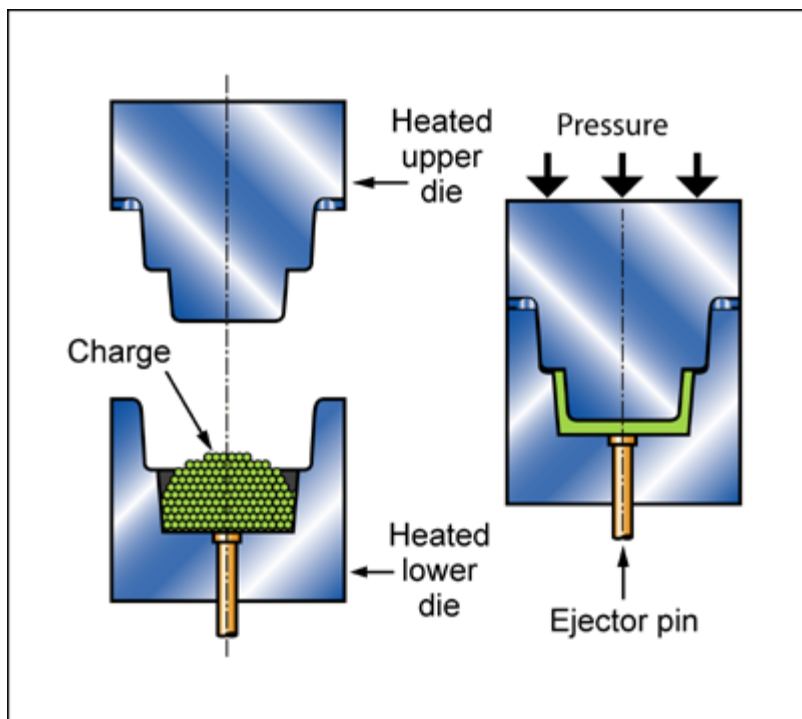


## Description

### Process schematic



### The process

In COMPRESSION MOLDING a pre-measured quantity of polymer - usually a thermoset - in the form of granules or a pre-formed tablet containing resin and hardener is placed in a heated mold. The mold is closed creating sufficient pressure to force the polymer into the mold cavity. The polymer is allowed to cure, the mold is opened and the component removed. A variant, polymer forging, is used to form thermoplastics that are difficult to mold, such as ultra high molecular weight polyethylene, or shapes that have thick walls or large and abrupt changes in section area. Compression molding is widely used to shape the composites BMC and SMC. BMC (Bulk Molding Compound) and SMC (Sheet Molding Compound) differ in the shape and content of reinforcement and filler. BMC has less (15-25% of glass fiber) and it is the easiest to mold to 3-dimensional shapes. SMC has more (up to 35%) of glass fiber and is limited to sheet shapes. DMC (Dough Molding Compound) is the genesis - a dough-like mix of thermosetting polyester, polyurethane or epoxy with hardener, chopped glass fiber, filler and coloring agent. Two more - GMT (Glass Mat Thermoplastics) and TSC (Thermoplastic Sheet Compounds) - are the thermoplastic equivalent, based on nylon 6 or polypropylene. The word "dough" conveys well the way in which they are shaped: squeezed between a pair of dies, like a pie crust.

## Material compatibility

Glasses	✓
Polymers - thermoplastics	✓
Polymers - thermosets	✓

## Shape

Flat sheet	✓
Dished sheet	✓
Solid 3-D	✓

## Economic compatibility

Relative tooling cost	high
Relative equipment cost	high
Labor intensity	low
Economic batch size (units)	500 - 2e6

## Physical and quality attributes

Mass range	0.2 - 20 kg
Range of section thickness	1.5 - 25 mm
Tolerance	0.15 - 1 mm
Roughness	0.2 - 1.6 $\mu\text{m}$
Surface roughness (A=v. smooth)	A

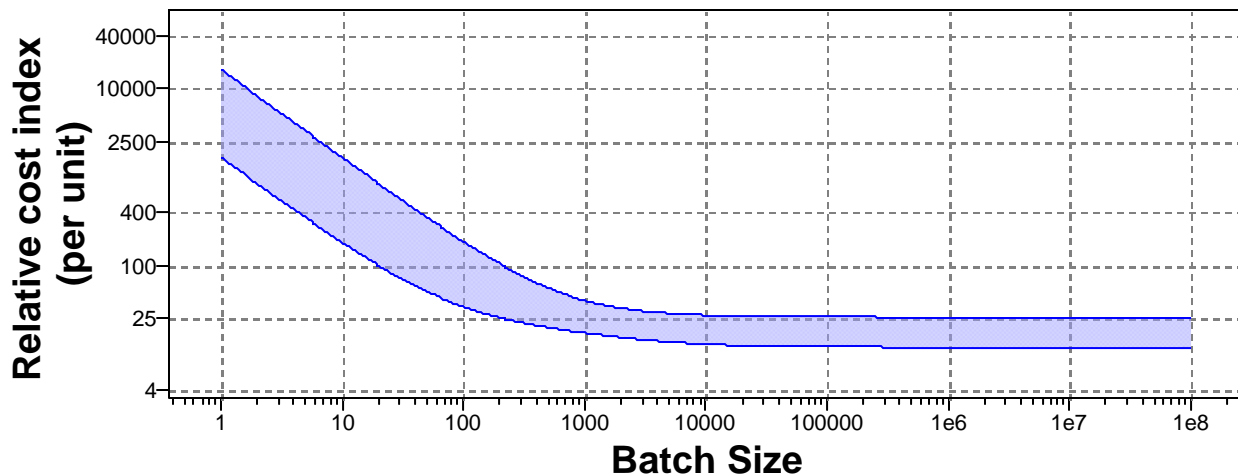
## Process characteristics

Primary shaping processes	✓
Discrete	✓

## Cost model and defaults

Relative cost index (per unit) \* 17.3 - 40.2

Parameters: Material Cost = 8USD/kg, Component Mass = 1kg, Batch Size = 1e3, Overhead Rate = 150USD/hr, Discount Rate = 5%, Capital Write-off Time = 5yrs, Load Factor = 0.5



Material Cost=8USD/kg, Component Mass=1kg, Overhead Rate=150USD/hr, Capital Write-off Time=5yrs, Load Factor=0.5, Discount Rate=5%

Capital cost	* 1.64e4 - 9.84e4 USD
Material utilization fraction	* 0.8 - 0.95
Production rate (units)	* 10 - 100 /hr
Tooling cost	* 1.64e3 - 1.64e4 USD
Tool life (units)	* 2e3 - 2e5

## Supporting information

### Design guidelines

Compression molding is limited to simple shapes without undercuts. Complex shapes are more economically produced by injection molding or resin transfer molding. The components generally require some finishing to remove flash. BMC, SMC, etc. moldings have good surface finish and accurate dimensioning, good enough for auto manufacturers to use them for external body components. SMC moldings yield high quality panels and casings; shapes in which the sheet thickness is more or less uniform. BMC moldings yield simple 3-dimensional shapes with changes in section.

### Technical notes

The process is mainly used with thermosets. Elastomers and thermoplastics can be processed but they require a long heating and cooling cycle, reducing the production rate. The process is frequently used for particle and short fiber-reinforced composites. Several different resin systems are used for BMC, SMC, etc. Among thermosets, polyester, vinyl ester and phenolic resins are best; among thermoplastics, polypropylene, nylon or PEEK (but this is expensive). The mold is made from aluminum, cast iron or steel, heated by steam or electricity to the curing or molding temperature (typically 140-160°C). Typical cycle times are 2-4 minutes.

### Typical uses

Electrical and electronic components, tableware, washing machine agitators, utensil handles, container caps, appliance housings; SMC: body panels and bumpers for cars and trucks, gas and electricity meter boxes, and electrical housings. BMC: more complicated shapes.

### The economics

Although the tooling costs are high, they are not as high as injection molding or resin transfer molding; they depend, of course, on the size and complexity of the molds. Compression molding is most frequently used for large components where it is cheaper than injection molding or resin transfer molding; the upper size limit is set only by the press capacity. Tooling costs are relatively high for BMC, SMC molding, so it tends to be limited to large batch sizes.

### The environment

The process itself does not damage the environment, but flash and scrap cannot be recycled for

## Links

MaterialUniverse

Reference