

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

EFFECT OF MOLDING CONDITIONS ON MECHANICAL PROPERTIES

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### I. Object

During injection molding, the viscous polymer is forced to flow at high rates into the mold cavity. During this flow, the molecules tend to become oriented in the direction of flow, and if the rate of flow and of cooling is higher than the rate at which the molecules can relax into their preferred random coil configurations, the flow induced molecular orientation can persist in the molded part. This orientation can profoundly affect the mechanical properties of the molded part. In some molded parts, "weld lines" are formed by the intersection of two or more separately flowing melt fronts. The mechanical strength across this weld line is often much lower than the published strength of the material. One reason for this is that both rapid injection cycles and rapid cooling combine to reduce diffusion across the weld line. Another is that the molecules are actually oriented in the melt front at right angles to the flow. The object of this experiment is to gain an appreciation for the influence of molding methods and conditions on resulting mechanical properties. To accomplish this, we will examine the properties of polyolefine parts made by injection molding and by non-flow compression molding. We will also examine weld line behavior by appropriately setting the valves in our mold to create a weld line at right angle to the test direction.

### II. References

1. E.C. Bernhardt, Processing of Thermoplastic Materials, Van Nostrand-Reinhold, New York (1959).
2. S.L. Rosen, Fundamental Principles of Polymeric Materials, J. Wiley, New York (1971).
3. Z. Tadmore and C.G. Gogos, Principles of Polymer Processing, J. Wiley, New York (1979).

### III. Equipment and Supplies

1. Arburg Screw Injection Molding Machine
2. Instron Tensile Testing Machine
3. Injection Mold, gated to provide weld line
4. Compression Molding Machine with 1/8" deep mold.

5. Routing machine for preparing tensile specimens from compression molded plate
6. Mold Temperature controller and indicator systems

#### IV. Procedure

1. The following injection molding parameters should provide a useful starting point:

- \* Barrel Temperatures, Zones 4,3,2 = 450 °F
- \* Hydraulic Pressure= 400 psi
- \* Delay Injection= 1 sec
- \* Injection= 0.1 sec
- \* Pressure Hold= 4 sec
- \* Cool Time= 35 sec
- \* Die Open (automatic mode) = 0.6 sec

2. The mold temperature controller used with the injection molding machine should be set, initially, at 75 F. This setting may be increased as one of the parameters in the study to 150 F in steps of 25 F as part of your study.

3. Your instructor will help you set up the compression molding machine. Typical compression molding temperature may be 350-400 F, and typical compression force on an 8" x 8 1/4" plate may be 15 tons. Due to the large thermal mass of our compression molding system, a typical cycle may take an hour to produce one plate. Consequently, compression molding should be done in parallel with the injection molding experiments.

4. Using the conditions in steps 1 and 2 as a guide, injection mold at least 10 parts on the automatic cycle after good appearing parts have been obtained. Mark and save these parts. Then change the valves in the mold runner system and repeat the molding process, using the same conditions. parameter of the molding cycle, for example the injection rate, and repeat the above to mold parts both with and without weld lines. At this point, increase the mold temperature controller setting, wait for equilibrium, and repeat the experiment at the beginning of step 4. Continue until work at the highest mold temperature setting has been concluded. Mark and save these parts. Next change a

5. Parts should be tested with the Instron testing machine after they have cooled to room temperature. A cross-head rate of 2 in./min. should be used for most testing work. Test a minimum of three specimens from each batch. More testing may be required if the elongation at break varies by more than 25% or if the strength varies by more than 10% within the batch. Average the results. If you have sufficient specimens, you may wish to try testing at a different

cross-head rate, for example 1 in./min. The rate dependence of mechanical behavior of polymers above their glass transition temperatures may be clearly seen.

6. Your instructor will help you set up the router for milling test specimens from the compression molded sheet. These parts should be tested at the same cross-head rate used in step 5 so that the effect of orientation in the injection molded vs the non-orientation in the compression molded specimens can be clearly seen.

#### **V. Report**

1. Provide graphs which compare strength and ductility of injection molded bars vs the molding conditions employed. How can one minimize the detrimental effects of weld lines through changes in molding conditions?
2. Compare the properties of bars injection molded without weld lines to those of the compression molded specimens. What is the influence of molecular orientation on observed properties? What is the influence of injection molding conditions on molecular orientation?
3. What influence does the rate of testing have on the mechanical properties observed? Why?