

Tooling

ver 1

Tool Design Options

- Cast
- Lay-up
- Machined
- Sprayed-cast
- Electro-formed

Molds



Mold



Mold Machining



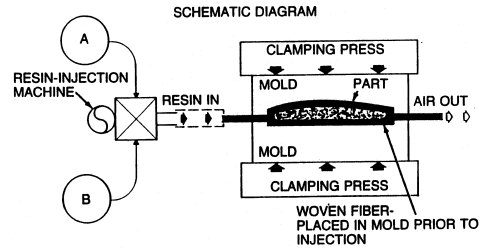
Tool Considerations

- Physicals (pressure, temperature, time, operators)
- Economics (cost, quality, production rate, useful service life)
- Part Design (configuration, material, tolerance, size)
- Process (filament winding, lay-up, compression molding, etc.)

Cast Composite Tool Fabrication (closed mold for RTM)

1. Create Master Pattern (a multi-step process)
2. Define Parting Plane
3. Fabricate Parting Plate
4. Set-up Pattern and Parting Plate
5. Fabricate Containment Box
6. Apply PVA Release
7. Apply Surface Coat
8. Cast Mold Half
9. Invert and Remove Parting Plate
10. Apply PVA Release
11. Apply Surface Coat
12. Cast Mold Half
13. Separate Mold Halves
14. Remove Master Pattern
15. Release and Season Mold

RTM Process



Master Pattern Options

- Solids Model
- Plaster / Plastic Faced Plaster (PFP)
- Polymer Styling Compounds
- Tooling Boards
- Castable Polymers
- Monolithic Graphite
- Wood

Plaster / Plastic Faced Plaster (PFP)

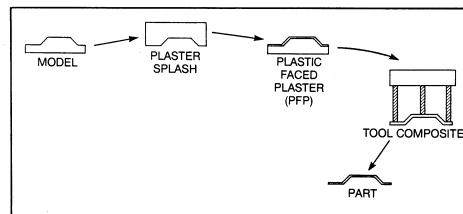


Figure 5-13. Composite tool fabrication.

Master Pattern Considerations

- Physicals (durability, impact resistance, CTE mismatch)
- Economics (cost - material, labor)
- Part Design (detail, tolerance, size)
- Process (machinability, hand work)

Relative Tooling Costs

Type	Cost Index*
Epoxy/Gypsum Prototype Temporary Tools	0.3
Low Mass Laminated Tools - Room Temperature Polyester, Epoxy	3-5
High Mass Laminated Tools - Temperature Controlled Polyester, Epoxy	5-8
Mass Cast Tools - Temperature Controlled Acrylic, Low Profile Polyester, Epoxy	5-8
Net Cast Aluminum	6-9
Electroformed Nickel Steel	12-15
Machined Steel	20-50

* Open Mold = 1.0

Wiseman, D.H., "Method of Mast Casting Molds for RTM", Paper 3-C, 50th Annual Conference, Composites Institute, SPI, February, 1995

Thermal Properties

Material	CTE (ppm/°F)	k (BTU/in/hr/ft ² /°F)	Max T (°F)	C _p (BTU/ft ³ /°F)
Graphite Epoxy	2-5	100	250-300	20
Glass Epoxy	4-6	5	250-300	25
Mass Cast Acrylic (Al filled)	13	35	250-300	
Cast Ceramic	0.5-3	5	2000	30
Cast Aluminum	13	1300	600-750	40
Nickel	7	450	1000+	60
Steel	6	450	900+	60

Mechanical Properties

Material	Comp. Strength (ksi)
Graphite Epoxy	40
Glass Epoxy	
Mass Cast Acrylic (Al filled)	
Cast Ceramic	10
Cast Aluminum	50
Nickel	150
Steel	150-300 (hardened)

Tooling Comparison

Material:	Gr/Ep	Mass Cast Poly/Metal	Al	Al Spray	Ni/Comp	Steel
Feature						
Pattern	-	-	+	-	-	+
Lead Time	+	+			-	-
Finish			+	+	+	+
Tolerance			+	+	+	+
Lifetime	-	-	-	-	+	+
Cost	+	+		+	+	-
CTE	+		-	-	+	+
Strength					+	+
Weight	+	+	+	+	-	-
Service Temp.	-	-	-	-	+	+