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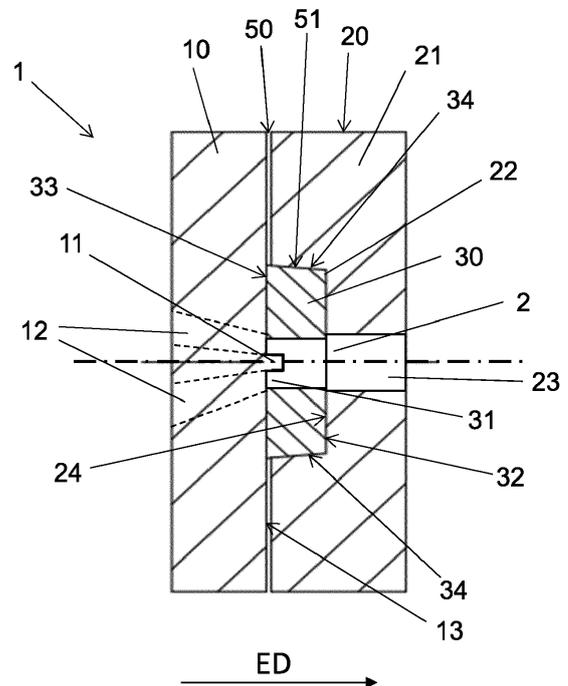
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(54) **EXTRUSION DIE**

(57) The invention relates to an extrusion die (1) having an extrusion channel (2) with an extrusion direction, comprising
a feed plate (10) defining a first part of the extrusion channel (2) to allow extrusion material to flow into the extrusion die, and
a die plate (20) defining a second part of the extrusion channel (2) comprising one or more forming openings (31) that define at least partially the shape of an extruded product,

characterized in that the die plate (20) comprises an insert (30) and an insert holder (21) with a recess (23) to receive the insert, wherein the recess (23) is arranged at a side of the insert holder facing the feed plate (10), wherein the insert (30) comprises the one or more forming openings (31), wherein the feed plate, insert and insert holder are designed to create a spacing (50) between the feed plate and the insert holder when the feed plate is pressed in the extrusion direction against the insert.

Figure 1



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Description

[0001] The present invention relates to an extrusion die to be used in the extrusion moulding of objects. The extrusion die may for example be used for extrusion of metals such as aluminium, magnesium and copper.

[0002] Extrusion of metals, such as aluminium, is a widely-used technique for forming objects with a definitive cross-sectional profile. In aluminium extrusion, a billet of aluminium/aluminium alloy is heated to a suitable temperature and placed into an extrusion machine. In the extrusion machine, the billet is pushed against an input side of the extrusion die. The aluminium is forced through the extrusion die.

[0003] In the extrusion die an extrusion channel is provided comprising one or more forming openings through which the aluminium is forced. The forming openings define at least partially the smallest cross sections of the extrusion channel and therewith normally define the shape of the extruded product.

[0004] In a known embodiment of an extrusion die, the extrusion die comprises a feed plate and a die plate. During use the feed plate and the die plate are arranged against each other, to define the extrusion channel. The feed plate may comprise a number of through-going openings to distribute the material over the cross section of the object to be extruded. The die plate comprises a number of forming openings, which alone or in combination with extensions of the feed plate may form the smallest cross-section of the extrusion die that is used to form the extruded objects.

[0005] A drawback of the known extrusion die is that the large forces that are exerted on the extrusion die by the billet results in bending of the extrusion die. This bending may be a repetitive bending of the extrusion die. As a result of this bending, the dimensions of the cross-section of the extruded object may not be as desired and vary over time. These variations in the cross-section may become larger than the tolerances of the product. This is in particular of relevance in the extrusion of products having small tolerances.

[0006] The life time of the extrusion die may also be affected by the occurrence of stress cracks that may typically occur in relative sharp corners of the forming openings of the extrusion die due to repetitive bending of the extrusion die.

[0007] It is an object of the invention to provide an extrusion die suitable for metal extrusion that shows better resistance for the forces exerted on the extrusion die during the extrusion process with respect to life time and/or product dimensions of the product to be extruded.

[0008] The invention provides an extrusion die having an extrusion channel with an extrusion direction, comprising a feed plate defining a first part of the extrusion channel to allow extrusion material to flow into the extrusion die, and a die plate defining a second part of the extrusion channel comprising one or more forming openings that define at least partially the shape of an extruded

product,

characterized in that the die plate comprises an insert and an insert holder with a recess to receive the insert, wherein the recess is arranged at a side of the insert holder facing the feed plate, wherein the insert comprises the one or more forming openings, wherein the feed plate, insert and insert holder are designed to create a spacing between the feed plate and the insert holder when the feed plate is pressed in the extrusion direction against the insert.

[0009] In accordance with the invention an insert having the one or more forming openings is arranged in a recess in the insert holder. The recess is arranged at a side of the insert holder facing the feed plate. The insert may protrude from the insert holder and/or a part of the feed plate to be brought into contact with the insert may protrude from the feed plate to create the spacing between the feed plate and the insert holder.

[0010] When during an extrusion process, a billet is pressed against the feed plate, all forces exerted by the billet on the feed plate will be guided through the insert and to will be subsequently exerted on the insert holder.

[0011] It has been found that the division of the die plate in two parts, i.e. an insert holder and an associated insert, as claimed in claim 1, wherein the forces are guided from the feed plate through the insert to the insert holder may result in substantial less bending of the extrusion die when a billet is forced through the extrusion die. This has the beneficial effects that the dimensions of the cross-section of the extruded product will be more consistent with the intended product dimensions and/or that the variance in dimensions of the cross-section of the extruded product will be smaller.

[0012] Moreover, the life time of the extrusion die may substantially increase, since the extrusion die is less subject to bending stresses.

[0013] The use of an insert has the additional advantage that the insert is exchangeable. This means that when the forming openings are damaged or worn, or when it is desired to create a product with a different cross-section, it may be sufficient to only exchange the insert instead of the whole die plate.

[0014] The feed plate may be a lead plate, only for guiding of extrusion material to the die plate, or a mandrel comprising an extension that extends into the one or more forming openings to define the smallest cross section of the extrusion channel.

[0015] In an embodiment, a thickness of the insert holder in extrusion direction is at least 1.5 times, for example at least 2 times the thickness of the insert in extrusion direction. The insert is arranged in a recess at the side of the insert holder adjacent to the feed plate. Since the forces are guided from the feed plate through the insert to the insert holder, the insert holder may bend due to the forces exerted on the insert holder. As a result of the bending, the half of the insert holder arranged at the side of the feed plate will be compressed and the insert will be firmly held by side surfaces of the recess due to

this compressed side of the insert holder. This has the advantage that there is less space/possibility for the insert to deform as a result of the forces exerted on the insert.

[0016] In an embodiment, the thickness of the insert holder in extrusion direction is maximally 3 times the thickness of the insert in extrusion direction. By maximizing the thickness of the insert holder, the insert holder can still be used in conventional extrusion machines with sufficient thickness for both the insert and the insert holder. Thereby, if the thickness of the insert holder becomes too large, the above described beneficial effect of bending of the insert holder may no longer be present.

[0017] The insert may comprise a first base surface and a second base surface and a number of side surfaces. The first base surface and the second base surface are mainly perpendicular to the extrusion direction. The side surfaces extend between the first base surface and the second base surface. Correspondingly, the recess may comprise a bottom surface extending mainly perpendicular to the extrusion direction and side surfaces.

[0018] The first base surface, the second base surface and the side surfaces of the insert and the bottom surface and side surfaces of the recess may be flat surfaces or curved surfaces.

[0019] During use, the first base surface of the insert may be arranged against the bottom surface of the recess, and the second base surface of the insert opposite to the first base surface may be arranged against a surface of the feed plate.

[0020] Side surfaces of the recess and side surfaces of the insert may be arranged at a small distance from each other creating a side surface spacing between the respective side surfaces. This side surface spacing is smaller than the spacing between the feed plate and the insert holder.

[0021] For example, the spacing between the feed plate and the insert holder is in the range of 0.1 to 1.0 mm, for example 0.2 to 0.8 mm, while the side surface spacing between side surfaces of the recess and side surfaces of the insert may be in the range of 0.01 to 0.2 mm, for example 0.02 to 0.15, whereby the spacing between the feed plate and the insert holder will be larger than the side surface spacing.

[0022] When a load is exerted by a billet on the insert, the insert and insert holder may deform. Due to the relatively small side surface spacing between the side surfaces of the recess and the insert, an initial bending of the insert and insert holder will be stopped by the side surfaces of the recess. Further deformation of the insert will be prevented by the insert holder with the result of only small bending at the location of the forming openings in the insert.

[0023] Some side surface spacing between side surfaces of the insert and side surfaces of the recess is advantageous as this may facilitate the placement of the insert in the recess and removal of the insert out of the recess.

[0024] In an embodiment, side surfaces of the recess and/or at least four side surfaces of the insert are angled with respect to the extrusion direction.

[0025] The insert can be more easily mounted in the recess and removed from the recess when the side surfaces of the recess and/or at least four side surfaces of the insert are angled with respect to the extrusion direction.

[0026] Advantageously, the angle of the side surfaces of the recess is substantially the same as the angle of the side surfaces of the insert. This results in substantially the same side surface spacing between side surfaces of the recess and side surfaces of the insert along a substantial part of the side surfaces in extrusion direction.

This result in an even better limiting of the deformation of the insert after initial deformation that results in filling the side surface spacing between the insert and the recess.

[0027] The angle of the side surfaces of the insert may be in the range of 0.1 to 10 degrees, for example in the range of 0.5 to 5 degrees with the extrusion direction.

[0028] In an embodiment, in cross section, parallel to the extrusion direction, the insert comprises a trapezoid shape, wherein a first base surface of the insert in contact with the bottom surface of the recess is smaller than a second base surface in contact with a feed plate surface. The trapezoid shape may be an isosceles trapezoid having a line of symmetry parallel to the extrusion direction.

[0029] In an embodiment, a smallest cross-section of the extrusion channel, seen in extrusion direction, is arranged in a half of the insert adjacent to the feed plate. By arranging the smallest cross-section of the extrusion channel, in the first half of the insert, the one or more forming openings, or at least the smallest cross sections thereof are arranged in the part of the insert which is less susceptible for bending. This is beneficial for product quality.

[0030] In an embodiment, the inner shape of the recess substantially corresponds with the outer shape of the insert.

[0031] In an embodiment, the extrusion die comprises a second insert, and wherein the insert holder comprises a second recess to receive the second insert, wherein the feed plate, insert, second insert and insert holder are designed such that when the second insert is arranged in the insert holder, the insert and the second insert contact the feed plate, while a spacing remains between the feed plate and insert holder when the feed plate is pressed in the extrusion direction against the insert and the second insert. In this embodiment, a second insert is arranged in a second recess of the insert holder. In this embodiment, the advantages of the inserts may be obtained for both

[0032] In an embodiment, the insert holder comprises a pre-tensioned outer ring. To further withstand the large forces exerted on the extrusion die when pressing a billet into the extrusion channel, a pre-tensioned outer ring may be arranged on the insert holder to limit deformation of

the insert holder.

[0033] In an embodiment, the extrusion die is configured for extrusion of metal, such as aluminium, magnesium and copper. The same principle may however, where advantageous, be used in extrusion dies for other materials.

[0034] Further characteristics and advantages of the invention will now be elucidated by a description of embodiments of the invention, with reference to the accompanying drawings, in which:

Figure 1 schematically depicts a cross-section of an extrusion die according to an embodiment of the invention;

Figures 2A, 2B and 2C show a top view and two cross-sections of the insert holder of the embodiment of Figure 1;

Figures 3A, 3B and 3C show a top view and two cross-sections of the insert of the embodiment of Figure 1; and

Figures 4A and 4B show a top view and a cross-section of an alternative embodiment of an extrusion die of the invention.

[0035] Figure 1 shows schematically a cross-section of an extrusion die generally denoted by reference numeral 1. The extrusion die 1 comprises a feed plate 10 and a die plate 20. The die plate 20 comprises an insert holder 21 comprising a recess 22. In the recess 22 an insert 30 is placed.

[0036] Figures 2A, 2B and 2C show separately a top view and two cross-sections of the insert holder 21, and Figures 3A, 3B and 3C separately a top view and two cross-sections of the insert 30.

[0037] The extrusion die 1 comprises an extrusion channel 2 through which extrusion material, such as heated metal can flow. In the extrusion channel 2 one or more forming openings 31 are provided to form a predetermined outer shape of the extruded product. In the shown example, the smallest cross-section of the extrusion channel 2 is formed by the one or more forming openings 31 provided in the insert 30 and an extension 11 arranged on the feed plate 10. This extension 11 defines an inner surface of the cross-section of the product to be extruded, for example an interior channel in the product to be extruded.

[0038] The extrusion die 1 comprises a extrusion direction ED. In this application, the extrusion direction ED is the main direction of extrusion in the extrusion channel 2 of the extrusion die 1, as indicated by an arrow in Figure 1.

[0039] The feed plate 10 comprises a plurality of feed channels 12 that define a first part of the extrusion channel 2. The feed channels 12 distribute the extrusion material, for example metal, over the one or more forming openings 31.

[0040] In embodiments, in which the feed plate 10 comprises an extension 11 that defines part of the final shape

of the extruded product, the feed plate 10 is also indicated as mandrel. If the feed plate 10 is only used to distribute extrusion material over the one or more forming openings 31, the feed plate 10 is also indicated as lead plate.

[0041] The feed plate 10 comprises a flat surface 13 which is perpendicular to the extrusion direction ED and arranged to be pressed against the insert 30 as described below.

[0042] The insert holder 21, as shown in Figures 2A, 2B and 2C, comprises the recess 22 and a product channel 23 through which the extruded product may leave the extrusion die 1. The product channel 23 has a cross section which is typically larger than the smallest cross section of the extrusion channel 2 to avoid that the shape of the product is changed due to the movement through the product channel 23.

[0043] The recess 21 comprises a bottom surface 24 and a number of side surfaces 25. The bottom surface 24 is a flat surface perpendicular to the extrusion direction.. In the shown embodiment, the side surfaces 25 are arranged at an angle A (see Figure 2B) of 2 degrees with the extrusion direction ED. In practice, this angle A may for example be in the range of 0.1 to 10 degrees. The side surfaces 25 are mainly flat surfaces.

[0044] The insert 30, as shown in Figures 3A, 3B and 3C, has in a cross-section in parallel with the extrusion direction ED a trapezoid shape.

[0045] The insert 30 comprises a first base surface 32, a second base surface 33, four angled side surfaces 34 and four straight side surfaces 35. The four angled side surfaces 34 are arranged at four opposite sides of the insert 30. The first base surface 32 is a flat surface which may be arranged against the bottom surface 23 of the recess 21. The second base surface 33 is a flat surface intended to be arranged against the flat surface 13 of the feed plate 10.

[0046] The angled side surfaces 34 have an angle B (see Figure 3B) with respect to the extrusion direction ED substantially corresponding to the angle A of the side surfaces of the recess 22 of about 2 degrees with respect to the extrusion direction ED. The angle B may correspondingly be in the range of 0.1 to 10 degrees. The straight side surfaces 35 run parallel to the extrusion direction ED. In an alternative embodiment, the straight side surfaces 35 may also be angled with respect to the extrusion direction ED, wherein the angle can be advantageously the same as the corresponding side surface of the recess 22. The advantages of the straight side surfaces 35 is that these straight side surfaces 35 do not require additional machining, while the angled side surfaces 34 in four directions may provide sufficient support during bending to maintain deformation of the insert 30 below a certain level, as will be explained below.

[0047] In Figure 1, it can be seen that when the feed plate 10 and die plate 20 with insert 30 are arranged against each other, the flat surface 13 of the feed plate 10 is arranged against the second base surface of the insert 30. The first base surface 32 of the insert 30 is

arranged against the bottom surface 24 of the recess 22 of the insert holder 21.

[0048] The insert 30 has a thickness in extrusion direction ED which is larger than the depth of the recess 22. As the thickness of the insert 30 in extrusion direction ED is larger than the depth of the recess 22, the insert 30 protrudes from the recess 22. As a result, there is a spacing 50 between the feed plate 10 and the insert holder 21. The spacing 50 is for instance in the range of 0.1 to 1.0 mm, for example 0.3 mm.

[0049] There is also a side surface spacing 51 between the side surfaces 25 of the recess 22 and the angled side surfaces 34 of the insert 30. The side surface spacing 51 is substantially smaller than the spacing 50. The side surface spacing 51 is for instance in the range of 0.01 to 0.2 mm, for example 0.04 mm.

[0050] The insert 30 may be positioned with respect to the insert holder 20 by positioning pins and holes (not shown). The insert 30 may further be fixed to the insert holder 20 by bolts (not shown). Correspondingly, the feed plate 10 may be positioned with respect to the insert holder 21 by positioning pins and holes.

[0051] Generally, it is advantageous when a thickness IHT of the insert holder 21 (see Figure 2B) is in extrusion direction ED at least 1.5 times, for example at least 2 times, the thickness INT of the insert 30 (see Figure 3B), but smaller than 3 times the thickness INT of the insert 30. In the shown embodiment, the thickness of the insert holder 21 is in extrusion direction ED about 2.5 times the thickness of the insert 30.

[0052] The extrusion die 1 may be used as follows.

[0053] When a billet of heated metal material, for example aluminium is pressed against the feed side of the feed plate 10, i.e. the side opposite to the side of the flat surface 13, the metal material will flow through the extrusion channel 2. The feed channels 12 will distribute the extrusion material over the smallest cross section of the extrusion channel 2 formed between the forming opening 31 of the insert 30 and the extension 11 of the feed plate 10. In this smallest cross-section the predetermined cross-section of the extruded product will be formed. The extruded product moves out of the extrusion die 1 through the product channel 23 for further product treatment, such as cooling.

[0054] The pressing of the billet on the extrusion die 1 results in a large pressing force being exerted on the extrusion die 1. Since there is a spacing 50 between the feed plate 10 and the insert holder 21, this pressing force is guided into the insert 30 and subsequently via the insert 20 to the insert holder 21.

[0055] By guiding the pressing force through the insert 30, the deformation of the one or more forming openings 31 may be substantially decreased. This has an advantageous effect on the product quality and/or life time of the extrusion die 1. For example, the extrusion die 1 may be longer used since the product remains within the required product tolerances. Also, since less bending occurs, there are less variations in the cross-section of the

final extruded product.

[0056] When a large pressing force is exerted on the insert 30 still some bending of insert holder 20 and/or insert 30 may occur. As a result of this bending, the angled side surfaces 25 of the recess 22 and the angled side surfaces 35 of the insert 30 will be moved towards and against each other. When the side surfaces 25 of the recess 22 and the angled side surfaces 35 of the insert 30 are placed against, the insert holder 21 counteracts further bending of the insert 30.

[0057] In view of this, it is beneficial that the bending of the insert holder 21 will cause that, in extrusion direction ED, the side of the insert holder 21 will be compressed towards the center line therewith counteracting any bending of the insert 30.

[0058] It has been found that this configuration of insert holder 21 and insert 30 substantially limits the bending of the insert 30, in particular bending of the location of the one or more forming openings of the insert 30. This improves the product quality and reduces the variance between products extruded with the extrusion die 1.

[0059] The one or more forming openings 31, i.e. the part of the opening in the insert 30 forming the smallest cross section of the extrusion channel 2 are arranged, seen in extrusion direction, in the half of the insert 30 arranged during use adjacent to the feed plate 10. This has the advantage that the one or more forming openings 31 are arranged in the part of the insert 30 which is less susceptible for bending in this configuration of the extrusion die 1. This has a further beneficial effect on product quality and life-time of the extrusion die.

[0060] The embodiment shown in Figures 1-3 comprises a single insert. In an alternative embodiment, the extrusion die may comprise multiple inserts and the insert holder may comprise multiple recesses to receive the multiple inserts.

[0061] Figure 4 shows an embodiment of a die plate 20 comprising an insert holder 21 having a first recess and a second recess. In the first recess a first insert 30 is arranged. In the second recess a second insert 40 is arranged. Both the first insert 30 and the second insert 40 protrude from the respective recess such that second base surfaces 33 of the first insert 30 and the second insert 40 lie in the same plane, which plane is spaced from the insert holder 21. When the feed plate is pressed against the die plate 20, a flat surface of the feed plate will be arranged against the second base surfaces 33 of the first insert 30 and the second insert 40, while remaining spaced with respect to the insert holder 21.

[0062] The recesses and the inserts may further be configured as explained with respect to the embodiment of Figures 1-3.

[0063] When a force is exerted on the die plate by a billet pressed against the feed plate, the pressing force will be guided from the feed plate through the first and second inserts to the insert holder. As described above with respect to a single insert both inserts 30, 40 will have the advantages of less bending and as a result less de-

formation at the one or more forming openings in the inserts 30, 40.

[0064] As a result, product quality of a product extruded with this extrusion die may be substantially better than obtained with a conventional extrusion die.

[0065] In figure 4B, a pre-tensioned ring 60 is drawn in dashed lines around the insert holder 21. Such pre-tensioned ring 60 may further improve the capability of the extrusion die 1 to withstand deformations caused by pressing forces on the extrusion die.

Reference numerals

[0066]

1	extrusion die
2	extrusion channel
10	feed plate
11	extension
12	feed channels
13	flat surface
20	die plate
21	insert holder
22	recess
23	product channel
24	bottom surface
25	side surfaces of recess
30	insert
31	forming openings
32	first base surface
33	second base surface
34	angled side surfaces of insert
35	straight side surfaces of insert
40	second insert
50	spacing
51	side surface spacing
60	pre-tensioned ring
A	angle A
B	angle B
ED	extrusion direction
IHT	thickness of insert holder
INT	thickness of insert

Claims

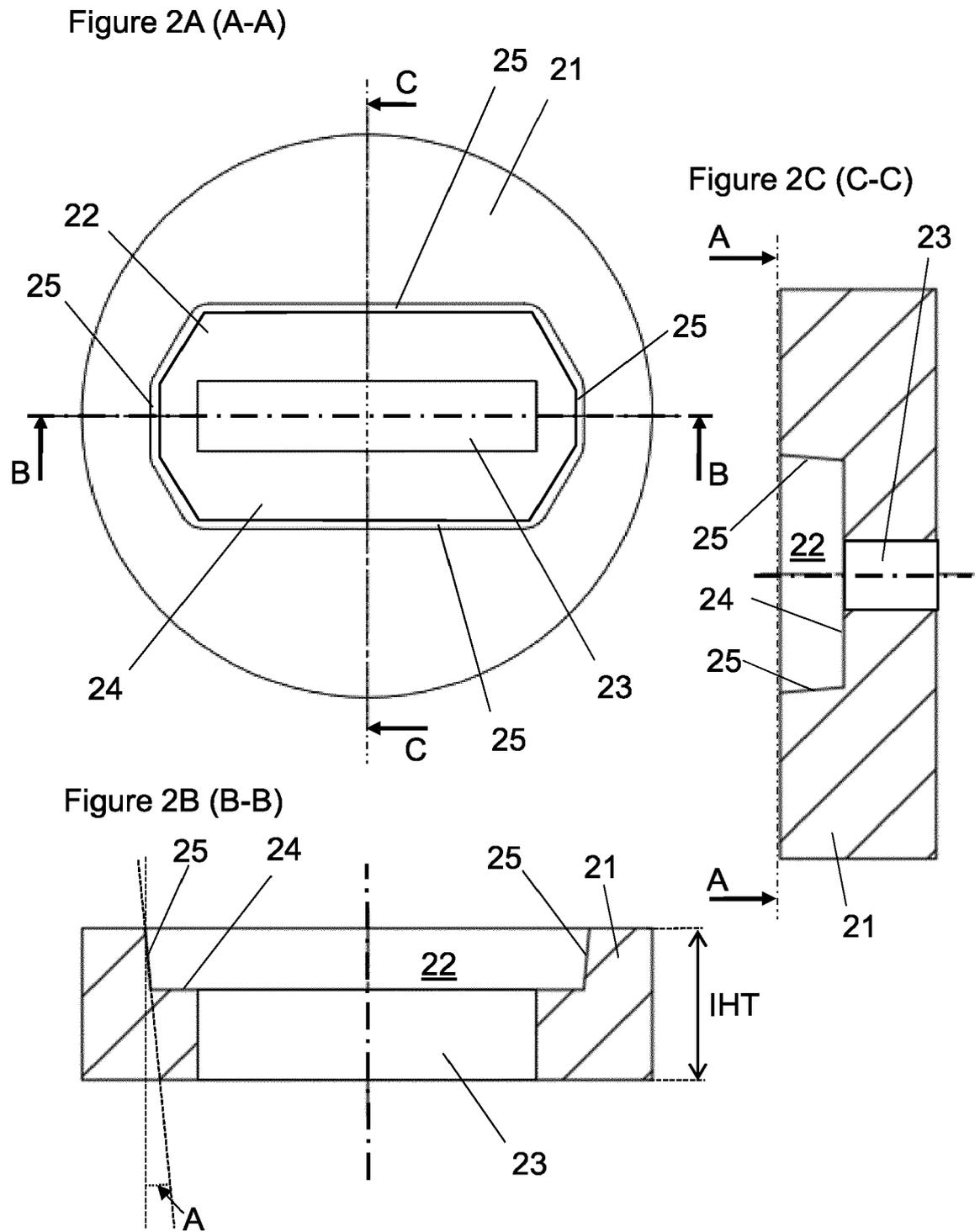
1. Extrusion die having an extrusion channel with an extrusion direction, comprising a feed plate defining a first part of the extrusion channel to allow extrusion material to flow into the extrusion die, and a die plate defining a second part of the extrusion channel comprising one or more forming openings that define at least partially the shape of an extruded product, **characterized in that** the die plate comprises an insert and an insert holder with a recess to receive the insert, wherein the recess is arranged at a side

of the insert holder facing the feed plate, wherein the insert comprises the one or more forming openings, wherein the feed plate, insert and insert holder are designed to create a spacing between the feed plate and the insert holder when the feed plate is pressed in the extrusion direction against the insert.

2. Extrusion die according to claim 1, wherein a thickness of the insert holder in extrusion direction is at least 1.5 times the thickness of the insert in extrusion direction.
3. Extrusion die according to claim 1 or 2, wherein side surfaces of the recess are angled with respect to the extrusion direction.
4. Extrusion die according to claim 3, wherein an angle of the side surfaces of the recess with respect to the extrusion direction is in the range of 0.1 to 10 degrees.
5. Extrusion die according to any of the preceding claims, wherein at least four side surfaces of the inserts are angled with respect to the extrusion direction.
6. Extrusion die according to claim 2 and 5, wherein the angle of the side surfaces of the recess is substantially the same as the angle of the side surfaces of the insert.
7. Extrusion die according to claim 5 or 6, wherein an angle of the side surfaces of the insert with respect to the extrusion direction is in the range of 0.1 to 10 degrees.
8. Extrusion die according to any of the preceding claims, wherein, in cross section, parallel to the extrusion direction, the insert comprises a trapezoid shape, wherein an outer surface at a longer base side of the insert is arranged against the feed plate and an outer surface at a smaller base side is arranged against a surface of the insert holder.
9. Extrusion die according to any of the preceding claims, wherein a smallest cross-section of the extrusion channel, seen in extrusion direction, is arranged in a half of the insert adjacent to the feed plate.
10. Extrusion die according to any of the preceding claims, wherein, when the feed plate is pressed in the extrusion direction against the insert, the spacing between the feed plate and the insert holder is in the range of 0.1 to 1.0 mm.
11. Extrusion die according to any of the preceding claims, wherein, when the insert is arranged in the

recess, a side surface spacing between side surfaces of the recess and side surfaces of the insert is in the range of 0.01 to 0.2 mm.

- 12. Extrusion die according to any of the preceding claims, wherein the extrusion die comprises a second insert, and wherein the insert holder comprises a second recess to receive the second insert, wherein the feed plate, insert, second insert and insert holder are designed such that when the second insert is arranged in the insert holder, the insert and the second insert contact the feed plate, while a spacing remains between the feed plate and insert holder when the feed plate is pressed in the extrusion direction against the insert and the second insert. 5
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- 13. Extrusion die according to any of the preceding claims, wherein the inner shape of the recess substantially corresponds with the outer shape of the insert. 20
- 14. Extrusion die according to any of the preceding claims, wherein the insert holder comprises a pre-tensioned outer ring. 25
- 15. Extrusion die according to any of the preceding claims, wherein the extrusion die is configured for extrusion of metal. 30
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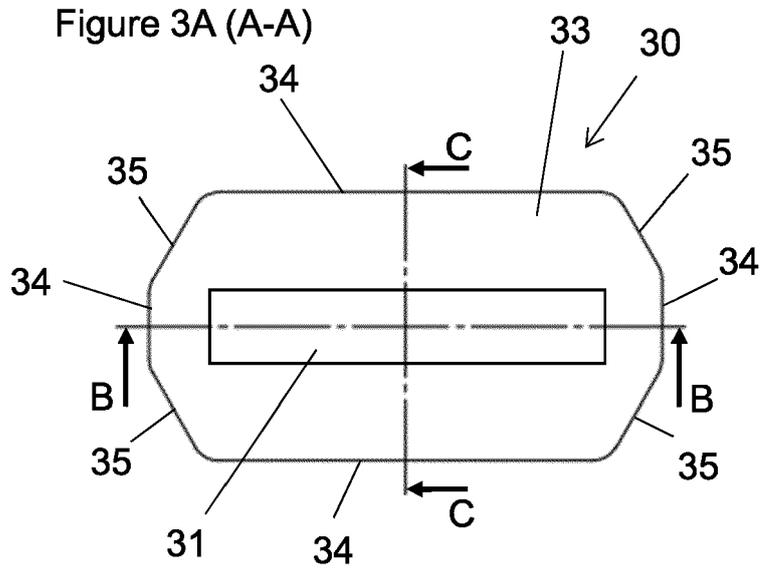


Figure 3C (C-C)

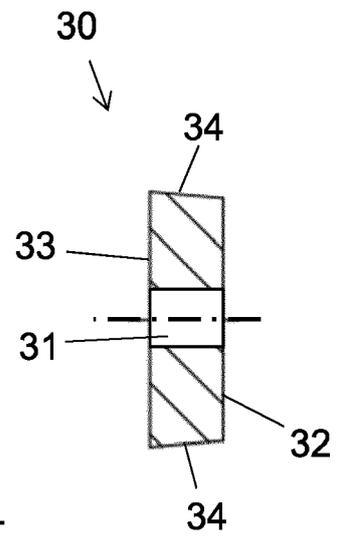
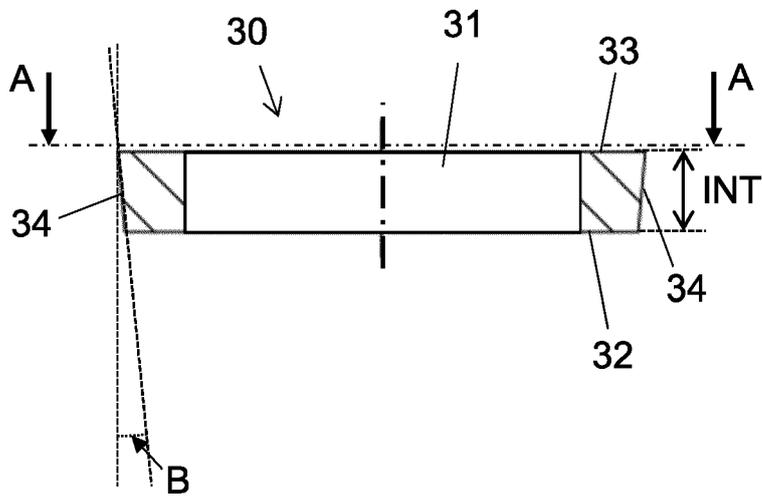
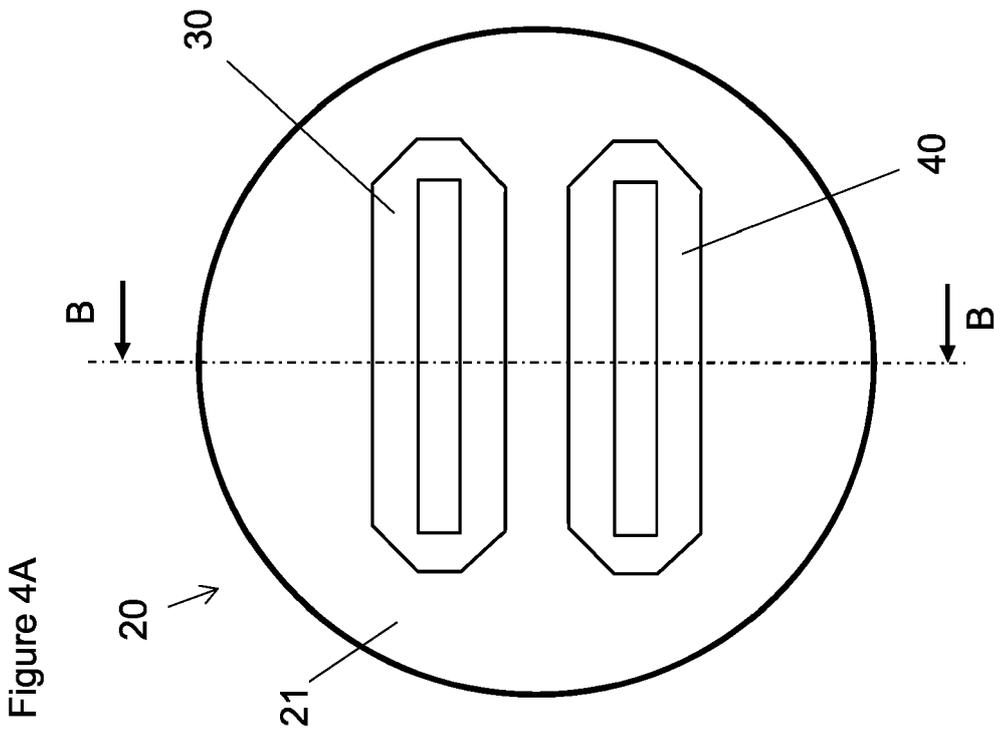
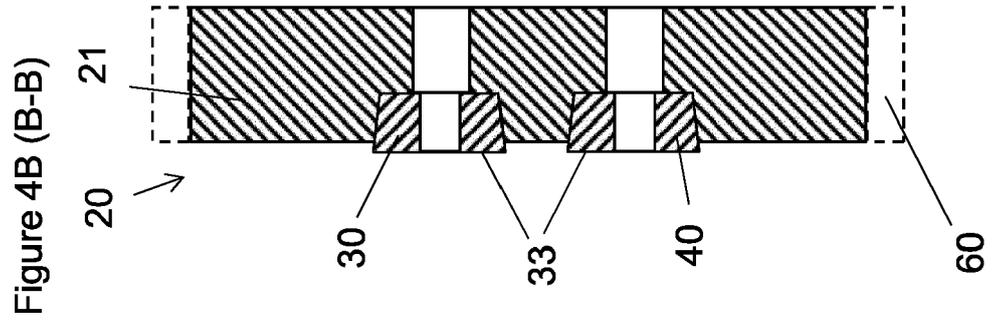


Figure 3B (B-B)







EUROPEAN SEARCH REPORT

Application Number
EP 21 15 4074

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Y	* page 2, lines 16-56; figure 3 * -----	3,4,8,12	
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 9 June 2021	Examiner Augé, Marc
CATEGORY OF CITED DOCUMENTS		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	
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			

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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