METHOD FOR PRODUCING THERMOPLASTIC RESIN COMPOSITION PELLET

TECHNICAL FIELD

[0001] This disclosure relates to a method for producing a thermoplastic resin composition pellet.

BACKGROUND

[0002] In one commonly known method for producing thermoplastic resin composition pellets having a breadth and length of the scale of a few millimeters, a molten thermoplastic resin composition is discharged as a plurality of strands from orifices (hole outlets) of a die plate that is joined to a die section at the end of an extruder, and then these molten strands are cooled using a cooling device and cut using a pelletizer.

[0003] When a standard die plate is used, a problem may occur of formation of lumps of melted resin composition in the orifices of the die plate, which is also referred to as "die build-up", and destabilization of strand production.

[0004] A technique of blowing gas into the orifices of a die plate to remove die build-up has been proposed as a technique for solving this problem (refer to PTL 1). Moreover, a technique that involves setting the number of orifices in a die plate as 30 or more while setting the length of orifices positioned at both edges of the die plate as shorter than the length of orifices positioned at the center of the die plate has been proposed as a method for stabilizing all discharged strands (refer to PTL 2). Furthermore, PTL 3 discloses a technique of setting the length (land length) of orifices of a die section as less than 20 mm and the shear rate of the die section as 600 s^{-1} to 900 s^{-1}.

CITATION LIST

Patent Literature

[0005] PTL 1: JP 2014-000320 A
PTL 2: JP 2006-001015 A
PTL 3: JP 2015-217552 A

SUMMARY

(Technical Problem)

[0006] However, the conventional techniques described above experience the

following problems.

The technique in PTL 1 is a technique for physically removing die build-up through blowing of gas against the die build-up, rather than a technique for preventing the actual occurrence of die build-up, and thus cannot restrict the amount of die build-up that is formed. Moreover, this technique cannot suppress a rise in resin temperature when the extrusion rate is increased, which is problematic as the amount of die build-up increases.

The technique in PTL 2 stabilizes strands by setting orifices at both edges of a die plate as shorter than orifices at the center of the die plate. However, the occurrence of die build-up cannot be inhibited with the orifice diameter, orifice length, and extrusion rate described in the examples of PTL 2, and there is a problem that the amount of die build-up increases in a situation in which the extrusion rate is increased as previously described.

Moreover, according to the description in the examples of PTL 3, the shear rate at orifices of a die section is 1,000 s^{-1} (note that the orifice diameter is 3.6 mm, and the flow rate per one orifice is 18 kg/hr), and the residence time of resin composition in the orifices is increased, which results in a fall in pellet productivity and tends to increase the amount of die build-up.

[0007] As described above, there is demand for a technique that can restrict the amount of die build-up at the outlets of orifices in a die plate, stabilize strands discharged from the outlets of the orifices in the die section, raise pellet productivity, and increase the yield of non-defective pellets.

[0008] An objective of this disclosure is to inhibit the occurrence of die build-up at the openings of orifices and produce good quality thermoplastic resin composition pellets.

(Solution to Problem)

[0009] The inventors conducted diligent investigation with the aim of advantageously solving the problems set forth above. Through this investigation, the inventor discovered that by setting orifices in a die plate as a specific form while also optimizing the residence time of resin at openings of these orifices, it is possible to effectively inhibit the occurrence of die build-up at the openings of the orifices, and to stably produce strands so as to obtain good quality thermoplastic resin composition pellets in a good yield. The present disclosure was completed based on this discovery.

[0010] Specifically, this disclosure provides the following.

[1] A method for producing a thermoplastic resin composition pellet

comprising:

using an extruder having an attached die plate including a plurality of orifices having an internal diameter D of 3.2 mm to 8 mm and a length L that is 0.3 times to 2.0 times the internal diameter D to obtain a thermoplastic resin composition through melt-kneading and to obtain one or more thermoplastic resin composition strands with an average residence time T of the thermoplastic resin composition in the orifices of 1 ms to 20 ms; and

pelletizing the thermoplastic resin composition strands to obtain one or more thermoplastic resin composition pellets.

[2] The method for producing a thermoplastic resin composition pellet according to the foregoing [1], wherein

an orifice that, among the plurality of orifices, is positioned at an outermost edge in a width direction of the die plate has a length Lo that is 0.5 times to 0.8 times a length Lc of an orifice that, among the plurality of orifices, is positioned most centrally in the width direction of the die plate.

[3] The method for producing a thermoplastic resin composition pellet according to the foregoing [1] or [2], wherein

an orifice that, among the plurality of orifices, is positioned at an outermost edge in a width direction of the die plate has an internal diameter Do that is 1.05 times to 1.3 times an internal diameter Dc of an orifice that, among the plurality of orifices, is positioned most centrally in the width direction of the die plate.

[4] The method for producing a thermoplastic resin composition pellet according to any one of the foregoing [1] to [3], wherein

at least part of a surface of the die plate at which the orifices open and inner surfaces of the orifices has a surface hardness of 800 to 5,000.

[5] The method for producing a thermoplastic resin composition pellet according to any one of the foregoing [1] to [4], wherein

at least one selected from the group consisting of a cooling device, a pelletizer, a dehydration device, a pellet cooler, a pellet screener, an external lubricant addition device, a pellet transporter, a metal screener, a contaminant screener, a fines separator, an intermediate tank, a product tank, a metal detector, a dry air generator, and a dehydration device is further used downstream of the extruder.

[6] The method for producing a thermoplastic resin composition pellet according to the foregoing [5], wherein

the cooling device is a tank in which cooling water is stored.

[7] The method for producing a thermoplastic resin composition pellet according to the foregoing [5], wherein

the cooling device is a channel having an angle of inclination of 30° to 85° formed between an extension direction of the channel and a horizontal plane, and in which cooling water flows from one end to another end.

[8] The method for producing a thermoplastic resin composition pellet according to the foregoing [7], wherein

cooling water is sprayed at at least one location in the channel.

[9] The method for producing a thermoplastic resin composition pellet according to the foregoing [5], wherein

either or both of the intermediate tank and the product tank include a pellet mixer for homogeneously mixing the thermoplastic resin composition pellets.

[10] The method for producing a thermoplastic resin composition pellet according to any one of the foregoing [1] to [9], wherein

at least 95% of the thermoplastic resin composition pellets have an external diameter of 2 mm to 4 mm and a length of 2 mm to 4 mm.

[11] The method for producing a thermoplastic resin composition pellet according to any one of the foregoing [1] to [10], wherein

the thermoplastic resin composition contains at least one thermoplastic resin selected from the group consisting of a polyamide resin, a polyphenylene ether resin, a polystyrene resin, a polycarbonate, a polyolefin resin, a polyoxymethylene, and a polyphenylene sulfide.

[12] The method for producing a thermoplastic resin composition pellet according to any one of the foregoing [1] to [11], wherein

the thermoplastic resin composition contains a polyphenylene ether resin and another thermoplastic resin.

[13] The method for producing a thermoplastic resin composition pellet according to the foregoing [12], wherein

the other thermoplastic resin is at least one thermoplastic resin selected from the group consisting of a polyamide resin, a polystyrene resin, a polyolefin resin, and a polyphenylene sulfide.

[14] The method for producing a thermoplastic resin composition pellet according to the foregoing [12] or [13], wherein

the thermoplastic resin composition contains: a thermoplastic resin

including 20 parts by mass to 98 parts by mass of a polyphenylene ether resin and 2 parts by mass to 80 parts by mass of a polystyrene resin; and 0 parts by mass to 50 parts by mass of a flame retardant relative to 100 parts by mass, in total, of the polyphenylene ether resin and the polystyrene resin.

[15] The method for producing a thermoplastic resin composition pellet according to any one of the foregoing [12] to [14], further comprising

compressing and pulverizing the polyphenylene ether resin to obtain a compressed and pulverized polyphenylene ether resin, wherein

the thermoplastic resin composition is obtained through melt-kneading of the compressed and pulverized polyphenylene ether resin and the other thermoplastic resin.

[16] The method for producing a thermoplastic resin composition pellet according to the foregoing [15], wherein

the compressed and pulverized polyphenylene ether resin has an average particle diameter of 1,000 μm to 3,000 μm, and a proportion thereof having a particle diameter of 106 μm or less is 20 mass% or less.

(Advantageous Effect)

[0011] According to this disclosure, it is possible to inhibit the occurrence of die build-up at the openings of orifices and produce good quality thermoplastic resin composition pellets.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] In the accompanying drawings:

FIGS. 1A to 1C illustrate an overview of a method for producing a thermoplastic resin composition pellet according to a presently disclosed embodiment;

FIGS. 2A and 2B illustrate a die section attached to an extruder used in one example of the method for producing a thermoplastic resin composition pellet according to the present embodiment; and

FIGS. 3A and 3B illustrate a die section attached to an extruder used in another example of the method for producing a thermoplastic resin composition pellet according to the present embodiment.

DETAILED DESCRIPTION

[0013] The following provides a detailed description of an embodiment of the present disclosure (hereinafter, referred to as the "present embodiment") with

reference to the drawings as necessary. It should be noted that the following embodiment is provided as an example for explaining the present disclosure and is not intended to limit the present disclosure to the following content. Moreover, this disclosure can be implemented with various alterations that are within the essential scope thereof.

[0014] Note that in the drawings, positional relationships such as up, down, left, and right are based on the positional relationships illustrated in the drawings unless specified otherwise. Moreover, elements in the drawings that are the same or have the same function are denoted using the same reference sign and repeated explanation thereof is omitted. Furthermore, the ratios of dimensions in the present embodiment are not limited to the ratios of dimensions illustrated in the drawings.

[0015] (Method for producing thermoplastic resin composition pellet)

In a method for producing a thermoplastic resin composition pellet according to the present embodiment, it is essential to use an extruder having an attached die plate including a plurality of orifices having an internal diameter D of 3.2 mm to 8 mm and a length L that is 0.3 times to 2.0 times the internal diameter D.

Moreover, in addition to the extruder having the attached die plate described above, one or more selected from a cooling device, a pelletizer, a dehydration device, a pellet cooler, a pellet screener, an external lubricant addition device, a pellet transporter, a metal screener, a contaminant screener, a fines separator, an intermediate tank, a product tank, a metal detector, a dry air generator, and a dehydration device may be further used downstream of the extruder in the production method of the present embodiment.

[0016] It is essential that the method for producing a thermoplastic resin composition pellet according to the present embodiment includes a step of using the extruder to obtain a thermoplastic resin composition through melt-kneading and to obtain one or more thermoplastic resin composition strands with an average residence time T of the thermoplastic resin composition in the orifices of 1 ms to 20 ms (melt-kneading step).

The production method of the present embodiment is also required to include a subsequent step of pelletizing the thermoplastic resin composition strands to obtain one or more thermoplastic resin composition pellets (pelletization step). Note that the thermoplastic resin composition strands may be cooled using a cooling device prior to the pelletization. In the pelletization,

cylindrically-shaped thermoplastic resin composition pellets may be obtained by, for example, cutting suitably cooled thermoplastic resin composition strands to an appropriate length using a pelletizer.

[0017] The method for producing a thermoplastic resin composition pellet according to the present embodiment can lower the temperature of resin composition at openings of the orifices in the die plate and inhibit the occurrence of die build-up at the openings of the orifices, and enables stable production of thermoplastic resin composition strands and acquisition of thermoplastic resin composition pellets with a high proportion of non-defective pellets.

[0018] The following provides a detailed description of one example of the method for producing a thermoplastic resin composition pellet according to the present embodiment that uses the extruder having the attached die plate described above and, downstream thereof, a cooling device, a pelletizer, (a dehydration device), a pellet cooler, a pellet screener, an external lubricant addition device, a pellet transporter, a metal screener, a contaminant screener, a fines separator, an intermediate tank, a product tank, a metal detector, a dry air generator, and a dehydration device in this order.

[0019] FIGS. 1A to 1C illustrate an overview of the method for producing a thermoplastic resin composition pellet according to the present embodiment. FIG. 1A illustrates an overview of one example of the method for producing a thermoplastic resin composition pellet according to the present embodiment, FIG. 1B illustrates an overview of another example of the method for producing a thermoplastic resin composition pellet according to the present embodiment, and FIG. 1C is a perspective view illustrating a cooling device illustrated in FIG. 1B in enlarged form (note that the long-dash dotted lines in FIG. 1C indicate omission).

[0020] In one example of the production method of the present embodiment, a thermoplastic resin composition (chemical make-up described further below) is first obtained through melt-kneading using an extruder 1. The melt-kneading conditions can be set as appropriate in accordance with the objective or application.

[0021] Examples of the extruder 1 include, but are not specifically limited to, a single screw extruder and a multiscrew extruder, such as a twin screw extruder. The single screw extruder may, for example, be a single screw extruder produced by BUSS AG (Ko-Kneader series) in which the screw shaft

is rotated while being driven forward or backward. The multiscrew extruder may, for example, be a counter-rotating twin screw extruder or a co-rotating twin screw extruder (for example, the ZSK series produced by Coperion Inc., the TEM series produced by Toshiba Machine Co., Ltd., or the TEX series produced by The Japan Steel Works, Ltd.). The extruder 1 is preferably a high-torque extruder such as the Mc series, McPlus series, or Mc18 series produced by Coperion Inc., the SS series or SX series produced by Toshiba Machine Co., Ltd., or the α2 series or α3 series produced by The Japan Steel Works, Ltd.

Although the specifications and size of the extruder 1 are not specifically limited, the barrel internal diameter (diameter) is preferably 40 mm to 300 mm, and the effective barrel length is preferably 10 times to 60 times the barrel internal diameter.

The barrel configuration of the extruder 1 is not specifically limited and the extruder 1 may include a plurality of barrels with a solid conveying zone, a melt conveying zone, a kneading zone, and the like being formed in desired barrels. Moreover, the extruder 1 may include a vent such as a vacuum vent or an atmospheric vent in a desired barrel, and may include a top feeder, a side feeder, and/or a liquid addition device. When the length of the extruder (effective barrel length) is taken to be 100%, the lengths of the various zones may, for example, be a solid conveying zone length of 10% to 30%, a melt conveying zone length of 30% to 85%, and a kneading zone length of 5% to 40%.

Examples of screw elements that may be used in the barrels include a double-flight or triple-flight kneading block (right-handed, left-handed, neutral, or back-feeding), a double-flight or triple-flight flighted screw (right-handed or left-handed), a single-flight, double-flight, or triple-flight notch screw or cut screw, and a seal ring. Such screw elements may be used in combination as appropriate.

Although no specific limitations are placed on the extrusion rate, in the case of a 58 mm Φ twin screw extruder, for example, the extrusion rate may be 300 kg/hr to 1,500 kg/hr, and the screw rotation speed may be 300 rpm to 1,500 rpm.

[0022] In performance of the melt-kneading step using the extruder 1, flame retardants, powder fillers, fibrous fillers, various additives, and so forth other than thermoplastic resins may be used as necessary.

[0023] Specific examples of flame retardants that can be used include phosphorus-based flame retardants such as phosphate ester compounds and condensed phosphate esters. Examples of phosphorus-based flame retardants include aromatic phosphate esters such as triphenyl phosphate, tricresyl phosphate, trixylenyl phosphate, cresyl diphenyl phosphate, 2-ethylhexyl diphenyl phosphate, tert-butylphenyl diphenyl phosphate, bis(tert-butylphenyl) phenyl phosphate, tris(tert-butylphenyl) phosphate, isopropylphenyl diphenyl phosphate, bis(isopropylphenyl) diphenyl phosphate, and tris(isopropylphenyl) phosphate; condensed phosphate esters such as resorcinol bis(diphenyl phosphate) (RDP), resorcinol bis(dixylenyl phosphate), bisphenol A bis(diphenyl phosphate), and biphenyl bis(diphenyl phosphate); and phosphazene compounds. One phosphorus-based flame retardant may be used individually, or two or more phosphorus-based flame retardants may be used in combination.

The proportion in which a flame retardant is used in the melt-kneading step is preferably less than 30 mass%.

[0024] Examples of powder fillers include potassium titanate whisker, magnesium sulfate whisker, aluminum borate whisker, calcium carbonate whisker, silicon carbide whisker, zinc oxide whisker, calcium silicate (wollastonite), mica, talc, glass flake, pulverized glass, titanium oxide, calcium carbonate, clay, kaolin, barium sulfate, silica, alumina, magnesium oxide, and magnesium sulfate. In particular, calcium silicate, mica, talc, glass flake, pulverized glass, titanium oxide, calcium carbonate, kaolin, and silica are preferable. One powder filler may be used individually, or two or more powder fillers may be used in combination. In terms of size, the powder filler may have an average particle diameter of 0.01 μm to less than 500 μm, preferably 0.01 μm to 300 μm, and more preferably at least 0.1 μm and less than 106 μm.

The proportion in which a powder filler is used in the melt-kneading step is preferably less than 60 mass%.

[0025] Examples of fibrous fillers include glass fiber, carbon fiber, and metal fiber. One fibrous filler may be used individually, or two or more fibrous fillers may be used in combination. In terms of size, the fibrous filler preferably has a fiber diameter of 5 μm to 50 μm and a fiber length of 1 mm to 5 mm.

The proportion in which a fibrous filler is used in the melt-kneading

step is preferably less than 60 mass%.

[0026] Examples of additives include liquid additives (for example, silicon oil, hydrocarbon oil, and water), powder filler dispersants (for example, ethylene bisamide, calcium stearate, zinc stearate, and stearic acid), olefinic elastomers (for example, ethylene-propylene elastomer and ethylene-octene elastomer), functionalizing agents (for example, maleic acid, fumaric acid, itaconic acid, maleic anhydride, malic acid, and citric acid), various colorants, coloring aids (for example, titanium oxide), ultraviolet absorbers, antistatic agents, and stabilizers (for example, zinc oxide, zinc sulfide, and stabilizers based on phosphorus, sulfur, and hindered phenols).

[0027] In one example of the production method of the present embodiment, molten thermoplastic resin composition is then formed into strands in a die section 2 positioned at the downstream end of the extruder 1.

[0028] FIGS. 2A and 2B illustrate a die section attached to an extruder used in one example of the method for producing a thermoplastic resin composition pellet according to the present embodiment. FIG. 2A is a cross-sectional view when the die section is cut along a plane perpendicular to a bottom surface thereof and is more specifically a cross-sectional view of the die section at a plane along a line I-I indicated in FIG. 2B. FIG. 2B is a cross-sectional view when the die section is cut along a plane parallel to the bottom surface thereof and is more specifically a cross-sectional view of a die plate at a plane along a line II-II indicated in FIG. 2A.

[0029] FIGS. 3A and 3B illustrate a die section attached to an extruder used in another example of the method for producing a thermoplastic resin composition pellet according to the present embodiment. FIG. 3A is a cross-sectional view when the die section is cut along a plane perpendicular to a bottom surface thereof and is more specifically a cross-sectional view of the die section at a plane along a line I-I indicated in FIG. 3B. FIG. 3B is a cross-sectional view when the die section is cut along a plane parallel to the bottom surface thereof and is more specifically a cross-sectional view of a die plate at a plane along a line II-II indicated in FIG. 3A.

[0030] The die section 2 illustrated in FIGS. 2A and 2B and the die section 2 illustrated in FIGS. 3A and 3B may have the same configuration other than differing in terms of the angle of inclination (not illustrated) formed between an extension direction of the orifices and an axial direction of the extruder.

Specifically, in the case of the die section 2 illustrated in FIGS. 2A

and 2B, the angle of inclination (not illustrated) formed between the extension direction of the orifices and the axial direction of the extruder in the cross-section of FIG. 2A may be 0° to 60°, and in the case of the die section 2 illustrated in FIGS. 3A and 3B, the angle of inclination (not illustrated) formed between the extension direction of the orifices and the axial direction of the extruder in the cross-section of FIG. 3A may be 80° to 100° (i.e., roughly 90°).

[0031] The die section 2 includes a die connecting section 21, a screen changer section 22 for removing contaminants contained in molten resin by filtration, a manifold section 23, and a die plate section 24.

[0032] The screen changer section 22 may have an attached breaker plate to which one type or a combination of two or more types of metal meshes having an opening size of #20 to #300 can be attached. A super plate that can increase filtration area by a factor of 1.5 to 2.0 may be attached to the breaker plate. Moreover, the breaker plate may be detached in a situation in which the thermoplastic resin composition contains a reinforcing material.

[0033] The manifold section 23 has a channel for resin composition therein. The width of this resin composition channel (i.e., the length in the width direction of the die section 2) gradually increases toward the downstream end of the die section 2 (i.e., from upstream to downstream in the axial direction of the extruder). Specifically, in each of FIGS. 2B and 3B, lines that define the channel extend symmetrically at both sides in the width direction of the die section 2 as straight lines from a position at which the width of the channel starts to gradually increase toward the downstream end of the die section 2.

It should be noted that the manifold section 23 of the present embodiment is not limited to that illustrated in FIGS. 2B and 3B and the lines that define the channel may extend asymmetrically at both sides in the width direction of the die section 2, and may extend in a curved shaped. However, from a viewpoint of productivity and the like, the lines that define the channel are preferably symmetrical and are preferably straight lines.

[0034] As illustrated in FIGS. 2B and 3B, in a cross-sectional view when the die section 2 is cut along a plane parallel to the bottom surface thereof, an angle $\theta 1$ formed between a line that defines the channel at a section where the channel width is constant and a line that defines the channel at a section where the channel width gradually increases is preferably 20° to 70°, and more

preferably 25° to 65°.

Note that the angle θ1 is the smaller angle among angles formed between the line defining the channel at the section where the channel width is constant and the line defining the channel at the section where the channel width gradually increases.

Setting the angle θ1 as 20° or more enables an increase in the number of orifices provided in the die plate section 24 (i.e., an increase in productivity). However, if the angle θ1 is set as more than 70°, fluidity of molten resin composition at both edges in the width direction of the die section 2 is reduced, a difference in flow rate arises between strands at a central part of the die plate section 24 and strands at both edges of the die plate section 24, and production of strands at both edges is easily destabilized.

The angle θ1 may be defined in a cross-section that passes through the center of the channel. Moreover, in a case in which all or some of a line defining the channel is curved, the angle θ1 may be defined after taking an average straight line for this line.

[0035] As previously explained, the die plate section 24 is a section for forming resin composition strands from molten resin composition and includes a plurality of orifices 24o that are cylindrically-shaped through-holes.

The number of orifices is preferably 10 or more, more preferably 12 or more, and even more preferably 15 or more.

The internal diameter D of the orifices is 3.2 mm to 8 mm, preferably 3.7 mm to 8.0 mm, more preferably 4.0 mm to 8.0 mm, and even more preferably 4.0 mm to 7.0 mm. An internal diameter D of less than 3.2 mm tends to increase the die pressure (pressure in the die section) and raise the resin composition temperature, whereas an internal diameter D of more than 8.0 mm excessively reduces the die pressure and destabilizes strands.

The length L of the orifices is 0.3 times to 2.0 times the internal diameter D of the orifices, preferably 0.4 times to 1.5 times the internal diameter D of the orifices, and more preferably 0.5 times to 1.0 times the internal diameter D of the orifices. If a ratio (L/D) of the orifice length L relative to the orifice internal diameter D is less than 0.3, the die pressure may excessively decrease and strands may be destabilized. If L/D is more than 2.0, the die pressure may excessively increase, the resin composition temperature may rise, and the amount of die build-up may increase. Moreover, the amount

of die build-up may further increase due to an increase in friction between molten resin composition and the inner walls of the orifices 24o.

[0036] Particularly in a case in which a small-scale extruder is operated at a raised extrusion rate, it is necessary to increase the number of orifices and reduce the die pressure. An increase in the number of orifices necessitates widening of the channel width of the manifold section 23. Moreover, widening of the channel width of the manifold section 23 tends to lead to significant slowing of the flow rate of resin flowing at both edges of the manifold section 23 and tends to destabilize strands at both edges.

[0037] In the production method of the present embodiment, it is essential that the average residence time T of melt-kneaded thermoplastic resin composition in the orifices is 1 ms to 20 ms. The average residence time T is preferably 2 ms to 15 ms, and more preferably 3 ms to 15 ms.

The average residence time T can be calculated by the following formula.

Average residence time T = Total orifice internal volume V/Volumetric flow rate Q

If T is shorter than 1 ms, the die pressure decreases and strands are destabilized, whereas if T is longer than 20 ms, the die pressure increases, the resin temperature rises, and die build-up increases.

[0038] In the production method of the present embodiment, the resin composition flow rate per one orifice 24o is preferably 20 kg/hr to 120 kg/hr, more preferably 25 kg/hr to 100 kg/hr, and even more preferably 30 kg/hr to 100 kg/hr. A flow rate of less than 20 kg/hr may lead to an excessively long residence time, whereas a flow rate of more than 120 kg/hr may lead to an excessively short residence time.

[0039] In the present embodiment, an orifice that, among the plurality of orifices, is positioned at an outermost edge in the width direction of the die plate preferably has a length Lo (refer to FIGS. 2B and 3B) that is 0.5 times to 0.8 times, and more preferably 0.5 times to 0.7 times, a length Lc (refer to FIGS. 2B and 3B) of an orifice that, among the plurality of orifices, is positioned most centrally in the width direction of the die plate.

In a situation in which the melt viscosity of the thermoplastic resin composition is high or the number of orifices is more than 10, the flow rate of resin composition at both edges in the width direction of the manifold section tends to become slow. If Lo/Lc is less than 0.5, the die pressure at both edges

may excessively decrease and strands may be destabilized. Moreover, if Lo/Lc is more than 0.8. the flow rate at both edges slows.

For example, the lengths of only the two orifices positioned at the outermost edges in the width direction may be shorter than the length of an orifice positioned most centrally in the width direction. Alternatively, the length of the orifices may gradually decrease in a tapered-form or may decrease stepwise from a most central position in the width direction toward positions at the outer edges in the width direction.

[0040] Moreover, an orifice that, among the plurality of orifices, is positioned at an outermost edge in the width direction of the die plate section preferably has an internal diameter Do (refer to FIGS. 2B and 3B) that is 1.05 times to 1.3 times, and more preferably 1.1 times to 1.3 times, an internal diameter Dc (refer to FIGS. 2B and 3B) of an orifice that, among the plurality of orifices, is positioned most centrally in the width direction of the die plate.

Setting Do/Dc within a range of 1.05 to 1.3 has an effect of increasing the flow rate at both edges through the same action as when the range of Lo/Lc is set.

[0041] It is preferable that at least part of a surface of the die plate at which the orifices open and inner surfaces of the orifices has a surface hardness of 800 to 5,000, and more preferably 800 to 4,000.

Note that "surface hardness" refers to HV hardness, and this HV hardness can be measured in accordance with JIS Z 2244.

The material of the die plate is normally SUS or SKD and the surface hardness of the die plate typically only reaches approximately 50 even when these materials are subjected to quench hardening. If the hardness is of this level, the surface of the die plate at which the orifices open and the inner surfaces of the orifices tend to be easily scratched. For example, openings of the orifices or the like may be easily scratched when a metal blade is used to sever strands, even when a blade that is made from a soft material such as brass or copper is used, and this scratching acts as a cause of die build-up. Moreover, if the hardness is of the level described above, the inner surfaces of the orifices tend to be abraded through long-term use and this abrasion may act as a cause of die build-up.

[0042] In view of the circumstances described above, it is preferable that all or part of the surface of the die plate, inclusive of the surface of the die plate at which the orifices open and the inner surfaces of the orifices, is subjected

to surface treatment to increase the hardness of the surface of the die plate. Examples of the surface treatment include nitriding treatment and metal vapor deposition treatment. Through the surface treatment, unevenness may be formed in the structure of the inner surfaces of the orifices and outlet surfaces of the orifices such that contact between molten resin composition and the inner surfaces of the orifices becomes point contact, and die build-up may be reduced through reduction in contact area. Additionally or alternatively, the surface treatment may reduce affinity with molten resin composition to enable reduction of die build-up.

The nitriding treatment is preferably commonly known nitriding treatment or the New Kanuc Process of Kanuc Corporation (Japan), and is particularly preferably the New Kanuc Process. In a case in which the New Kanuc Process is carried out, the surface hardness of the die plate surface can be increased to approximately 1,000 and die build-up can be inhibited.

Examples of the metal vapor deposition treatment include chemical vapor deposition film formation and physical vapor deposition film formation. The coating material may, for example, be titanium carbide, titanium carbonitride, chromium carbide, titanium nitride, or titanium aluminum nitride, and is preferably titanium aluminum nitride.

In a case in which titanium aluminum nitride is vapor deposited by physical vapor deposition film formation, the surface hardness of the die plate surface is increased to approximately 3,500 and susceptibility of the surface to scratching is reduced. However, since vapor deposition is performed over the inner surfaces of the orifices in this case, it is preferable that the orifice internal diameter D is 5 mm or more and that the ratio (L/D) of the orifice length L relative to the orifice internal diameter D is less than 1.

[0043] In one example of the production method of the present embodiment, the resultant thermoplastic resin composition strands are subsequently cooled using a cooling device 3.

[0044] Examples of the cooling device 3 include a tank in which cooling water is stored (strand cooling tank 3a in FIG. 1A) and a channel having an angle of inclination θ2 of 30° to 85° formed between an extension direction of the channel and a horizontal plane, and in which cooling water flows from one end to another end (strand guide 3b in FIGS. 1B and 1C).

The angle of inclination θ2 is the smaller angle among angles formed between the extension direction of the channel and a horizontal plane.

As illustrated in FIGS. 1A and 1B, the strand cooling tank 3a is used as the cooling device 3 in one example of the method for producing a thermoplastic resin composition pellet according to the present embodiment and the strand guide 3b is used as the cooling device 3 in another example of the method for producing a thermoplastic resin composition pellet according to the present embodiment.

[0045] Examples of the cooling water used in the cooling device 3 include pure water, deionized water, industrial water, and cooling water circulated by a cooling tower.

[0046] No specific limitations are placed on the strand cooling tank 3a other than being a tank in which cooling water can remain for a specific time. Note that the cooling water may be exchanged intermittently or continuously.

The cooling water is normally supplied from a downstream side of the strand cooling tank 3a and discharged from an upstream side of the strand cooling tank 3a such that cooling is performed through a countercurrent of the cooling water relative to the discharged strands.

It is preferable that a plurality of strand guide rollers (refer to FIG. 1C) is used in the strand cooling tank 3a to stabilize the strands. In a situation in which the strands move inwards, operation is performed with rotation of the strand guide rollers fixed.

Moreover, an air wiper with a function of blowing air or a plastic fiber brush may be used in the strand cooling tank 3a to remove water attached to the surfaces of the strands.

[0047] The strand guide 3b includes one or more channels along which thermoplastic resin composition strands and cooling water can be passed. The number of channels may be set in accordance with the number of orifices 24o in the die plate section 24. For example, the number of channels may be 8 to 20, but is not specifically limited thereto. Moreover, walls of a specific height (for example, 8 mm to 20 mm) may be provided between the channels such that strands do not encroach into adjacent channels. The channels are preferably designed such that strands discharged from the orifices 24o each fall into the width direction center of a corresponding channel. For example, the distance between adjacent walls (i.e., the channel width) may be set in accordance with the distance between the orifices.

As previously explained, in the strand guide 3b, the angle of inclination $\theta 2$ formed between the extension direction of the strand guide 3b

and a horizontal plane is preferably 30° to 85°, more preferably 35° to 85°, and even more preferably 40° to 80°.

Cooling water flows from upstream to downstream in the strand guide 3b. The cooling water serves to both cool and transport the strands.

In the strand guide 3b, a spraying device 3bv that can further cool the strands by spraying cooling water may be used at one or more locations between a position at which the strands land in the water and a position at which the strands enter a pelletizer 4 (described further below). Particularly in the case of strands that have a low softening temperature, it is preferable that cooling water is sprayed in multiple stages.

Moreover, an angle of inclination θ3 (refer to FIG. 1B) formed between an extension direction of the orifices 24o and the extension direction of the channels is preferably 5° to 60°, and more preferably 5° to 55° in order to reduce resistance of the strands and water.

Note that the angle of inclination θ3 is the smaller angle among angles formed between the extension direction of the orifices 24o and the extension direction of the channels.

In a case in which the strand guide 3b is used as the cooling device 3, it is preferable that a dehydration device 16 is used before a subsequent pellet cooling device 5 as illustrated in FIG. 1B.

[0048] Regardless of which of the strand cooling tank 3a and the strand guide 3b is used, a smaller distance L1 from the openings of the orifices to the cooling device (i.e., the interval between a position at which strands are discharged externally from the die plate section and a position at which the strands land in water in the cooling device) results in more stable strands. The distance L1 may typically be 50 mm to 200 mm.

[0049] In one example of the production method of the present embodiment, the cooled thermoplastic resin composition strands are subsequently pelletized (cut) by the pelletizer 4 to obtain thermoplastic resin composition pellets (refer to FIG. 1A).

The pelletizer 4 may, for example, be a pelletizer that has a rotary blade width of 200 mm to 500 mm and a take-up rate of 60 m/minute to 300 m/minute. The pelletizer 4 may be a dry-type pelletizer or a wet-type pelletizer. In a case in which the strand cooling tank 3a is used as the cooling device 3, a dry-type pelletizer may be used, and air may be blown against a rotary blade or a fixed blade to prevent the generation of fines. In the case of a

wet-type pelletizer, strands and cooling water may pass along the strand guide 3b and be simultaneously subjected to pelletization.

[0050] It is preferable that 95% or more of pellets obtained using the pelletizer 4 have an external diameter of 2 mm to 4 mm and a length of 2 mm to 4 mm. The proportion of such pellets is more preferably 96% or more, and even more preferably 97% or more, and it is more preferable that the external diameter is 2.2 mm to 3.8 mm and the length is 2.2 mm to 3.8 mm, and even more preferable that the external diameter is 2.5 mm to 3.5 mm and the length is 2.5 mm to 3.5 mm.

In a case in which a wet-type pelletizer is used as the pelletizer 4, water is attached to the surface of the pellets and thus a dehydration device may be used to remove this attached water. The dehydration device may operate by centrifugation or drying.

[0051] In the present embodiment, the thermoplastic resin composition pellets are subsequently cooled using the pellet cooler 5 (refer to FIG. 1A).

Pellets are obtained in the pelletizer 4 by cutting the strands at 120°C to 150°C to prevent generation of fines and moisture absorption by the pellets. Since an inner part of the pellets is at an even higher temperature, discoloration of the pellets due to thermal degradation may occur if the pellets are not cooled. In a situation in which a water-absorbent resin is used as a raw material for the pellets, an aluminum bag having an internal coating of a polyethylene resin may be used as a packaging bag. However, storage of the pellets in the bag while still at a high temperature causes shrinkage and hardening of the aluminum bag. This may lead to a problem of the bag falling during transport when loaded into a palette. Moreover, in a situation in which high-temperature pellets collide with the inner wall of a Pneuma pipe, a thin skin referred to as floss may be formed. For these reasons, it is preferable that the pellet cooler 5 is used to cool the pellets to a temperature of approximately 40°C to 70°C. The pellet cooler 5 may, for example, be a fluid-bed type pellet cooler or a pellet cooler in which the pellets are transferred to a perforated plate and are cooled through cooling gas from below. For example, the air cooling-type pellet cooler ASC series produced by Tanaka Co., Ltd. (Japan) can be preferably used.

[0052] In the present embodiment, the cooled thermoplastic resin composition pellets are subsequently passed through a pellet screener 6 (refer to FIG. 1A).

The pellet screener 6 removes pellets that are longer than 4 mm, twin pellets formed through fusion of strands, fines obtained as cut pellet scraps, and the like from among the pellets that have been pelletized in the pelletizer 4.

[0053] In the present embodiment, an external lubricant addition device 7 is used to apply an external lubricant onto the screened thermoplastic resin composition pellets (refer to FIG. 1A).

The external lubricant addition device 7 is a device that applies external lubricant onto the surface of the pellets and is formed from an external lubricant supplying device and/or a mixer that homogeneously mixes the external lubricant and the pellets. Since the external lubricant is a powdered additive, the external lubricant tends to separate from the pellets when added in an amount of more than 0.05 parts by mass. Accordingly, the pellets may be mixed with oil in advance using an oil addition device, and subsequently mixed with the additive.

[0054] In the present embodiment, the thermoplastic resin composition pellets to which the external lubricant has been applied are transported by a pellet transporter 8 (refer to FIG. 1A).

The pellet transporter 8 is formed from a pipe in which the pellets are transported and a gas blower that transports the pellets. The gas blower may be a pressurization-type blower that blows from an upstream side or a suction-type blower that sucks from a downstream side. It is preferable that the inside of the pipe, and particularly a bent section of the pipe, is subjected to abrasion resistance treatment such as ceramic treatment or nitriding treatment (New Kanuc Process of Kanuc Corporation) because abrasion tends to occur thereat due to pellet collisions.

[0055] In the present embodiment, the transported thermoplastic resin composition pellets are subsequently passed through a metal screener 9 (refer to FIG. 1A).

The metal screener 9 is a device that is used in a case in which metal fragments having a diameter or length of 0.1 mm or more that are present in the pellets are to be removed. Small metal fragments and the like contained in a raw material may become included in the pellets. Accordingly, in a case in which the pellets are to be used for an electronic component, it is preferable that the pellets are passed through the metal screener 9.

[0056] In the present embodiment, the thermoplastic resin composition

pellets are passed through a contaminant screener 10 (refer to FIG. 1A).

The contaminant screener 10 is a device that is used in a case in which pellets containing contaminants formed in the extruder that cannot be filtered out by the metal mesh attached to the breaker plate of the screen changer section 22 or pellets having fragments of die build-up attached thereto are to be removed. The contaminant screener 10 may, for example, be a screener that has sensors for detecting contaminants on front and rear surfaces relative to pellet flow, but the removal rate of contaminants using such a screener is relatively low. Accordingly, the removal rate of contaminants may be improved by using a contaminant screener that has two front/rear sensors and two left/right sensors (i.e., four sensors in total) or by using two contaminant screeners that each only have two sensors such as described above.

[0057] In the present embodiment, the thermoplastic resin composition pellets are passed through a fines separator 11 (refer to FIG. 1A).

The fines separator 11 may be provided between the pelletizer 4 and a product tank 13. The term "fines" refers to fragments of pellets of 1 mm or less in size and floss produced during transport of the pellets through piping. The fines separator 11 may be a cyclone-type device that separates material having a small particle diameter or may be a device that ionizes fines. In particular, it is preferable that the fines separator 11 is a cyclone-type device and that the fines separator 11 is provided above the product tank 13.

[0058] The thermoplastic resin composition pellets that are obtained may be temporarily stored in an optional intermediate tank 12 (not illustrated). However, in the present embodiment, the pellets are stored in the product tank 13 (described further below).

The intermediate tank 12 may be used in a situation in which, upon operation of the various devices to start production, initially produced pellets are to be checked in terms of size or physical properties before being used as products.

The product tank 13 is a device in which pellets are stored. The product tank 13 is required to have a capacity that enables storage for approximately 1 hour to 72 hours. In order to homogeneously mix the thermoplastic resin composition pellets, it is preferable that the intermediate tank 12 and/or the product tank 13 includes a pellet mixing device such as a mechanical mixer or a gas circulation-type mixer.

[0059] Moreover, a metal detector 14 is used on the thermoplastic resin

composition pellets in the present embodiment.

The metal detector 14 may, for example, have a configuration in which several 5,000 gauss to 15,000 gauss magnets are arranged in a row, and in which 3 to 5 of such rows are present. The metal detector 14 can be attached at an outlet of the product tank 13 to detect pellets containing metal fragments.

[0060] In the present embodiment, a dry air generator 15 may be used to expose the thermoplastic resin composition pellets to dry air as post-treatment.

For example, in a situation in which the thermoplastic resin composition pellets contain a water-absorbent resin such as a polyamide resin, when the atmosphere surrounding these pellets has a temperature of 40°C or lower, the pellets absorb moisture from the atmosphere. The dry air generator 15 may be used to deal with this issue. The dry air generator 15 may be a device that generates dry air having a dew point of –40°C and an absolute humidity of 0.119 g/m^3.

[0061] <Thermoplastic resin composition>

The thermoplastic resin composition used in the method for producing a thermoplastic resin composition pellet according to the present embodiment contains a thermoplastic resin and may optionally further contain flame retardants, powder fillers, fibrous fillers, various additives, and so forth such as previously described.

[0062] Examples of thermoplastic resins that can be used include polyamide resins (for example, nylon 6, nylon 46, nylon 66, nylon 610, aromatic nylons, aromatic polyamides, and hydrocarbon polyamides), polyphenylene ether resins (described in detail further below), polystyrene resins (for example, general purpose polystyrene (GPPS), high impact polystyrene (HIPS), styrene-butadiene copolymer (styrene-butadiene block copolymer or hydrogenated styrene-butadiene block copolymer), acrylonitrile-styrene copolymer, and acrylonitrile-butadiene-styrene copolymer), polycarbonates, polyolefin resins (for example, polyethylene resins such as linear low-density polyethylene, low-density polyethylene, and high-density polyethylene, and polypropylene resins such as polypropylene (homopolymer or copolymer)), polyoxymethylenes (for example, homopolyoxymethylene and copolymer polyoxymethylene), polyphenylene sulfides, polyamide-imides, polyarylates, polyarylsulfones, polyethersulfones, polyetherimides, polytetrafluoroethylene,

and polyether ketones.

In particular, at least one selected from the group consisting of a polyamide resin, a polyphenylene ether resin, a polystyrene resin, a polycarbonate, a polyolefin resin, a polyoxymethylene, and a polyphenylene sulfide is preferably used as the thermoplastic resin. One of these thermoplastic resins may be used individually, or two or more of these thermoplastic resins may be used in combination.

[0063] Furthermore, it is preferable to use a polyphenylene ether resin and another thermoplastic resin together as the thermoplastic resin. In this case, the other thermoplastic resin is preferably at least one selected from the group consisting of a polyamide resin, a polystyrene resin, a polyolefin resin, and a polyphenylene sulfide.

Note that the "other thermoplastic resin" referred to herein is not inclusive of polyphenylene ether resins.

[0064] Examples of polyphenylene ether resins that can be used include, but are not limited to, poly(2,6-dimethyl-1,4-phenylene ether), poly(2-methyl-6-ethyl-1,4-phenylene ether), poly(2-methyl-6-phenyl-1,4-phenylene ether), poly(2,6-dichloro-1,4-phenylene ether), and polyphenylene ether copolymers such as a copolymer of 2,6-dimethylphenol and another phenol (for example, 2,3,6-trimethylphenol or 2-methyl-6-butylphenol). One of these polyphenylene ether resins may be used individually, or two or more of these polyphenylene ether resins may be used in combination. In particular, poly(2,6-dimethyl-1,4-phenylene ether) and a copolymer of 2,6-dimethylphenol and 2,3,6-trimethylphenol are preferable, and poly(2,6-dimethyl-1,4-phenylene ether) is more preferable as a polyphenylene ether resin. The polyphenylene ether resin may be a blend with a polystyrene resin.

[0065] The polyphenylene ether resin can be produced, for example, by preparing one or more desired monomer components and then performing polymerization thereof by a standard method in a polymerization tank. This polymerization may be conducted in the presence of a good solvent such as an aromatic hydrocarbon. Alternatively, a commercially available product may be used as the polyphenylene ether resin.

[0066] From a viewpoint of purity, it is preferable that the polyphenylene ether resin includes residual good solvent, such as an aromatic hydrocarbon,

as a binder component. The content of the good solvent in the polyphenylene ether resin is preferably 0.005 mass% to 0.3 mass%, more preferably 0.005 mass% to 0.25 mass%, and even more preferably 0.01 mass% to 0.1 mass%. A residual good solvent content of 0.005 mass% or more in the polyphenylene ether resin enables an adequate compression molding effect to be obtained, although this is dependent on the temperature and linear pressure in compression, whereas a residual good solvent content of 0.3 mass% or less can sufficiently inhibit discoloration caused by melting of the polyphenylene ether resin.

[0067] The polyphenylene ether resin preferably has a reduced viscosity (units: g/dL; measured in chloroform at 30°C) of 0.10 to 0.70. A polyphenylene ether resin reduced viscosity of 0.10 or more can maintain good mechanical strength of the resultant thermoplastic resin composition pellets, whereas a polyphenylene ether resin reduced viscosity of 0.70 or less can maintain fluidity in melt-kneading. For the same reasons, the reduced viscosity of the polyphenylene ether resin is more preferably 0.20 or more, and even more preferably 0.30 or more, and is more preferably 0.65 or less, and even more preferably 0.60 or less.

Note that the reduced viscosity is taken to be a value measured with respect to a 0.5 g/dL solution at 30°C with chloroform solvent using an Ubbelohde viscometer.

[0068] A styrene-butadiene copolymer used as the polystyrene resin that can be used as the other thermoplastic resin may have a partially random form or tapered form. The styrene-butadiene copolymer preferably has a weight average molecular weight of 30,000 to 500,000, a styrene content of 25 mass% to 70 mass%, and a butadiene content of 75 mass% to 30 mass%.

[0069] A resin obtained through copolymerization of a styrene monomer and a carboxyl group-containing monomer (for example, citric acid or maleic anhydride) or a resin obtained through graft addition of a carboxyl group-containing monomer using an extruder can be used as the polystyrene resin, and a resin obtained through graft addition of a carboxyl group-containing monomer using an extruder can be used as the polyphenylene ether resin (hereinafter, such resins are referred to collectively as "carboxyl group-modified polymers"). However, the proportion of such carboxyl group-modified polymers in the thermoplastic resin composition is preferably less than 5 mass%.

[0070] The thermoplastic resin composition used in the method for producing a thermoplastic resin composition pellet according to the present embodiment is preferably a resin composition obtained through melt-kneading of a compressed and pulverized polyphenylene ether resin, which is obtained by compressing and pulverizing a polyphenylene ether resin, and another thermoplastic resin such as described above. In other words, the method for producing a thermoplastic resin composition pellet according to the present embodiment preferably further includes a step of compressing and pulverizing a polyphenylene ether resin to obtain a compressed and pulverized polyphenylene ether resin (PPE compression and pulverization step), and the thermoplastic resin composition is preferably obtained through melt-kneading of this compressed and pulverized polyphenylene ether resin and another thermoplastic resin such as described above. This can reduce oxidative degradation products in the resultant thermoplastic resin composition pellets.

[0071] The polyphenylene ether resin used in the PPE compression and pulverization step is preferably a polyphenylene ether resin having an average particle diameter of less than 700 μm or a collection of microparticles having a particle diameter of less than 700 μm.

The average particle diameter refers to the particle diameter at a cumulative value of 50%.

Moreover, the polyphenylene ether resin used in the PPE compression and pulverization step preferably has a bulk density of 0.35 g/cc to 0.75 g/cc.

[0072] In the PPE compression and pulverization step, the prepared polyphenylene ether resin may, for example, be compressed at a temperature that is not higher than the glass transition temperature (Tg) of the polyphenylene ether resin. The polyphenylene ether resin is restricted from reaching a temperature exceeding Tg during compression. Although no specific limitations are placed on the temperature in compression so long as the polyphenylene ether resin can be pressurized without exceeding Tg during compression, the temperature is preferably 20°C to Tg, and more preferably approximately 20°C to 170°C. If the temperature in compression exceeds Tg, residual amine that may be contained in the polyphenylene ether resin may detach and cause reduction of quality in processing.

[0073] Examples of molding machines that can be used in the compression operation of the polyphenylene ether resin include compression molding machines such as a compression roll-type machine and a tableting-type

machine. In particular, it is preferable to use a roll-type compression molding machine that can pass a polyphenylene ether resin having low apparent specific gravity between a pair of pressing rolls provided in opposition, can pulverize a plate-shaped polyphenylene ether resin obtained through the compressing in a subsequently described pulverization operation, and can perform sizing to a desired particle diameter.

[0074] In a case in which a plate-shaped polyphenylene ether resin is obtained using a roll-type compression molding machine, the linear pressure (roll pressure/roll width) of the roll-type compression molding machine is preferably 0.7 kN/cm to 11 kN/cm, more preferably 1.0 kN/cm to 8.0 kN/cm, and even more preferably 1.5 kN/cm to 7.0 kN/cm. If the linear pressure is less than 0.7 kN/cm, the compressive effect is small and, as a result, porosity in an inner part of the polyphenylene ether resin is not sufficiently reduced, apparent specific gravity is not sufficiently improved, the compressed product is brittle, and fine powder tends to be generated in pulverization. Moreover, if the linear pressure is more than 11 kN/cm, the compressed product becomes excessively hard and pulverization becomes difficult, which conversely increases the amount of fine powder.

The gap between the rolls (roll clearance) is preferably approximately 1 mm to 3 mm, and the roll rotation speed is preferably 2 rpm to 20 rpm.

[0075] The polyphenylene ether resin can be compressed in the compression operation such that the bulk density of the post-compression polyphenylene ether resin is preferably 0.70 g/cm^3 to 1.0 g/cm^3, and more preferably 0.72 g/cm^3 to 0.85 g/cm^3. In relation to the above, the polyphenylene ether resin that is subjected to the compression operation may be heated (for example, a polyphenylene ether resin obtained straight after performing polymerization of one or more desired monomer components and subsequent drying) or non-heated (for example, a polyphenylene ether resin for which a certain time has passed after performing polymerization of one or more desired monomer components and subsequent drying, or a commercially available polyphenylene ether resin).

Note that the bulk density of the polyphenylene ether resin is expressed by (polyphenylene ether resin weight)/(polyphenylene ether resin volume).

[0076] An additive that serves as a binder may be used in the compression operation as necessary. For example, the polyphenylene ether resin and the

additive may be mixed in advance using a blender and the resultant mixture may subsequently be supplied into the compression molding machine. Examples of additives that can be used include flame retardants, such as phosphorus-based flame retardants, and antioxidants.

[0077] The inside of the molding machine used in the compression operation is preferably maintained under an atmosphere having an oxygen concentration of 10 volume% or less. Maintaining an oxygen concentration of 10 volume% or less can prevent the occurrence of a dust explosion and can effectively remove oxygen attached to the surface of the polyphenylene ether resin in compression. For the same reasons, the oxygen concentration inside the molding machine is more preferably 3 volume% or less, and even more preferably 1 volume% or less.

The method by which the oxygen concentration inside the molding machine is reduced is typically a method in which an inert gas (for example, nitrogen or carbon dioxide) is supplied into the molding machine.

[0078] In the PPE compression and pulverization step, the compression operation is followed by pulverization of the post-compression polyphenylene ether resin to obtain a compressed and pulverized polyphenylene ether resin. The pulverization operation may be carried out using a granulator. This enables adjustment of the particle diameter of the compressed and pulverized polyphenylene ether resin.

[0079] Examples of pulverizing devices that can be used in the pulverization operation of the polyphenylene ether resin include a jaw crusher, a cone crusher, a flake crusher, a hammer mill, a feather mill, a ball mill, a high-speed rotation mill, and a jet mill.

[0080] The pulverization device rotor speed and screen opening size may be adjusted in the pulverization operation such that the bulk density of the post-pulverization polyphenylene ether resin (compressed and pulverized polyphenylene ether resin) is 0.35 g/cc to 0.70 g/cc, and the proportion of the post-pulverization polyphenylene ether resin having a particle diameter of 106 μm or less is preferably 20 mass% or less, more preferably less than 15 mass%, and even more preferably less than 10 mass%.

[0081] The average particle diameter of the compressed and pulverized polyphenylene ether resin obtained through the PPE compression and pulverization step is preferably 1,000 μm to 3,000 μm. When the average particle diameter of the compressed and pulverized polyphenylene ether resin

is 1,000 μm or more, sufficient transport capability in melt-kneading can be ensured and a rise in resin composition temperature can be effectively suppressed. Moreover, when the average particle diameter of the compressed and pulverized polyphenylene ether resin is 3,000 μm or less, micro-mixing in melt-kneading with another thermoplastic resin can be increased and better quality thermoplastic resin composition pellets can be obtained. For the same reasons, the average particle diameter of the compressed and pulverized polyphenylene ether resin is more preferably 1,100 μm or more, and even more preferably 1,200 μm or more, and is more preferably 2,000 μm or less, and even more preferably 1,500 μm or less.

[0082] In addition, the proportion of the compressed and pulverized polyphenylene ether resin obtained through the PPE compression and pulverization step that has a particle diameter of 106 μm or less is preferably 20 mass% or less. When the proportion of the compressed and pulverized polyphenylene ether resin that has a particle diameter of 106 μm or less is 20 mass% or less, sufficient transport capability in melt-kneading can be ensured and a rise in resin composition temperature can be effectively suppressed. For the same reasons, the proportion of the compressed and pulverized polyphenylene ether resin that has a particle diameter of 106 μm or less is more preferably less than 15 mass%, and even more preferably less than 10 mass%.

[0083] Note that the PPE compression and pulverization step set forth above may be implemented continuously with the melt-kneading step using the extruder or may be implemented non-continuously therewith. However, the melt-kneading step is normally implemented non-continuously with the PPE compression and pulverization step by, for example, storing the compressed and pulverized polyphenylene ether resin that is obtained through the PPE compression and pulverization step for a certain period, and subsequently implementing the melt-kneading step.

[0084] In another example of the present embodiment, a preferable thermoplastic resin composition contains: a thermoplastic resin including 20 parts by mass to 98 parts by mass of a polyphenylene ether resin and 2 parts by mass to 80 parts by mass of a polystyrene resin; and 0 parts by mass to 50 parts by mass of a flame retardant relative to 100 parts by mass, in total, of the polyphenylene ether resin and the polystyrene resin.

In another example of the present embodiment, a particularly

preferable thermoplastic resin composition contains: a thermoplastic resin including 30 parts by mass to 90 parts by mass of a polyphenylene ether resin and 10 parts by mass to 70 parts by mass of a polystyrene resin; and 0 parts by mass to 50 parts by mass of a flame retardant relative to 100 parts by mass, in total, of the polyphenylene ether resin and the polystyrene resin.

Note that "containing 0 parts by mass" of a component means that the component is not contained.

[0085] A thermoplastic resin composition pellet produced through the method for producing a thermoplastic resin composition pellet according to the present embodiment can be suitably used for electrical and electronic components, OA components, automotive components, and so forth.

EXAMPLES

[0086] The following provides a more detailed description of the present disclosure through examples. However, the present disclosure is not in any way limited by the following examples.

[0087] (Example 1)

<Configuration of extruder and downstream devices>

A device configuration such as illustrated in FIG. 1A was adopted in which a co-rotating twin screw extruder (TEM-58SS (12 barrels) produced by Toshiba Machine Co., Ltd.) was used as an extruder.

The barrel configuration and conditions of the various devices were as follows.

Barrel 1: First feeding port (top feed barrel, gravimetric feeder A, gravimetric feeder B)

Barrel 2: Closed barrel

Barrel 3: Closed barrel

Barrel 4: Closed barrel

Barrel 5: Second feeding port (side feed (liquid addition) barrel)

Barrel 6: Closed barrel (first kneading zone)

Barrel 7: Closed barrel

Barrel 8: Closed barrel

Barrel 9: Closed barrel (second kneading zone)

Barrel 10: Vacuum vent

Barrel 11: Closed barrel

Barrel 12: Closed barrel

Barrel set temperature: 280°C

Die section set temperature: 280°C

[0088] Single-flight screws for high conveyance of powder raw material were used in barrels 1 and 2, and double-flight screws were used in barrels 3 to 5. A first kneading zone was provided in barrel 6 and a second kneading zone was provided in barrel 9. Moreover, a vacuum vent provided in barrel 10 was used to perform degassing at −0.09 MPa.

In the screw configuration of the first kneading zone, screws having a small compressive effect such as a right-handed kneading block, a neutral kneading block, and a right-handed double-flight notch screw were combined as appropriate.

In the screw configuration of the second kneading zone, at least one screw having a high compressive effect such as a left-handed kneading block, a left-handed screw, or a left-handed single-flight notch screw was combined with the first kneading zone screws as appropriate.

[0089] Screen changer section: Metal meshes were attached to a breaker plate in an (upstream side) #20/#40/#80/#20 (downstream side) configuration (#20: No. 20 metal mesh).

Manifold section: Manifold angle θ1 of 60°

Die plate section: Die plate section having configuration illustrated in FIG. 2B; orifice internal diameter D: 4.0 mm; orifice length L: 6.0 mm; number of rows of orifices: 1; number of orifices per one row: 25

[0090] Cooling device: Strand cooling tank of 600 mm in width by 6,000 mm in length

Cooling water temperature: 40°C ±3°C

Water depth: 100 mm

Number of strand guide rollers: 4

Strand guide rollers were installed at at least a location at which strands entered the water and were fixed-type rollers that did not rotate about an axis such that strands at both edges did not move toward the center (refer to FIG. 1C). The distance L1 from the openings of the orifices to the cooling device (perpendicular distance from the outlets of the orifices to the liquid surface) was set as 120 mm. The length of a section of strand that was immersed in the cooling water was set as 2,000 mm and water attached to the surfaces of the strands after immersion was removed using an air wiper.

[0091] Pelletizer: A rotary blade of 300 mm in width was used. A target of

cylindrically-shaped pellets of 3 mm in length by 3 mm in diameter was set. The strand temperature at the entrance of the pelletizer was set as 140°C. The take-up rate of the pelletizer was 100 m/minute.

Pellet cooler: Outlet temperature 50°C

Pellet screener: A vibrating sieve was used. Long pellets, joined (twin) pellets, and fines (small-diameter pellets) were removed.

External lubricant addition device: 0.03 parts by mass of ethylene bisamide added to pellet surface

Pellet transporter: Pushing-type Pneuma; air flow rate: 30 m^3/hr

Metal screener: High-sensitivity selector DIA-ARRESUTER produced by DAIKA Co., Ltd.

Contaminant screener: Contaminant screener PLATON II produced by Kubota Corporation

Fines separator: XENOFILTER produced by Kawata Mfg. Co., Ltd.

Intermediate tank: Not used

Product tank: Volume 3 m^3

Metal detector: Three rows of magnets, each including three 13,000 gauss magnets, were provided at an outlet of the product tank.

Bagging was carried out using 25 kg bags.

[0092] <Measurement and evaluation methods>

Measurements and evaluations related to production of thermoplastic resin composition pellets in Example 1 (and also in Examples 2 to 18 and Comparative Examples 1 to 7) were performed as follows.

[0093] (0) Average residence time T

The resin composition density was taken to be 1.1 g/cm^3 in Examples 1 to 4 and 12 to 17, and Comparative Examples 1 to 6, 1.5 g/cm^3 in Examples 5 to 10, and 18, and Comparative Example 7, and 1.56 g/cm^3 in Example 11, and a value obtained by dividing the total orifice internal volume V by the volumetric flow rate Q was taken to be the average residence time T (ms).

[0094] (1) Temperature measurement of resin composition

In production of thermoplastic resin composition pellets, the tip of a sensor of a thermometer (Handheld Thermometer HD-1100 produced by Anristu Meter Co., Ltd.) was inserted into a strand discharged from the opening of a 10^{th} orifice from the right as viewed in a direction from the die plate toward barrel 1, and the resin composition temperature (°C) was measured.

[0095] (2) Pressure measurement in die section

In production of thermoplastic resin composition pellets, the pressure (MPa) in the die section was measured using a die pressure gauge (CZ-200P produced by RKC Instrument Inc.) installed in an upper part of the manifold section.

[0096] (3) Evaluation of level of die build-up

In production of thermoplastic resin composition pellets, a vernier caliper was used to measure the size of die build-up at the openings (strand discharge outlets) of the orifices in the die plate 10 minutes from the start of strand discharge. A judgment was made in accordance with the following judgment standard.

<Judgment standard>

1: Die build-up length of 1 mm or less

2: Die build-up length of 3 mm or less

3: Die build-up length of 5 mm or less

4: Die build-up length of 7 mm or less

5: Die build-up length of 10 mm or less

6: Die build-up length of 15 mm or less

7: Die build-up length of more than 15 mm

[0097] (4) Evaluation of strand stability

In production of thermoplastic resin composition pellets, the condition of strands was inspected 20 minutes after that start of strand discharge and an evaluation was made in accordance with the following judgment standard.

<Judgment standard (judgment criterion: appearance of strand stability)>

1: None of the strands exhibit strand curling or strand breakage

2: Only strands at both edges or one strand exhibits curling but without breakage

3: A few strands in both edge directions of the strands exhibit curling but without breakage

4: One to a few strands in both edge directions of the strands exhibit curling and breakage

5: Strand breakage occurs frequently

Note that strand curling refers to twisting of a strand, whereas strand breakage refers to breakage of a strand such that the strand can no longer be pulled.

[0098] (5) Calculation of proportion of non-defective pellets

In production of thermoplastic resin composition pellets, an outlet chute of the pelletizer was switched 1 hour after the start of strand discharge to sample 5 kg of pellets. A pellet screener was used with respect to the sampled pellets to select long pellets, twin pellets, and small-diameter pellets. The total amount of long pellets, twin pellets, and small-diameter pellets was calculated as an average amount per 1 hour W (kg/hr), and then the proportion of non-defection pellets (%) was determined from W and the extrusion rate Q (kg/hr) by the following formula.

$$A\ (\%) = (Q - W)/Q \times 100$$

[0099] <Production of thermoplastic resin composition pellets>

A polyphenylene ether resin (S201A produced by Asahi Kasei Plastics Singapore Pte Ltd.; referred to herein as "PPE 3") in an amount of 75 parts by mass was loaded into the gravimetric feeder A of the extruder and was fed at the first feeding port in barrel 1. A mixture was prepared by using a tumbler to mix 4 parts by mass of high impact polystyrene (HIPS) (produced by Petrochemicals (Malaysia) Sdn. Bhd.; product name: CT60), 3 parts by mass of general purpose polystyrene (GPPS) (produced by PS Japan Corporation; product name: 685), 1 part by mass of polyethylene (produced by Asahi Kasei Chemicals Corporation; product name: M1804), and 4 parts by mass of a hydrogenated styrene-ethylene block copolymer (SEBS) (produced by Shell; product name: G1651) as a polystyrene resin, and 0.6 parts by mass of a stabilizer (Irganox 1010/ADK STAB PEP 36 = 1:2), and 12.6 parts by mass of the resultant mixture was loaded into the gravimetric feeder B of the extruder and was fed at the first feeding port in barrel 1.

A liquid addition gravimetric feeder was used to feed 12 parts by mass of a flame retardant (produced by Daihachi Chemical Industry Co., Ltd.; product name: CR731) at the second feeding port via a liquid injection nozzle attached to barrel 5.

With the extrusion rate set as 1,000 kg/hr and the screw rotation speed set as 500 rpm, a thermoplastic resin composition was obtained by lightly mixing raw materials fed from the first feeding port and the flame retardant fed from the second feeding port in the first kneading zone provided in barrel 6, and then completely melting these materials in the second kneading zone provided in barrel 9. Next, thermoplastic resin composition pellets were produced through steps such as forming the molten thermoplastic resin composition into strands at the die plate provided at the downstream end of

the extruder and cutting these strands in the pelletizer.

[0100] As a result, the pressure in the die section, resin composition temperature, amount of die build-up, strand stability, and proportion of non-defective pellets were good in Example 1.

Note that detailed conditions and evaluation results for Example 1 and the other subsequently described examples are summarized in Tables 1 to 3 and 5.

[0101] (Comparative Example 1)

Comparative Example 1 was implemented in the same way as Example 1 with the exception that the orifice length L was set as 10.0 mm (L/D = 2.5). As a result, the amount of die build-up increased and strand breakage occurred more frequently.

[0102] (Comparative Example 2)

Comparative Example 2 was implemented in the same way as Example 1 with the exception that the orifice internal diameter D was set as 3.0 mm and the orifice length L was set as 4.5 mm. As a result, the pressure in the die section increased and the resin composition temperature rose, and thus the extrusion rate was reduced to 440 kg/hr. However, despite this, the pressure in the die section increased, the resin composition temperature rose, the amount of die build-up increased, and strand breakage occurred more frequently.

[0103] (Comparative Example 3)

Comparative Example 3 was implemented in the same way as Example 1 with the exception that the orifice length L was set as 1.0 mm (L/D = 0.25). As a result, a flow rectifying effect at the orifices was lost and strand breakage occurred frequently.

[0104] (Comparative Example 4)

Comparative Example 4 was implemented in the same way as Example 1 with the exception that the same orifices as in Comparative Example 1 were used, the extrusion rate was set as 375 kg/hr, and the rotation speed was set as 250 rpm. As a result, the average residence time T increased, the amount of die build-up increased, and strand breakage occurred more frequently.

[0105] (Examples 2 to 4)

Example 2 was implemented in the same way as Example 1 with the exception that, in particular, HIPS and GPPS were replaced with SEBS. Examples 3 and 4 were implemented in the same way as Example 1 with the exception that an additional side feeder (third feeding port) was attached to

barrel 8, and a portion of HIPS was loaded into the side feeder and fed from the third feeding port.

As a result, the pressure in the die section, resin composition temperature, amount of die build-up, strand stability, and proportion of non-defective pellets were good in Examples 2 to 4.

[0106] (Example 5)

Example 5 was implemented in the same way as Example 1 with the exception that the compounded components, conditions, and so forth were changed as shown in Table 1. In particular, in Example 5, 30 parts by mass of glass fiber was loaded into a side feeder attached to barrel 8 and was fed from a third feeding port.

As a result, the pressure in the die section, resin composition temperature, amount of die build-up, strand stability, and proportion of non-defective pellets were good in Example 5.

[0107] (Examples 6 and 7)

Examples 6 and 7 were implemented in the same way as Example 1 with the exception that the compounded components, conditions, and so forth were changed as shown in Table 1.

In Example 6, the surface of the die plate (surface of die plate at which orifices open and inner surfaces of orifices) was subjected to the New Kanuc Process to achieve a surface hardness (HV hardness) of 1,000.

In Example 7, the surface of the die plate (surface of die plate at which orifices open and inner surfaces of orifices) was subjected to titanium aluminum nitride (TiAlN) vapor deposition treatment to achieve a surface hardness of 3,500.

As a result, the amount of die build-up was significantly reduced, and the pressure in the die section, resin composition temperature, strand stability, and proportion of non-defective pellets were good in both of Examples 6 and 7.

[0108] (Examples 8 and 9)

Examples 8 and 9 were implemented in the same way as Example 1 with the exception that the compounded components, conditions, and so forth were changed as shown in Table 1.

In Example 8, among the 25 orifices included in the die plate, the length L (Lc) of 15 orifices in a central part was set as 5.0 mm, and the length L of 5 orifices at each side outward thereof in the width direction of the die

plate was reduced stepwise by 0.3 mm for each orifice such that the orifices at the outermost edges each had a length Lo of 3.5 mm (Lo/Lc = 3.5/5.0).

In Example 9, among the 25 orifices included in the die plate, the internal diameter D (Dc) of 15 orifices in a central part was set as 5.0 mm, and the internal diameter D of 5 orifices at each side outward thereof in the width direction of the die plate was increased stepwise by 0.1 mm for each orifice such that the orifices at the outermost edges each had an internal diameter Do of 5.5 mm (Do/Dc = 5.5/5.0).

As a result, strand stability was improved in both of Examples 8 and 9 compared to Example 5.

[0109] (Example 10)

Example 10 was implemented in the same way as Example 1 with the exception that the compounded components, conditions, and so forth were changed as shown in Table 1.

As a result, the pressure in the die section, resin composition temperature, amount of die build-up, strand stability, and proportion of non-defective pellets were good in Example 10.

[0110] (Example 11)

Example 11 was implemented in the same way as Example 1 with the exception that the compounded components, conditions, and so forth were changed as shown in Table 1. In particular, mica was used instead of glass fiber in Example 11.

As a result, the pressure in the die section, resin composition temperature, amount of die build-up, strand stability, and proportion of non-defective pellets were good in Example 11.

[0111]

Table 1

				Example 1	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9	Example 10	Example 11
Compounded components	PPE 3 (S201A)		First feeding port (top 1)	75	75	75	75	75	75	65	50	45	45	45	45	45	45	45
	HIPS (CT60)	Other thermoplastic resins	First feeding port (top 2)	4	4	4	4	4	0	8	10	5	5	5	5	5	5	5
	GPPS (685)			3	3	3	3	3	0	-	7	10	10	10	10	10	-	-
	Polyethylene			1	1	1	1	1	1	2	2	-	-	-	-	-	-	-
	SEBS (G1651)			4	4	4	4	4	11	2	2	-	-	-	-	-	-	-
	Stabilizer, etc.			0.6	0.6	0.6	0.6	0.6	0.6	0.6	1.8	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Flame retardant		Second feeding port	12	12	12	12	12	12	13	13	-	-	-	-	-	10	10
	HIPS	Other thermoplastic resins	Third feeding port	-	-	-	-	-	-	10	16	10	10	10	10	10	10	10
	Glass fiber			-	-	-	-	-	-	-	-	30	30	30	30	30	30	-
	Mica			-	-	-	-	-	-	-	-	-	-	-	-	-	-	30
Orifice conditions	Orifice internal diameter D		mm	4.0	4.0	3.0	4.0	4.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0	Do = 5.5 Dc = 5.0	5.0	5.0
	Orifice length L		mm	6.0	10.0	4.5	1.0	10.0	4.0	5.0	5.0	5.0	5.0	5.0	Lc = 5.0 Lo = 3.5	5.0	5.0	5.0
	L/D		-	1.5	2.5	1.5	0.25	2.5	1.0	1.0	1.0	1.0	1.0	1.0	0.7-1.0	1.0-1.1	1.0	1.0
	Number		Orifices	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
	Surface treatment		-	No	No	No	No	No	No	No	No	No	New Kanuc Process	TiAlN treatment	No	No	No	No
Operating conditions, etc.	Extrusion rate		kg/hr	1000	1000	440	1000	375	1000	1500	1500	1000	1000	1000	1000	1000	1000	1000
	Screw rotation speed		rpm	500	500	250	500	250	500	1000	1000	700	700	700	700	700	700	800
	Distance L1 from orifice openings to cooling device		mm	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
	Flow rate per one orifice		kg/hr	40	40	18	40	15	40	60	60	40	40	40	40	40	40	40
	Average residence time T		ms	7.5	12.4	7.2	1.2	33.2	5.0	6.5	6.5	13.2	13.2	13.2	9.3	10.3	13.2	13.2
Results	Resin composition temperature		°C	347	380	375	334	364	340	344	330	357	356	354	351	350	346	354
	Pressure in die section		MPa	4.1	8.4	8.3	0.8	2.8	2.7	1.8	1.5	4.8	4.7	4.6	3.8	3.7	4.1	3.9
	Level of die build-up		-	3	7	6	-	5	1	3	3	4	1	1	2	2	4	4
	Strand stability		-	2	4	4	5	4	1	2	2	3	2	2	1	1	3	3
	Proportion of non-defective pellets		%	97.4	91	92	46	94.2	99.2	97.4	97.5	96.3	98.4	98.2	98.3	98.1	96.8	95.2

[0112] (Examples 12 to 15)

Examples 12 to 15 were implemented in the same way as Example 1 with the exception that a barrel configuration was adopted in which a first feeding port was provided in barrel 1, a first kneading zone was provided in barrels 3 and 4, a vacuum vent was provided in barrel 5, a second feeding port (flame retardant) was provided in barrel 6, a third feeding port (HIPS) was provided in barrel 8, and a fourth feeding port (flame retardant) was provided in barrel 11, and the compounded components, conditions, and so forth were changed as shown in Table 2.

In particular, a flame retardant was not fed in Examples 12 and 13.

Moreover, a polyphenylene ether resin (S202A produced by Asahi Kasei Plastics Singapore Pte Ltd.; referred to herein as "PPE 4") having a lower molecular weight was used instead of PPE 3 in Example 13.

Furthermore, the flame retardant was fed as portions from the second feeding port and the fourth feeding port in Examples 14 and 15 because a large amount of the flame retardant was used.

As a result, in Example 13, the lower molecular weight of the used polyphenylene ether resin led to a fall in the resin composition temperature and a corresponding decrease in the amount of die build-up, and the pressure in the die section, strand stability, and proportion of non-defective pellets were good.

Moreover, the pressure in the die section, resin composition temperature, amount of die build-up, strand stability, and proportion of non-defective pellets were good in Examples 14 and 15.

[0113] (Example 16)

In the device configuration of Example 1, the strand cooling tank was changed to a strand guide (3b in FIG. 1B). The strand guide was a member having a width of 600 mm and a length of 1,500 mm, and including 20 channels that each had a width of 10.7 mm. The width and number of channels was matched to the spacing and number of orifices in the die plate. The angle of inclination θ2 formed between the extension direction of the channels and a horizontal plane was 75°. Moreover, the angle of inclination θ3 formed between the extension direction of the orifices and the extension direction of the channels was 15°. A wet-type pelletizer and a dehydration device were attached to the strand guide and were connected to the device configuration from the pellet screener (vibrating sieve) onward. Production of pellets was

implemented in the same way as in Example 1 except for the points described above.

In Example 16, the vertical distance from the outlets of the orifices to the strand guide was 200 mm.

The pressure in the die section, resin composition temperature, amount of die build-up, strand stability, and proportion of non-defective pellets were good in Example 16.

[0114] (Comparative Example 5)

Comparative Example 5 was implemented in the same way as Example 16 with the exception that the compounded components, conditions, and so forth were changed as shown in Table 1.

The orifice length L was set as 15.0 mm in Comparative Example 5.

As a result, the increase in orifice length led to a corresponding increase in die build-up, destabilization of strands, and decrease in the proportion of non-defective pellets in Comparative Example 5.

[0115]

Table 2

				Example 12	Example 13	Example 14	Example 15	Example 16	Comparative Example 5
Compounded components	PPE 3 (S201A)		First feeding port (top 1)	70	-	-	60	70	70
	PPE 4 (S202A)			-	70	55	-	-	-
	GPPS (685)	Other thermoplastic resins	First feeding port (top 2)	10	-	-	-	10	10
	HIPS (CT60)			10	10	5	5	10	10
	Stabilizer			0.6	0.6	0.6	0.6	0.6	0.6
	Flame retardant		Second feeding port	-	-	10	10	-	-
	HIPS (CT60)	Other thermoplastic resins	Third feeding port	10	20	10	10	10	10
	Flame retardant		Fourth feeding port	-	-	20	15	-	-
Orifice conditions	Orifice internal diameter D		mm	4.0	4.0	4.0	4.0	6.0	6.0
	Orifice length L		mm	4.0	4.0	4.0	4.0	6.0	15.0
	L/D		-	1.0	1.0	1.0	1.0	1.0	2.5
	Number		Orifices	25	25	25	25	20	20
Operating conditions, etc.	Extrusion rate		kg/hr	1000	1000	1000	1000	1000	1000
	Screw rotation speed		rpm	500	500	1300	1200	500	500
	Distance L1 from orifice openings to cooling device		mm	120	120	120	120	200	200
	Flow rate per one orifice		kg/hr	40	40	40	40	50	50
	Average residence time T		ms	5.0	5.0	5.0	5.0	13.4	33.6
Results	Resin composition temperature		°C	360	343	312	334	360	386
	Pressure in die section		MPa	5.2	3.7	1.6	0.8	4.1	9.5
	Level of die build-up		-	3	2	3	3	3	5
	Strand stability		-	2	1	2	2	2	4
	Proportion of non-defective pellets		%	97.6	98.3	98.4	97.6	99.2	93.1

[0116] (Example 17)

Example 17 was implemented in the same way as Example 1 with the exception that a barrel configuration was adopted in which a first feeding port was provided in barrel 1, a first kneading zone was provided in barrels 3 and 4, a vacuum vent was provided in barrel 5, a second feeding port was provided in barrel 6, a second kneading zone was provided in barrel 9, and a vacuum vent was provided in barrel 10, and the compounded components, conditions, and so forth were changed as shown in Table 3.

In Example 17, dry air having a dew point of –40°C and an absolute humidity of 0.119 g/m^3 was fed into the product tank to prevent moisture absorption by polyamide resin. Moreover, a polyamide resin (nylon 66; 1300S produced by Asahi Kasei Corporation) was used as a thermoplastic resin and a masterbatch (copper/1300S = 10:90) was used as a stabilizer.

As a result, the pressure in the die section, resin composition temperature, amount of die build-up, strand stability, and proportion of non-defective pellets were good in Example 17.

[0117] (Comparative Example 6)

Production of pellets was implemented in the same way as in Example 17 with the exception that the compounded components, conditions, and so forth were changed as shown in Table 3.

The orifice length L was set as 10 mm in Comparative Example 6.

As a result, the resin composition temperature rose, the amount of die build-up increased, strands were destabilized, and the proportion of non-defective pellets decreased in Comparative Example 6.

[0118] (Example 18)

Production of pellets was implemented in the same way as in Example 17 with the exception that the compounded components, conditions, and so forth were changed as shown in Table 3.

Glass fiber was fed from the second feeding port in Example 18.

As a result, the pressure in the die section, resin composition temperature, amount of die build-up, strand stability, and proportion of non-defective pellets were good in Example 18.

[0119] (Comparative Example 7)

Production of pellets was implemented in the same way as in Example 18 with the exception that the compounded components, conditions, and so forth were changed as shown in Table 3.

The orifice length L was set as 10 mm in Comparative Example 7.

As a result, the resin composition temperature rose, the amount of die build-up increased, strands were destabilized, and the proportion of non-defective pellets decreased in Comparative Example 7.

[0120]

Table 3

			Example 17	Comparative Example 6	Example 18	Comparative Example 7
Compounded components	Nylon 66	First feeding port	100	100	70	70
	Stabilizer		1.0	1.0	1.0	1.0
	Glass fiber	Second feeding port	-	-	30	30
Orifice conditions	Orifice internal diameter D	mm	4.0	4.0	4.0	4.0
	Orifice length L	mm	4.0	10.0	4.0	10.0
	L/D	-	1.0	2.5	1.0	2.5
	Number	Orifices	29	29	29	29
Operating conditions, etc.	Extrusion rate	kg/hr	1300	1300	1300	1300
	Screw rotation speed	rpm	800	800	800	800
	Distance L1 from orifice openings to cooling device	mm	120	120	120	120
	Flow rate per one orifice	kg/hr	45	45	45	45
	Average residence time T	ms	4.4	11.1	4.4	11.1
Results	Resin composition temperature	°C	311	353	349	374
	Pressure in die section	MPa	1.4	5.9	3.9	8.4
	Level of die build-up	-	2	4	2	4
	Strand stability	-	2	5	3	5
	Proportion of non-defective pellets	%	98.8	94.1	99	92.3

[0121] (Example 19)

<Production of PPE 1 (compressed and pulverized polyphenylene ether resin)>

A commercially available polyphenylene ether resin (PPE 3) was compressed using a granulator produced by Hosokawa Micron Corporation (device name: CS-75; diameter: 400 mm; width: 120 mm) to obtain a plate-shaped polyphenylene ether resin under conditions of an oxygen concentration of 1 volume%, a roll clearance of 1.5 mm, a roll rotation speed of 7 rpm, and a linear pressure of 6 kN/cm. Next, the plate-shaped polyphenylene ether resin was pulverized (sized) using a flake crusher produced by Hosokawa Micron Corporation (device name: FC-200) and a ϕ 3 mm screen to obtain a compressed and pulverized polyphenylene ether resin (PPE 1).

[0122] The following methods were used to determine the average particle diameter, proportion having a particle diameter of 106 μm or less, bulk density, and reduced viscosity of PPE 1, PPE 3, PPE 4, and subsequently described PPE 2.

[0123] <Average particle diameter>

In accordance with the sieving test method of JIS Z 8815, sieves having screen opening sizes of 2,360 μm, 1,700 μm, 1,180 μm, 850 μm, 600 μm, 425 μm, 300 μm, 212 μm, 150 μm, 106 μm, and 75 μm were arranged vertically and fixed with a saucer positioned at the bottom. After 100 g of a sample had been loaded, a shaker was used to vibrate the sieves, and then the weight of particles remaining on each of the sieves was measured. The relationship between the sieve opening diameter and the amount of particles (mass%) was graphically represented by taking the particle diameter of sample remaining on the sieve having an opening size of 2,360 μm to be the simple average of 3,000 μm and 2,360 μm, taking the particle diameter of sample remaining on the sieve having an opening size of 1,700 μm to be the simple average of 2,360 μm and 1,700 μm, and taking the particle diameter of sample in the saucer at the bottom to be half of 75 μm (i.e., 37.5 μm). The particle diameter at a cumulative value of 50% was taken to be the average particle diameter. The results are shown in Table 4.

[0124] <Proportion having particle diameter of 106 μm or less>

The proportion of particles that passed through the sieve having an opening size of 106 μm upon vibration of the sieves by the shaker was determined as a weight ratio. The results are shown in Table 4.

[0125] <Bulk density>

The bulk density (loose) was measured in accordance with JIS K5101. The results are shown in Table 4.

[0126] <Reduced viscosity>

The reduced viscosity (g/dL) of a 0.5 g/dL solution was measured at 30°C with chloroform solvent using an Ubbelohde viscometer. The results are shown in Table 4.

[0127]

Table 4

	Average particle diameter (particle diameter at cumulative value of 50%)	Proportion having particle diameter of 106 μm or less	Bulk density	Reduced viscosity
	μm	Mass%	g/cm^3	g/dL
PPE 1	1200	5	0.63	0.51
PPE 2	800	12	0.59	0.51
PPE 3	580	14	0.55	0.51
PPE 4	470	19	0.52	0.41

[0128] <Configuration of extruder and downstream devices>

A device configuration such as illustrated in FIG. 1A was adopted in which a co-rotating twin screw extruder (TEM-58SX (12 barrels) produced by Toshiba Machine Co., Ltd.) was used as an extruder.

The barrel configuration and conditions of the various devices were as follows.

Barrel 1: First feeding port (top feed barrel, gravimetric feeder A, gravimetric feeder B, first feeding port oxygen concentration: 3.0 volume%)

Barrel 2: Closed barrel

Barrel 3: Closed barrel

Barrel 4: Closed barrel

Barrel 5: Second feeding port (side feed (liquid addition) barrel)

Barrel 6: Closed barrel

Barrel 7: Closed barrel (first kneading zone)

Barrel 8: Third feeding port (side feed barrel)

Barrel 9: Closed barrel (second kneading zone)

Barrel 10: Vacuum vent

Barrel 11: Closed barrel

Barrel 12: Closed barrel

Barrel set temperature: 280°C

Die section set temperature: 280°C

[0129] Single-flight screws for high conveyance of powder raw material were used in barrels 1 and 2, and double-flight screws were used in barrels 3 to 5. A first kneading zone was provided in barrel 7, a third feeding port was provided in barrel 8, and a second kneading zone was provided in barrel 9. Moreover, a vacuum vent provided in barrel 10 was used to perform degassing at −0.09 MPa.

In the screw configuration of the first kneading zone, screws having a

small compressive effect such as a right-handed kneading block, a neutral kneading block, and a right-handed double-flight notch screw were combined as appropriate.

In the screw configuration of the second kneading zone, at least one screw having a high compressive effect such as a left-handed kneading block, a left-handed screw, or a left-handed single-flight notch screw was combined with the first kneading zone screws as appropriate.

[0130] Screen changer section: Metal meshes were attached to a breaker plate in an (upstream side) #20/#40/#80/#20 (downstream side) configuration (#20: No. 20 metal mesh).

Manifold section: Manifold angle θ1 of 60°

Die plate section: Die plate section having configuration illustrated in FIG. 2B; orifice internal diameter D: 4.0 mm; orifice length L: 6.0 mm; number of rows of orifices: 1; number of orifices per one row: 25

[0131] The device configuration of the cooling device onward was the same as in Example 1.

[0132] <Measurement and evaluation methods>

Measurements and evaluations related to production of thermoplastic resin composition pellets in Example 19 (and also in Examples 20 to 31, Comparative Examples 8 to 11, and Reference Examples 1 to 3) were performed as follows.

[0133] (0) Average residence time T

The resin composition density was taken to be 1.1 g/cm^3 in Examples 19 to 26, Reference Example 1, and Comparative Examples 8 to 11, 1.3 g/cm^3 in Example 27, 1.36 g/cm^3 in Example 28, 1.51 g/cm^3 in Example 29, 1.1 g/cm^3 in Example 30 and Reference Example 2, and 0.95 g/cm^3 in Example 31 and Reference Example 3, and a value obtained by dividing the total orifice internal volume V by the volumetric flow rate Q was taken to be the average residence time T (ms).

[0134] (1) Temperature measurement of resin composition

Measurement was performed in the same way as in Example 1.

[0135] (2) Pressure measurement in die section

Measurement was performed in the same way as in Example 1.

[0136] (3) Evaluation of level of oxidative degradation products

Evaluation of the number of oxidative degradation products was performed by using a press mold to compression mold thermoplastic resin

composition pellets at 250°C to prepare 5 flat plates of 180 mm in diameter and 1 mm in thickness. Black spots formed at the surface of these flat plates were determined to be oxidative degradation products. The number of oxidative degradation products was evaluated by counting the number of these black spots. Specifically, the front and rear surfaces of the 5 flat plates were observed using a ×10 magnifying glass, and a score was calculated by counting black spots having a maximum diameter of less than 200 μm as 1 point and black spots having a maximum diameter of 200 μm or more as 3 points.

[0137] (4) Evaluation of level of die build-up

Evaluation was performed in the same way as in Example 1.

[0138] (5) Evaluation of strand stability

Evaluation was performed in the same way as in Example 1.

[0139] <Production of thermoplastic resin composition pellets>

PPE 1 in an amount of 65 parts by mass was loaded into the gravimetric feeder A of the extruder and was fed at the first feeding port in barrel 1. A mixture was prepared by using a tumbler to mix 4 parts by mass of high impact polystyrene (HIPS) (produced by Petrochemicals (Malaysia) Sdn. Bhd.; product name: CT60), 3 parts by mass of general purpose polystyrene (GPPS) (produced by PS Japan Corporation; product name: 685), 1 part by mass of polyethylene (produced by Asahi Kasei Chemicals Corporation; product name: M1804), and 4 parts by mass of a hydrogenated styrene-ethylene block copolymer (SEBS) (produced by Kraton Polymers (United States of America); product name: G1651) as a polystyrene resin, and 0.6 parts by mass of a stabilizer (Irganox 1010/ADK STAB PEP 36 = 1:2), and 12.6 parts by mass of the resultant mixture was loaded into the gravimetric feeder B of the extruder and was fed at the first feeding port in barrel 1.

A liquid addition gravimetric feeder was used to feed 12 parts by mass of a flame retardant (produced by Daihachi Chemical Industry Co., Ltd.; product name: CR731) at the second feeding port via a liquid injection nozzle attached to barrel 5.

High impact polystyrene (HIPS) (produced by Petrochemicals (Malaysia) Sdn. Bhd.; product name: CT60) in an amount of 13 parts by mass was fed at the third feeding port in barrel 8.

With the extrusion rate set as 1,000 kg/hr and the screw rotation speed set as 840 rpm, a thermoplastic resin composition was obtained by lightly

mixing raw materials fed from the first feeding port and the flame retardant fed from the second feeding port in the first kneading zone provided in barrel 7, and then feeding HIPS from the third feeding port in barrel 8 and completely melting these materials in the second kneading zone provided in barrel 9. Next, thermoplastic resin composition pellets were produced through steps such as forming the molten thermoplastic resin composition into strands at the die plate provided at the downstream end of the extruder and cutting these strands in the pelletizer.

[0140] As a result, the pressure in the die section and resin composition temperature were good, the amounts of oxidative degradation products and die build-up were small, and strand stability was good in Example 19.

[0141] (Reference Example 1)

Reference Example 1 was implemented in the same way as Example 19 with the exception that PPE 1 was changed to PPE 3. As a result, the number of oxidative degradation products and amount of die build-up increased compared to Example 19.

[0142] (Example 20)

<Production of PPE 2 (compressed and pulverized polyphenylene ether resin)>

A compressed and pulverized polyphenylene ether resin (PPE 2) was obtained under the same conditions as used to produce PPE 1 with the exception that the linear pressure in production of PPE 1 described above was changed to 3 kN/cm.

[0143] <Production of thermoplastic resin composition pellets>

Production of thermoplastic resin composition pellets was implemented in the same way as in Example 19 with the exception that PPE 1 was changed to PPE 2. As a result, the pressure in the die section and resin composition temperature were good, the amounts of oxidative degradation products and die build-up were small, and strand stability was good in the same way as in Example 19.

[0144] (Comparative Example 8)

Comparative Example 8 was implemented in the same way as Example 19 with the exception that the extrusion rate of the extruder was set as 250 kg/hr and the screw rotation speed was set as 210 rpm such that the extrusion rate/rotation speed ratio was the same as in Example 19. As a result, the average residence time T increased (30 ms), the number of oxidative

degradation products and amount of die build-up increased, and strand breakage occurred more frequently.

[0145] (Comparative Example 9)

Comparative Example 9 was implemented in the same way as Example 19 with the exception that the orifice length L was set as 10.0 mm (L/D = 2.5). As a result, the number of oxidative degradation products and amount of die build-up increased, and strand breakage occurred more frequently.

[0146] (Comparative Example 10)

Comparative Example 10 was implemented in the same way as Example 19 with the exception that the orifice length L was set as 1.0 mm (L/D = 0.25). As a result, a flow rectifying effect at the orifices was lost and strand breakage occurred frequently.

[0147] (Comparative Example 11)

Comparative Example 11 was implemented in the same way as Example 19 with the exception that the orifice internal diameter D was set as 2.5 mm and the orifice length L was set as 3.8 mm. As a result, the pressure in the die section increased, the resin composition temperature rose, the number of oxidative degradation products and amount of die build-up increased, and strand breakage occurred frequently.

[0148] (Example 21)

Example 21 was implemented in the same way as Example 19 with the exception that the orifice length L was set as 4.0 mm (L/D = 1.0). As a result, the pressure in the die section and resin composition temperature were good, the amounts of oxidative degradation products and die build-up were small, and strand stability was good in the same way as in Example 19.

[0149] (Example 22)

Example 22 was implemented in the same way as Example 21 with the exception that the fed amount of PPE 1 was changed to 50 parts by mass and the fed amount of HIPS from the third feeding port was changed to 28 parts by mass. As a result, the pressure in the die section and resin composition temperature were good, the amounts of oxidative degradation products and die build-up were small, and strand stability was good in the same way as in Example 21.

[0150] (Example 23)

Example 23 was implemented in the same way as Example 21 with the exception that the surface of the die plate (surface of die plate at which

orifices open and internal surfaces of orifices) was subjected to the New Kanuc Process to achieve a surface hardness (HV hardness) of 1,000. As a result, the amount of die build-up decreased more than in Example 21, the number of oxidative degradation products was small, and strand stability was good.

[0151] (Example 24)

Example 24 was implemented in the same way as Example 21 with the exception that the surface of the die plate (surface of die plate at which orifices open and internal surfaces of orifices) was subjected to titanium aluminum nitride (TiAlN) vapor deposition treatment to achieve a surface hardness (HV hardness) of 3,500. As a result, the amount of die build-up decreased more than in Example 21, the number of oxidative degradation products was small, and strand stability was good.

[0152] (Example 25)

Example 25 was implemented in the same way as Example 21 with the exception that, among the 25 orifices included in the die plate, the length L (Lc) of 15 orifices in a central part of the die plate was set as 4.0 mm, and the length L of 5 orifices at each side outward thereof in the width direction of the die plate was reduced stepwise by 0.3 mm for each orifice such that the orifices at the outermost edges each had a length Lo of 2.5 mm (Lo/Lc = 2.5/4.0 = 0.625). As a result, strand stability was improved compared to Example 21.

[0153] (Example 26)

Example 26 was implemented in the same way as Example 21 with the exception that, among the 25 orifices included in the die plate, the internal diameter D (Dc) of 15 orifices in a central part of the die plate was set as 4.0 mm, and the internal diameter D of 5 orifices at each side outward thereof in the width direction of the die plate was increased stepwise by 0.1 mm for each orifice such that the orifices at the outermost edges each had an internal diameter Do of 4.5 mm (Do/Dc = 4.5/4.0 = 1.125). As a result, strand stability was improved compared to Example 21.

[0154] (Example 27)

Example 27 was implemented in the same way as Example 21 with the exception that the metal meshes were detached from the breaker plate of the screen changer section, the fed amount of PPE 1 was changed to 50 parts by mass, the fed amount of HIPS from the third feeding port was changed to 8

parts by mass, and 20 parts by mass of glass fiber (produced by Nitto Boseki Co., Ltd.; product name: CSF-3PE-293) was fed from the third feeding port. As a result, the pressure in the die section and resin composition temperature were good, the amounts of oxidative degradation products and die build-up were small, and strand stability was good.

[0155] (Example 28)

Example 28 was implemented in the same way as Example 27 with the exception that mica (produced by Beijing Houxin Trading Co., Ltd.; product name: BHT Mica 200-D) was used instead of glass fiber. As a result, the pressure in the die section and resin composition temperature were good, the amounts of oxidative degradation products and die build-up were small, and strand stability was good.

[0156] (Example 29)

Example 29 was implemented in the same way as Example 27 with the exception that the fed amount of PPE 1 was changed to 40 parts by mass, the fed amount of glass fiber from the third feeding port was changed to 15 parts by mass, and 15 parts by mass of mica (same as in Example 28) was fed from the third feeding port. As a result, the pressure in the die section and resin composition temperature were good, the amounts of oxidative degradation products and die build-up were small, and strand stability was good.

[0157] (Example 30)

An extruder was used that was the same as in Example 21 with the exception that a first kneading zone was provided in barrels 3 and 4, a vacuum vent was provided in barrel 5, a second feeding port (gravimetric feeder C) was provided in barrel 6, a second kneading zone was provided in barrel 7, and a third kneading zone was provided in barrel 9.

PPE 1 in an amount of 30 parts by mass was loaded into the gravimetric feeder A of the extruder and was fed at the first feeding port in barrel 1. Moreover, a blend of 10 parts by mass of a hydrogenated styrene-ethylene block copolymer (SEBS) (produced by Kraton Polymers (United States of America); product name: G1651) as a thermoplastic resin, 0.5 parts by mass of maleic anhydride, and 0.6 parts by mass of a stabilizer (Irganox 1010/ADK STAB = 1:2) was loaded into the gravimetric feeder B and was fed at the first feeding port in barrel 1. Furthermore, 60 parts by mass of a polyamide resin (nylon 66; produced by Asahi Kasei Corporation; product name: 1300S) as a thermoplastic resin was loaded into the gravimetric feeder

C and was fed at the second feeding port in barrel 6.

Dry air having a dew point of −40°C and an absolute humidity of 0.119 g/m^3 was fed into the product tank using a dry air generator to prevent moisture absorption by polyamide resin.

With the exception that the screw rotation speed was changed to 500 rpm, a thermoplastic resin composition was obtained under the same operating conditions as in Example 21 by lightly mixing raw materials fed from the first feeding port in the first kneading zone provided in barrels 3 and 4, subsequently feeding raw materials fed from the second feeding port in barrel 6, and then completely melting these materials in the second kneading zone provided in barrel 7 and the third kneading zone provided in barrel 9. Next, thermoplastic resin composition pellets were produced through steps such as forming the molten thermoplastic resin composition into strands at the die plate provided at the downstream end of the extruder and cutting these strands in the pelletizer in the same way as in Example 21. As a result, the pressure in the die section and resin composition temperature were good, the amounts of oxidative degradation products and die build-up were small, and strand stability was good in the same way as in Example 21.

[0158] (Reference Example 2)

Reference Example 2 was implemented in the same way as Example 30 with the exception that PPE 1 was changed to PPE 3. As a result, the number of oxidative degradation products increased compared to Example 30, and there was a corresponding increase in pressure in the die section.

[0159] (Example 31)

Example 31 was implemented in the same way as Example 30 with the exception that maleic anhydride was not added, and the polyamide resin was changed to an equivalent amount of polypropylene (NOVATEC PP EA9FT produced by Japan Polypropylene Corporation). As a result, the pressure in the die section and resin composition temperature were good, the amounts of oxidative degradation products and die build-up were small, and strand stability was good.

[0160] (Reference Example 3)

Reference Example 3 was implemented in the same way as Example 31 with the exception that PPE 1 was changed to PPE 3. As a result, the number of oxidative degradation products increased compared to Example 31 and there was a corresponding increase in the pressure in the die section.

[0161]

Table 5

				Example 19	Reference Example 1	Example 20	Comparative Example 8	Comparative Example 9	Comparative Example 10	Comparative Example 11	Example 21	Example 22	Example 23	Example 24	Example 25	Example 26	Example 27	Example 28	Example 29	Example 30	Reference Example 2	Example 31	Reference Example 3
Compounded components	PPE 1 (compressed and pulverized PPE)		First feeding port (top 1)	65	0	0	65	65	65	65	65	50	65	65	65	65	50	50	40	30	0	30	0
	PPE 2 (compressed and pulverized PPE)			0	0	65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PPE 3 (non-compressed and pulverized PPE)			0	65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	30
	HIPS	Other thermoplastic resins	First feeding port (top 2)	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	0	0	0	0
	GPPS			3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	0	0	0
	Polyethylene			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
	SEBS			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	10	10	10	10
	Stabilizer, etc.			0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Maleic anhydride			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0
	Flame retardant		Second feeding port	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	0	0	0	0
	Nylon 66	Other thermoplastic resins		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	60	0	0
	Polypropylene			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	60
	HIPS		Third feeding port	13	13	13	13	13	13	13	13	28	13	13	13	13	8	8	8	0	0	0	0
	Glass fiber			0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	15	0	0	0	0
	Mica			0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	15	0	0	0	0
Orifice conditions	Orifice internal diameter D		mm	4.0	4.0	4.0	4.0	4.0	4.0	2.5	4.0	4.0	4.0	4.0	4.0	Do = 4.5 Dc = 4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Orifice length L		mm	6.0	6.0	6.0	6.0	10.0	1.0	3.8	4.0	4.0	4.0	4.0	Lc = 4.0 Lo = 2.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	L/D		-	1.5	1.5	1.5	1.5	2.5	0.25	1.5	1.0	1.0	1.0	1.0	0.63-1.0	0.89-1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Number		Orifices	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
	Surface treatment		-	No	No	No	No	No	No	No	No	No	New Kanuc Process	TiAlN treatment	No	No	No	No	No	No	No	No	No
Operating conditions, etc.	Extrusion rate		kg/hr	1000	1000	1000	250	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
	Screw rotation speed		rpm	840	840	840	210	840	840	840	840	840	840	840	840	840	840	840	840	500	500	500	500
	Top chute oxygen concentration		Volume%	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	Flow rate per one orifice		kg/hr	40	40	40	10	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
	Average residence time T		ms	7.5	7.5	7.5	30.0	12.4	1.2	1.9	5.0	5.0	5.0	5.0	4.5	5.3	5.9	6.2	6.9	5.0	5.0	5.4	5.4
Results	Resin composition temperature		°C	347	346	351	340	363	339	385	343	336	342	343	339	337	356	350	350	345	348	332	335
	Pressure in die section		MPa	4.1	4.3	3.8	4.7	6.7	0.7	9.3	2.7	1.8	2.8	2.7	2.9	3.0	4.9	3.7	3.7	1.9	2.1	3.1	3.7
	Level of oxidative degradation products		-	8	23	11	17	35	9	67	7	4	8	7	6	5	9	12	11	4	21	5	24
	Level of die build-up		-	2	3	2	6	7	2	6	2	2	1	1	2	2	3	3	3	2	3	2	3
	Strand stability		-	2	2	2	4	4	5	4	2	2	2	2	1	1	2	2	2	2	2	2	2

[0162] Note that the metal screener and the contaminant screener were used in each of the examples. Accordingly, pellets containing metal were not substantially present at the metal detector (magnets) provided at the outlet of the product tank, pellets having die build-up attached thereto were not substantially present, and the amount of fines present among the pellets was less than 100 ppm.

INDUSTRIAL APPLICABILITY

[0163] According to this disclosure, it is possible to inhibit the occurrence of die build-up at the openings of orifices in a die plate and produce good quality thermoplastic resin composition pellets by lowering the resin composition temperature at the openings of the orifices.

REFERENCE SIGNS LIST

[0164]

1	extruder
2	die section
21	die connecting section
22	screen changer section
23	manifold section
24	die plate section
24o	orifice
3	cooling device
3a	strand cooling tank
3b	strand guide
3bv	spraying device
4	pelletizer
5	pellet cooler
6	pellet screener
7	external lubricant addition device
8	pellet transporter
9	metal screener
10	contaminant screener
11	fines separator
12	intermediate tank
13	product tank
14	metal detector

15	dry air generator
16	dehydration device
D	orifice internal diameter
Do	orifice internal diameter
Dc	orifice internal diameter
L	orifice length
Lo	orifice length
Lc	orifice length
θ1	angle
θ2	angle
θ3	angle
L1	distance from orifice openings to cooling device

CLAIMS

1. A method for producing a thermoplastic resin composition pellet comprising:

using an extruder having an attached die plate including a plurality of orifices having an internal diameter D of 3.2 mm to 8 mm and a length L that is 0.3 times to 2.0 times the internal diameter D to obtain a thermoplastic resin composition through melt-kneading and to obtain one or more thermoplastic resin composition strands with an average residence time T of the thermoplastic resin composition in the orifices of 1 ms to 15 ms; and

pelletizing the thermoplastic resin composition strands to obtain one or more thermoplastic resin composition pellets.

2. The method for producing a thermoplastic resin composition pellet according to claim 1, wherein

an orifice that, among the plurality of orifices, is positioned at an outermost edge in a width direction of the die plate has a length Lo that is 0.5 times to 0.8 times a length Lc of an orifice that, among the plurality of orifices, is positioned most centrally in the width direction of the die plate.

3. The method for producing a thermoplastic resin composition pellet according to claim 1 or 2, wherein

an orifice that, among the plurality of orifices, is positioned at an outermost edge in a width direction of the die plate has an internal diameter Do that is 1.05 times to 1.3 times an internal diameter Dc of an orifice that, among the plurality of orifices, is positioned most centrally in the width direction of the die plate.

4. The method for producing a thermoplastic resin composition pellet according to any one of claims 1 to 3, wherein

at least part of a surface of the die plate at which the orifices open and inner surfaces of the orifices has a surface hardness of 800 to 5,000.

5. The method for producing a thermoplastic resin composition pellet according to any one of claims 1 to 4, wherein

at least one selected from the group consisting of a cooling device, a

pelletizer, a dehydration device, a pellet cooler, a pellet screener, an external lubricant addition device, a pellet transporter, a metal screener, a contaminant screener, a fines separator, an intermediate tank, a product tank, a metal detector, a dry air generator, and a dehydration device is further used downstream of the extruder.

6. The method for producing a thermoplastic resin composition pellet according to claim 5, wherein

the cooling device is a tank in which cooling water is stored.

7. The method for producing a thermoplastic resin composition pellet according to claim 5, wherein

the cooling device is a channel having an angle of inclination of 30° to 85° formed between an extension direction of the channel and a horizontal plane, and in which cooling water flows from one end to another end.

8. The method for producing a thermoplastic resin composition pellet according to claim 7, wherein

cooling water is sprayed at at least one location in the channel.

9. The method for producing a thermoplastic resin composition pellet according to claim 5, wherein

either or both of the intermediate tank and the product tank include a pellet mixer for homogeneously mixing the thermoplastic resin composition pellets.

10. The method for producing a thermoplastic resin composition pellet according to any one of claims 1 to 9, wherein

at least 95% of the thermoplastic resin composition pellets have an external diameter of 2 mm to 4 mm and a length of 2 mm to 4 mm.

11. The method for producing a thermoplastic resin composition pellet according to any one of claims 1 to 10, wherein

the thermoplastic resin composition contains at least one thermoplastic resin selected from the group consisting of a polyamide resin, a polyphenylene ether resin, a polystyrene resin, a polycarbonate, a polyolefin

resin, a polyoxymethylene, and a polyphenylene sulfide.

12. The method for producing a thermoplastic resin composition pellet according to any one of claims 1 to 11, wherein

the thermoplastic resin composition contains a polyphenylene ether resin and another thermoplastic resin.

13. The method for producing a thermoplastic resin composition pellet according to claim 12, wherein

the other thermoplastic resin is at least one thermoplastic resin selected from the group consisting of a polyamide resin, a polystyrene resin, a polyolefin resin, and a polyphenylene sulfide.

14. The method for producing a thermoplastic resin composition pellet according to claim 12 or 13, wherein

the thermoplastic resin composition contains: a thermoplastic resin including 20 parts by mass to 98 parts by mass of a polyphenylene ether resin and 2 parts by mass to 80 parts by mass of a polystyrene resin; and 0 parts by mass to 50 parts by mass of a flame retardant relative to 100 parts by mass, in total, of the polyphenylene ether resin and the polystyrene resin.

15. The method for producing a thermoplastic resin composition pellet according to any one of claims 12 to 14, further comprising

compressing and pulverizing the polyphenylene ether resin to obtain a compressed and pulverized polyphenylene ether resin, wherein

the thermoplastic resin composition is obtained through melt-kneading of the compressed and pulverized polyphenylene ether resin and the other thermoplastic resin.

16. The method for producing a thermoplastic resin composition pellet according to claim 15, wherein

the compressed and pulverized polyphenylene ether resin has an average particle diameter of 1,000 μm to 3,000 μm, and a proportion thereof having a particle diameter of 106 μm or less is 20 mass% or less.