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(54) **Method and apparatus for cooling molten filaments in spinning apparatus**

Verfahren und Vorrichtung zur Abkühlung von aus der Schmelze gesponnenen Fäden

Méthode et dispositif pour refroidir les filaments filés au fondu

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Description

1. Field of the Invention

The present invention relates to a method for cooling a plurality of molten filaments comprised of a thermoplastic resin extruded from dies and to an apparatus for carrying out that method.

2. Description of the Related Art

Figure 3 shows a spinning apparatus for filaments comprised of polyethylene, polypropylene, or other thermoplastic resins. In this apparatus, a plurality of molten filaments 2 extruded from a die 1 are cooled by cooling air blown from a cooling apparatus 3 and then taken up with a draft. The cooling apparatus 3 comprises a chimney 4 connected to a die 1 in a manner so as to surround the molten filaments 2 and a gas temperature adjustment apparatus 5 composed of coolers. The apparatus 5 cools the cooling air to the desired temperature and the cooling air is fed to the chimney 4 by a fan 6 and is blown from the inner peripheral surface thereof through a filter 7. Reference numeral 8 is an exhaust fan.

In the cooling of molten filaments, if the temperature of the cooling air is lowered or the air flow rate is increased so as to rapidly cool the filaments, only the surface of the filaments will be cooled and solidified. If a draft is applied to the filaments in that state, the filaments will melt and break or the elasticity, tensile strength, and other physical properties of the yarn will be lowered.

Conversely, if the filaments are gradually cooled, the filaments tend to adhere to each other and, further, the cooling zone must be made longer, and thus the size of the apparatus is necessarily increased.

Even if the spinning speed is increased or changed, if the cooling is carried out without changing the length of the cooling zone, a rapid cooling becomes necessary, and thus the problems discussed above will arise.

US-A-3,070,839 describes apparatus which varies the cooling potential of the cooling air along the filament path by giving a greater volume to the flow of air at the upstream region than at the downstream region. GB-A-0,998,664 describes apparatus which uses a similar method to cool filaments, the rate of the flow downstream being greater by about 35% than upstream.

Accordingly, an object of the present invention is to obviate the above-mentioned problems, caused by a too rapid or gradual cooling of the filaments.

Other objects and advantages of the present invention will be apparent from the following description.

In accordance with the present invention, there is provided a method of cooling molten filaments in a spinning apparatus, where a plurality of molten filaments extruded from a die are cooled by cooling air blown out from a cooling apparatus and are taken up with a draft, wherein the temperature of the cooling air blown from

the cooling apparatus is controlled, characterised in that, the cooling zone is divided into a plurality of sections and a cooling apparatus is provided in each section so that the cooling effect in the upstream region of the filament path is made weaker than the cooling effect in the downstream region of the filament path.

In accordance with the present invention, there is also provided a spinning apparatus where a plurality of molten filaments extruded from a die are cooled by cooling air blown from a cooling device and taken up with a draft, the cooling device being adapted to perform greater cooling in downstream regions of the filament path than in upstream regions of the filament path, characterised in that the cooling device comprises a plurality of cooling apparatus and in that the strength of cooling is stepwise changed by providing that the cooling air discharged from the different cooling apparatus is at different temperatures along the length of the filament path.

The present invention will be better understood from the description set forth below with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of a spinning apparatus provided with a cooling apparatus according to a first embodiment of the present invention; Fig. 2 is a schematic view of a spinning apparatus provided with another cooling apparatus; and Fig. 3 is a schematic view of a conventional spinning apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to the present invention, the above-mentioned problems can be solved by controlling the temperature and/or volume of the cooling air so that the cooling is performed stronger, in stages or continuously, from upstream to downstream of the filament flow.

The easiest way to change the cooling in stages and the easiest in terms of control is to divide the cooling zone into several sections, a cooling apparatus is provided for each section, and the cooling by the apparatus is made stronger in the downstream direction.

To change the cooling continuously, it is possible to adopt, for example, a method of arranging a heater in the flow path of the cooling air, and the pitch of the heating wires is made closer in the upstream direction so as to gradually increase the amount of heat generated, whereby the cooling air is warmed by contact with the heater and then blown or a method of forming the flow path of the cooling air is gradually narrowed in the upstream direction or the pressure loss is gradually increased to gradually reduce the amount of air upstream of the filament flow.

Further, when changing the spinning speed is changed, the degree of strength of the cooling can be changed.

Although the temperature and volume of air for cool-

ing largely depend upon the materials to be extruded, the temperature of the molten filaments, and the extrusion rate, the temperature of the cooling air is preferably -20°C to 140°C, more preferably 0 to 100°C, and the volume of the cooling air to be blown is preferably 2 to 40 m³/kg, more preferably 5 to 25 m³/kg. The materials to be extruded include, for example, polyethylene, polypropylene and other thermoplastic resins.

The molten filaments extruded from the die are cooled weakly at the upstream portion of the cooling zone and strongly at the downstream portion thereof. When the cooling is weak, the temperature difference of the filament surface and interior is made small and the draft is applied in that state to ensure that, a uniform draft is applied, whereby the elasticity, tensile strength, and other physical properties of the filaments are improved, and melting and breaking occur with difficulty. Further, at the downstream side where the filaments are taken up, a strong cooling is performed for solidification, so adhesion between filaments occurs with difficulty. Thus, it is possible to make the cooling zone shorter than with gradual cooling of the whole.

If the spinning speed is increased, it is possible to avoid rapid cooling by increasing the ratio of the weak cooling in the cooling zone. Note that when the spinning speed is reduced, there is no problem if the ratios of the strength of the cooling are varied.

Embodiments

Figure 1 shows a first embodiment of two-stage cooling apparatus according to the present invention, having the same construction as that of the cooling apparatus 3 provided in the spinning apparatus as shown in Fig. 3, except for the filter at the bottom of the cooling apparatus 3, i.e., is comprised of a chimney 12 and a gas temperature adjustment apparatus 13 comprised of coolers. The said apparatus sends the cooling air, cooled to a desired low temperature by the top stage gas temperature adjustment apparatus 13, to the chimney 12 by the fan 14 and connects this to a cooling apparatus 11 so that it is blown out from the inside peripheral surface. It blows out relatively high temperature cooling air from the top stage and relatively low temperature cooling air from the bottom stage thus slowly cooling the molten filaments 2 at the top stage and rapidly cooling them at the bottom stage.

For example, when polyethylene is used, the preferable cooling conditions are as follows:

Top stage: 30°C x 8 m³/kg

Bottom stage: 10°C x 8 m³/kg

In the above-mentioned embodiment, the temperature of the cooling air blown out from the bottom stage is made lower than that at the top stage, but it is also possible to change the air amounts of the fans 6 and 14 so as to increase the amount of air of the bottom stage over the top stage and further possible to change both the temperature and air amount of the top and bottom

stages.

A typical example of the cooling condition when polyethylene is used is as follows:

Top stage: 20°C x 4 m³/kg

Bottom stage: 10°C x 8 m³/kg

The embodiment shown in Fig. 2 is comprised in the same way as the apparatus shown in Fig. 1 outside of the fact that the fan 6 in the apparatus shown in Fig. 1 is made an exhaust fan and the cooling air of the bottom stage is exhausted from the fan 16, heated by the heater 17, then blown out from the top stage. As a result, cooling air of a relatively higher temperature is blown out from the top stage and cooling air of a relatively lower temperature is blown out from the bottom stage.

The above-mentioned embodiment shows an example where two cooling apparatuses are connected for two-stage cooling, but in another embodiment three or more cooling apparatuses may be connected for multi-stage cooling and in still another embodiment heating wires may be wound around the internal peripheral surface of the chimney and the pitch made gradually closer upstream so as to heat the cooling air and give it a temperature gradient so that the temperature gradually falls downstream, whereby the cooling can be made continuously stronger downstream. Further, in another embodiment, the flow path of the cooling air can be formed to be gradually narrower upstream or formed so that the pressure loss gradually increases, thereby gradually decreasing the amount of the cooling air upstream.

As mentioned above, according to the method of claim 1, the cooling is made performed weaker at the upstream side and stronger at the downstream side, thereby improving the elasticity, tensile strength, and other physical properties of the filaments without enlarging the apparatus and further making molten breakage difficult and preventing mutual adhesion of filaments.

According to the method of claim 2, even if the spinning speed is changed to make it faster, the ratio of the weaker portion of the cooling at the cooling zone can be increased so as to avoid rapid cooling or elongation of the cooling zone.

In the cooling apparatus of claim 6, a plurality of cooling apparatuses are connected so as to strengthen the cooling in stages downstream.

In the cooling apparatus of claim 7, the temperature of the cooling air can be given a temperature gradient descending in the downstream direction and the cooling can be made continuously stronger downstream.

In the cooling apparatus according to claim 8, the volume of the cooling air can be gradually increased downstream and thus the cooling can be made continuously stronger downstream.

Claims

1. A method of cooling molten filaments (2) in a spinning apparatus, where a plurality of molten fila-

ments (2) extruded from a die (1) are cooled by cooling air blown out from a cooling apparatus (3,11) and are taken up with a draft, wherein the temperature of the cooling air blown from the cooling apparatus (3,11) is controlled, characterised in that the cooling zone is divided into a plurality of sections and a cooling apparatus is provided for each section so that the cooling effect in the upstream region of the filament path is stepwise made weaker than the cooling effect in the downstream region of the filament path.

2. A method of cooling molten filaments as claimed in claim 1, further comprising the steps of changing the speed at which the filaments are spun by the spinning apparatus, whereby the degree of strength of the cooling is changed, the amount of time the filaments are exposed to the air being proportional to said speed, and of adjusting the cooling effect by changing the degree of cooling by the cooling apparatus at each section.
3. A method according to claim 1 or 2, wherein the temperature of the cooling air is stepwise controlled by heater means.
4. A spinning apparatus where a plurality of molten filaments (2) extruded from a die (1) are cooled by cooling air blown from a cooling device (3,11) and taken up with a draft, the cooling device (3,11) being adapted to perform greater cooling in downstream regions of the filament path than in upstream regions of the filament path, characterised in that the cooling device comprises a plurality of cooling apparatus and in that the strength of cooling is stepwise changed by providing that the cooling air discharged from the different cooling apparatus is at different temperatures along the length of the filament path.
5. An apparatus according to claim 4 wherein there is provided a heater for each cooling section in the flow path of the cooling air, said heater including heating wires arranged such that the pitch of the heating wire is closer in the upstream region of the filament path than in the downstream region, whereby the temperature of the cooling air is higher near the extruding die than near the take up means.
6. An apparatus according to claim 4 or 5, wherein the flow path of the cooling air in each cooling section is formed so as to be more restricted in the upstream parts of the filament path or is formed so as to have increased pressure loss in those parts.

Patentansprüche

1. Verfahren zur Abkühlung von aus der Schmelze gesponnenen Fäden (2) in einer Spinnvorrichtung, wobei eine Vielzahl von aus einer Matrice (1) extrudierten, aus der Schmelze gesponnenen Fäden durch eine aus einer Kühlvorrichtung (3, 11) ausströmende Kühlluft abgekühlt und unter Verstreckung aufgenommen wird, worin die Temperatur der aus der Kühlvorrichtung (3, 11) ausströmenden Kühlluft kontrolliert wird, dadurch gekennzeichnet, daß die Kühlzone in eine Vielzahl von Bereichen unterteilt ist und eine Kühlvorrichtung für jeden Bereich vorgesehen ist, so daß der Kühleffekt im stromaufwärts befindlichen Bereich der Fadenbahn schwächer als der Kühleffekt im stromabwärts befindlichen Bereich der Fadenbahn ist.
2. Verfahren zur Abkühlung von aus der Schmelze gesponnenen Fäden nach Anspruch 1, das darüber hinaus eine Änderung der Geschwindigkeit, bei der die Fäden durch die Spinnvorrichtung gesponnen werden, wobei der Grad der Stärke der Kühlung geändert wird, und die Zeitspanne, die die Fäden der Luft ausgesetzt werden, proportional zu der Geschwindigkeit ist, und Einstellen der Kühleffektes durch Änderung des Grades der Kühlung durch die Kühlvorrichtung an jedem Bereich, umfaßt.
3. Verfahren nach Anspruch 1 oder 2, worin die Temperatur der Kühlluft schrittweise durch Heizvorrichtungen kontrolliert wird.
4. Spinnvorrichtung, in der eine Vielzahl von aus einer Matrice (1) extrudierten, aus der Schmelze gesponnenen Fäden (2) von einer aus einer Kühlvorrichtung (3, 11) ausströmenden Kühlluft abgekühlt und unter Verstreckung aufgenommen wird, wobei die Kühlvorrichtung (3, 11) so eingestellt ist, im stromabwärts befindlichen Bereich der Fadenbahn eine stärkere Abkühlung als in den stromaufwärts befindlichen Bereichen der Fadenbahn durchzuführen, dadurch gekennzeichnet, daß die Kühlvorrichtung eine Vielzahl von Kühlgeräten umfaßt und daß die Stärke der Kühlung dadurch schrittweise geändert wird, daß die von den unterschiedlichen Kühlgeräten ausströmende Luft unterschiedliche Temperaturen entlang der Länge der Fadenbahn aufweist.
5. Vorrichtung nach Anspruch 4, wobei im Strömungsweg der Kühlluft eine Heizung für jeden Kühlungsbereich im Strömungsweg vorgesehen ist, wobei die Heizung Heizungsdrähte beinhaltet, die so angeordnet sind, daß der Abstand des Heizungsdrahtes im stromaufwärts befindlichen Bereich der Fadenbahn enger als im stromabwärts befindlichen Bereich ist, wodurch die Temperatur der Kühlluft in

der Nähe der Extrusionsmatrize höher als in der Nähe der Aufnahmevorrichtung ist.

6. Vorrichtung nach Anspruch 4 oder 5, wobei der Strömungsweg der Kühlluft in jedem Kühlungsbe-
reich so ausgebildet ist, daß dieser in den stromauf-
wärts befindlichen Teilen der Fadenbahn mehr ein-
geschränkt ist oder so ausgebildet ist, daß in diesen
Teilen ein erhöhter Druckverlust vorliegt.

Revendications

1. Procédé pour le refroidissement de filaments fon-
dus (2) dans un appareil à filer, dans lequel une plu-
ralité de filaments fondus (2) extrudés dans une fili-
ère (1) sont refroidis par de l'air de refroidissement
soufflé par un appareil de refroidissement (3, 11) et
sont repris par un courant d'air, dans lequel la tem-
pérature de l'air de refroidissement soufflé par l'ap-
pareil de refroidissement (3, 11) est réglée, carac-
térisé en ce que la zone de refroidissement est di-
visée en une pluralité de segments et qu'il est prévu
un appareil de refroidissement pour chaque seg-
ment, de sorte que l'effet de refroidissement dans
la zone amont du trajet du filament est pas à pas
rendu plus faible que l'effet de refroidissement dans
la zone aval du trajet du filament.

2. Procédé pour le refroidissement de filaments fon-
dus suivant la revendication 1, comprenant, par
ailleurs, les étapes consistant à modifier la vitesse
à laquelle les filaments sont filés par l'appareil à fi-
ler, le degré d'intensité du refroidissement étant ain-
si modifié, le laps de temps pendant lequel les fila-
ments sont exposés à l'air étant proportionnel à la-
dite vitesse, et à régler l'effet de refroidissement en
modifiant le degré de refroidissement par l'appareil
de refroidissement à chaque segment.

3. Procédé pour le refroidissement de filaments fon-
dus suivant la revendication 1 ou 2, dans lequel la
température de l'air de refroidissement est réglée
pas à pas par des moyens chauffants.

4. Appareil à filer, dans lequel une pluralité de fila-
ments fondus (2) extrudés dans une filière (1) sont
refroidis par de l'air de refroidissement soufflé par
un dispositif de refroidissement (3, 11) et repris par
un courant d'air, le dispositif de refroidissement
étant adapté pour réaliser un refroidissement plus
intense dans les zones avant du trajet du filament
que dans les zones amont du trajet du filament, ca-
ractérisé en ce que le dispositif de refroidissement
comprend une pluralité d'appareils de refroidisse-
ment et en ce que l'intensité de refroidissement est
modifiée pas à pas en prévoyant que l'air de refroi-
dissement évacué des différents appareils de refroi-

dissement est à des températures différentes sur la
longueur du trajet du filament.

5. Appareil suivant la revendication 4, dans lequel il
est prévu un élément chauffant pour chaque seg-
ment du trajet de circulation de l'air de refroidisse-
ment, ledit élément chauffant comportant des fils
chauffants disposés de manière que la distance en-
tre les fils chauffants est plus étroite dans la zone
amont du trajet du filament que dans la zone aval,
la température de l'air de refroidissement étant ainsi
supérieure près de la filière d'extrusion que près du
moyen de reprise.

6. Appareil suivant la revendication 4 ou 5, dans lequel
le trajet de l'air de refroidissement dans chaque
segment de refroidissement est formé de manière
à être plus restreint dans les parties amont du trajet
du filament ou est formé de manière à présenter
une perte de pression accrue dans ces parties.

Fig. 1

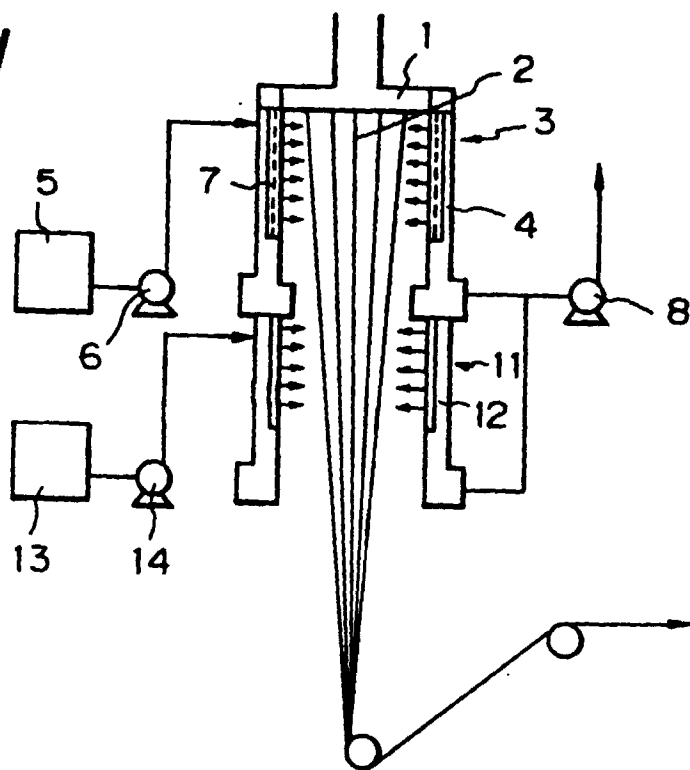


Fig. 2

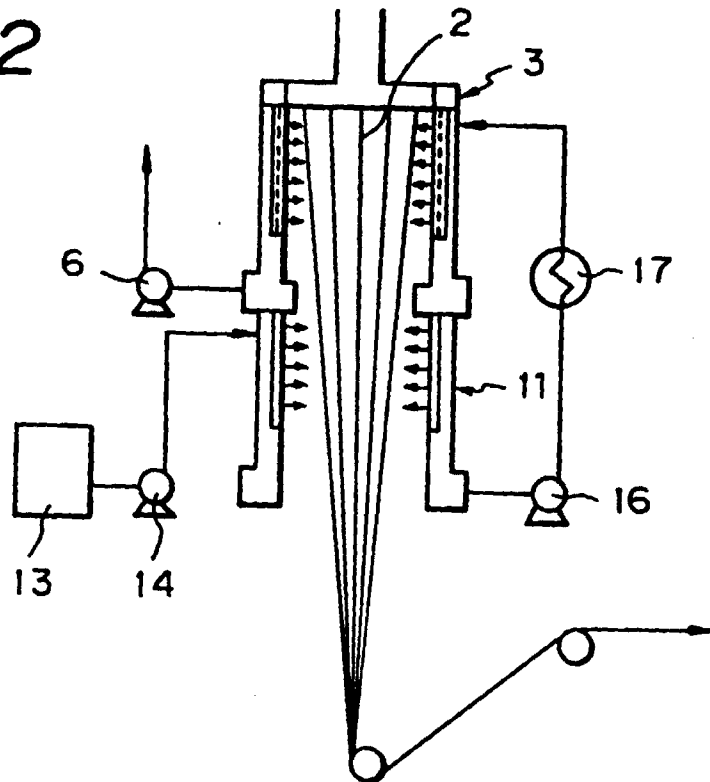


Fig. 3

