Designing Composite Parts For Automotives Using Long Glass Polypropylene
Tipco Group: First in India

2016  
Glass Mat Reinforced Thermoplastics (GMT)  
60% **Jute** Reinforced Polypropylene Long Fibre Compounds (J-LFT)  

2015  
Thermoset **Epoxy** Moulding Compounds  

2014  
**Long Glass** Fiber Polyamide (LGF-PA6, PA66), Fully-Wetted  

2012  
**Long Glass** Fiber Polypropylene (LGF-PP), Fully-Wetted  
**ATP Plast**®  

2008  
**Autotech** Polymers India Pvt. Ltd. plant in North India (near Palwal)  
Unsaturated Dry-Polyester Moulding Compounds: Electronic Industry  

2003  
**Mitsui Technology**: Chemically Super-Coupled Glass Reinforced PP  

1999  
**Tipwood**® Jute Phenolic Composites patented  
Additive Masterbatches for Packaging Industry  

1997  
**Mitsui Technology**: High Crystallinity Polypropylene Compounds  
**Colortek**® Liquid Colour Masterbatches for Thermoplastics  

1996  
**Hoechst**® PP Compounds Technology: Hostacom® & Hostalene PP®  

1990  
Bumper, Instrument Panel & Automotive Compounds for **Maruti Suzuki**  

1983  
Thermoplastics Compounding started at Valsad (Gujarat) with  
**Ferro Technology**: Filled & Reinforced PP Compounds **Tipcolene**®  

1978  
Thermoset Injection Moulding Compounds introduced in India  

1974  
India’s 1st continuous, fully automated BUSS Kneader compounding line  

1959  
**Philips Technology**: PF Resins for Brakelining, Foundry, Telecom, Railways  

1945  
India’s 1st Polymer & Plastics Raw Materials Manufacturer: **Tipcolite**®
Macro Trends – 21st Century

- Renewable Energy, Electric Vehicles
- Energy Conservation
- Global Warming
- Sustainable Development
- Safety
- Green Environment
- Carbon Footprint
- GHG Emissions
- Smart Technologies
- Survival
Automotive Industry Drivers – Regulations

India set to Leap Frog from BS4 (Euro 4) to BS6 (Euro 6) by 2020

**Stringent Safety Standards**

**Tighter Emission norms**

**Euro V (Diesel)**
- NOx: 180 mg/km
- CO: 500 mg/km

**EURO V (Gasoline)**
- NOx: 60 mg/km
- CO: 1000 mg/km

**Euro VI (Diesel)**
- NOx: 80 mg/km
New Bio Fuels, Electric Vehicles

Engine: Diesel over Petrol

New Power train systems, New transmission systems

Light weighting with Composites, Part Integration

Cost of Conversion

New Technology versus Cost of Implementation
Typical Product development Project

Initiation | Definition | Concept Generation | Basic Engineering | Detail Engineering | Tooling | Pre-production | Production

[Diagram showing the stages of product development with an arrow indicating the sequence]
Composite Design Project

Application Functionality, Specifications

Material
- Carbon Fiber
- Glass fiber
- Aramid
- Jute
- Talc
- Epoxy
- Polypropylene
- Polyamide
- Polyester
- Polycarbonate
- Vinly Ester

Application Development Process Methodology

Manufacture Process and Tooling
- Injection Molding
- Compression Molding
- SMC
- LFRT
- HPRTM
- Resin Infusion
- Blow Molding

CAE & Part Design

Flow Simulation
- Structural Simulation
- Topology Optimisation

Design Robustness to meet Endurance Testing
Current Application: Requirements & design

Is Replacement feasible?

Application development expertise

Processing & Material Knowledge
CAE-Topology/Topography

Commercial evaluation vs. current metal solution

Detailed CAE Process (Moldflow)

Create plastic concept & select material taking into account: Molding Process, tooling, assembly techniques, sealing solutions, function integration, etc.

Detailed CAE: Mechanical

Fiber orientation

Check performance vs. technical requirements

Not optimal

Optimization loop

Optimal design w.r.t.: Weight/Cost Quality, etc.
A composite material can be designed to achieve required mechanicals by selecting the right fibre reinforcement and right polymer.

<table>
<thead>
<tr>
<th></th>
<th>SMC</th>
<th>LFT – IM PP 40% GF</th>
<th>Die Casting Aluminum</th>
<th>Stamped Steel</th>
<th>CFT PP 60% GF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tensile Strength (Mpa)</strong></td>
<td>110 – Along the Fiber length</td>
<td>135</td>
<td>210</td>
<td>450</td>
<td>500 – Along the fiber length</td>
</tr>
<tr>
<td><strong>Impact Strength</strong></td>
<td>Best</td>
<td>Better</td>
<td>Best</td>
<td>Base Line</td>
<td>Better</td>
</tr>
<tr>
<td><strong>Tool Life</strong></td>
<td>5,00,000</td>
<td>500000</td>
<td>150000</td>
<td>100000</td>
<td>500000</td>
</tr>
<tr>
<td><strong>Weight Reduction</strong></td>
<td>Higher than steel</td>
<td>Highest</td>
<td>Moderate</td>
<td>lowest</td>
<td>Highest</td>
</tr>
<tr>
<td><strong>Part Cost</strong></td>
<td>Moderate</td>
<td>Lowest</td>
<td>Moderate</td>
<td>Scrap, Labor and Trimming</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
Thermal and Chemical Exposure

Long Term Heat ageing: Effect of Heat on Electrical and Mechanical Properties. Property to look for Relative Temperature Index RTI – AT what temperature the Properties fall below 50% of original

UV Resistance: Effect of UV rays of Sunlight on plastic components leading to Cracking, Discoloration, Drop in tensile strength. Measurement of time taken for Polymer degradation (Oxidation) by Xenon Arc Method
Fatigue Loading

LFPP3010 and LFPP4010
Tensile Fatigue @ 5Hz @ 23 Deg.C

Speed of Impact: High speed impact
Crash simulation of Airbag

Creep Loading

Wear Rate Calculation
Painting is carried out on polymers for three major reasons:
1. Mass reproducibility: Customer desire products with his selected color shade
2. Color Matching with other body parts
3. Improve UV resistance: eg. ABS

There are three ways that painting can affect the mechanical strength of plastics.
1. Solvents can cause surface crazing, or even environmental stress cracking.
2. Curing of Paints can relieve molded-in stresses in the plastic part, potentially causing warpage.
   Extreme high temperatures may cause thermal degradation of the polymer.
3. Mechanical Effects: The crack can continue through into the substrate and can cause the paint to delaminate from the substrate; or it can “channel” through the paint without affecting the substrate.

Flammability Resistance:

- Automotive — FMVSS 302
- Aerospace — FAR 25.853
- Limiting Oxygen Index — ASTM D 2863 or ISO 4589
- Flame spread — ASTM E 162
- Smoke density — ASTM E 662
- Heat release — ASTM E 1354

NVH Vibration:
Composites promote Noise Level reduction

Improved electrical and thermal insulation
Composite Manufacturing Processes

Thermoset Composites Processing
- Short-Fiber Composites
  - Injection Molding
  - Compression Molding
  - Liquid Molding
  - Spray-Up
- Continuous-Fiber Composites
  - Lay-Up
  - Filament Winding
  - Liquid Molding
  - Pultrusion

Thermoplastic Composites Processing
- Short-Fiber Composites
- Continuous-Fiber Composites
  - Injection Molding
  - Compression Molding
  - Lay-Up
  - Thermoforming
Selection of Manufacturing Process

Composite Technologies

*Fiber Length vs Cycle Time vs Part Complexity*

- Thermoforming
- T-RTM
- HP-RTM
- Hand Spray Layup
- Prepreg Layup
- GMT
- Fiber Length in mm:
  - Endless
  - 10 to 50
  - 1.5 to 5
- Cycle Time in Minutes:
  - 1 Minute
  - 2 Minutes
  - 10 Minutes
  - 100 Minutes
- Part Complexity:
  - Low
  - High

Thermoset
Thermoplastic
## Comparison of Molding Processes

<table>
<thead>
<tr>
<th></th>
<th>Hand Layup (FRP)</th>
<th>Light RTM</th>
<th>Pressure RTM</th>
<th>SMC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tooling Investment</strong></td>
<td>Rs. 20,000</td>
<td>Rs. 1-2 lac</td>
<td>Rs. 10-20 lac</td>
<td>Rs. 60 lac -90 lac</td>
</tr>
<tr>
<td><strong>Output per tool per shift</strong></td>
<td>2 Panels</td>
<td>5 Panels</td>
<td>20 Panels</td>
<td>100-120 Panels</td>
</tr>
<tr>
<td><strong>Class A Finish</strong></td>
<td>Not Available</td>
<td>Not available</td>
<td>Validated</td>
<td>Validated</td>
</tr>
<tr>
<td><strong>B Surface</strong></td>
<td>Rough/ugly</td>
<td>Rough</td>
<td>Mold finish</td>
<td>Mold finish, highest quality</td>
</tr>
<tr>
<td><strong>Ribs and fasteners</strong></td>
<td>Not possible</td>
<td>Not possible</td>
<td>Not Possible</td>
<td>All features possible</td>
</tr>
<tr>
<td><strong>Time to T0 Part for validation</strong></td>
<td>7 days</td>
<td>2 Week</td>
<td>4 weeks</td>
<td>12-16 weeks</td>
</tr>
</tbody>
</table>
## Designing for Manufacturing Process

### Compression Molding

<table>
<thead>
<tr>
<th></th>
<th>Preform Molding</th>
<th>Sheet Molding Compound</th>
<th>Bulk Molding Compound</th>
<th>Resin Transfer Molding</th>
<th>Cold Press Molding</th>
<th>Spray-Up &amp; Hand Lay-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Inside Radius, in.</td>
<td>1/8</td>
<td>1/16</td>
<td>1/16</td>
<td>1/4</td>
<td>1/4</td>
<td>1/4</td>
</tr>
<tr>
<td>Molded-in holes</td>
<td>yes*</td>
<td>yes*</td>
<td>yes*</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Trimmed-In Mold</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Core Pull &amp; Sides</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Undercuts</td>
<td>no</td>
<td>yes</td>
<td>yes**</td>
<td>yes**</td>
<td>no</td>
<td>yes**</td>
</tr>
<tr>
<td>Minimum Recommended Draft (no in-mold coating)</td>
<td>1/4 in. to 6 in. depth: 2° to 3°</td>
<td>2°</td>
<td>3°</td>
<td>1°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Recommended Draft (in-mold coating)</td>
<td>4° or as required</td>
<td>not applicable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Practical Thickness, in.</td>
<td>0.045</td>
<td>0.080</td>
<td>0.060</td>
<td>0.080***</td>
<td>0.080</td>
<td>0.060</td>
</tr>
<tr>
<td>Maximum Practical Thickness, in.</td>
<td>1/4</td>
<td>1/2</td>
<td>1</td>
<td>1/2</td>
<td>no limit</td>
<td></td>
</tr>
<tr>
<td>Normal Thickness Variation, in.</td>
<td>± 0.010</td>
<td>± 0.010</td>
<td>± 0.010</td>
<td>± 0.020</td>
<td>± 0.020</td>
<td>± 0.030</td>
</tr>
<tr>
<td>Maximum Thickness Build-Up, Heavy Build-Up and Increased Cycle</td>
<td>2-to-1 max.</td>
<td>as required</td>
<td>as required</td>
<td>2-to-1 max.</td>
<td>2-to-1 max.</td>
<td>as required</td>
</tr>
<tr>
<td>Corrugated Sections</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Metal Inserts</td>
<td>not recommended</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Bosses</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>not recommended</td>
<td>not recommended</td>
<td>yes</td>
</tr>
<tr>
<td>Ribs</td>
<td>not recommended</td>
<td>yes</td>
<td>yes</td>
<td>not recommended</td>
<td>not recommended</td>
<td>yes</td>
</tr>
<tr>
<td>Molded-In Labels</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Raised Numbers</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Finished Surfaces (Reproduces Mold Surface)</td>
<td>two</td>
<td>two</td>
<td>two</td>
<td>two</td>
<td>two</td>
<td>one</td>
</tr>
</tbody>
</table>
Design and CAE Support from Tipco

- **Initiation of Idea**
  - Brainstorming
  - Part Optimization design tools
  - Design for Lightweighting
  - Composite Material Design

- **Conceptual Generation**
  - Mold filling analysis
  - Shrinkage / warpage analysis
  - Modal analysis
  - Impact analysis
  - Thermal analyses etc

- **Basic Engineering**
  - Tool layout
  - Trouble shooting

- **Detail Engineering**

- **Manufacturing, Design Validation and Testing**
Comparative Properties of All Materials

**Specific Tensile Strength**

<table>
<thead>
<tr>
<th>Material</th>
<th>Specific Tensile Strength (MPa/g•cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>0.06</td>
</tr>
<tr>
<td>Aluminium</td>
<td>0.08</td>
</tr>
<tr>
<td>SMC</td>
<td>0.07</td>
</tr>
<tr>
<td>PP LFT 30% GF</td>
<td>0.10</td>
</tr>
<tr>
<td>CFT PP 60% GF</td>
<td>0.38</td>
</tr>
</tbody>
</table>

**Tensile Strength**

<table>
<thead>
<tr>
<th>Material</th>
<th>Tensile Strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>450</td>
</tr>
<tr>
<td>Aluminium</td>
<td>210</td>
</tr>
<tr>
<td>SMC</td>
<td>120</td>
</tr>
<tr>
<td>PP LFT 30% GF</td>
<td>120</td>
</tr>
<tr>
<td>CFT PP 60% GF</td>
<td>500</td>
</tr>
</tbody>
</table>
LONG GLASS FIBER FPP PRODUCT RANGE

- LFPP2010 – PP Long Glass Fibre 20%
- LFPP3010 – PP Long Glass Fibre 30%
- LFPP3510 – PP Long Glass Fibre 35%
- LFPP4010 – PP Long Glass Fibre 40%
- LFPP5010 – PP Long Glass Fibre 50%
- LFPP6010 – CONENTRATE
- LFPP – S SERIES – 6 MM PELLET LENGTH
- LCFPA6 – Under Development
CASE STUDIES IN LIGHTWEIGHTING
Light weighting Applications in Passengers Car

Part Name: Gear Shifter Lever Housing
Material Grade: LFPP3510
15% savings in Weight
28% Cost savings
Better Dimensional Accuracy
Very good Creep and Fatigue resistance

Part Name: Gear Shifter Lever Adapter
Material Grade: LFPP3510
17% savings in Weight
28% Cost savings

Part Name: Battery Tray replacing sheet metal
Model: All Passenger cars
Grade: LFPP4010
Corrosion resistance
30% Weight Reduction
Part Integration
Light weighting Opportunities in Passengers Car

Front End Module

LFPP3010
40% Weight savings.
Contributing towards Emission and Fuel efficiency objectives of OEM.
Part Integration eliminating complex welding process.

SHIFTER DRUM – WINDOW REGULATOR ASSEMBLY

Sheet Metal part Under Approval

LFPP3 2010
40% Weight savings.
Sheet metal to PPLGF conversion.
Elimination of corrosion and Rattle noise.
Contributing towards Emission and Fuel efficiency objectives of OEM.

LFPP3510
20% Weight savings
Part name: Battery Cover
OEM: ND
Model: MHCV
Grade: PP LF 40%
Benefits:
- Corrosion resistance
- 30% Weight Reduction
- Part Integration

Part name: Cowl Vent Grill
OEM: Navistar
Model: I-70
Grade: PP LF 40%

Part name: Freightliner Battery Box
OEM: Mack Truck
Model: MHCV
Grade: PP LF 40% - UV STABILISED
Part Weight: 2 Kgs (GAIM)

Part name: Fuel Inlet Valve
OEM: Ford
Model: Transit Vehicle
Grade: PP LF 30%
New Applications For Light weighting
PA Long Carbon Fibre for Precision Parts

- High strength-to-weight ratio
- Resistant to deformation and crack propagation
- Superb load carrying ability
- Exceptional long-term creep resistance
- Cyclical fatigue endurance
- Outstanding dimensional stability
- Performance maintained at low and elevated temperatures
- Low coefficient of thermal expansion
- Dampen vibrations and sound

<table>
<thead>
<tr>
<th>Properties</th>
<th>ASTM Method</th>
<th>Unit</th>
<th>Long carbon fiber PA CF 40% PA-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.fiber Contain @ 550°C</td>
<td>D 5630</td>
<td>%</td>
<td>40</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>D 792</td>
<td>----</td>
<td>1.31</td>
</tr>
<tr>
<td>Tensile Strength @ Break</td>
<td>D 638</td>
<td>Kg/cm²</td>
<td>2300</td>
</tr>
<tr>
<td>Elongation @ Break</td>
<td>D 638</td>
<td>%</td>
<td>2.7</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>D 790</td>
<td>Kg/cm²</td>
<td>3976</td>
</tr>
<tr>
<td>Flexural Modulus</td>
<td>D 790</td>
<td>Kg/cm²</td>
<td>228000</td>
</tr>
<tr>
<td>(N) Izod Impact, 23°C</td>
<td>D 256</td>
<td>kg.cm/cm</td>
<td>34.2</td>
</tr>
</tbody>
</table>

Potential Applications:
- Bearing brasses of balls;
- Cooling system impellers;
- Washers;
- Guides and sliding bushings;
- Ring gears;
- Clutches;
- Pulleys;
Future Light weighting Opportunities in Commercial Vehicles

- Part name: Truck Bed Bottom
- OEM: NA
- Model: MHCV
- Grade: PP LF 20% - UV STABILISED
- Part Weight: 12 Kgs
- Benefits:
  - Corrosion resistance
  - 50% Weight reduction
  - Light weighting solution to meet BS6 emission norms
Composite in India: Future Focus

- **Composite Leaf Springs**
- **CNG Composite Cylinder**
- **Foot Step for SUV’s**
- **Seat Back with CFRP**
- **Tail Gate**

### Inner Structural part: LFPP
- **Outer Skin:** PP
- **Weight reduction:** 3kg versus Metal
Application Development Support

Preliminary Assessment
- Application Design & Functional Requirements
- Application Development Expertise

Concept Design
- Conversion Feasibility Analysis – Value Proposition
- Processing and Material Selection
- CAE Design Evaluation

Basic Engineering
- Plastic Concept Design considering Material, Manufacturing process, tooling and assembly
- Detailed CAE Moldflow and Structural Strength simulation
- Final Optimised Design

Final Engineering and Part Testing
- Prototype Tool Development
- Part Design validation as per Endurance testing
- Field testing
Tipco Group

Autotech Polymers  Thermoplastics

Tipco Industries  Thermosets

Tipwood Div.  Composites

Serving India since 1945
Autotech Product Line

**Tipcolene®** Filled & Reinforced PP Compounds

**Tipcofil®** Engineering Thermoplastics Compounds

**ATP-PLAST®** Long-Glass Fibre Polypropylene & Nylons

**Jute-PP®** Long Jute Fibre Reinforced Polypropylene

**Tiplene®** Masterbatches & Concentrates

**Tiprene®** Elastomers
Tipcolene®

- Filled & Reinforced PP Compounds
- Engineering Plastics Compounds
- Long Glass Fiber Thermoplastics Compounds
- Maleic Anhydride PP Coupling Agent
- Jute Polypropylene Compounds
Tipcolite®

Phenolic Resins – Resol & Novolac
Phenolic Molding Compounds – Injection
Long Glass / Fabric Impregnated Materials
Unsaturated Polyester Injection Compounds
Why Tipco’s LGF PP better than Many popular imported brands in India

Tipco’s 60% LGF PP

Competitor’s 60% LGF PP

Tipco’s LGF PP granules are fully impregnated and NO free Glass fiber visible
Advantage of Impregnated LFT Pultrusion

Very High Stiffness and Impact Strength is obtained

Glass fibre is retained as Skeleton Structure after Ash Content Test
Long Glass Fibers vs. Short Glass Fibers
Comparison

Composite Performance 30% GF-PP

Fiber Volume

Long-Fiber
Technologies

Short-Glass

Tensile

Stiffness

Impact

Fiber length

LFT Technology Boosts Material Property Profile:
Impact, Creep, Short & Long Term Heat Resistance
Thank You