United States of America

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The Director

of the United States Patent and Trademark Office has received an application for a patent for a new and useful invention. The title and description of the invention are enclosed. The requirements of law have been complied with, and it has been determined that a patent on the invention shall be granted under the law.

Therefore, this United States

Patent

grants to the person(s) having title to this patent the right to exclude others from making, using, offering for sale, or selling the invention throughout the United States of America or importing the invention into the United States of America, and if the invention is a process, of the right to exclude others from using, offering for sale or selling throughout the United States of America, products made by that process, for the term set forth in 35 U.S.C. 154(a)(2) or (c)(1), subject to the payment of maintenance fees as provided by 35 U.S.C. 41(b). See the Maintenance Fee Notice on the inside of the cover.

Coke Morgan Stewart

Acting Director of the United States Patent and Trademark Office

Maintenance Fee Notice

If the application for this patent was filed on or after December 12, 1980, maintenance fees are due three years and six months, seven years and six months, and eleven years and six months after the date of this grant, or within a grace period of six months thereafter upon payment of a surcharge as provided by law. The amount, number and timing of the maintenance fees required may be changed by law or regulation. Unless payment of the applicable maintenance fee is received in the United States Patent and Trademark Office on or before the date the fee is due or within a grace period of six months thereafter, the patent will expire as of the end of such grace period.

Patent Term Notice

If the application for this patent was filed on or after June 8, 1995, the term of this patent begins on the date on which this patent issues and ends twenty years from the filing date of the application or, if the application contains a specific reference to an earlier filed application or applications under 35 U.S.C. 120, 121, 365(c), or 386(c), twenty years from the filing date of the earliest such application ("the twenty-year term"), subject to the payment of maintenance fees as provided by 35 U.S.C. 41(b), and any extension as provided by 35 U.S.C. 154(b) or 156 or any disclaimer under 35 U.S.C. 253.

If this application was filed prior to June 8, 1995, the term of this patent begins on the date on which this patent issues and ends on the later of seventeen years from the date of the grant of this patent or the twenty-year term set forth above for patents resulting from applications filed on or after June 8, 1995, subject to the payment of maintenance fees as provided by 35 U.S.C. 41(b) and any extension as provided by 35 U.S.C. 156 or any disclaimer under 35 U.S.C. 253.

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Ma et al.

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(45) Date of Patent: May 13, 2025

(54) **DIE MOLDING APPARATUS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 54 days.

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B21J 1/00 (2006.01)
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CPC ***B22D 17/32*** (2013.01); ***B21J 1/006*** (2013.01); ***B21J 5/02*** (2013.01); ***B22D 17/02*** (2013.01); ***C21D 9/0062*** (2013.01); ***F27D 15/02*** (2013.01)

(58) **Field of Classification Search**
CPC B22D 18/02; C21D 9/0062; B21J 1/006; B21J 5/02; F27D 15/02
See application file for complete search history.

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(57) **ABSTRACT**

The present application relates to the technical field of amorphous alloy molding apparatuses, and more particularly to a die molding apparatus. The die molding apparatus includes: a forming structure, a material loading structure, and a vacuum pumping structure. The forming structure includes a forming furnace body having a heating cavity, a material waiting housing having a transition cavity, a feeding pipe having two ends respectively connected with the heating cavity and the transition cavity, and a vacuum control valve arranged on the feeding pipe. The material loading structure includes a material loading arm and a material loading driving mechanism, one end of the material loading arm is located in the transition cavity, and the other

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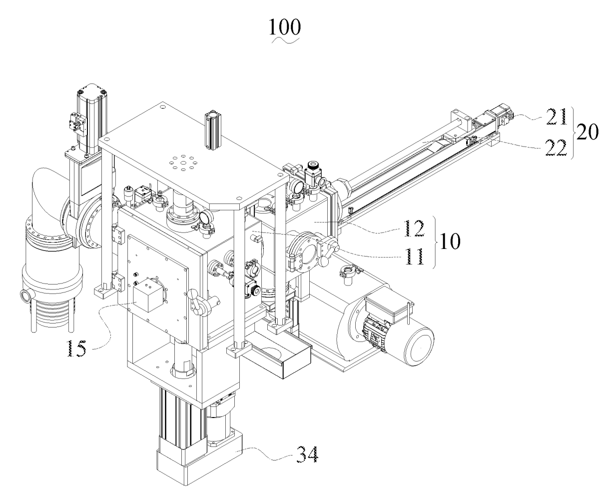

end of the material loading arm is penetrated through a material loading hole sealingly.

12 Claims, 3 Drawing Sheets

(51) **Int. Cl.**

B21J 5/02	(2006.01)
B22D 17/02	(2006.01)
C21D 9/00	(2006.01)
F27D 15/02	(2006.01)

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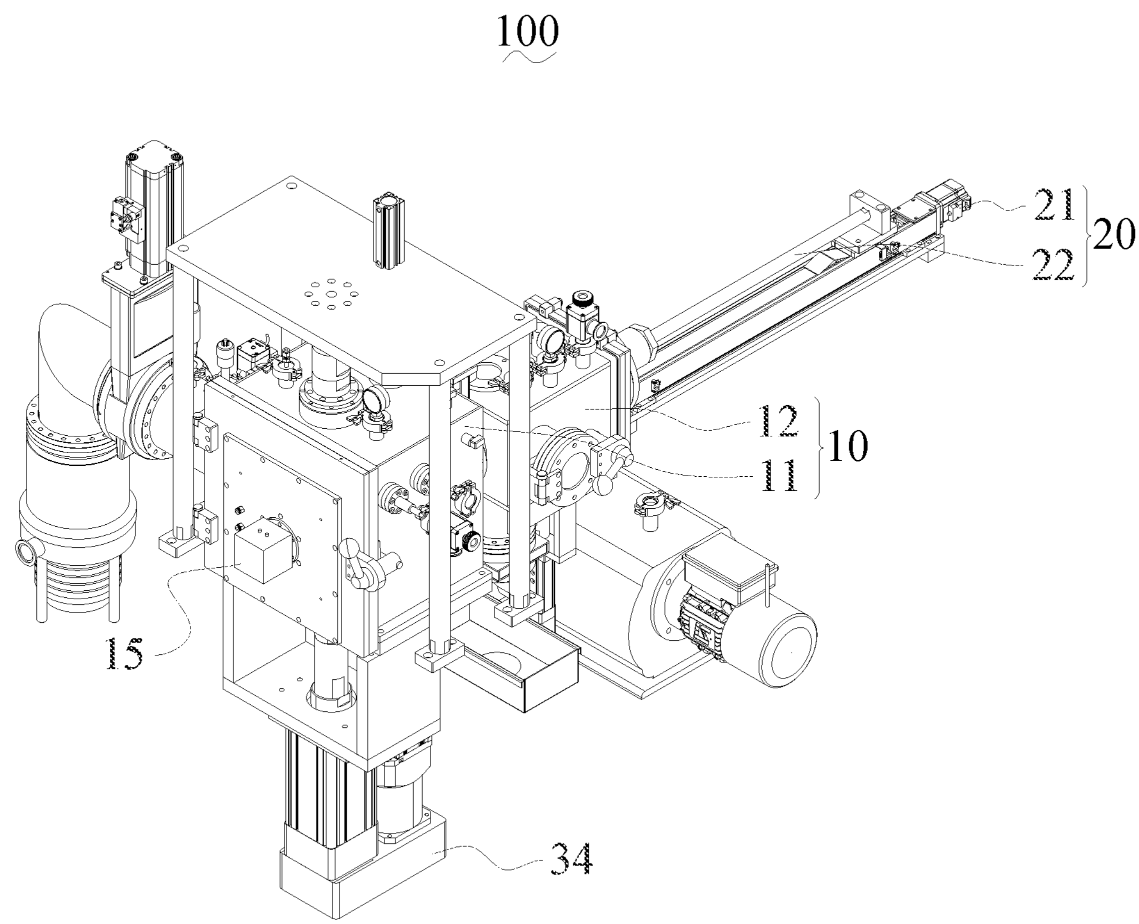
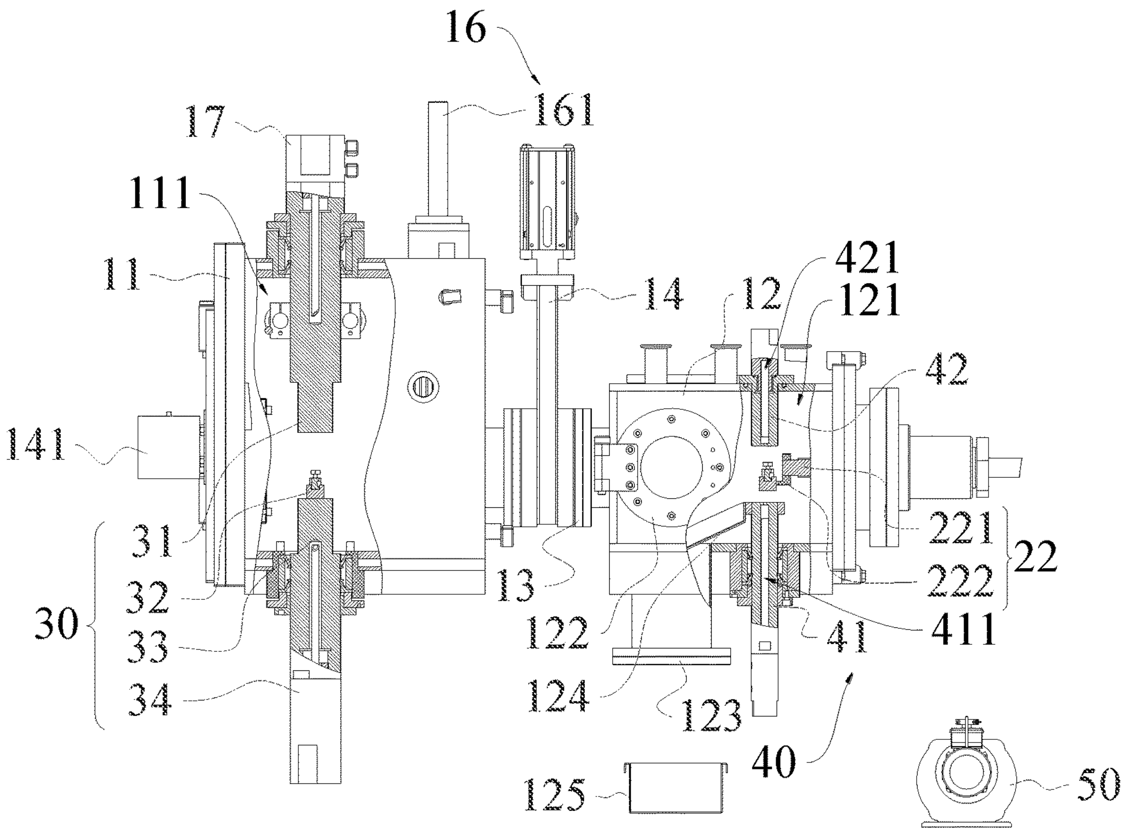


FIG. 1


16
161
17
111
11
14
12
421
121
42
141
221
22
31
222
32
13
122
411
30
33
41
124
34
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125
50

FIG. 2

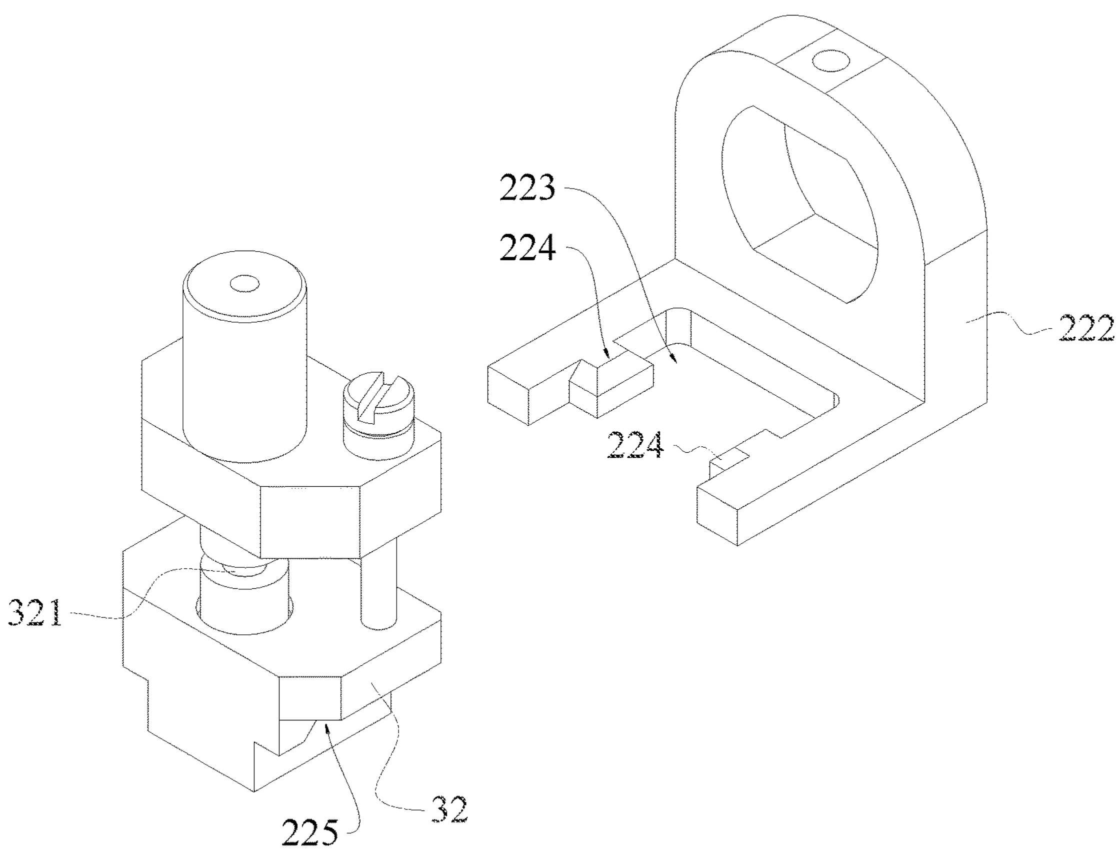
223
224
222
224
321
225
32

FIG. 3

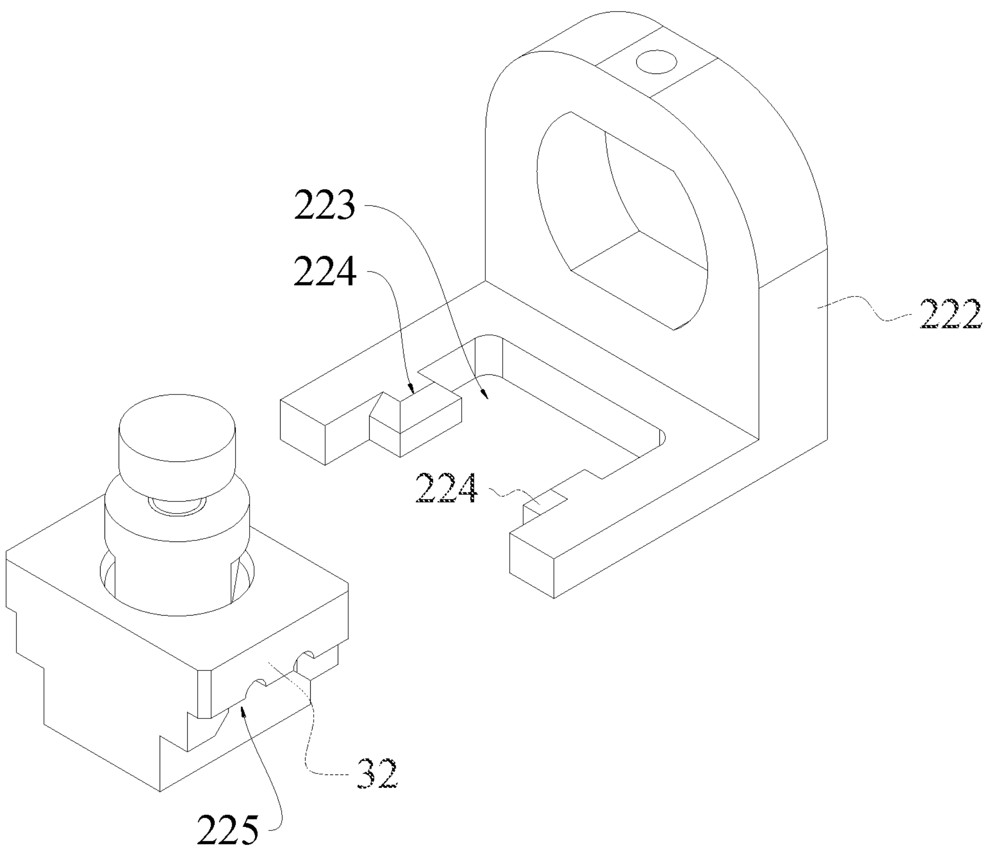

FIG. 4

DIE MOLDING APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

This present application is a National Stage Appl. of International Patent Application No. PCT/CN2021/114021 with an international filing date of Aug. 23, 2021 designating the United States, now pending, and further claims foreign priority benefits to Chinese Patent Application No. 202010884952.X filed on Aug. 28, 2020. The contents of all of the aforementioned applications, including any intervening amendments thereto, are incorporated herein by reference.

FIELD

The present application relates to the technical field of amorphous alloy molding apparatuses, and more particularly to a die molding apparatus.

BACKGROUND

The statements herein only provide background information related to the present application, and do not necessarily constitute as prior art.

Amorphous alloys have excellent mechanical properties, resistance to various media corrosion, soft magnetic, hard magnetic and unique expansion characteristics and other physical properties. Amorphous alloys have good processability near the glass transition temperature thereof, so it is often necessary to heat the amorphous alloys to the supercooled liquid phase region and conduct thermoplastic forming to obtain the required structure.

However, in the thermoplastic forming process of the amorphous alloys, especially in continuous and repetitive production and manufacturing, the amorphous alloys are usually heated from room temperature to the supercooled liquid phase region thereof, and then the amorphous alloys are cooled to the room temperature after thermoplastic forming. Since the amorphous alloys at high temperatures are prone to oxidation with air, after a single processing, the processed amorphous alloy needs to be cooled along with the forming furnace body, which leads to a long heating time. During this cooling process, the amorphous alloys are also prone to characteristic changes; in addition, during the thermoplastic forming of a plurality of amorphous alloys, the heating cavity of the forming furnace body needs to be vacuumized again for each thermoplastic forming, which results in a long working tempo and low efficiency.

SUMMARY

One of objects of embodiments of the present application is to provide a die molding apparatus, in order to solve the problem that how to reduce the manufacturing tempo of the amorphous alloys, and to improve the manufacturing efficiency and safety.

In order to solve above technical problem, the technical solution adopted in embodiments of the present application is:

A die molding apparatus is provided for thermoplastic forming of an amorphous alloy, and the die molding apparatus includes:

a forming structure, including: a forming furnace body with a heating cavity; a material waiting housing with a transition cavity, a feeding pipe provided with two

ends respectively in communicated with the heating cavity and the transition cavity, and a vacuum control valve arranged on the feeding pipe;

a material loading structure, including: a material loading arm and a material loading driving mechanism; the material waiting housing is provided with a material loading hole being in communicated with the transition cavity, one end of the material loading arm is located in the transition cavity and configured for carrying the amorphous alloy, the other end of the material loading arm is configured to penetrate through the material loading hole sealingly and slidably, and the material loading driving mechanism is connected with the other end of the material loading arm; and

a vacuum pumping structure, configured for pumping out gas in the heating cavity and the transition cavity, such that vacuum degrees of the heating cavity and the transition cavity reach a predetermined value;

the vacuum control valve has a turn-on state and a turn-off state, and when the vacuum control valve is in the turn-on state, the feeding pipe communicates the heating cavity and the transition cavity, the material loading driving mechanism drives the material loading arm to slide, such that the material loading arm carries the amorphous alloy to the heating cavity or the amorphous alloy back to the transition cavity through the feeding pipe; and when the vacuum control valve is in the turn-off state, the heating cavity is sealed and isolated from the transition cavity.

In an embodiment, the forming structure further includes: a heat insulation mechanism comprising a heat insulation shield arranged in the heating cavity and a heat insulation driver connected with the forming furnace body; the heat insulation driver drives the heat insulation shield to seal an orifice of the feeding pipe, so as to prevent heat from entering the transition cavity through the feeding pipe.

In an embodiment, the die molding apparatus further includes: a mold mechanism; and the mold mechanism includes: an upper pressure head arranged in the heating cavity, a lower pressure head located below the upper pressure head and arranged slidably relative to the upper pressure head, a forming driving mechanism connected with the forming furnace body and configured for driving the lower pressure head to move up and down relative to the upper pressure head, and a forming mold detachably arranged on the lower pressure head; the forming mold is provided with a forming cavity configured for accommodating the amorphous alloy, and the lower pressure head moves toward the upper pressure head to press against the forming mold to plastically form the amorphous alloy.

In an embodiment, the material loading arm includes an arm body and a clamping claw arranged at an end of the arm body, the other end of the arm body passes through the material loading hole and is connected with the material loading driving mechanism, the clamping claw is located in the transition cavity and configured to detachably clamp the forming mold.

In an embodiment, the clamping claw is provided with a clamping groove, and an end of the forming mold is champed in the clamping groove.

In an embodiment, groove walls on both sides of the clamping groove are protruded with positioning blocks, and positions on the forming mold corresponding to the positioning blocks are provided with positioning grooves matched with the positioning blocks.

In an embodiment, the die molding apparatus further includes a cooling structure configured for cooling the forming mold.

In an embodiment, the cooling structure includes a lower cooling column vertically arranged and provided with a lower cooling channel; an end of the lower cooling column is located in the transition cavity and provided with a cooling end surface configured for placing the forming mold, and the other end of the lower cooling column is located outside of the transition cavity and connected with an external cooling water source.

In an embodiment, the lower cooling column is connected with the material waiting housing slidably and sealingly.

In an embodiment, the cooling structure further includes a cooling driving mechanism for driving the lower cooling column to slide up and down, and an upper cooling column arranged opposite to the lower cooling column, the upper cooling column is provided with an upper cooling channel.

In an embodiment, the material waiting housing is provided with a discharge port arranged in communicated with the transition cavity, and the die molding apparatus further includes a blanking groove, one end of the blanking groove is connected with the discharge port, and the other end of the blanking groove is arranged adjacent to the cooling end surface.

In an embodiment, the material waiting housing is further provided with a feeding port, and the die molding apparatus further includes a discharging valve configured for sealing the discharging port and a feeding valve configured for sealing the feeding port.

In an embodiment, the forming furnace body includes a furnace body provided with the heating cavity and a heating mechanism arranged in the heating cavity.

The beneficial effect of the die molding apparatus provided by the embodiments of the present application is that: the amorphous alloy is sent into the heating cavity that has been heated, which can realize the rapid temperature rise of the amorphous alloy. The present application is provided with the transition cavity and the vacuum degree of the transition cavity is pumped to a predetermined value, after the amorphous alloy has completed the thermoplastic forming, the vacuum control valve is turned on, and the processed amorphous alloy is conveyed back to the transition cavity through the material loading arm, then the vacuum control valve is turned off, the heating cavity is kept at a predetermined vacuum degree and the amorphous alloy is cooled in the transition cavity, so that the processed amorphous alloy does not need to be cooled with the forming furnace body, and the cooling efficiency is high to achieve rapid cooling. Moreover, the heat of the forming furnace body is retained to save energy consumption, and the temperature in the heating cavity can rise to the predetermined temperature in a short time in the next thermoplastic forming process, thus the thermoplastic forming efficiency of the amorphous alloy is further improved. In addition, the amorphous alloy is taken and placed in the transition cavity with a low temperature, the safety is high.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to explain the embodiments of the present application more clearly, a brief introduction regarding the accompanying drawings that need to be used for describing the embodiments of the present application or the prior art is given below; it is obvious that the accompanying drawings described as follows are only some embodiments of the present application, for those skilled in the art, other drawings can also be obtained according to the current drawings on the premise of paying no creative labor.

FIG. **1** is a structural schematic view of a die molding apparatus provided by an embodiment of the present application;

FIG. **2** is a partially sectional schematic view of the die molding apparatus in FIG. **1**;

FIG. **3** is a schematic view of a forming mold matched with a champing claw in an embodiment in FIG. **1**; and

FIG. **4** is a schematic view of a forming mold matched with a champing claw in another embodiment in FIG. **1**.

DETAILED DESCRIPTION OF EMBODIMENTS

In order to make the purpose, the technical solution and the advantages of the present application be clearer and more understandable, the present application will be further described in detail below with reference to accompanying figures and embodiments. It should be understood that the specific embodiments described herein are merely intended to illustrate but not to limit the present application.

It is noted that when a component is referred to as being “fixed to” or “disposed on” another component, it can be directly or indirectly on another component. When a component is referred to as being “connected to” another component, it can be directly or indirectly connected to another component. It needs to be understood that, directions or location relationships indicated by terms such as “up”, “down”, “left”, “right”, and so on are the directions or location relationships shown in the accompanying figures, which are only intended to describe the present application conveniently and simplify the description, but not to indicate or imply that an indicated device or component must have specific locations or be constructed and manipulated according to specific locations; therefore, these terms shouldn’t be considered as any limitation to the present application. The terms “the first” and “the second” are only used in describe purposes, and should not be considered as indicating or implying any relative importance, or impliedly indicating the number of indicated technical features, “a plurality of” means two or more, unless there is additional explicit and specific limitation.

In order to explain the technical solution described in the present application, the following is a detailed description in combination with the specific drawings and embodiments.

As shown in FIGS. **1** to **3**. The embodiment of the present application provides a die molding apparatus **100**, which is used for thermoplastic forming of amorphous alloy **321**. The die molding apparatus includes a forming structure **10**, a material loading structure **20** and a vacuum pumping structure **50**. The forming structure **10** includes a forming furnace body **11** with a heating cavity **111**, a material waiting housing **12** with a transition cavity **121**, a feeding pipe **13** with two ends respectively in communicated with the heating cavity **111** and the transition cavity **121**, and a vacuum control valve **14** arranged on the feeding pipe **13**. In an embodiment, the heating cavity **111** heats the amorphous alloy to its supercooled liquid phase region under a predetermined vacuum degree. The material loading structure **20** includes a material loading arm **22** and a material loading driving mechanism **21**. The material waiting housing **12** is provided with a material loading hole arranged in communicated with the transition cavity **121**. One end of the material loading arm **22** is located in the transition cavity **121** and is used for carrying the amorphous alloy **321**. The other end of the material loading arm **22** is configured to penetrate through the material loading hole sealingly and slidably. In an embodiment, the feeding pipe **13** and the material loading arm **22** are respectively located at both ends of the material waiting housing **12**. The material loading driving mechanism **21** is connected to the other end of the material loading arm **22**. The material loading driving mechanism **21** is used to drive the material loading arm **22** to slide back and forth, so as to convey the amorphous alloy **321** from the transition cavity **121** to the heating cavity **111**, or convey the amorphous alloy **321** from the heating cavity **111** back to the transition cavity **121**. The vacuum pumping structure **50** is used for pumping out the gas in the heating cavity **111** and/or the transition cavity **121**. In an embodiment, the vacuum pumping structure **50** includes a mechanical pump and a molecular pump, the vacuum of the heating cavity **111** and/or the transition cavity **121** is firstly pumped to less than 1*10−1 Pa through the mechanical pump, and the vacuum of the heating cavity **111** and/or the transition cavity **121** is then pumped to less than 5*10−5 Pa through the molecular pump. The vacuum control valve **14** has a turn-on state and a turn-off state. When the vacuum control valve **14** is in the turn-on state, the feeding pipe **13** is in communicated with the heating cavity **111** and the transition cavity **121**, and the loading driving mechanism **21** drives the material loading arm **22** to slide, so that the material loading arm **22** conveys the amorphous alloy **321** to the heating cavity **111** or the amorphous alloy **321** from the heating cavity **111** back to the transition cavity **121** through the feeding pipe **13**. When the vacuum control valve **14** is turned off, the heating cavity **111** and the transition cavity **121** are sealed and isolated.

As shown in FIGS. **1** and **3**, the present application is provided with the transition cavity **121** and the vacuum degree of the transition cavity **121** is pumped to a predetermined value, after the amorphous alloy **321** has completed the thermoplastic forming, the vacuum control valve **14** is turned on, and the processed amorphous alloy **321** is conveyed back to the transition cavity **121** through the material loading arm **22**, then the vacuum control valve **12** is turned off, the heating cavity **111** is kept at a predetermined vacuum degree and the amorphous alloy **321** is cooled in the transition cavity **121**, so that the processed amorphous alloy **321** does not need to be cooled with the forming furnace body **11**, and the cooling efficiency is high. Moreover, the heat of the forming furnace body **11** is retained, and the temperature in the heating cavity **111** can rise to the predetermined temperature in a short time in the next thermoplastic forming process, thus the thermoplastic forming efficiency of the amorphous alloy is further improved, and tempo is reduced.

As shown in FIGS. **1** and **3**, in an embodiment, the volume of the heating cavity **111** is larger than the volume of the transition cavity **121**. Therefore, during the next thermoplastic forming, only a small amount of gas in the transition cavity **121** needs to be extracted, so that the vacuum in the transition cavity **121** is not lower than the vacuum in the heating cavity **111**. Then, the vacuum control valve **14** is turned on, and the amorphous alloy **321** to be processed is conveyed to the heating cavity **111** through the material loading arm **22**, which ultimately improves the production efficiency.

In an embodiment, a material waiting area is arranged in the transition cavity **121**, and the amorphous alloy **321** to be thermoplastic formed can be placed in the material waiting area in advance, and the vacuum degree of the transition cavity **121** can be pumped to the predetermined value at the same time. After the thermoplastic forming of the previous amorphous alloy **321** is completed, it is conveyed back to the transition cavity **121**, and then the amorphous alloy **321** in the material waiting area is conveyed to the heating cavity **111** to continue the thermoplastic forming of the amorphous alloy **321**, so as to achieve continuous production.

As shown in FIGS. **1** and **3**, in an embodiment, the forming structure **10** further includes a heat insulation mechanism **16**, which includes a heat insulation shield arranged in the heating cavity **111** and a heat insulation driver **161** connected to the forming furnace body **11**. The heat insulation driver **161** drives the heat insulation shield to seal the orifice of the feeding pipe **13** to prevent heat from entering the feeding pipe **13**. In an embodiment, when the vacuum control valve **14** is in the turn-on state, the heat insulation driver **161** drives the heat insulation shield to open the orifice of the feeding pipe **13**; when the vacuum control valve **14** is turned off, the heat insulation driver **161** drives the heat insulation shield to seal the orifice of the feeding pipe **13**. Alternatively, the heat insulation shield can be made of molybdenum and stainless steel.

As shown in FIGS. **3** and **4**, in an embodiment, the die molding apparatus **100** further includes a mold mechanism **30**, which includes an upper pressure head **31** arranged in the heating cavity **111**, a lower pressure head **33** located below the upper pressure head **31** and slidably arranged with respect to the upper pressure head **31**, a forming driving mechanism **34** connected with the forming furnace body **11** and used to drive the lower pressure head **33** to move up and down with respect to the upper pressure head **31**, and a forming mold **32** detachably arranged on the lower pressure head **33**; the forming mold **32** is provided with a forming cavity for accommodating the amorphous alloy **321**, and the lower pressure head **33** moves toward the upper pressure head **31** and presses the forming mold **32** to form the amorphous alloy. In an embodiment, the forming furnace body **11** is provided with a forming hole, and one end of the lower pressure head **33** is slidably and sealing penetrated the forming hole to connect the forming driving mechanism. In an embodiment, the forming driving mechanism can be a servo motor.

In an embodiment, the driving force range of forming driving mechanism **34** for driving the lower pressure head **33** is 100-30000 N, the travel range of lower pressure head **33** is 0~50 mm, and the moving speed range of lower pressure head **33** is 0.01~2 mm/s; in an embodiment, the lower pressure head **33** pre-presses the forming mold **32** between the upper pressure head **31** and the lower pressure head **33** with a driving force of 100 N. In an embodiment, the die molding apparatus **100** further includes an infrared thermometer **141** connected to the forming furnace body **11**. The infrared thermometer **141** directly detects the real-time temperature of the amorphous alloy **321** in the forming mold **32** through the temperature measurement window. When the temperature reaches the temperature conversion point Tg in the supercooled liquid phase region of the amorphous alloy **321**, the forming driving mechanism **34** drives the lower pressure head **33** to move to pressurize the forming mold **32** and perform thermoplastic forming. In an embodiment, the temperature measuring window is made of vacuum glass. The infrared thermometer **141** directly detects the temperature of amorphous alloy **321** through non-contact manner, which is conducive to improving the forming quality, automatic feeding and discharging, and realizing continuous production.

As shown in FIGS. **1** and **3**, in an embodiment, the die molding apparatus **100** further includes a pull pressure sensor **17** at which the upper pressure head **31** is provided. The pull pressure sensor **17** monitors the driving force received by the upper pressure head **31** in real time, and feeds back the monitoring results to the forming driving mechanism **34**, so that the forming driving mechanism **34** can adjust the driving force, to form a closed-loop control system and accurately control the pressure. The maximum range of the pressure sensor **17** is 50000 N.

In an embodiment, the material loading arm **22** includes an arm body **221** and a clamping claw **222** arranged at one end of the arm body **221**. The other end of the arm body **221** is penetrated the material loading hole and connected with the loading driving mechanism **21**. The clamping claw **222** is located in the transition cavity **121** and is used to detachably clamp the forming mold **32**. The forming mold **32** can be conveyed from the transition cavity **121** to the lower pressure head **33**, or the forming mold **32** can be conveyed from the lower pressure head **33** back to the transition cavity **121** through clamping the forming mold **32** with the clamping claw **222**. In an embodiment, the material loading driving mechanism **21** includes a servo motor, the speed range of the material loading arm **22** moving towards the lower pressure head **33** is 2~100 mm/s, the travel range of the material loading arm **22** is 0~650 mm, and the speed of the material loading arm **22** returning to the transition cavity **121** is 100 mm/s.

As shown in FIGS. **3** and **4**, in an embodiment, the clamping claw **222** is provided with a clamping groove **223**, and one end of the forming mold **32** is clamped to the clamping groove **223**; the groove walls on both sides of the clamping groove **223** are convexly arranged with positioning blocks **224**, and the positions of the forming mold **32** corresponding to each positioning block **224** are provided with positioning grooves **225** that are matched with the positioning blocks **224**. The stability of the forming mold **32** in the conveying process can be improved through the matching of the positioning grooves **225** and the positioning blocks **224**. In an embodiment, after the forming mold **32** is moved and transported to the lower pressure head **33**, the forming driving mechanism **34** drives the lower pressure head **33** to rise a predetermined distance, so that the positioning grooves **225** and the positioning blocks **224** are separated from each other, and thus the forming mold **32** is completely released to the lower pressure head **33**.

In an embodiment, the die molding apparatus **100** further includes a cooling structure **40** for cooling the forming mold **32**. The cooling structure **40** includes a lower cooling column **41** vertically arranged and provided with a lower cooling channel **411**. An end of the lower cooling column **41** is located in the transition cavity **121** and provided with a cooling end surface for placing the forming mold **32**. The other end of the lower cooling column **41** is located outside the transition cavity **121** and is connected with an external cooling water source. In an embodiment, after the amorphous alloy **321** completes the thermoplastic forming, the material loading arm **22** carries the forming mold **32** to the cooling end surface of the lower cooling column **41**, and the cooling end surface faces upwards, and the forming mold **32** is cooled through the cooling water in the lower cooling channel **411**, thus the cooling efficiency of the forming mold **32** is improved.

As shown in FIGS. **1** and **3**, in an embodiment, the lower cooling column **41** is connected with the material waiting housing **12** slidably and sealingly. The cooling structure **40** further includes a cooling driving mechanism for driving the lower cooling column **41** to slide up and down, and an upper cooling column **42** that is opposite to the lower cooling column **41**. The upper cooling column **42** is provided with an upper cooling channel **421**. The cooling driving mechanism drives the lower cooling column **41** to move upward, so that both ends of the forming mold **32** are respectively contacted with the upper cooling column **42** and the lower cooling column **41**, thereby further improving the cooling efficiency of the forming mold **32**. The upper cooling column **42** is provided therein with a thermocouple, and when the material is cooled to the predetermined temperature detected through the thermocouple, the cooling is stopped.

As shown in FIGS. **1** and **3**, in an embodiment, inert gas can be released into the transition cavity **121** to further improve the cooling efficiency of the forming mold **32**. The material waiting housing **12** is provided with a vacuum electromagnetic angle valve, which is used to monitor the air pressure in the transition cavity **121**. After the air pressure in the transition cavity **121** is balanced with the atmospheric pressure, the gas cooling of the forming mold **32** is completed.

In an embodiment, the circulating cooling water with temperature of 300K is introduced into the lower cooling channel **411** and the upper cooling channel **421** to cool the forming mold **32** below a temperature of 425K.

As shown in FIGS. **1** and **3**, in an embodiment, the material waiting housing **12** is provided with a discharge port which is in communicated with the transition cavity **121**. The die molding apparatus **100** further includes a blanking groove **124**, one end of the blanking groove **124** is connected to the discharge port, and the other end of the blanking groove **124** is adjacent to the cooling end surface.

In an embodiment, the die molding apparatus **100** further includes a receiving box **125** loaded with coolant. The receiving box **125** is located below the discharge port. After the forming mold **32** is transported to the cooling end surface, the cooling driving mechanism drives the lower cooling column **41** to rise by a predetermined distance, so that the positioning grooves **225** and the positioning blocks **224** are separated from each other, the loading driving mechanism **21** drives the material loading arm **22** to retract, and the cooling driving mechanism drives the lower cooling column **41** to fall by a predetermined distance, such that the material loading arm **22** is driven by the material loading driving mechanism **21** to push the forming mold **32** into the blanking groove **124**, so that the forming mold **32** falls into the receiving box **125** from the discharge port, and the receiving box **125** is located below the discharge port.

In an embodiment, the material waiting housing **12** is further provided with a feeding port, and the die molding apparatus further includes a discharge valve **123** for sealing the discharge port and a feeding valve **122** for sealing the feeding port. The forming mold **32** loaded with the amorphous alloy **321** to be machined can be placed on the material loading arm **22** through the feeding port.

As shown in FIGS. **1** and **3**, in an embodiment, the forming furnace body **11** includes a furnace body with a heating cavity **111** and a heating mechanism arranged in the heating cavity **111**, the heating mechanism is used to heat the forming mold **32**. In an embodiment, the heating mechanism includes a plurality of tantalum heaters, the tantalum heaters are arranged around the circumference of the lower pressure head **33**, the heating temperature range of the heating mechanism is 373~1500K, and the heating rate is 2~30K/min.

In an embodiment, the die molding apparatus **100** further includes a human-machine interface, which is connected to the material waiting housing **12** and can rotate 360°.

In an embodiment, the die molding apparatus **100** further includes a control structure, which is a PLC control system and is used to control the forming structure **10**, the material loading structure **20** and the vacuum pumping structure **50**.

The aforementioned embodiments are only preferred embodiments of the present application. For one of ordinary skill in the art, according to the thought of the present application, specific implementation modes and application scopes may be modified, and the content of the specification should not be interpreted as any limitation to the present application.

What is claimed is:

1. A die molding apparatus for thermoplastic forming of an amorphous alloy, comprising:

a forming structure, comprising: a forming furnace body with a heating cavity; a material waiting housing with a transition cavity, a feeding pipe provided with two ends respectively in communication with the heating cavity and the transition cavity, and a vacuum control valve arranged on the feeding pipe;

a material loading structure, comprising: a material loading arm and a material loading driving mechanism; wherein the material waiting housing is provided with a material loading hole being in communication with the transition cavity, one end of the material loading arm is located in the transition cavity and configured for carrying the amorphous alloy, the other end of the material loading arm is configured to penetrate through the material loading hole sealingly and slidably, and the material loading driving mechanism is connected with the other end of the material loading arm; and

a vacuum pumping structure, configured for pumping out gas in the heating cavity and the transition cavity, such that vacuum degrees of the heating cavity and the transition cavity reach a predetermined value;

wherein the vacuum control valve has a turn-on state and a turn-off state, and when the vacuum control valve is in the turn-on state, the feeding pipe communicates the heating cavity and the transition cavity, the material loading driving mechanism drives the material loading arm to slide, such that the material loading arm carries the amorphous alloy to the heating cavity or carries the amorphous alloy back to the transition cavity through the feeding pipe; and after the amorphous alloy is thermoplastic formed in the heating cavity, and is then conveyed to the transition cavity for cooling; the vacuum control valve is in the turn-off state, to seal and isolate the heating cavity from the transition cavity;

wherein a material waiting area is arranged in the transition cavity, an amorphous alloy to be thermoplastic formed is placed in the material waiting area in advance, and the vacuum degree of the transition cavity is pumped to the predetermined value; the material waiting area is further configured to receive a previous amorphous alloy being thermoplastic formed and conveyed from the heating cavity, and the amorphous alloy to be thermoplastic formed is then conveyed to the heating cavity to continue the thermoplastic forming of the amorphous alloy; and

wherein die molding apparatus further comprises:

a mold mechanism, comprising:

an upper pressure head arranged in the heating cavity, a lower pressure head located below the upper pressure head and arranged slidably relative to the upper pressure head, a forming driving mechanism connected with the forming furnace body and configured for driving the lower pressure head to move up and down relative to the upper pressure head, and a forming mold detachably arranged on the lower pressure head; the forming mold is provided with a forming cavity configured for accommodating the amorphous alloy, and the lower pressure head moves toward the upper pressure head to press against the forming mold to plastically form the amorphous alloy.

2. The die molding apparatus according to claim **1**, wherein the forming structure further comprises:

a heat insulation mechanism, comprising a heat insulation shield arranged in the heating cavity and a heat insulation driver connected with the forming furnace body; the heat insulation driver drives the heat insulation shield to seal an orifice of the feeding pipe, so as to prevent heat from entering the transition cavity through the feeding pipe.

3. The die molding apparatus according to claim **1**, wherein the material loading arm comprises an arm body and a clamping claw arranged at an end of the arm body, the other end of the arm body passes through the material loading hole and is connected with the material loading driving mechanism, the clamping claw is located in the transition cavity and configured to detachably clamp the forming mold.

4. The die molding apparatus according to claim **3**, wherein the clamping claw is provided with a clamping groove, and an end of the forming mold is clamped in the clamping groove.

5. The die molding apparatus according to claim **4**, wherein groove walls on both sides of the clamping groove are protruded with positioning blocks, and positions on the forming mold corresponding to the positioning blocks are provided with positioning grooves matched with the positioning blocks.

6. The die molding apparatus according to claim **1**, further comprising: a cooling structure configured for cooling the forming mold.

7. The die molding apparatus according to claim **6**, wherein the cooling structure comprises a lower cooling column vertically arranged and provided with a lower cooling channel; an end of the lower cooling column is located in the transition cavity and provided with a cooling end surface configured for placing the forming mold, and the other end of the lower cooling column is located outside of the transition cavity and connected with an external cooling water source.

8. The die molding apparatus according to claim **7**, wherein the lower cooling column is connected with the material waiting housing slidably and sealingly.

9. The die molding apparatus according to claim **8**, wherein the cooling structure further comprises a cooling driving mechanism for driving the lower cooling column to slide up and down, and an upper cooling column arranged opposite to be to the lower cooling column, the upper cooling column is provided with an upper cooling channel.

10. The die molding apparatus according to claim **7**, wherein the material waiting housing is provided with a discharge port arranged in communication with the transition cavity, and the die molding apparatus further comprises a blanking groove, one end of the blanking groove is connected with the discharge port, and the other end of the blanking groove is arranged adjacent to the cooling end surface.

11. The die molding apparatus according to claim **10**, wherein the material waiting housing is further provided with a feeding port, and the die molding apparatus further comprises a discharging valve configured for sealing the discharging port and a feeding valve configured for sealing the feeding port.

12. The die molding apparatus according to claim **1** wherein the forming furnace body comprises a furnace body provided with the heating cavity and a heating mechanism arranged in the heating cavity.

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