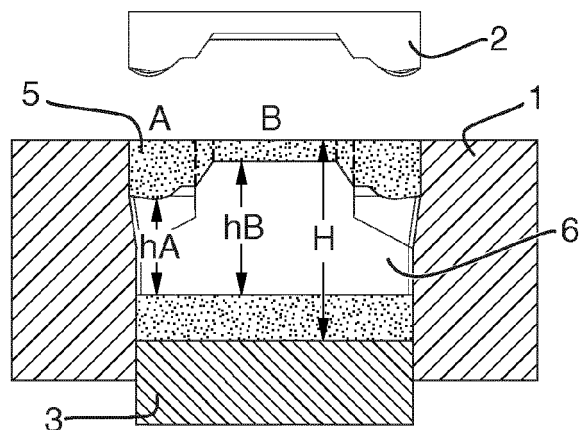


Fig 1a
Prior Art

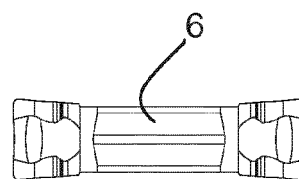


Fig 1b

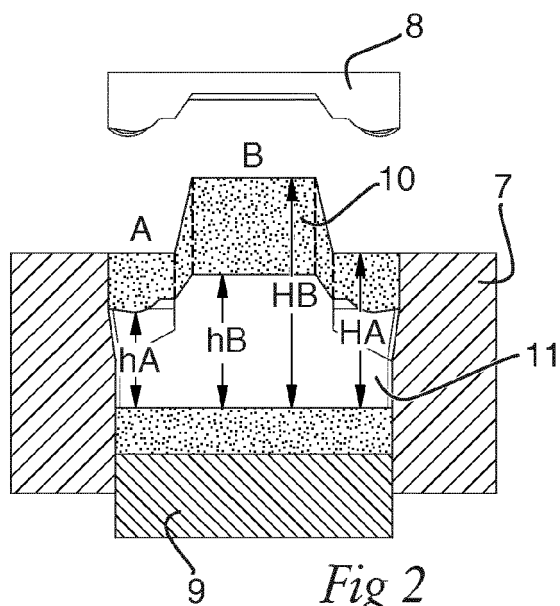


Fig 2

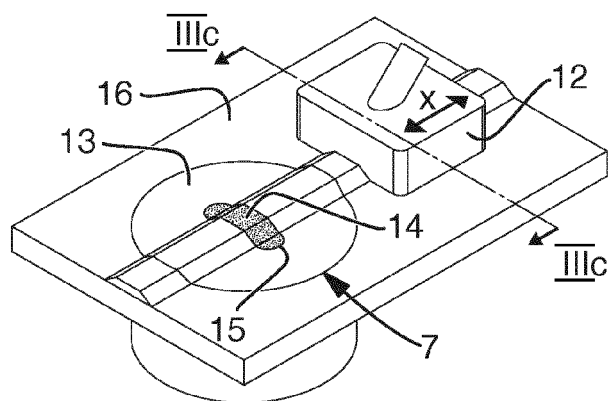


Fig 3a

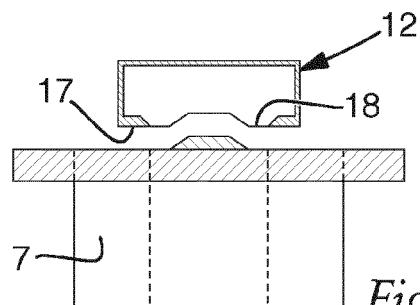


Fig 3b

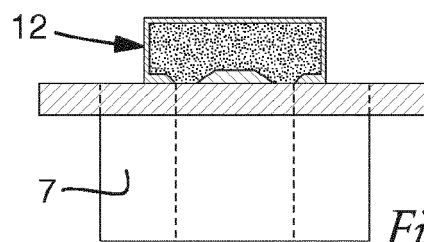
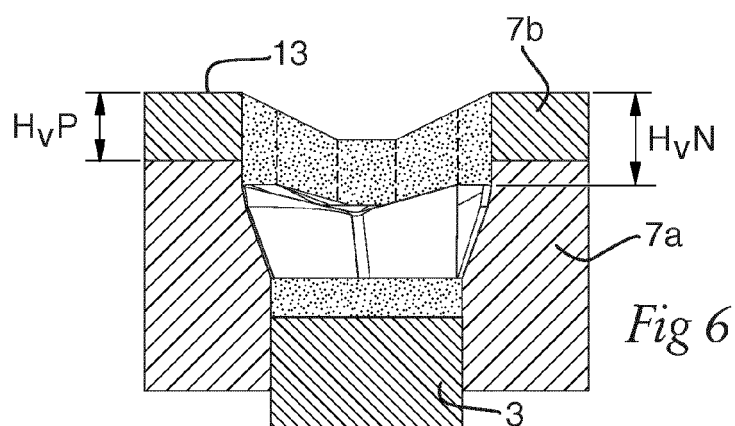
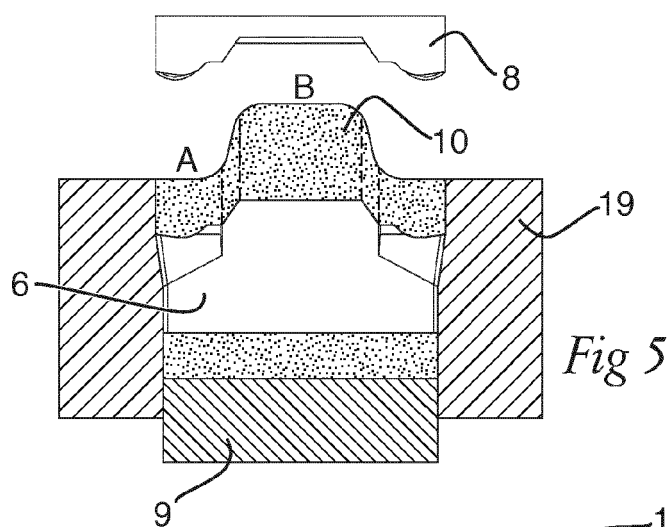
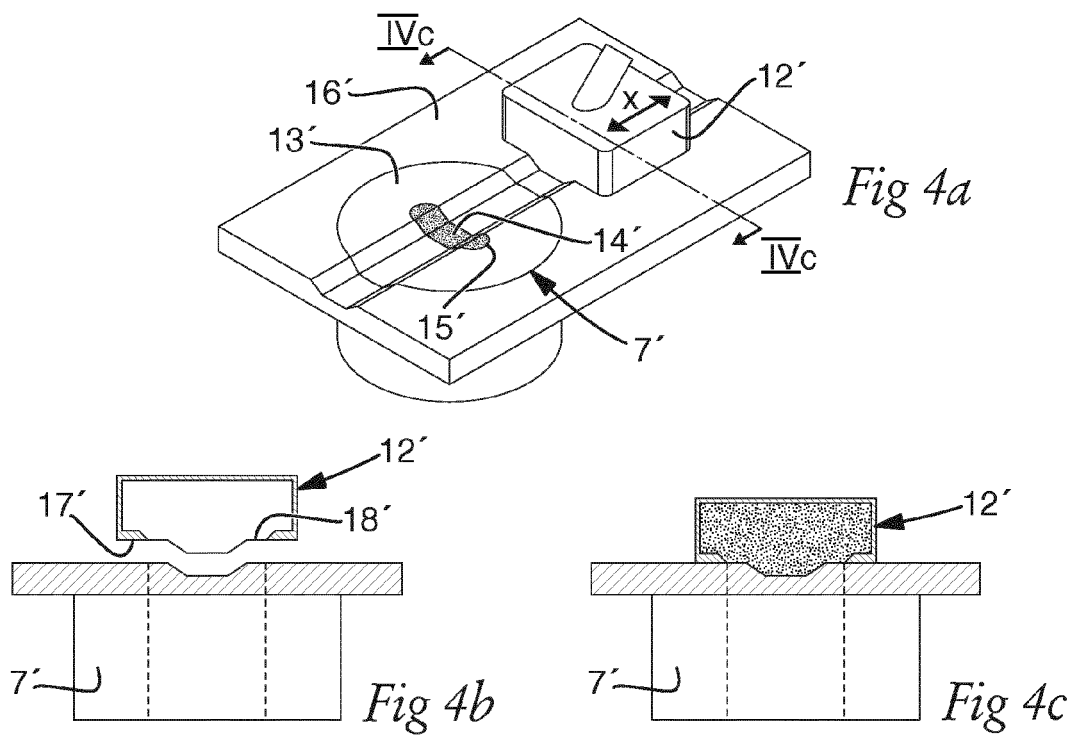
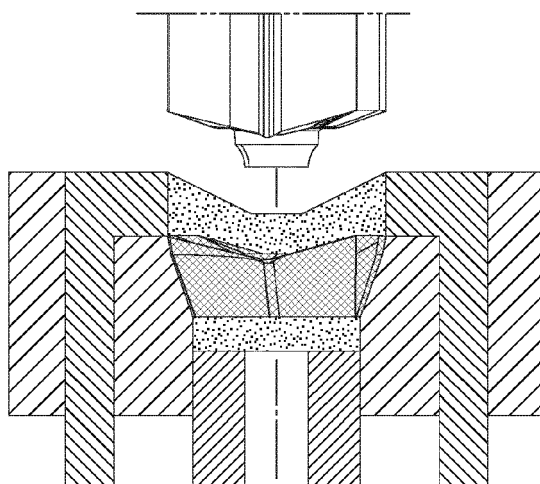
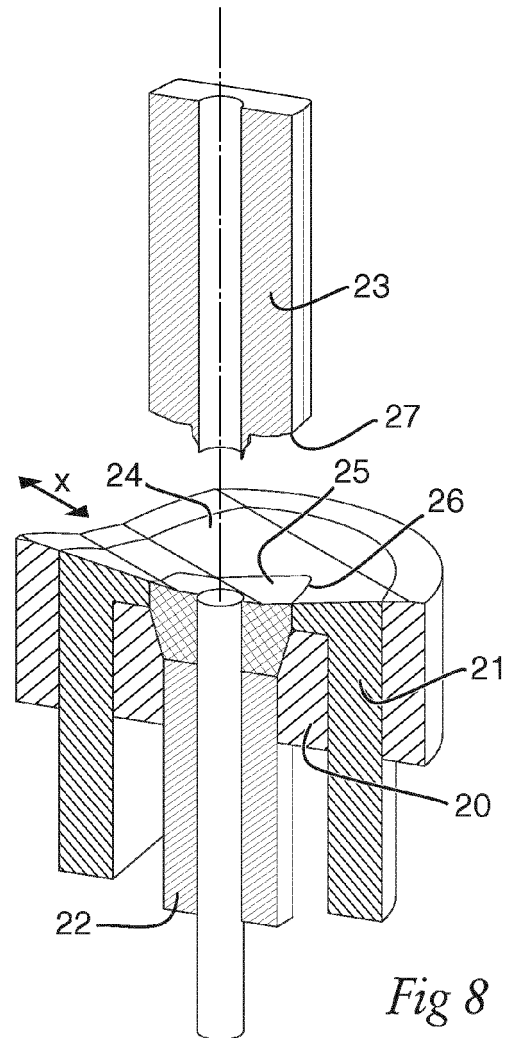
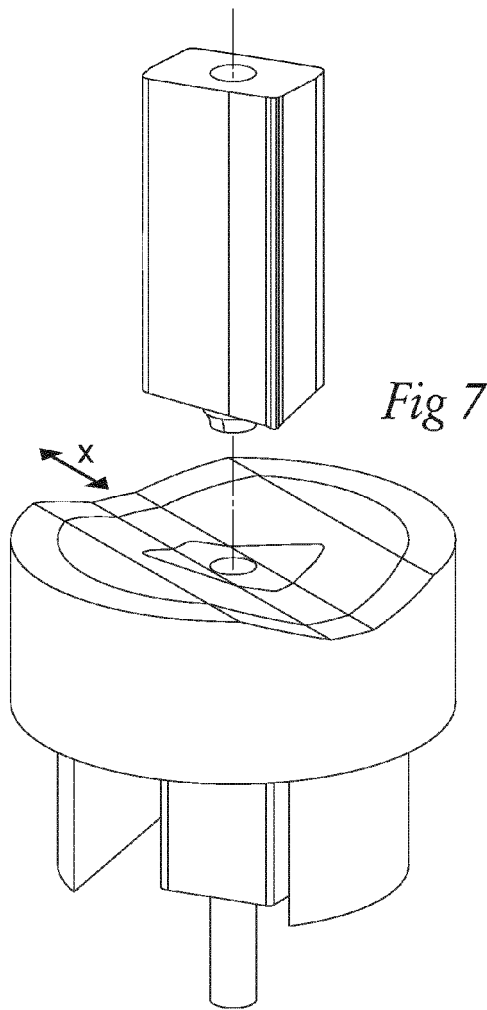


Fig 3c





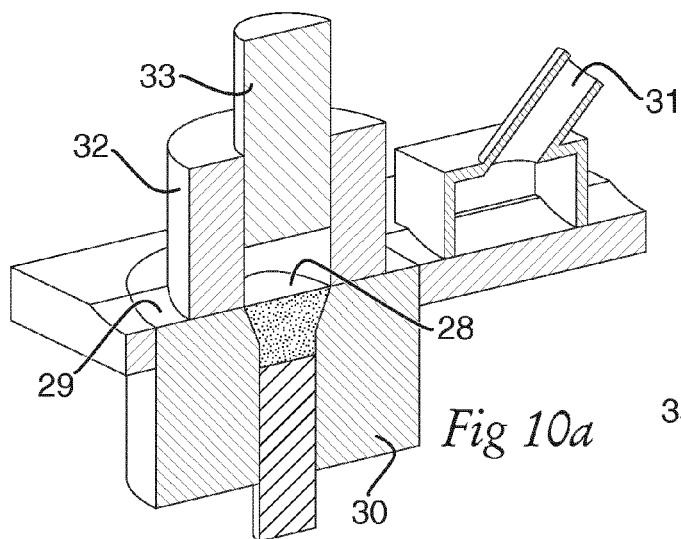


Fig 10a

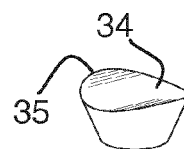


Fig 10b

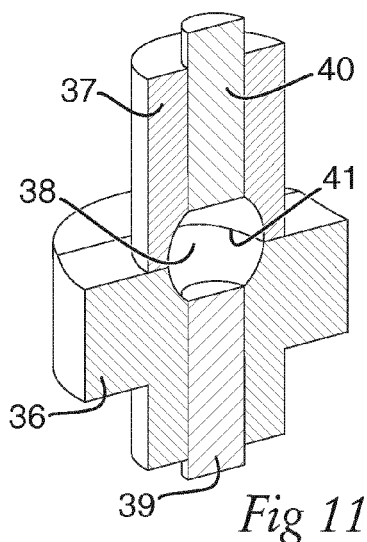


Fig 11

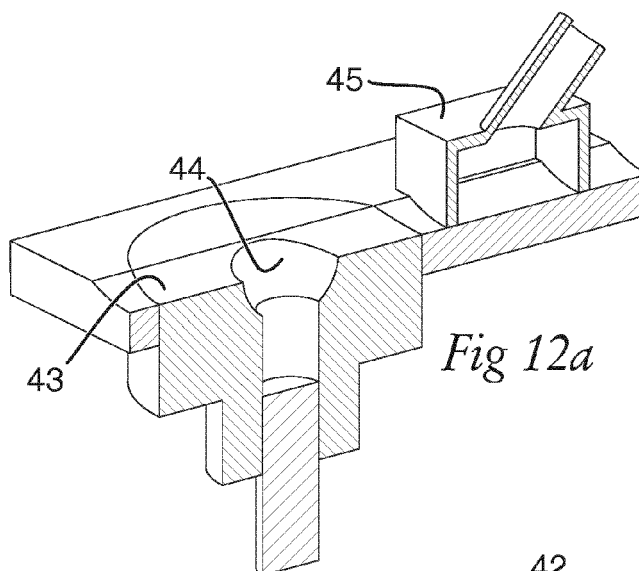


Fig 12a

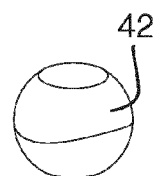


Fig 12b

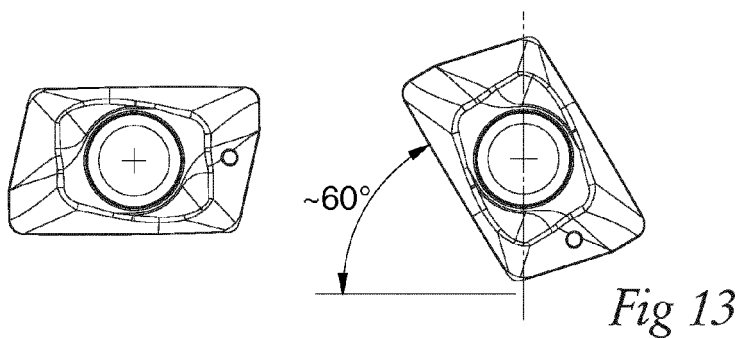


Fig 13



EUROPEAN SEARCH REPORT

 Application Number
 EP 14 19 1177

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Y	* abstract; figures 1-2 *		
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			B22F B30B B28B
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		15 April 2015	Aliouane, Nadir
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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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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