Maximum Rate of an Extruder

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For a given extruder, the maximum possible rate depends upon the motor power. An estimate for the rate can be made based on the heat capacity1(kW hr/kg) of the polymer from inlet temperature to product temperature. The wattage of the motor is then divided by the heat capacity to give the potential rate. For example, the heat capacity for melting and heating LDPE is about 0.2 kW hr/kg, so a 50-kW drive with 90% efficiency would have a maximum rate of 0.9 x 50/0.2 = 225 kg/hr.

However, to attain the maximum rate, the screw must be designed to generate energy needed by the flow rate that it produces. Some screws develop inadequate energy, and they require heat from the barrel zone to produce the desired melt temperature. Other screw may develop too much energy, and they will require some barrel cooling. The ideal design is one that neither requires significant heating or cooling at the desired rate. This minimization of heat conduction in the polymer will help optimize the thermal uniformity of the melt, especially in the melt section near the exit.

Screw performance can then be judged on the ratio of motor power to polymer energy needs. First, the rate of an operating extruder can be multiplied by the polymer heat capacity. This is divided by the prevailing power consumption and efficiency to give a performance quotient. If the quotient is greater than one, then the barrel is heating the polymer. If the quotient is less than one, then the barrel is cooling the polymer. Ideally, the quotient should be near unity.

For example, LDPE with a heat capacity of 0.2 kW-hr/kg is being processed at a rate of 200 kg/hr. and the motor is using 41 kW at 90% efficiency. Then, the performance quotient is 0.2 x 200 (.9*41) = 1.08. The conclusion is that the barrel is providing some of the energy of the polymer. This could be corrected by changing the screw design to have a slightly shallower channel depth (to increase energy development) and a slightly longer lead length (to maintain the rate of the shallower channel).

1Heat capacities for various polymers can be found in Principles of Polymer Processing, by Tadmor and Gogos, Appendix A. The curves need to be integrated to find the heat capacity between inlet and product temperature.

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See also:

- Designing high performance screws
- Estimating flow rate of a continuous sheet line
- Rheometers versus melt index for polymer analysis
- Technical developments
- Measuring RPM

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