Alternatives in Fiber Reinforced Thermoplastics

SPE/ACCE

September 12-13, 2002

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Alternative Thermoplastic Materials

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Fiber and Resin Combinations

Standard Matrix Resins	*Reinforcement Fibers*
Polypropylene (PP)	Carbon
Polyamide (N6)	E-Glass
Polyphenylene Sulfide (PPS)	S2-Glass
Polyetherimide (PEI)	Aramid
Polyetheretherketone (PEEK)	Hybrids

Other (PMMA, PET, PC, N11, N12, N6/6, TPI, etc.)

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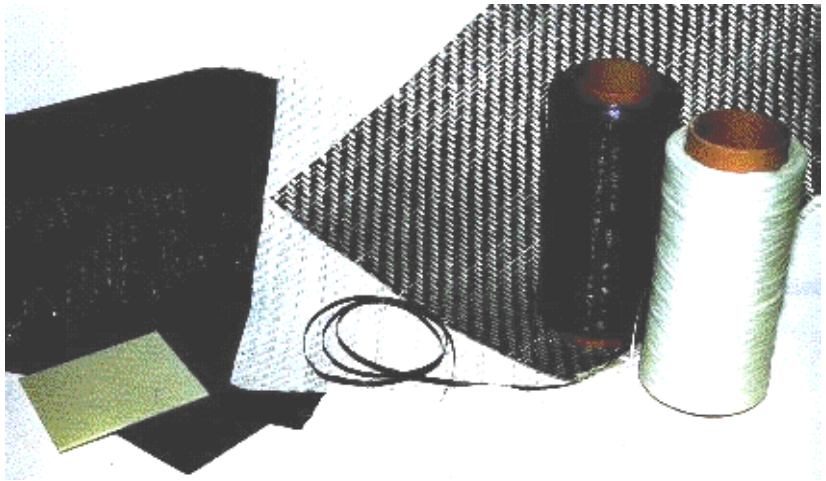
Product Forms



- **Flexible Towpreg**
- **Woven Fabric**
- **Braided Sleeving**
- **Unidirectional Tape**
- **Chopped Compression Molding Compound**
- **Molded Plates**
- **Thermoformable Laminates**

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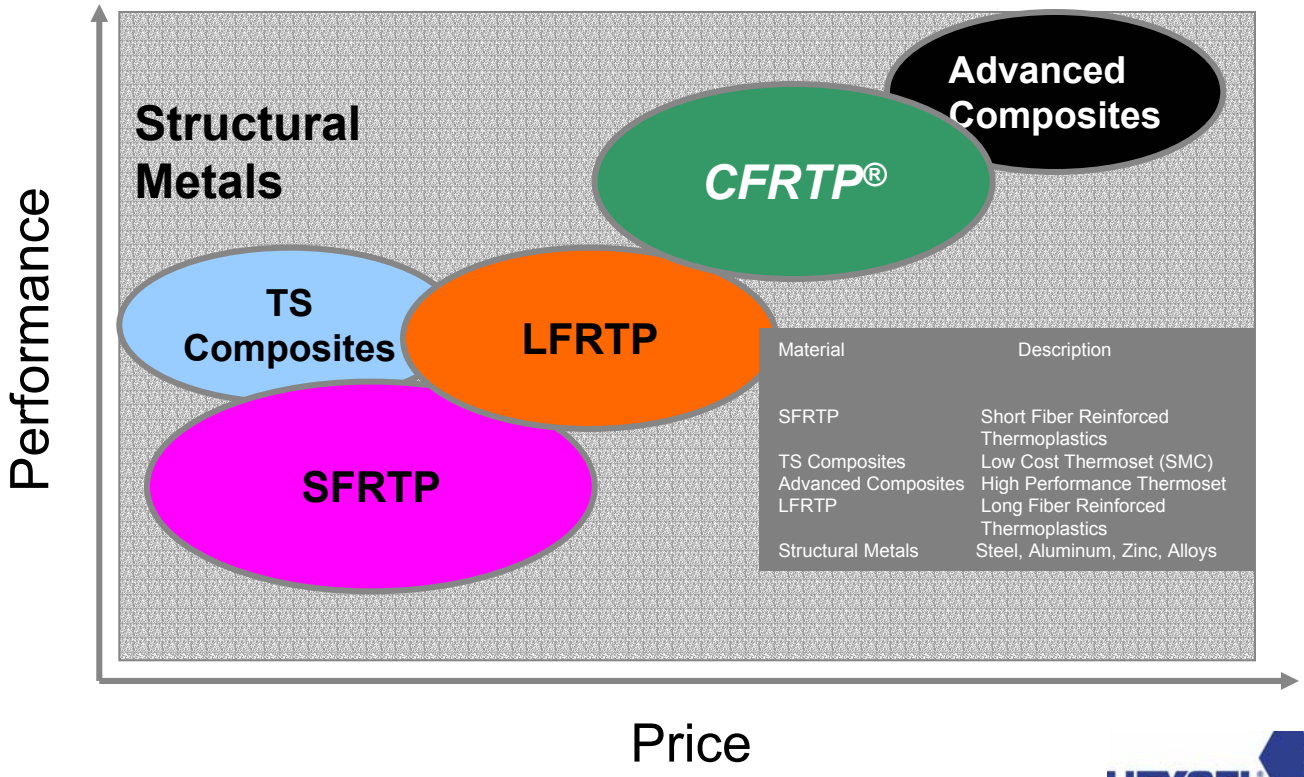
Product Focus

TowFlex Continuous Fiber Reinforced Thermoplastic Materials (CFRTP) fill a cost and performance gap between long-fiber reinforced thermoplastics and thermoset advanced composites



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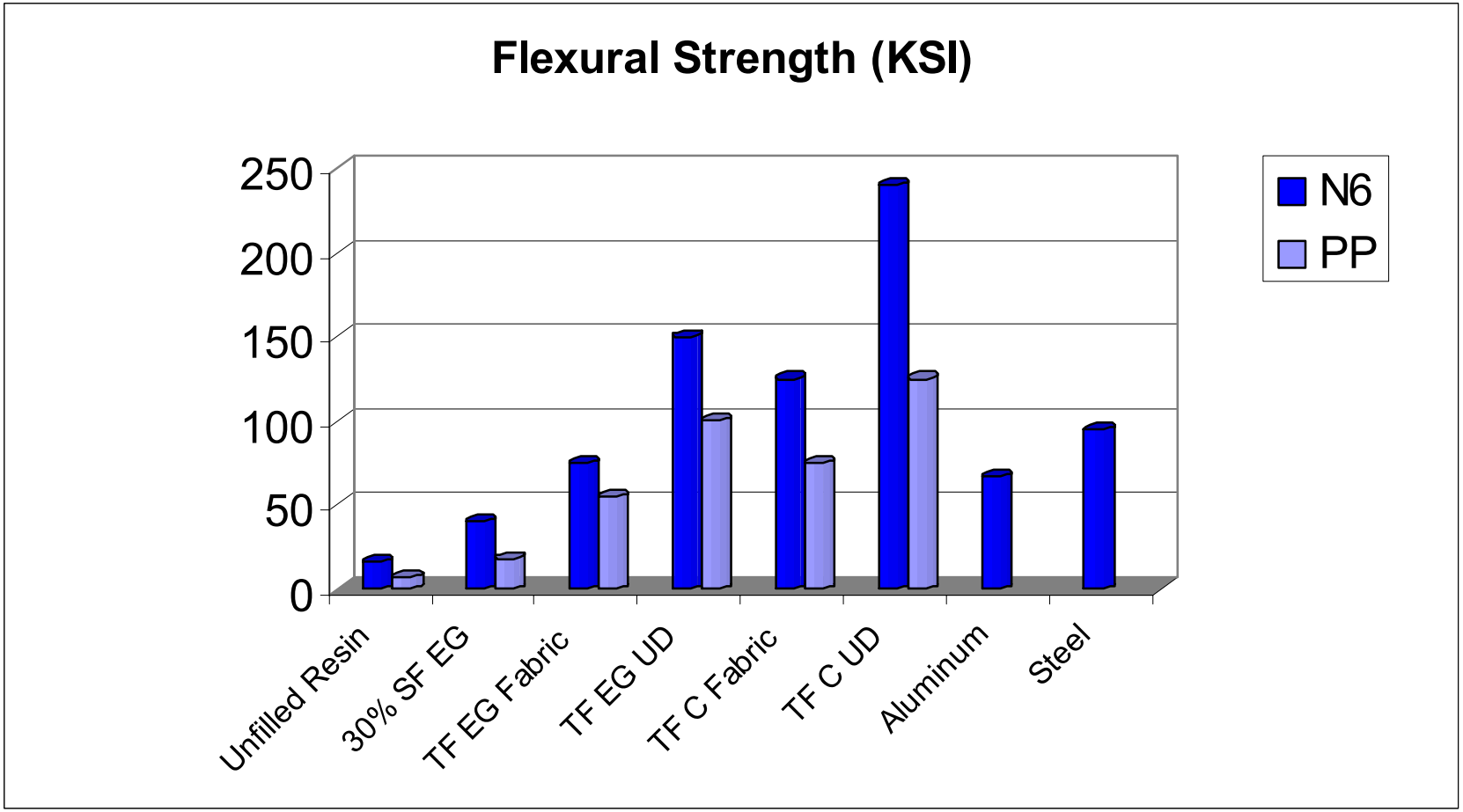
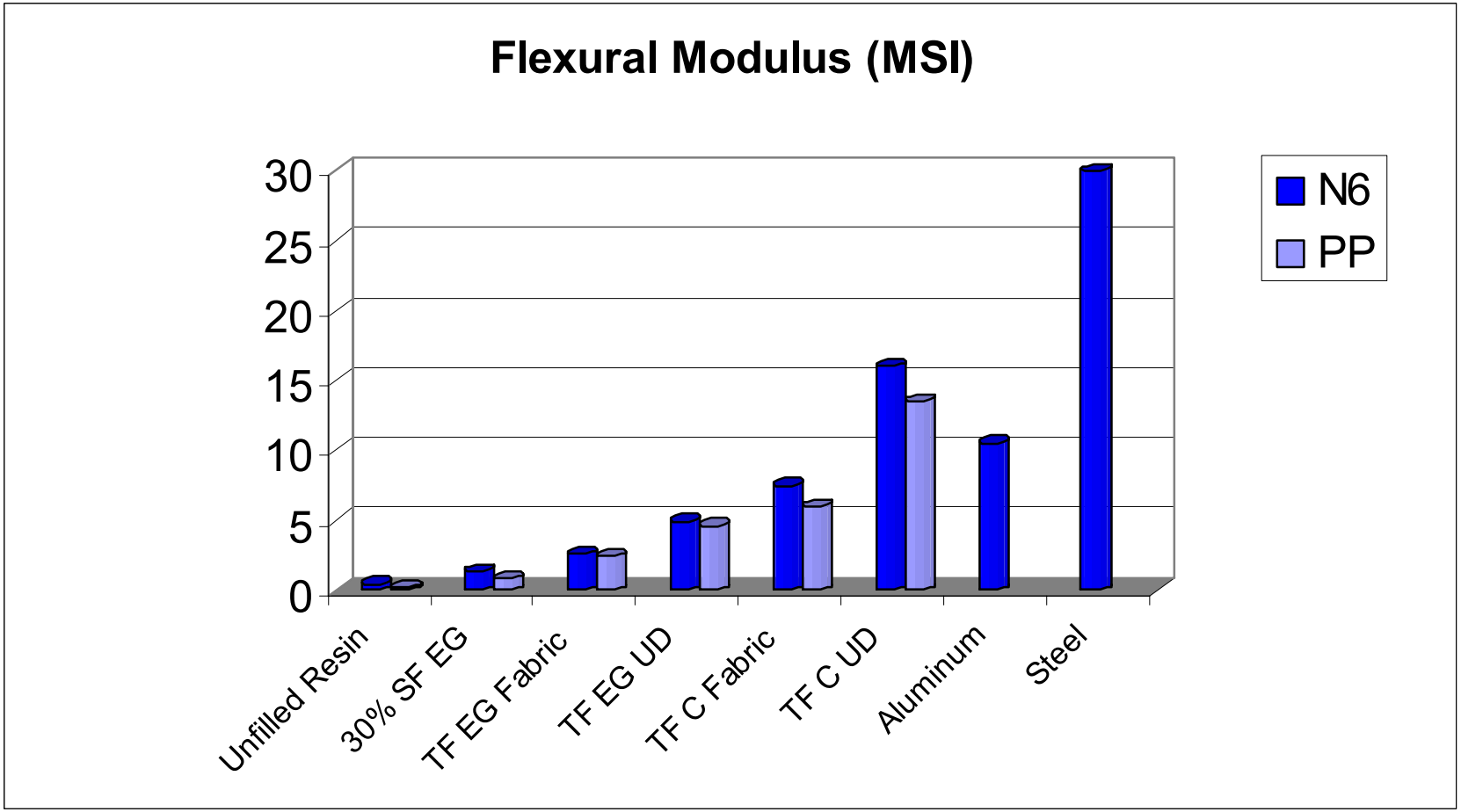
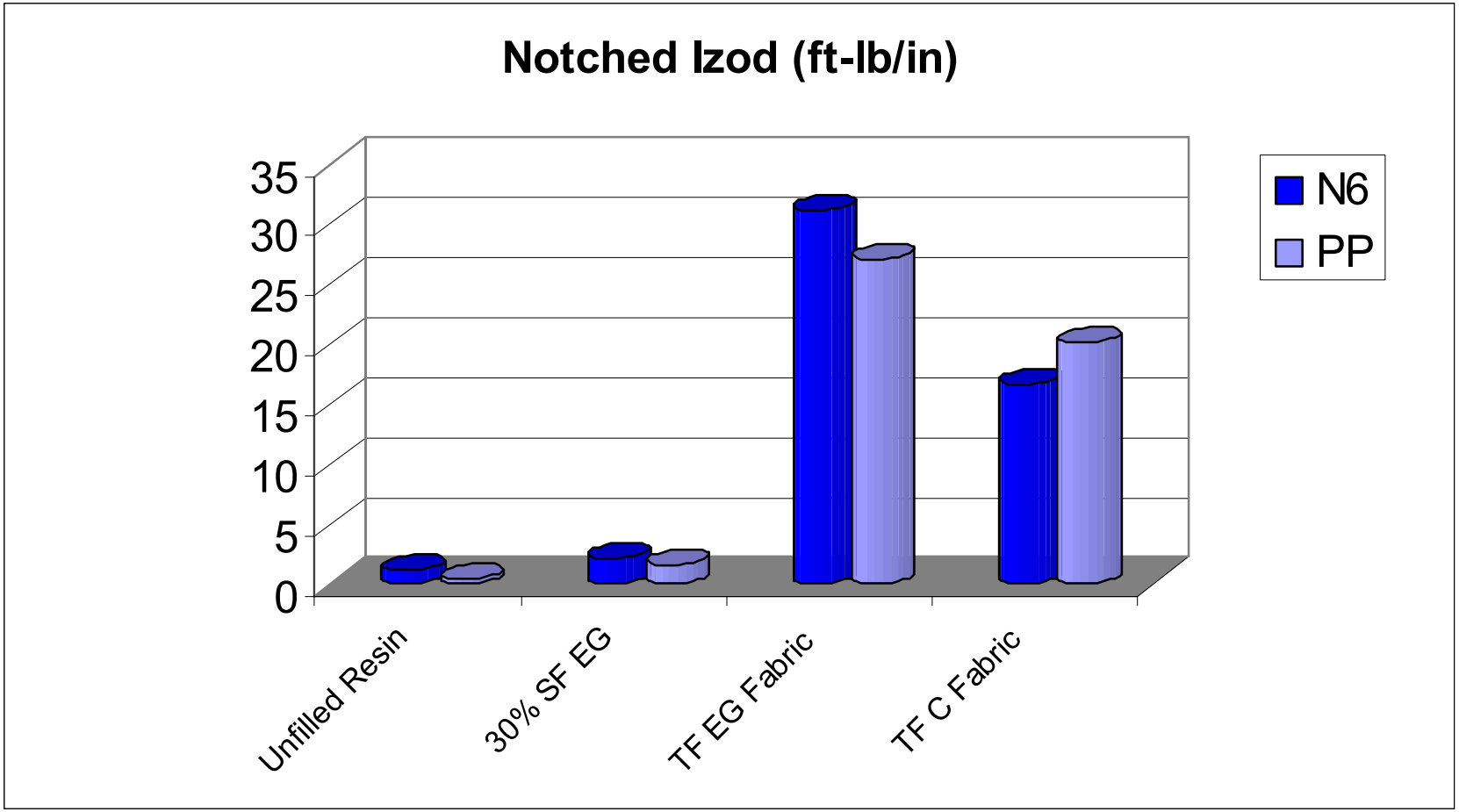
Mechanical Properties



Mechanical Properties



Mechanical Properties



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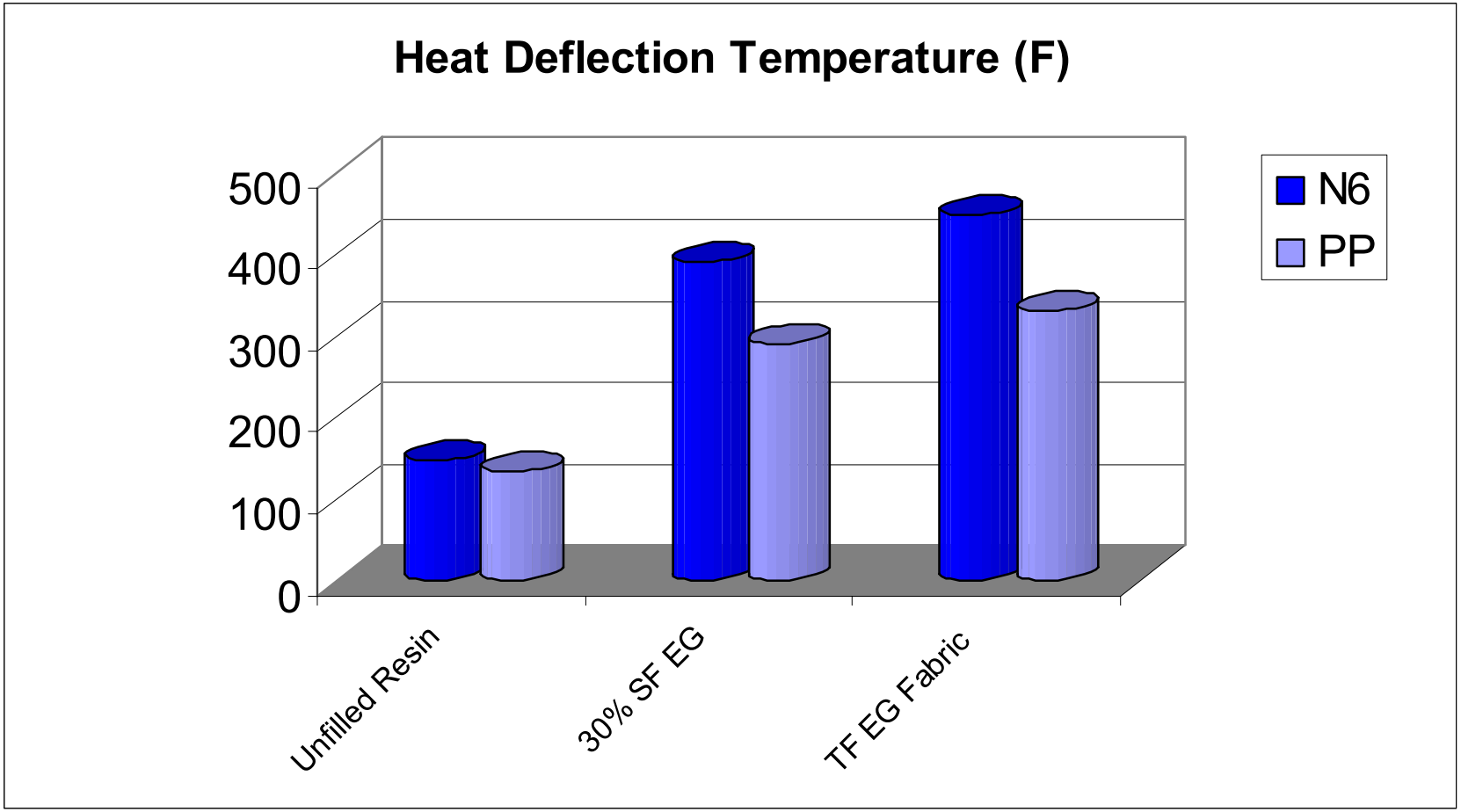

BMW M3 Bumper System

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BMW M3 Bumper System

- Selected E-glass/Nylon 6 vs. E-glass/PP due to:
  - Higher service temperature (>100F increase)
  - Improved flexural/tensile/compressive strength properties (>25% increase)
- Processing:
  - Continuous sheet produced from *TowFlex*® fabric
  - Bumper beams and crush column boxes matched-mold thermoformed from sheet
  - Crush column profiles continuously produced from *TowFlex*® fabric
  - Beams, crush columns, boxes assembled via HF welding

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Value Points

- Performance
  - Crash Performance @ High Under-Hood Temperatures
- Reduction in Part Numbers
  - Sub-Assembled
- 60% Weight Savings (2.8 kg/6.2 lbs total)
  - Fuel Economy/Emissions/Weight Distribution
- Recyclable
- M3 Volume/Specialty Vehicle
  - Reduced Tooling Cost

BMW Process Flow

TowFlex® Hexcel

TowFlex® Consolidator, AC.S

Bumper Manufacturer, Jacobs

Assembly, BMW

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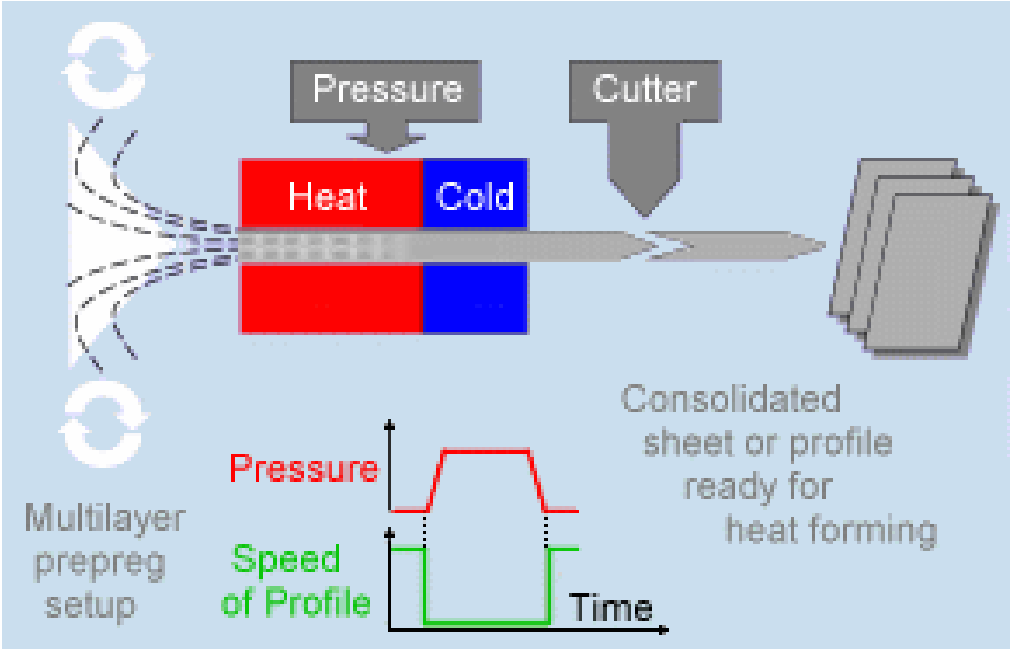
Continuous Sheets and Profiles

•Produced by AC.S from TowFlex fabric

•Multiple fabric rolls for multi-layer sheets and profiles

• Sheets used for beam and crash box thermoforming

• Profiles used for crush columns



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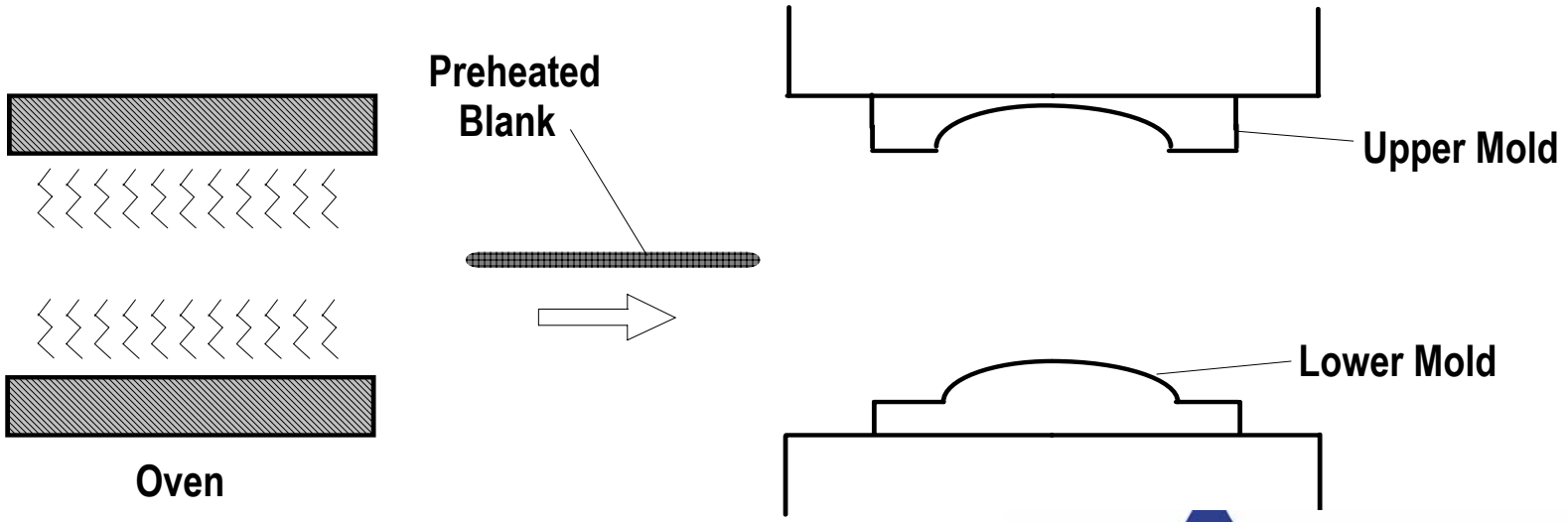
Matched–Mold Thermoforming

- Parts produced by Jacob Composites
- Beams and Crash Boxes formed from consolidated sheet
- Beams, crash boxes, and crush column profiles assembled via HF welding



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Compression Molding

- Use unconsolidated fabrics/tapes (vs. preconsolidated sheets)
- Use flat preforms
- Matched molds form and consolidated preforms (no hand-layup)
- Heated and cooled molds or shuttle press

Compression Molding Concept

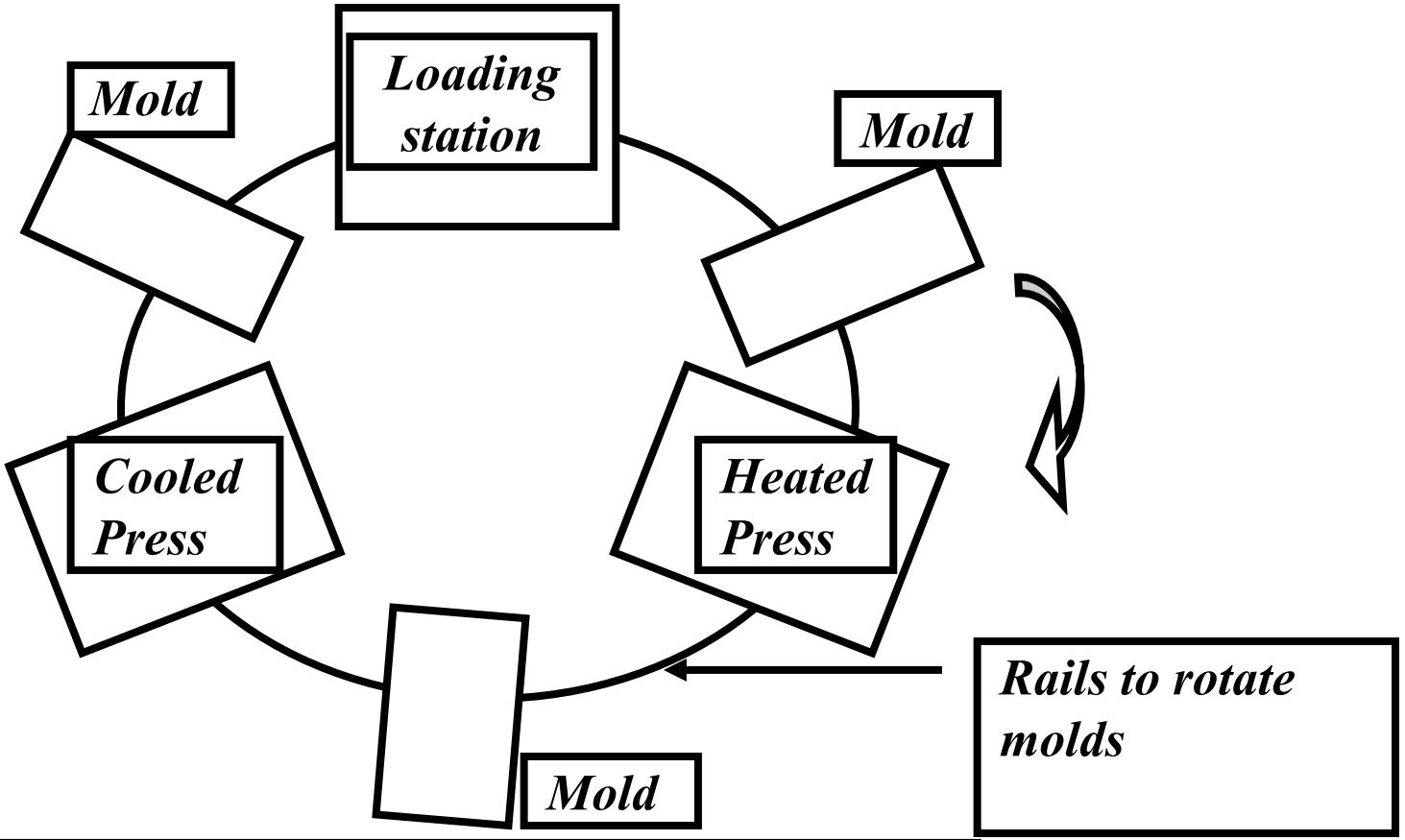

Figure 5.1: Three rotating mold-shuttle system

Co-molding Concepts

- Use TowFlex as a stiffening element combined with unreinforced or discontinuous reinforced TP resins

- Overmold using “conventional” TP molding processes
  - Injection Molding
  - Compression Molding
  - Thermoforming
  - Blow Molding

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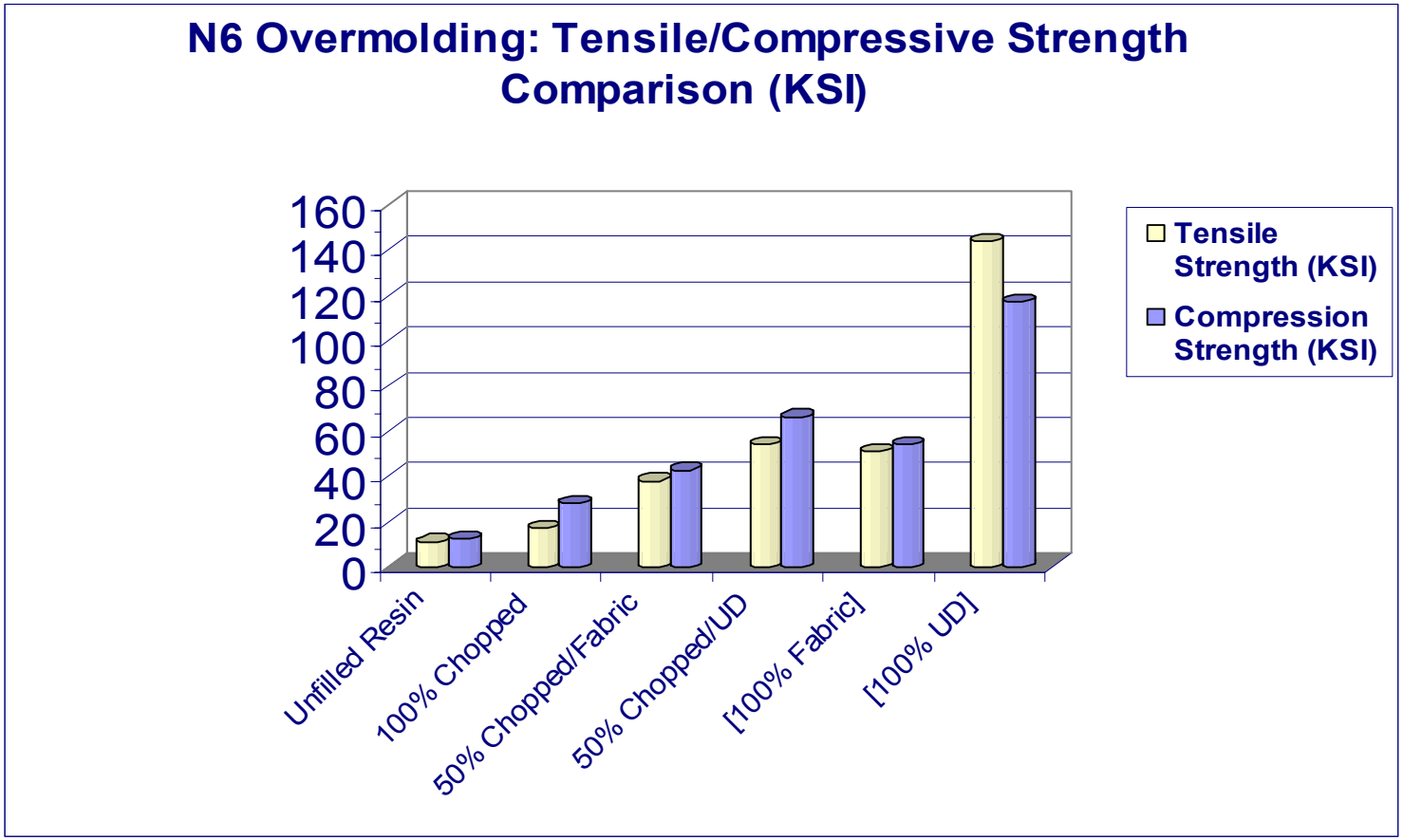
Co-molding Preliminary Data



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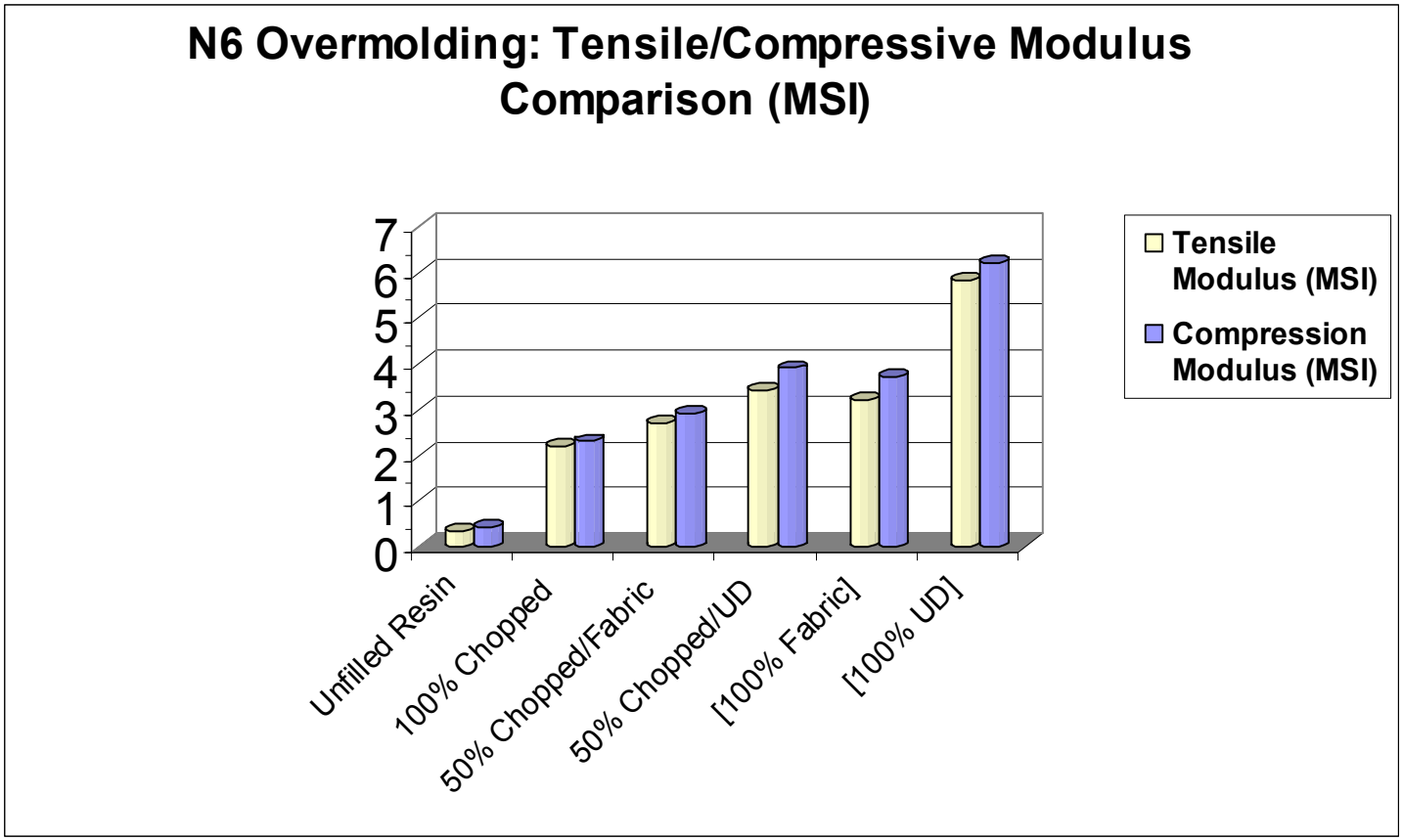

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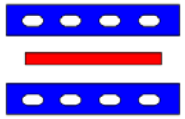
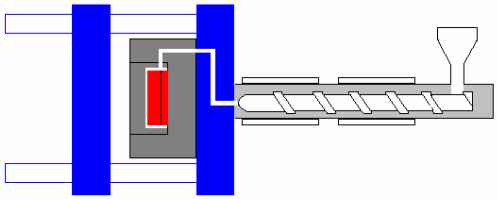
Injection Overmolding

Step 1 : TowFlex IR heating

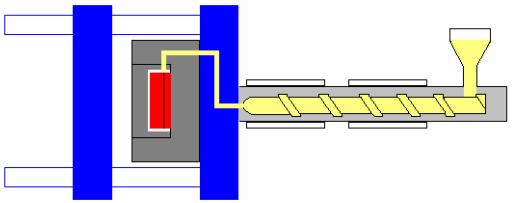


Manual transfer

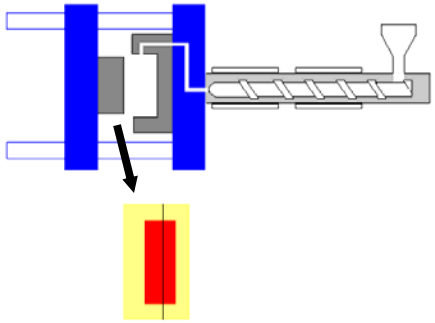
Step 2 : forming in molding press



Step 3 : Resin injection for overmolding



Step 4 : demolding



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Co-Forming

With GMT Sheet

With Unreinf. Sheet

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Joining Processes

Standard TP Joining Processes Evaluated

- Adhesive Bonding
- Vibration Welding
- Ultrasonic Welding
- Spin Welding
- Hot Plate Welding

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Application Development Support

- Material recommendations and data
- Part and tooling design support
- Prototype parts development
- Materials and molded parts testing/analysis
- Production molding technology transfer and support

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Summary

- Solutions in Fiber Reinforced Thermoplastics
  - Multiple Resin & Fiber Combinations
  - High Temperature
  - High Stiffness and/or Strength Requirement
  - Maintain/Reduce Design Weight
  - Utilize and Expand Existing Thermoplastic Processes