

L190,472

# PATENT SPECIFICATION

DRAWINGS ATTACHED

L190,472



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## COMPLETE SPECIFICATION

### Method and apparatus for the production of Tubular Film

We, MITSUBISHI PETROCHEMICAL COMPANY LIMITED, a Japanese Company of 4, 2-chome, Marunouchi, Chiyoda-ku, Tokyo, Japan, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of manufacturing a tubular film from thermoplastic resins and to apparatus used therefor.

In a conventional inflation method of manufacturing a film, the film of thermoplastic resin is obtained by inflating a molten resin extruded from an annular die to a predetermined dimension in one step on a predetermined position of the annular die by a pressurized gaseous coolant confined in the resulting tubular film, and, simultaneously, fixing the dimension of the resulting tubular film by cooling rapidly with a gaseous coolant blown from an annular cooling ring.

The conventional method mentioned above has disadvantages in that thermal and mechanical stresses exerted on the resin at the time of melting and kneading the same in the extruder and annular die remain in the resulting film without being relaxed sufficiently, due to the rapid cooling, and that the molecular orientation in the resin is enhanced by the rapid inflation and simultaneous extension thereof. As a result, the qualities of film manufactured according to the conventional method, for example, the optical properties such as transparency and gloss are drastically deteriorated.

Moreover, in the conventional method, various difficulties are encountered in winding up the resulting film and in the subsequent processing of the same such as bag-making, or printing, due to shrinkage of the film which stems from the fact that molecules of the resin are subjected to a considerable orientation during the tube-forming process.

On the other hand, a film having excellent

optical properties may be manufactured by inflating the resin while cooling rapidly according to the conventional technique but at a position sufficiently displaced from the annular die, because, by so doing, the thermal and mechanical stresses exerted on the molten resin are sufficiently relaxed. However, in this technique a long period of time elapses between the extrusion of the molten resin from the annular die and its rapid cooling. Thus molecules of the molten resin are preferentially and substantially oriented in the direction toward which the resulting film is taken up. As a result, the mechanical properties of the resulting film become directional, and the film shows considerable differences in properties in longitudinal and transversal directions. There are other accompanying disadvantages in that the resulting tubular film, flattened by a pair of pinch rollers, tends to lack slipperiness and be blocked due to insufficient cooling (because the cooling point is near the pinch rollers), and that the operational stability is disturbed by vibration of the molten resin due to atmospheric fluctuations, giving rise to wrinkling and uneven thickness of the resulting film.

In addition, tubular film manufactured by the conventional method at high speed tends to have less than the desired mechanical properties and reduced processing stability, so that film having satisfactory qualities for practical use may not be obtained.

An object of this invention is to provide a method of manufacturing from thermoplastic resin, stable tubular films having excellent optical properties such as transparency and gloss, excellent impact strength and tensile strength and greater uniformity of thickness and shape.

Another object of this invention is to provide apparatus, and more particularly an annular cooling device, for use in carrying out the process having increased cooling efficiency.

According to the present invention there is provided a process for the continuous manufacture of tubular film of a thermoplastic resin

which comprises extruding a molten thermoplastic resin from an annular die, to form a tubular film of which the internal gaseous pressure is superatmospheric, and subjecting the extruded tubular film successively (a) to cooling to a temperature not lower than the softening point of said resin by directing a gaseous coolant onto its exterior, (b) to expansion by reduction of pressure exterior of the tube and (c) to further expansion to a predetermined diameter under the action of the gaseous medium at superatmospheric pressure confined in the tubular film and simultaneously to coding by application of gaseous coolant rapidly to below the softening point of said resin.

The thermoplastic resin may be, for example, high or low density polyethylene, polypropylene, polyvinyl chloride, polystyrene, polyamide or polyester.

There may be obtained by the method of this invention a tubular film having excellent optical properties such as transparency and gloss, and mechanical properties such as impact strength and tensile strength, as well as an excellent dynamic property of less directionality, and substantially free from shrinkage in winding and subsequent processing steps. It will be noted that the method is characterised by the step of cooling the molten resin extruded from an annular die in two steps and inflating the resin in two steps.

In accordance with the preferred form of the invention, the inflated resin is cooled by means of a gaseous coolant blown out from an annular cooling device.

More particularly, the method comprises preliminarily cooling a molten resin extruded from an annular die with a gaseous coolant to a softening point of said resin measured according to Vicat Method (ASTM D-1525), or higher than that, preliminarily inflating and extending the resin by air of reduced pressure surrounding the film, cooling said resin subsequently with a gaseous coolant rapidly below the said softening point of said resin while further inflating the same to a predetermined dimension by a gaseous medium sealed in a tubular film of said resin and fixing the dimension of the resulting tubular film.

In the method of this invention, the temperature of the preliminary cooling referred to above is normally from the softening point as determined according to the Vicat Method to a temperature higher than the softening point by 60°C, preferably 30°C. For example, when using a low density polyethylene produced by High Pressure method as a material, a temperature between the softening temperature and about 100°C is preferable.

We have also found that in an annular cooling device employed in the method of this invention, a reduced pressure suitable for causing the 1st step inflation, i.e. the preliminary inflation, may be obtained from a suction created by the blowing of the gaseous coolant

for the 2nd step cooling, i.e. final cooling, if a slit for blowing the gaseous coolant for the 1st step cooling, i.e. the preliminary cooling, is arranged at such an angle that the gaseous coolant may be blown against the tubular film in a direction between the horizontal direction and at most 30° of angle of elevation, while a slit for blowing the gaseous coolant for the 2nd step cooling, i.e. final cooling, is arranged at such an angle that the gaseous coolant may be blown against the running tubular film in a direction between a direction parallel with respect to the running direction thereof and at most 30° of inclination to the axis of the tubular film.

Thus, by so constructing the cooling device according to this invention, there is no need for any mechanical means such as vacuum pump suction for reducing pressure in an inflating chamber in which the tubular film is housed.

Moreover, if the inflating chamber mentioned above is provided with a plurality of air-inlet tubes having valve means thus furnishing through-passages between open air and the inflating chamber, the degrees of reduced pressure at respective portions of periphery of the tubular film may be optionally controlled by adjusting the amounts of air passing through the air-inlet tubes by way of the valve means to control the inflating condition optionally thereby preventing uneven thickness of the resulting tubular film.

Thus, in accordance with this invention, there is also provided an annular cooling device for use in the manufacture of tubular film of thermoplastic resin according to claim 11 by vertical or substantially vertical inflation — extrusion from an annular die, which device is coaxial with said die and comprises in series successively more remote from the die a first coolant chamber provided with a single continuous annular gas discharge orifice or port concentric with the extrusion axis for blowing a gaseous coolant for preliminary cooling against a tubular film in a direction between a direction parallel with the longitudinal axis of the film and in the direction of travel of said film, and a direction inclined towards the axis of said film, and making an angle of at the most 30° with said axis, a film expanding chamber for enabling the tubular film thus cooled to expand during its passage through the chamber, and a final coolant chamber provided with a gas discharge orifice or port for blowing a gaseous coolant for final cooling against the preliminarily inflated tubular film in a direction between that which is parallel with the longitudinal axis of the film and in the direction of travel of said film, and a direction inclined towards said axis of said film and making an angle of at the most 30° with said axis.

In the annular cooling device of this invention, the reason for limiting the angle of slit for blowing gaseous coolant for preliminary

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cooling as set forth above is that with the angle of depression, i.e., below the horizontal direction, the gaseous coolant is blown opposite to the running direction of the tubular film causing turbulences which shake the tubular film and lead to uneven thickness of the resulting film, while with the angle of elevation of more than 30°, it becomes difficult to maintain the reduced pressure of the inflation chamber.

Likewise, the reason for limiting the angle of slit for blowing gaseous coolant for final cooling as set forth above is that with the angle of inclination outside the parallel direction with respect to the running direction of the tubular film, the cooling effect may not be expected, while the angle of inclination of more than 30° towards axis of the tubular film reduces the suction effect and the reduced pressure necessary for the inflating chamber may not be obtained.

In the device of this invention, normally, aperture of slit is preferably 2—6 mm., and the ratio of inner diameter of the preliminary coolant chamber, i.e. a cooling ring, to that of final coolant chamber, i.e. a cooling ring, is preferably 1:1.1—2.0.

A particular embodiment of the process and apparatus of this invention is set forth in the following description taken in connection with the accompanying drawings in which;

Fig. 1 is a schematic diagram illustrating the manufacturing of a tubular film of thermoplastic resins using the device of this invention;

Figs. 2 and 3 show working conditions of the device of this invention;

Fig. 4 is a plan view of the device shown in Fig. 2; and

Fig. 5 is a sectional view of Fig. 4 at line A-A.

Now, an embodiment of the manufacturing of a tubular film using the device of this invention will be explained in the following by making references to the drawings:

As illustrated in Fig. 1, a tubular film is manufactured by heating, melting and kneading thermoplastic resins in a conventional extruder 1, extruding the molten resin continuously from an annular die 2, cooling thus extruded resin 3 with a gaseous coolant blown from a cooling device 5 placed at a predetermined position over the annular die 2 and connected with a blower 4, inflating the resin 3 with a pressurized gaseous medium until it reaches to a predetermined dimension, flattening thus inflated resin by a pair of nip rolls 7 via a guide plate 6, and winding up the resulting flattened tubular film 8 onto a winder 9.

The cooling device 5, for example, integrally comprises a feed pipe 18, a coolant chamber 11 for preliminary cooling provided with slits 10, a coolant chamber 15 for final cooling provided with slits 14, and an inflating chamber 13 which is maintained at a reduced pressure

by suction created by blowing a gaseous coolant 12 from the slits 14 at a high speed in a parallel direction with respect to running direction of the preliminarily cooled tubular film along the outer surface thereof.

The molten resin 3 extruded from the annular die 2 is preliminarily cooled with the gaseous coolant blown from slits 10 of the coolant chamber 11 down to near the softening temperature of the resin, then, subsequently, the tubular body of the resin 3 is preliminarily inflated and extended in the inflating chamber being maintained at a reduced pressure of about 2—3 mm. to 10—20 mm. of water up to a predetermined degree of inflation which is normally 2—5 times.

The preliminarily inflated resin 16 is then cooled rapidly with the gaseous coolant blown from slits 14 of the coolant chamber 15 down below the softening point of the resin, while, simultaneously, the preliminarily inflated resin 16 is further inflated under atmospheric pressure by a pressurized gaseous medium confined therein up to a predetermined dimension at which the tubular film 17 is fixed.

Fig. 3 illustrates another embodiment of the annular cooling device according to this invention in which the molten resin 3 extruded from the annular die 2 is led to a preliminary cooling ring 5 which comprises a coolant chamber 23 for preliminary cooling provided with blowing slits 22 and an inflating chamber 25 provided with tubes 31, where the extruded resin is preliminarily cooled with the gaseous coolant blown from the slits 22 down to near the softening temperature of the resin. Subsequently, the preliminarily cooled resin is preliminarily inflated and extended up to a predetermined degree of inflation which is normally 2—5 times, in an inflating chamber 25 maintained at a reduced pressure of about 2—3 mm. to 10—20 mm. of water by suction created by a high speed stream of the gaseous coolant blown from slits 26 of a cooling ring 5<sup>1</sup> for final cooling.

The resin 16 thus preliminarily cooled and inflated is passed through a ring 33 for preventing heat radiation which is disposed between the cooling ring 5 for preliminary cooling and the cooling ring 5<sup>1</sup> for final cooling, then, cooled rapidly in a coolant chamber 27 for final cooling having blowing slits 26 down to below the softening temperature, while, simultaneously, inflated under atmospheric pressure by a gaseous medium confined in the resin 16 up to a predetermined dimension at which the tubular film 17 is fixed.

It will be understood that the particular profile of the tubular film at 3 and 16 as shown in Figures 2 and 3 is due to a combination of effects. Thus the tensile strength of the resin in the vicinity 3 of the extruder outlet where the thickness of the film is thicker than the rest of the portion is greatest in this vicinity. Moreover the film is being inflated whilst tra-

velling at high speeds. The expansion of the film in the vicinity 16 is effected by the action of the negative pressure created by the stream of air blown from the slits 10 and 14. As the film expands to contact the inner wall of the ring 33 the stream of air is cut off and as a result the venturi action of the air stream ceases and the expansion of the film is lessened.

5 Figs. 4 and 5 illustrate an embodiment of the cooling device according to this invention in which Fig. 4 is a plan view thereof and Fig. 5 is a sectional view of Fig. 4 at line A-A.

10 In the present embodiment, a part of air fed from a gaseous coolant feed pipe 18 is introduced to a coolant chamber 111 for preliminary cooling, if desired, provided with turbulent plates 21, and blown out from slits 10. The remainder of air is introduced to a coolant chamber 15 for final cooling, if desired, provided with baffles to increase turbulence 21, and blown out from slits 14. Between the coolant chambers 11 and 15, there is an inflating chamber 13 provided with a plurality of air-inlet tubes 19 having valve means 20.

15 In the prior art methods, when a high blow ratio is attempted in order to improve the quality of the film, there is the necessity of raising the tube interior pressure and since the film is inflated up to the desired blow ratio at stretch, the operation is unstable and the resulting tubular film has an uneven thickness. Much more, when the production at high speeds is attempted, the coolant air has to be supplied in a large amount from one place causing the tubular film to sway to and fro with consequent unstable operation. Further-

more, the contact between the coolant air and the film is not intimate enough and only a part of the coolant air contributes to the actual cooling.

20 In contradistinction, in the present invention, since the expansion and inflation of the tubular film is effected in two separate steps by the negative pressure created by the stream of air blown out from the cooling slits of the preliminary cooling ring and those of the final cooling ring, and by the slightly pressurized air in the interior of the tube, the expansion of the film can be accomplished exactly as designed with the desired contour of the tube. In the arrangement of the present invention, the extruded tubular film is supported at three points, viz. the lowermost extruding die, the group of cooling rings in the middle and the upper most nip roll, and it travels quite stably therethrough without causing any swaying at all.

25 Moreover, owing to the construction of the cooling rings of the present invention, the coolant air flows along with the running tubular film for a relatively long distance while in an intimate contact therewith, thus, the heat exchanging therebetween is sufficiently effected in the meantime to enhance the cooling efficiency. Needless to say, this greatly contributes to the high speed production of the film.

30 The following Examples will serve to illustrate the invention:

#### EXAMPLE 1

35 The qualities of films manufactured under the following conditions according to the present invention and the prior art methods were compared with each other:

Manufacturing conditions:

|                        |                                                                                                                                                        |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| Material resin         | High-pressure polyethylene (YUKALON YK-50, trade name, product of Mitsubishi Petrochemical Co., Ltd.)                                                  |
|                        | Melt index — 4.0                                                                                                                                       |
|                        | Density — 0.9240                                                                                                                                       |
| Extruder diameter      | 65 mm $\phi$                                                                                                                                           |
| Screw                  | $\left\{ \begin{array}{l} \text{L/D 22} \\ \text{Compression ratio 3.3} \\ \text{Type : Long metering type.} \end{array} \right.$                      |
| Annular die diameter   | 100 mm $\phi$                                                                                                                                          |
| Cooling ring           | $\left\{ \begin{array}{l} \text{Present invention — As shown in Fig. 2.} \\ \text{Prior art — For conventional one-step cooling.} \end{array} \right.$ |
| Processing temperature | 150°C.                                                                                                                                                 |
| Screw speed            | 40 r.p.m.                                                                                                                                              |
| Extrusion rate         | 20 kg/h.                                                                                                                                               |
| Tube-up speed          | 40 m/min.                                                                                                                                              |
| Film size              | $\left\{ \begin{array}{l} \text{Thickness 0.02 mm.} \\ \text{Width 200 mm.} \end{array} \right.$                                                       |
| Blow-up ratio          | Approx. 1.3                                                                                                                                            |

The results are shown in the following Table 1:

TABLE 1

|                               |                                                   | Present invention           | prior art <sup>(1)</sup> | "(2) |
|-------------------------------|---------------------------------------------------|-----------------------------|--------------------------|------|
| Height of frost line (mm)     |                                                   | 230                         | 150                      | 400  |
| Film cooling temperature (°C) |                                                   | Preliminary 100<br>Final 60 | 80                       | 80   |
| Qualities of Film             | Gloss (0/00) <sup>(1)</sup>                       | 98                          | 75                       | 98   |
|                               | Haze (%) <sup>(2)</sup>                           | 8.0                         | 10.5                     | 8.0  |
|                               | Blocking degree (g) <sup>(3)</sup>                | 150                         | 250                      | 500  |
|                               | Tear strength (kg/cm) <sup>(4)</sup>              |                             |                          |      |
|                               | MD                                                | 180                         | 180                      | 180  |
|                               | TD                                                | 125                         | 130                      | 150  |
|                               | Sand-bag drop impact strength (cm) <sup>(5)</sup> | 35                          | 25                       | 10   |
|                               | Thermal shrinkage (%) <sup>(6)</sup>              |                             |                          |      |
|                               | MD                                                | 1-2>                        | 3-4                      | 4-5  |
|                               | TD                                                | 1>                          | 2                        | 1>   |

Note: <sup>(1)</sup> JIS Z-8741-61.

<sup>(2)</sup> ASTM D-1003-61.

<sup>(3)</sup> According to Mitsubishi Method in which an energy required to open up the flattened tubular film pressed with a load of 20 kg/2 cm<sup>2</sup> at 20°C for 10 minutes is measured in terms of gram.

<sup>(4)</sup> JIS Z-1702-59.

<sup>(5)</sup> CS-227-59 (American Commercial Standard).

<sup>(6)</sup> According to Mitsubishi Method in which shrinkage is measured after being kept in an oil bath at 100°C for 10 minutes.

5 As can be noted from Table II, when a tubular film of a thermoplastic resin is manufactured according to the conventional inflation method as in "Prior art (1)", the optical properties such as gloss and transparency are poor and it tends to shrink causing various inconveniences in the winding operation and in the subsequent processing such as bag-making, printing, etc.

10 Although the optical properties such as luster and haze are improved in the conventional inflation method if the rapid cooling is effected at a point sufficiently apart from the annular die as in "Prior art (2)" shown in Table 1, the openability is degraded due to insufficient

cooling and the directionality in the strength also becomes apparent.

In contradistinction, as can be clearly noted from Table I, the tubular film obtained according to this invention has excellent optical properties such as gloss and transparency, blocking as well as superior impact strength, directionality and shrinking property over those of tubular films obtained according to the prior art methods. 20 25

#### EXAMPLE 2

The present Example illustrates the comparison between the method of this invention and that of prior art with respect to manufacturing of tubular film at a high speed. 30

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| Material resin        | High-pressure polyethylene (YUKALON YK-50, trade name, product of Mitsubishi Petrochemical Co., Ltd.) |
|                       | Melt index — 4.0                                                                                      |
|                       | Density — 0.9250                                                                                      |
| Extruder diameter     | 65 mm $\phi$                                                                                          |
| Screw dimension       | { L/D 22<br>Compression ratio 3.3<br>Type : Long metering type.                                       |
| Annular dies diameter | 100 mm $\phi$                                                                                         |
| Cooling ring          | { Present invention — As shown in Fig. 2.<br>Prior art — For conventional one-step cooling.           |

The results are shown in the following Table 2:

TABLE 2

|                             | Present invention |      |           | Prior art |           |
|-----------------------------|-------------------|------|-----------|-----------|-----------|
| Film dimension (mm)         |                   |      |           |           |           |
| Thickness                   | 0.02              | 0.04 | 0.012—0.3 | 0.02      | 0.012—0.3 |
| Width                       | 250               | 250  | 50—550    | 250       | 50—550    |
| Processing temperature (°C) | 150               | 150  | 150       | 150       | 150       |
| Height of frost line (mm)   | 230               | 230  | 200—250   | 150       | 150—200   |
| Blow-up ratio               | 1.6               | 1.6  | 0.5—3.5   | 1.6       | 0.5—3.5   |
| Screw speed (r.p.m.)        | 110               | 110  | 10—110    | 42        | 10—42     |
| Extrusion rate (kg/h)       | 54                | 54   | 5—54      | 21.6      | 5—21.6    |
| Tube-up speed (m/min)       | 100               | 50   | 10—100    | 40        | 10—40     |

As can be noted from Table 2, the prior art method is only capable of manufacturing the film having 0.02 mm. thickness at a rate of about 40 m. per minute, or, at an extrusion rate of 22 kg. per hour, at the most, due to the poor cooling efficiency.

In contrast, the method of this invention is capable of manufacturing the film having 0.02 mm. thickness at a rate of about 1100m. per minute, or, at an extrusion rate of 54 kg. per hour, without experiencing operational insta-

bilities such as zigzagging and fluctuation in width of the flattened tubular film, and free from shrinkage and gauge instability.

#### WHAT WE CLAIM IS:—

1. A process for the continuous manufacture of tubular film of thermoplastic resin which comprises inflation-extruding a molten thermoplastic resin from an annular die to form a tubular film of which the internal gaseous pressure is superatmospheric, and subjecting the extruded tubular film successively (a) to

|                       |                                                                                                       |
|-----------------------|-------------------------------------------------------------------------------------------------------|
| Material resin        | High-pressure polyethylene (YUKALON YK—50, trade name, product of Mitsubishi Petrochemical Co., Ltd.) |
|                       | Melt index — 4.0                                                                                      |
|                       | Density — 0.9250                                                                                      |
| Extruder diameter     | 65 mm $\phi$                                                                                          |
| Screw dimension       | { L/D 22<br>Compression ratio 3.3<br>Type : Long metering type.                                       |
| Annular dies diameter | 100 mm $\phi$                                                                                         |
| Cooling ring          | { Present invention — As shown in Fig. 2.<br>Prior art — For conventional one-step cooling.           |

The results are shown in the following Table 2:

TABLE 2

|                             | Present invention |      |           | Prior art |           |
|-----------------------------|-------------------|------|-----------|-----------|-----------|
| Film dimension (mm)         |                   |      |           |           |           |
| Thickness                   | 0.02              | 0.04 | 0.012—0.3 | 0.02      | 0.012—0.3 |
| Width                       | 250               | 250  | 50—550    | 250       | 50—550    |
| Processing temperature (°C) | 150               | 150  | 150       | 150       | 150       |
| Height of frost line (mm)   | 230               | 230  | 200—250   | 150       | 150—200   |
| Blow-up ratio               | 1.6               | 1.6  | 0.5—3.5   | 1.6       | 0.5—3.5   |
| Screw speed (r.p.m.)        | 110               | 110  | 10—110    | 42        | 10—42     |
| Extrusion rate (kg/h)       | 54                | 54   | 5—54      | 21.6      | 5—21.6    |
| Tube-up speed (m/min)       | 100               | 50   | 10—100    | 40        | 10—40     |

As can be noted from Table 2, the prior art method is only capable of manufacturing the film having 0.02 mm. thickness at a rate of about 40 m. per minute, or, at an extrusion rate of 22 kg. per hour, at the most, due to the poor cooling efficiency.

In contrast, the method of this invention is capable of manufacturing the film having 0.02 mm. thickness at a rate of about 1100m. per minute, or, at an extrusion rate of 54 kg. per hour, without experiencing operational insta-

bilities such as zigzagging and fluctuation in width of the flatted tubular film, and free from shrinkage and guage instability.

#### WHAT WE CLAIM IS:—

1. A process for the continuous manufacture of tubular film of thermoplastic resin which comprises inflation-extruding a molten thermoplastic resin from an annular die to form a tubular film of which the internal gaseous pressure is superatmospheric, and subjecting the extruded tubular film successively (a) to



- cooling to a temperature not lower than the softening point of said resin by directing a gaseous coolant onto its exterior (b) to expansion by reduction of pressure exterior of the tube and (c) to further expansion to a predetermined diameter under the action of the gaseous medium at superatmospheric pressure confined in the tubular film and simultaneously to cooling by application of gaseous coolant rapidly to below the softening point of said resin.
- 5 2. A process according to claim 1 wherein said thermoplastic resin is high- or low density polyethylene, polypropylene, polyvinyl chloride, polystyrene, a polyamide or a polyester.
- 10 3. A process according to claim 1 wherein the thermoplastic resin is high pressure low density polyethylene and the first cooling is effected to a temperature between the softening temperature thereof and 100°C.
- 15 4. A process according to claim 11 or 2 substantially as hereinbefore described with reference to either of the foregoing specific Examples 11 and 2.
- 20 5. An annular cooling device for use in the manufacture of a tubular film of thermoplastic resin according to claim 11 by vertical or substantially vertical inflation — extrusion from an annular die, which device is coaxial with said die and comprises in series successively
- 25 more remote from the die a first coolant chamber provided with a single continuous annular gas discharge orifice or port concentric with the extrusion axis for blowing a gaseous coolant for preliminary cooling against a tubular film in a direction between a direction parallel with the longitudinal axis of the film and in the direction of travel of said film, and a direction inclined towards the axis of said film,
- 30 and making an angle of at the most 30° with said axis, a film expanding chamber for enabling the tubular film thus cooled to expand during its passage through the chamber, and a final coolant chamber provided with a gas discharge orifice or port for blowing a gaseous coolant for final cooling against the preliminary inflated tubular film in a direction between that which is parallel with the longitudinal axis of the film and in the direction of travel of said film, and a direction inclined towards said axis of said film and making an angle of at the most 30° with said axis.
- 35 6. An annular cooling device according to claim 4 wherein the chamber for preliminarily causing the tubular film to expand diametrically, is provided with a plurality of valve-controlled gas inlet tubes.
- 40 7. An annular cooling device according to claim 6 wherein the width of the slot-shaped coolant discharge orifices are 2 to 6 mm and the ratio of the internal diameter of the first annular coolant chamber to that of the final annular coolant chamber is 1:1.1—2.0.
- 45 8. An annular cooling device according to any of claims 5—7 substantially as hereinbefore described with reference to the accompanying drawings.
- 50 9. A process according to claim 1 wherein the cooling and inflation steps of the said process are effected by the use of a device as claimed in any of claims 5—8.
- 55 60 65 70

Agents for the Applicants,  
V. GALLAFENT & CO.,  
Chartered Patent Agents,  
8, Staple Inn,  
London, W.C.1.

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