

Rotational Molding

Load polymer **powder** into cold mold and rotate rapidly to pack powder onto mold walls. Then heat to fuse powder particles together (sintering).

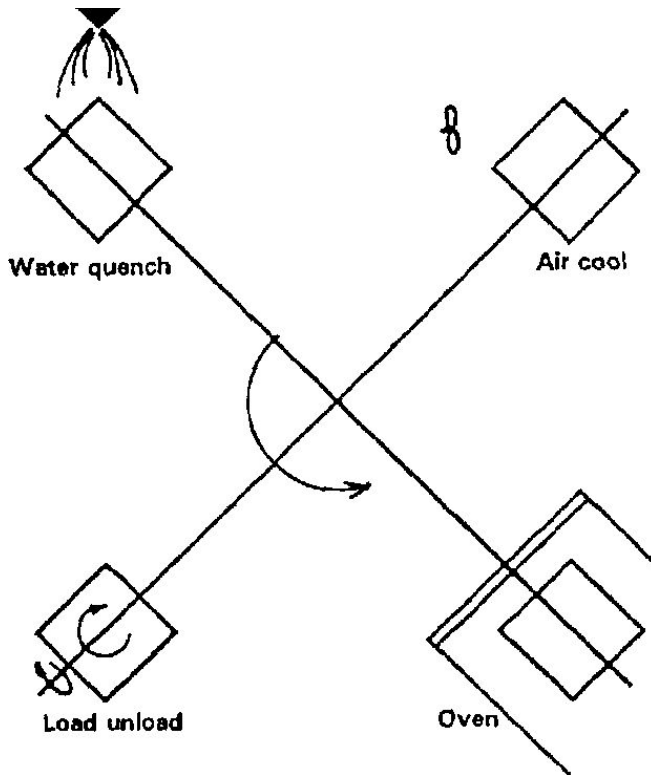


Figure 1: Diagram of a four-station rotational molding operation.

1. Load and Rotate to Pack Powder
2. Heat to Sinter Powder
3. Air Cool
4. Water Cool
5. Unload back at Station 1

Rotational Molding ROTATION TO PACK POWDER

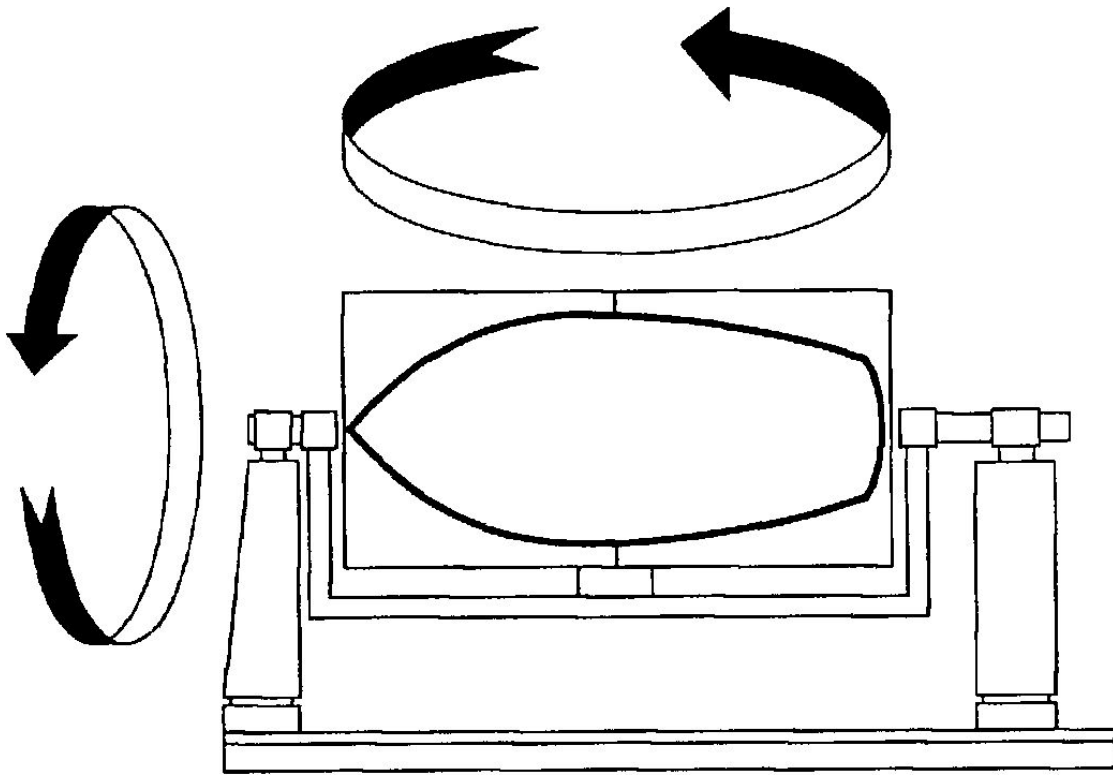


Figure 2: Mold and rotating mechanism for rotational molding.

Proper design of gimbal for rotation in two directions ensures polymer powder is uniformly packed on interior surface of the hollow mold.

Rotational Molding SINTERING

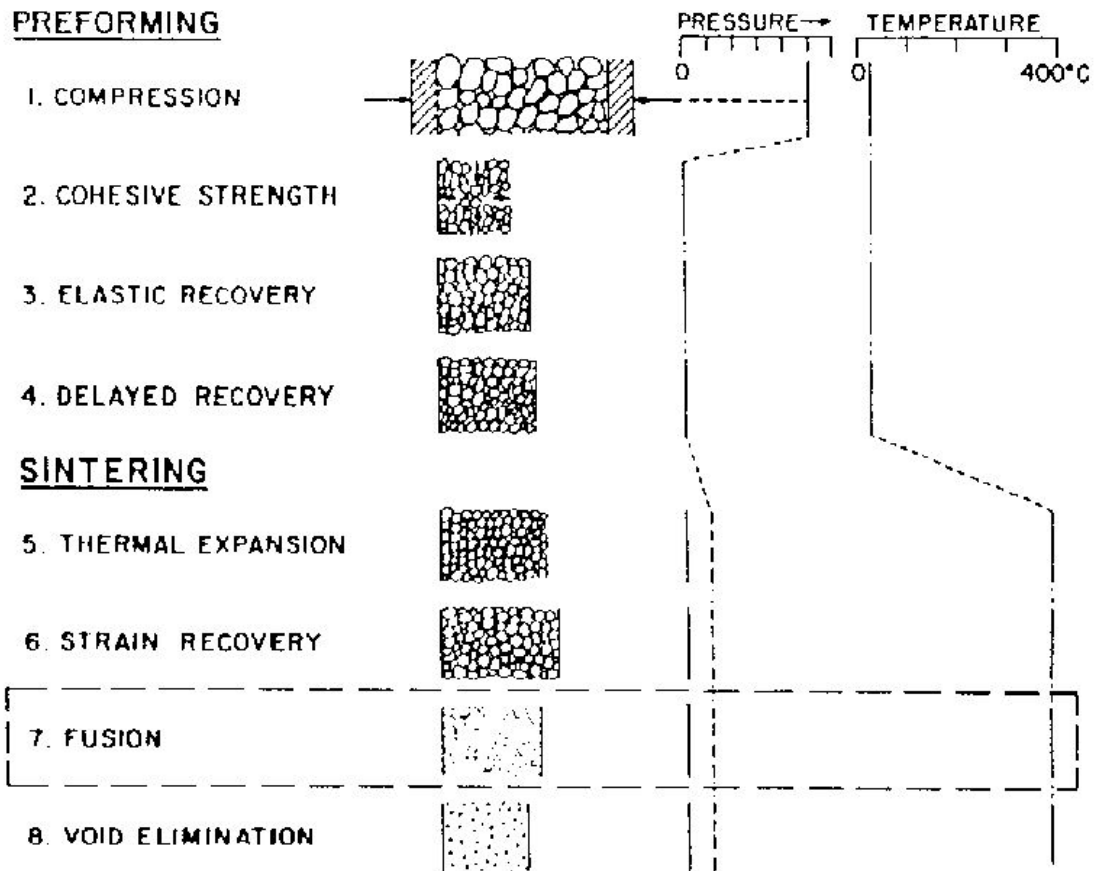


Figure 3: Schematic of the sintering process.

Rotational Molding FRENKEL MODEL OF SINTERING

Define our measure of the interparticle contact as X , the radius of the circle of contact between two spherical particles.

$$X = a \sin \theta$$

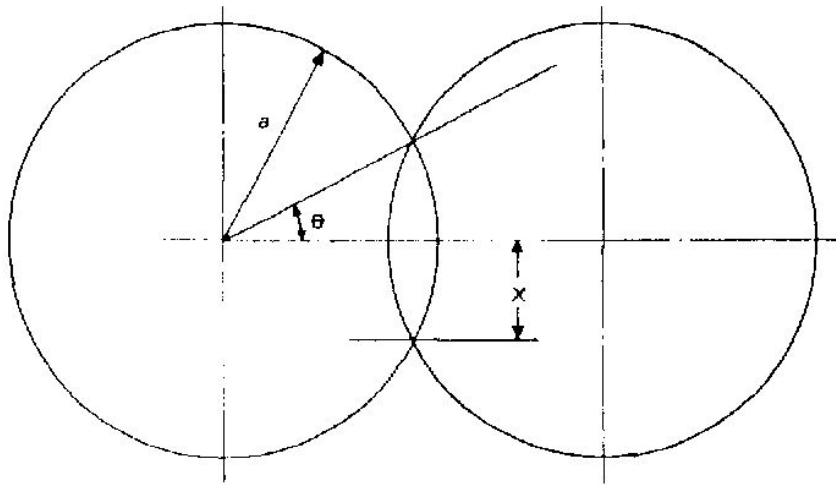


Figure 4: Interparticle contact.

$$\text{Early Stage: } \frac{X^2}{a_0} = \frac{3\gamma}{2\eta}t$$

γ is the surface tension

η is the zero shear rate viscosity

$$\text{Late Stage: } \frac{da}{dt} = \frac{3\gamma}{4\eta}$$

$\frac{\gamma}{\eta}$ CONTROLS THE RATE OF SINTERING

Surface tension decreases weakly as temperature is raised.

Viscosity decreases rapidly as temperature is raised.

Thus sintering rate is fastest at higher temperatures.

Rotational Molding SINTERING

Early Stage: $\frac{X^2}{a_0} = \frac{3\gamma}{2\eta}t$

Dimensionless: $\frac{X^2}{a_0^2} = \frac{3}{2} \frac{\gamma}{\eta a_0} t$

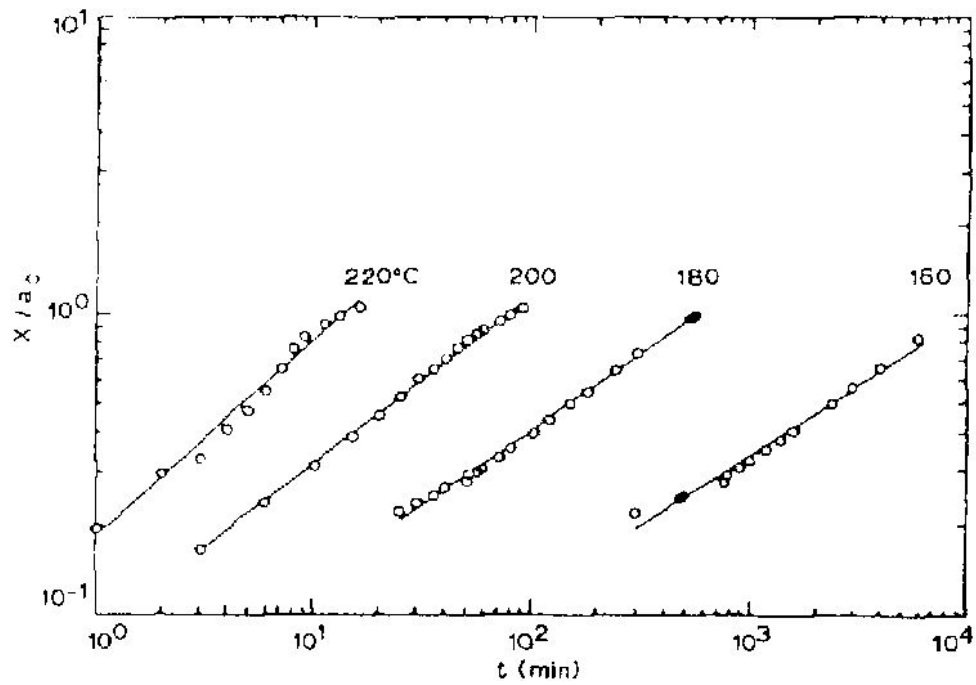


Figure 5: Sintering of spherical PMMA particles at four temperatures.

Rotational Molding

ADVANTAGES

1. Low Pressure Process \Rightarrow Inexpensive Molds
(whereas injection molds are very expensive to machine)
2. Suitable for Large Parts
(whereas injection molding and blow molding have size limitations)
3. Wall Thickness is Uniform
(also true for injection molding, but not for blow molding)
4. Low Residual Stresses
(whereas injection molding and blow molding freeze-in polymer orientation and stress)

DISADVANTAGES

1. Requires Powders
2. LONG CYCLE TIMES: Entire mold must be heated and cooled in each cycle.
(for this reason rotational molding is only commonly used for crystalline polymers such as polyethylene and polypropylene, as then one only needs heat to just above melting point and cool to 20K below melting point)
3. Low Orientation means Lower Strength
(whereas stretch-blow and other blow molding operations impart considerable additional strength to the molded part by intentionally orienting the polymer chains).