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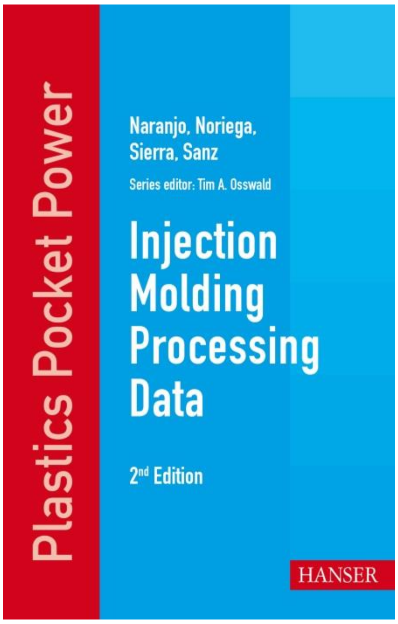

Sample Pages

Injection Molding, Processing Data

Alberto Naranjo C., Maria del Pilar Noriega E., Juan Diego Sierra M. & Juan Rodrigo Sanz

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2 Injection Technology

A modern injection molding machine with its most important elements is shown in Figure 2.1. The components of the injection molding machine are the plasticating unit, clamping unit, control unit, and the mold.

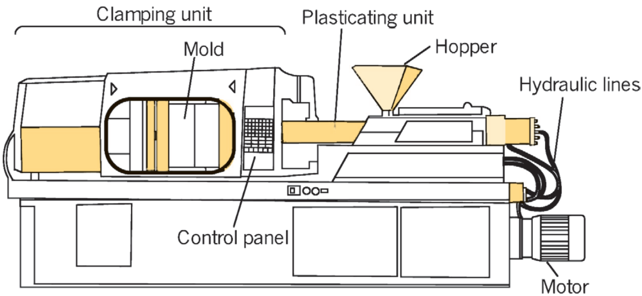


Figure 2.1 Schematic of an injection molding machine. See Figure 2.7 for a more detailed representation of the machine

Today, injection molding machines are classified by the following international convention

Manufacturer type T/P

where T is the clamping force in metric tons and P is defined as

$$P = \frac{v_{max} \; p_{max}}{1000}$$

where v_{max} is the maximum shot size in cm^3 and p_{max} is the maximum injection pressure in bar. The clamping force T

can be as low as 1 metric ton for small machines, and as high as 11,000 tons.

There is another classification regarding specific energy consumption (kWh/kg), the Euromap 60.1. There are 10 efficiency classes: Class 1 (> 1.5 kWh/kg) to Class 10 (≤ 0.25 kWh/kg). For small machines (screw ≤ 25 mm) the class definition is different.

2.1 The Injection Molding Cycle

The sequence of events during the injection molding of a plastic part, as shown in Figure 2.2, is called the injection molding cycle. The cycle begins when the mold closes, followed by the injection of the polymer into the mold cavity. Once the cavity is filled, a holding pressure is maintained to compensate for material shrinkage. In the next step, the screw turns, feeding the next shot to the front of the screw. This causes the screw to retract as the next shot is prepared. Once the part is sufficiently cool, the mold opens and the part is ejected. Figure 2.3 presents the sequence of events during the injection molding cycle. The figure shows that the cycle time is dominated by the cooling of the part inside the mold cavity. However, in some cases the plasticating time can be longer than the cooling time, e.g., when the mold cavity number is high for the plasticating unit capacity; the plasticating time is also longer than the cooling time when the parts have thin walls. The total cycle time can be calculated using

$$t_{\text{cycle}} = t_{\text{closing}} + t_{\text{injectionunitforward}} + t_{\text{injection}} + t_{\text{cooling}} + t_{\text{ejection}}$$

3 Useful Equations and Theory

ESTIMATING COOLING DURING INJECTION MOLDING

The cooling time for a plate-like part of thickness *h* can be estimated using

$$t_{cooling} = \frac{h^2}{\pi^2 \cdot \alpha} \ln\left(\frac{8}{\pi^2} \frac{T_M - T_W}{T_D - T_W} \right)$$

and for a cylindrical geometry of diameter *D* using

$$t_{cooling} = \frac{D^2}{23.14\alpha} \ln\left(0.692 \frac{T_M - T_W}{T_D - T_W} \right)$$

In the above equations α represents effective thermal diffusivity, T_M represents the average melt temperature, T_W the average mold temperature, and T_D the average part temperature at ejection.

EQUATIONS FOR PRESSURE FLOW THROUGH A SLIT

Pressure flow through a slit, such as shown in Figure 3.1, is commonly encountered in flows inside injection molds. The Newtonian flow field is described using

$$v_z(y) = \left(\frac{h^2 \Delta p}{8\mu\, L}\right)\left[1 - \left(\frac{2y}{h}\right)^2\right]$$

$$Q = \frac{W\, h^3\, \Delta p}{12\,\mu\, L}$$

When using the power law model equation the flow field is described by

$$v_z(y) = \left(\frac{h}{2(s+1)}\right)\left(\frac{h\Delta p}{2mL}\right)^s\left[1 - \left(\frac{2y}{h}\right)^{s+1}\right]$$

$$Q = \frac{Wh^2}{2(s+2)}\left(\frac{h\Delta p}{2mL}\right)^s$$

where $s = 1/n$ and $v_z(y)$ is the velocity profile across the gap and Q the total volumetric flow rate through a slit of width W.

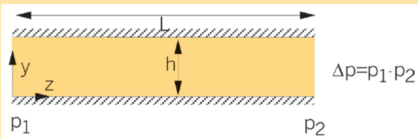


Figure 3.1 Schematic diagram of a pressure flow through a slit

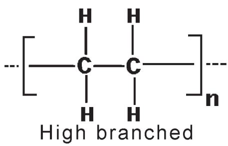
5 Polymer Data (for Standard Materials without Fillers or Modifiers)

5.1 Polyolefins

5.1.1 Low Density Polyethylene (LDPE)

Basic technical data

- Density: 0.910 to 0.926 g/cm^3
- Melting point: 105 to 115 °C
- Glass transition temperature: −133 to −120 °C



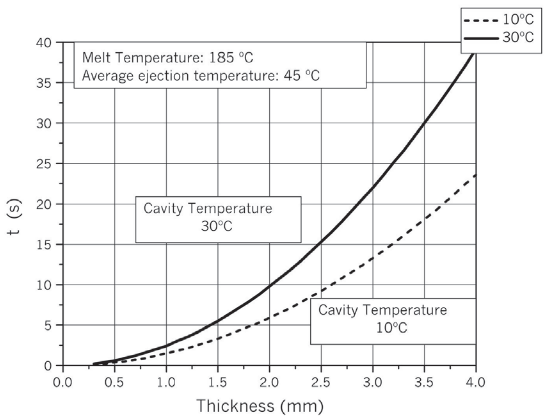


Figure 5.1 Mold cooling with LDPE

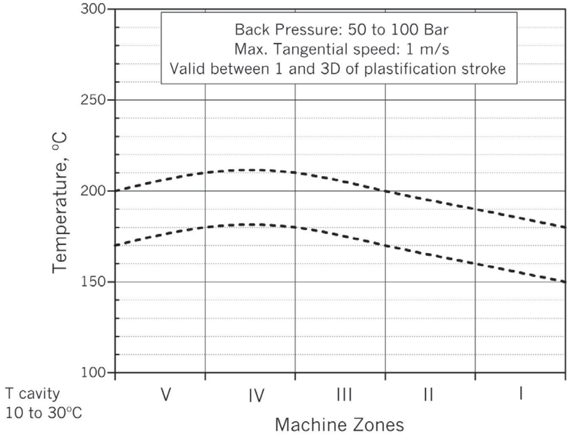


Figure 5.2 Recommended temperature profiles for processing LDPE

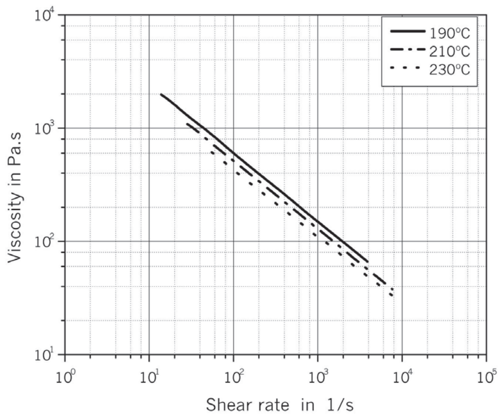


Figure 5.3 Viscosity vs shear rate of LDPE

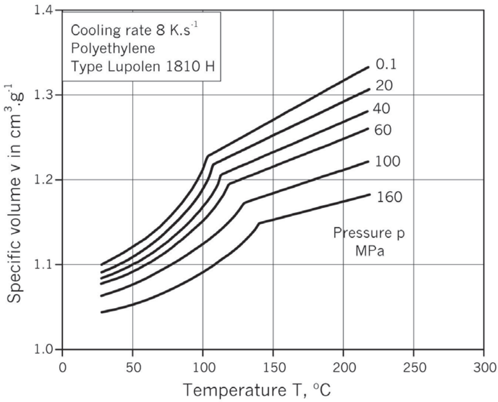


Figure 5.4 PVT diagram for LDPE

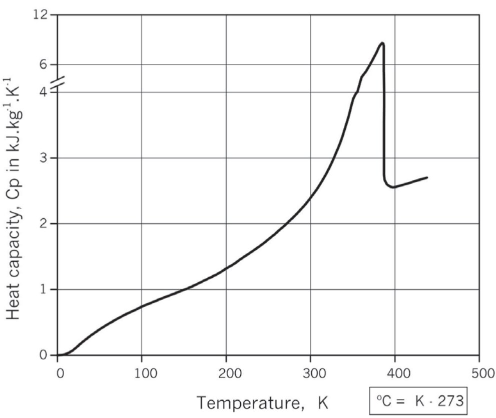


Figure 5.5 Heat capacity vs temperature of LDPE