

DESCRIPTION

APPARATUS AND PROCESS FOR PRODUCING POLYMER

Technical Field

5 [0001]

The present invention relates to an apparatus and process for producing a polymer.

Background Art

10 [0002]

As a process for producing a polymer such as (meta)acrylic polymer, a method is known wherein solution polymerization or bulk polymerization is conducted to give a polymer composition comprising a polymer and an unreacted monomer in a reactor, and then volatile components mainly containing the unreacted monomer are removed from the polymer composition using a devolatilizing extruder to give the polymer as an extruded material (for example, see Patent Literatures 1-4).

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Citation List

[0003]

Patent Literature

Patent Literature 1: JP-A-50-40688

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Patent Literature 2: JP-A-2003-96105

Patent Literature 3: JP-A-2000-211010

Patent Literature 4: JP-A-2005-112870

Summary of Invention

5 Technical Problem

[0004]

In such process for producing a polymer, a pressure-regulating valve is used to regulate a pressure in the reactor, and a polymer composition obtained by passing
10 through the pressure-regulating valve is supplied to the devolatilizing extruder (see Patent Literature 4).

[0005]

However, the conventional apparatus for producing a polymer using the usual pressure-regulating valve has a
15 problem that if the apparatus is continuously operated for a long time, the movement of the pressure-regulating valve becomes awkward, so that the continuous operation for a long time is impossible.

[0006]

20 The object of the present disclosure is to provide an apparatus for producing a polymer which is able to be operated stably and continuously for a long time and a process for producing polymer conducted by using the apparatus.

Solution to Problem

[0007]

In the usual pressure-regulating valve, a stem for supporting and controlling a valve element is inserted into a guide for slidably guiding the stem therethrough. It is considered that a polymer composition enters a gap between the surface of the stem and the internal surface of the guide, and an unreacted monomer in the polymer composition is polymerized (for example, by heat) on the site and the resulting polymer is attached to the stem and/or the guide. Then, it is understood that, when the apparatus for producing a polymer continuously is operated for a long time, the attached polymer inhibits sliding of the stem, thereby the movement of the pressure-regulating valve become awkward (in other words, it becomes impossible to smoothly control the valve element as intended). The inventors have considered earnestly on an apparatus for producing a polymer which is able to prevent attachment of the polymer to the stem and/or the guide of the pressure-regulating valve, and finally completed the embodiments of the present disclosure.

[0008]

The present disclosure provides the following [1] to [6].

[1] An apparatus for producing a polymer provided

with a reactor, a pressure-regulating valve and a devolatilizing extruder so that a polymer composition obtained from the reactor is supplied to the devolatilizing extruder through the pressure-regulating valve,

5 wherein the pressure-regulating valve comprises a valve element, a body having a space for housing the valve element, a stem for supporting and controlling the valve element, a guide for slidably guiding the stem, and a fluid feed port through which a fluid comprising a polymerization
10 inhibitor is fed into a gap between a surface of the stem and an internal surface of the guide, and the gap is communicated with the space in the body so that the fluid fed from the fluid feed port flows into the space.

[2] The apparatus for producing a polymer according
15 to the above [1], wherein the pressure-regulating valve comprises further a lantern ring in a sealing part between the stem and the guide, and the fluid feed port is located adjacently to the lantern ring.

[3] A process for producing a polymer by using the
20 apparatus for producing a polymer according to the above [1] or the above [2], wherein the process comprises:

subjecting raw materials comprising a monomer and a polymerization initiator to a polymerization reaction in the reactor with regulating a pressure in the reactor by
25 the pressure-regulating valve, and taking out a polymer

composition comprising a polymer and an unreacted monomer from the reactor;

5 passing the polymer composition taken out from the reactor to the space in the body of the pressure-regulating valve with feeding a fluid comprising a polymerization inhibitor from the fluid feed port in the pressure-regulating valve to obtain the polymer composition which is mixed with the fluid, and

10 supplying the polymer composition which is mixed with the fluid obtained by passing through the pressure-regulating valve to the devolatilizing extruder, and taking out from the devolatilizing extruder an extruded material in which volatile components comprising the unreacted monomer are at least partly removed from the polymer
15 composition to obtain the polymer as the extruded material.

[4] The process for producing a polymer according to the above [3], wherein the fluid comprising the polymerization inhibitor is a fluid which is formed by dissolving the polymerization inhibitor in the monomer.

20 [5] The process for producing a polymer according to the above [3] or the above [4], wherein a content ratio of the polymerization inhibitor in the fluid comprising the polymerization inhibitor is 5-2,000 ppm by weight based on the total weight of the fluid.

25 [6] The process for producing a polymer according to

any one of the above [3] to [5], wherein a ratio of a
supplying flow rate of the polymer composition to a
supplying flow rate of the fluid comprising the
polymerization inhibitor, both to the pressure-regulating
5 valve, is within a range of from 80:20 to 99.9:0.1.

Effect of Invention

[0009]

According to the present disclosure, there is provided
10 an apparatus for producing a polymer which is able to
prevent attachment of a polymer to a stem and/or a guide in
a pressure-regulating valve, thereby being able to be
operated stably and continuously for a long time.
Additionally, a process for producing a polymer conducted
15 by using the apparatus is provided.

According to one aspect, there is provided an
apparatus for producing a polymer provided with a reactor,
a pressure-regulating valve and a devolatilizing extruder
so that a polymer composition obtained from the reactor is
20 supplied to the devolatilizing extruder through the
pressure-regulating valve,

wherein the pressure-regulating valve comprises a
valve element, a body having a space for housing the valve
element, a stem for supporting and controlling the valve
25 element, a guide for slidably guiding the stem, and a fluid

feed port through which a fluid comprising a polymerization inhibitor is fed into a gap between a surface of the stem and an internal surface of the guide, and the gap is communicated with the space in the body so that the fluid
5 fed from the fluid feed port flows into the space.

According to another aspect, there is provided a process for producing a polymer by using the apparatus for producing a polymer as disclosed herein, wherein the
10 process comprises:

subjecting raw materials comprising a monomer and a polymerization initiator to a polymerization reaction in the reactor with regulating a pressure in the reactor by the pressure-regulating valve, and taking out a polymer
15 composition comprising a polymer and an unreacted monomer from the reactor;

passing the polymer composition taken out from the reactor to the space in the body of the pressure-regulating valve with feeding a fluid comprising a polymerization inhibitor from the fluid feed port in the pressure-regulating valve to obtain the polymer composition which is mixed with the fluid, and
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supplying the polymer composition which is mixed with the fluid obtained by passing through the pressure-regulating valve to the devolatilizing extruder, and taking
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out from the devolatilizing extruder an extruded material in which volatile components comprising the unreacted monomer are at least partly removed from the polymer composition to obtain the polymer as the extruded material.

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Brief Description of Drawings

[0010]

Fig. 1 shows a schematic sectional view of a pressure-regulating valve used in an apparatus for producing a polymer in one embodiment of the present invention. Fig. 1(a) shows the pressure-regulating valve in an open state, and Fig. 1(b) shows the pressure-regulating valve in a close state.

Fig. 2(a) shows a schematic partial enlarged view of

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the pressure-regulating valve shown in Fig. 1. Fig. 2(b) shows a schematic partial enlarged view of a modification of the pressure-regulating valve of Fig. 2(a).

Fig. 3 shows a schematic view of an apparatus for producing a polymer in one embodiment of the present invention.

Following reference signs denote the following elements:

	1	valve element
10	3	space
	5	body
	5a	seat part
	7a	inlet port
	7b	outlet port
15	9	stem
	11	gap
	13	guide
	15	sealing part
	15a	packing
20	15b	lantern ring
	17	fluid feed port
	19	driving part
	20	pressure-regulating valve
	31	raw material monomer fluid tank
25	33	polymerization initiator fluid tank

35, 37 pump
39 raw material supply line
40 reactor
41a supply port
5 41b effluent port
43 jacket
45 stirrer
50 preheater
51 polymerization inhibitor containing fluid tank
10 53 pump
60 devolatilizing extruder
61 supply port
65 discharge line
67 recovery tank
15 100 apparatus for producing a polymer

Description of Embodiments

[0011]

The apparatus for producing a polymer of the present
20 invention has at least a reactor, a pressure-regulating
valve and a devolatilizing extruder. Hereinafter, first,
the pressure-regulating valve is explained, then the
apparatus for producing a polymer of the present invention
using the pressure-regulating valve, and a process for
25 producing a polymer of the present invention which is

conducted by using the apparatus are explained.

[0012]

The pressure-regulating valve 20 used in the apparatus for producing a polymer of the present invention comprises, for example as shown in Fig. 1, the valve element 1, the body 5 having the space 3 for housing the valve element 1, the stem 9 for supporting and controlling the valve element 1, the guide 13 for slidably guiding the stem 9 therein (in other words, the guide 13 for guiding the slidable stem 9), and the fluid feed port 17 through which a fluid comprising a polymerization inhibitor (hereinafter also referred to as a polymerization inhibitor containing fluid) is fed into the gap 11 between the surface of the stem 9 and the internal surface of the guide 13. The gap 11 is communicated with the space 3 in the body 5 so that the polymerization inhibitor containing fluid fed from the fluid feed port 17 flows into the space 3 in the body 5.

[0013]

The pressure-regulating valve 20 is used to regulate the pressure in a reactor which is described below. The polymer composition obtained from the reactor is supplied from the inlet port 7a of the body (or valve box) 5, passes through the space 3 in the body 5, and flows out through the outlet port 7b (in Fig. 1, the flow direction of the polymer composition is shown by the open arrow). The

outflow rate of the polymer composition from the outlet port 7b in the pressure-regulating valve 20 is regulated by the valve element 1, as a result, the pressure in the reactor is regulated.

5 [0014]

The valve element (or disk) 1 is operated by sliding the stem 9 along the internal surface of the guide 13 by the driving part 19 (in the embodiment shown in Fig. 1, by moving the stem 9 up and down in an axial direction of the stem 9). The valve element 1 is maintained in a state to be supported by the stem 9 during the stem 9 is operated by sliding.

[0015]

Fig. 1 shows the pressure-regulating valve 20 so-called as a globe valve type. The stem 9 is moved up and down within the guide 13 by the driving part 19, thereby the valve element 1 which is supported at the tip of the stem 9 is also simultaneously moved up and down. When the valve element 1 is placed at the bottom (see Fig. 1(b)), the valve element 1 is engaged with (or pressed against) the seat part (or valve seat) 5a in the body 5, and stops the flow of the polymer composition through the space 3 (close state). When the valve element 1 is placed at the top (see Fig. 1(a)), the polymer composition is passed through the space 3 flowing between the valve element 1 and

the seat part 5a (open state). Then, the outflow rate of the polymer composition from the pressure-regulating valve 20 and thus the pressure in the reactor can be regulated by regulating the position of the valve element 1 in the longitudinal (up-and-down) direction (open degree) by the stem 9. The seat part 5a may be integrated in the body 5 or be a separate part from it.

[0016]

However, the pressure-regulating valve which is able to be used in the present invention is not limited thereto, any appropriate constitution can be applied as long as the valve element 1 supported by the stem 9 can be operated by sliding the stem 9 in the guide 13, as a result, the outflow rate of the polymer composition from the pressure-regulating valve 20 and thus the pressure in the reactor can be regulated. For example, in the pressure-regulating valve 20 shown in Fig. 1, the inlet port and the outlet port may be used in reverse (i.e. the inlet port 7a and the outlet port 7b are changed to and used as the outlet port and the inlet port, respectively), and the polymer composition may be flowed in the opposite direction of that indicated by the open arrow in Fig. 1. Also, for example, other constitution such as so-called gate valve, needle valve (in these constitutions, a stem for supporting a valve element is moved up and down in the axial direction)

can be used, and the shape of the valve element 1 and the structure of the body 5 and the like can be appropriately selected depending on the constitution.

[0017]

5 With respect to the stem 9 and the guide 13, the gap 11 is present between them so that the stem 9 can be slid along the internal surface of the guide 13. The gap 11 also has a function as a flow passage for the polymerization inhibitor containing fluid fed from the fluid feed port 17.

10 The size of the gap 11 (representatively, being the value obtained by subtracting the outer diameter of the stem 9 from the inner diameter of the guide 13 and being divided by two) is, but not limited to, for example, 0.01-15 mm, preferably 0.1-10 mm. When the gap size is not more than

15 the above upper limit, the stem 9 can be adequately slid in the guide 13. When the gap size is not less than the above lower limit, the polymerization inhibitor containing fluid fed from fluid feed port 17 into the gap 11 is facilitated to flow to the space 3 and the effect to inhibit the entry

20 of the polymer composition to the gap 11 can be ensured.

[0018]

 The gap 11 between the stem 9 and the guide 13 generally is sealed with the sealing part 15 at the opposite end of the valve element 1. By providing with the

25 sealing part 15, the pressure in the space 3 in the body 5

can be maintained and the incorporation of impurities into the polymer composition from outside can be prevented. The known shaft sealing can be applied to the sealing part 15. In this embodiment, as shown in Fig. 1 and Fig. 2(a), a gland packing is used in the sealing part 15, but not limited thereto, the sealing part 15 can be made from an O-ring sealing, a bellows sealing and the like in place of the gland packing.

[0019]

One or more of the fluid feed ports 17 can be provided at any suitable position as long as the polymerization inhibitor containing fluid can be fed into the gap 11 between the surface of the stem 9 and the internal surface of the guide 13. For example, as shown in Fig. 1 and Fig. 2(a), the fluid feed port 17 can be located between the sealing part 15 and the space 3. Additionally, for example, as shown in Fig. 2(b), when the sealing part 15 comprises the packing 15a and the lantern ring 15b (as shown in the figure, the lantern ring 15b can be located between the packings 15a, but not limited thereto), the fluid feed port 17 can be located adjacently to the lantern ring 15b.

[0020]

By using such pressure-regulating valve 20 for regulating the pressure in the reactor, since the polymerization inhibitor containing fluid fed from the

fluid feed port 17 flows into the space 3 in the body 5 through the gap 11, the flow of the polymerization inhibitor containing fluid effectively prevents the polymer composition from entering the gap 11. Furthermore, the polymerization inhibitor in the polymerization inhibitor containing fluid prevents the unreacted monomer contained in the polymer composition from being polymerized additionally. As a result, the attachment of the polymer to the stem 9 and/or the guide 13 can effectively be prevented to allow the pressure-regulating valve 20 to keep operating preferably without fixing even when it is continuously operated for a long time.

[0021]

Next, an apparatus for producing a polymer of the present invention using such pressure-regulating valve 20 will be described.

[0022]

The apparatus for producing a polymer 100 of the present invention is provided with at least the reactor 40, the pressure-regulating valve 20 and the devolatilizing extruder 60 as shown in Fig. 3, and is made up so that the polymer composition obtained from the reactor 40 is supplied to the devolatilizing extruder 60 through the pressure-regulating valve 20.

[0023]

In this embodiment, the apparatus for producing a polymer 100 can be provided with further the raw material monomer fluid tank 31 and the polymerization initiator fluid tank 33. These tanks 31 and 33 are connected to the supply port 41a of the reactor 40 via the pumps 35 and 37, respectively, and the raw material supply line 39.

[0024]

The reactor 40 is preferably a reactor of a complete mixing type. Specifically, the reactor 40 is provided with the supply port 41a and the effluent port 41b, and preferably further provided with the jacket 43 as a temperature regulating means for regulating a temperature of an outer surface of the reactor and the stirrer 45 for stirring a content therein. The effluent port 41b is preferably located at a top of the reactor, although this embodiment is not limited thereto. On the other hand, the supply port 41a may be generally located at an appropriate position of a lower part of the reactor, although this embodiment is not limited thereto. Furthermore, the reactor 40 may be provided with a temperature sensor T for detecting a temperature in the reactor and a pressure sensor P for detecting a pressure inside the reactor. The detecting part of the pressure sensor P is not necessarily located inside the reactor as long as it can detect the pressure in the reactor. The detecting part of the pressure

sensor P may be located outside the reactor 40, for example, adjacent to the effluent port 41b on the connecting line which connects the effluent port 41b to downstream devices (shown by the symbol P enclosed by a dotted line in Fig. 3).

5 [0025]

Additionally, in this embodiment, the apparatus for producing a polymer 100 may be further provided with the preheater 50 between the reactor 40 and the pressure-regulating valve 20. The effluent port 41b of the reactor 40 is connected to the inlet port of the preheater 50, and the outlet port of the preheater 50 is connected to the inlet port 7a of the pressure-regulating valve 20. As the preheater 50, any appropriate heater can be used as long as it can heat a viscous fluid. When the apparatus for producing a polymer 100 is provided with the preheater 50, the pressure sensor P may be located adjacent to the effluent port 41b on the connecting line which connects the effluent port 41b to the preheater 50 (shown by the symbol P enclosed by a dotted line in Fig. 3).

20 [0026]

The pressure-regulating valve 20 is as described above. The outlet port 7b of the pressure-regulating valve 20 is connected to the supply port 61 of the devolatilizing extruder 60. Additionally, in this embodiment, the apparatus for producing a polymer 100 may be further

provided with the polymerization inhibitor containing fluid tank 51. This tank 51 is connected to the fluid feed port 17 of the pressure-regulating valve 20 via the pump 53.

[0027]

5 As the devolatilizing extruder 60, a single or multi screw devolatilizing extruder can be used. The extruded material obtained after devolatilization is taken out from the discharge line 65. Furthermore, in this embodiment, the apparatus for producing a polymer 100 may be provided with
10 the recovery tank 67 for storing the monomer which is separately recovered from the volatile components (mainly containing the unreacted monomer) which are separated in the devolatilizing extruder 60.

[0028]

15 Next, a process for producing a polymer conducted by using such apparatus will be described.

[0029]

 The process for producing a polymer of the present invention uses the above apparatus for producing a polymer
20 100 and comprises,

 subjecting raw materials comprising a monomer and a polymerization initiator to a polymerization reaction in the reactor 40 with regulating a pressure in the reactor by the pressure-regulating valve 20, and taking out a polymer
25 composition comprising a polymer and an unreacted monomer

from the reactor 40 (the polymerization step);

passing the polymer composition taken out from the reactor 40 to the space 3 in the body 5 of the pressure-regulating valve 20 with feeding the polymerization inhibitor containing fluid from the fluid feed port 17 in the pressure-regulating valve 20 to obtain the polymer composition which is mixed with the polymerization inhibitor containing fluid (the pressure-regulating valve passing step), and

supplying the polymer composition which is mixed with the polymerization inhibitor containing fluid obtained by passing through the pressure-regulating valve 20 to the devolatilizing extruder 60, and taking out an extruded material, in which volatile components comprising the unreacted monomer are at least partly removed from the polymer composition, from the devolatilizing extruder 60 to obtain the polymer as the extruded material (the devolatilizing and extruding step).

[0030]

Hereinafter, the preparation of the raw material and the polymerization inhibitor containing fluid, and each step will be described in detail. In this embodiment, a case of conducting continuous polymerization of a methacrylic ester monomer, in other words, a case of producing a methacrylic ester polymer as a polymer will be

described as an example, although the present invention is not limited thereto. Additionally, in this embodiment, though the polymerization step may use a bulk polymerization or a solution polymerization, a case of
5 using a bulk polymerization without use of a solvent will be described.

[0031]

- Preparation of a raw material

At first, a monomer as the raw material, the
10 polymerization initiator and the like are prepared.

[0032]

As the raw material monomer, a methacrylic ester monomer is used in this embodiment.

Examples of the methacrylic ester monomer are

15 - alkyl methacrylate (of which alkyl group has 1 to 4 carbons) alone, or

- a mixture of not less than 80% by weight of alkyl methacrylate (of which alkyl group has 1 to 4 carbons) and not more than 20% by weight of other vinyl monomer
20 copolymerizable therewith.

Examples of alkyl methacrylate (of which alkyl group has 1 to 4 carbons) include methyl methacrylate, ethyl methacrylate, n-propyl methacrylate, isopropyl methacrylate, n-butyl methacrylate, t-butyl methacrylate, sec-butyl
25 methacrylate, isobutyl methacrylate, and the like. Among

them, methyl methacrylate is preferred. The above described examples of alkyl methacrylate may be used alone or in combination of at least two of them.

Examples of copolymerizable vinyl monomer include, for
5 example, methacrylic esters such as benzyl methacrylate and 2-ethylhexyl methacrylate (except for the above described alkyl methacrylate (of which alkyl group has 1 to 4 carbons)); acrylic esters such as methyl acrylate, ethyl acrylate, propyl acrylate, butyl acrylate, and 2-ethylhexyl
10 acrylate; unsaturated carboxylic acids or acid anhydrides thereof such as acrylic acid, methacrylic acid, maleic acid, itaconic acid, maleic acid anhydride, and itaconic acid anhydride; hydroxy group-containing monomers such as 2-hydroxyethyl acrylate, 2-hydroxypropyl acrylate,
15 monoglycerol acrylate, 2-hydroxyethyl methacrylate, 2-hydroxypropyl methacrylate, and monoglycerol methacrylate; nitrogen-containing monomers such as acrylamide, methacrylamide, acrylonitrile, methacrylonitrile, diacetoneacrylamide, and dimethylaminoethyl methacrylate;
20 epoxy group-containing monomers such as allyl glycidyl ether, glycidyl acrylate, and glycidyl methacrylate; styrene based monomers such as styrene and α -methylstyrene. The above described examples of copolymerizable vinyl monomer may be used alone or in combination of at least two
25 of them.

[0033]

As the polymerization initiator, for example, a radical initiator is used in this embodiment.

Examples of a radical initiator include azo compounds
5 such as azobisisobutyronitrile, azobisdimethylvaleronitrile, azobiscyclohexanenitrile, 1,1'-azobis(1-acetoxy-1-phenylethane), dimethyl 2,2'-azobisisobutylate, and 4,4'-azobis-4-cyanovaleric acid; organic peroxides such as benzoyl peroxide, lauroyl peroxide, acetyl peroxide,
10 caprylyl peroxide, 2,4-dichlorobenzoyl peroxide, isobutyl peroxide, acetyl cyclohexylsulfonyl peroxide, t-butyl peroxy-pivalate, t-butyl peroxyneodecanoate, t-butyl peroxyneohexanoate, t-butyl peroxy-2-ethylhexanoate, 1,1-di(t-butylperoxy)cyclohexane, 1,1-di(t-butylperoxy)-3,3,5-trimethylcyclohexane,
15 1,1-di(t-hexylperoxy)-3,3,5-trimethylcyclohexane, diisopropyl peroxydicarbonate, diisobutyl peroxydicarbonate, di-sec-butyl peroxydicarbonate, di-n-butyl peroxydicarbonate, bis(2-ethylhexyl) peroxydicarbonate, bis(4-t-butylcyclohexyl)
20 peroxydicarbonate, t-amyl peroxy-2-ethylhexanoate, 1,1,3,3-tetramethyl butyl peroxy-ethylhexanoate, 1,1,2-trimethyl propyl peroxy-2-ethylhexanoate, t-butyl peroxy isopropyl monocarbonate, t-amyl peroxy isopropyl monocarbonate, t-butyl peroxy-2-ethylhexyl carbonate, t-butyl peroxy allyl
25 carbonate, t-butyl peroxy isopropyl carbonate, 1,1,3,3-

tetramethyl butyl peroxy isopropyl monocarbonate, 1,1,2-trimethyl propyl peroxy isopropyl monocarbonate, 1,1,3,3-tetramethyl butyl peroxy isononate, 1,1,2-trimethyl propyl peroxy-isononate, and t-butyl peroxybenzoate. These
5 polymerization initiators may be used alone or in combination of at least two of them.

[0034]

The polymerization initiator is selected depending on the kinds of the polymer to be produced and the raw
10 material monomer used. For example, although the present invention is not particularly limited, those of radical polymerization initiator having a half-life not more than one minute at the polymerization temperature are preferable. When the half-life at the polymerization temperature is not
15 more than one minute, the reaction rate is not too slow, thus the initiator is suitable for the polymerization reaction in the continuous polymerization apparatus.

[0035]

The supply amount of the polymerization initiator
20 (radical initiator) is, but not particularly limited, generally 0.001 to 1 weight parts with respect to 100 weight parts of the raw material monomer (the raw material monomer eventually supplied to the reactor 40). When two or more polymerization initiators are used in combination, the
25 total weight should be within the above range.

[0036]

In addition to the raw material monomer and the polymerization initiator described above, any appropriate other component(s), for example, a chain transfer agent, a mold release agent, a rubbery polymer such as butadiene and styrene-butadiene rubber (SBR), and the like may be used. The chain transfer agent is used for adjusting a molecular weight of the polymer to be produced. The mold release agent is used for improving moldability (or processability) of an obtained polymer.

[0037]

As the chain transfer agent, either monofunctional or polyfunctional chain transfer agent can be used. Specifically, examples thereof include alkyl mercaptans such as n-propyl mercaptan, isopropyl mercaptan, n-butyl mercaptan, t-butyl mercaptan, n-hexyl mercaptan, n-octyl mercaptan, 2-ethylhexyl mercaptan, n-dodecyl mercaptan, and t-dodecyl mercaptan; aromatic mercaptans such as phenyl mercaptan and thiocresol; mercaptans having 18 or less carbons such as ethylene thioglycol; polyalcohols such as ethylene glycol, neopentyl glycol, trimethylolpropane, pentaerythritol, dipentaerythritol, tripentaerythritol, and sorbitol; those of which hydroxyl group is esterified with thioglycolic acid or 3-mercaptopropionic acid, 1,4-dihydronaphthalene, 1,4,5,8-tetrahydronaphthalene, β -

terpinene, terpinolene, 1,4-cyclohexadiene, hydrogen sulfide and the like. These may be used alone or in combination of two or more of them.

[0038]

5 The supply amount of the chain transfer agent is not particularly limited since it varies depending on the kind of the chain transfer agent used and the like. For example, in a case of using mercaptans, it is preferably 0.01 to 3 weight parts, and more preferably 0.05 to 1 weight parts
10 with respect to 100 weight parts of the raw material monomer (the raw material monomer eventually supplied to the reactor 40). The used amount within this range is preferable because it does not impair the mechanical property of the polymer and maintain the thermal stability
15 preferably. When two or more chain transfer agents are used in combination, the total weight should be within the above range.

[0039]

 Although the mold release agent is not particularly
20 limited, examples thereof include esters of higher fatty acids, higher fatty alcohols, higher fatty acids, higher fatty acid amides, metal salts of higher fatty acids and the like. The mold release agent may be used alone or in combination of two or more of them.

25 [0040]

As the esters of higher fatty acids, specifically, examples thereof include saturated fatty acid alkyl esters such as methyl laurate, ethyl laurate, propyl laurate, butyl laurate, octyl laurate, methyl palmitate, ethyl palmitate, propyl palmitate, butyl palmitate, octyl palmitate, methyl stearate, ethyl stearate, propyl stearate, butyl stearate, octyl stearate, stearyl stearate, myristyl myristate, methyl behenate, ethyl behenate, propyl behenate, butyl behenate, and octyl behenate; unsaturated fatty acid alkyl esters such as methyl oleate, ethyl oleate, propyl oleate, butyl oleate, octyl oleate, methyl linoleate, ethyl linoleate, propyl linoleate, butyl linoleate, and octyl linoleate; saturated fatty acid glycerides such as lauric monoglyceride, lauric diglyceride, lauric triglyceride, palmitic monoglyceride, palmitic diglyceride, palmitic triglyceride, stearic monoglyceride, stearic diglyceride, stearic triglyceride, behenic monoglyceride, behenic diglyceride, and behenic triglyceride; and unsaturated fatty acid glycerides such as oleic monoglyceride, oleic diglyceride, oleic triglyceride, linolic monoglyceride, linolic diglyceride, linolic triglyceride. Among them, methyl stearate, ethyl stearate, butyl stearate, octyl stearate, stearic monoglyceride, stearic diglyceride, stearic triglyceride, and the like are preferred.

As the higher fatty alcohols, specifically, examples thereof include saturated fatty (or aliphatic) alcohols such as lauryl alcohol, palmityl alcohol, stearyl alcohol, isostearyl alcohol, behenyl alcohol, myristyl alcohol, and cetyl alcohol; and unsaturated fatty (or aliphatic) alcohols such as oleyl alcohol, and linolyl alcohol. Among them, stearyl alcohol is preferred.

[0042]

As the higher fatty acids, more specifically, examples thereof include saturated fatty acids such as caproic acid, caprylic acid, capric acid, lauric acid, myristic acid, palmitic acid, stearic acid, arachidic acid, behenic acid, lignoceric acid, and 12-hydroxyoctadecanoic acid; and unsaturated fatty acids such as palmitoleic acid, oleic acid, linoleic acid, linolenic acid, cetoleic acid, erucic acid, and ricinoleic acid.

[0043]

As the higher fatty acid amides, specifically, examples thereof include saturated fatty acid amides such as lauric acid amide, palmitic acid amide, stearic acid amide, and behenic acid amide; unsaturated fatty acid amides such as oleic acid amide, linoleic acid amide, and erucic acid amide; and amides such as ethylene-bis-lauric acid amide, ethylene-bis-palmitic acid amide, ethylene-bis-stearic acid amide, and N-oleyl stearamide. Among them,

stearic acid amide and ethylene-bis-stearic acid amide are preferred.

[0044]

As the metal salts of higher fatty acids, examples
5 thereof include sodium salts, potassium salts, calcium salts and barium salts of the above-described higher fatty acids, and the like.

[0045]

A used amount of the mold release agent is preferably
10 adjusted in a range from 0.01 to 1.0 parts by weight, and more preferably adjusted in a range from 0.01 to 0.50 parts by weight, with respect to 100 parts by weight of a polymer contained in a polymer composition to be obtained.

[0046]

15 With reference to Fig. 3, the raw material monomer fluid comprising at least the monomer is prepared by appropriately mixing the above monomer (one or a mixture of two or more kinds) with other component such as the chain transfer agent if necessary. This is charged to the raw
20 material monomer fluid tank 31. On the other hand, the polymerization initiator fluid comprising at least the polymerization initiator is prepared by appropriately mixing the above polymerization initiator with the monomer optionally, and with other component such as the chain
25 transfer agent if necessary. This is charged to the

polymerization initiator fluid tank 33. The polymerization initiator fluid may be the polymerization initiator alone, or a mixture of the monomer and the polymerization initiator (further may comprise other component(s) such as the chain transfer agent if necessary). In the latter case, the polymerization initiator fluid is preferably a polymerization initiator solution which is formed by completely dissolving the polymerization initiator in the monomer.

10 [0047]

- Preparation of the polymerization inhibitor containing fluid

On the other hand, the polymerization inhibitor containing fluid is prepared.

15 [0048]

The polymerization inhibitor containing fluid is any fluid as long as it contains the polymerization inhibitor, but is preferably a fluid which is formed by dissolving the polymerization inhibitor in a solvent which does not facilitate the polymerization reaction of the unreacted monomer.

[0049]

The examples of the solvent include, for example, organic solvents such as toluene, xylene, ethyl benzene, methyl isobutyl ketone, methyl alcohol, ethyl alcohol,

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octane, decane, cyclohexane, decalin, butyl acetate, and pentyl acetate; and a monomer used as a raw material of the polymer to be produced, in particular, the monomer used as a raw material of the polymer to be produced is preferably used. The monomer used as a raw material of the polymer to be produced is usually a liquid form. When the above monomer is used as a solvent, the incorporation of the impurity into the produced polymer can be prevented. Additionally, the polymerization inhibitor containing fluid comprises the polymerization inhibitor, therefore, the polymerization of the monomer as a solvent in this fluid is also inhibited.

[0050]

Examples of the polymerization inhibitor include, for example, hydroquinone, hydroquinone monomethyl ether, tert-butylcatechol, 4-methoxy-1-naphthol, 1,4-naphthoquinone, 2,4-dimethyl-6-tert-butylphenol, phenothiazine, benzophenothiazine, dinitrobenzen, p-phenyldiamine, dimethyldithiocarbamic acid salt and the like. Among them, 2,4-dimethyl-6-tert-butylphenol is preferred from the viewpoint of being less likely to exert an adverse influence such as coloration even if it remains in the polymer. The polymerization inhibitor to be used is appropriately selected depending on the polymer to be produced and the monomer to be used as a raw material.

[0051]

The content of the polymerization inhibitor in the polymerization inhibitor containing fluid is preferably 5-2,000 ppm by weight, more preferably 10-500 ppm by weight based on the total weight of the fluid. When the content is not more than the above upper limit, the proportion of the polymerization inhibitor contained in the polymer becomes not too high, thereby the coloration of the polymer finally obtained (the extruded material) can be effectively avoided. Additionally, when the content is not less than the above lower limit, the polymerization of the unreacted monomer in the gap 11 in the pressure-regulating valve 20 can be effectively inhibited, furthermore, when the monomer is used as a solvent, the polymerization of the monomer can also be effectively inhibited.

[0052]

With reference to Fig. 3, the polymerization inhibitor is added to the above solvent to prepare the polymerization inhibitor containing fluid. This is charged to the polymerization inhibitor containing fluid tank 51.

[0053]

- Polymerization step

The monomer and the polymerization initiator are continuously supplied to the reactor 40 from the raw material monomer fluid tank 31 and the polymerization

initiator fluid tank 33 via the supply port 41a. Specifically, the raw material monomer fluid containing the monomer is supplied from the raw material monomer fluid tank 31 by the pump 35, and the polymerization initiator fluid containing the polymerization initiator is continuously supplied from the polymerization initiator fluid tank 33 by the pump 37, and they pass through the raw material supply line 39 together, and are continuously supplied to the reactor 40 via the supply port 41a.

10 [0054]

With respect to supplying the polymerization initiator to the reactor 40, when the mixture of the monomer and the polymerization initiator is supplied from the polymerization initiator fluid tank 33 as the polymerization initiator fluid, it is preferable to adjust a ratio A:B in a range from 80:20 to 98:2 wherein A represents the supply flow rate (kg/h) of the raw material monomer fluid from the raw material monomer fluid tank 31, and B represents the supply flow rate (kg/h) of the polymerization initiator fluid (this is the mixture of the monomer and polymerization initiator, of which content ratio of the polymerization initiator is 0.002-10% by weight) from polymerization initiator fluid tank 33.

[0055]

25 The monomer and polymerization initiator supplied to

the reactor 40 as described above are subjected to a polymerization reaction in the reactor 40, thereby at least part of the monomer is polymerized to give the polymer. In this embodiment, the polymerization step is conducted by a bulk polymerization, but the present invention is not limited thereto. The content in the reactor 40 is stirred by the stirrer 45, preferably is completely mixed state.

[0056]

In the polymerization step, the continuous polymerization can be conducted under a condition in which the reactor is filled with the reaction mixture while substantially no gas phase is present (hereinafter referred to as the fully filled condition). When the effluent port 41b of the reactor 40 is located at the top of the reactor, the fully filled condition is conveniently realized simply by conducting the supply to the reactor 40 and the taking out from the reactor 40, continuously.

[0057]

Furthermore, in the polymerization step, the continuous polymerization is conducted under the adiabatic condition. The adiabatic condition can be realized by making the temperature of the inside of the reactor 40 and the temperature of the outer surface thereof approximately equal to each other. Specifically, The adiabatic condition can be realized by adjusting the supply amounts of the raw

material comprising the monomer and the polymerization initiator to the reactor 40 with operating the pumps 35 and 37 so that the temperature of the outer surface of the reactor 40 set for the jacket 43 and the temperature inside the reactor 40 detected by the temperature sensor T correspond to each other.

[0058]

The temperature of the continuous polymerization in the polymerization step is understood as the temperature in the reactor 40 (detected by the temperature sensor T). The polymerization step is conducted, for example, at a temperature from 120-180°C, more preferably at a temperature from 130-180°C, though it depends on the type of the used polymerization initiator. When this temperature is too high, the syndiotacticity of the produced polymer is decreased, the generation of the oligomer is increased, and the heat resistance of the polymer finally obtained (the extruded material) tends to be decreased. However, it should be noted that the temperature in the reactor may change depending on various conditions until it reaches a static state.

[0059]

The pressure of the continuous polymerization in the polymerization step is understood as the pressure in the reactor 40 (detected by the pressure sensor P). This

pressure is regulated by the pressure-regulating valve 20 and is a pressure not less than a vapor pressure of the raw material monomer at the temperature in the reactor to prevent the vaporization of the raw material monomer in the reactor. The pressure is generally about 1.0-2.0 MPaG, preferably 1.2-3.5 MPaG (G: gauge pressure).

[0060]

A period of the continuous polymerization in the polymerization step is understood as an average residence time in the reactor 40. The average residence time in the reactor 40 can be set depending on the productivity of the polymer in the polymer composition and the like, and is, for example, from 15 minutes to 6 hours, preferably from 20 minutes to 2 hours, but not limited thereto. When the period is more than necessary, the generation of the oligomer such as a dimer and trimer is increased, and the heat resistance of the polymer finally obtained (the extruded material) tends to be decreased. The average residence time in the reactor 40 can be adjusted by changing the supply amount (supply flow rate) of the monomer or the like to the reactor 40 with the use of the pumps 35 and 37.

[0061]

As described above, the polymer composition is continuously taken out from the effluent port 41b of the

reactor 40. The obtained polymer composition comprises the produced polymer and the unreacted monomer, and may further comprise the unreacted polymerization initiator, decomposed substance of the polymerization initiator, and the like.

5 The main volatile component in the polymer composition is the unreacted monomer.

[0062]

The polymerization rate in the polymer composition is, for example, 40 to 70% by weight, although this embodiment
10 is not limited thereto. The polymerization rate in the polymer composition appropriately corresponds to the content ratio of the polymer in the polymer composition. When the content ratio of the polymer is too high, the efficiency of mixing and heat transfer is decreased and the
15 stability tends to be decreased. When the content ratio of the polymer is too low, the separation of the volatile components in which the unreacted monomer is main component tends to become difficult.

[0063]

20 • Preheating step

With reference to Fig. 3, the polymer composition taken out from the reactor 40 as described above is fed into the preheater 50 and preheated if necessary, but it is not necessary in the present invention.

25 [0064]

The preheater 50 is used for the purpose of increasing efficiency of the devolatilization in the devolatilizing extruder 60. The polymer composition acquires a part or all of the quantity of heat required to volatilize the volatile components by preheating.

[0065]

The preheating temperature in the preheater 50 is preferably 180-220°C. When the preheating temperature is not more than the above upper limit, the vaporization of the volatile components in the polymer composition can be avoided and the polymer composition can be transferred in the liquid state at a constant flow rate.

[0066]

• Pressure-regulating valve passing step (Outflow rate regulating step)

Next, with reference to Fig. 3, the polymer composition obtained as described above (the polymer composition taken out from the reactor 40, preferably the polymer composition which is preheated in the preheater 50) is passed through the pressure-regulating valve 20.

[0067]

The polymer composition obtained as described above is continuously supplied to the space 3 in the body 5 of the pressure-regulating valve 20 via the inlet port 7a with continuously feeding the polymerization inhibitor

containing fluid into the pressure-regulating valve 20 from the polymerization inhibitor containing fluid tank 51 via the fluid feed port 17 by the pump 53 (see Figs. 1(a) and (b)).

5 [0068]

The supply amount (feed rate) of the polymerization inhibitor containing fluid to the pressure-regulating valve 20 is appropriately regulated depending on the size of the pressure-regulating valve 20, the flow rate of the polymer composition, the desired pressure, and so on. It is preferable to adjust a ratio X:Y in a range from 80:20 to 99.9:0.1 wherein X represents the supply flow rate (kg/h) of the polymer composition to the pressure-regulating valve 20, and Y represents the supply flow rate (kg/h) of the polymerization inhibitor containing fluid. The supply flow rate X (kg/h) of the polymer composition is understood as the total flow rate (A+B) of the supply flow rate A (kg/h) of the raw material monomer fluid from the raw material monomer fluid tank 31, and the supply flow rate B (kg/h) of the polymerization initiator fluid (this is the mixture of the monomer and the polymerization initiator, of which content ratio of the polymerization initiator is 0.002-10% by weight) from the polymerization initiator fluid tank 33. When the supply amount of the polymerization inhibitor containing fluid is within the above range, the proportion

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of the polymerization inhibitor contained in the polymer becomes not too high, thereby the coloration of the polymer finally obtained (the extruded material) can be effectively avoided, and the effect to inhibit the attachment of the polymer to the stem 9 and/or the guide 13 can be ensured.

[0069]

In the pressure-regulating valve 20, when the polymer composition is passed through the space 3, the outflow rate of the polymer composition is regulated by the valve element 1, thereby, the pressure in the reactor 40 located upstream is regulated. More specifically, for example, the position of the valve element 1 in the longitudinal (up-and-down) direction (open degree) is regulated by the stem 9 so as to provide the desired pressure (at upstream from the pressure-regulating valve).

[0070]

The pressure of the polymer composition is, but not limited to, at the upstream side of the pressure-regulating valve 20, for example, 1.0-4.0 MPaG, preferably 1.2-3.5 MPaG (gauge pressure). The open degree of the pressure-regulating valve 20 is regulated so that the pressure in the reactor 40 detected by the pressure sensor P is the predetermined pressure. When the pressure of the polymer composition at the upstream side is within the above range, the pressure in the reactor 40 can become a pressure

suitable for conducting the polymerization step. Additionally, the pressure at the downstream side of the pressure-regulating valve 20 is regulated by a pressure-regulating valve (not shown in the drawings) located on a vent line (not shown in the drawings) of the devolatilizing extruder 60, for example, at -1.2 to 0.4 MPaG, preferably -0.09 to 0.35 MPaG (gauge pressure). When the pressure of the polymer composition at the downstream side is within the above range, the devolatilization of the devolatilizing extruder 60 can effectively conducted.

[0071]

Additionally, in the pressure-regulating valve 20, the polymerization inhibitor containing fluid fed from the fluid feed port 17 flows to the space 3 through the gap 11, and mixed with the polymer composition in the space 3. Since the polymerization inhibitor containing fluid is fed from the fluid feed port 17, the inside of the gap 11 is pressured. The pressure in the gap 11 is higher than that in the space 3 in the body 5, and therefore the entry of the polymer composition (e.g. the unreacted monomer and the polymer) to the gap 11 from the space 3 can be sufficiently inhibited. With respect to the suitable range of the pressure in the gap 11 is appropriately set depending on the size of the pressure-regulating valve 20, the flow rate of the polymer composition and the desired pressure. It is

preferable to provide a body of a feeding pump for the polymerization inhibitor containing fluid tank with a safety device such as a relief valve in order to make the pressure not too high.

5 [0072]

Thus, the polymer composition which is mixed with the polymerization inhibitor containing fluid is supplied from the space 3 of the pressure-regulating valve 20 through the outlet port 7b.

10 [0073]

- Devolatilizing extrusion step

Next, with reference to Fig. 3, the polymer composition obtained as described above (the polymer composition mixed with the polymerization inhibitor
15 containing fluid which is obtained by passing through the pressure-regulating valve 20) is continuously supplied to the devolatilizing extruder 60 via the supply port 61, and subjected to a devolatilizing extruding process.

[0074]

20 In the devolatilizing extruder 60, the volatile components comprising the unreacted monomer is at least partially removed from the polymer composition, and discharged via a vent line (not shown in the drawings) as a gaseous substances, and the residual extruded material is
25 formed into pellets by a cutter (not shown in the drawings)

if necessary, and discharged from the discharge line 65.

[0075]

As a method using a devolatilizing extruder, any suitable methods can be used, suitably methods described in, for example, JP-A-3-49925, JP-B-51-29914, JP-B-52-17555, JP-B-1-53682, JP-A-62-89710 and the like.

[0076]

Generally, the devolatilizing extrusion process is conducted by extruding the continuously supplied polymer composition with a screw under heating, for example, to 200-290°C to continuously separate and remove at least part of, preferably most of, more preferably substantially all of the volatile components contained in the polymer composition. The pressure of the devolatilizing extrusion process is, for example, about -1.2 to 0.4 MPaG (gauge pressure) as a vent pressure.

[0077]

Thus, the polymer can be obtained as the extruded material after the devolatilizing extrusion. The extruded material substantially consists of the polymer, and may possibly comprise other components, for example, the residue of the polymerization inhibitor.

[0078]

Furthermore, before, during or after devolatilization of the polymer composition in the devolatilizing extruder,

lubricants such as higher alcohols and higher fatty acid esters, an ultraviolet absorbing agent, a heat stabilizing agent, a colorant, an antistatic agent and the like can be added to the polymer, if necessary.

5 [0079]

On the other hand, the volatile components removed in the devolatilizing extruder 60 can be recycled as a raw material monomer for polymerization. The volatile components comprises the unreacted raw material monomer as
10 a major component, and comprises other volatile components, for example, impurities originally contained in the raw material monomer, additives used if necessary, volatile by-product(s) generated in the process of polymerization, oligomer such as dimer and trimer, decomposed substance of
15 the polymerization initiator, and the like, as well as impurities such as the polymerization inhibitor and the solvent (in particular, monomer) contained in the polymerization inhibitor containing fluid. In general, since a larger amount of the impurities make the obtained
20 resin composition colored, it is not preferable. Then, the volatile components removed in the devolatilizing extruder 60 (which includes the unreacted raw material monomer as a major component and also includes impurities as described above) may be passed through a monomer recovery column (not
25 shown in the drawings), and treated by means of

distillation, adsorption and the like in the monomer recovery column to remove the impurities from the above described volatile components. Thereby, the unreacted raw material monomer can be recovered with high purity, so that
5 it can be suitably reused as the raw material monomer for polymerization. For example, continuous distillation is conducted in the monomer recovery column to recover the unreacted raw material monomer with high purity as a distillate liquid from the top of the monomer recovery
10 column, and it may be transferred and recycled to the raw material monomer fluid tank 31 after it is reserved in the recovery tank 67 once, or it may be transferred and recycled to the raw material monomer fluid tank 31 without being reserved in the recovery tank 67. On the other hand,
15 the impurities removed in the monomer recovery column may be disposed as a waste.

[0080]

In order to prevent the recovered raw material monomer from causing the polymerization reaction in the recovery
20 tank 67 or the raw material monomer fluid tank 31, it is preferable that a polymerization inhibitor exists in these tanks at a ratio of, for example, 2 to 8 ppm by weight with respect to the raw material monomer, and more preferably, in addition to this, an oxygen concentration in a gas phase
25 in these tanks is set at 2 to 8% by volume. If the

recovered raw material monomer is wanted to be stored in the recovery tank 67 for a long time, it is preferable to store it at a low temperature of, for example, 0 to 5°C.

[0081]

5 Therefore, as understood from the above description, according to the apparatus for producing a polymer of the present invention and the process for producing a polymer conducted by using the apparatus, attachment of the polymer to the stem 9 and/or the guide 13 of the pressure-regulating valve 20 can efficiently be prevented, therefore,
10 the operation can stably continue for a long time.

[0082]

 In this embodiment, a case of conducting the bulk polymerization in the polymerization step is described.
15 However, the present invention is not limited thereto, the solution polymerization may be conducted in the polymerization step. In such embodiment, since a solvent is used for the solution polymerization, the apparatus for producing a polymer is provided, in addition to a similar
20 configuration to the apparatus described in the above with reference to Fig. 3, with a solvent tank and a supply line and a pump associated with the solvent tank to supply the solvent to the reactor 40. The solvent can be supplied to the reactor 40 after being mixed with the raw material
25 monomer and/or the polymerization initiator, or can be

supplied to the reactor 40 directly. The polymerization step is conducted similarly to the polymerization step described above, except that the solvent is used in the polymerization reaction. The solvent can be appropriately
5 selected depending on the raw material monomer of the solution polymerization reaction and the like, and includes, but not limited to, for example, toluene, xylene, ethyl benzene, methyl isobutyl ketone, methyl alcohol, ethyl alcohol, octane, decane, cyclohexane, decalin, butyl
10 acetate, pentyl acetate, and the like. In this case, a ratio C:D is, but not limited to, for example, 70:30 to 95:5, preferably 80:20 to 90:10, wherein C represents a supply flow rate (kg/h) of the raw material monomer fluid from the raw material monomer fluid tank 31, and D
15 represents a supply flow rate (kg/h) of the solvent to the reactor 40.

Examples

[0083]

20 Hereinafter, examples of the process for producing a polymer of the present invention are shown below, although the present invention is not limited to these examples.

[0084]

(Example 1)

25 In this example, generally, the process for producing

a polymer as described above was conducted to produce a polymer in the form of pellets. More specifically, this was as explained below.

[0085]

5 The raw material monomer fluid having the following composition was prepared.

- methyl methacrylate 98.718% by weight
- methyl acrylate 0.908% by weight
- a chain transfer agent (n-octylmercaptan) 0.261% by

10 weight

-a mold release agent (stearyl alcohol) 0.113% by weight

On the other hand, the polymerization initiator fluid having the following composition was prepared.

- 15 - methyl methacrylate 99.520% by weight
- polymerization initiator [1,1-di(t-butylperoxy)cyclohexane] 0.480% by weight

Furthermore, 2,4-dimethyl-6-tert-butylphenol as a polymerization inhibitor was dissolved in methyl methacrylate at 50 ppm by weight to prepare the polymerization inhibitor containing fluid.

20

[0086]

For producing a polymer in this example, the apparatus for producing a polymer shown in Fig. 3 was used. A complete mixing type reactor having a capacity of 13

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litters was used as the reactor 40. The monomer raw material fluid and the polymerization initiator fluid which were prepared above were charged to the raw material monomer fluid tank 31 and the polymerization initiator fluid tank 33, respectively. Further, the polymerization inhibitor containing fluid prepared above was charged to the polymerization inhibitor containing fluid tank 51.

[0087]

The raw material monomer fluid and the polymerization initiator fluid were supplied to the reactor 40 via the supply port 41a from the raw material monomer fluid tank 31 and the polymerization initiator fluid tank 33, respectively.

[0088]

The supply of the monomer raw material fluid and the polymerization initiator fluid to the reactor 40 was performed so that a ratio of flow rates of them was 17.6:1 (by weight), and an average residence time in the reactor 40 was 26 minutes. The temperature in the reactor 40 and the temperature of the jacket 43 were 175°C.

[0089]

The pressure in the reaction system was automatically controlled by using the pressure-regulating valve 20 shown in Fig. 1 so that the pressure in the reactor 40 is 1.60 MPaG (gauge pressure). The polymerization inhibitor

containing fluid was continuously fed into the pressure-regulating valve 20 from the polymerization inhibitor containing fluid tank 51 via the fluid feed port 17. The feed was performed so that the ratio of the flow rate of the polymerization inhibitor containing fluid to the pressure-regulating valve 20 to the total flow rate of the raw material monomer fluid and the polymerization initiator fluid to the reactor 40 was 1:79 (by weight).

[0090]

The reaction mixture in the reactor 40 was continuously taken out as a polymer composition via the effluent port 41b. The polymer composition thus obtained was preheated by passing through the preheater 50 set at 200°C. After passing the polymer composition through the pressure-regulating valve 20, the volatile components such as the unreacted raw material monomer were removed in the devolatilizing extruder 60 set at 240°C and the residue was extruded in a molten state and cooled with water and cut into pellets, and then the pellets were discharged from the discharge line 65. Thus, the polymer was produced in the form of pellets.

[0091]

A polymerization rate (% by weight) was determined from the supply weights per hour of the raw material monomer fluid and the polymerization initiator fluid, and

the production (discharge) weight per hour of the pellets.
The polymerization rate was 56% by weight.

[0092]

5 The above production operation of a polymer was
continued for 10 days. During this operation, the pressure
in the reactor 40 can be regulated in the range of $1.60 \pm$
0.01 MPaG (gauge pressure).

[0093]

(Comparative Example 1)

10 A polymer was produced similarly to Example 1, except
for using methyl methacrylate in place of the
polymerization inhibitor containing fluid.

[0094]

15 The above production of a polymer was continuously
performed. As a result, at 3 days after starting the
operation, since the movement of the pressure-regulating
valve 20 became awkward, and the pressure in the reactor 40
was increased to 1.65 MPaG (gauge pressure), then the
operation was stopped.

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Industrial Applicability

[0095]

The present invention can be used for producing a
polymer such as (meta)acrylic polymers.

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[0096]

The present application claims priority to Japanese Patent Application No. 2011-173503 filed on August 9, 2011, entitled "APPARATUS AND PROCESS FOR PRODUCING POLYMER."

5 The contents of that application are incorporated herein by the reference thereto in their entirety.

CLAIMS

1. An apparatus for producing a polymer provided with a reactor, a pressure-regulating valve and a devolatilizing extruder so that a polymer composition obtained from the reactor is supplied to the devolatilizing extruder through the pressure-regulating valve,

wherein the pressure-regulating valve comprises a valve element, a body having a space for housing the valve element, a stem for supporting and controlling the valve element, a guide for slidably guiding the stem, and a fluid feed port through which a fluid comprising a polymerization inhibitor is fed into a gap between a surface of the stem and an internal surface of the guide, and the gap is communicated with the space in the body so that the fluid fed from the fluid feed port flows into the space.

2. The apparatus for producing a polymer according to claim 1, wherein the pressure-regulating valve comprises further a lantern ring in a sealing part between the stem and the guide, and the fluid feed port is located adjacently to the lantern ring.

3. A process for producing a polymer by using the apparatus for producing a polymer according to claim 1 or claim 2, wherein the process comprises:

subjecting raw materials comprising a monomer and a polymerization initiator to a polymerization reaction in the reactor with regulating a pressure in the reactor by the pressure-regulating valve, and taking out a polymer composition comprising a polymer and an unreacted monomer from the reactor;

passing the polymer composition taken out from the reactor to the space in the body of the pressure-regulating valve with feeding a fluid comprising a polymerization inhibitor from the fluid feed port in the pressure-regulating valve to obtain the polymer composition which is mixed with the fluid, and

supplying the polymer composition which is mixed with the fluid obtained by passing through the pressure-regulating valve to the devolatilizing extruder, and taking out from the devolatilizing extruder an extruded material in which volatile components comprising the unreacted monomer are at least partly removed from the polymer composition to obtain the polymer as the extruded material.

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4. The process for producing a polymer according to claim 3, wherein the fluid comprising the polymerization inhibitor is a fluid which is formed by dissolving the polymerization inhibitor in the monomer.

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5. The process for producing a polymer according to claim 3 or claim 4, wherein a content ratio of the polymerization inhibitor in the fluid comprising the polymerization inhibitor is 5-2,000 ppm by weight based on the total weight of the fluid.

6. The process for producing a polymer according to any one of claims 3-5, wherein a ratio of a supplying flow rate of the polymer composition to a supplying flow rate of the fluid comprising the polymerization inhibitor, both to the pressure-regulating valve, is within a range from 80:20 to 99.9:0.1.