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PLASTIC EXTRUSION PROCESS IN CHILL ROLL CASTING OF FILM FOR IMPROVED FLATNESS

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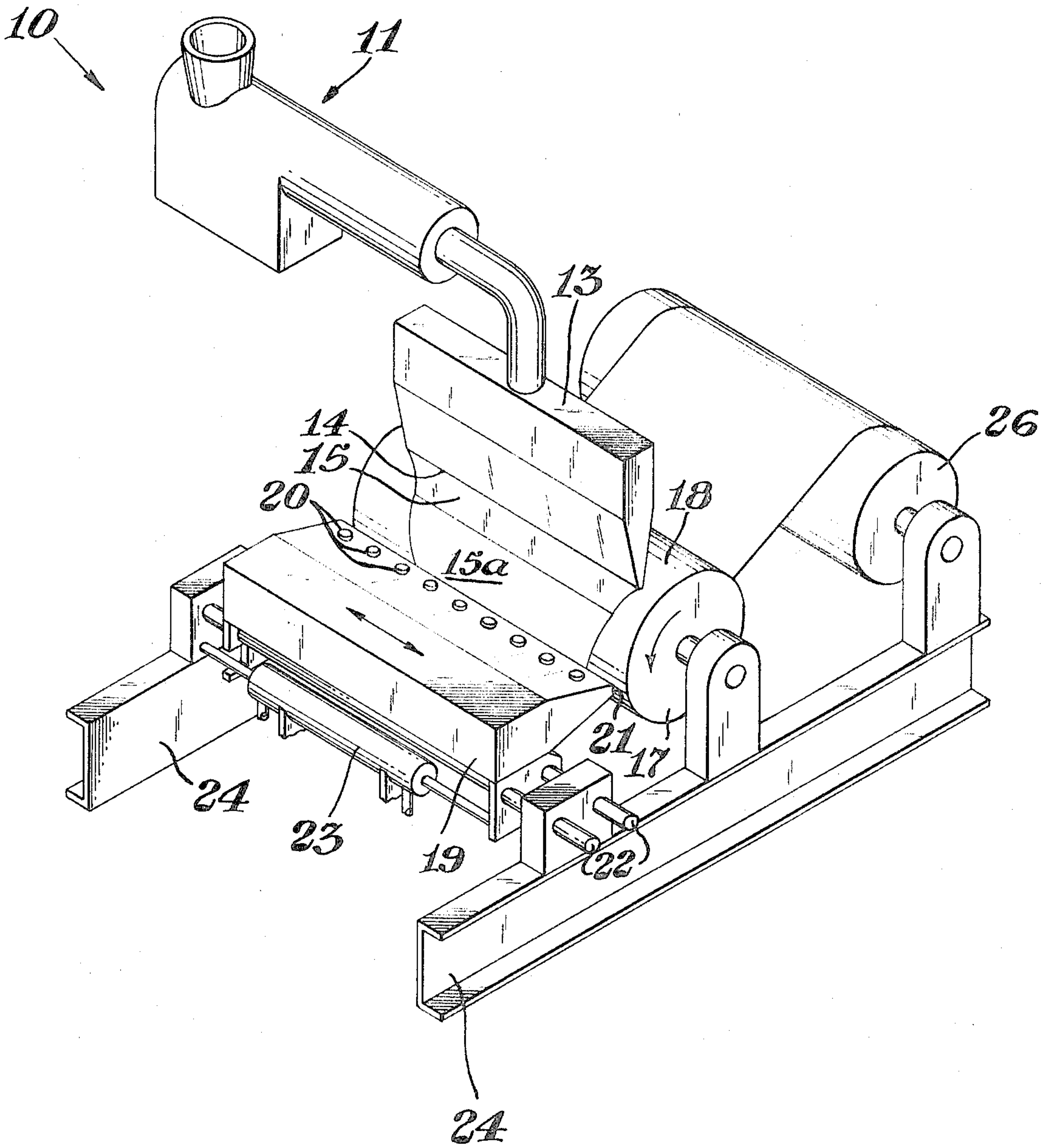

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PLASTIC EXTRUSION PROCESS IN CHILL ROLL CASTING OF FILM FOR IMPROVED FLATNESS

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ABSTRACT OF THE DISCLOSURE

In chill roll rasting of plastic film, improved flatness is obtained by oscillating the intensity of a flat stream of gas which is applied transverse to the direction of extrusion. By adjustment of the air stream, thick or thin spots may be reduced and distributed across the film.

This invention relates to the extrusion of plastic film, and more particularly relates to an improved method of chill roll casting of synthetic thermoplastic resins.

A substantialy problem exists in the preparation of synthetic thermoplastic film in obtaining what is referred to as a flat film or a lay flat film. In a chill roll casting process such as is set forth in U.S. Letters Pat. 3,121,915 wherein a synthetic resinous material is extruded from a slot die and the extruded film passed to a cooled drum or chill roll, the freshly extruded film is stretched between the orifice of the die and the chill roll. The chill roll serves to reduce the temperature of the film and provide control of the degree of stretch introduced between the die and the roll. The cooled film is then removed from the roll and wound onto a supply or mill roll. The film as initially extruded and removed from the chill roll can be flat; that is, readily conformed to a flat surface. However, if minor thickness variations are present in the film which is wound onto the mill roll, film unwound from the mill roll may have sag or bag or other indications of non-flatness due to the cumulative effect of the minor thickness variations and subsequent shrinkage of the film on the roll. Various methods and means have been employed to eliminate such non-uniformities and reduce them to as small a degree as possible. In the preparation of film by a tube or bubble process, various winding techniques have been employed to distribute the non-uniformities in a random manner across the width of the roll so that the deviation of the unwound film from a flat configuration would be minimal. Employing a chill roll casting process, such an approach is not practical.

It would be desirable if there were available an improved method for the chill roll casting of synthetic resinous film.

It would also be desirable if there were an improved method for reducing non-uniformities in a chill roll cast film.

It would also be beneficial if there were a method which would permit distributing such non-uniformities across the width of a chill roll cast film.

These benefits and other advantages in accordance with the present invention are achieved in a method for the preparation of a synthetic resinous thermoplastic sheet wherein a heat plastified synthetic resinous film forming material is extruded as a linear sheet from a slot die, the sheet being above the thermoplastic temperature of the material, the extruded sheet contacted with a generally arcuate cooled surface, the sheet being maintained against the surface generally adjacent the point of initial contact therewith by means of a generally planiform stream of gas directed toward the arcuate surface and disposed generally transversely to the direction of extrusion, the improvement which comprises cyclically varying the intensity of the planiform stream of gas in a direction generally transverse to the direction of extrusion.

Further features and advantages of the present invention will become more apparent from the following specification taken in connection with the drawing wherein:

The figure schematically depicts apparatus suitable for practicing the method of the invention.

In the figure there is depicted a film extrusion apparatus generally designated by the reference numeral **10**. The apparatus **10** comprises in cooperative combination an extruder **11**. The extruder **11** is in operative combination with a slot sheeting die **13** having an elongate extrusion orifice **14**. A heat plastified thermoplastic resinous sheet **15** emerges from the orifice **14**. A chill roll **17** is disposed adjacent the orifice **14**. The chill roll **17** has a generally arcuate or cylindrical cooling surface **18** upon which the film **15** is deposited in a generally sheet-like form. The roll **17** rotates in a direction as indicated by the arrow and generally is operated in such a manner that the surface speed is greater than the linear speed of extrusion and the film **15** is stretched or drawn to form a film **15*a***. An air knife or air doctor **19** is disposed adjacent the roll **17**. The air doctor **19** has an elongate discharge orifice **21** which delivers a planiform blast of air generally at the point of contact of the film **15*a*** with the roll **17**. The air doctor **19** has a plurality of adjusting means **20** adapted to selectively vary the dimension of the orifice **21** and permit selective adjustment thereof. The air knife **19** is slidably supported on ways **22** which permit lateral oscillation of the air knife in a direction generally normal to the direction of extrusion of the film **15**. An air knife actuating means **23** is operatively connected to the air knife **19** and to a frame or support **24**. The linear actuator **23** such as an air or hydraulic cylinder serves to oscillate the air knife **19** in the direction indicated by the double headed arrow. Beneficially, the width of the air knife **19** is at least equal to the width of the film **15*a*** plus the distance through which the air knife is moved by the actuator **23**. Advantageously, the air knife **19** is twice the width of the film **15*a***, but considerable benefit is achieved when narrower air knives are employed. The cooled film **15*a*** passes from the chill roll **17** and is wound onto a mill roll **26**.

In operation of the apparatus **10** and in the practice of the method of the invention, thermoplastic material is extruded by the extruder **11** through the die **13** from the orifice **14** and onto the rotating chill roll **17** where it engages the arcuate surface **18** and is cooled below its thermoplastic temperature and is subsequently passed to a mill roll such as the mill roll **26**. Various tensioning devices, if desired, are readily incorporated between the chill roll **17** and the mill roll **26**. The thickness of the film across the width of the roll is then determined by any convenient measuring means; that is, the transverse film profile. Air is provided to the air knife and in regions where the thickness of the film is greater than desired, the orifice **21** on the air knife is narrowed to reduce the air blast in the particular location. Reduction of the air blast appears to permit the thicker film to stretch to reduce the variation in thickness across the film. The air knife subsequently is then oscillated back and forth across the width of the film in such a manner that the entire width of the film is subjected to the uneven air blast. The uneven air blast shows a strong tendency to cause the non-uniformities to appear at various locations across the width of the film; for example, for the thicker region of the film to move from one edge toward the other edge. Beneficially, oscillation of the air knife delivering a non-uniform blast of gas for a distance as small as 5 percent of the web width improves the flatness of film obtained, and oscillation of the air knife for 100 percent of the web width very significantly improves the flatness of the film. For many applications, satisfactory adjustment of the air knife is made after die adjustments have been made to obtain as much control as is practically possible of the film thickness.

By observing the windup mill roll, which is the roll **26**, thick spots in the film become readily apparent because of the increased diameter of the wound film roll in regions where the film has maximum thickness. Subsequent adjustment of the air knife by closing or reducing the orifice in the region of the film which is the thickest and oscillation of the air knife changes the product from a film exhibiting severe sag or bag to a film having commercially acceptable characteristics. The frequency of oscillation may be varied within wide limits. However, it is usually desirable that the air knife oscillate at least about ten full cycles in the preparation of a mill roll, and beneficially at least about thirty cycles. For the preparation of most film, an oscillation rate of about one cycle per minute is satisfactory.

Although the process of the invention in one specific embodiment has been described in relation to the oscillation of the air knife, it is obvious that only the cyclic oscillation of thhe variation in intensity in the air stream is necessary to accomplish the purpose of the invention. This can be achieved in a variety of other manners. For example, the adjusting members, such as the adjusting members **20**, of an air doctor such as that depicted in the apparatus of the figure can be cyclically varied by means of a rotating cam mechanically coupled thereto or the gap varied by means of variable length adjusting bolts such as are depicted in U.S. Letters Patent 2,938,231 wherein the adjusting bolts may be sequentially heated and cooled in accordance with almost any desired pattern by means of a controlled cam operating individual switches to each of the adjusting bolts or varying individual voltage control units. Alternately, a rotating mandrel may be disposed within a fixed air doctor, the mandrel having a helical groove on the surface therof and serving to act as a restrictor to the flow of gas from the plenum of the air doctor to the discharge slot. If, for example, a helically disposed groove having one turn over the length of the rotor is employed, a high pressure zone will traverse the slot for each turn of the rotor; or if a single land equivalent to the groove is disposed on the rotor, a low pressure zone will traverse the air doctor opening. Other means causing a pressure variation to cyclically traverse the air doctor opening will be readily apparent to those skilled in the art.

The present invention is readily employed with a wide variety of synthetic resinous materials and with particular benefit in the preparation of polyolefin films such as polyethylene, polypropylene and resinous film forming polymers of ethylene and/or propylene with other

monomers such as ethyl acrylate, acrylic acid and the like.

As is apparent from the foregoing specification, the present invention is susceptible of being embodied with various alterations and modifications which may differ particularly from those that have been described in the preceding specification and description. For this reason, it is to be fully understood that all of the foregoing is intended to be merely illustrative and is not to be construed or interpreted as being restrictive or otherwise limiting of the present invention.

What is claimed is:

1. In a method for the preparation of a synthetic resinous thermoplastic sheet wherein a heat plastified synthetic resinous film forming material is extruded as a linear sheet from a slot die, the sheet being above the thermoplastic temperature of the material, the extruded sheet contacted with a generally arcuate cooled surface, the sheet being maintained against the surface generally adjacent the point of initial contact therewith by means of a generally planiform stream of gas directed toward the arcuate surface and disposed generally transversely to the direction of extrusion, the improvement which comprises

cyclically oscillating a variation in intensity in the planiform stream of gas in a direction generally transverse to the direction of extrusion.

2. The method of claim **1** wherein the planiform stream of gas is non-uniform across the width of the sheet.

3. The method of claim **2** wherein the planiform stream of gas is restricted in a location generally equivalent to a portion of the extruded film having a thickness greater than the adjacent area of the film.

4. The method of claim **1** wherein the sheet is subsequently wound onto a roll and the stream of gas is oscillated at a rate sufficient to provide at least 10 full cycles of oscillation during preparation of the roll.

5. The method of claim **1** wherein the sheet is stretched between the extrusion die and the arcuate surface.

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