Description

Process schematic

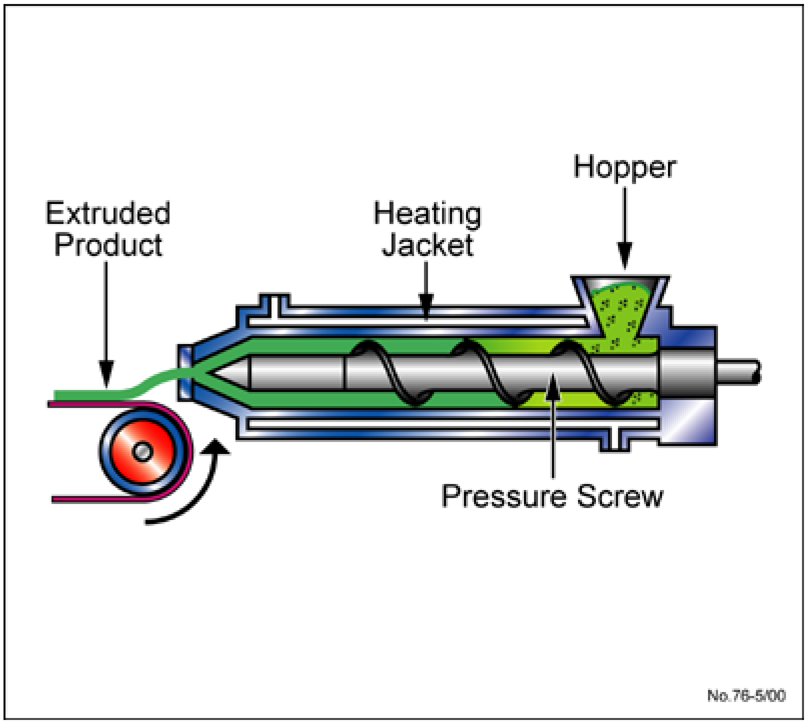

Figure caption

Polymer extrusion uses a heated hydraulic ram or screw to force the polymer through a shaped die.

The process

POLYMER EXTRUSION is the work-horse of the polymer shaping industry, producing semi-finished products such as rod, tube, sheet, film and other prismatic sections in huge quantities. The raw materials as powder granules or pellets are fed into a barrel with one or more rotating screws in a heating chamber and the resulting melt is forced through a shaped die orifice. The process blends, compounds, homogenizes and extrudes the polymer mix at temperatures between 135 and 370 C. The extrudate is cooled as it leaves the die, using air or water cooling; it may subsequently be 'drawn down' to a smaller cross-section. Variations of the process include film blowing, extrusion blow molding and filament forming. The process is used to coat wire, which can be achieved at high speeds. Extrusion is also used as a pre-process other molding processes such as injection molding, producing polymer blends in pellet form.
The process has the advantage of relatively low tooling costs, though capital costs are high and the output usually requires further processing, varying from simply cutting to size to remelting and injection molding.
Die design is complicated by 'die swell' -- the expansion of the section after it leaves the die, caused by the visco-elastic nature of flow in long-chain polymers. Because of this the tolerances are not as tight as for pressure molding processes, though this can be improved by running the extruded section through a second "sizing" die.

Material compatibility

Polymers - thermoplastics	✔

Shape

Circular prismatic	✔
Non-circular prismatic	✔
Flat sheet	✔

Economic compatibility

Relative tooling cost	low
Relative equipment cost	high
Labor intensity	low

Physical and quality attributes

Mass range	10	-	1e3	kg
Range of section thickness	0.02	-	20	mm
Tolerance	0.5	-	1	mm
Roughness	0.5	-	1.6	µm
Surface roughness (A=v. smooth)	A			

Process characteristics

Primary shaping processes	✓
Continuous	✓

Cost model and defaults

Capital cost	8.2e4	-	6.56e5	USD
Material utilization fraction	0.9	-	0.99	
Tooling cost	820	-	4.1e3	USD

Supporting information

Design guidelines

Section shapes are limited to uniform prismatic cross-sections. Fairly complex cross-sections are possible, including hollow shapes. Precise, reproducible extrusion of sheet and prismatic sections relies on very precise control of temperature, blend composition and extrusion rate.

Technical notes

Most amorphous and semi-crystalline thermoplastics and a range of particulate and short fiber filled thermoplastic composites can be extruded. Although the process is most widely used for thermoplastics, it can also used for thermosets, elastomers and foams with suitable modifications to the process; the curing starts as the polymer-plus-hardener mix are heated in barrel of the extruder and reaches completion after leaving the die.

Typical uses

Rods, channels, pipes, tubes, window frames, plastic coated wire, seals, edge guards, filaments, film (film blowing process), sheet stock, pellet stock (e.g. for injection molding).

The economics

The capital cost of the extruder, like that of an injection molder, is high. Tooling cost for simple tool-steel dies are modest, but large, complex dies become expensive.

The environment

Dust exposure in resin formulation requires air filtration. Thermostatic controller malfunctions can be extremely hazardous.

Links

MaterialUniverse

Reference