

### Processing, Quiz 1 1/7/2000

You are at a job interview at Phillips Petroleum, a producer of high-density polyethylene (HDPE). Your potential boss hasn't decided if he wants to hire another Synthetic Chemist, such as himself, or a Processing Engineer, i.e. you. (*You have decided that Tulsa, Oklahoma is the town for you.*) You need to make a brief, concise and convincing argument, to your potential boss, that he would be much better off with a processing engineer. The first 2 questions are meant to guide your argument.

a) **-Discuss** the value of a Polymer Processing Engineer to a polyolefin (polyethylene / polypropylene) producer such as Phillips.

**-Explain** how your services are more valuable than those of a synthetic chemist to a group with many chemists.

**-You** may need to explain your view of the relationship between Phillips and their customers.

b) **-Give an example** of where Phillips may have over invested in synthetic chemistry while overlooking processing issues. (One example was given in class, if you don't remember then be creative.)

c) The plasticating screw extruder is involved in almost every polymer processing operation.

**-Your** potential boss wants you to explain the basic components of the extruder.

**-Your** answer should include a sketch of an extruder and its components and;

**-an indication** of where (what part of the machine) the 5 elementary steps of polymer processing are involved in the extruder. (solids processing; melting; pressurization and pumping; mixing; devolatilization and stripping).

d) One of your strong points is an understanding of the basics of non-Newtonian rheology.

**-Your** potential boss wants to know what non-Newtonian rheology has to do with processing. (Give an example from non-Newtonian flow from the extruder, i.e. a flow property that would not be seen in a Newtonian fluid such as water.)

e) Your potential boss knows a little more processing than he has lead-on up to this point. He takes from his desk drawer a part from an injection molding operation that hasn't been trimmed, i.e. with gate, sprue, runners, cold slug and moldings.

**-Sketch** a typical untrimmed injection molded part of this type showing these components and;

**-explain** three typical problems with these parts, 1) excessive flashing; 2) weld line; and 3) short shot.

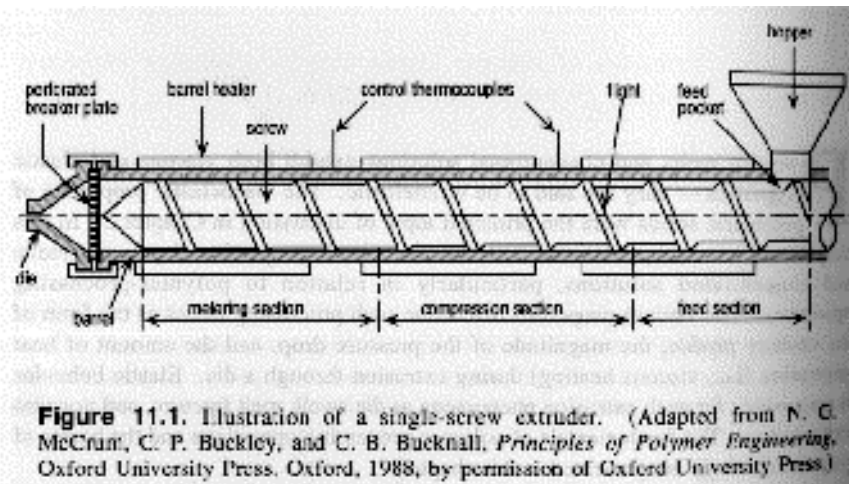
## Answers: Quiz 1 Polymer Processing

1/7/2000

a) The basic line of argument is that although synthetic chemists (your potential boss) are obviously the highest form of life (at Phillips) there is a need to look at the application of the amazing materials chemists are capable of making in processing operations at the earliest stages of development so as not to waste the valuable time of the synthetic team on new polymers that can not be processed. The main example is the money Phillips put into metallocene olefins to later find out that these materials "jam-up" extruders. Another argument is that Phillips needs to talk to their customers, i.e. polymer processing plants, in the language of the customer and for this reason a processing engineer could serve somewhat like a translator between the potential of chemistry and the reality of processed polymers.

b) Metallocene example is what I was thinking of.

c)



Solids-at the hopper and in the initial stages of the barrel.

Melting-in the central part of the barrel

Pressurization-after melting to the end of the screw just before the die. Drag-flow drives pressurization.

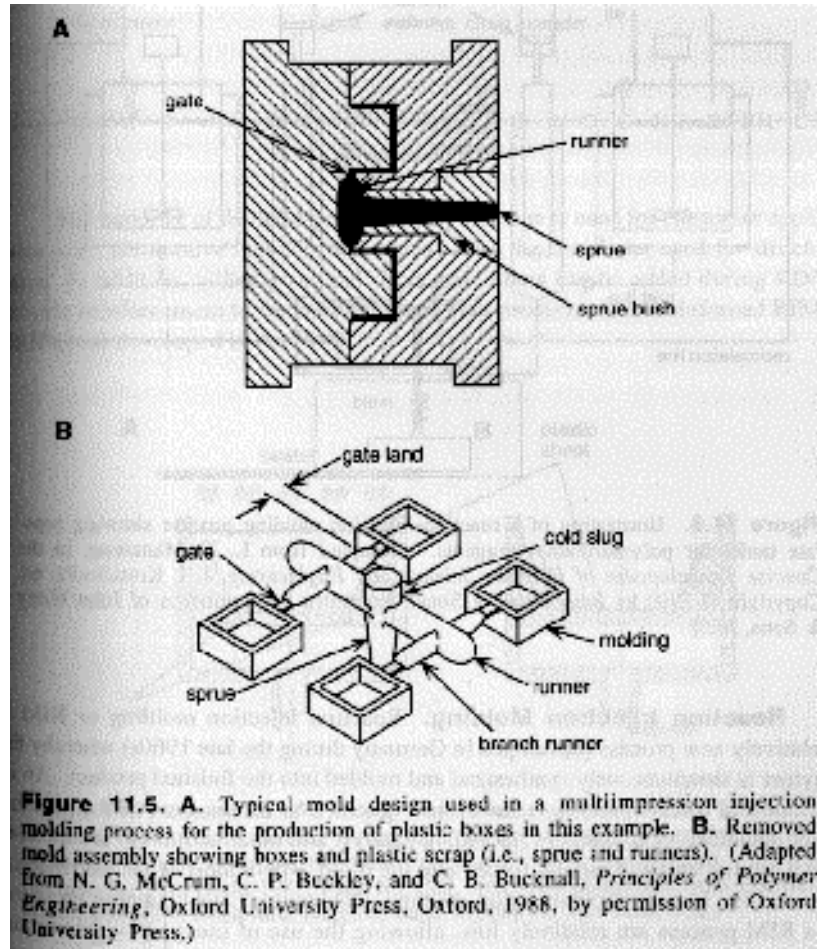
Mixing-Laminar mixing occurs by stretching of fluid elements, particulate mixing occurs near the hopper in the barrel.

Devolitization can be accomplished by venting sections (not shown) where the screw narrows in diameter and a vent is inserted in the barrel.

d) A number of unexpected features occur in the flow of polymers in processing, most notable are the presence of large normal stresses (forces perpendicular to the direction of flow); elasticity of the fluid that leads to rebound of flow streams and spinability; and shear thinning behavior, i.e. the viscosity drops with a power-law as the shear rate increases. All of these features are related in one way or another to the fluid having "structure", in this case having a chain-like colloidal scale structure.

The example that was mentioned in class is die swell at the die of the extruder.

e)



Excessive flashing occurs along the parting line of the mold and involves polymer melt leaking in to the small gap between the molds. It typically occurs when the clamping pressure is too high or when the mold or injection temperature is too high.

A weld line occurs where two melt fronts meet and is usually the weakest part of an injection molded part. Weld lines can sometimes be avoided by careful mold design and by simulation of the mold filling behavior on a computer.

Short shot occurs when there is insufficient polymer in the shot to fill the mold or when the clamping pressure is too low. It can also be related to too high of an injection temperature and a number of other factors.