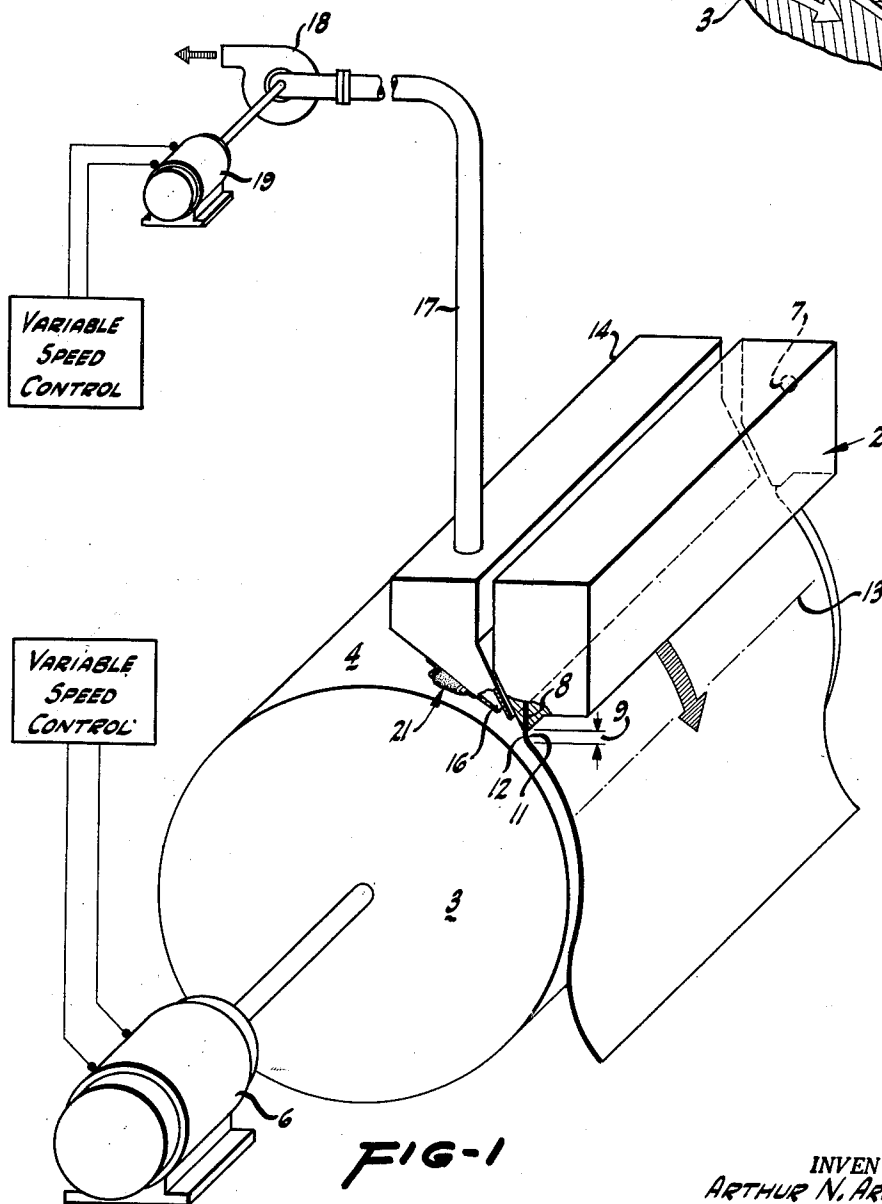
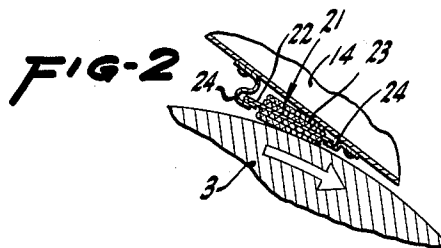


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METHOD AND APPARATUS FOR PROVIDING OPTIMUM OPTICAL
PROPERTIES OF POLYOLEFINS BY CONTROLLING
THE EXTRUSION OF THE MATERIAL
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METHOD AND APPARATUS FOR PROVIDING OPTIMUM OPTICAL PROPERTIES OF POLY-OLEFINS BY CONTROLLING THE EXTRUSION OF THE MATERIAL

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This invention relates to extrusion of film forming plastic material, and particularly to the extrusion of polyolefin material to form self-supporting flexible film therefrom.

In the extrusion of polyolefin, such as polypropylene and polyethylene, it is the general practice to force the material continuously under pressure and while it is in heated molten state, from an elongated orifice or slot in an extrusion device or die onto a continuously moving casting surface, such as the surface of a highly polished metal roll. When the polyolefin is ejected from the extrusion slot, a continuously moving section thereof exists in free unsupported state between the extrusion slot and its location of contact with the roll. After the material deposits on the roll, it soon sets to a self-supporting film; the location of such setting on the casting roll being commonly known as the frost line.

Heretofore, there has been a problem with respect to polyolefins in obtaining desirable optical properties in the finished film, particularly at relatively high speed operations which the economics of commercial operations require. Various film defects occur, namely, the film may lack desired clarity because of undue cloudiness known as haze, and it may not have suitable gloss or in other words sheen. Moreover, if the film is deposited unevenly onto the casting surface, which can be detected if the aforementioned frost line is uneven or wavy, so-called puckering of the film occurs, namely, blisters or baggy pockets are formed; and if too much air or smoke from the molten polyolefin becomes entrapped between the casting roll and the polyolefin, the optical properties of the film are also adversely affected.

Summarizing the invention, it has as its objects, among others, the provision of an improved, simple and economical method and apparatus for overcoming the foregoing problems, particularly at relatively high speed commercial operations. This is accomplished by subjecting the leading and trailing faces of the section or sheet of material flowing out of the extrusion device to a slight differential pressure of a particular range with the lesser pressure on the trailing face of the aforementioned unsupported section, providing for adjustment of the amount of the differential pressure and the speed of movement of the casting surface, and correlating such adjustments within the slight differential pressure range to provide for optimum operating conditions within such range.

Desirably, the differential pressure is effected by means of applying a partial vacuum to a vacuum chamber or suction box located between the extrusion device and the moving casting surface, and having an opening in the form of a slot facing the trailing face of the unsupported section flowing from such extruder. A pad is provided between the vacuum chamber and the casting surface in wiping contact with the casting surface to provide a barrier dam to the outside atmosphere. This pad requires relatively frequent replacement because it becomes fouled with excess oily material which deposits on the casting surface from the extruded material and is wiped off by the pad. If the pad is not replaced, excess oil collected by the pad fouls the casting surface which impairs the quality of the resultant film. In the invention hereof, the pad is slidably mounted on a trackway carried by the

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suction chamber to enable it to be quickly removed and replaced with a clean pad without causing undue shut-down of the apparatus.

Reference is now made to the drawings for a more detailed description of the invention.

FIG. 1 is a fragmentary isometric schematic view of the apparatus; and

FIG. 2 is a fragmentary transverse cross-section taken through the aforementioned wiping pad and its mounting.

The process and apparatus are applicable to the production of any type of polyolefin film wherein the aforementioned problems occur, such as polypropylene and polyethylene. The material is continually forced under pressure in a conventional manner into a conventional extruder 2 extending axially of conventional cooled casting roll 3 having a highly polished casting surface 4, usually chrome plated; the roll being driven by suitable variable speed drive means 6. Material is continuously fed into the extruder under pressure by suitable conventional means through inlet 7; and the extruder is maintained in heated condition by suitable means (not shown). Continuous flow of molten material from the extruder is through slot 8; and it will be noted that a section or sheet of unsupported extruded material indicated at 9 flows continuously from the discharge end of slot 8 to the location at which the material is deposited onto casting surface 4.

The face 11 of the extruded material away from casting surface 4 is referred to as the leading face and the opposite face 12 adjacent the casting surface is designated the trailing face. For purposes of illustration, the so-called frost line, namely, the location at which the polyolefin sets to a solid state is indicated by phantom line 13. In this connection, the frost line is in advance of the location at which the set film is removed from the casting roll by conventional means (not shown), and is wound on rewind mechanism (not shown). Location of the frost line can be readily observed because of a marked difference in the appearance of the film after it has set solid. Hence, an operator can readily determine whether the frost line is uniform or substantially straight, or irregular or wavy.

A vacuum chamber or suction box 14 is positioned between extruder 2 and casting roll 3, and extends axially of the casting roll; the vacuum chamber having an axially extending slot 16 which faces trailing face 12 of unsupported section 9. Chamber 14 is connected by piping 17 to a variable speed blower 18 driven by suitable adjustable variable speed drive means 19, such as an electric motor, whereby the amount of differential pressure on the trailing and leading faces of section 9 can be adjusted. Leading face 11 is subjected to atmospheric pressure. Thus, the differential pressure is such that the pressure on trailing face 12 is less than on leading face 11.

To enhance maintenance of the suction, a barrier pad or dam 21 of soft absorbent material is carried by the underside of chamber 14 and extends axially the full width of the chamber in wiping contact with casting surface 4. The barrier pad not only enhances maintenance of the vacuum but also provides a barrier to pumping of air between the extruded material and the casting surface 4 caused by rotation of roll 3 in the direction of movement of the film being formed, and which would otherwise collect between the extruded material and the casting surface and adversely affect optical properties of the film.

Barrier pad 21 also serves to keep the casting surface 4 clean of oily material which deposits on the surface from the polyolefin extruded. If not removed periodically, excess oil absorbed by the pad because of its wiping action, remains on the casting surface causing film imperfections. To enable quick removal and replacement of

the pad so that a fresh pad can be employed when the pad has absorbed excess oil, a special slidable mounting therefor is provided on the underside of chamber 14.

Such mounting comprises an elongated flat bar 22 of suitable material such as metal or wood, extending axially of roll 3, and has wrapped around the opposite ends thereof a suitable continuous strip 23 of absorbent material, such as felt or plush, in several layers so as to have good sealing contact with the underside of chamber 14 and casting surface 4. The sides of bar 22 are slidably mounted on a trackway comprising angle shaped rails 24 secured to the bottom of chamber 14 and also extending axially of the casting roll 3. Thus, when the material 23 is to be replaced, this can be readily done by sliding bar 22 endwise in an axial direction with reference to the roll until it has been removed from the trackway, replacing a fresh strip of the material 23 thereon, and then reinserting the pad by pushing it axially along the trackway.

For providing good optical properties of the film, it is important that the polyolefin be in substantially amorphous condition before it is deposited onto casting surface 4, namely, it should not have substantially crystallized at the time of deposit. In other words, the distance of the discharge end of extruder slot 8 from casting surface 4 should be such that the unsupported free section 9 of the material should be relatively short. This distance is also known as film travel.

For medium density polyethylene commonly employed as polyethylene film wrappers (about 0.928 to 0.945 density), the film travel distance is desirably between about 1¼ to 1¾ inches, and preferably about 1½ inches. For polypropylene which is generally of substantially the same density, the distance should desirably be about ½ to 1 inch, and preferably about ¾ of an inch. If the polyolefin deposited onto casting surface 4 is in substantially crystallized condition, the resultant film lacks lustre or gloss and becomes hazy or cloudy.

Although it would normally be expected that the greater the peripheral speed of rotation of casting roll 3 the greater the amount of haze imparted to the film because of the air pumping effect, particularly at relatively high practical commercial operating speeds, it has been found pursuant to this invention that if a slight amount of vacuum is maintained on the trailing face 12 of section 9, casting roll 3 can be operated at relatively high speeds suitable for commercial production, and that this speed can be varied within a relatively wide range as long as the slight vacuum range is maintained.

The vacuum for polyolefin including polypropylene and polyethylene is desirably maintained at an amount equivalent to about 0.10 to 0.80 inch of water; and for medium density polyethylene, the desirable partial vacuum is equivalent to about 0.30 to 0.6 inch of water. However, at relatively high speeds, the gloss or sheen of the film becomes impaired, but it has been found pursuant to this invention, that with speeds up to about 500 ft. per minute and even more, the gloss impairment will not be so great that the film will not meet commercial specifications.

Since the extent or amount of vacuum and speed are both individually adjustable, this provides a means for correlating the adjustments for any given conditions to provide optimum conditions under the slight amount of vacuum noted. In this connection, the differential pressure applied to section 9 forces it toward vacuum chamber 14 causing it to deposit uniformly or evenly on the casting surface 4, and thus form a substantially even non-wavy frost line. If the frost line is uneven, then this means that the material is not being deposited uniformly onto casting surface 4, which will result in the aforementioned puckering.

By observing the frost line, the operator can readily make the desired adjustments to provide optimum conditions within the slight vacuum range applied. In addition to minimizing pumping of air between the extruded material and the casting surface which impairs optical prop-

erties of the film, the vacuum also has the advantageous effect of withdrawing smoke generated by the hot extruded polyolefin which if trapped between the material and the casting surface 4 would also impair optical properties.

The following are illustrative of particular embodiments of the invention wherein the polyethylene was of the type employed for wrappers, such as bread wrappers, of a medium density grade (about 0.941) with a melt index of about 2. The diameter of casting roll 3 was about 24 inches having the usual chrome plated casting surface; and such casting surface was maintained at a temperature of about 130° F. by conventional means (not shown) for circulation of cooling water therethrough.

Extruder 2 was a conventional Aetna Standard extruder having a 6 inch barrel diameter; and its barrel length was about 12 ft. The barrel pressure was maintained at about 1,700 lbs. per square inch for an operating speed of about 100 ft. per minute of film movement, namely, the take-off speed of the film from casting roll 3, about 2,500 lbs. per square inch at 200 ft. per minute, about 3,000 lbs. per square inch at 300 ft. per minute, and about 3,500 lbs. per square inch at about 460 ft. per minute. The temperature of the molten polyethylene fed into the die at 100 ft. per minute was about 603° F., at 200 ft. per minute about 610° F., at 300 ft. per minute about 612° F., and at 460 ft. per minute about 620° F.

Elongated discharge slot 8 of the extruder was set (about 0.015 in. in width) to provide a film thickness of about 1 mil (0.001 in.); and the extruder was so located and spaced with reference to the casting roll surface to position its extruder slot 8 at about a 45° angle to the tangent of roll and provide a film travel (length of section 9) of about 1½ in. The width of slot 16 of vacuum chamber 14 facing section 9 was about ¼ in.

Haze was measured in percent in accordance with ASTM Method D-1003-59T by a conventional pivotable sphere haze meter, made by H. A. Gardner Laboratories of Bethesda, Maryland. The less the reading, the less haze there is in the film, and consequently the clearer the film. Gloss was measured in accordance with ASTM Method D-523-53T by a H. A. Gardner Laboratories Gloss Meter with a 45° head. The greater the reading the better the gloss or in other words the sheen characteristics of the film.

The following were found to be the optical properties of the film at various amounts of vacuum equivalent to inches of water for the speeds indicated:

[100 ft. per minute]			
Vacuum		Haze (percent)	Gloss
0.07	-----	3.7	83.3
0.12	-----	3.5	83.8
0.18	-----	3.4	83.6
0.25	-----	3.1	83.7
[200 ft. per minute]			
0.120	-----	3.8	82.3
0.255	-----	3.3	82.4
0.365	-----	2.9	83.0
0.570	-----	2.9	81.5
[300 ft. per minute]			
0.12	-----	3.8	81.8
0.25	-----	3.1	81.3
0.36	-----	2.9	81.3
0.62	-----	3.1	77.4
[460 ft. per minute]			
0.21	-----	3.7	78.0
0.31	-----	3.4	78.6
0.48	-----	3.1	78.2
0.68	-----	3.3	76.0

From the preceding, it will be noted that at lower vacuums for all the speeds, the percent of haze was slightly higher but that as the amount of vacuum was increased, the percent of haze decreased. At higher speeds of 300 and 460 ft. per minute, the percent haze increases slightly when the amount of vacuum increases beyond a certain degree.

The gloss decreases generally with increase in vacuum, particularly at the higher speeds. However, the gloss is acceptable commercially because the specifications call for gloss not to be below 75.0, and haze not above 4.0 percent. The optimum conditions for minimum haze and maximum gloss properties of the film do not occur at the same particular amount of vacuum although the haze and gloss values are commercially satisfactory within the aforementioned vacuum range equivalent to about 0.1 to 0.8 in. of water. As the percent haze is below commercial specification of 4.0 percent, it is desirable for any given operating speed to adjust the amount of vacuum to provide for maximum gloss.

Thus, for example, with respect to the 460 ft. per minute speed, although the lowest haze of 3.1 percent is at a vacuum equivalent to about 0.48 inch of water, to obtain maximum gloss, the vacuum blower speed may be set to create a vacuum equivalent to about 0.31 inch of water which provides maximum gloss.

Without application of vacuum under the aforementioned operating conditions, the following data illustrate how commercial specifications of not more than 4.0 percent haze and over 75.0 gloss are not satisfied at higher operating speeds.

	Haze	Gloss
100 ft.-----	4.0	84.4
200 ft.-----	4.3	84.2
300 ft.-----	4.4	78.8
460 ft.-----	5.1	72.3

As the speed increases, the amount of haze increases, and the gloss decreases. Comparing the 460 ft. speed without application of vacuum with the same speed with vacuum applied, the marked improvement in optical properties due to the slight amount of vacuum employed will be apparent.

Moreover, without application of vacuum, puckering of the film increases markedly with increase in speed. At higher speeds of 300 ft. per minute and above, the puckering is so great as to render the film commercially unacceptable. However, within the amount of slight vacuum range applied according to this invention puckering is obviated.

I claim:

1. The method of controlling the optical properties of polyolefin film while it is continuously being formed by continuous deposit of molten polyolefin from an extrusion device on to a continuously moving casting surface which is spaced from the device whereby a continuously moving section of the polyolefin exists in such space between the casting surface and the device, and whereby after deposit on such surface the film sets along a frost line extending transversely of the direction of movement of the film; which comprises effecting said deposit of the polyolefin onto said casting surface while the polyolefin is in substantially amorphous condition and simultaneously subjecting the leading and trailing faces of said section to a differential pressure with the lesser pressure at the trailing face, providing means for adjustment of the amount of said differential pressure, providing means for adjustment of the speed of movement of said casting surface, and correlating such adjustments to control the character of said frost line for providing optimum optical properties in said film.

2. The method of controlling the optical properties of polyolefin film while it is continuously being formed by continuous deposit of molten polyolefin from an extrusion

device onto a continuously moving casting surface which is spaced from the device whereby a continuously moving section of the polyolefin exists in such space between the casting surface and the device, and whereby after deposit on such surface the film sets along a frost line extending transversely of the direction of movement of the film; which comprises effecting said deposit of the polyolefin onto said casting surface while the polyolefin is in substantially amorphous condition and simultaneously subjecting the trailing face of said section to a slight partial vacuum while the leading face is subjected to atmospheric pressure, providing means for adjustment of the amount of said vacuum, providing means for adjustment of the speed of movement of said casting surface, and correlating such adjustments to control the character of said frost line for providing optimum optical properties in said film.

3. The method of controlling the optical properties of polyolefin film while it is continuously being formed by continuous deposit of molten polyolefin from an extrusion device onto a continuously moving casting surface which is spaced from the device whereby a continuously moving section of the polyolefin exists in such space between the casting surface and the device, and whereby after deposit on such surface the film sets along a frost line extending transversely of the direction of movement of the film; which comprises effecting said deposit of the polyolefin film onto said casting surface while the polyolefin is in substantially amorphous condition and simultaneously subjecting the trailing face of said section to a partial vacuum equivalent to about 0.1 to 0.8 inch of water while the leading face is subjected to atmospheric pressure to provide substantially minimum haze in the deposited film, providing means for adjustment of the amount of said vacuum, providing means for adjustment of the speed of movement of said casting surface, and correlating such adjustments to control the character of said frost line for providing optimum optical properties in said film.

4. The method of claim 3 wherein the polyolefin is medium density polyethylene and the amount of partial vacuum is equivalent to about 0.30 to 0.60 inch of water.

5. The method of controlling the optical properties of polyolefin film while it is continuously being formed by continuous deposit of molten polyolefin from an extrusion device onto a continuously moving casting surface which is spaced from the device whereby a continuously moving section of the polyolefin exists in such space between the casting surface and the device, and whereby after deposit on such surface the film sets along a frost line extending transversely of the direction of movement of the film; which comprises providing a chamber between said extrusion device and said moving casting surface having an opening facing the trailing face of said section, effecting said deposit of the polyolefin onto said casting surface while the polyolefin is in substantially amorphous condition and simultaneously maintaining said chamber under a slight partial vacuum to subject said trailing face to said vacuum while the leading face is subjected to atmospheric pressure, damming off the space between said chamber and said casting surface by a pad in wiping contact with said casting surface, periodically removing and replenishing said pad to preclude oil from the polyolefin from accumulating on said casting surface, providing means for adjustment of the amount of said vacuum, providing means for adjustment of the speed of movement of said casting surface, and correlating such adjustments to control the character of said frost line for providing optimum optical properties in said film.

6. The method of controlling the optical properties of polyolefin film while it is continuously being formed by continuous deposit of molten polyolefin from an extrusion device onto a continuously moving casting surface which is spaced from the device whereby a con-

tinuously moving section of the polyolefin exists in free unsupported state in such space between the casting surface and the device, and whereby after deposit on such surface the film sets along a frost line extending transversely to the direction of movement of the film; which comprises effecting said deposit of the polyolefin onto said casting surface while the polyolefin is in substantially amorphous condition and simultaneously subjecting the trailing face of said free unsupported moving section to a slight partial vacuum while the leading face is subjected to atmospheric pressure, providing means for adjustment of the amount of said vacuum, providing means for adjustment of the speed of movement of said casting surface, and correlating such adjustments while maintaining said frost line substantially even.

7. In an extrusion apparatus, a continuously movable casting surface, an extrusion device having a slot extending transversely of the direction of movement of said casting surface for continuously extruding material onto said casting surface from a free unsupported continuously moving section thereof between said slot and said casting surface, a chamber between said extrusion device and said casting surface having an opening facing the trailing face of said section, means connected to said chamber for maintaining a partial vacuum therein, a pad rearwardly of said chamber opening between said cham-

ber and said casting surface in wiping contact with said casting surface, and a trackway carried by said chamber slidably supporting said pad to facilitate removal and replacement thereof.

8. In an extrusion apparatus, a casting roll rotatable about an axis, an extrusion device having a slot for continuously extruding material onto said roll from a free unsupported continuously moving section thereof between said slot and said roll, said device and its slot extending axially of said roll, a chamber between said extrusion device and said roll extending axially of said roll and having an axially extending opening facing the trailing face of said section, means connected to said chamber for maintaining a partial vacuum therein, a pad extending axially of said roll rearwardly of said chamber opening between said chamber and said roll in wiping contact with said roll, and a trackway carried by said chamber extending axially of said roll slidably supporting said pad for movement axially of said roll to facilitate removal and replacement thereof.

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