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(54) **FILM PRODUCING APPARATUS AND METHOD OF PRODUCING FILM**

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(57) **ABSTRACT**

The present invention provides a film producing apparatus and a method of producing a film both of which improve the efficiency of producing a film. A film producing apparatus includes a plasticizer separating section configured to separate a portion of a film-forming plasticizer from a film at a stage previous to a cleaning section.

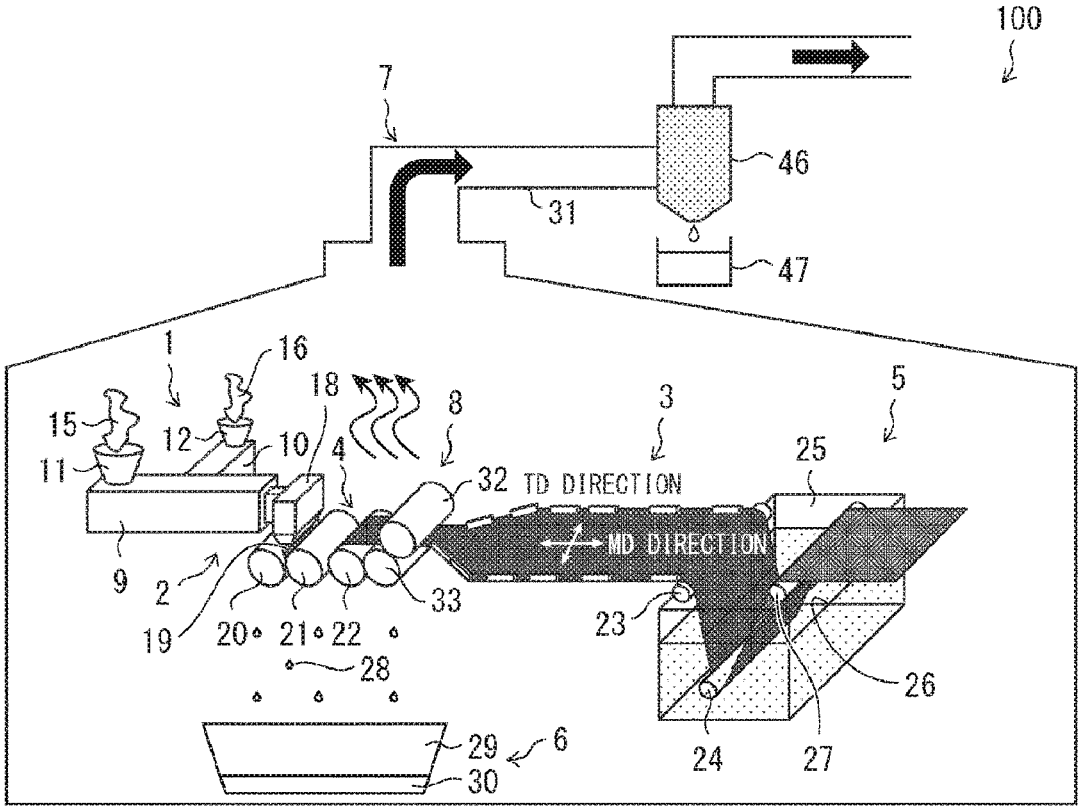


FIG. 1

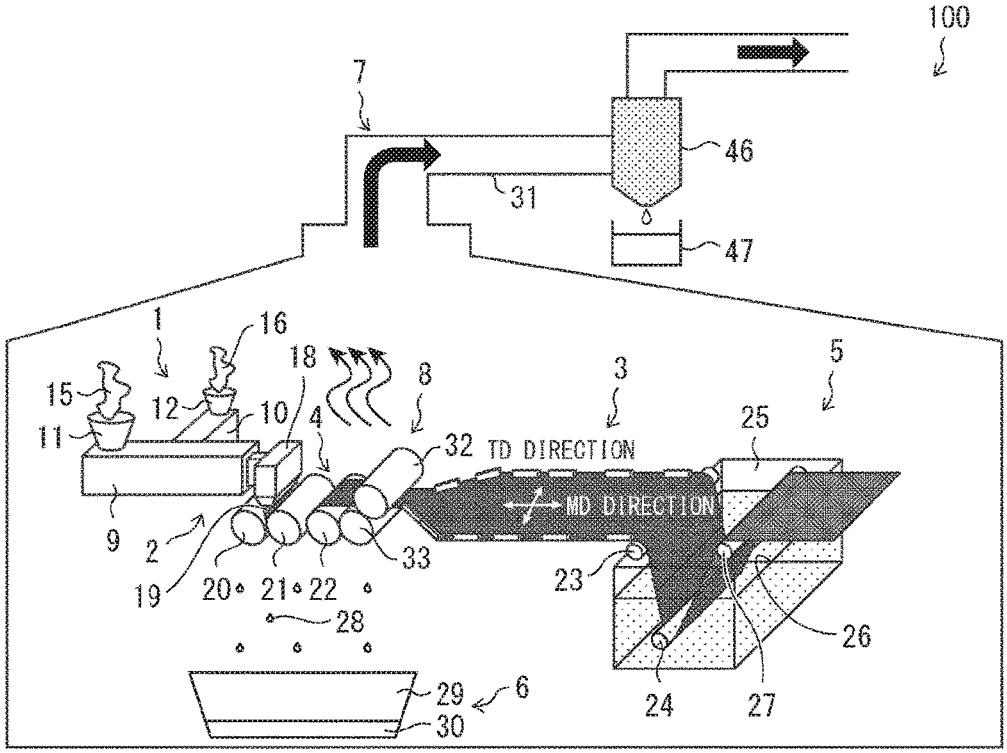

100
7
46
31
47
1
16
18
8
3
5
15
12
10
4
32
TD DIRECTION
25
11
MD DIRECTION
9
2
33
19
20
21
22
23
28
26
29
6
30
24
27

FIG. 2

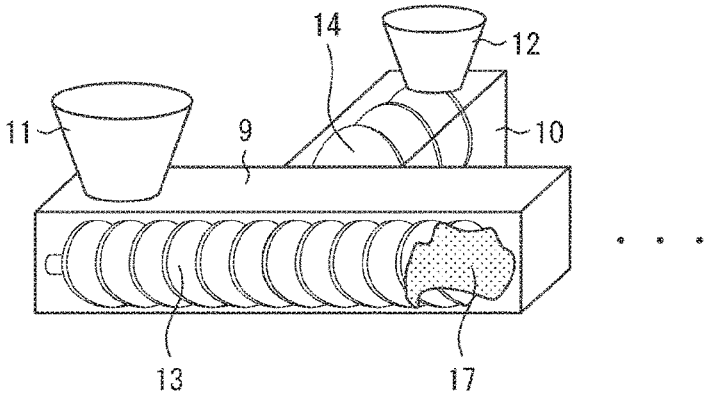

14
12
11
9
10
13
17

FIG. 3

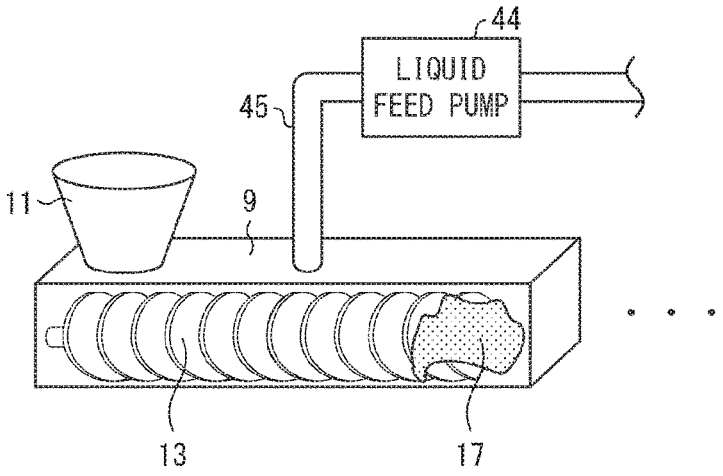


FIG. 4

	POLYETHYLENE	LIQUID PARAFFIN
PREPARATION	1	4.3
BEFORE STRETCHING	1	3.2
BEFORE CLEANING	1	2.0

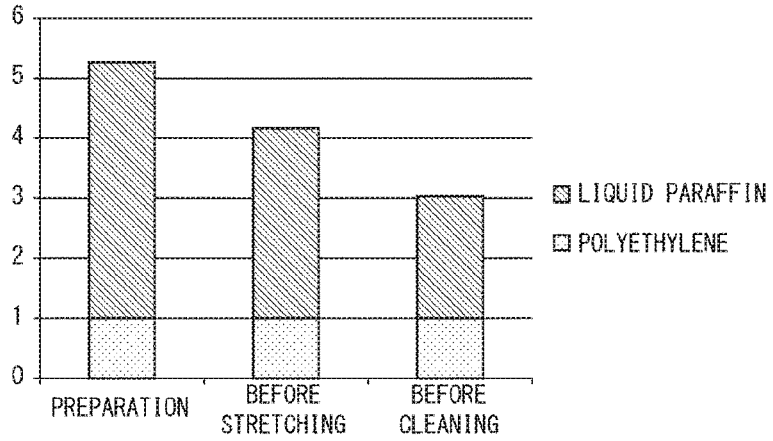


FIG. 5

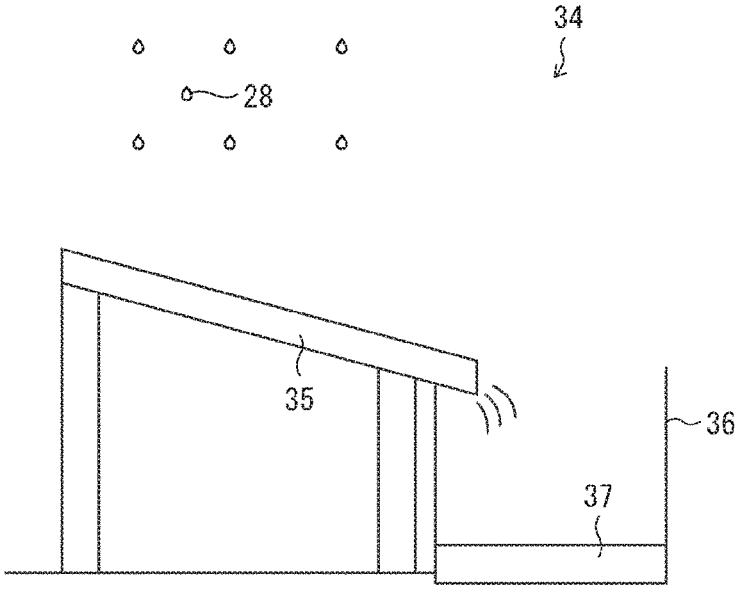


FIG. 6

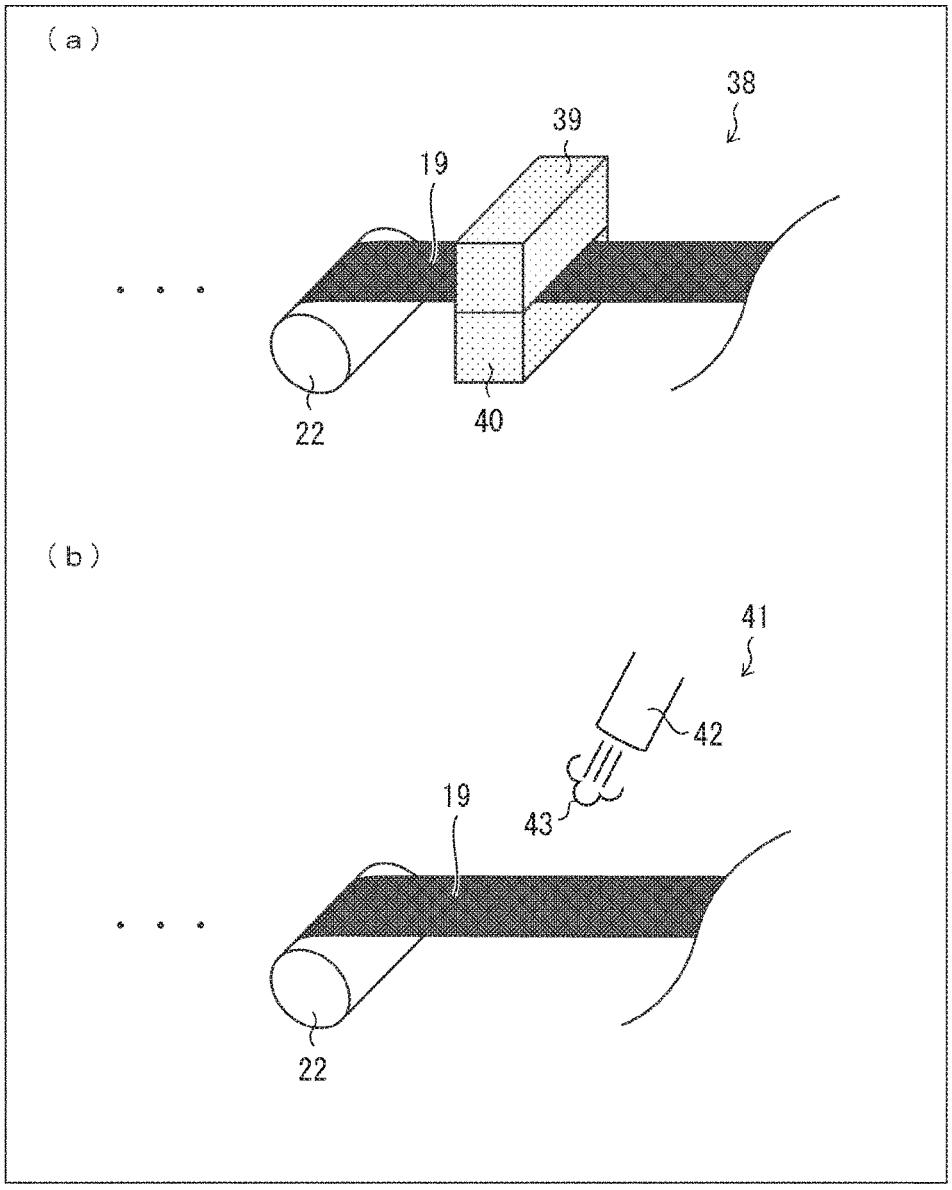
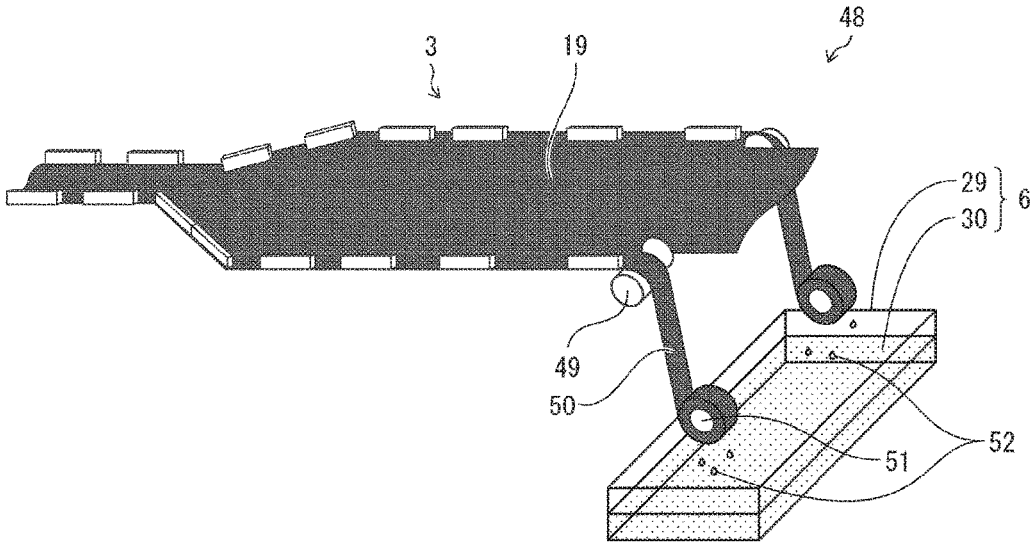


FIG. 7



FILM PRODUCING APPARATUS AND METHOD OF PRODUCING FILM

[0001] This Nonprovisional application claims priority under 35 U.S.C. § 119 on Patent Application No. 2017-041081 filed in Japan on Mar. 3, 2017, the entire contents of which is hereby incorporated by reference.

TECHNICAL FIELD

[0002] The present invention relates to a film producing apparatus and a film producing method both of which form a film in a form of a sheet by kneading a polyolefin resin and a film-forming plasticizer to prepare a polyolefin resin solution, and then performing extrusion molding of the polyolefin resin solution thus prepared.

BACKGROUND ART

[0003] Nonaqueous electrolyte secondary batteries such as a lithium-ion secondary battery are in widespread use as batteries for a personal computer, a mobile telephone, a portable information terminal, an electric vehicle, and others. Attention is paid to, in particular, the lithium-ion secondary battery because the lithium-ion secondary battery has a higher energy density, emits less carbon dioxide, and makes a greater contribution to energy saving than a conventional secondary battery. Under the circumstances, the demand for the lithium-ion secondary battery has grown greatly. To meet this demand, it has been required to reduce the costs of producing the lithium-ion secondary battery and a separator for the nonaqueous electrolyte secondary battery (hereinafter referred to as a "nonaqueous electrolyte secondary battery separator").

[0004] The so-called wet film forming method is known as a technique for producing the nonaqueous electrolyte secondary battery separator and other films. According to the wet film forming method, a film in a form of a sheet is formed by kneading a polyolefin resin and a liquid paraffin (film-forming plasticizer) to prepare a polyolefin resin solution, and then performing extrusion molding of the polyolefin resin solution thus prepared.

[0005] Patent Literature 1 discloses a technique of cleaning the film to remove a liquid paraffin from the film.

CITATION LIST

Patent Literature

[Patent Literature 1]

[0006] Japanese Patent Application Publication, Tokukai, No. 2014-102882 (Publication Date: Jun. 5, 2014)

SUMMARY OF INVENTION

Technical Problem

[0007] In the technique disclosed in Patent Literature 1, a film enters a cleaning tank in a state in which the film has a large amount of liquid paraffin adhered thereto. Unfortunately, the technique disclosed in Patent Literature 1 has the problem of a decreased efficiency of producing a film for the following reasons (1) and (2).

[0008] (1) The liquid paraffin adhered to the film hinders cleaning of the film, resulting in a decreased efficiency of cleaning the film.

[0009] (2) A liquid paraffin is relatively expensive. Thus, it is considered that the cost of producing a film can be reduced by collecting and reusing a liquid paraffin. However, collection of a used liquid paraffin requires extraction of a liquid paraffin having been mixed into a cleaning liquid in the cleaning tank. Due to such an extraction, collection of a liquid paraffin becomes a time-consuming and heavy-load operation.

[0010] The present invention has been made in view of the above problem, and it is an object of the present invention to provide a film producing apparatus and a film producing method both of which enable improvement in efficiency of producing a film.

Solution to Problem

[0011] In order to achieve the above object, a fill producing apparatus in accordance with an aspect of the present invention includes: a kneading section configured to knead a polyolefin resin and a film-forming plasticizer to prepare a polyolefin resin solution; an extruding section configured to perform extrusion molding of the polyolefin resin solution thus prepared to form a film in a form of a sheet; a stretching section configured to stretch the film; a cleaning section configured to clean the film; and a plasticizer separating section configured to separate a portion of the film-forming plasticizer from the film at a stage previous to the cleaning section.

[0012] In order to achieve the above object, a method of producing a film in accordance with an aspect of the present invention includes: a first kneading step including kneading a first polyolefin resin and a first film-forming plasticizer to prepare a first polyolefin resin solution; an extruding step including performing extrusion molding of the first polyolefin resin solution thus prepared to form a film in a form of a sheet; a stretching step including stretching the film; a cleaning step including cleaning the film; and a plasticizer separating step including separating a portion of the first film-forming plasticizer from the film at a stage previous to the cleaning step.

[0013] According to the above configuration, separating a portion of the film-forming plasticizer from the film before cleaning of the film enables preventing the occurrence of a situation in which the film-forming plasticizer contained in the film hinders cleaning of the film.

[0014] According to the above configuration, separating a portion of the film-forming plasticizer from the film before cleaning of the film also eliminates the need to extract a portion of the film-forming plasticizer which portion has been mixed into the cleaning liquid in the cleaning tank or enables the mixed portion of the film-forming plasticizer to be extracted with a light load.

[0015] Thus, the above configuration enables improvement in efficiency of producing a film.

[0016] Further, a film producing apparatus in accordance with an aspect of the present invention includes: a kneading section configured to knead a polyolefin resin and a film-forming plasticizer to prepare a polyolefin resin solution; an extruding section configured to perform extrusion molding of the polyolefin resin solution thus prepared to form a film in a form of a sheet; a stretching section configured to stretch the film; a cleaning section configured to clean the film; and a conveying section configured to convey the film from the extruding section to the cleaning section, the conveying section causing the film to enter the cleaning section in a

state in which the amount of the film-forming plasticizer contained in the film is decreased by not less than 30% to not more than 70% relative to the amount of the film-forming plasticizer contained in the polyolefin resin solution which is equal in volume to the film.

[0017] Still further, a method of producing a film in accordance with an aspect of the present invention includes: a first kneading step including kneading a first polyolefin resin and a first film-forming plasticizer to prepare a first polyolefin resin solution; an extruding step including performing extrusion molding of the first polyolefin resin solution thus prepared to form a film in a form of a sheet; a stretching step including stretching the film; a cleaning step including cleaning the film; and a conveying step including conveying the film from an extruding section, in which the extruding step is performed, to a cleaning section, in which the cleaning step is performed, the conveying step including causing the film to enter the cleaning section in a state in which the amount of the first film-forming plasticizer contained in the film is decreased by not less than 30% to not more than 70% relative to the amount of the first film-forming plasticizer contained in the first polyolefin resin solution which is equal in volume to the film.

[0018] According to the above configuration, a small amount of film-forming plasticizer contained in the film at the start of cleaning of the film enables preventing the occurrence of a situation in which the film-forming plasticizer contained in the film hinders cleaning of the film.

[0019] According to the above configuration, a small amount of film-forming plasticizer contained in the film at the start of cleaning of the film also eliminates the need to extract a portion of the film-forming plasticizer which portion has been mixed into the cleaning liquid in the cleaning tank or enables the mixed portion of the film-forming plasticizer to be very easily extracted with a light load.

[0020] Thus, the above configuration enables improvement in efficiency of producing a film

Advantageous Effects of Invention

[0021] The present invention enables improvement in efficiency of producing a film.

BRIEF DESCRIPTION OF DRAWINGS

[0022] FIG. **1** is a schematic diagram illustrating the configuration of a film producing apparatus in accordance with an embodiment of the present invention.

[0023] FIG. **2** is a diagram transparently illustrating the insides of two kneading chambers.

[0024] FIG. **3** is a schematic diagram illustrating an example of a modification made to the configuration illustrated in FIG. **2**.

[0025] FIG. **4** is a graph showing an example of weight ratios between polyethylene and a liquid paraffin in a polyethylene resin solution.

[0026] FIG. **5** is a schematic diagram illustrating another example of a first plasticizer collecting section.

[0027] (a) and (b) of FIG. **6** are schematic diagrams illustrating other examples of a plasticizer separating section.

[0028] FIG. **7** is a schematic diagram illustrating another example of the plasticizer separating section.

DESCRIPTION OF EMBODIMENTS

[0029] Embodiments for carrying out the present invention will be discussed below with reference to FIGS. **1** to **7**.

[0030] FIG. **1** is a schematic diagram illustrating the configuration of a film producing apparatus **100** in accordance with an embodiment of the present invention. FIG. **2** is a diagram transparently illustrating the insides of kneading chambers **9** and **10**, which are provided in the film producing apparatus **100**. FIG. **3** is a schematic diagram illustrating an example of a modification made to the configuration illustrated in FIG. **2**.

[0031] The film producing apparatus **100** includes a kneading section **1**, an extruding section **2**, a stretching section **3**, a conveying section **4**, a cleaning section **5** first plasticizer collecting section **6**, a second plasticizer collecting section **7**, and a plasticizer separating section **8**.

[0032] The kneading section **1** includes a kneading chamber **9**, a kneading chamber **10**, a polyolefin resin feed opening **11**, a film-forming plasticizer feed opening **12**, a screw **13**, and a screw **14**. Further, the kneading chamber **9** and the kneading chamber **10** are connected to each other.

[0033] When the polyolefin resin **15** is fed into the polyolefin resin feed opening **11**, the polyolefin resin **15** enters the kneading chamber **9**. Examples of the polyolefin resin **15** include polyethylene. Meanwhile, when the film-forming plasticizer (first film-forming plasticizer) **16** is fed into the film-forming plasticizer feed opening **12**, the film-forming plasticizer **16** enters the kneading chamber **10**. Alternatively, the film-forming plasticizer **16** can enter both the kneading chamber **9** and the kneading chamber **10** through both the polyolefin resin feed opening **11** and the film-forming plasticizer feed opening **12**.

[0034] Further alternatively, in a case where the film-forming plasticizer **16** is in the form of a liquid at normal temperature, the film-forming plasticizer **16** can be fed into the kneading chamber **9** through the use of a liquid feed pump **44** and a liquid feed pipe **45** as illustrated in FIG. **3**, rather than through the use of the kneading chamber **10**, the film-forming plasticizer feed opening **12**, and the screw **14**.

[0035] Examples of the film-forming plasticizer **16** in the form of a liquid at normal temperature include: liquid paraffin; phthalate esters such as dibutyl phthalate, bis(2-ethylhexyl) phthalate, dioctyl phthalate, and dinonyl phthalate; and unsaturated higher alcohols such as oleyl alcohol. Examples of the film-forming plasticizer **16** in the form of a solid at normal temperature include: paraffin wax; and saturated higher alcohols such as stearyl alcohol.

[0036] The screw **14** kneads the film-forming plasticizer **16** having entered the kneading chamber **10**, and extrudes the film-forming plasticizer **16** from the kneading chamber **10** to the kneading chamber **9**. The screw **13** kneads (i) the polyolefin resin **15** having entered the kneading chamber **9** and (ii) the film-forming plasticizer **16** having been extruded from the kneading chamber **10** to the kneading chamber **9**, so that a polyolefin resin solution (first polyolefin resin solution) **17** is prepared (first kneading step).

[0037] The extruding section **2** includes the screw **13** and a die **18**. The extruding section **2** performs, through the use of the die **18**, extrusion molding of the polyolefin resin solution **17** having been extruded from the kneading chamber **9** by the screw **13**, so as to form a film **19** in the form of a sheet (extruding step). Using the die **18** is merely an example. As alternatives to the die **18**, various kinds of

devices capable of performing extrusion molding of the polyolefin resin solution **17** can be used.

[0038] The stretching section **3** stretches the film **19** in a machine direction (MD; also referred to as MD direction) and in a transverse direction (TD; also referred to as TD direction) (stretching step). The MD direction, which is a lengthwise direction of the film **19**, is a direction of the flow of the film **19** during the production through the use of the film producing apparatus **100**. The TD direction is a direction perpendicular to the MD direction.

[0039] The conveying section **4** includes a roller **20**, a roller **21**, a roller **22**, a roller **23**, and a roller **24**. The conveying section **4** conveys the film **19** so that the film **19** passes through the extruding section **2**, the stretching section **3**, and the cleaning section **5** in this order (conveying step).

[0040] The cleaning section **5** includes a cleaning tank **25**. The cleaning tank **25** is filled with a cleaning liquid **26**. Examples of the cleaning liquid **26** include: hydrocarbons such as pentane, hexane, and heptane; alcohols such as methanol, ethanol, and isopropanol; ketones such as acetone and methyl ethyl ketone; and chlorine-based hydrocarbons such as methylene chloride and 1,1,1-trichloroethan. The film **19** having been stretched by the stretching section **3** enters the cleaning section **5** and is then immersed in the cleaning liquid **26**. The film **19** is cleaned by being immersed in the cleaning liquid **26** (cleaning step). This cleaning removes a portion of the film-forming plasticizer **16** which portion has adhered to the film **19**. The film **19** having been cleaned passes through a roller **27**, thereby being pulled out of the cleaning liquid **26** and then being gotten out of the cleaning section **5**.

[0041] By the way, the film **19** having been formed by the extruding section **2** has a high temperature. Such a high-temperature film **19** is cooled in the process of passing through the roller **20**, the roller **21**, and the roller **22**. The cooling causes phase separation between the polyolefin resin **15** and the film-forming plasticizer **16** both of which have been dissolved with each other, thereby forming a microporous structure having a skeleton of the polyolefin resin **15**. The cooling separates, from the film **19**, a certain amount of portion of the film-forming plasticizer **16** contained in the film **19**. Specifically, a certain amount of portion of the film-forming plasticizer **16** contained in the film **19** is dripped from the film **19**. In FIG. **1**, a portion of the film-forming plasticizer **16** which portion has been dripped from the film **19** corresponds to drops **28**. Moreover, the film **19** having been formed by kneading in the extruding section **2** and extrusion through the die **18** has a high temperature. Thus, a portion of the film-forming plasticizer **16** contained in the film **19** is volatilized from the film **19**.

[0042] The first plasticizer collecting section **6** includes a container **29** for receiving the drops **28**. The first plasticizer collecting section **6** causes the container **29** to receive the drops **28**, thereby collecting a portion of the film-forming plasticizer **16** which portion has been dripped from the film **19** (plasticizer collecting step). In FIG. **1**, a liquid **30** stored in the container **29** is the drops **28** collected and obtained by the container **29**.

[0043] The container **29** is preferably provided immediately below the area where the film **19** is cooled. As described previously, during cooling of the film **19**, a large amount of portion of the film-forming plasticizer **16** is dripped from the film **19**. Providing the container **29** immediately below the area where the film **19** is cooled allows the film-forming plasticizer **16** to be received immediately below the film **19** being cooled. This achieves an adequately high rate of collection of a used film-forming plasticizer **16**.

[0044] Further, the container **29** is preferably provided immediately below the plasticizer separating section **8**, which will be described later. As described later, during separation of the film-forming plasticizer **16** from the film **19**, a large amount of portion of the film-forming plasticizer **16** is dripped from the film **19**. Providing the container **29** immediately below the plasticizer separating section **8** achieves an adequately high rate of collection of a used film-forming plasticizer **16**.

[0045] Providing the first plasticizer collecting section **6** enables collection of a portion of the film-forming plasticizer **16** which portion has been dripped from the film **19**. This makes it possible to increase a rate of collection of a used film-forming plasticizer **16**. Consequently, the cost of producing the film **19** can be reduced by reusing the film-forming plasticizer **16**. Note that the collected film-forming plasticizer **16** can be purified for reuse if necessary.

[0046] The second plasticizer collecting section **7** includes: a suction port **31** for suctioning a gas containing a portion of the film-forming plasticizer **16** which portion has been volatilized from the film **19**; a liquefying device (the so-called condenser) **46** provided in the passage of the suction port **31**; and a container **47** provided in a position where the film-forming plasticizer **16** having been liquefied by the liquefying device **46** is received. The liquefying device **46** is configured by, for example, an electrostatic precipitation mist collector, a filter mist collector, or a centrifugal mist collector. The liquefying device **46** is preferably provided in an atmosphere where a temperature is adjusted to an optimum temperature for producing the film **19** (e.g., in a clean room where the film producing apparatus **100** is installed). In the second plasticizer collecting section **7**, the suction port **31**, the liquefying device **46**, and the container **47** collect a portion of the film-forming plasticizer **16** which portion has been volatilized from the film **19** (plasticizer collecting step). The gas having been suctioned through the suction port **31** passes through the liquefying device **46**. Thereafter, the gas may be discharged out of the film producing apparatus **100** or may be returned to the film producing apparatus **100**. The suction port **31** can also be referred to as an outlet. Note, however, that the liquefying device **46** is not necessary in a case where the volatilized portion of the film-forming plasticizer from the film **19** can be naturally liquefied by an atmosphere surrounding the volatilized portion of the film forming plasticizer **16**. In this case, a portion of the film-forming plasticizer **16** which portion has been liquefied by, for example, a ramp in the passage of the suction port **31** is collected.

[0047] Providing the second plasticizer collecting section **7** enables collection of a portion of the film-forming plasticizer **16** which portion has been volatilized from the film **19**. This makes it possible to increase a rate of collection of a used film-forming plasticizer **16**. Consequently, the cost of producing the film **19** can be reduced by reusing the film-forming plasticizer **16**. Note that the collected film-forming plasticizer **16** may be purified for reuse if necessary.

[0048] The plasticizer separating section **8** includes a nip roller **32** and a nip roller **33** between which the film **19** is sandwiched. The nip roller **32** and the nip roller **33** are provided at a stage previous to the stretching section **3** (at a stage previous to the cleaning section) and at a stage

subsequent to the roller **22**. The nip roller **32** can slide one surface of the film **19** without rotating. The nip roller **33** can slide another surface of the film **19** without rotating. The nip roller **32** and the nip roller **33** sandwich the film **19** therebetween, thereby dropping a portion of the film-forming plasticizer **16** from the film **19**. In the plasticizer separating section **8**, the nip rollers **32** and **33** separate a portion of the film-forming plasticizer **16** from the film **19** at the stage previous to the stretching section **3** (plasticizer separating step).

[0049] Providing the plasticizer separating section **8** to separate a portion of the film-forming plasticizer **16** from the film **19** before cleaning of the film **19** enables preventing the occurrence of a situation in which the film-forming plasticizer **16** having adhered to the film **19** hinders cleaning of the film **19**.

[0050] Providing the plasticizer separating section **8** to separate a portion of the film-forming plasticizer **16** from the film **19** before cleaning of the film **19** also eliminates the need to extract a portion of the film-forming plasticizer **16** which portion has been mixed into the cleaning liquid **26** in the cleaning tank **25** or enables the mixed portion of the film-forming plasticizer **16** to be extracted with a light load.

[0051] Thus, providing the plasticizer separating section **8** allows for improvement in efficiency of producing the film **19**.

[0052] Note that the nip rollers **32** and **33** may each be replaced by a blade, an air knife, or other component that can slide the film **19** to drop a portion of the film-forming plasticizer **16** from the film **19**. In other words, even replacing the nip roller **32** by a blade or an air knife and/or replacing the nip roller **33** by a blade or an air knife can achieve a function that is much the same as the function of the plasticizer separating section **8**.

[0053] Stretching of the film **19** by the stretching section **3** requires a certain amount of plasticizer for evenly stretching the film **19**. Thus, it is effective that before the film **19** enters the stretching section **3**, a portion of the film-forming plasticizer **16** is separated from the film **19** to such an extent that the stretching section **3** does not become excessively contaminated with a retained portion of the film-forming plasticizer **16** in the film **19**, and then, before the film **19** enters the cleaning section **5**, another portion of the film-forming plasticizer **16** in the film **19** is further separated.

[0054] The plasticizer separating section **8** separates portion of the film-forming plasticizer **16** from the film **19**, so that the conveying section **4** causes the film **19** to enter the stretching section **3** in a state in which the amount of film-forming plasticizer **16** contained in the film **19** is decreased by not less than 10% to not more than 40% relative to the amount of film-forming plasticizer **16** contained in the polyolefin resin solution **17** which is equal in volume to the film **19**.

[0055] The plasticizer separating section **8** separates a portion of the film-forming plasticizer **16** from the film **19**, so that the conveying section **4** causes the film **19** to enter the cleaning section **5** in a state in which the amount of film-forming plasticizer **16** contained in the film **19** is decreased by not less than 30% to not more than 70% relative to the amount of film-forming plasticizer **16** contained in the polyolefin resin solution **17** which is equal in volume to the film **19**. Note, however, that a decreased amount resulting from the not less than 30% to not more than 70% decrease will be larger than that resulting from the not less than 10% to not more than 40% decrease. In other words, the amount of film-forming plasticizer **16** contained in the film **19** at the entry into the stretching section **3** is larger than the amount of film-forming plasticizer **16** contained in the film **19** at the entry into the cleaning section **5**.

[0056] FIG. **4** is a graph showing an example of weight ratios between polyethylene as an example of the polyolefin resin **15** and a liquid paraffin as an example of the film-forming plasticizer **16**, in a polyethylene resin solution as an example of the polyolefin resin solution **17**. Specifically, FIG. **4** shows weight ratios obtained when the weight of polyethylene is assumed to be **1**. In the graph shown in FIG. **4**, "PREPARATION" indicates a timing when kneading of polyethylene and liquid paraffin is completed. Further, in the graph shown in FIG. **4**, "BEFORE STRETCHING" indicates a timing immediately before the film **19** enters the stretching section **3**. Still further, in the graph shown in FIG. **4**, "BEFORE CLEANING" indicates a timing immediately before the film **19** enters the cleaning section **5**.

[0057] A small amount of film-forming plasticizer **16** contained in the film **19** at the start of cleaning of the film **19** can prevent the occurrence of a situation in which the film-forming plasticizer **16** having adhered to the film **19** hinders cleaning of the film **19**.

[0058] A small amount of film-forming plasticizer **16** contained in the film **19** at the start of cleaning of the film **19** also eliminates the need to extract a portion of the film-forming plasticizer **16** which portion has been mixed into the cleaning liquid **26** in the cleaning tank **25** or enables the mixed portion of the film-forming plasticizer **16** to be very easily extracted with a light load.

[0059] This enables improvement in efficiency of producing the film **19**.

[0060] The film producing apparatus **100** uses the plasticizer separating section **8** to bring about a state in which a desired amount of film-forming plasticizer **16** is contained in the film **19**. However, using the plasticizer separating section **8** is not always a requirement to bring about such a state. For example, the plasticizer separating section **8** can be omitted in the fill producing apparatus **100**, provided that such a state is achieved by dripping or volatilization of a portion of the film-forming plasticizer **16** from the film **19** or by heating of the film **19** in the stretching section **3**.

[0061] Examples of a finished product that includes a film produced by the film producing apparatus **100** include a nonaqueous electrolyte secondary battery separator. However, an application for which the film producing apparatus **100** is used is not limited to the production of a nonaqueous electrolyte secondary battery separator. The film producing apparatus **100** can also serve as apparatuses for producing various films that can be produced by a wet film forming method.

[0062] Portions of the film-forming plasticizer **16** which portions have been collected by the first plasticizer collecting section **6** and by the second plasticizer collecting section **7** are made available for reuse. Specifically, the kneading section **1** kneads a polyolefin resin **15** or other polyolefin resin which is different from the polyolefin resin **15**, the collected portions of the film-forming plasticizer **16**, and a separately prepared film-forming plasticizer (second film-forming plasticizer). Through the kneading, the kneading section **1** prepares a polyolefin resin solution (second poly-

olefin resin solution) (second kneading step). The cost of producing the film **19** can be reduced by reusing the film-forming plasticizer **16**.

[0063] FIG. **5** is a schematic diagram illustrating a first plasticizer collecting section **34**.

[0064] The first plasticizer collecting section **34** illustrated in FIG. **5** is different from the first plasticizer collecting section **6** illustrated in FIG. **1** in the following points. Specifically, the first plasticizer collecting section **34** includes a liquid receiving member **35** for receiving drops **28**; and a container **36** provided in such a position that a portion of the film-forming plasticizer **16** is flown into the container **36** through the liquid receiving member **35**. In FIG. **5**, a liquid **37** stored in the container **36** is the drops **28** collected and obtained by the container **36**. The liquid receiving member **35** is preferably arranged in a tilted position so as to allow a portion of the film-forming plasticizer **16** to be flown into the container **36**. The liquid receiving member **35** may be an open pipe.

[0065] The liquid receiving member **35** is preferably provided immediately below the area where the film **19** is cooled. As described previously, during cooling of the film **19**, a large amount of portion of the film-forming plasticizer **16** is dripped from the film **19**. Providing the liquid receiving member **35** immediately below the area where the film **19** is cooled allows the film-forming plasticizer **16** to be received immediately below the film **19** being cooled. This achieves an adequately high rate of collection of a used film-forming plasticizer **16**.

[0066] Further, the liquid receiving member **35** is preferably provided immediately below the plasticizer separating section **8**. During separation of the film-forming plasticizer **16** from the film **19**, a large amount of portion of the film-forming plasticizer **16** is dripped from the film **19**. Providing the liquid receiving member **35** immediately below the plasticizer separating section **8** achieves an adequately high rate of collection of a used film-forming plasticizer **16**.

[0067] That is, the first plasticizer collecting section **6** illustrated in FIG. **1** is realized in the form of the container **29**, whereas the first plasticizer collecting section **34** illustrated in FIG. **5** is realized in the form of a combination of the liquid receiving member **35** and the container **36**. The film producing apparatus **100** may include the first plasticizer collecting section **34** in place of the first plasticizer collecting section **6**.

[0068] (a) of FIG. **6** is a schematic diagram illustrating a plasticizer separating section **38**.

[0069] The plasticizer separating section **38** illustrated in (a) of FIG. **6** is different from the plasticizer separating section **8** illustrated in FIG. **1** in the following points. Specifically, the plasticizer separating section **38** includes a sponge **39** and a sponge **40** both of which make contact with the film **19**. On contact with the film **19**, the sponge **39** and the sponge **40** each suck up a portion of the film-forming plasticizer **16** from the film **19**. The sponges **39** and **40** each have pores communicating with each other. A material of the sponges **39** and **40** can be urethane rubber having a hardness of 20 to 60, polyvinyl chloride (PVC), polyvinyl alcohol (PVA), or polypropylene (PP). Each of the sponges **39** and **40** may have a flat surface for making contact with the film **19** or may be shaped in a cylinder so as to rotate and make contact with the film **19**.

[0070] That is, the plasticizer separating section **8** illustrated in FIG. **1** is realized in the form of the nip rollers **32** and **33**, whereas the plasticizer separating section **38** illustrated in (a) of FIG. **6** is realized in the form of the sponges **39** and **40**. The film producing apparatus **100** may include the plasticizer separating section **38** in place of the plasticizer separating section **8**.

[0071] (b) of FIG. **6** is a schematic diagram illustrating a plasticizer separating section **41**.

[0072] The plasticizer separating section **41** illustrated in (b) of FIG. **6** is different from the plasticizer separating section **8** illustrated in FIG. **1** in the following points. Specifically, the plasticizer separating section **41** includes an air blast mechanism **42**. The air blast mechanism **42** blasts air **43** toward the film **19** to blow a portion of the film-forming plasticizer **16** off the film **19**.

[0073] That is, the plasticizer separating section **8** illustrated in FIG. **1** is realized in the form of the nip rollers **32** and **33**, whereas the plasticizer separating section **41** illustrated in (b) of FIG. **6** is realized in the form of the air blast mechanism **42**. The film producing apparatus **100** may include the plasticizer separating section **41** in place of the plasticizer separating section **8**.

[0074] FIG. **7** is a schematic diagram illustrating a plasticizer separating section **48**.

[0075] The plasticizer separating section **48** illustrated in FIG. **7** is different from the plasticizer separating section **8** illustrated in FIG. **1** in the following points. That is, the plasticizer separating section **48** includes: a slitting section **49** configured to slit the film **19** having been stretched by the stretching section **3** to cut off the end portions of the film **19** which end portions extend in the TD direction; and a slit scrap collecting section **51** configured to collect a slit scrap **50** which is caused by slitting the film **19**. The slitting section **49** and the slit scrap collecting section **51** are located downstream of the stretching section **3** and upstream of the cleaning tank **25** of the cleaning section **5**. The end portions of the film **19** having been stretched by the stretching section **3** which end portions extend in the TD direction are larger in thickness than a center portion of the film **19** having been stretched by the stretching section **3** which center portion extends in the TD direction, and the end portions contain a larger amount of film-forming plasticizer **16** than the center portion. Thus, it is possible to effectively collect the film-forming plasticizer **16** from the slit scrap **50**. Examples of a method of collecting the film-forming plasticizer **16** from the slit scrap **50** include a method including: pressing the collected slit scrap **50** to squeeze the film-forming plasticizer **16** out of the slit scrap **50**; and storing the squeezed film-forming plasticizer **16** in a container for receiving the squeezed film-forming plasticizer **16**.

[0076] The slit scrap collecting section **51** is preferably such that the slit scrap **50** is wound up by, for example, a bobbin to collect the film-forming plasticizer **16**. When the slit scrap **50** is wound up by, for example, a bobbin, winding of the slit scrap **50** separates the film-forming plasticizer **16** from the slit scrap **50**, and thus causes drops **52** containing the film-forming plasticizer **16** to be dripped. Thus, it is preferable that a container **29** for receiving the drops **52** is provided immediately below the slit scrap collecting section **51**. Providing the container **29** immediately below the slit scrap collecting section **51** achieves an increase in rate of

collection of the film-forming plasticizer **16** and reduction of contamination with the film-forming plasticizer **16** in the step.

[0077] Note that the slitting section **49** can perform slitting by any of methods including generally used slit methods such as a shear cutting method and a razor cutting method.

[0078] That is, the plasticizer separating section **8** illustrated in FIG. **1** is realized in the form of nip rollers **32** and **88**, while the plasticizer separating section **48** illustrated in FIG. **7** is realized in the form of a combination of the slitting section **49** and the slit scrap collecting section **51**. The film producing apparatus **100** may include the plasticizer separating section **48** in place of the plasticizer separating section **8**.

[0079] Note that the present invention also encompasses a film producing method using the film producing apparatus **100**.

[0080] [Recap]

[0081] A film producing apparatus in accordance with an embodiment of the present invention includes: a kneading section configured to knead a polyolefin resin and a film-forming plasticizer to prepare a polyolefin resin solution; an extruding section configured to perform extrusion molding of the polyolefin resin solution thus prepared to form a film in a form of a sheet; a stretching section configured to stretch the film; a cleaning section configured to clean the film; and a plasticizer separating section configured to separate a portion of the film-forming plasticizer from the film at a stage previous to the cleaning section.

[0082] Further, a method of producing a film in accordance with an embodiment of the present invention includes: a first kneading step including kneading a first polyolefin resin and a first film-forming plasticizer to prepare a first polyolefin resin solution; an extruding step including performing extrusion molding of the first polyolefin resin solution thus prepared to form a film in a form of a sheet; a stretching step including stretching the film; a cleaning step including cleaning the film; and a plasticizer separating step including separating a portion of the first film-forming plasticizer from the film at a stage previous to the cleaning step.

[0083] According to the above configuration, separating a portion of the film-forming plasticizer from the film before cleaning of the film enables preventing the occurrence of a situation in which the film-forming plasticizer contained in the film hinders cleaning of the film.

[0084] According to the above configuration, separating a portion of the film-forming plasticizer from the film before cleaning of the film also eliminates the need to extract a portion of the film-forming plasticizer which portion has been mixed into the cleaning liquid in the cleaning tank or enables the mixed portion of the film-forming plasticizer to be extracted with a light load.

[0085] Thus, the above configuration enables improvement in efficiency of producing a film.

[0086] Further, a film producing apparatus in accordance with an embodiment of the present invention is preferably configured such that the plasticizer separating section is configured to separate a portion of the film-forming plasticizer from the film at a stage previous to the stretching section.

[0087] Stretching of the film by the stretching section requires a certain amount of plasticizer for evenly stretching the film. Thus, it is effective that before the film enters the stretching section, a portion of the film-forming plasticizer is separated from the film to such an extent that the stretching section does not become excessively contaminated with a retained portion of the film-forming plasticizer in the film.

[0088] Still further, a film producing apparatus in accordance with an embodiment of the present invention is preferably configured such that the plasticizer separating section includes nip rollers between which the film is sandwiched or includes a blade(s) that slides the film or an air knife(s) that slides the film.

[0089] According to the above configuration, the plasticizer separating section can be realized in the form of nip rollers or in the form of a blade(s) or an air knife(s).

[0090] Further, a film producing apparatus in accordance with an embodiment of the present invention is preferably configured such that the plasticizer separating section includes sponges that make contact with the film.

[0091] According to the above configuration, the plasticizer separating section can be realized in the form of sponges.

[0092] Still further, a film producing apparatus in accordance with an embodiment of the present invention is preferably configured such that the plasticizer separating section includes an air blast mechanism for blasting air toward the film.

[0093] According to the above configuration, the plasticizer separating section can be realized in the form of an air blast mechanism.

[0094] Further, a film producing apparatus in accordance with an embodiment of the present invention is preferably configured such that the plasticizer separating section includes: a slitting section configured to slit the film to cut off end portions of the film; and a slit scrap collecting section configured to collect a slit scrap which is caused by slitting the film.

[0095] According to the above configuration, the plasticizer separating section can be realized in the form of a combination of the slitting section and the slit scrap collecting section.

[0096] Further, a film producing apparatus in accordance with an embodiment of the present invention includes: a kneading section configured to knead a polyolefin resin and a film-forming plasticizer to prepare a polyolefin resin solution; an extruding section configured to perform extrusion molding of the polyolefin resin solution thus prepared to form a film in a form of a sheet; a stretching section configured to stretch the film; a cleaning section configured to clean the film; and a conveying section configured to convey the film from the extruding section to the cleaning section, the conveying section causing the film to enter the cleaning section in a state in which the amount of the film-forming plasticizer contained in the film is decreased by not less than 30% to not more than 70% relative to the amount of the film-forming plasticizer contained in the polyolefin resin solution which is equal in volume to the film.

[0097] Still further, a method of producing a film in accordance with an embodiment of the present invention includes: a first kneading step including kneading a first polyolefin resin and a first film-forming plasticizer to prepare a first polyolefin resin solution; an extruding step including performing extrusion molding of the first polyolefin resin solution thus prepared to form a film in a form of a sheet; a stretching step including stretching the film; a

cleaning step including cleaning the film; and a conveying step including conveying the film from an extruding section, in which the extruding step is performed, to a cleaning section, in which the cleaning step is performed, the conveying step including causing the film to enter the cleaning section in a state in which the amount of the first film-forming plasticizer contained in the film is decreased by not less than 30% to not more than 70% relative to the amount of the first film-forming plasticizer contained in the first polyolefin resin solution which is equal in volume to the film.

[0098] According to the above configuration, a small amount of film-forming plasticizer contained in the film at the start of cleaning of the film enables preventing the occurrence of a situation in which the film-forming plasticizer contained in the film hinders cleaning of the film.

[0099] According to the above configuration, a small amount of film-forming plasticizer contained in the film at the start of cleaning of the film also eliminates the need to extract a portion of the film-forming plasticizer which portion has been mixed into the cleaning liquid in the cleaning tank or enables the mixed portion of the film-forming plasticizer to be very easily extracted with a light load.

[0100] Thus, the above configuration enables improvement in efficiency of producing a film.

[0101] Further, a film producing apparatus in accordance with an embodiment of the present invention is preferably configured such that the conveying section causes the film to enter the stretching section in a state in which the amount of the film-forming plasticizer contained in the film is decreased by not less than 10% to not more than 40% relative to the amount of the film-forming plasticizer contained in the polyolefin resin solution which is equal in volume to the film, and the amount of the film-forming plasticizer contained in the film at the entry into the stretching section is larger than the amount of the film-forming plasticizer contained in the film at the entry into the cleaning section. That is, a decreased amount resulting from the not less than 10% to not more than 40% decrease will be equal to or smaller than that resulting from the not less than 30% to not more than 70% decrease.

[0102] Still further, a method of producing a film in accordance with an embodiment of the present invention is preferably configured such that the conveying step includes causing the film to enter a stretching section, in which the stretching step is performed, in a state in which the amount of the first film-forming plasticizer contained in the film is decreased by not less than 10% to not more than 40% relative to the amount of the first film-forming plasticizer contained in the first polyolefin resin solution which is equal in volume to the film, and the amount of the first film-forming plasticizer contained in the film at the entry into the stretching section is larger than the amount of the first film-forming plasticizer contained in the film at the entry into the cleaning section. That is, a decreased amount resulting from the not less than 10% to not more than 40% decrease will be equal to or smaller than that resulting from the not less than 30% to not more than 70% decrease.

[0103] The above configuration easily achieves the not less than 30% to not more than 70% decrease.

[0104] Further, a method of producing a film in accordance with an embodiment of the present invention is preferably configured to further include: a plasticizer collecting step including collecting the portion of the first film-forming plasticizer which portion has been separated from the film; and a second kneading step including kneading a second polyolefin resin, the portion of the first film-forming plasticizer which portion has been collected in the plasticizer collecting step, and a second film-forming plasticizer to prepare a second polyolefin resin solution.

[0105] According to the above configuration, the cost of producing a film can be reduced by reusing the film-forming plasticizer.

[0106] Further, embodiments of the present invention can also be expressed as below.

[0107] That is, a film producing method in accordance with an embodiment of the present invention includes: a first kneading step of kneading a polyolefin resin and a first film-forming plasticizer to prepare a first polyolefin resin solution; an extruding step of performing extrusion molding of the first polyolefin resin solution thus prepared to form a film in a form of a sheet; a stretching step of stretching the film; a cleaning step of cleaning the film; and a plasticizer separating step of separating a portion of the first film-forming plasticizer from the film at a stage previous to the cleaning step.

[0108] Further, a film producing method in accordance with an embodiment of the present invention includes: a first kneading step of kneading a polyolefin resin and a first film-forming plasticizer to prepare a first polyolefin resin solution; an extruding step of performing extrusion molding of the first polyolefin resin solution thus prepared to form a film in a form of a sheet; a stretching step of stretching the film; a cleaning step of cleaning the film; and a conveying step of conveying the film from an extruding section, in which the extruding step is performed, to a cleaning section, in which the cleaning step is performed, the conveying step causing the film to enter the cleaning section in a state in which the amount of the first film-forming plasticizer contained in the film is decreased by not less than 30% to not more than 70% relative to the amount of the first film-forming plasticizer contained in the first polyolefin resin solution which is equal in volume to the film.

[0109] Still further, a film producing method in accordance with an embodiment of the present invention is configured such that the conveying step includes causing the film to enter a stretching section, in which the stretching step is performed, in a state in which the amount of the first film-forming plasticizer contained in the film is decreased by not less than 10% to not more than 40% relative to the amount of the first film-forming plasticizer contained in the first polyolefin resin solution which is equal in volume to the film, and the amount of the first film-forming plasticizer contained in the film at the entry into the stretching section is larger than the amount of the first film-forming plasticizer contained in the film at the entry into the cleaning section.

[0110] Further, a film producing method in accordance with an embodiment of the present invention further includes: a plasticizer collecting step of collecting the portion of the first film-forming plasticizer which portion has been separated from the film; and a second kneading step of kneading a polyolefin resin, the portion of the first film-forming plasticizer which portion has been collected in the plasticizer collecting step, and a second film-forming plasticizer to prepare a second polyolefin resin solution.

[0111] The present invention is not limited to the embodiments, but can be altered by a skilled person in the art within

the scope of the claims. The present invention also encompasses, in its technical scope, any embodiment derived by combining technical means disclosed in differing embodiments.

REFERENCE SIGNS LIST

[0112] **1**: Kneading section
[0113] **2**: Extruding section
[0114] **3**: Stretching section
[0115] **4**: Conveying section
[0116] **5**: Cleaning section
[0117] **6**: First plasticizer collecting section
[0118] **7**: Second plasticizer collecting section
[0119] **8**: Plasticizer separating section
[0120] **15**: Polyolefin resin (first polyolefin resin
[0121] **16**: Film-forming plasticizer
[0122] **17**: Polyolefin resin solution (first polyolefin resin solution
[0123] **19**: Film
[0124] **29**: Container
[0125] **31**: Suction port
[0126] **32**: Nip roller
[0127] **33**: Nip roller
[0128] **34**: First plasticizer collecting section
[0129] **35**: Liquid receiving member
[0130] **36**: Container
[0131] **38**: Plasticizer separating section
[0132] **39**: Sponge
[0133] **40**: Sponge
[0134] **41**: Plasticizer separating section
[0135] **42**: Air blast mechanism
[0136] **43**: Air
[0137] **48**: Plasticizer separating section
[0138] **49**: Slitting section
[0139] **51**: Slit scrap collecting section
[0140] **100**: Film producing apparatus

1. A film producing apparatus comprising:
a kneading section configured to knead a polyolefin resin and a film-forming plasticizer to prepare a polyolefin resin solution;
an extruding section configured to perform extrusion molding of the polyolefin resin solution thus prepared to form a film in a form of a sheet;
a stretching section configured to stretch the film;
a cleaning section configured to clean the film; and
a plasticizer separating section configured to separate a portion of the film-forming plasticizer from the film at a stage previous to the cleaning section.

2. The film producing apparatus according to claim **1**, wherein the plasticizer separating section is configured to separate a portion of the film-forming plasticizer from the film at a stage previous to the stretching section.

3. The film producing apparatus according to claim **1**, wherein the plasticizer separating section includes nip rollers between which the film is sandwiched or includes a blade(s) that slides the film or an air knife(s) that slides the film.

4. The film producing apparatus according to claim **1**, wherein the plasticizer separating section includes sponges that make contact with the film.

5. The film producing apparatus according to claim **1**, wherein the plasticizer separating section includes an air blast mechanism for blasting air toward the film.

6. The film producing apparatus according to claim **1**, wherein the plasticizer separating section includes: a slitting section configured to slit the film to cut off end portions of the film; and a slit scrap collecting section configured to collect a slit scrap which is caused by slitting the film.

7. A film producing apparatus comprising:
a kneading section configured to knead a polyolefin resin and a film-forming plasticizer to prepare a polyolefin resin solution;
an extruding section configured to perform extrusion molding of the polyolefin resin solution thus prepared to form a film in a form of a sheet;
a stretching section configured to stretch the film;
a cleaning section configured to clean the film; and
a conveying section configured to convey the film from the extruding section to the cleaning section,
the conveying section causing the film to enter the cleaning section in a state in which the amount of the film-forming plasticizer contained in the film is decreased by not less than 30% to not more than 70% relative to the amount of the film-forming plasticizer contained in the polyolefin resin solution which is equal in volume to the film.

8. The film producing apparatus according to claim **7**, wherein the conveying section causes the film to enter the stretching section in a state in which the amount of the film-forming plasticizer contained in the film is decreased by not less than 10% to not more than 40% relative to the amount of the film-forming plasticizer contained in the polyolefin resin solution which is equal in volume to the film, and
the amount of the film-forming plasticizer contained in the film at the entry into the stretching section is larger than the amount of the film-forming plasticizer contained in the film at the entry into the cleaning section.

9. A method of producing a film comprising:
a first kneading step comprising kneading a first polyolefin resin and a first film-forming plasticizer to prepare a first polyolefin resin solution;
an extruding step comprising performing extrusion molding of the first polyolefin resin solution thus prepared to form a film in a form of a sheet;
a stretching step comprising stretching the film;
a cleaning step comprising cleaning the film; and
a plasticizer separating step comprising separating portion of the first film-forming plasticizer from the film at a stage previous to the cleaning step.

10. A method of producing a film comprising:
a first kneading step comprising kneading a first polyolefin resin and a first film-forming plasticizer to prepare a first polyolefin resin solution;
an extruding step comprising performing extrusion molding of the first polyolefin resin solution thus prepared to form a film in a form of a sheet;
a stretching step comprising stretching the film;
a cleaning step comprising cleaning the film; and
a conveying step comprising conveying the film from an extruding section, in which the extruding step is performed, to a cleaning section, in which the cleaning step is performed,
the conveying step comprising causing the film to enter the cleaning section in a state in which the amount of the first film-forming plasticizer contained in the film is decreased by not less than 30% to not more than 70%

relative to the amount of the first film-forming plasticizer contained in the first polyolefin resin solution which is equal in volume to the film.

11. The method of producing a film according to claim **10**, wherein the conveying step comprises causing the film to enter a stretching section, in which the stretching step is performed, in a state in which the amount of the first film-forming plasticizer contained in the film is decreased by not less than 10% to not more than 40% relative to the amount of the first film-forming plasticizer contained in the first polyolefin resin solution which is equal in volume to the film, and

the amount of the first film-forming plasticizer contained in the film at the entry into the stretching section is larger than the amount of the first film-forming plasticizer contained in the film at the entry into the cleaning section.

12. The method of producing a film according to claim **9**, further comprising:

a plasticizer collecting step comprising collecting the portion of the first film-forming plasticizer which portion has been separated from the film; and

a second kneading step comprising kneading a second polyolefin resin, the portion of the first film-forming plasticizer which portion has been collected in the plasticizer collecting step, and a second film-forming plasticizer to prepare a second polyolefin resin solution.

13. The method of producing a film according to claim **10**, further comprising:

a plasticizer collecting step comprising collecting the portion of the first film-forming plasticizer which portion has been separated from the film; and

a second kneading step comprising kneading a second polyolefin resin, the portion of the first film-forming plasticizer which portion has been collected in the plasticizer collecting step, and a second film-forming plasticizer to prepare a second polyolefin resin solution.

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