

Description

TECHNICAL FIELD

[0001] The present invention relates to a method and apparatus for injection foaming molding for foaming a melt of a light alloy to form a foaming molded product.

BACKGROUND ART

[0002] For the conventional production of a foam metal, the following methods are known: in a method disclosed in Japanese Patent Publication No. Hei 1-51528 (Technique 1), a thickener and a blowing agent are added to a melted metal followed by agitating, the whole mold is heated to the melting point of the foamed metal or higher, the agitation is terminated to start a foaming process, in which the air within the mold is released by expanding a number of bubbles generated by thermal decomposition of the blowing agent to allow a foam metal to fill the inner portion of the mold entirely, thereby blocking the mold in a sealed state to form an uniform cell structure under equilibration of the pressure by the rise of internal pressure by the bubbles, and the resulting foam metal is cooled and coagulated in the mold.

[0003] In a method disclosed in US patent No. 2983597 (Technique 2), a hydrogenated metal is mixed to a melted metal and decomposed, and the metal is foamed by generation of hydrogen gas. Further, a second alloyed melted metal is supplied from a halfway screw while extruding a mixture of a melted metal and a hydrogenated metal by a first screw at a gas decomposition temperature or lower to perform a continuous foaming molding by generation of decomposed gas.

[0004] In a method disclosed in Japanese Patent Publication No. 2002-511526 (Technique 3), a molded product is obtained by compressing a blowing agent and a metal powder, heating the resulting semi-finished material within a mold to a melting temperature range to allow the material to foam followed by cooling.

[0005] In a method disclosed in Japanese Patent Laid-Open No. Hei 9-241780 (Technique 4), as a solution of the problems of a method for adding a blowing agent to a melted metal to generate hydrogen, thereby foaming the metal, and a method for mixing a blowing agent to a metal powder followed by compression molding and then foaming the metal in a mold by heating, a foam metal is obtained by adding 0.1-5%, based on weight, of titanium hydroxide to a metal having a melting point of 420°C or higher, uniformly dispersing it by agitation, then injecting the melt to a mold, reheating the melt in the mold to 630°C or higher to allow the melt to foam followed by cooling and coagulation.

[0006] However, the methods for producing a foam metal of Techniques 1-4 have the following problems. Technique 1 needs much time for the heating since the melted metal is heated and agitated in the mold, and has a problem with the productivity since the same mold

is also used for the cooling after foaming. Further, a large mold is needed to form a large molded product. In case of a large mold, since the heating and cooling depends on only the heat conductive electric heating from the wall surface, and a metal having a physical property of excellent heat insulating property is formed as the foamed body at the time of cooling, further much time is needed as a result.

[0007] In Technique 2, although a metal body can be continuously formed by foaming with hydrogen gas similarly to Technique 1, a molded product of a desired three-dimensional shape or a molded product of a complicated shape cannot be formed since a function of injecting into a mold is not provided. Since the control for holding constant mixing ratio of the melted metal to the blowing agent such as titanium hydride or magnesium hydride can be performed only by the screw rotating speed with instability, the feed rate of the blowing agent cannot be kept constant, nor is the foaming ratio stabilized. Accordingly, the dispersion of product quality (foaming state) is increased.

[0008] In Technique 3, it is needed to uniformly mix the powder for obtaining a uniform foamed body, and this requires much time and an increased cost. Although a three-dimensional shaped product can be obtained, the control of temperature and time in the foaming by gas decomposition and the melting of the metal powder is difficult, therefore it is difficult to obtain a foaming molded product having uniform cells.

[0009] In Technique 4, although a three-dimensional shape can be molded, much time is needed to reheat the melt to 630°C or higher in the mold similar to the problem of Technique 1, and there is a problem with the production efficiency. Since there is a need for increasing a temperature of the mold to 630°C or higher, cost for the mold is high. In case of a large mold, the temperature control of the melt in the mold is difficult to increase the dispersion of quality.

[0010] The present invention thus has an object to provide a method and apparatus for injection foaming molding of a light alloy, which can minimize the difference in foaming state between batches with good productivity.

DISCLOSURE OF THE INVENTION

[0011] The present invention involves a method for injection foaming molding of a light alloy comprising the steps of; holding a melt of a light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component in respectively specified percentages at a temperature lower than the decomposition temperature of the blowing agent; agitating the melt to allow the thickener and the blowing agent to disperse; measuring a predetermined amount of the melt for the injection into a mold; and then injecting the melt into the mold to produce a foaming molded article of the light alloy, in which the melt is temperature-

adjusted to a temperature higher than the decomposition temperature of the blowing agent and also inhibited to foam by pressuring at least immediately before the injection.

[0012] Since the thickener and the blowing agent are preliminarily added to the melt in the specified percentages, the difference in foaming state between batches is minimized. Although the decomposition of the blowing agent is caused immediately before the injection, the foaming of the melt is inhibited since the inner capacity of a measuring part is made constant, and the melt is laid in the pressured state. Therefore, since the melt releases the pressure at once within the mold immediately after the injection and foams to spread into every corner of the mold, the transfer property of the mold is enhanced to enable the formation of a foaming molded article of a complicated shape. Since the heating of the mold to the decomposition temperature of the blowing agent or higher is dispensed, the productivity is improved.

The present invention further involves a method for injection foaming molding of a light alloy comprising the steps of; holding a melt of a light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component in respectively specified percentages at a temperature lower than the decomposition temperature of the blowing agent; introducing the melt to an injection molding device having an agitating function, a measuring function and an injecting function; agitating the melt to allow the thickener and the blowing agent to disperse; measuring a predetermined amount of the melt for the injection into a mold; and injecting the melt into the mold to produce a foaming molded article of the light alloy, wherein the melt is temperature-adjusted to the decomposition temperature of the blowing agent or higher and also inhibited to foam by pressuring at least immediately before the injection. Since the melt containing the thickener and the blowing agent in the specified percentages are held at a temperature lower than the decomposition temperature of the blowing agent, then introduced into the injection molding device, and agitated within the injection molding device, the thickener and the blowing agent are dispersed to minimize the difference in foaming state between batches. Although the decomposition of the blowing agent is caused immediately before the injection, the foaming of the melt is inhibited since the inner capacity of a measuring part is made constant, and the melt is laid in the pressured state. Therefore, since the melt releases the pressure at once within the mold immediately after the injection and foams to spread into every corner of the mold, the transfer property of the mold is enhanced to enable the formation of a foaming molded article of a complicated shape. Further, since the heating of the mold to the decomposition temperature of the blowing agent or higher is dispensed, the productivity is improved.

The method for injection foaming molding of the light al-

loy of the present invention is characterized in that the temperature of the melt is lower than the decomposition temperature of the blowing agent at the time of agitating the melt.

[0013] The blowing agent can be uniformly dispersed without decomposition in the melt by holding the temperature of the melt at a temperature lower than the decomposition temperature of the blowing agent at the time of agitating the melt.

[0014] The present invention involves a method for injection foaming molding of a light alloy comprising the steps of; agitating a melt of a light alloy containing a predetermined amount of a thickener to allow the thickener to disperse; supplying an inert gas as a blowing agent into the melt in a specified percentage while agitating to allow the inert gas to disperse; measuring a predetermined amount of the melt for the injection into a mold; and then injecting the melt to the mold to produce a foaming molded article of the light alloy, wherein the melt is inhibited to foam by pressuring the melt at least until the injection is performed after the supply of the inert gas.

[0015] The melt containing the thickener is agitated to allow the thickener to disperse, and a predetermined amount of the inert gas is supplied into the melt and evenly dispersed by agitation with a screw, whereby a foaming molded article having a substantially uniform cell structure can be formed. Since the measuring part is laid in the pressured state before the injection, the foaming of the inert gas in the melt is inhibited. Therefore, since the melt releases the pressure at once in the mold immediately after the injection and foams to spread into every corner of the mold, the transfer property of the mold is enhanced to enable the formation of a foaming molded article of a complicated shape. Since the heating of the mold to the decomposition temperature of the blowing agent or higher is dispensed, the productivity is improved.

[0016] The method for injection foaming molding of the light alloy of the present invention is characterized in that the pressuring is performed by a pressing force caused by the agitation with the screw.

[0017] The predetermined amounts of the thickener and the blowing agent added to the melt can be dispersed by agitation, and the measuring part can be laid in the pressured state by the pressuring force by the screw for feeding the melt to the front part of a barrel. Therefore, the foaming of the blowing agent in the melt can be inhibited.

[0018] The method for injection foaming molding of the light alloy of the present invention is also characterized in that the melt is injected in an injection amount reduced by a foaming portion relative to the inner capacity of the mold to break the pressuring, whereby the melt is allowed to foam within the mold to obtain the foaming molded article.

[0019] The melt is injected into the mold in an injection amount reduced by the foaming portion relative to the

inner capacity of the mold, whereby the mold opening at the foaming is dispensed, and the size and shape of the foaming molded article can be precisely controlled.

[0020] The method for injection foaming molding of the light alloy of the present invention is characterized in that the melt is injected in an injection amount equal to the inner capacity of the mold, and the mold is opened by the capacity of a foaming portion to break the pressuring, whereby the melt is allowed to foam to obtain the foaming molded article.

[0021] Since the pressure is suddenly released by opening the mold substantially simultaneously with the injection or after the injection, the melt sufficiently spreads into minute parts in the mold, and a foaming molded article of a complicated shape can be formed.

[0022] The present invention further involves a method for injection foaming molding of a light alloy comprising the steps of; adjusting the temperature of a melt of a light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component in respectively specified percentages to a temperature lower than the decomposition temperature of the blowing agent; supplying the melt into a barrel having a screw provided to be rotatable, protrudable and retreatable; agitating the melt by rotating the screw to allow the thickener and the blowing agent to disperse; measuring the melt in a measuring part formed in a front portion of the barrel by retreating the screw with rotation; and adjusting the temperature of the melt to the decomposition temperature of the blowing agent or higher while inhibiting the foaming of the melt by pressuring the melt in the measuring part the capacity of which is made constant by stopping the retreat of the screw at least immediately before the injection; and injecting the melt into a mold by protruding the screw to obtain a foaming molded article.

[0023] Since the melt of the light alloy to be supplied into the barrel contains the thickener and the blowing agent in the specified percentages, the thickener and the blowing agent are uniformly dispersed in a kneading part in the barrel. Since the melt is injected after measuring, the difference in foaming state between batches is minimized. Although the decomposition of the blowing agent is caused immediately before the injection, the capacity is made constant state by stopping the screw, and the foaming of the melt is inhibited while laying the melt in the pressured state. Therefore, since the melt releases the pressure at once within the mold immediately after the injection and foams to spread into every corner of the mold, the transfer property of the mold is enhanced to enable the formation of a foaming molded article of a complicated shape. Since the heating of the mold to the decomposition temperature of the blowing agent or higher is dispensed, the productivity is improved.

[0024] The present invention also involves a method for injection foaming molding of a light alloy using an apparatus for injection foaming molding having a barrel

containing a screw and a cylinder communicating with a front portion within the barrel through a communicating passage and containing a plunger, the method comprising; (a) a supplying process for supplying the melt of the light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component in respectively specified percentages, which is temperature-adjusted and held at a temperature lower than the decomposition temperature of the blowing agent, into the barrel; (b) an agitating process for agitating the melt by rotating the screw within the barrel to allow the thickener and the blowing agent to disperse; (c) a measuring process for introducing and measuring the melt from the barrel to a measuring part formed in the front portion within the cylinder by retreating the plunger through the communicating passage; (d) a pressuring process for adjusting the temperature of the melt to the decomposition temperature of the blowing agent or higher and pressuring the melt by generating the gaseous component in the measuring part the capacity of which is made constant by stopping the retreat of the plunger to inhibit the foaming of the melt at least immediately before injection; and (e) an injection foaming process for injecting the melt inhibited to foam in the pressuring process into a mold communicating with the inner portion of the cylinder in the front portion of the cylinder by protruding the plunger to foam the melt.

[0025] Since the melt containing the thickener and the blowing agent in the specified percentages is held at a temperature lower than the decomposition temperature of the blowing agent, then introduced into the injection molding device, and agitated within the injection molding device, the thickener and the blowing agent are dispersed to minimize the difference in foaming state between batches. Although the decomposition of the blowing agent is caused immediately before the injection, the capacity is made constant by stopping the plunger to inhibit the foaming of the melt while laying the melt in the pressured state. Therefore, since the melt releases the pressure at once within the mold immediately after the injection and foams to spread into every corner of the mold, the transfer property of the mold is enhanced to enable the formation of a foaming molded article of a complicated shape. Since the heating of the mold to the decomposition temperature of the blowing agent or higher is dispensed, the productivity is improved.

[0026] The present invention involves a method for injection foaming molding of a light alloy comprising the steps of; holding a melt of the light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component in respectively specified percentages at a temperature lower than the decomposition temperature of the blowing agent; agitating the melt to allow the thickener and the blowing agent to disperse; measuring a predetermined amount of the melt for the injection into a mold; and injecting the melt into the mold through an injection nozzle

to produce a foaming molded article of the light alloy, wherein the temperature of the melt is raised to the decomposition temperature of the blowing agent or higher at least immediately before the injection into the mold.

[0027] Since the thickener and the blowing agent are preliminarily added to the melt in the specified percentages, the difference in foaming state between batches is minimized. Since the temperature of the melt to be injected is raised to the decomposition temperature of the blowing agent or higher at least immediately before the injection into the mold, the reheating of the mold to the decomposition temperature of the blowing agent or higher is dispensed, the cooling time of the mold is also shortened, and the productivity is thus improved.

[0028] The method for injection foaming molding of the light alloy of the present invention is characterized in that the temperature of the melt is raised to the decomposition temperature of the blowing agent or higher at the time of passing through the nozzle.

[0029] Since the thickener and the blowing agent are preliminarily added to the melt in the specified percentages, the difference in foaming state between batches is minimized. Since the temperature of the melt to be injected is raised to the decomposition temperature of the blowing agent or higher at the time of passing through the nozzle, the reheating of the mold to the decomposition temperature of the blowing agent or higher is dispensed, the cooling time of the mold is also shortened, and the productivity is thus improved.

[0030] The present invention involves an apparatus for injection foaming molding of a light alloy comprising; a cylindrical member for receiving a melt of a light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component, wherein the melt is agitated by an agitating means provided rotatably in the inner portion to allow the thickener and the blowing agent to disperse; a movable member provided to be protrudable and retreatable within the cylindrical member, the movable member forming a measuring part for measuring the melt in cooperation with the cylindrical member at the tip of the cylindrical member by retreating, and injecting the melt with the gaseous component generated therein into a mold communicating with the measuring part by protruding; and a position retaining means for retaining the position of the movable member against an increase in internal pressure of the cylindrical member in the generation of the gaseous component, so that the melt after the completion of the measurement can be retained in the pressured state to inhibit the foaming thereof.

[0031] According to such a structure, since the melt including the thickener and the foaming agent preliminarily added in specified percentages can be supplied to the cylindrical member, the difference in foaming state between batches is minimized. Since the position of the movable member can be retained by the position retaining means to keep constant capacity of the measuring part in the cylindrical member although the decomposi-

tion of the blowing agent is caused immediately before the injection, the melt can be laid in the pressured state while inhibiting the foaming of the melt. Therefore, since the melt releases the pressure at once within the mold immediately after the injection and foams to spread into every corner of the mold, the transfer property of the mold is enhanced to enable the formation of a foaming molded article of a complicated shape. Since the heating of the mold to the decomposition temperature of the blowing agent or higher is dispensed, the productivity is improved.

[0032] The apparatus for injection foaming molding of the light alloy of the present invention is characterized in that the position retaining means is a solenoid valve provided in a hydraulic circuit of a hydraulic cylinder for protruding and retreating the movable member so as to be capable of interrupting the incoming and outgoing of oil to a hydraulic cylinder.

[0033] According to such a structure, the protruding and retreating of the movable member can be easily controlled. Therefore, the position of the movable member can be controlled according to the foaming state of the blowing agent, and the melt can be easily held in the pressured state.

[0034] The apparatus for injection foaming molding of the light alloy of the present invention is characterized in that the movable member is composed of a rotatable agitating screw.

[0035] According to such a structure, the thickener and the blowing agent in the melt supplied into the cylindrical member can be evenly dispersed.

[0036] The apparatus for injection foaming molding of a light alloy of the present invention is characterized in that the cylindrical member comprises a barrel for agitating the melt and a cylinder connected thereto to introduce and measure the agitated melt, and the movable member is a plunger provided within the cylinder.

[0037] According to such a structure, since the melt containing the thickener and the blowing agent in specified percentages can be supplied to the cylindrical member, the difference in foaming state between batches is minimized.

[0038] The present invention further involves an apparatus for injection foaming molding of a light alloy comprising; a barrel for receiving the melt of the light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component, the barrel comprising a temperature adjusting means capable of adjusting the temperature of the melt from a temperature lower than the decomposition temperature of the blowing agent to the decomposition temperature or higher, in which the gaseous component can be generated by adjusting the temperature of the melt to the decomposition temperature of the blowing agent or higher by the temperature adjusting means; a screw provided within the barrel to be rotatable, protrudable and retreatable and adapted to agitate the melt by rotating to allow the thickener and the blowing agent to

disperse, to form a measuring part in cooperation with the barrel at the tip of the barrel by retreating, and to inject the measured melt from the barrel into a mold by protruding; and a position retaining means for retaining the position of the screw against an increase in internal pressure of the barrel in the generation of the gaseous component so that the melt after the completion of the measurement can be retained in the pressured state to inhibit the foaming thereof.

[0039] According to such a structure, since the melt containing the thickener and the blowing agent preliminarily added thereto can be supplied into the barrel and surely dispersed, the difference in foaming state of every injection is minimized. The temperature of the melt in the barrel can be easily adjusted to control the state of the blowing agent in the melt, and the difference in foaming state between batches can be further minimized. Further, since the temperature can be adjusted so as to cause the decomposition of the blowing agent immediately before the injection and the capacity of the measuring part within the barrel can be kept constant by the position retaining means for the screw, the foaming of the melt can be inhibited to lay the melt in the pressured state. Therefore, since the melt releases the pressure at once in a mold immediately after the injection and foams to spread into every corner of the mold, the transfer property of the mold is enhanced to enable the formation of a foaming molded article of a complicated shape. Since the heating of the mold to the decomposition temperature of the blowing agent or higher is dispensed, the productivity is improved.

[0040] The present invention involves an apparatus for injection foaming molding of a light alloy comprising; a barrel for receiving a melt of a light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component, the barrel having a first temperature adjusting means capable of adjusting the temperature of the melt to a temperature lower than the decomposition temperature of the blowing agent, in which the melt is agitated with a screw provided rotatably in the inner portion to allow the thickener and the blowing agent to disperse; a cylinder connected to the barrel and having a second temperature adjusting means capable of adjusting the temperature of the melt to the decomposition temperature of the blowing agent or higher; a plunger provided within the cylinder to be protrudable and retreatable and adapted to form a measuring part for measuring the melt in cooperation with the cylinder at the tip of the cylinder by retreating and to inject the measured melt from the cylinder to a mold by protruding; and a position retaining means for retaining the position of the plunger against an increase in internal pressure of the cylinder in the generation of the gaseous component so that the melt after the completion of the measurement can be retained in the pressured state to inhibit the foaming thereof.

[0041] According to such a structure, since the melt containing the thickener and the blowing agent preliminarily

added thereto can be supplied into the barrel and surely dispersed, the difference in foaming state in every injection is minimized. Since the position of the movable member can be retained by the position retaining means to keep constant capacity of the measuring part in the cylindrical member although the decomposition of the blowing agent is caused immediately before the injection, the foaming of the melt can be inhibited while laying the melt in the pressured state. Therefore, since the melt releases the pressure at once within the mold immediately after the injection and foams to spread into every corner of the mold, the transfer property of the mold is enhanced to enable the formation of a foaming molded article of a complicated shape. Since the heating of the mold to the decomposition temperature of the blowing agent or higher is dispensed, the productivity is improved. The cylinder enables a precise measurement of the melt. Therefore, since the difference of melt injection amounts between batches for injection molding is minimized, a molded product is precisely produced.

[0042] The present invention involves an apparatus for injection foaming molding of a light alloy comprising; a cylindrical member for receiving the melt of the light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component, in which the melt is agitated by an agitating means provided rotatably in the inner portion to allow the thickener and the blowing agent to disperse; a movable member provided to be protrudable and retreatable within the cylindrical member, which forms a measuring part for measuring the melt in cooperation with the cylindrical member at the tip of the cylindrical member by retreating and injects the melt to a mold communicating with the measuring part through an injection nozzle by protruding; and a nozzle heating means capable of heating the melt to the decomposition temperature of the blowing agent or higher at the time of passing the melt through the nozzle.

[0043] According to such a structure, since the melt containing the thickener and the blowing agent preliminarily added thereto can be supplied into the barrel and surely dispersed, the difference in foaming state in every injection is minimized. Since the melt is injected through the injection nozzle, the injection pressure can be increased. The temperature of the melt is raised to the decomposition temperature of the blowing agent or higher when the melt is passed through the nozzle, or immediately before the injection into the mold, whereby the blowing agent is decomposed to generate the gaseous component. Accordingly, since the melt foams at once within the mold immediately after the injection, the heating of the mold to the decomposition temperature of the blowing agent or higher is dispensed and the productivity is improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0044]

Fig. 1 is a general illustrative view showing one embodiment according to an apparatus for injection foaming molding of a light alloy of the present invention;

Fig. 2 is a general illustrative view showing another embodiment of the apparatus for injection foaming molding of a light alloy of the present invention;

Fig. 3 is a view showing an essential part of the embodiment of the apparatus for injection foaming molding of a light alloy of the present invention, which illustrates a molding process;

Fig. 4 is a view showing an essential part of the embodiment of the apparatus for injection foaming molding of a light alloy of the present invention, which illustrates the molding process; and

Fig. 5 is a view showing an essential part of the other embodiment of the apparatus for injection foaming molding of a light alloy of the present invention, which illustrates the molding process.

BEST MODE FOR CARRYING OUT THE INVENTION

[0045] Preferred embodiments of the present invention will be described based on the drawings. Fig. 1 shows one embodiment of the present invention. An apparatus for injection foaming molding 1 according to this embodiment is composed of an injection molding device 3 and a mold clamping device 17 as shown in Fig. 1.

[0046] The injection molding device 3 comprises; a feed port 8 for supplying a melt of a light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component; a cylindrical member A for agitating the melt supplied from the feed port 8 by an agitating means 4 provided rotatably to allow the thickener and the blowing agent to disperse; a movable member B provided to be protrudable and retreatable within the cylindrical member A, which forms a measuring part 6 for measuring the melt in cooperation with the cylindrical member A at the tip of the cylindrical member A by retreating and injects the melt with the gaseous component generated therein into a mold 24 communicating with the measuring part 6 by protruding; and a position retaining means C for retaining the position of the movable member B against an increase in internal pressure of the cylindrical member A in the generation of the gaseous component so that the melt after the completion of the measurement can be held in the pressured state to inhibit the foaming thereof. A barrel 7 that is the cylindrical member A for agitating the melt comprises a temperature adjusting means 10 for adjusting the temperature of the melt 2 of the light alloy supplied and the melt 2 of the light alloy supplied to an injection part 9. The injection part 9 for injecting the melt 2 measured by the measuring part 6 into the mold 24 is

provided at the tip of the barrel 7.

[0047] Since the barrel 7 is substantially vertical as shown in Fig. 1, the melt 2 of the light alloy supplied surely moves to the lower portion within a kneading part 5 by its own weight.

[0048] The injection part 9 has an L-shaped passage 11, wherein the passage of the melt 2 of the light alloy is vertical in kneading and agitating and horizontal in injection. Accordingly, even in the case, as shown in Fig. 1, where the injection molding device 3 is connected to the mold clamping device 17, the setting area of the apparatus for injection foaming molding 1 can be minimized as much as possible.

[0049] In this apparatus for injection foaming molding 1, a nozzle part 13 having a valve means 12 is provided at the tip of the L-shaped passage 11 provided at the lower end of the barrel 7. This tip part is allowed to abut on the mold 24 which horizontally slides to open and close by the mold clamping device 17.

[0050] Of the components of the apparatus for injection foaming molding 1, the lower end opening part of a hopper 14 for receiving the melt of the light alloy melted in a melting furnace (not shown) and storing it in the melted state is connected to the feed port 8 in the upper portion of the barrel 7. The hopper 14 comprises a temperature control means such as a heating heater. By this temperature control means, the melt 2 in the hopper 14 can be controlled, for example, to a constant temperature equal to or higher than a liquid phase temperature and lower than the foaming temperature of the blowing agent, or equal to or higher than the decomposition temperature of the blowing agent.

[0051] The hopper 14 further comprises a feeder for quantitatively supplying the thickener and the blowing agent to be added to the melt 2 of the light alloy. The powdery thickener and the blowing agent can be quantitatively supplied by this feeder to minimize the difference in foaming state between batches. The melt of the light alloy containing predetermined amounts of the thickener and the blowing agent may be supplied directly to the hopper 14.

[0052] As the thickener to be added to the melt 2 of the light alloy, a known one such as calcium can be used. As the blowing agent, a known metallic hydroxide including titanium hydroxide can be applied. Titanium hydroxide causes gas decomposition at about 640°C. In the use of an AL alloy as a light alloy, the liquid phase line temperature is 630°C, and the liquid phase line temperature or higher described later means a temperature of 630°C or higher, and the titanium hydroxide can be dispersed by agitation without causing any decomposition by holding the melt temperature, for example, at 630°C by the temperature adjusting means 10 of the barrel.

[0053] The hopper 14 is filled with an inert gas 18 such as Ar supplied by an inert gas feeding unit 16 to seal the level of the melt 2 of the light alloy with the inert gas 18. The position retaining means C is provided at the upper

end of the barrel 7 that is the cylindrical member A. The position retaining means C comprises a drive motor 19 and a screw hydraulic cylinder 21 connected to the drive motor 19.

[0054] A through spline hole is provided in the drive shaft of the drive motor 19, and a spline shaft provided at the upper portion of the screw 4 rotatably inserted into the barrel 7 is inserted through to permit the transmission of a rotational driving force and the axial movement of the screw 4.

[0055] The screw hydraulic cylinder 21 having a vertically protruding and retreating cylinder rod 2 is connected to the upper portion of the drive motor 19. The screw 4 is connected to the cylinder rod 20 of the screw hydraulic cylinder 21, and arranged in a cantilever form so that the lower end is free within the barrel 7. Therefore, a stirring blade of the screw 4 is protruded (moved downward) through the drive motor 19 by downwardly protruding the cylinder rod 20 of the screw hydraulic cylinder 21, whereby the melt 2 of the light alloy collected in the lower end part within the barrel 7 can be passed to the L-shaped passage 11 and injected into the mold 24 through the nozzle part 13.

[0056] When the screw hydraulic cylinder 21 is operated to move the screw 4 that is the movable member B upward in the axial direction, the measuring part 6 is formed in a lower portion within the barrel 7. The measuring part 6 can be properly set by the retreating quantity of the screw hydraulic cylinder 21 so as to provide a capacity necessary for obtaining a molded product. A valve means 12 of the nozzle part 13 is closed except the time of injection. As the valve means 12, similar ones as those described later can be applied.

[0057] The circumferential surface of the barrel 7 and the injection part 9 is covered with the temperature adjusting means 10. The temperature adjusting means 10 is composed of a plurality of vertically separated heating heaters. The temperature of the melt of the light alloy in the barrel 7 can be adjusted at least in two systems by these heating heaters. Accordingly, the temperature control can be performed separately in the upper portion and lower portion of the barrel 7 to control the decomposition of the blowing agent in the melt 2.

[0058] The mold clamping device 17 comprises a link housing 26 raised on a base 25, a fixed board 28 fixed to the housing 26 through a horizontal tie bar 27, a fixed mold 24b fixed to the fixed board 28, a movable board 29 slidably inserted and supported relative to the tie bar 27, and a movable mold 24a fixed to the movable board 29 so as to be openable and closable by sliding horizontally relative to the fixed mold 24b. A mold clamping cylinder 30 is fixed to the outer surface center of the link housing 26, and the tip of the cylinder rod 31 of the mold clamping cylinder 30 is connected to the center part of the movable board 29. The link housing 26 is connected to the movable board 29 through a plurality of links 32 which are folded when the both are mutually approached, and substantially linearly arranged in the hor-

izontal direction when the both are separated.

[0059] An extrusion cylinder 33 is provided on the side surface of the movable board 29 on the link housing 26 side, and an extrusion rod 34 of the extrusion cylinder 33 is connected to a product protruding mechanism of the movable mold 24a through the movable board 29. Accordingly, in this mold clamping device 17, the cylinder rod 31 of the mold clamping cylinder 30 is protruded to extend the links 32 linearly into a stretched state, whereby the movable mold 24a can be strongly pressed to the fixed mold 24b. The release of a product is performed by protruding the extrusion rod 34 of the extrusion cylinder 33 to operate the product protruding mechanism.

[0060] Since the melt 2 of the light alloy is allowed to foam at once within the mold 24 after the injection by the apparatus for injection foaming molding 1 described above, the melt 2 spreads into every corner of the mold 24. Accordingly, the transfer property to the mold 24 is enhanced to enable the formation of a foaming molded article of a complicated shape. Further, since the heating of the mold to the decomposition temperature of the blowing agent or higher is dispensed, the productivity is improved.

[0061] The operation of the apparatus for injection foaming molding 1 of this embodiment and a method for injection foaming molding of a light alloy by this apparatus will be described.

[0062] The melt 2 of the light alloy is fed mechanically or by a means such as an electromagnetic pump from a melting furnace (not shown) into the hopper 14. As the melting furnace, a high frequency induction furnace, an electromagnetic induction heating furnace, or the like can be used regardless of the kind. The melt 2 of the light alloy in the hopper 14 is temperature-adjusted to a temperature of the liquid phase line temperature or higher and lower than the decomposition temperature of the blowing agent, and held at a uniform temperature by a temperature control means such as heating heaters or the like provided on the hopper 14. The thickener and the blowing agent are quantitatively supplied to the melt 2 of the light alloy by the feeder (not shown) provided on the hopper 14. According to this, the difference in foaming state between batches can be minimized. As occasion demands, an agitating means for agitating the melt 2 of the light alloy in the hopper 14 may be provided to impart an agitating effect. By providing the above-mentioned inert gas feeding unit 16 on the hopper 14, the oxidation of the melt can be prevented.

[0063] The melt 2 of the light alloy put in the hopper 14 is supplied to the upper portion of the barrel 7 while gas-sealing it, the melt 2 of the light alloy is temperature-adjusted to and held at a temperature of the liquid phase line temperature or higher and lower than the decomposition temperature of the blowing agent by the heating heater, and the melt 2 of the light alloy is agitated by rotating the screw 4 in the kneading part 5 within the barrel 7 to allow the thickener and the blowing agent to

disperse. Accordingly, by keeping the blowing agent at a temperature lower than the foaming temperature at the time of agitation, whereby the blowing agent can be uniformly dispersed because it is powdery.

[0064] When the melt 2 containing only the thickener is supplied into the barrel 7, an inert gas quantitative feeding unit (not shown) is provided on the barrel 7 corresponding to the kneading part 5, whereby inert gas that is the blowing agent can be supplied to the melt in a specified percentage when the thickener is allowed to disperse by agitation, and the inert gas is evenly dispersed into the melt 2.

[0065] When the melt 2 is agitated in the kneading part 5, the melt 2 of the light alloy is pushed downwardly within the barrel 7 by a pushing force accompanying the rotation of the screw 4; a load is applied to the axially upper portion of the screw 4. On the other hand, a fixed back pressure is set on the screw hydraulic cylinder 21 constituting the position retaining means, and when an internal pressure overcoming the back pressure is generated in the barrel 7, the screw 4 is moved axially upward and retreated to a predetermined position set according to a molded product volume. The melt 2 of the light alloy is measured in the measuring part 6 between the screw 4 and the L-shaped passage 11. In this embodiment, although the screw 4 is retreated with rotation by the rise of the internal pressure of the barrel 7 caused by the rotation, the screw 4 may be retreated without rotation by the screw hydraulic cylinder 21, or retreated with rotation by the screw hydraulic cylinder 21. A back-flow preventive means such as a check ring is preferably provided at the tip of the screw 4, and by providing it, the melt 2 of the light alloy can be smoothly carried down, at the time of retreating, and measured in the measuring part 6 according to the molded product volume. At the measurement, the nozzle part 13 of the L-shaped passage 11 is closed by the valve means 12.

[0066] After the measurement is completed, the melt 2 is laid in the pressured state at least immediately before the injection to inhibit the foaming by temperature-adjusting so as to be heated to the decomposition temperature of the blowing agent within the measuring part 6 by the heating heaters, and promoting the decomposition of the blowing agent within the measuring part 6 the capacity of which is made constant by stopping the retreat of the screw 4. Since the measuring part 6 can be laid in the pressured state also by the pushing force of the melt 2 by the rotation of the screw 4, the foaming of the blowing agent raised in temperature to the decomposition temperature of the blowing agent can be inhibited.

[0067] The melt 2 is then injected into the mold 24 by opening the valve means 12 of the nozzle part 13 and protruding the screw 4, and the melt 2 inhibited to foam is allowed to rapidly foam within the mold 24 lower in pressure than in the barrel 7, whereby the formation of a molded article is performed.

[0068] At the injection into the mold 24, when the melt

2 of the light alloy is injected into the mold 24 in an injection amount equal to the inner capacity of the mold 24, the pressure of the gaseous component is released at once by sliding and opening the movable mold 24a by the volume of a foaming portion after the injection to allow the melt 2 of the light alloy to foam in the sliding direction, whereby a foaming molded article in which foamed cells are uniformly dispersed can be obtained. When the melt 2 of the light alloy is injected to the mold 24, a skin layer is formed on the surface where the melt 2 comes in contact with the mold 24.

[0069] Since the pressure of the gaseous component restricted to expand in the melt 2 of the light alloy is suddenly released by injecting the melt 2 of the light alloy into the mold 24 and opening the mold 24 substantially simultaneously with the injection or after the injection, the foamed melt 2 of the light alloy sufficiently spreads into minute parts in the mold 24, and a foaming molded article of a complicated shape can be formed.

[0070] When the melt 2 of the light alloy is injected into the mold 24 in an injection amount reduced by a foaming portion relative to the inner capacity of the mold (the molded product capacity), the pressure of the gaseous component is released at once in the mold 24 after the injection to allow the melt 2 of the light alloy to foam, and a foaming molded article in which foamed cells are uniformly dispersed can be obtained.

[0071] By reducing the injection amount of the melt 2 of the light alloy to be injected into the mold 24 by the foaming portion in this way, the size and shape of a foaming molded article can be precisely controlled without being influenced by the stopping precision in opening the mold, the parallel degree of the mold, or the like.

[0072] According to the method for injection foaming molding using the apparatus for injection foaming molding 1 as described above, since the thickener and the blowing agent are preliminarily added to the melt 2 of the light alloy to be supplied into the barrel 7 in respectively specified percentages, the variations of the resulting molded product between injections can be minimized. Since the thickener and the blowing agent are uniformly dispersed in the kneading part 5 within the barrel 7, a molded product with uniformly dispersed foamed cells can be obtained. Further, according to such an injection, the difference in foaming state between batches is minimized.

[0073] Although the gaseous component is generated by decomposition of the blowing agent immediately before the injection, the capacity of the measuring part 6 is made constant by stopping the screw 4 to inhibit the foaming of the melt (the expansion of the gaseous component). Therefore, the melt 2 of the light alloy is made to release the pressure at once within the mold 24 immediately after the injection to foam, whereby the melt can be filled into every corner of the mold 24. Accordingly, the transfer property to the mold 24 is enhanced, the productivity is improved, and the formation of a foaming molded article of a complicated shape can be

performed. The mold is depressurized by a pressure reducing means such as a vacuum pump, whereby the transfer property and the moldability of a foaming molded article of complicated shape can be further improved.

[0074] Another embodiment according to the apparatus for injection foaming molding of the present invention will be further described in reference to Fig. 2. As shown in Fig. 2, an apparatus for injection foaming molding 40 of this embodiment comprises two members of a horizontal plunger type injection part 9 different from that of the apparatus for injection foaming molding 1 and the same vertical barrel 7 as that of the apparatus 1.

[0075] Fig. 2 is a general illustrative view showing the apparatus for injection foaming molding 40 of a light alloy of this embodiment. The apparatus for injection foaming molding 40 has substantially the same structure for the barrel 7 and the mold clamping device 17 as the apparatus for injection foaming molding 1 except the horizontal plunger type injection part 9. As a melt of a light alloy, a thickener and a blowing agent, those described above are applicable.

[0076] This apparatus for injection foaming molding 40 of a light alloy comprises an injection molding device 43, and a mold clamping device 17. The injection molding device 43 comprises a barrel 47 having an agitating function, the barrel being composed of a kneading part 45 having a feed port 58 for supplying a melt 2 containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component in respectively specified percentages at an upper portion and a screw 44 provided in the inner portion to be rotatable, protrudable and retreatable, in which the melt 2 is agitated by the screw 44 to allow the thickener and the blowing agent to disperse, and a storage part 46 formed by retreating the screw 44; and a plunger injection machine 50 having a measuring function and an injecting function, the machine comprising a cylinder 42 a front portion of which is connected to the lower end of the barrel 47 through a communicating passage 41 provided at the lower end of the cylinder 42, and a plunger 48 protrudable and retreatable along the axis of the cylinder 42 within the cylinder 42, in which a measuring part 49 is formed at the inner front portion of the cylinder 42 by retreating the plunger 48, and the melt 2 of the light alloy is injected by protruding the plunger 48. The mold clamping device 17 comprises a mold 24 for allowing the melt 2 injected from the plunger injection machine 50 to foam. The apparatus also comprises a temperature adjusting means 51 for adjusting the temperature of the melt 2 of the light alloy supplied from the feed port 58 to the barrel 47 and the melt 2 of the light alloy supplied to the plunger injection machine 50.

[0077] A nozzle part 52 having a valve means 12 is provided at the tip of the plunger injection machine 50 of the apparatus for injection foaming molding 40. The tip part abuts on the mold 24 which is horizontally slid to open and close by the mold clamping device 17.

[0078] Of the components of the apparatus for injection

foaming molding 40, a hopper 53 has the same structure as the hopper 14 described above, and comprises a feeder and a temperature control means such as a heating heater.

[0079] The barrel 47 also has the same structure as in the apparatus for injection foaming molding 1 of the above-mentioned embodiment. As shown in Fig. 2, a screw hydraulic cylinder 56 having a vertically protruding and retreating cylinder rod 55 is connected to the upper portion of a drive motor 54, and the screw 44 is connected to the cylinder rod 55 of the screw hydraulic cylinder 56 through the drive motor 54. Therefore, the cylinder rod 55 of the screw hydraulic cylinder 56 is protruded down to protrude (move down) the stirring blade of the screw 44 through the drive motor 54, whereby the melt 2 of the light alloy collected in the lower end within the barrel 47 is supplied into the cylinder 42 of the plunger injection machine 50 through the communicating passage 41.

[0080] The screw hydraulic cylinder 56 is adapted so that a storage part 46 can be formed at a lower portion within the barrel 47 when it is moved axially upward. Further, this cylinder has a sufficient stroke to move the plunger from the position for forming the storage part 46 to the position capable of closing the communicating passage 41.

[0081] As shown in Fig. 2, the circumferential surface of the barrel 47 and the cylinder 42 of the plunger injection machine 50 is covered with the temperature adjusting means 51. The temperature adjusting means 51 is composed of a plurality of separated heating heaters. By controlling the heating heaters, at least the melt 2 of the light alloy in the barrel 47 can be adjusted to a temperature lower than the decomposition temperature of the blowing agent added thereto, and at least the melt 2 of the light alloy in the cylinder 42 can be adjusted to a temperature allowing the blowing agent added thereto to decompose to generate the gaseous component or higher.

[0082] The plunger injection machine 50 is connected to the barrel 47 through the communicating passage 41 formed at the lower end of the barrel 47. The plunger injection machine 50 comprises the cylinder 42 having the nozzle part 52 with the valve means 12 in the front portion and the plunger 48 protrudable and retreatable within the cylinder 42. The plunger 48 is driven by the hydraulic pressure of the plunger hydraulic cylinder 57. When the plunger 48 is retreated, a measuring part 49 is formed in the front portion of the cylinder 42. The capacity of the measuring part 49 can be properly set by the retreating quantity of the plunger 48 to attain a capacity necessary for providing a molded product. The plunger hydraulic cylinder 57 has a sufficient stroke to move the plunger 48 from the position for forming the measuring part 49 to the position capable of closing the connection passage 41 connected to the vicinity of the tip of the cylinder 42 by protruding. The plunger 48 is provided so as to close the communicating passage 41

when the injection is completed. Accordingly, the melt 2 of the light alloy for the next molding injection can be supplied into the barrel 47 immediately after the injection. The valve means 12 of the nozzle part 52 is laid in a closed state except the time of injection. As the valve means 12, a one adapted to block the nozzle by a mechanical or spring type shut-off valve provided at the tip of the nozzle can be used.

[0083] According to the apparatus for injection foaming molding 40 as described above, the melt 2 can be inhibited to foam in the state where the gaseous component is generated within the melt 2 at least immediately before the injection, and made to foam at once into the mold 24 after the injection. Therefore, the melt 2 spreads into every corner of the mold 24, whereby the transfer property to the mold 24 is enhanced, and the productivity is improved. Further, the formation of a foaming molded article of a complicated shape can be performed. The maintenance and management of the apparatus can be facilitated by constituting the barrel 47 and the injection part from two separate members.

[0084] The operation of the apparatus for injection foaming molding 40 of this embodiment and a method for injection foaming molding using this apparatus will be described.

[0085] The melt 2 of a light alloy is put into a hopper 53 from the melting furnace described above in the same manner. A thickener and a blowing agent decomposing at a high temperature to generate a foaming gas are added to the melt 2 in respectively specified percentages, and the resulting melt is temperature-adjusted to a liquid phase line temperature or higher and a temperature lower than the decomposition temperature of the blowing agent by a temperature control means of the hopper 53. In this way, a supplying process for supplying the temperature-adjusted melt 2 of the light alloy into the barrel 47 is performed. The thickener and the blowing agent to be added to the melt 2 may be put into the hopper 53 by providing a feeder on the hopper 53, or the melt 2 containing predetermined amounts of the thickener and the blowing agent may be put into the hopper 53.

[0086] The melt 2 is then supplied to the upper portion of the barrel 47, adjusted to and held at the liquid phase line temperature or higher and a temperature lower than the decomposition temperature of the blowing agent, and the thickener and the blowing agent are uniformly dispersed in an agitating process for agitating the melt 2 by rotating the screw 44 in the kneading part 45 within the barrel 47. When the melt 2 containing only the thickener is supplied into the barrel 47, an inert gas quantitative feeding unit (not shown) is provided to the barrel 47 corresponding to the kneading part 45, whereby inert gas that is the blowing agent can be supplied to the melt 2 in a specified percentage at the time of dispersing the thickener by agitation, and uniformly dispersed into the melt 2.

[0087] At this time, the plunger 48 of the plunger in-

jection machine 50 is protruded to the position for closing the communicating passage 41 as shown in Fig. 3. The screw 44 in the barrel 47 is retreated with rotation, whereby the storage part 46 is formed between the screw 44 and the communicating passage 41 instead of the above-mentioned measuring part 6, and a primary measurement is performed in this storage part 46. The storage part 46 is adjusted by the retreating quantity of the screw 44 so as to have a capacity larger than the amount of the melt to be injected. The screw 44 may be retreated without rotation, or retreated with rotation. The backflow preventive means described above can be provided at the tip of the screw 44.

[0088] Then, a measuring process for introducing the melt 2 from the barrel 47 to the measuring part 49 formed at the front portion within the cylinder 42 through the communicating passage 41 by opening the communicating passage 41 to retreat the plunger 48 of the plunger injection machine 50 is performed. In this measuring process, the screw 44 within the barrel 47 is protruded (moved down) simultaneously with the retreat of the plunger 48 as shown in Fig. 4. A pressuring force by the screw 44 is worked to press the melt 2 of the light alloy into the measuring part 49 formed at the front portion of the cylinder 42 with a positive pressure while the plunger 48 retreats to a predetermined position set according to the molded product volume, whereby the melt is secondarily measured.

[0089] Since the melt 2 including the thickener and the blowing agent preliminarily added in the specified percentages is held at a temperature lower than the decomposition temperature of the blowing agent, and then introduced to and agitated in an injection molding device 43, the thickener and the blowing agent are uniformly dispersed to minimize the difference in foaming state in every injection.

[0090] When the measuring by pressing is completed, the communicating passage 41 is closed by the screw 44, as shown in Fig. 5, to prevent the backflow of the melt 2 of the light alloy from the measuring part 49. At the time of measurement, the nozzle part 52 at the tip of the cylinder 542 of the plunger injection machine 50 is closed by the valve means 12.

[0091] After the secondary measurement is thus completed, the melt 2 is temperature-adjusted to the decomposition temperature of the blowing agent or higher at least immediately before the injection by each temperature adjusting means 51, and the decomposition within the measuring part 49 the capacity of which is made constant by stopping the retreat of the plunger 48 is promoted, whereby a pressuring process for laying the melt in the pressured state to inhibit the foaming thereof is performed. Namely, although the blowing agent gradually starts the decomposition to generate the gaseous component as the melt 2 of the light alloy is heated to the decomposition temperature of the blowing agent within the measuring part 49 by the temperature adjusting means 51, the foaming of the melt 2 is inhibited by

pressuring since the increase in capacity is suppressed by the back pressure of the plunger 48.

[0092] Then, an injection foaming process for injecting the melt 2 inhibited to foam in the pressurizing process into the mold 24 communicating with the front portion within the cylinder 42 followed by foaming by protruding the plunger 48 is performed to form a molded article.

[0093] At the injection to the mold 24, a method for injecting the melt 2 of the light alloy in an injection amount equal to the inner capacity of the mold 24 into the mold 24 and opening the mold by a foaming portion to obtain the foaming molded article similarly to the above-mentioned method, and a method for injecting the melt 2 of the light alloy into the mold 24 in an amount reduced by the foaming portion to obtain the foaming molded article within the mold with a constant capacity can be applied.

[0094] According to the method for injection foaming molding using the apparatus for injection foaming molding 40, since the foaming of the melt 2 (the expansion of the gaseous component) is inhibited in a state where the capacity is made constant by stopping the plunger 48 although the blowing agent is decomposed to generate the gaseous component immediately before the injection, the pressure is released at once in the mold 24 immediately after the injection to allow the melt to foam, whereby the melt 2 can spread into every corner of the mold 24. Accordingly, the transfer property to the mold 24 is enhanced to enable the formation of a foaming molded article of a complicated shape. The transfer property and the moldability of a foaming molded article of a complicated shape can be further improved by depressurizing the mold by a pressure reducing means similarly to the above-mentioned embodiment.

[0095] When inert gas is supplied to the melt 2 in a specified percentage as a blowing agent by an inert gas quantitative feeding unit (not shown) by use of the apparatuses for injection foaming molding 1 and 40 as described above, the inert gas is also dispersed by agitation in the kneading parts 5 and 45 of the barrels 7 and 47, and a predetermined amount of the melt 2 is measured for the injection into the mold 24, and then the melt is injected into the mold 24. When the temperature is raised by the temperature adjusting means 10 and 51 before the injection to the mold 24, the expansion of the gaseous component is promoted. At that time, the increase in capacity is suppressed by stopping the retreat of the screw 4 in the apparatus for injection foaming molding 1 and by stopping the retreat of the plunger 48 in the apparatus for injection foaming molding 40, and in such a pressured state, the foaming of the melt 2 (the expansion of the gaseous component) is inhibited. The screw 4 and the plunger 48 are protruded while opening the valve means 12 of the nozzle parts 13 and 52 to inject the melt 2 of the light alloy into the mold 24, whereby the pressuring force acting on the melt 2 is released at once to allow the melt to foam, whereby the formation

of a molded article is performed.

[0096] Since the inert gas is supplied in the specified percentage and uniformly dispersed into the melt 2 even in the use of the inert gas as the blowing agent, a foaming molded article having a substantially uniform cell structure can be formed while minimizing the difference in foaming state between injections.

[0097] The supply of Ar gas as a blowing agent from the barrel in the apparatus for injection foaming molding 40 with the above inert gas quantitative feeding unit provided on the barrel will be further described.

[0098] A predetermined amount of the thickener is added to the melt 2 of the light alloy supplied from the melting furnace to the hopper 53 similarly to the above. At this time, the temperature is adjusted to the liquid phase line temperature or higher by the temperature control means of the hopper 53.

[0099] The temperature-adjusted melt 2 is supplied into the barrel 47, and agitated in the kneading part 45 while adjusting the temperature to the liquid phase line temperature or higher to thereby disperse the thickener. At this time, a high-temperature Ar gas is supplied from the inert gas quantitative feeding unit (not shown) to the melt 2, whereby the Ar gas is also dispersed into the melt 2. The melt 2 is then fed to the storage part 46 in the lower portion of the barrel 47.

[0100] When the addition amount of the thickener to be added to the melt 2 fed to the storage part 46 is small, no pressure overcoming the back pressure of the screw 44 is generated because the pressure of the melt 2 generated by the rotation of the screw 44 in the barrel 47 is small. In such a case, the screw 44 of the kneading part 45 is retreated by driving the screw hydraulic cylinder 56 in the axial direction to feed the melt 2 to the storage part 46 by its own weight of the melt 2, a pressure for feeding the melt 2 to the measuring part 49 of the plunger injection machine 50 is generated by protruding (moving down) the screw 44 to feed the melt 2 to the measuring part 49 by a positive pressure. As a matter of course, when the addition amount of the thickener is large and the pressure overcoming the screw back pressure is generated in the melt 2 by the rotation of the screw 44, the drive by the cylinder is not necessarily required for the feed of the melt 2 to the storage part.

[0101] The measured melt 2 is raised in temperature by the temperature adjusting means 51 within the measuring part 49 before the injection to promote the expansion of the Ar gas included therein. However, since the capacity is made constant by stopping the plunger 48 to inhibit the foaming, and the pressure is released at once in the mold 24 immediately after the injection to allow the melt to foam, the melt spreads into every corner of the mold 24 and a foaming molded article with foamed cells uniformly dispersed therein can be thus obtained.

[0102] Another embodiment according to the apparatus for injection foaming molding of the present invention will be described. An apparatus for injection foaming molding of this embodiment has the same device struc-

ture as the above-mentioned apparatus for injection foaming molding 1 or the apparatus for injection foaming molding 40 except the points described below. Accordingly, only the different points will be described, omitting the description for the similar points.

[0103] This apparatus for injection foaming molding is adapted to disperse, measure and then inject a melt of a light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component into a mold through an injection nozzle, and comprises a nozzle heating means capable of raising the temperature of the melt to the decomposition temperature of the blowing agent or higher when passing the melt through the nozzle in the injection. As the nozzle heating means, a known heating means such as a resistance heating heater or induction heating heater provided on the circumference of the injection nozzle can be used, and the induction heating heater capable of shortening the temperature rising time is more preferably used.

[0104] According a method for injection foaming molding using this apparatus for injection foaming molding, since the melt including the thickener and the blowing agent preliminarily added thereto in respectively specified percentages is prepared similarly to the above embodiments, and agitated to allow the thickener and the blowing agent to uniformly disperse, the difference in foaming state in every injection is minimized.

[0105] The temperature of the melt is adjusted to a temperature lower than the decomposition temperature of the blowing agent to inhibit the foaming at the time of measuring, and raised to the decomposition temperature of the blowing agent or higher at the time of the passage to the injection nozzle or immediately before the injection into the mold to allow the melt to rapidly foam in the mold after the injection by the gaseous component generated by the decomposition of the blowing agent at the time of the passage to the injection nozzle (immediately before the injection into the mold). Therefore, the reheating of the mold to the decomposition temperature of the blowing agent or higher is dispensed, and the productivity is enhanced.

[0106] Although the present invention is described with the preferred embodiments, the present invention is not limited to these embodiments, and various changes are possible within the technical range of the present invention.

[0107] For example, a shutter member may be provided in the hopper and the feed port part of the barrel connected thereto to intermittently supply the melt from the hopper to the barrel. According to this, the addition of the thickener and the blowing agent in the specified percentages to the melt stored in the hopper can be facilitated.

[0108] In the method for injection foaming molding using the apparatus for injection foaming molding 40 according to the embodiment, the primary measurement is performed in the storage part 46 formed in the front

portion of the barrel 47 by retreating the screw 44, and the melt 2 is introduced to and measured in the measuring part 49, which is formed in the front portion within the cylinder 42 by retreating the plunger 48, from the barrel 47 through the communicating passage 41 by protruding the screw 44. However, the melt 2 may be introduced to and measured in the measuring part 49, which is formed by retreating the plunger 48 while rotating the screw 44 without retreating successively to the agitation by the screw 44. According to this, the screw hydraulic cylinder 56 can be dispensed to simplify the device structure, and the primary measuring operation can be omitted.

[0109] A pressure detection means such as a pressure gauge or pressure sensor may be provided in the hydraulic circuit of the screw hydraulic cylinders 21 and 56 and the plunger hydraulic cylinder 57 to detect the back pressure generated in the screw or plunger 48 at the time of raising the temperature of the melt to the decomposition temperature of the blowing agent or higher. According to this, the temperature rising state of the melt 2 or the decomposition degree of the blowing agent can be estimated from the change in the back pressure accompanied by the temperature rise of the melt 2.

[0110] By detecting the change in the back pressure, the pressure of the hydraulic cylinder can be controlled by use of the detection value as a control parameter to control the foaming state of the melt 2. Namely, when the melt 2 is controlled in such a manner that the melt 2 is partially foamed before injection, the partially foamed melt 2 is pressured to inhibit the further foaming, and the resulting melt 2 is injected into the mold 24, whereby the unfoamed part is suddenly foamed in the mold 24, the melt 2 before the injection (at the time of measuring) can be controlled to a desired foaming state. The partial foaming of the melt 2 may be performed not by the pressure control of the hydraulic cylinder but by the position control of the hydraulic cylinder.

[0111] Although the present invention is described in the above preferred embodiments, the present invention is not restrictive to these embodiments. The present invention will be understood to include various other embodiments without departing from the spirit and scope of the present invention.

INDUSTRIAL APPLICABILITY

[0112] According to the method for injection foaming molding and apparatus for injection foaming molding of the present invention, since the melt is adjusted to the decomposition temperature of the blowing agent or higher and inhibited to foam by pressuring at least immediately before injection, the difference in foaming state between batches is minimized. Since the capacity in the measuring part is made constant although the decomposition of the blowing agent is caused immediately before the injection, the melt is inhibited to foam in the pressured state. Therefore, since the melt releases the

pressure at once in the mold immediately after the injection to foam, the melt spreads into every corner of the mold. Accordingly, the transfer property to the mold is enhanced to enable the formation of a foaming molded article of a complicated shape. Since the heating of the mold to the decomposition temperature of the blowing agent or higher is dispensed, the productivity is improved.

Claims

1. A method for injection foaming molding of a light alloy comprising the steps of holding a melt of a light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component in respectively specified percentages at a temperature lower than the decomposition temperature of said blowing agent, then agitating said melt to allow said thickener and said blowing agent to disperse, measuring a predetermined amount of said melt for the injection into a mold, and injecting said melt into said mold to produce a foaming molded article of the light alloy,

wherein said melt is temperature-adjusted to the decomposition temperature of said blowing agent or higher and also inhibited to foam by pressuring at least immediately before said injection.

2. A method for injection foaming molding of a light alloy comprising the steps of holding a melt of a light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component in respectively specified percentages at a temperature lower than the decomposition temperature of said blowing agent, introducing said melt to an injection molding device having an agitating function, a measuring function and an injecting function, agitating said melt to allow said thickener and said blowing agent to disperse, measuring a predetermined amount of said melt for the injection into a mold, and injecting said melt into said mold to produce a foaming molded article of the light alloy,

wherein said melt is temperature-adjusted to the decomposition temperature of said blowing agent or higher and inhibited to foam by pressuring at least immediately before said injection.

3. The method for injection foaming molding of the light alloy according to claim 1, wherein the temperature of said melt is lower than the decomposition temperature of said blowing agent at the time of agitating said melt.

4. The method for injection foaming molding of the light alloy according to claim 2, wherein the temperature of said melt is lower than the decomposition

temperature of said blowing agent at the time of agitating said melt.

5. A method for injection foaming molding of a light alloy comprising the steps of agitating a melt of a light alloy containing a predetermined amount of a thickener to allow said thickener to disperse, supplying inert gas as a blowing agent into said melt in a specified percentage while agitating to allow said inert gas to disperse, measuring a predetermined amount of said melt for the injection into a mold, and injecting said melt into said mold to produce a foaming molded article of the light alloy,

wherein said melt is inhibited to foam by pressuring said melt at least until said injection is performed after the supply of said inert gas.

6. The method for injection foaming molding of the light alloy according to claim 5, wherein said pressuring is performed by a pressing force caused by said agitation with a screw.

7. The method for injection foaming molding of the light alloy according to claim 1, wherein said melt is injected in an injection amount reduced by a foaming portion relative to the inner capacity of the mold to break said pressuring, whereby said melt is allowed to foam within said mold to obtain the foaming molded article.

8. The method for injection foaming molding of the light alloy according to claim 2, wherein said melt is injected in an injection amount reduced by a foaming portion relative to the inner capacity of said mold to break said pressuring, whereby said melt is allowed to foam within said mold to obtain the foaming molded article.

9. The method for injection foaming molding of the light alloy according to claim 5, wherein said melt is injected in an injection amount reduced by a foaming portion relative to the inner capacity of said mold to break said pressuring, whereby said melt is allowed to foam within said mold to obtain the foaming molded article.

10. The method for injection foaming molding of the light alloy according to claim 1, wherein said melt is injected in an injection amount equal to the inner capacity of said mold, and said mold is opened by the capacity of a foaming portion to break said pressuring, whereby said melt is allowed to foam to obtain the foaming molded article.

11. The method for injection foaming molding of the light alloy according to claim 2, wherein said melt is injected in an injection amount equal to the inner capacity of said mold, and said mold is opened by

the capacity of a foaming portion to break said pressuring, whereby said melt is allowed to foam to obtain the foaming molded article.

12. The method for injection foaming molding of the light alloy according to claim 5, wherein said melt is injected in an injection amount equal to the inner capacity of said mold, and said mold is opened by the capacity of a foaming portion to break said pressuring, whereby said melt is allowed to foam to obtain the foaming molded article.

13. A method for injection foaming molding of a light alloy comprising the steps of adjusting the temperature of a melt of a light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component in respectively specified percentages to a temperature lower than the decomposition temperature of said blowing agent, supplying said melt into a barrel having a screw provided to be rotatable, protrudable and retreatable, agitating said melt by rotating said screw to allow said thickener and said blowing agent to disperse, measuring said melt in a measuring part formed at a front portion of said barrel by retreating said screw with rotation, adjusting the temperature of said melt to the decomposition temperature of said blowing agent or higher while inhibiting the foaming of said melt by pressuring the melt within the measuring part the capacity of which is made constant by stopping the retreat of said screw at least immediately before injection, and injecting said melt into said mold by protruding said screw to obtain a foaming molded article.

14. A method for injection foaming molding of a light alloy using an apparatus for injection foaming molding comprising a barrel containing a screw and a cylinder containing a plunger, a front portion of said cylinder communicating with the front portion of the barrel through a communicating passage, comprising:

- (a) a supplying process for supplying the melt of the light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component in respectively specified percentages, which is temperature-adjusted and held at a temperature lower than the decomposition temperature of said blowing agent, into said barrel;
- (b) an agitating process for agitating said melt within said barrel by rotating said screw within the barrel to allow said thickener and said blowing agent to disperse;
- (c) a measuring process for introducing and measuring said melt from said barrel to a measuring part formed in the front portion in said cyl-

inder by retreating said plunger through said communicating passage;

- (d) a pressuring process for adjusting the temperature of said melt to the decomposition temperature of said blowing agent or higher, and pressuring said melt to inhibit the foaming of said melt by generating the gaseous component within said measuring part the capacity of which is made constant by stopping the retreat of said plunger at least immediately before injection; and

- (e) an injection foaming process for injecting said melt inhibited to foam in said pressuring process into a mold communicating with the inner portion of said cylinder in the front portion of said cylinder by protruding said plunger.

15. A method for injection foaming molding of a light alloy comprising the steps of holding a melt of a light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component in respectively specified percentages at a temperature lower than the decomposition temperature of said blowing agent, agitating said melt to allow said thickener and said blowing agent to disperse, measuring a predetermined amount of said melt for the injection into a mold, and injecting said melt into said mold through an injection nozzle to produce a foaming molded article of the light alloy,

wherein said melt is heated to the decomposition temperature of said blowing agent or higher at least immediately before the injection into said mold.

16. The method for injection foaming molding of the light alloy according to claim 15, wherein the temperature of said melt is raised to the decomposition temperature of said blowing agent or higher at the time of passing through said nozzle.

17. An apparatus for injection foaming molding of a light alloy comprising:

a cylindrical member for receiving a melt of a light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component, wherein said melt is agitated by an agitating means provided rotatably in the inner portion to allow said thickener and said blowing agent to disperse; a movable member provided to be protrudable and retreatable within said cylindrical member, said movable member forming a measuring part for measuring said melt in cooperation with said cylindrical member at the tip of said cylindrical member by retreating and injecting said melt with the gaseous component generated

therein into a mold communicating with said measuring part by protruding; and a position retaining means for retaining the position of said movable member against an increase in internal pressure of said cylindrical member in the generation of said gaseous component so that said melt after the completion of the measurement can be retained in the pressured state to inhibit the foaming thereof.

18. The apparatus for injection foaming molding of the light alloy according to claim 17, wherein said position retaining means is a solenoid valve provided in a hydraulic circuit of a hydraulic cylinder for protruding and retreating said movable member so as to be capable of interrupting the incoming and outgoing of oil to the hydraulic cylinder.

19. The apparatus for injection foaming molding of the light alloy according to claim 17, wherein said movable member is composed of a rotatable agitating screw.

20. The apparatus for injection foaming molding of the light alloy according to claim 17, wherein said cylindrical member comprises a barrel for agitating said melt and a cylinder connected thereto to introduce and measure said agitated melt, and said movable member is a plunger provided within said cylinder.

21. An apparatus for injection foaming molding of a light alloy comprising:

a barrel for receiving a melt of the light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component, said barrel comprising a temperature adjusting means capable of adjusting the temperature of said melt from a temperature lower than the decomposition temperature of said blowing agent to the decomposition temperature or higher, in which the gaseous component can be generated by adjusting the temperature of said melt to the decomposition temperature of said blowing agent or higher by said temperature adjusting means; a screw provided within said barrel to be rotatable, protrudable and retreatable and adapted to agitate said melt by rotating to allow said thickener and said blowing agent to disperse, to form a measuring part in cooperation with said barrel at the tip of said barrel by retreating, and to inject the measured melt from said barrel into a mold by protruding; and

a position retaining means for retaining the position of said screw against an increase in internal pressure of said barrel in the generation of said gaseous component so that said melt

after the completion of the measurement can be retained in the pressured state to inhibit the foaming thereof.

22. An apparatus for injection foaming molding of a light alloy comprising:

a barrel for receiving a melt of a light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component, said barrel having a first temperature adjusting means capable of adjusting the temperature of said melt to a temperature lower than the decomposition temperature of said blowing agent, in which said melt is agitated by a screw provided rotatably in the inner portion to allow said thickener and said blowing agent to disperse;

a cylinder connected to said barrel and having a second temperature adjusting means capable of adjusting the temperature of said melt to the decomposition temperature of said blowing agent or higher;

a plunger provided within said cylinder to be protrudable and retreatable, said plunger forming a measuring part for measuring said melt in cooperation with said cylinder at the tip of said cylinder by retreating, and injecting the measured melt from said cylinder into a mold by protruding; and

a position retaining means for retaining the position of said plunger against an increase in internal pressure of said cylinder in the generation of said gaseous component, so that said melt after the completion of the measurement can be retained in the pressured state to inhibit the foaming thereof.

23. An apparatus for injection foaming molding of a light alloy comprising:

a cylindrical member for receiving a melt of the light alloy containing a thickener and a blowing agent decomposing at a high temperature to generate a gaseous component, in which said melt is agitated by an agitating means provided rotatably in the inner portion to allow said thickener and said blowing agent to disperse;

a movable member provided within said cylindrical member to be protrudable and retreatable, said member forming a measuring part for measuring said melt in cooperation with said cylindrical member at the tip of said cylindrical member by retreating and injecting said melt into a mold communicating with said measuring part through an injection nozzle by protruding; and

a nozzle heating means capable of heating said

melt to the decomposition temperature of said blowing agent or higher at the time of passing said melt through said nozzle.

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FIG. 1

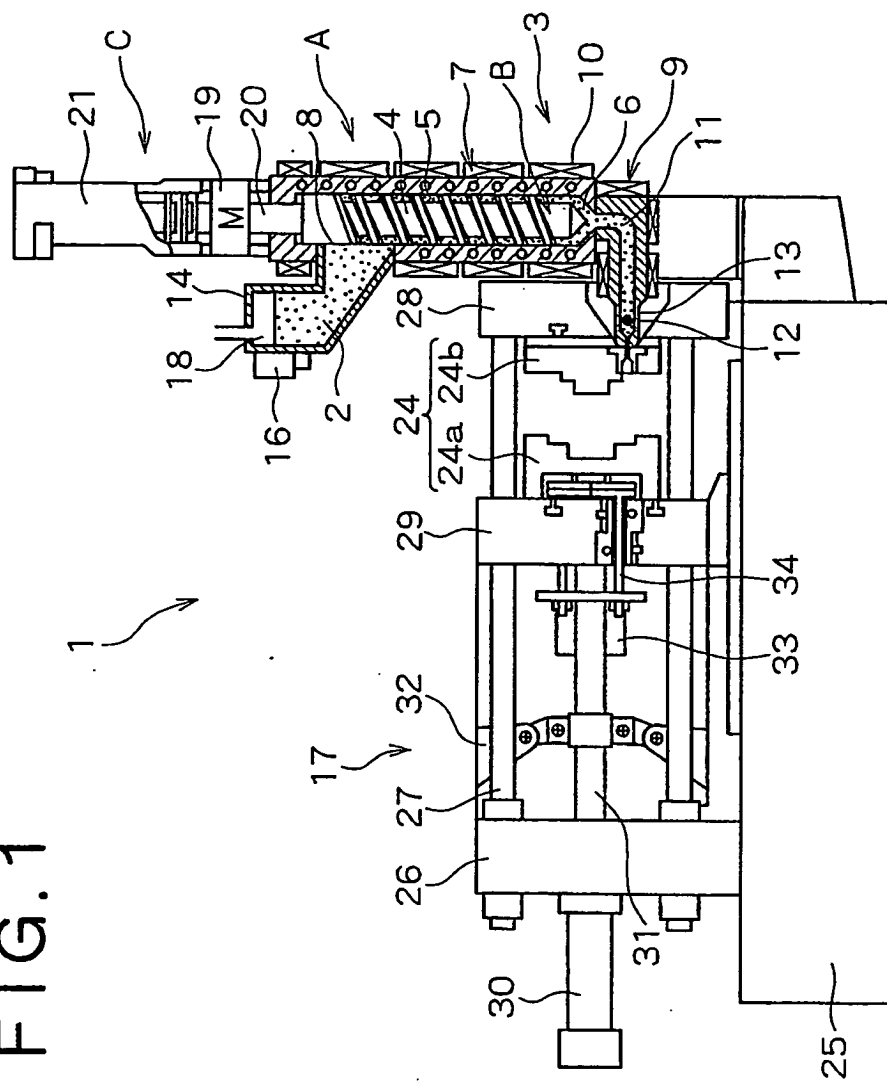


FIG. 2

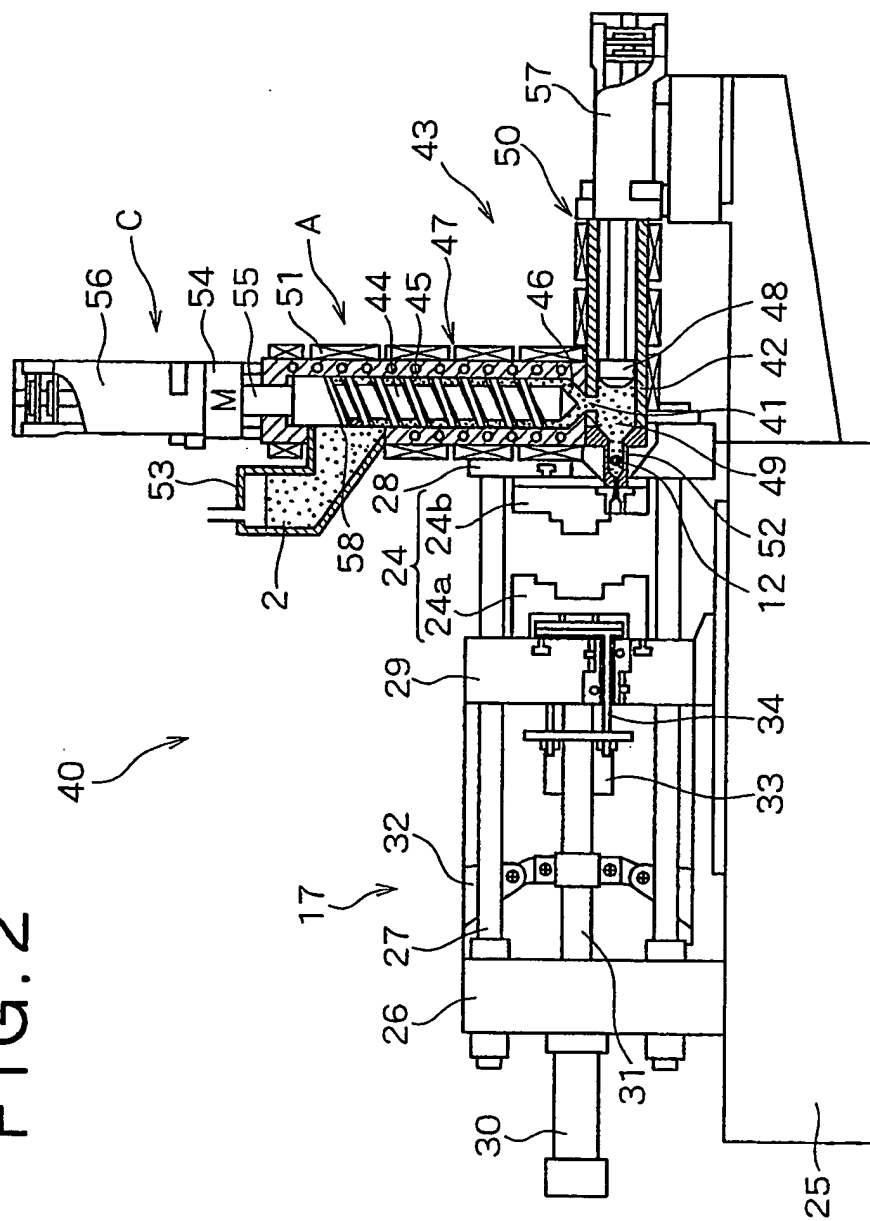


FIG. 3

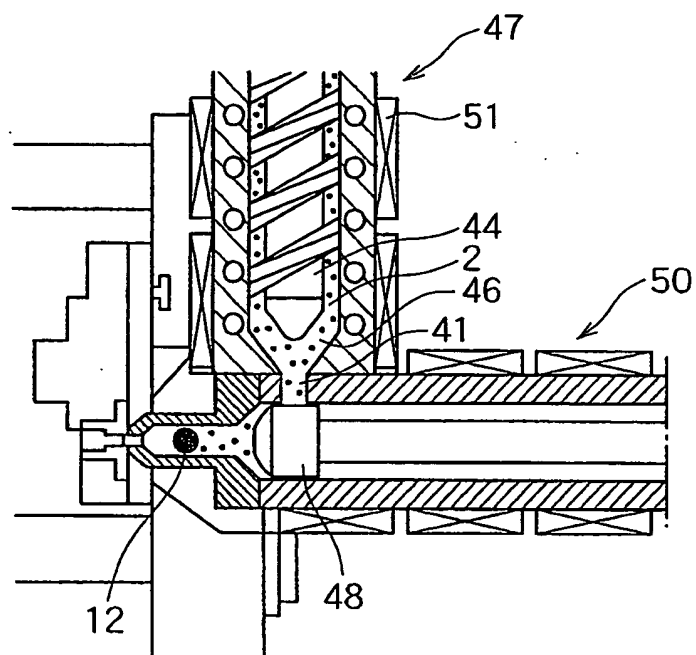


FIG. 4

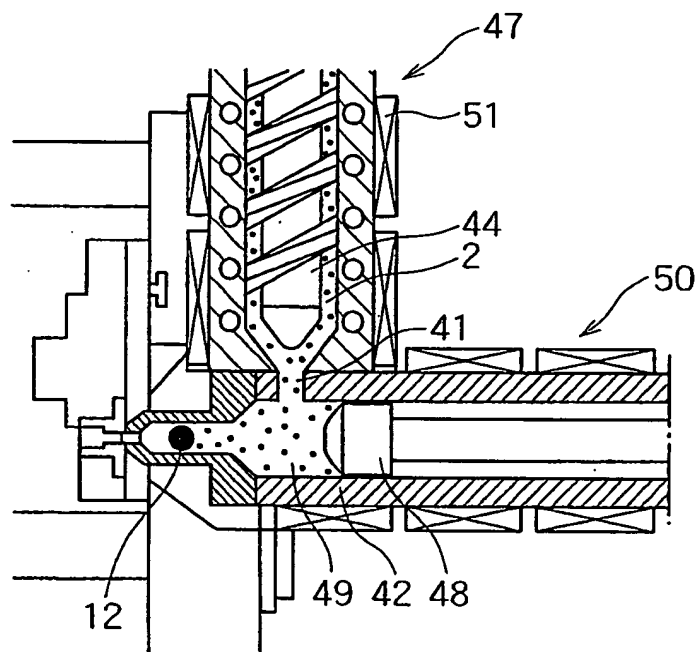
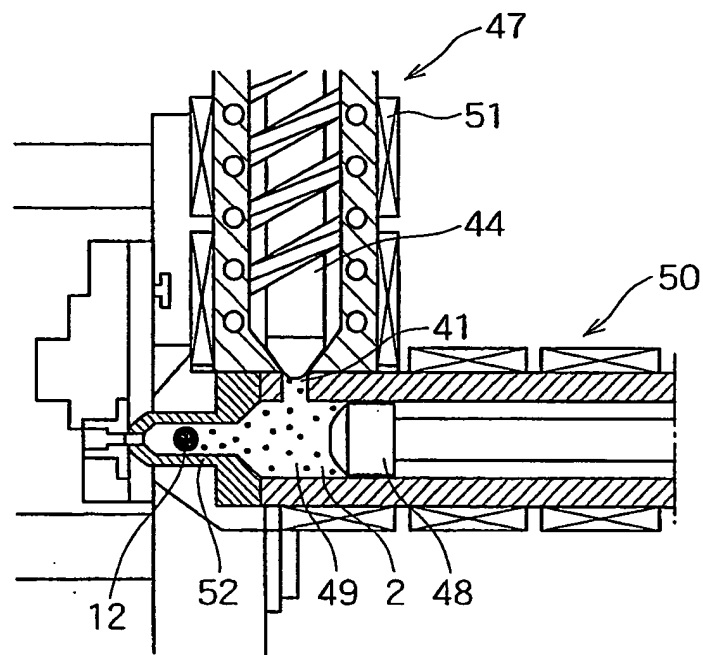


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP03/09698

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl ⁷ C22C1/08, B22D25/02, B22D19/14, B22D19/00 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) Int.Cl ⁷ C22C1/08, B22D25/02, B22D19/14, B22D19/00 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2003 Kokai Jitsuyo Shinan Koho 1971-2003 Jitsuyo Shinan Toroku Koho 1996-2003 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 9-241780 A (Shinko Wire Co., Ltd.), 16 September, 1997 (16.09.97), Full text (Family: none)	1-23
A	JP 1-127631 A (Director General, Agency of Industrial Science and Technology), 19 May, 1989 (19.05.89), Full text (Family: none)	1-23
P,A	JP 2002-371327 A (Shinko Wire Co., Ltd.), 26 December, 2002 (26.12.02), Full text (Family: none)	1-23
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 17 November, 2003 (17.11.03)		Date of mailing of the international search report 02 December, 2003 (02.12.03)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

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