

UNIVERSITY OF TEXAS AT AUSTIN
DEPARTMENT OF CHEMICAL ENGINEERING
CHE 395E

SHEET EXTRUSION OPERATIONS

I. Object

In contrast to the other experiments in this course, this experiment is relatively unstructured and designed to test your intuitive understanding of heat transfer and polymer rheology. The object of the exercise is to demonstrate the continuous production of extruded sheet. The sheet must conform to the following specifications:

- (1) The sheet thickness shall be 0.006 +/- 0.001 in. thick across the width of the sheet. The only exception to this tolerance shall be the immediate edge of the sheet. In actual process this would be trimmed. You may allow 1/8 in. from each edge to be out of specification.
- (2) The sheet width shall be no less than 4.0 inches. Quality points will be awarded for production of sheet wider than 4 inches.
- (3) Continuous production of product must be demonstrated. One way to demonstrate stable production is to produce sufficient film to produce a one inch thick roll of product on the core. Quality points will be awarded for maintaining tolerance over the length of the production run. Time is money. Quality points will be awarded for the highest rate of production of material that meets specifications.

II. References

1. E. C. Bernhardt, "Processing of Thermoplastic Materials", Van Nostrand Reinhold Co., New York, 1959. pps. 282-288.
2. Z. Tadmore and C. G. Gogos, "Principles of Polymer Processing", Wiley-Interscience, New York, 1979. pps. 545- 551.

III. Equipment and Supplies

1. One inch, 30:1 Killian Plasticating Extruder.
2. Killian Chill Roll Assembly.
3. Six inch sheet die.
4. Killion Film Winding Apparatus.

5. Polytroller Chill Roll Temperature Control System.
6. Thermoplastic, to be assigned by instructor.
7. Micrometer, 0 to 1 inch.
8. Gap Gauges.
9. Balance.
10. Stop watch
11. Allen Head wrench set

IV. Procedures

While this experiment is designed to be relatively unstructured and assumes that the student is familiar with the operation of the extruder, the following hints and comments should prove useful:

A. CHILL ROLL ASSEMBLY

(1) Best film flatness and finish will be obtained when the chill rolls are operated at an elevated temperature. For example, LLPE works best at roll temperatures in excess of 130 °F. The issue is a matter of heat transfer from the film. If the rolls are too cold or the contact time too long, heat is primarily transferred from the polymer surface in contact with the first roll. This causes the film to warp and wrinkle and set prior to contacting the second roll. Good film is produced when the film is still warm enough to finish and set by the second roll. Use the roll temperature control to obtain the best operating temperature at each through put.

(2) The film will be drawn down or uniaxially extended if the linear velocity of the chill roll assembly is higher than that of the material being pumped through the die. Draw down can be used to adjust the gauge thickness of the film, however the width of the film will also be affected. The amount of draw down on film width can be controlled, somewhat, by the distance between the film die lip and the point on the chill roll where the film makes contact. This distance is adjusted by raising and lowering the entire chill roll assembly with the screw provided at the assembly base. **WHEN ADJUSTING THIS DISTANCE BE SURE NOT TO CONTACT THE CHILL ROLL WITH THE DIE. THIS COULD IRREVERSABLY DAMAGE THE CHILL ROLL!!**

(3) The extrudate is threaded through the chill roll assembly by passing it under the large chill roll and between the small chill roll and the rubber coated pinch roll. This can be done easily by the operator as follows:

- a. Wear cotton gloves.
- b. set the chill roll take up rate, visually, to be the same as the film extrusion rate.
- c. Press the extruded film with hand to the front edge of the chill roll and hold the film in place as it passes under this roll.
- d. Guide the film through the pinch roll assembly. Then set the pneumatic pinch roll by placing the air valve in the down position.

B. SHEETING DIE

The temperature of the sheeting die is adjustable by the temperature controller on the extruder in the usual way. The sheeting die is a typical manifold fed die with adjustable die lip and internal dam. The die may be set by adjusting the Allen Head screws on the front surface of the die. Uniform film often requires that small adjustments be made while material is flowing through the die to compensate for pressure drop in the manifold.

(1) Before beginning the experiment use the gap gauges to determine the lip separation at several points along the width of the slit. Record this information so that the die can be returned to its original configuration after the experiment is completed.

(2) If the die lip is not at a uniform distance from the chill roll, some variation in film thickness will be caused by different degrees of draw down across the width of the film. Be sure that the die and chill roll assembly are squared off properly to avoid this problem. The die may be tilted slightly about the feed port axis to provide small adjustments to film thickness. AGAIN, TAKE CARE NOT TO CONTACT THE CHILL ROLL WITH THE DIE FACE. Try these adjustments before adjusting the die gap.

(3) Should adjustments to the die gap be necessary, these are best made while the machine is operating. When the problem has been corrected, shut the machine off and measure the new gap settings with the gap gauge.

C. FILM WINDING APPARATUS

The film winding apparatus is provided with a motor speed adjustment and a slip clutch. The motor speed should be set to give a linear velocity that is much higher than that of the extrusion line. The slip clutch will then act to provide constant tension in the film as it winds. Film can be attached to the PVC core provided by simply wrapping it on itself a few times. For best results, the winding apparatus shaft must be parallel with the pinch roll on the chill roll assembly.

V. Data Taking Procedures

- A. Each extrusion run reported should be completely characterized. Characterization must include all extruder settings, mass throughput rate, chill roll temperature, and the distance from chill roll to die, and die gap.
- B. The film produced in each extrusion run shall be saved and characterized as follows:
- (1) Film uniformity of thickness shall be measured at the center and near the outer edges. The Uniformity Index, defined as minimum thickness/maximum thickness, shall be reported at the beginning, in the middle, and at the end of each production run.
 - (2) Film width shall be recorded at the beginning, in the middle, and at the end of each production run. The Draw Ratio, defined as the ratio of the take-up velocity of the melt to the die velocity shall be calculated. This ratio can be most easily determined from knowledge of the die and film geometry by: $\text{Draw Ratio} = V_2/V_1 = S_1/S_2$ where S_i is the cross-sectional area and V_i the velocity at position i .
 - (3) Film mechanical properties shall be measured with the Table Model Instron Testing Machine in Room 3.460. Properties of the film should be measured both in the machine and transverse directions to judge the presence of any anisotropy induced by the processing conditions employed.

VI. Data Analysis

- A. Discuss the relationships, if any between the film mechanical properties and Draw Ratio, and temperatures used to process the film. Is anisotropy in film properties a more sensitive function of temperature, absolute rate, or Draw Ratio?
- B. Compare the die lip gap used to the Uniformity Index of the film. Discuss these results.
- C. Use your operating experience with this system to suggest needed improvements in equipment, etc. to produce higher quality, balanced property, films.