Manufacturing Methods Overview

Process Goals:

- **Control fiber orientation & location**
- **Control per ply thickness**
- **Control fiber volume**
- **Minimize voids**
- **Reduce internal stresses**
- **Minimize costs**

Evaluation:

- **Investment**
- **Materials**
- **Processing**
- **Quality**
- **Products**

Manufacture of Prepreg Materials
Advanced Prepreg Procurement Specifications

Uncured Physical Properties:

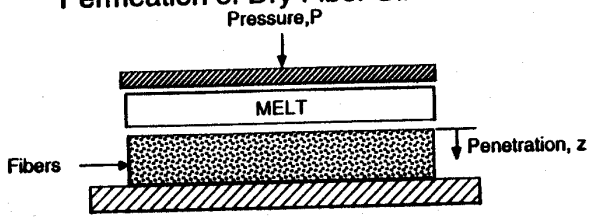
- **Filaments or Tows per unit width**
- **Volatiles**
- **Resin Content**
- **Tack**
- **Tack retention**
- **Flow**
- **Workmanship**
- **Alignment**
- **Gaps/spacing**
- **Width**
- **Length**
- **Uniformity**
- **Storage**

Cured (laminated) Mechanical Properties*:

- **Longitudinal (0°)**
  - **-Tensile strength & modulus**
  - **-Compression strength & modulus**
  - **-Flexural strength & modulus**
  - **-Horizontal shear strength**
- **Transverse (90°)**
  - **-Tensile strength &modulus**
  - **-Flexural strength &modulus**

***At both room & service temperature**

Permeation of Dry Fiber Structures



$$V = \frac{-S\,dP}{\eta\,dz}$$

$S \propto r_h^{2/3}$

$$S = \frac{r_f^2}{4k}\frac{(1-V_f)^3}{V_f^2}$$

$$V = \frac{dz}{dt} = \frac{-S\,dP}{\eta\,dz}$$

V = Velocity
S = Apparent Permeability
r_h = hydraulic radius = flow x-section / wetted perimeter
V_f = volume fraction fiber
r_f = fiber radius
k = Kozeny Constant (flow coefficient)

$$z^2 = \frac{-2\,S\,dP\,t}{\eta}$$ (penetration depth for constant dP)

PERMEATION EXAMPLE

- ALIGNED CARBON FIBERS

$r_f = 4\ \mu m$

$V_f = 0.8$ (easy to pack)

$k = 18$ (from experiments)

Obtain: $S = 0.0028\ (\mu m)^2$

- $-dP = 100$ psi $= 689.5$ kPa
- $\eta = 10{,}000$ P $= 1$ kPa s (PEEK @ 400°C)
- $t = 100$ s

Obtain: $z = 19.6\ \mu m$ (penetrate 2.4 fibers deep)

Alternative Combining (Prepregging) Processes

Hot Melt

Solution

Slurry/Emulsion

Dry Powder

Fiber Commingling

Film

Surface Polymerization

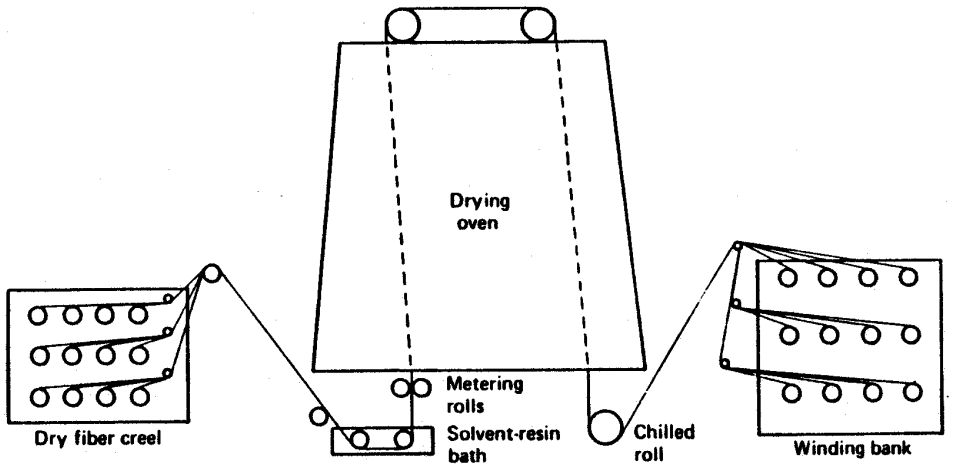


Fig. 1 Typical towpreg manufacturing process

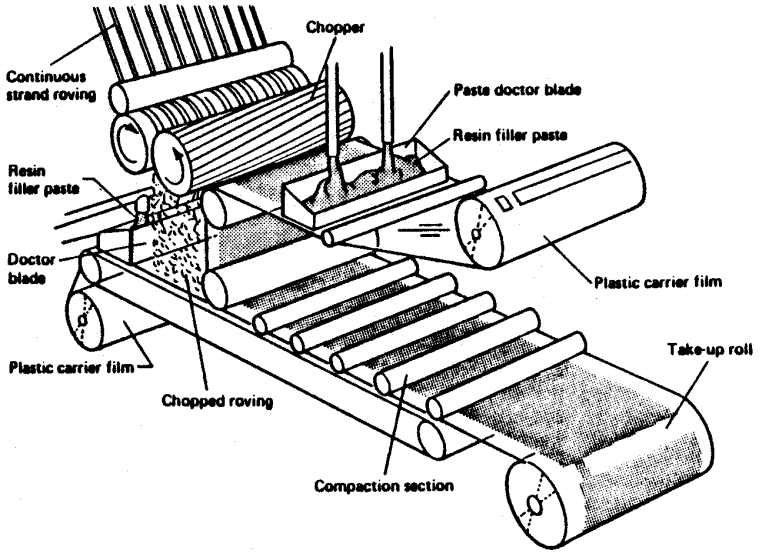
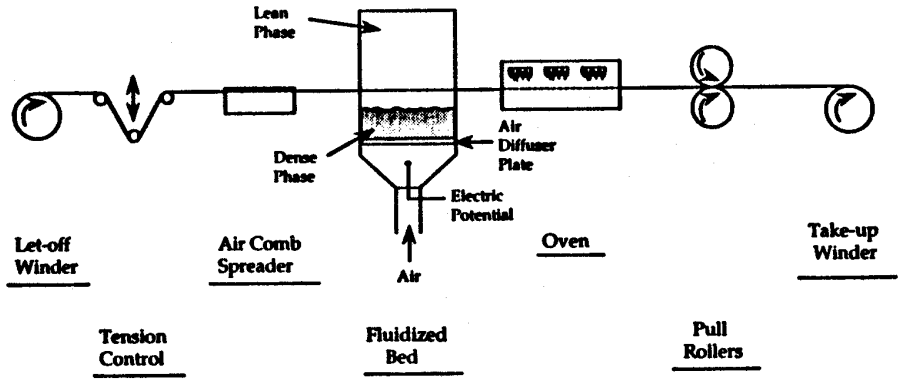


Fig. 1 Sheet molding compound processing machine

Electrostatic Fluidized Bed Powder Fusion Coating Process



UNIT OPERATIONS IN COMPOSITES MANUFACTURING