

Glass Mat Reinforced Recycled Thermoplastics

ver 1

Outline

- Motivation
- Recycling issues
- Why reinforce?
- GMRT properties
- Commercialization
- Applications

Motivation

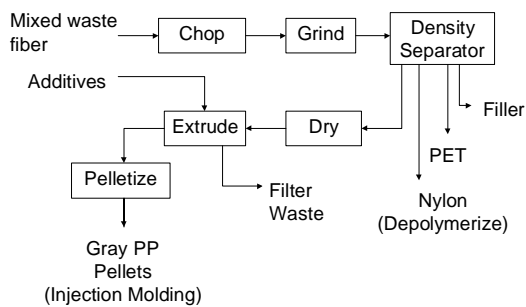
- Large quantities of textile and carpet waste
 - > 2 Billion kg per year
- Manufacturing waste significant in Georgia
 - > 50 Million kg per year
 - Most is landfilled
 - Most is carpet
 - High concentration of nylon, PP and PET
- **Need to recycle!**

Mixed Thermoplastics have Poor Properties

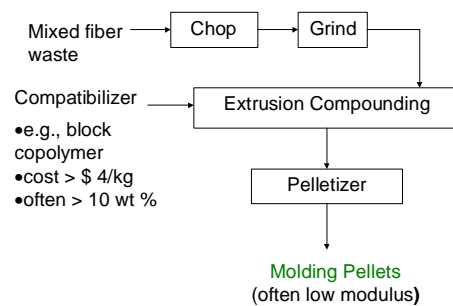
- Mostly incompatible
 - True for nylon, PP and PET
- Primary changes
 - Tensile strength
 - Elongation
 - Impact strength
- Therefore separate?



Hard to Separate



Compatibilization Expensive



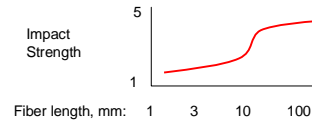
Why Reinforce?

Fibers dominate properties (99 %) (GPa)

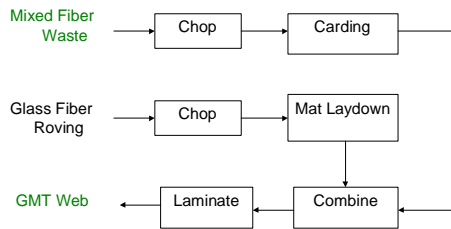
| | Thermoplastic | Glass Fiber | Composite 60 vol %, unidirectional |
|------------------|---------------|-------------|---------------------------------------|
| Tensile Strength | 0.05 | 3.5 | 2 |
| Modulus | 2 | 70 | 40 |

Why Glass Mat?

- Avoid fiber breakage
- Extrusion Compounding
- Fibers in: 3 mm or greater
- Fibers out: 1 mm or less typical
- Increase Impact Strength

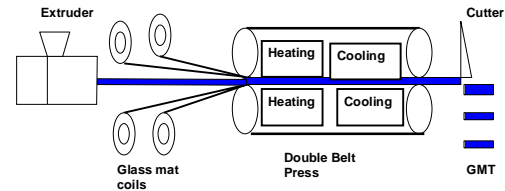


Why Glass Mat?



"Filler Tolerant" Process

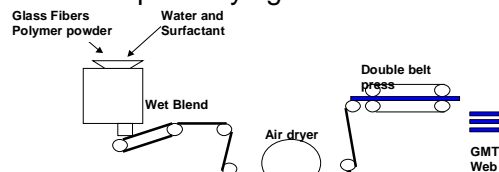
Conventional GMT Process



Features:

- Low viscosity resin
- Thick sheet (3.7 mm)
- Slow
- High capital costs
- Established commercially

"Paper" Laying Process

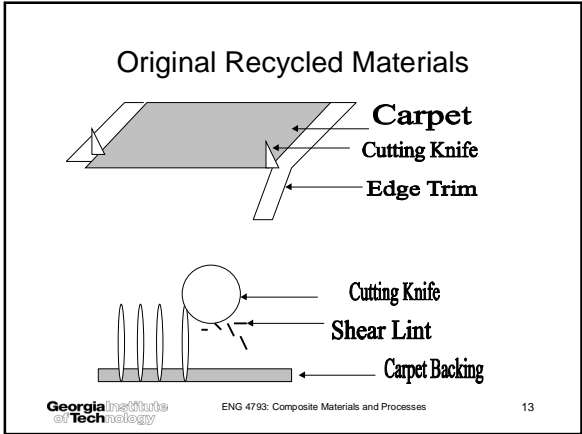


Features:

- Any viscosity resin
- Thin sheets
- Fast
- High capital costs
- Energy Intensive Drying
- Established commercially
- Good quality

Original Recycled Materials

| Materials | Edge Trim | Shear Lint | Separated PP |
|---------------------------------|----------------------|----------------------|--------------|
| Source | Carpet Manufacturing | Carpet Manufacturing | Old carpet |
| PP wt % | 40 | >98 | >98 |
| Other | SBR, Nylon, Filler | Sizing, Dirt | Nylon |
| Fiber length, mm | > 25 | < 1 | < 1 |
| Bulk Density, kg/m ³ | 250 | 200 | 200 |



Unreinforced Properties

| Property | Materials | | |
|--------------------------------------|------------|--------------|---------------------|
| | Edge trim | Separated PP | Typical virgin PP |
| Tensile strength, MPa (ksi) | 17.9 (2.6) | 30.4 (4.4) | 29.0-38.6 (4.2-5.6) |
| Tensile modulus, GPa (ksi) | 1.43 (207) | 1.51 (219) | 1.04-1.73 (150-250) |
| Elongation at break, % | 9 | 32 | 200-500 |
| Izod impact strength, J/m (ft-lb/in) | 16 (0.3) | 27 (0.5) | 21-32 (0.4-0.6) |

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GMRT Properties

| Properties | GMT samples | | | |
|----------------------------|-----------------|------------------|--------------------|--------------|
| | GMT / Edge trim | GMT / Shear lint | GMT / Separated PP | Molded Azdel |
| Density, g/cm ³ | 1.52 | 1.12 | 1.18 | 1.17 |

ASTM D 792

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Tensile Properties

| Properties | GMT samples | | | |
|-----------------------------|-----------------|------------------|--------------------|--------------|
| | GMT / Edge trim | GMT / Shear lint | GMT / Separated PP | Molded Azdel |
| Tensile Strength, MPa (ksi) | 109 (15.8) | 84.1 (12.2) | 87. (12.7) | 78.0 (11.3) |
| Tensile Modulus, GPa (Msi) | 5.72 (0.83) | 5.86 (0.86) | 6.83 (0.99) | 5.67 (0.82) |

ASTM D 638

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Flexural Properties

| Properties | GMT samples | | | |
|------------------------------|-----------------|------------------|--------------------|--------------|
| | GMT / Edge trim | GMT / Shear lint | GMT / Separated PP | Molded Azdel |
| Flexural Modulus, GPa (Msi) | 3.80 (0.55) | 3.08 (0.45) | 3.42 (0.49) | 3.38 (0.49) |
| Flexural Strength, MPa (ksi) | 56.6 (8.2) | 53.1 (7.7) | 64.2 (9.3) | 110.4 (16.0) |

ASTM D 790

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Dynatup impact testing

| Properties | GMT samples | | | |
|----------------------------------|-----------------|------------------|--------------------|--------------|
| | GMT / Edge trim | GMT / Shear lint | GMT / Separated PP | Molded Azdel |
| Maximum load, kN (lb) | 3.23 (725) | 3.71 (835) | 3.31 (745) | 3.48 (783) |
| Deflection at max. load, mm (in) | 7.1 (0.28) | 8.6 (0.34) | 6.7 (0.27) | 8.6 (0.34) |
| Total energy absorbed, J (ft-lb) | 21.4 (15.8) | 21.7 (16.0) | 28.3 (20.9) | 22.4 (16.5) |
| Sample thickness, mm (in) | 3.0 (0.12) | 3.7 (0.145) | 4.0 (0.158) | 3.6 (0.14) |

ASTM D 3763, impact velocity = 3.4 m/s

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Georgia Composites Formed

- Astechologies majority owner
 - EAC an affiliate
- Initial focus:
 - GMRT web
 - Recycled PP
 - Automotive applications
- New production line started 1999
- First commercial applications qualified in 1999

Concluding Remarks

- **Thermoplastics can be recycled effectively as GMT composites**
 - Properties match virgin GMT
 - Cost is less than virgin GMT
- The “breadth” of this technology isn’t known
 - How “dirty” can it be?
 - What mixtures should be avoided?
- The “science” for this approach to recycling isn’t known
 - How do you predict properties for reinforced mixtures?
 - How important is long fiber length?
 - What additives are necessary?