(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 208 930 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
21.07.2010 Bulletin 2010/29

(51) Int Cl.:
F23Q 7/00 *(2006.01)*

(21) Application number: **10250011.3**

(22) Date of filing: **06.01.2010**

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

(30) Priority: **15.01.2009 JP 2009006912**

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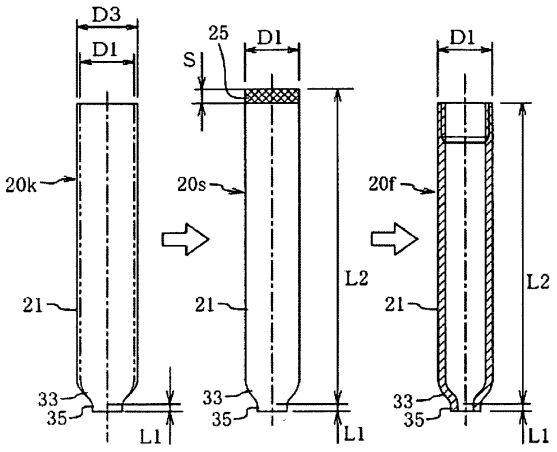
(54) **Manufacturing method of heater tube of glow plug and glow plug**

(57) [Objective] An object is to maintain at a predetermined amount the projection length of a projecting mouth portion projecting frontward from a tapered-off portion at the front end of a heater tube, to thereby prevent occurrence of welding failure, which would otherwise occur when a front end of a heat generation coil disposed within the heater tube is welded to the projecting mouth portion.

[Means for Solution]

The diameter D21 of a straight hole portion 123 of a forming hole 121 of a die 101 used in each of press steps including the final press step is made greater than the outer diameter of a heater tube finished product. A blank material 20 to undergo forming is pressed, with a support member 151 disposed on the front end side of the forming hole 121, whereby the projection length L1 of a projecting mouth portion 35 is maintained at a predetermined projection length. When the blank material 20 is excessively long, its outer diameter increases. Therefore, the blank material 20 is then passed through an ironing hole so as to adjust the outer diameter of the straight tube portion 21 of the heater tube in-process product to a predetermined dimension. When the overall length is greater than a maximum allowable dimension, a rear-end unnecessary portion of the straight tube portion 21 is cut for adjustment. Desired dimensions can be imparted to the projecting mouth portion, etc.

FIG. 4



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Description

[Technical Field]

[0001] The present invention relates to a glow plug used for, for example, pre-heating for facilitating startup of a diesel engine, and more particularly to a method of manufacturing a heater tube (hereinafter may be simply referred to as a "tube"), which is a constituent part of such a glow plug, and to a glow plug.

[Background Art]

[0002] FIG. 5 shows a heater element 11, which partially constitutes a glow plug 10, and also schematically shows the structure of the element 11 by a partially sectioned enlarged view thereof. This heater element 11 is composed of a heater tube 31 having a cylindrical straight tube portion 21 and a closed hemispherical portion 30 provided at the front end of the straight tube portion 21; a heat generation coil (hereinafter may be simply referred to as a "coil") 41 which is formed of metal having a high melting point and is disposed within the heater tube 31; and an unillustrated insulating filling material (e.g., MgO powder). Within the heater tube 31, the heat generation coil 41 is welded to the hemispherical portion 30 at the front end (lower end in FIG. 5), and extends rearward (toward the upper end in FIG. 5).

[0003] Conventionally, a heater tube which partially constitutes the heater element 11 and in which the heat generation coil 41 is accommodated is manufactured from an iron-based metal tube (in general, a circular tube formed of low carbon steel; a blank tube) through a plurality of press steps (cold forging steps). This production method through press working is a cold forging process, which is basically the same as that employed in a production method for forming a tubular glow plug body (housing) (see, for example, Patent Document 1). In the cold forging process, a heater tube before the heat generation coil 41 is accommodated therein is formed as follows. As shown in the left-end drawing (1) of FIG. 6, there is prepared a starting blank material (a straight circular tube having a constant transverse cross section; hereinafter may be simply referred to as a "blank material)) 20 having a predetermined length. A front end (lower end in FIG. 6) of the blank material is drawn step by step in a plurality of press steps. Finally, a heater tube post-forming product 20k shown in the right-end drawing (4) of FIG. 6 is obtained. As shown in the drawing, the heater tube post-forming product 20k has a tapered-off portion 33 at the front end thereof. As shown in the left-hand drawing in FIG. 7, a coil 41 is disposed within the heater tube post-forming product 20k having the shape shown the left-end drawing (4) of FIG. 6 such that a distal end (wire end portion) 42 of the coil 41 is positioned in a cylindrical projecting mouth portion 35 projecting from the front end of the tapered-off portion 33 of the heater tube post-forming product 20k. Subsequently, the projecting mouth portion 35 and the coil distal end 42 are welded together, whereby the heater element 11 is completed as shown in the right-hand drawing of FIG 7.

[0004] A typical method of manufacturing the above-described heater tube post-forming product 20k from the blank material 20 is to draw the front end of the blank material 20 step by step through a plurality of (e.g., 10) press working steps (drawing steps) as shown in FIG. 6. Notably, in FIG. 6, some intermediate formed products are omitted. In each of the steps of drawing the blank material 20, a die 101 as shown in FIG. 8 is used. The left-hand drawing of FIG. 8 is a cross sectional view showing a die used in an intermediate press step (e.g., the fourth press step) and press working performed by use of the die. The right-hand drawing of FIG. 8 is a cross sectional view showing a die used in the final step (e.g., the tenth press step) and press working performed by use of the die. All the dies, including dies used in other press steps (stages), basically have the same structure, except that forming holes formed in the dies are rendered different from one another in accordance with the amount of drawing at the front end to be effected in the individual step. Accordingly, each of such dies has a forming hole 121 in which a blank material (in-process product) can be loaded (inserted) and which has, on the front end side thereof (the lower end side in FIG 8), a forming surface (inner surface for drawing) 131 corresponding to the drawing amount (drawing step) of the front end of the heater tube.

[0005] In a press step performed by use of such a die 101, a blank material 20 is loaded into the forming hole 121 of the die 101 from the rear side (the upper side in FIG. 8), and is pressed. However, as shown in FIG. 8, in intermediate and final press steps, a mandrel (pin) 201 whose front end surface is formed in accordance with the drawing amount at the front end of the blank material is typically inserted into the interior (hole) of the blank material from the rear side. Further, a cylindrical tubular sleeve punch 301, which has a transverse cross section approximately the same as that of the blank material 20 and is fitted onto the mandrel 201, is coaxially inserted into the forming hole 121, so that the front end of the sleeve punch 301 moves the rear end of the blank material 20 frontward over a predetermined stroke to thereby press (apply pressure to) the blank material 20 frontward. Thus, the front end of the blank material 20 undergoes a predetermined draw-forming in each press step. In this manner, the front end of the blank material 20 is drawn step by step through use of the dies fabricated for the respective press steps. As shown in the right-hand drawing of FIG 8, in the final press step, the blank material 20 is formed into the heater tube post-forming product 20k by use of a die 101 fabricated such that the heater tube post-forming product 20k has a desired front end shape. Notably, the diameter of the straight hole portion of the forming hole 121 of each die 101 is set such that the blank material 20 to be pressed can be inserted into the straight hole portion in a substantially clearance-free

state, and the diameter of the mandrel 201 is set such that the mandrel 201 can be inserted into the blank material 20 in a substantially clearance-free state.

[0006] Incidentally, since the right-hand drawing of FIG. 8 shows a die 101 used in the final press step, the front end of the forming hole 121 of the die 101 has a hemispherical forming surface 131 corresponding to the outer surface of the front end of the heater tube post-forming product 20k shown in the right-end drawing of FIG. 6. Further, at the center of the front end of the forming hole 121, there is provided a cylindrical hole 141 whose diameter is smaller than the outer diameter of the straight tube portion 21 of the heater tube 31. The cylindrical hole 141 extends frontward from the front end of the forming hole 121, and is used to form the projecting mouth portion 35 projecting frontward from the front end of the tapered-off portion 33 of the heater tube post-forming product 20k shown in the right-end drawing of FIG 6. That is, as a result of forming the front end of the forming hole 121 into the above-described shape, the hemispherical, tapered-off portion 33, which is not closed, is formed at the front end of the finally formed heater tube post-forming product 20k as shown in the right-end drawing of FIG. 6. Further, the projecting mouth portion 35, which projects frontward by a predetermined projection length L1, is formed at the front end of the tapered-off portion 33.

[0007] Conventionally, after formation of the front-end portion of the heater tube post-forming product 20k in such a manner, as described above, the distal end 42 of the coil 41 is inserted into the projecting mouth portion 35 at the front end of the tapered-off portion 33. The distal end 42 of the coil 41 is then positioned and welded to the projecting mouth portion 35. Notably, up to the time when the heat generation coil 41 is welded to the front end of the heater tube post-forming product 20k, the front end of the heater tube post-forming product 20k has the above-mentioned projecting mouth portion 35. However, at the time of welding, the projecting mouth portion 35 is molten and solidified, whereby the opening thereof is closed, and the tapered-off portion 33 assumes a hemispherical shape.

[Prior Art Document]

[Patent Document]

[0008] [Patent Document 1] Japanese Patent Publication (*kokoku*) No. H2-6412

[Summary of the Invention]

[Problems to be Solved by the Invention]

[0009] When the heat generation coil 41 is welded to the inner wall surface of the front end portion of the heater tube post-forming product (the right-end drawing of FIG. 6) 20k manufactured through the above-described press (forging) steps, in rare cases, the welding fails to be performed properly. Further, in some cases, the improperly performed welding adversely affects the temperature performance of a glow plug finished product. The present inventors found that such a problem occurs for the following reason.

[0010] The blank material (starting blank material) 20 used for the above-described press steps is one obtained through cutting a cylindrical tube to a predetermined length. For such a cutting operation, in some cases, only an upper-side dimensional tolerance is specified, with a lower-side dimensional tolerance fixed to 0. For example, in a case where the upper-side dimensional tolerance is +0.5, the length of the blank material 20 varies within a range of 0.5 mm. Meanwhile, in each of the above-described press steps, the blank material is compressed in the axial direction by an amount corresponding to the predetermined stroke set for each step. Meanwhile, at least in the die used in the final step, the front end of the blank material 20 is pushed into the cylindrical hole 141 provided at the front end of the forming hole 121 of the die, whereby the projecting mouth portion 35 is finally formed at the front end of the blank material. Accordingly, in the case where the length of the blank material is longer than a reference dimension, the front end of the blank material is pushed into the cylindrical hole 141 at the front end of the forming hole 121 of the die 101 by a greater amount corresponding to the difference between the length of the blank material and the reference dimension. Therefore, the length L2 of the heater tube post-forming product 20k, as measured from its rear end to the front end of the hemispherical, tapered-off portion 33 (the overall length - L1; hereinafter may be referred to as the "length of the straight tube portion") is maintained at a predetermined dimension (set dimension). However, in accordance with the dimensional difference, the projection length L1 of the projecting mouth portion 35 at the front end of the tapered-off portion 33 becomes longer than a reference dimension; and the greater the dimensional variation, the greater the projection length L1. That is, the heater tube post-forming product 20k formed through the final press step has a variation in the projection length L1 of the projecting mouth portion 35, which variation corresponds to a variation in the length of the blank material.

[0011] Conventionally, if the blank material 20 is longer than the reference dimension and the projection length L1 of the projecting mouth portion 35 at the formed tapered-off portion 33 is excessively large, a problem of improper welding between the projecting mouth portion 35 and the distal end 42 of the coil 41 occurs. Specifically, when the projection length L1 of the projecting mouth portion 35 at the tapered-off portion 33 is excessively large, the base material (a projecting wall portion of the projecting mouth portion 35) fails to be sufficiently melted, whereby the amount of molten metal (melt) becomes insufficient (excessively small), and welding failure occurs. In contrast, when the entirety of the projecting mouth portion 35 whose projection length L1 is excessively large

is melted, the amount (volume) of solidified melt becomes excessive (excessively large). In such a case, after welding of the coil 41, the hemispherical portion 30 of the heater element 11 has a wall thickness greater than a desired thickness, or fails to assume a desired hemispherical shape and accuracy. This leads to deterioration of the temperature performance of a glow plug finished product.

[0012] The present invention has been accomplished in order to solve such problems. A first object of the present invention is to maintain at a predetermined amount the projection length of a projecting mouth portion projecting frontward from a tapered-off portion at the front end of a heater tube, to thereby prevent occurrence of welding failure, which would otherwise occur when a front end of a heat generation coil disposed within the heater tube is welded to the projecting mouth portion. A second object of the present invention is to provide a heater tube which prevents generation of a variation in the temperature performance among glow plug finished products.

[Means for Solving the Problems]

[0013] The present invention which achieves the above-described objects is as follows. The invention described in claim 1 is a method of manufacturing a heater tube for a glow plug which includes a straight tube portion, a tapered-off portion provided at a front end of the straight tube portion, and a projecting mouth portion projecting frontward from a front end of the tapered-off portion, the method comprising a plurality of press steps in each of which a tubular blank material is loaded into a forming hole of a die, and is pressed frontward via a rear end of the blank material, the method being **characterized in that**

at least a die used in the final press step is formed such that a straight hole portion of a forming hole of the die has a diameter greater than an outer diameter of a straight tube portion of a heater tube finished product;

the die formed such that the straight hole portion of the forming hole of the die has a diameter greater than the outer diameter of the straight tube portion of the heater tube finished product is provided with a support member which is disposed on a front end side of the forming hole so as to support a front end of the blank material to thereby maintain a projection length of the projecting mouth portion at a predetermined projection length;

the blank material is pressed in a state in which the support member is provided;

a heater tube post-forming product formed from the blank material through press forming in the final press step is passed through an ironing hole of an ironing die formed such that the ironing hole has a diameter which can reduce an outer diameter of a straight tube portion of the heater tube post-forming product to an outer diameter equal to a predetermined outer diameter of the straight tube portion of the heater tube finished product, to thereby adjust the outer diameter of the straight tube portion of the heater tube post-forming product to the predetermined outer diameter; and

when an overall length of a heater tube obtained from the heater tube post-forming product through the ironing step is greater than a maximum allowable dimension, a rear-end unnecessary portion of a straight tube portion of the heater tube is removed so as to adjust the overall length to a predetermined dimension.

[0014] The invention described in claim 2 is a method of manufacturing a heater tube for a glow plug which includes a straight tube portion, a tapered-off portion provided at a front end of the straight tube portion, and a projecting mouth portion projecting frontward from a front end of the tapered-off portion, the method comprising a plurality of press steps in each of which a tubular blank material is loaded into a forming hole of a die, and is pressed frontward via a rear end of the blank material, the method being **characterized in that**

each of dies used in a plurality of press steps including the final press step is formed such that a straight hole portion of a forming hole of the die has a diameter greater than an outer diameter of a straight tube portion of a heater tube finished product;

each die formed such that the straight hole portion of the forming hole of the die has a diameter greater than the outer diameter of the straight tube portion of the heater tube finished product is provided with a support member which is disposed on a front end side of the forming hole so as to support a front end of the blank material to thereby maintain a projection length of the projecting mouth portion at a predetermined projection length;

in each of the plurality of press steps, the blank material is pressed in a state in which the support member is provided;

a heater tube post-forming product formed from the blank material through press forming in the final press step is passed through an ironing hole of an ironing die formed such that the ironing hole has a diameter which can reduce an outer diameter of a straight tube portion of the heater tube post-forming product to an outer diameter equal to a predetermined outer diameter of the straight tube portion of the heater tube finished product, to thereby adjust the outer diameter of the straight tube portion of the heater tube post-forming product to the predetermined outer diameter; and

when an overall length of a heater tube obtained from the heater tube post-forming product through the ironing step is greater than a maximum allowable dimension, a rear-end unnecessary portion of a straight tube portion of the heater tube is removed so as to adjust the overall length to a predetermined dimension.

[0015] The invention described in claim 3, which depends from the invention described in claim 2, is **characterized in that** the plurality of press steps including the final press step are successive press steps which are performed continuously. Notably, in the present invention, in order to improve dimensional accuracy, a mandrel

(pin) is desirably inserted into the tubular blank material when the blank material is loaded into the forming hole of the die, and is pressed frontward via the rear end of the blank material in the axial direction. Further, for the same reason, a mandrel is desirably inserted into the straight tube portion of the heater tube post-forming product when the heater tube post-forming product is ironed. Notably, in the following description, a heater tube in a process before being formed into the heater tube finished product will also be referred to as a "heater tube in-process product." In the present invention, the "heater tube post-forming product formed from the blank material through press forming in the final press step" means a heater tube in-process product which has undergone the plurality of press steps and is immediately before undergoing ironing work in the ironing step.

[0016] Further, in the present invention, the forming holes of the dies which are used in the respective steps in order to obtain the heater tube post-forming product are formed such that the above-described heater tube; i.e., that having a tapered-off portion at the front end of a straight tube portion thereof, and a projecting mouth portion projecting frontward from the front end of the tapered-off portion, is finally obtained as a heater tube post-forming product. Therefore, the forming hole is made slightly different among the dies used in the plurality of press steps so that the straight tube portion is pressed in the axial direction so as to plastically deform the front end of the straight tube portion step by step, and the heater tube post-forming product is finally obtained. However, this forming hole has a straight hole portion, and a forming surface which is formed at the front end of the straight hole portion and adapted to form the tapered-off portion and the projecting mouth portion in each forming step. The forming hole is identical with the forming holes of dies used in the conventional manufacturing method. That is, the straight hole portions of the dies used in the present invention are identical with the forming holes of dies used in the conventional manufacturing method, except for the diameter of the straight hole portions.

[0017] Further, in the present invention, the diameter of the straight hole portion of the forming hole of each die is made greater than the outer diameter of the straight tube portion of the heater tube finished product by an amount determined such that a tubular starting blank material obtained through cutting is allowed to expand radially outward so as to absorb an excessive volume of the blank material corresponding to a cutting tolerance (error) set for the entire length of the blank material. Further, examples of means for removing an unnecessary portion in the present invention include end machining by means of a cutting tool (cutting), cutting-off by means of a cutting-off tool, and grinding by means of a grinding stone.

[0018] The invention described in Claim 4 is a glow plug which includes a heater element disposed such that a front end of the heater element projects from a front end of the glow plug, wherein the heater element is configured such that a heat generation coil is disposed in a heater tube manufactured by a manufacturing method according to any one of claims 1 to 3, a front end of the heat generation coil is inserted into the projecting mouth portion projecting frontward from the front end of the tapered-off portion of the heater tube, and the front end of the heat generation coil is welded to the projecting mouth portion.

[Effects of the Invention]

[0019] In the manufacturing method of the present invention, the diameter of the straight hole portion of the forming hole of at least the die used in the final press step is made greater than the outer diameter of the straight tube portion of the heater tube finished product. Further, on the front end side of the forming hole of such a die, a support member is disposed so as to support the front end of the blank material. By virtue of this configuration, the projection length of the projecting mouth portion is maintained at a predetermined projection length. That is, even when the length of the blank material is longer than a reference dimension, the projection length of the projecting mouth portion at the front end of the blank material can be prevented from becoming longer than the predetermined projection length. As a result of contraction of the blank material in the axial direction stemming from the restriction on the projection length of the projecting mouth portion, the straight tube portion expands radially outward and has an outer diameter greater than the outer diameter of the straight tube portion of the heater tube finished product. Accordingly, in the present invention, even when a blank material whose overall length is greater than the reference dimension is contained in blank materials to be used, the projection length of the projecting mouth portion is prevented from becoming excessively large, whereby there can be obtained heater tube in-process products in which the projection length of the projecting mouth portion is maintained at the predetermined projection length.

[0020] Further, since the blank material having undergone the final press step subsequently undergoes ironing in an ironing step as described above, the outer diameter of the straight tube portion is adjusted (corrected) to a predetermined dimension. Moreover, the overall length of the ironed heater tube is greater than the overall length as measured before the heater tube is ironed. When the overall length is greater than a maximum allowable dimension, a rear-end unnecessary portion of the straight tube portion of the heater tube is removed, whereby the overall length is adjusted to the predetermined dimension. By virtue of removal of an unnecessary portion, heater tubes which have desired dimensions, including not only the projection length of the front end projecting mouth portion, but also the length between the front end of the tapered-off portion and the rear end of the straight tube portion, can be manufactured efficiently.

[0021] Notably, since the straight tube portion becomes thinner and longer as a result of ironing, the overall

length of the heater tube in-process product in this stage is longer than the reference dimension. However, the shapes and dimensions of the tapered-off portion and the projecting mouth portion projecting from the front end thereof are substantially free from the influence of the ironing work, and the accuracy attained before the ironing work is maintained as is. Accordingly, after the ironing work, while a front end portion of the heater tube in-process product is used as a reference, a rear end portion (unnecessary portion) of the straight tube portion, which is longer than the reference dimension, is cut (removed) by means of, for example, cutting, whereby heater tubes having a desired dimensional accuracy can be obtained.

[0022] In the case where the tip end of a coil is inserted into the projecting mouth portion at the front end of the tapered-off portion of a heater tube manufactured as described above, positioned, and welded to the projecting mouth portion, the amount of molten metal produced during the welding is prevented from becoming excessively small or excessively large, whereby occurrence of a failure associated with the welding can be prevented. Accordingly, there can be effectively prevented generation of a variation in temperature performance among glow plugs (finished products) each including a heater element composed of a heater tube manufactured by the method of the present invention and a heat generation coil welded thereto. Further, according to the present manufacturing method, since an unnecessary portion of the straight tube portion is removed, there can be attained an effect that the maximum allowable dimension set for the length of a straight tube (starting blank material) can be increased.

[0023] As described above, in the case of the glow plug described in claim 4, when the distal end of the heat generation coil and the projecting mouth portion are welded together in the process of manufacturing the heater element, the amount of molten metal produced during the welding is prevented from becoming excessively small or excessively large, because of small variation in the projection length of the projecting mouth portion. Therefore, a glow plug including a heater element composed of a heater tube manufactured by the above-described method and a heat generation coil welded thereto has a consistent temperature performance.

[Brief Description of the Drawings]

[0024]

[FIG. 1] A cross sectional view of a die used in an intermediate press step, which is used for describing a manufacturing method of the present invention, and a cross sectional view for describing a forming step performed by use of the die.

[FIG. 2] A cross sectional view of a die used in a final press step, which is used for describing the manufacturing method of the present invention, and a cross sectional view for describing a forming step performed by use of the die.

[FIG. 3] A cross sectional view of a die used in an ironing step, and a cross sectional view for describing a ironing step performed by use of the die.

[FIG. 4] Views showing a heater tube post-forming product having undergone the final press step, a heater tube after having undergone the ironing step, and a heater tube finished product obtained through removal of a rear end (unnecessary portion) of a straight tube portion of the heater tube.

[FIG. 5] A view schematically showing the structure of a glow plug and an enlarged, partially sectioned view of a heater element assembled to the glow plug.

[FIG. 6] Sectional views for describing steps of forming a heater tube which partially constitutes the heater element of FIG. 5.

[FIG. 7] Sectional views for describing steps of welding a heat generation coil to the heater tube.

[FIG. 8] Sectional view showing a conventional die for forming the heater tube, and showing the state of pressing performed by use of the die.

[Mode for Carrying out the Invention]

[0025] An embodiment of the manufacturing method according to the present invention will be described in detail with reference to FIGS. 1 to 4. Notably, a starting blank material (may be simply referred to as the "blank material"), and a tube formed through press steps are assumed to be identical with those shown at the left-hand and right-hand ends of FIG. 6. However, in the present embodiment, a heater tube post-forming product (a formed heater tube intermediate to be subjected to an ironing step) 20k is formed from the starting blank material through 11 press steps. Notably, in the following description, the starting blank material is assumed to have a length equal to a maximum allowable dimension. Further, in the present embodiment, dies similar to the conventional dies are used so as to draw the front end portion of the blank material 20 step by step in the first press step to the third press step; and a die 101 shown in FIGS. 1 and 2 and having a forming hole 121 peculiar to the present invention is used in the fourth press step to the eleventh press step (final press step). Notably, a heater tube in-process product (i.e., a blank material in the forming process) may also be simply referred to as the "blank material."

[0026] The dies 101 used in these steps have the same basic structure as the conventional dies 101 except for the following points. First, a support member 151 is disposed on the front end side of the forming hole 121 of each die 101 so as to support, in the corresponding press step, the front end of the blank material (the blank material to be pressed in press steps other than the final press step) 20, to thereby maintain the projection length L1 of the projecting mouth portion 35 of the blank material 20 at a predetermined projection length. Second, the dies 101 slightly differ from each other in terms of the shape of the front end of the forming hole 121 in accordance

with the drawing amount of the front end of the blank material. Therefore, here, the dies 101 used in the fourth press step shown in FIG. 1 and the eleventh step (final step) shown in FIG. 2 will be described. Notably, although the details will be described later, each of these dies 101 includes a mandrel 201 which is inserted into the blank material 20, and a sleeve punch 301 which axially presses the blank material 20 via its rear end.

[0027] First, the die 101 used in the fourth press step will be described with reference to FIG 1. This die 101 has the forming hole 121 which further draws, by an adequate degree, the front end of the blank material (see FIG 6(3)) 20 having undergone press forming in the third press step. This forming hole 121 has a straight hole portion 123, and a forming surface having a tapered-off shape (hereinafter may be referred to as the "tapered-off forming surface) 131 which is provided at the front end of the straight hole portion 123 and has a shape corresponding to the degree of drawing in the fourth press step. The diameter (bore diameter) D21 of the straight hole portion 123 is determined such that the blank material 20 having undergone the press working in the third press step can be loaded into the straight hole portion 123, and the diameter D21 is greater than the outer diameter D1 of a straight tube portion 21 of a heater tube finished product (see the right end of FIG. 4) 20fby, for example, 0.15 mm. Accordingly, this forming hole 121 is formed such that, when the blank material 20 is pressed in the axial direction, the outer diameter of the straight tube portion 21 of the blank material 20 can become greater than the outer diameter D1 of the straight tube portion 21 of the heater tube finished product 20f. Further, at the center of the tapered-off forming surface 131 at the front end of the forming hole 121 of the die 101, as shown in FIG. 1, a cylindrical hole 141 whose diameter is smaller than the diameter D21 is formed such that it further extends frontward from the front end of the forming hole 121 so as to form, through press forming, the cylindrical projecting mouth portion 35, which projects frontward from the front end of the tapered-off portion 33 of the blank material 20.

[0028] The rod-shaped (circular columnar) support member 151 is inserted into the cylindrical hole 141 to be movable in the vertical direction. Notably, this support member 151 is inserted into the cylindrical hole 141 in a substantially clearance-free state. The support member 151 is positioned in relation to the die 101 such that, when the blank material 20 is pressed in the present step, the front end of the support member 151 is maintained at a predetermined position so as to maintain the projection length L1 of the projecting mouth portion 35 at a predetermined length (stop the projecting mouth portion 35 at a predetermined position). The dies and support members used in the fifth press step and subsequent steps are also configured in the same manner as the die 101 and the support member 151 shown in FIG. 1. The difference is that, as described above, the tapered-off shape of the front end of the straight hole portion of the forming hole of each die is determined in accordance with the degree of drawing in each step such that the shape and dimension of the tapered-off front end of the straight hole portion become closer to those of the tapered-off portion and the projecting mouth portion of the finished product step by step.

[0029] Further, FIG. 2 is a pair of views showing the die 101 used in the eleventh press step (final step) and a press step performed by use of the die. The die 101 and the support member 151 used in the eleventh press step are formed such that the tapered-off portion 33 at the front end of the blank material 20 having undergone the press forming in the tenth press step and the projecting mouth portion 35 projecting forward from the front end of the tapered-off portion 33 are formed to finally have a predetermined diameter and a predetermined projection length L1. Further, like the dies used in the press forming in the fourth press step and subsequent press steps, the diameter (bore diameter) D21 of the straight hole portion 123 of the die used in the eleventh press step is greater than the outer diameter D1 of the straight tube portion 21 of the heater tube finished product 20f.

[0030] There will be described the fourth press step in which the blank material 20 having undergone the press forming in the previous step is press-formed by use of the die 101 shown in FIG. 1. The mandrel 201 and the sleeve punch 301 of the die 101 shown in FIG. 1 are moved upward, and the blank material 20 is loaded into the forming hole 121 of the die 101 from the rear end side (the upper end side in FIG. 1) such that the front end of the blank material 20 is located on the front-end side of the forming hole 121 (see the right-hand drawing of FIG. 1). Subsequently, the mandrel 201 is inserted into the blank material 20. As in the case of the conventional technique, this mandrel 201 has a diameter which enables its insertion into the blank material 20 in a substantially clearance-free state, and the front end of the mandrel 201 is rounded in accordance with the drawing amount of the front end of the blank material 20.

[0031] Next, in a state in which the blank material 20 is loaded and placed within the forming hole 121, a cylindrical tubular sleeve punch 301, which has a transverse cross section approximately the same as that of the blank material 20 and is fitted onto the mandrel 201, is coaxially inserted into the forming hole 121, so that a front-end portion of the sleeve punch 301 moves the rear end of the blank material 20 frontward over a predetermined stroke to thereby press (apply pressure to) the blank material 20 frontward. Thus, the front end of the blank material 20 is drawn to follow the shape of the tapered-off forming surface 131 at the front end of the forming hole 121, whereby a predetermined drawn shape to be imparted in this step is imparted to the front end of the blank material 20. In the present embodiment, the overall length of the used blank material 20 is longer than the reference dimension. However, since the rod-shaped support member 151 is disposed in the cylindrical hole

141 of the die 101 as described above, the projection length L1 of the projecting mouth portion 35 at the front end of the blank material 20 is maintained at a predetermined length set for this step. Meanwhile, the straight tube portion 21 of the blank material 20 is allowed to expand in the radial direction in the straight hole portion 123 during the pressing. Therefore, the straight tube portion 21 expands and deforms such that its outer diameter increases by an amount corresponding to the difference between the length of the starting blank material 20 and the reference dimension.

[0032] Then, the blank material 20 having undergone the press forming in the fourth press step is similarly press-formed in the fifth press step and subsequent steps by use of the dies for the respective press steps. In the eleventh press step, which is the final press step, the press forming is performed by use of the die 101 shown in FIG. 2. That is, in this eleventh press step, the front end of the blank material 20 is drawn to follow the shape of the tapered-off forming surface 131 at the front end of the forming hole 121, whereby the front end of the blank material 20 is formed into a tapered-off portion 33 having a predetermined shape and dimensions. In the present embodiment, the rod-shaped support member 151 is disposed in the cylindrical hole 141 of the die 101 as described above. Accordingly, the projection length L1 of the projecting mouth portion 35 at the front end of the blank material (heater tube post-forming product) 20k having undergone this final press step is maintained at the predetermined projection length. Meanwhile, in this press step as well, the straight tube portion 21 of the heater tube post-forming product 20k is allowed to expand in the radial direction within the straight hole portion 123 to thereby have an outer diameter greater than the outer diameter D1 of the heater tube finished product 20f. Accordingly, in the case where the starting blank material 20 is longer than the reference dimension, the straight tube portion 21 of the heater tube post-forming product 20k having undergone the final press step has an outer diameter D3 (see FIG 3 and the left-end drawing of FIG 4), which is greater than the outer diameter D1 indicated by lines in FIG 3 having alternate long and two short dashes.

[0033] As shown in FIG 3, a different mandrel 212 is inserted into the straight tube portion 21 of the heater tube post-forming product 20k having undergone the press-forming in the final press step. The heater tube post-forming product 20k with the mandrel 212 inserted thereinto is passed through an ironing hole 403 formed in an ironing die 401, starting from its front end. This ironing hole 403 is a cylindrical hole having a diameter D24 which can reduce the diameter of the straight tube portion 21 of the heater tube post-forming product 20k to the outer diameter D1 of the final heater tube finished product 20f. In the present example, the diameter D24 is made equal to D1. Thus, the straight tube portion 21 of the heater tube (ironed product) 20s having undergone the ironing step has an adjusted (corrected) outer diameter equal to the outer diameter D1 of the final heater tube finished product 20f.

[0034] The left-end drawing of FIG. 4 shows the heater tube post-forming product 20k which is to be ironed and which has an expanded straight tube portion 21; and the drawing on the right side thereof (the center drawing) shows the ironed heater tube 20s (a heater tube in-process product). Notably, the ironing hole 403 of the ironing die 401 of FIG. 3 has a larger-diameter guide portion 404 formed at the inlet (an upper opening in FIG 3) of the ironing hole 403.

[0035] The heater tube (ironed product) 20s having undergone the above-described ironing step has an increased overall length and an adjusted outer diameter equal to the outer diameter D1 of the final heater tube finished product 20f. That is, as shown at the center of FIG. 4, as a result of a slight reduction in the outer diameter D1 of the straight tube portion 21, the length L2 of the straight tube portion 21 is increased from the reference dimension by a small amount (crosshatched portion) S. Thus, the straight tube portion 21 has an unnecessary portion 25. Therefore, the unnecessary portion 25, which corresponds to the small amount S and is present at the rear end of the straight tube portion 21, is removed by means of, for example, turning. As a result, as shown on the right end of FIG. 4, in the present embodiment, there can be obtained a heater tube which has a desired dimensional accuracy not only in the outer diameter and the projection length L1 of the projecting mouth portion 35 at the front end of the tapered-off portion 33, but also in the length L2 of the straight tube portion 21 of the heater tube. Notably, when necessary, the inner surface of a rear end portion of the heater tube is machined simultaneously. In the case where such machining of the inner surface of the rear end portion is required, removal of the unnecessary portion can be performed in the same step. Since the removal of the unnecessary portion does not require a separate step, cost does not increase.

[0036] That is, in the heater tube 20f manufactured in the above-described manner, the projecting mouth portion 35 at the front end thereof has desired dimensions. The heat generation coil 41 is welded to such a heater tube 20f. Specifically, as in the case shown in FIG. 7, the distal end 42 of the heat generation coil 41 is inserted into the projecting mouth portion 35 at the front end of the tapered-off portion 33 of the heater tube 20f, positioned, and welded to the projecting mouth portion 35. Thus, a heater element 11 having the same structure as that shown in the enlarged view of FIG. 5 is obtained. Since the amount of molten metal produced at the time of welding is prevented from becoming excessively small or excessively large, occurrence of a failure associated with the welding; i.e., generation of an excessively large or small amount of molten metal, can be prevented. Accordingly, when a heater element 11 produced by mean of welding the heat generation coil 41 to the heater tube 20f manufactured as described above is used to assem-

ble a glow plug (a finished product) 10 such that a front end portion of the element 11 projects from the front end of the glow plug 10 as shown in FIG. 5, generation of a variation in temperature performance can be prevented. Notably, in the case where the starting blank material has a length which is equal to the reference length or less than the maximum allowable dimension, even when the straight tube portion becomes thinner and longer in the ironing step, its length does not exceed the maximum allowable dimension. Therefore, in the case of such a heater tube, no unnecessary portion is produced at the rear end of the straight tube portion, and it is clear that a step of removing the unnecessary portion is not required.

[0037] In the above-described embodiment, all the dies 101 respectively used in the successive fourth to the eleventh (final) press steps are configured such that the diameter of the straight hole portion 123 of the forming hole 121 is larger than the outer diameter D1 of the straight tube portion 21 of the heater tube finished product, and the support member 151 is disposed in each of the dies 101. Therefore, the dimensional accuracy of the projecting mouth portion 35 at the front end of the tapered-off portion 33 can be maintained at a very high level. However, depending on the desired dimensional accuracy, use of such a die is not required in all the press steps, and the present invention is not limited to the case where such a die is used in all the process steps. The dies, excluding the die used in the final press step, may be formed such that the straight hole portions of the dies used in alternate press steps have diameters larger than the outer diameter of the straight tube portion of the heater tube finished product, and the straight hole portions of the remaining dies have smaller diameters, so long as the blank material can be loaded into the forming hole of each die. Depending on the desired dimensional accuracy and so long as forming is possible, only the die used in the final press step may be configured such that the diameter of the straight hole portion of the forming hole is larger than the outer diameter of the straight tube portion of the heater tube finished product, and the support member may be disposed in that die only.

[Description of Reference Numerals]

[0038]

10: glow plug
20: blank material
20k: heater tube post-forming product having undergone the final press step
20s: heater tube having undergone the ironing step (ironed product)
20f: heater tube finished product
21: straight tube portion
25: unnecessary portion at the rear end of the straight tube portion
31: heater tube with a heat generation coil welded thereto
33: tapered-off portion
35: projecting mouth portion
101: die
121: forming hole
123: straight hole portion
151: support member
401: ironing die
403: ironing hole
D1: outer diameter of the straight tube portion of the heater tube finished product
D3: outer diameter of the straight tube portion of the blank material before being ironed
D21: diameter of the straight hole portion
L1: projection length of the projecting mouth portion
L2: length of the straight tube portion

Claims

1. A method of manufacturing a heater tube for a glow plug which includes a straight tube portion, a tapered-off portion provided at a front end of the straight tube portion, and a projecting mouth portion projecting frontward from a front end of the tapered-off portion, the method comprising a plurality of press steps in each of which a tubular blank material is loaded into a forming hole of a die, and is pressed frontward via a rear end of the blank material, the method being **characterized in that**

at least a die used in the final press step is formed such that a straight hole portion of a forming hole of the die has a diameter greater than an outer diameter of a straight tube portion of a heater tube finished product;

the die formed such that the straight hole portion of the forming hole of the die has a diameter greater than the outer diameter of the straight tube portion of the heater tube finished product is provided with a support member which is disposed on a front end side of the forming hole so as to support a front end of the blank material to thereby maintain a projection length of the projecting mouth portion at a predetermined projection length;

the blank material is pressed in a state in which the support member is provided;

a heater tube post-forming product formed from the blank material through press forming in the final press step is passed through an ironing hole of an ironing die formed such that the ironing hole has a diameter which can reduce an outer diameter of a straight tube portion of the heater tube post-forming product to an outer diameter equal to a predetermined outer diameter of the straight tube portion of the heater tube finished product, to thereby adjust the outer diameter of the straight tube portion of the heater tube post-forming product to the predetermined outer diameter; and

when an overall length of a heater tube obtained from

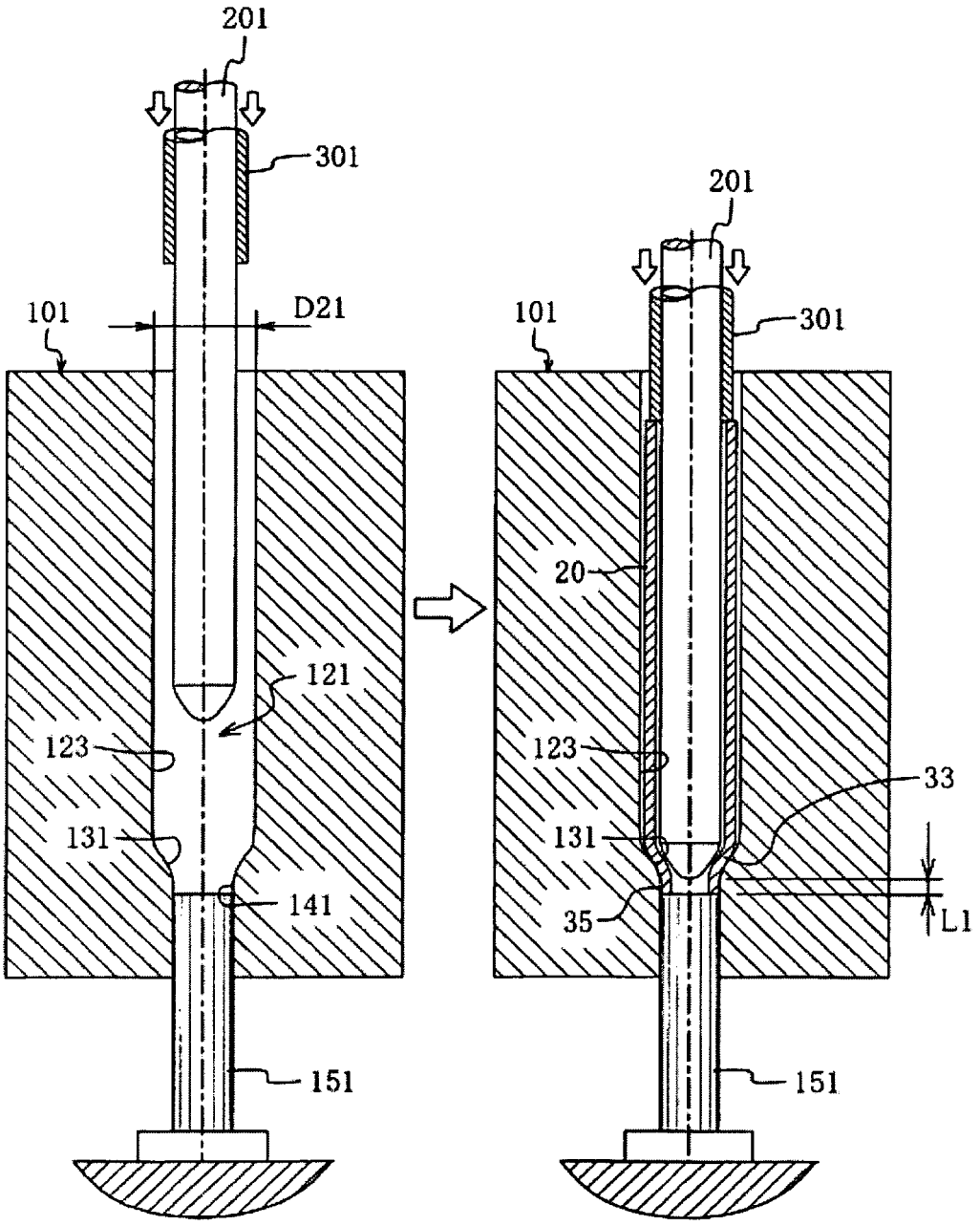
the heater tube post-forming product through the ironing step is greater than a maximum allowable dimension, a rear-end unnecessary portion of a straight tube portion of the heater tube is removed so as to adjust the overall length to a predetermined dimension.

2. A method of manufacturing a heater tube for a glow plug which includes a straight tube portion, a tapered-off portion provided at a front end of the straight tube portion, and a projecting mouth portion projecting frontward from a front end of the tapered-off portion, the method comprising a plurality of press steps in each of which a tubular blank material is loaded into a forming hole of a die, and is pressed frontward via a rear end of the blank material, the method being **characterized in that**
each of dies used in a plurality of press steps including the final press step is formed such that a straight hole portion of a forming hole of the die has a diameter greater than an outer diameter of a straight tube portion of a heater tube finished product;
each die formed such that the straight hole portion of the forming hole of the die has a diameter greater than the outer diameter of the straight tube portion of the heater tube finished product is provided with a support member which is disposed on a front end side of the forming hole so as to support a front end of the blank material to thereby maintain a projection length of the projecting mouth portion at a predetermined projection length;
in each of the plurality of press steps, the blank material is pressed in a state in which the support member is provided;
a heater tube post-forming product formed from the blank material through press forming in the final press step is passed through an ironing hole of an ironing die formed such that the ironing hole has a diameter which can reduce an outer diameter of a straight tube portion of the heater tube post-forming product to an outer diameter equal to a predetermined outer diameter of the straight tube portion of the heater tube finished product, to thereby adjust the outer diameter of the straight tube portion of the heater tube post-forming product to the predetermined outer diameter; and
when an overall length of a heater tube obtained from the heater tube post-forming product through the ironing step is greater than a maximum allowable dimension, a rear-end unnecessary portion of a straight tube portion of the heater tube is removed so as to adjust the overall length to a predetermined dimension.

3. A method of manufacturing a heater tube for a glow plug according to claim 2, wherein the plurality of press steps including the final press step are successive press steps which are performed continuously.

4. A glow plug comprising a heater element disposed such that a front end of the heater element projects from a front end of the glow plug, wherein the heater element is configured such that a heat generation coil is disposed in a heater tube manufactured by a manufacturing method according to any one of claims 1 to 3, a front end of the heat generation coil is inserted into the projecting mouth portion projecting frontward from the front end of the tapered-off portion of the heater tube, and the front end of the heat generation coil is welded to the projecting mouth portion.

FIG. 1


201
301
101
D21
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123
131
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151
201
301
101
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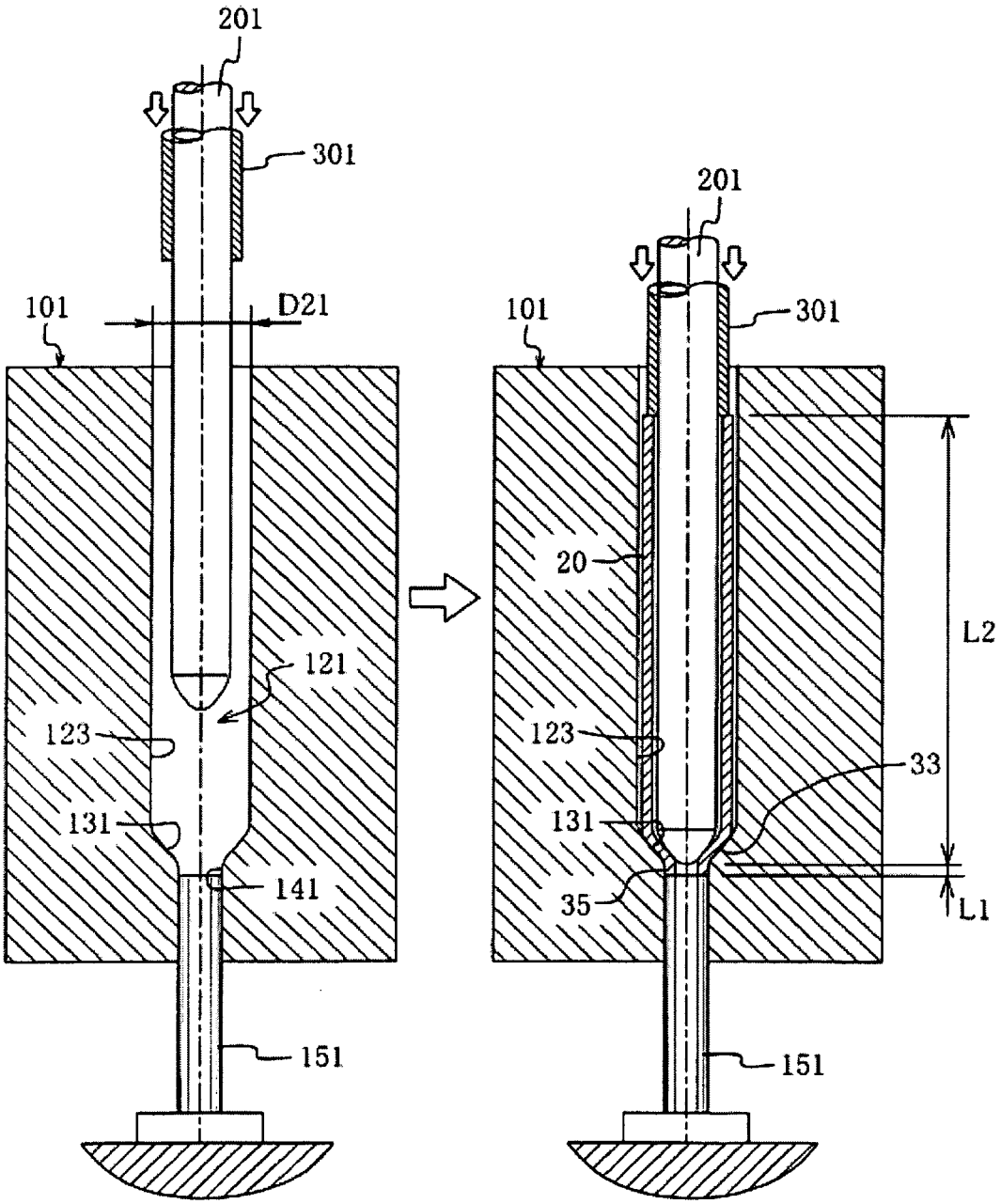
123
33
131
35
L1
151

FIG. 2


201
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L2
L1
151

FIG. 3

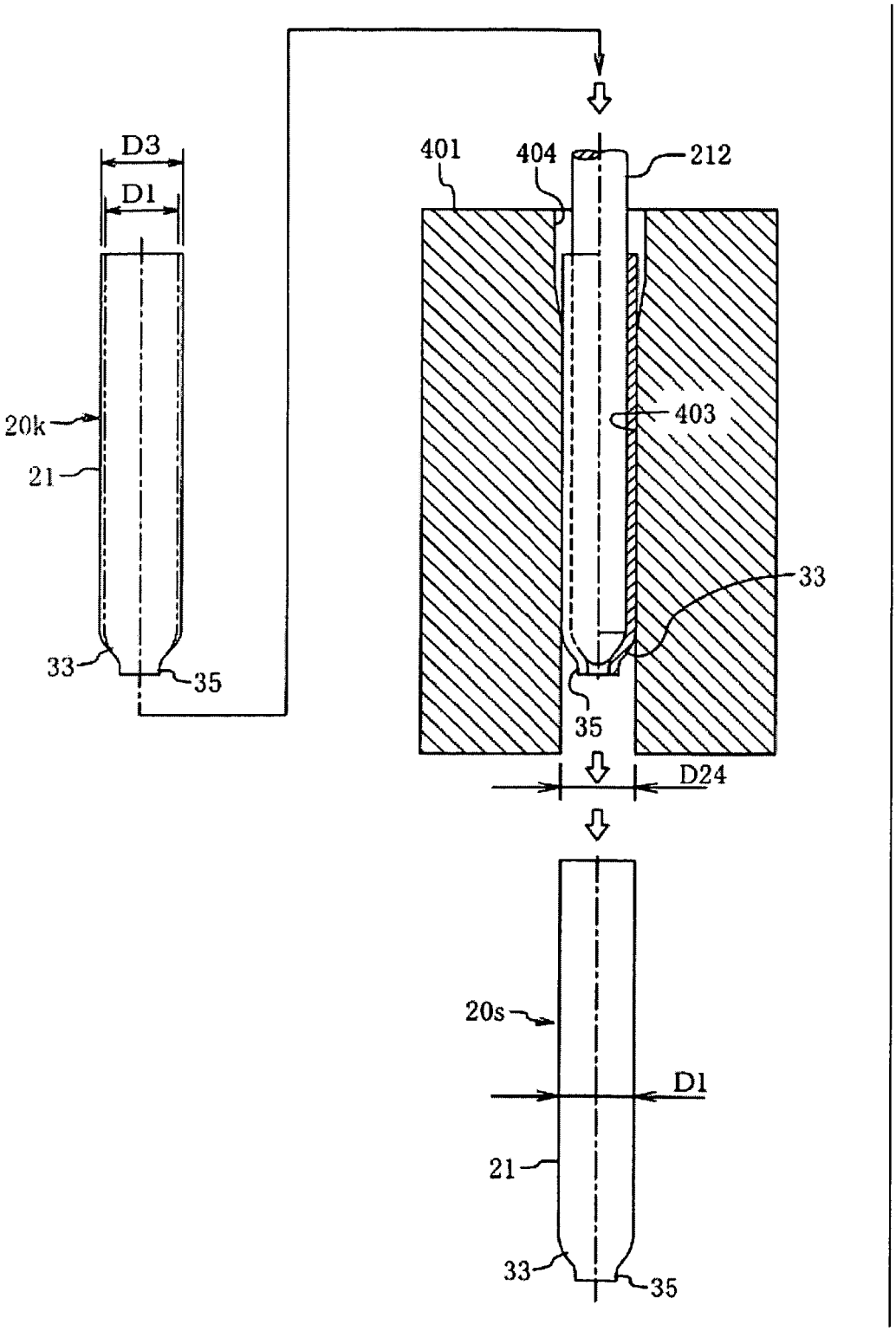


FIG. 4

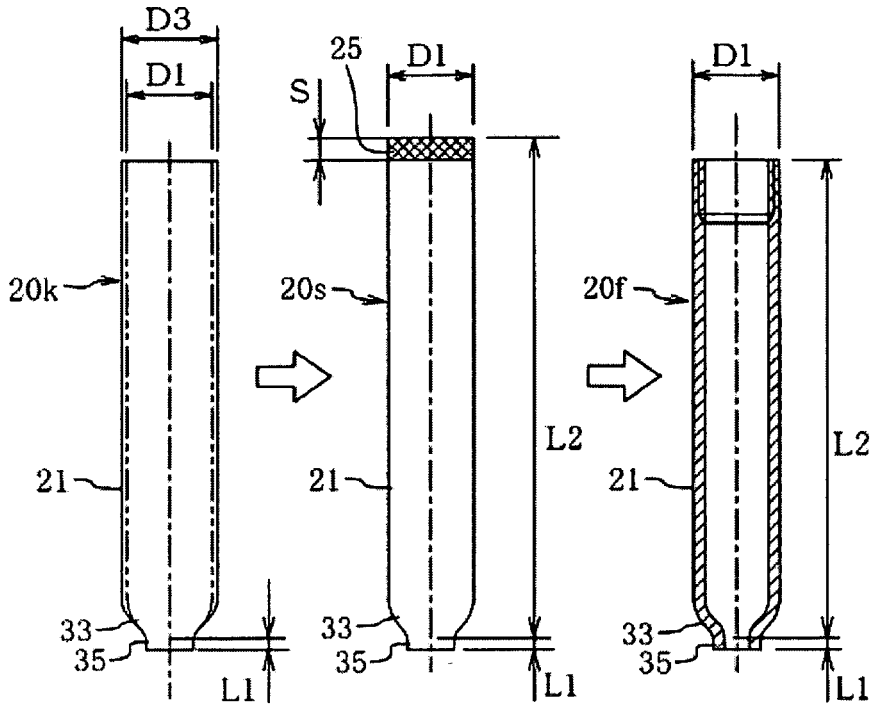


FIG. 5

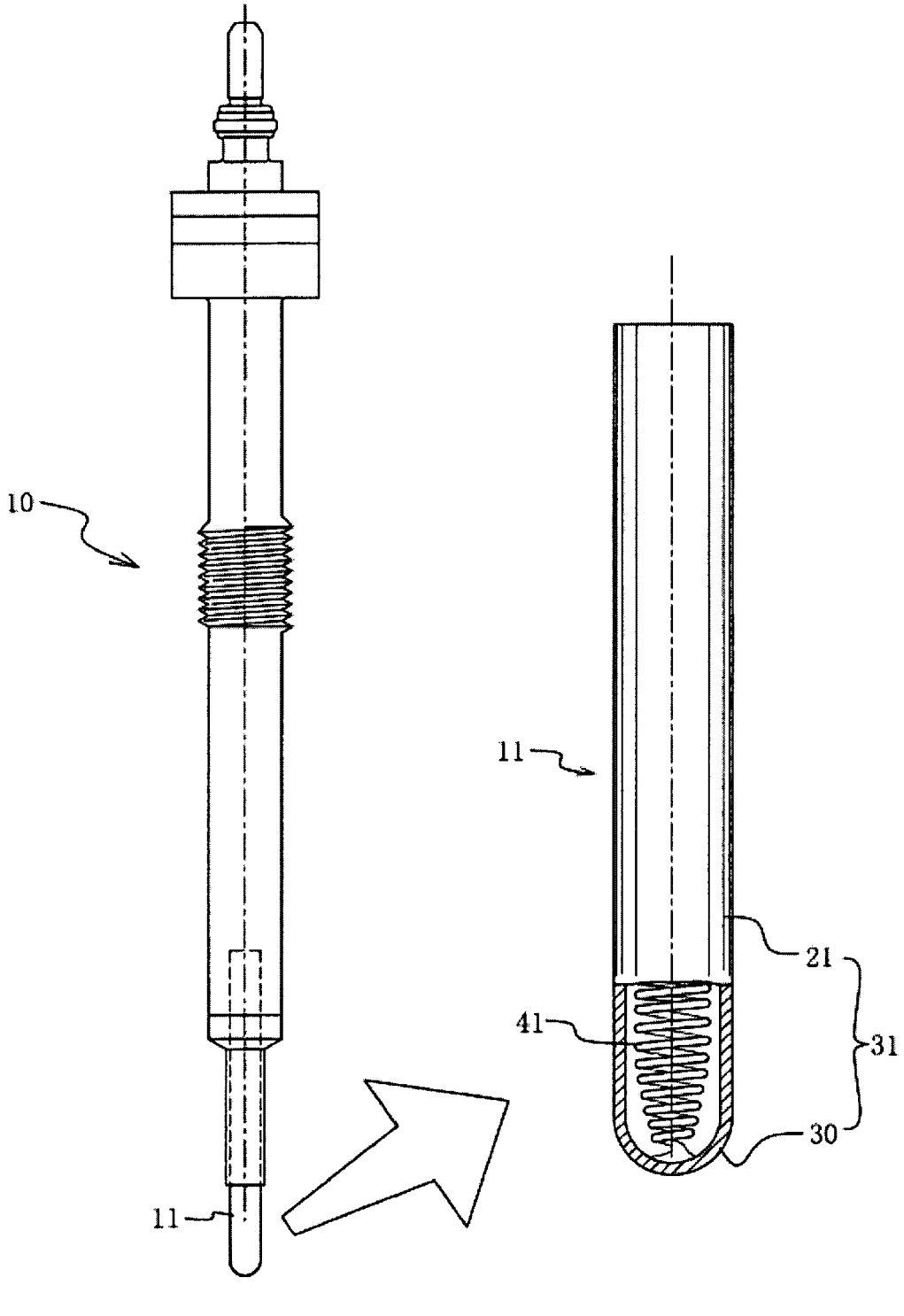


FIG. 6

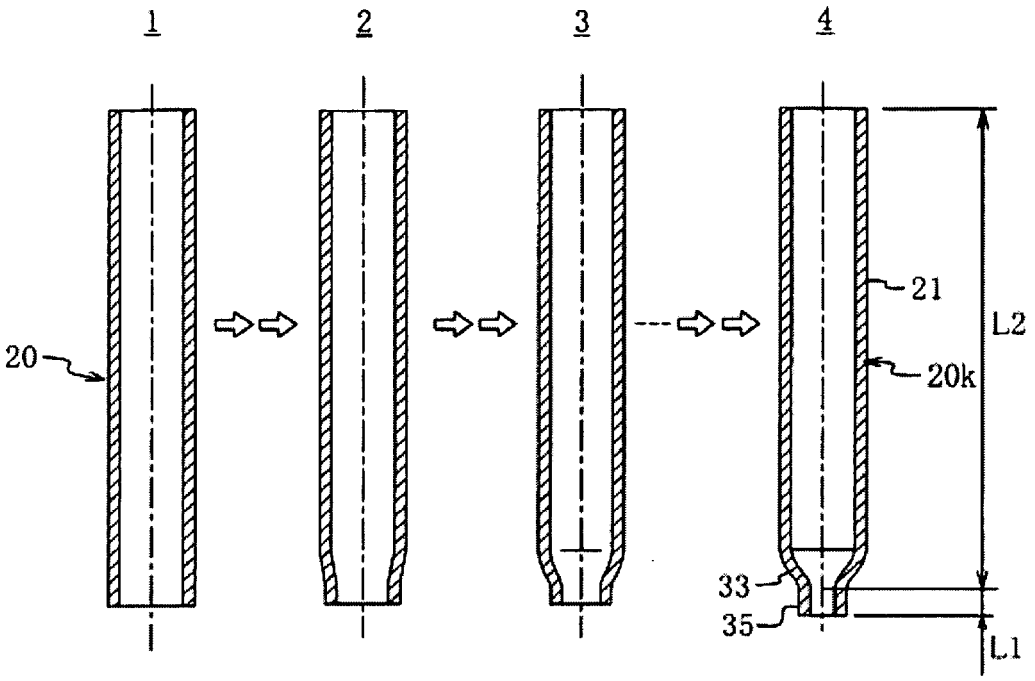


FIG. 7

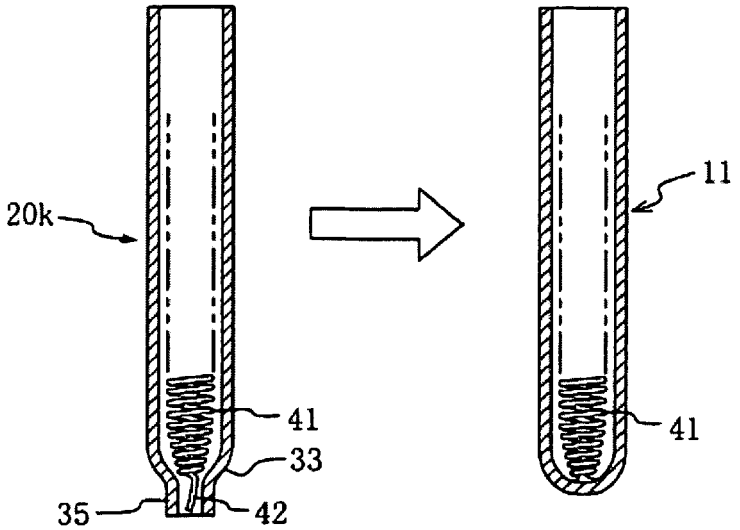
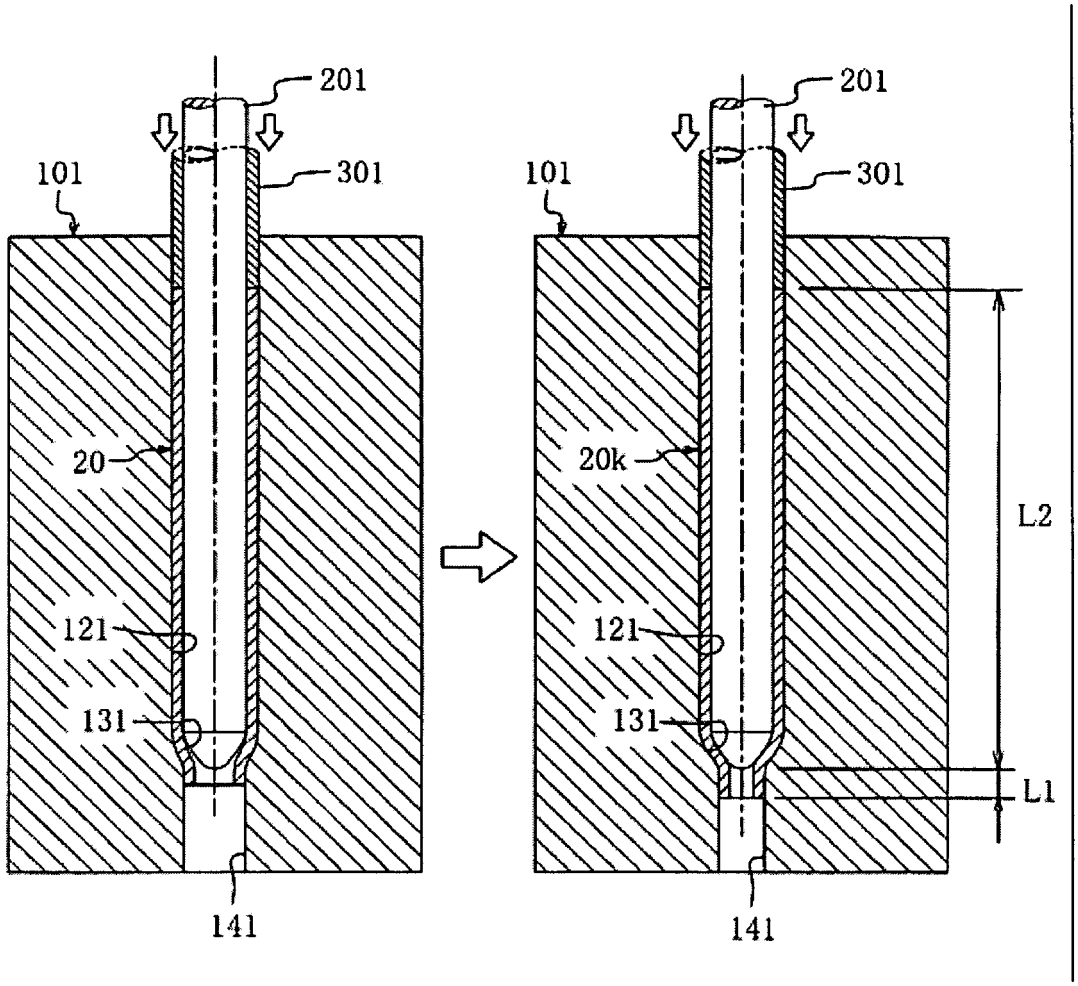


FIG. 8



REFERENCES CITED IN THE DESCRIPTION

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