2/22/2018
2018 OPEN DISCHARGE LAB

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

Characterization of an Extruder Operated at Open Discharge

I.Object

The flow behavior of polymer melts is distinctly non-Newtonian. However, if an extruder is operated at open discharge, $\Delta P=O$, the viscosity of the polymer and its dependence on velocity and temperature no longer affect the extruder operation. At this condition the throughput of a melt conveying extruder is dependent only on the screw geometry and screw speed. If the extruder is also used to melt incoming solid material, the flow observed may deviate from that expected due to heat transfer limitations. The object of this experiment is therefore to check the observed open discharge flow versus screw speed with that theoretically predicted for the metering section of a single stage plasticating screw to determine whether the deviations, if any, can be ascribed to heat transfer problems.

II. References

l. McKelvey, James M., "Polymer Processing", J. Wiley (New Yòrk) 1962, Chapts. 10 and 11.

2. Gore, W. L., and McKelvey, J. M., "Rheology, Vol. 3", ed. by F. R. Eirich, Academic Press (New York), 1960, Chapt. 16.

3. McKelvey, James M., Polymer Engineering and Science, 6, 131 (1966).

4. Modern Plastics Encyclopedia, section on extrusion.

5. Carley, J. F., SPE Journal, 9, 9 (mar. 153). mar, 1953

6. Carley, J. F., and Strub, R. A., Ind. Eng. Chem., 45, 970 (1953).

7. Carley, J. F., Mallouk, R. S., and McKelvey, J. M., Ind. Eng. Chem., 45, 974 (1953).

III. Equipment and Supplies

l. One inch, 30:l Killian plasticating extruder.

2. Triple beam balance.

3. Electric stopwatch or equivalent.

4. Polyethylene material.

5. Micrometer and calipers (may be borrowed from shop).

6. 600 ml glass beaker.

7. Paper toweling.

IV. Preliminary Work

Examine the theoretical framework leading to the open discharge equation, Q=αN, where

$$\alpha = \frac{\pi^2 D^2 H \sin(\theta)\cos(\theta)}{2}[1-\frac{2c}{D}-\frac{em}{\pi D \sin(\theta)}](1-\frac{c}{H})^2 F_D$$

(ref. 1, p. 250) and identify each term and its units. Other equations for relating **α** to the screw geometry and speed may also be examined in the literature if desired.

V. Extruder Startup Procedures

l. Turn on hopper and bearing cooling water. Water flow rate should be kept low provided that the flow is sufficient to keep the hopper cool when the barrel is heated.

2. Turn on the barrel and die heaters and set to desired level. For extrusion of polyethylene, all zones can be initially set to 400ºF. Adjustments may be necessary depending on the viscosity of the particular polymer used.

3. Allow heaters to heat to the set point. After set temperatures are reached allow an additional 10 minutes of heating to ensure that the material in the screw channel has melted.

4. Remove die and die plate from machine.

5. Place resin in the hopper and turn on screw drive as follows:

a. Set screw speed control to zero.

b. Turn on motor drive.

c. Slowly increase the speed control to reach desired speed while simultaneously watching the screw speed tachometer and the field current to the motor. UNDER NO CIRCUMSTANCE SHOULD THE FIELD CURRENT EXCEED 5.0 AMPS. If this occurs prior to reaching the desired screw speed, return the speed control to zero and either wait for the polymer to melt for an additional 10 minutes or adjust the temperature upward to reduce the melt viscosity.

d. If it is desired to turn off the motor drive, ALWAYS RETURN THE SCREW SPEED CONTROL TO ZERO PRIOR TO TURNING OFF THE MOTOR. THE SCREW MAY BREAK IF THE MOTOR DRIVE IS ACCIDENTLY TURNED ON WITH THE SCREW SPEED CONTROL SET AT A VALUE OTHER THAN ZERO.

VI. Data Taking Procedure

l. Obtain throughput, Q, versus screw speed, N, measurements as follows:

a. Allow machine to run for several minutes before measuring Q.

b. Weigh a piece of paper toweling on the balance.

c. Place the toweling in the glass beaker so that the glass interior is covered by paper.

d. Run the melt from the extruder into the beaker, timing the run time with the stop watch. Remove the paper and polymer melt and weigh to determine the mass rate of flow.

e. Use the published density of polyethylene to estimate the volume throughput.

f. Repeat the measurement procedure at a variety of screw speeds encompassing as wide a range as possible commensurate with the 5.0 amp limit on motor field current.

2. Increase the barrel setting temperatures by 50ºF, allow thermal equilibrium to occur and repeat step 1 above.

3. Repeat step 2.

4. Remove screw from the extruder. Your instructor will help you with this step.

5. Clean screw and measure the appropriate screw dimensions using the calipers and micrometer.

6. Reinstall screw.

7. Shut off heaters to extruder barrel.

8. Shut off cooling water to extruder hopper.

VII. Data Analysis

I. Examine the Q vs. N curves measured at three different temperatures. All data should fall on one line if heat transfer in the melting section is not limiting.

2. Obtain an experimental value for a and compare this with various theoretical estimates based on your measured screw geometry.

3. Discuss thoroughly the theoretical developments leading to parameter **α**. Assuming that good agreement is seen between the experimental and observed **α** values, estimate the isothermal operating lines {Q vs. ΔP) for this extruder at 450ºF for several screw speeds assuming a power law viscosity relationship with the power law factor, n = 0.33, and a zero shear viscosity of 0.10 lb. sec/in2 and explain how these curves could be used to estimate extrusion rates through various dies