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(54) PROCESS OF PRODUCING FITTINGS BY COLD PLASTIC DEFORMATION OF RAW COPPER TUBES

(57) The present invention concerns cold production process of fitting elements comprising the steps of
- providing a hard-drawn copper pipe (1) to be plastically deformed,
- providing a punch (3) configured to come into contact with the pipe (1),
- providing a mould (4) having a cavity (40) adapted to receive the pipe (1) and delimited by a moulding surface (41),
- providing actuation means (5) for the punch (3) configured to move the punch (3) to and from the cavity (40) of the mould (4),
- actuating the actuation means (5) to exert a deformation force on the pipe (1) so as to plastically deform it on the moulding surface (41),
- actuating the actuation means (5) to disengage the punch (3) and move it away from the pipe (1),
- extracting the pipe (1) from the cavity (40) of the mould (4).

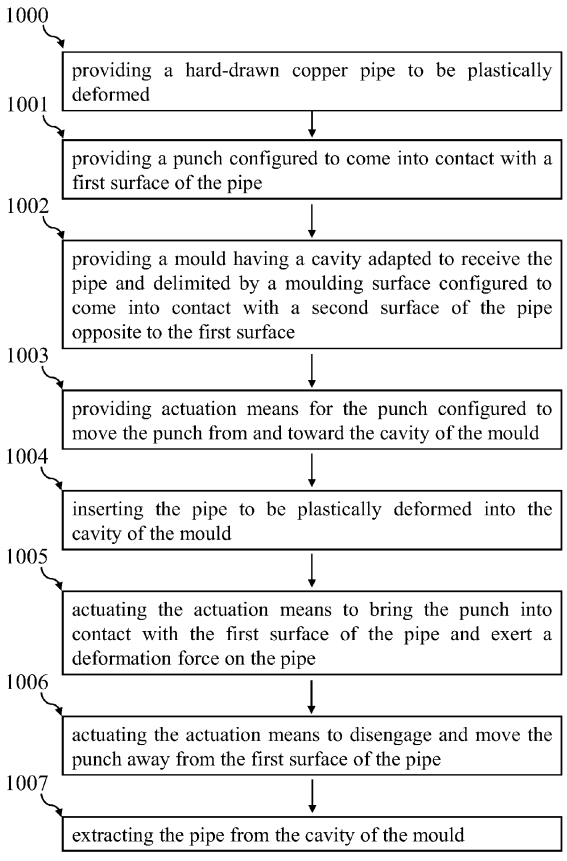

Fig. 1

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Description

Technical Field

[0001] The present invention relates to a process for the production of fitting elements, in particular by means of mechanical processing by cold plastic deformation of hard-drawn copper pipes.

[0002] The object of the present invention finds useful use in the sector of the production of fitting elements made of raw copper for hydraulics, in particular for refrigeration or air conditioning systems.

State of the art

[0003] It has long been known in the field of hydraulics to use fitting elements to fluid-dynamically connect two or more conduits that convey fluid or aeriform flows.

[0004] These fitting elements can be made by hot deep drawing of coils of annealed copper.

[0005] Disadvantageously, this process is significantly energy-intensive as it requires heating the workpiece.

[0006] Furthermore, disadvantageously, the use of annealed copper and the hot machining reduce the shape stability of the fitting element obtained by deep drawing.

[0007] Alternatively, the fitting elements are made by means of common mechanical machining processes by chip removal - such as, for example, turning or milling -, i.e. processes in which a workpiece is shaped by removing material using special cutting tools.

[0008] Disadvantageously, the machining processes by chip removal are characterized by high cycle times that significantly impact the production costs.

[0009] Furthermore, disadvantageously, the machining processes by chip removal find significant qualitative limits in the production of fitting elements with small diameters and thicknesses, in particular if these are made of ductile and malleable materials such as copper. In this regard, it should be noted that the interaction between the tool and the workpiece induces vibrations in the latter all the more significant the more the workpiece has reduced diameters and thicknesses, thus compromising the quality of the machined surface. This issue is of particular relevance in the machining of inner portions of the fitting elements since in this case, during turning, it is not possible to use tailstocks adapted to stabilize the workpiece.

Object of the invention

[0010] In this context, the task of the person skilled in the art underlying the present invention is to propose a process for the production of fitting elements that overcomes the drawbacks of the aforementioned prior art.

[0011] In particular, it is an object of the present invention to make available a process for the production of fitting elements that allows productivity to be increased without negatively impacting the final quality of the machined product and the production costs.

[0012] It is also an aim of the present invention to make available a process for the production of fitting elements with reduced thicknesses and diameters capable of achieving high quality standards.

SUMMARY OF THE INVENTION

[0013] The defined technical task and the specified aims are substantially achieved by a process for the production of fitting elements comprising the technical features set forth in one or more of the appended claims.

[0014] Advantageously, the process for the production of fitting elements by means of mechanical machining by cold plastic deformation, since they do not require the workpiece to be heated, allows to reduce the energy consumptions of the machining compared to hot deep drawing.

[0015] Furthermore, advantageously, the cold deformation hardens the material and increases the shape stability of the machined product.

[0016] Advantageously, the process for the production of fitting elements by means of mechanical machining by cold plastic deformation allows to obtain high production volumes reducing the machining cycle time compared to the mechanical machining by chip removal.

[0017] Furthermore, advantageously, the use of the process for the production of fitting elements by cold plastic deformation of hard-drawn copper pipes allows to obtain high quality standards and, in particular, allows to homogenize the quality of the machined products.

[0018] It should also be noted that the process for the production of fitting elements object of the present invention, by plastically deforming the hard-drawn copper pipe to be machined by interposing it between the mould and the punch, allows to precisely machine pipes with reduced diameters and thicknesses, as well as made of ductile and malleable materials such as copper.

LIST OF FIGURES

[0019] Further characteristics and advantages of the present invention will become more apparent from the description of an exemplary, but not exclusive, and therefore nonlimiting preferred embodiment of a process for the production of fitting elements, as illustrated in the attached drawings in which:

- Figure 1 shows a flowchart of the process for the production of fitting elements according to the present invention,
- Figure 2 shows a sectional view from the side of a step of the production process of Figure 1,
- Figure 3a shows a sectional view from the side of a hard-drawn copper pipe to be plastically deformed by the production process of Figure 1,
- Figure 3b shows a sectional view from the side of the pipe of Figure 3a after performing the production

process of Figure 1.

DETAILED DESCRIPTION

[0020] With reference to figure 1, the present invention relates to a process for the production of fitting elements, in particular by means of mechanical machinings by cold plastic deformation of hard-drawn copper pipes.

[0021] In the context of the present invention, *"mechanical machinings by plastic deformation"* means all those machinings that use mechanical stresses to induce plastic deformations in the workpiece - hereinafter "hard-drawn copper pipe 1" -, i.e. deformations that remain when the stresses cease.

[0022] The term *"cold",* on the other hand, means that the mechanical machining process takes place in the absence of heat input. The workpiece is therefore not supplied with heat either upstream or during the plastic deformation process.

[0023] As indicated in box 1000 of figure 1, the production process object of the present invention comprises a first step of providing a hard-drawn copper pipe 1 to be plastically deformed.

[0024] It should be pointed out that the hard-drawn copper differs from the annealed copper in that it has not undergone any thermal treatment of heating to a temperature below melting point, aimed at increasing its malleability and homogeneity.

[0025] The pipe 1 to be deformed has a constant cross-section along a main extension direction X-X, differently the machined pipe 1 - i.e. the pipe obtained following the production process object of the present invention - is characterized by a variable cross-section along the main extension direction X-X. The machined pipe 1 is identifiable with the fitting element or a component thereof and can therefore be classified as a finished product or a semi-finished product.

[0026] The production process object of the present invention is therefore configured to plastically deform the pipe 1 so as to locally vary its cross-section.

[0027] It should be specified that by *"cross-section"* is meant the section of the pipe oriented perpendicularly to the main extension direction X-X.

[0028] In detail, with reference to figure 3a, the pipe 1 to be deformed has a circular cross-section characterized by an initial outer diameter D_{ext} and a thickness s. The initial inner diameter D_{int} of the pipe 1 is obtained indirectly by subtracting twice the thickness s from the initial outer diameter D_{ext}.

[0029] According to one aspect, the initial outer diameter D_{ext} is comprised between a maximum value of 86 mm and a minimum value of 6 mm. Preferably, the initial outer diameter D_{ext} is comprised between 20 mm and 5 mm, even more preferably between 10 mm and 5 mm.

[0030] According to a further aspect, the thickness s is comprised between a maximum value of 3.5 mm and a minimum value of 0.73 mm. Preferably, the thickness s is comprised between 3 mm and 0.5 mm, even more preferably between 1.5 mm and 0.5 mm.

[0031] With reference to figure 3b, preferably, the machined pipe 1 has a circular variable cross-section along the main extension direction X-X.

[0032] For example, the machined pipe 1 comprises a first section 11 characterized by a first final outer diameter $D_{ext\,1}$ and a first final inner diameter $D_{int\,1}$; a second section 12 characterized by a second final outer diameter $D_{ext\,2}$ different from the first final outer diameter $D_{ext\,1}$ and a second final inner diameter $D_{int\,2}$ different from the first final inner diameter$D_{int\,1}$; and a third section 13, interposed between the first and the second section 11, 12, having an outer variable diameter along the main extension direction X-X between the first and the second final outer diameter$D_{ext\,1}$, $D_{ext\,2}$ and an inner variable diameter along the main extension direction X-X between the first and the second final inner diameter$D_{int\,1}$, $D_{int\,2}$.

[0033] Preferably, but not necessarily, the first final outer diameter $D_{ext\,1}$ is equal to the initial outer diameter D_{ext}, while the second final outer diameter $D_{ext\,2}$ is greater than the initial outer diameter D_{ext}.

[0034] According to one aspect, the ratio of the first to the second final outer diameter $D_{ext\,1}$, $D_{ext\,2}$ is less than or equal to 0.75.

[0035] Preferably, but not necessarily, the thickness s of the pipe 1 is modified by the mechanical processing object of the present invention.

[0036] As indicated in box 1001 of figure 1, the production process further comprises the step of providing a punch 3 configured to come into contact with a first surface 1a of the pipe 1 and exert on the latter a deformation force.

[0037] In particular, according to an aspect shown in figure 2, the first surface 1a is an inner surface of the pipe 1 to which the punch 3 has access through an end opening 14 of the pipe 1.

[0038] With reference to figure 2, in use, the punch 3 is inserted inside the pipe 1 through the end opening 14 along the main extension direction X-X so as to come into contact with the first surface 1a.

[0039] Preferably, the punch 3 extends along a longitudinal direction Y-Y that coincides with the main extension direction X-X of the pipe 1 when the punch 3 is inserted therein. More details on the geometric conformation of the punch 3 will be provided in a subsequent part of the description.

[0040] The production process further comprises the step of providing a mould 4 having a cavity 40 adapted to receive the pipe 1 and the punch 3.

[0041] In detail, the piston 3 is switchable between a first configuration in which it is extracted from the cavity 40 so as to allow insertion or extraction of the pipe 1, and a second configuration in which it is at least partially inserted into the cavity 40 to exert the aforesaid deformation force on the pipe 1. Preferably, the piston 3 switches between the first and second configuration by moving to and from the cavity 40 along the longitudinal direction Y-Y.

[0042] In particular, the cavity 40 is configured to arrange the pipe 1 with the main extension direction X-X aligned (coincident) with the longitudinal direction Y-Y of the punch 3.

[0043] The cavity 40 is delimited by a moulding surface 41 configured to come into contact with a second surface 1b of the pipe 1 opposite to the first surface 1a.

[0044] In particular, according to an aspect shown in figure 2, the second surface 1b is an outer surface of the pipe 1, i.e. opposite to the inner surface with which the piston 3 is configured to come into contact.

[0045] The moulding surface 41 has a geometric conformation complementary to that which is intended to be given to the pipe 1 - in particular, to the outer surface thereof - with the execution of the production process object of the present invention. In this regard, it should be noted that when the piston 3 exerts the deformation force on the first surface 1a, the second surface 1b abuts on the moulding surface 41 giving the pipe 1 the desired geometric conformation.

[0046] With reference to the embodiment of figure 2, the mould 4 comprises a main body 42 and a plurality of dies 43 connectable to the latter to define the cavity 40.

[0047] By interchanging the dies 43 connected to the main body 42 it is possible to change the shape given to the pipe 1 by the mechanical machining without the need to completely make a new mould 4. In other words, advantageously, the main body 42 and the dies 43 make a modular mould that allows to achieve a high production flexibility with reduced investments.

[0048] It should be noted that each die 43, when connected to the main body 42, determines a respective portion of the moulding surface 41 of the cavity 40. In other words, the cavity 40 of the mould 4 has a plurality of portions each of which is defined by a respective die 43.

[0049] Preferably, the dies 43 are at least three and each of them is distinct and geometrically different from the others. For example, in the embodiment of figure 2, the mould 4 comprises a first die 43a configured to define at least a part of the first section 11 of the machined pipe, a second die 43b configured to define at least part of the second section 12, and a third die 43c configured to define at least the third section 13.

[0050] In the case where the mould 4 comprises the main body 42 and the plurality of dies 43, the production process provides for a set-up step in which the main body 42 is provided and the dies 43 are connected to the main body 42 to define the cavity 40.

[0051] Preferably, moreover, the set-up step provides for selecting a punch 3 having a geometry compatible with that of the cavity 40 and for connecting the punch 3 to actuation means 5 described below.

[0052] With reference to figure 2, it should be specified that with the term *"compatible geometry"* it is meant that the punch 3 has a geometry complementary to the cavity 40 of the mould 4 scaled up by the thickness s of the pipe 1. In other words, the punch 3 is shaped to fill the cavity 40 of the mould 4 together with the deformed pipe 1 when it is in the second configuration.

[0053] In the embodiment of figure 2, the main body 42 of the mould 4 comprises a seat 44 inside which the dies 43 are stackable to define the cavity 40.

[0054] Preferably, the seat 44 has a cylindrical conformation and an insertion opening 45. Each die 43 has a cylindrical outer wall 46 that can be inserted complementarily into the seat 44 through the insertion opening 45.

[0055] To connect the dies 43 to the main body 42 of the mould 4, the dies 4 are sequentially inserted and stacked in the seat 44, in particular along the longitudinal direction Y-Y, as shown in figure 2.

[0056] As indicated in box 1003 of figure 1, the production process further comprises the step of providing actuation means 5 of the punch 3 configured to move the latter to and from the cavity 40 of the mould 4. In particular, the actuation means 5 are configured to switch the punch 3 between the aforesaid first and second configuration.

[0057] It should be specified that the actuation means 5, in addition to moving the punch 3 to bring it into contact with the first surface 1a of the pipe 1 and disengage it from the latter, are configured to actuate the piston 3 to exert the deformation force on the pipe 1.

[0058] According to one aspect, the punch 3, the mould 4 and the actuation means 5 are components of a machine for mechanical machinings by plastic deformation (not shown in the figures), in particular a deep drawing press.

[0059] Following the aforementioned steps, the production process provides for inserting the pipe 1 to be plastically deformed into the cavity 40 of the mould 4 (box 1004 of figure 1), and actuating the actuation means 5 to bring the punch 3 into contact with the first surface 1a of the pipe 1 and to exert the deformation force on the pipe 1 (box 1005 of figure 1).

[0060] By the action of the deformation force, the pipe 1 is plastically deformed so that the second surface 1b of the pipe 1 abuts completely against the moulding surface 41 of the mould 4 as shown in figure 2.

[0061] As indicated in box 1006 of figure 1, the production process then comprises the step of actuating the actuation means 5 to disengage the punch 3 and move it away from the first surface 1a of the pipe 1 which will thus be extractable from the cavity 40 of the mould 4.

[0062] The deformed pipe 1 is then extracted from the cavity 40 of the mould 4, preferably by means of an extractor element 6.

[0063] According to one aspect, the extractor element 6 is configured to come into contact with the deformed pipe 1 and remove it from the cavity 40 of the mould 4 by moving it along the main extension direction X-X.

[0064] Clearly, in order to satisfy contingent and specific needs, a person skilled in the art may make numerous modifications and variants to the configurations described above. Such modifications and variations are all also contained within the scope of the invention, as defined by the following claims.

Claims

1. Cold production process of fitting elements, **characterized in that** said process comprises the steps of

   - providing a hard-drawn copper pipe (1);
   - providing a punch (3) configured to come into contact with a first surface (1a) of the pipe (1);
   - providing a mould (4) having a cavity (40) adapted to receive the pipe (1), said cavity (40) being delimited by a moulding surface (41) configured to come into contact with a second surface of the pipe (1b) opposite to the first surface (1a);
   - providing actuation means (5) for the punch (3) configured to move the punch (3) from and toward the cavity (40) of the mould (4);
   - inserting the pipe (1) into the cavity (40) of the mould (4);
   - actuating the actuation means (5) to bring the punch (3) into contact with the first surface (1a) of the pipe (1) and exert a deformation force on the pipe (1), said deformation force plastically deforming the second surface (1b) of the pipe (1) against the moulding surface (41) of the mould (4);
   - actuating the actuation means (5) to disengage and move the punch (3) away from the first surface (1a) of the pipe (1);
   - extracting the pipe (1) from the cavity (40) of the mould (4).

2. Cold production process according to claim 1, wherein no heat is provided to the pipe (1) either before the step of inserting the pipe into the cavity (40) of the mould (4), or when the pipe is arranged in the cavity (40) of the mould (4).

3. Cold production process according to any one of the preceding claims, wherein:

   - the mould (4) comprises a main body (42) and a plurality of dies (43) connectable to the main body (42) to define the cavity (40), each die (43) when inserted into the main body (42) determines a portion of the moulding surface (41) of the cavity (40);
   - the cold production process, upstream of the step of inserting the pipe (1) to be formed in the cavity (40), provides a set-up step comprising the sub-steps of:

     - providing the main body (42) of the mould (4);
     - connecting the plurality of dies (43) to the main body (42) of the mould (4) to define the cavity (40) of the mould (4).

4. Cold production process according to claim 3, wherein the dies (43) are at least three, each die (43) being geometrically different from the others.

5. Cold production process according to claim 3 or 4, wherein the set-up step comprises the sub-steps of

   - selecting a punch (3) having a geometry compatible with the cavity (40) defined by the plurality of dies (43);
   - connecting the selected punch (3) to the actuation means (5).

6. Cold production process according to any one of claims 3 to 5, wherein:

   - the main body (42) of the mould (4) comprises a seat (44) inside which the dies (43) are stackable to define the cavity (40);
   - the sub-step of connecting the plurality of dies (43) to the main body (42) of the mould (4) provides for sequentially inserting and stacking the dies (43) in the seat (44) of the main body (42) of the mould (4).

7. Cold production process according to claim 6, wherein:

   - the seat (44) of the main body (42) of the mould (4) has a cylindrical conformation and an insertion opening (45);
   - each die (43) has a cylindrical outer wall (46) complementarily insertable into the seat (44) through the insertion opening (45).

8. Cold production process according to any one of the preceding claims, wherein:

   - said first surface (1a) of the pipe (1) is an inner surface of the pipe (1);
   - said second surface (1b) of the pipe (1) is an outer surface of the pipe (1) opposite to the inner portion (1a).

9. Cold production process according to any one of the preceding claims, wherein the pipe (1) has a circular section.

10. Cold production process according to claim 9 wherein the pipe (1) to be deformed has an outer diameter comprised between 86 mm and 6 mm and a thickness comprised between 3.5 mm and 0.73 mm.

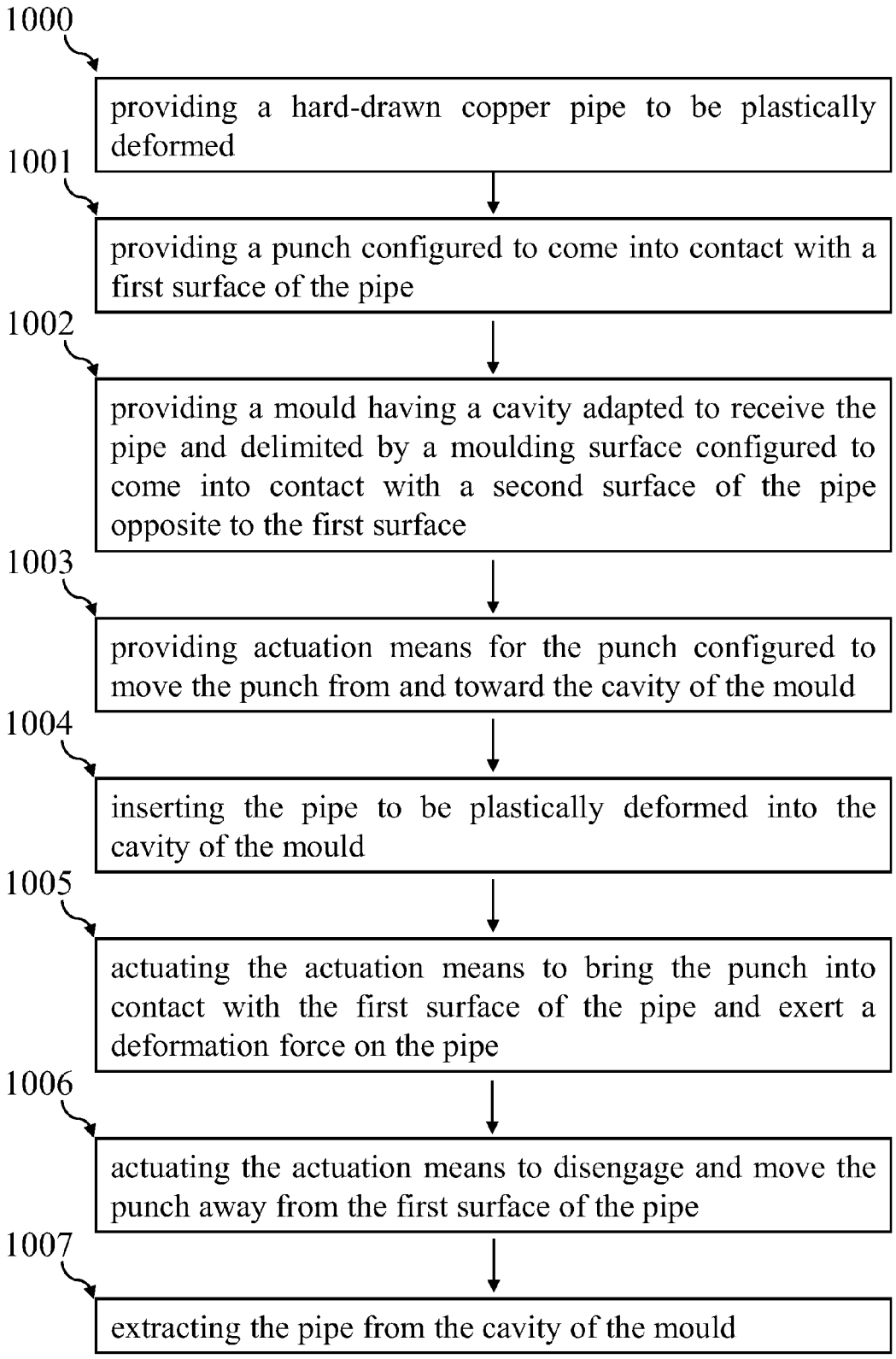

1000
providing a hard-drawn copper pipe to be plastically deformed
1001
providing a punch configured to come into contact with a first surface of the pipe
1002
providing a mould having a cavity adapted to receive the pipe and delimited by a moulding surface configured to come into contact with a second surface of the pipe opposite to the first surface
1003
providing actuation means for the punch configured to move the punch from and toward the cavity of the mould
1004
inserting the pipe to be plastically deformed into the cavity of the mould
1005
actuating the actuation means to bring the punch into contact with the first surface of the pipe and exert a deformation force on the pipe
1006
actuating the actuation means to disengage and move the punch away from the first surface of the pipe
1007
extracting the pipe from the cavity of the mould

Fig. 1

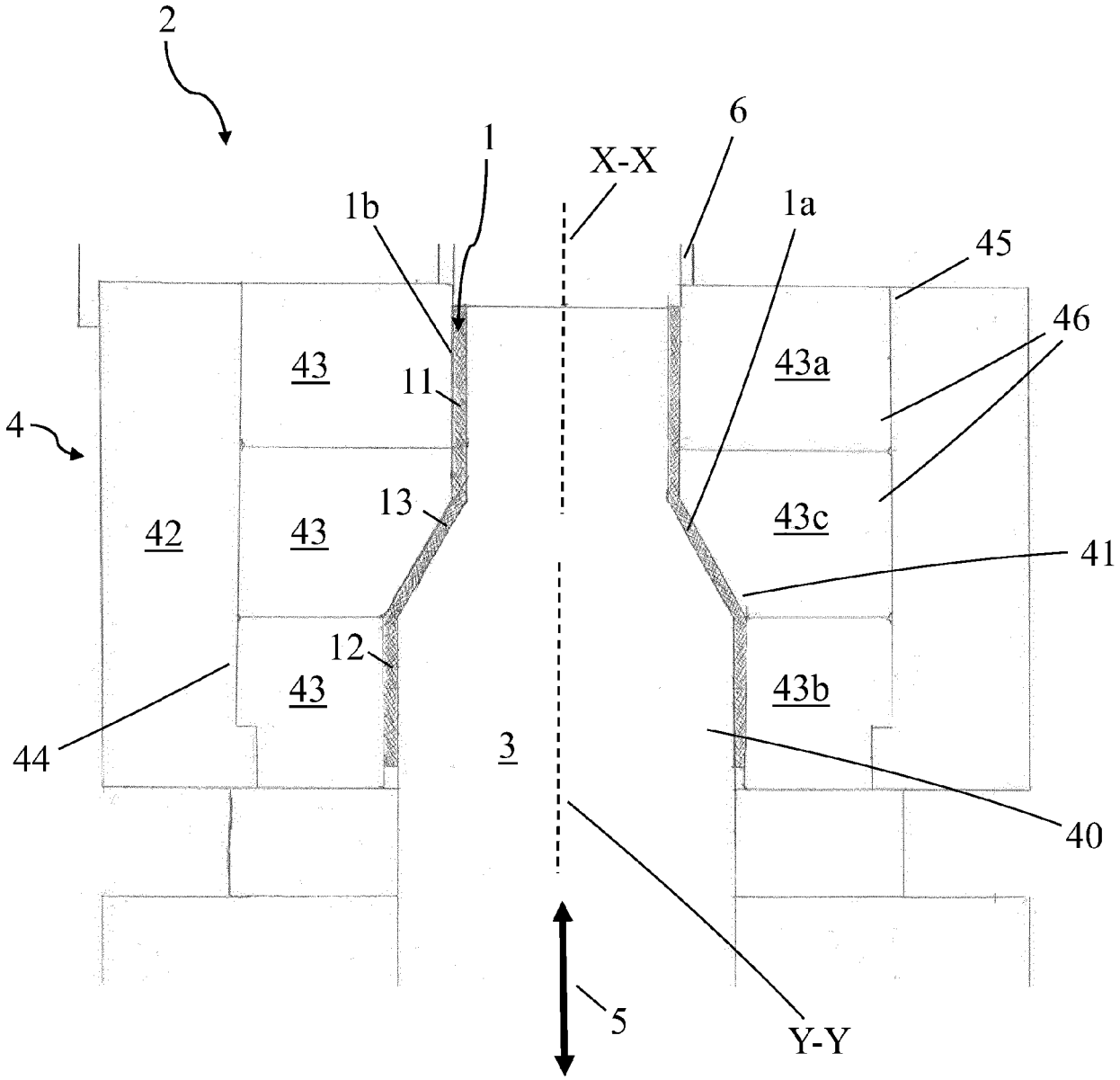


Fig. 2

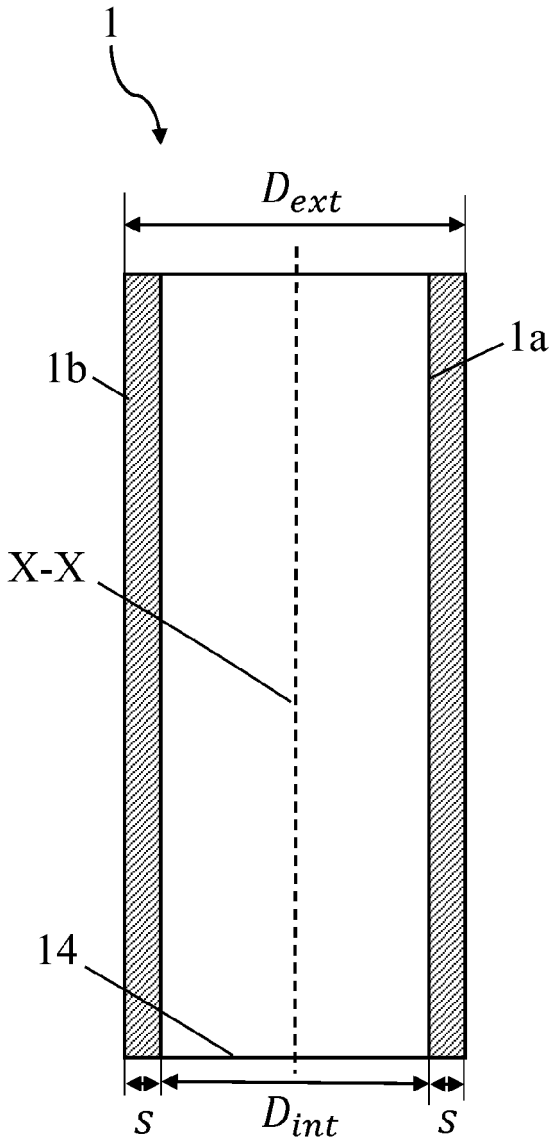
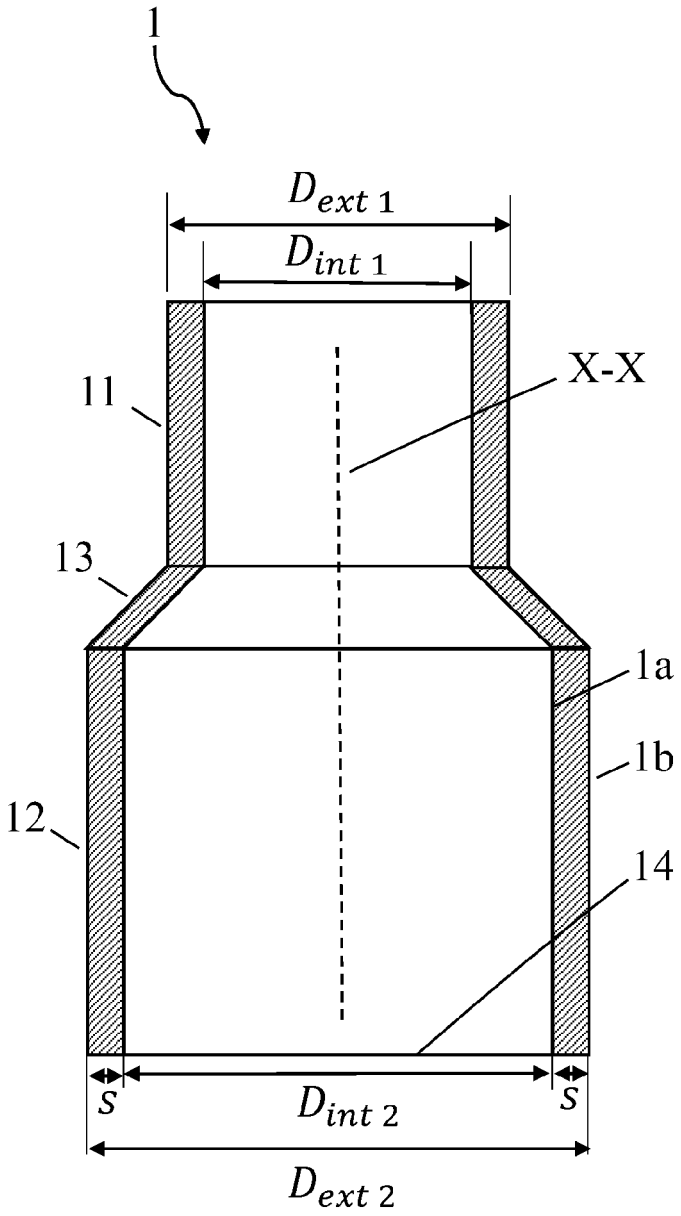

1
D_{ext}
1b
1a
X-X
14
s
D_{int}
s

Fig. 3a


1
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$D_{int\ 1}$
11
X-X
13
1a
1b
12
14
s
$D_{int\ 2}$
s
$D_{ext\ 2}$

Fig. 3b

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EUROPEAN SEARCH REPORT

Application Number
EP 24 15 3183

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	21 May 2024	Stanic, Franjo

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