LANXESS High Performance Materials
Addressing the trends in automotive

Jose Chirino, Technical Director, Americas

National Academy of Science Webinar: Assessment of Technologies for Improving Fuel Economy of Light-Duty Vehicles – Phase 3

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Agenda

- LANXESS Overview

- Plastics & Composites for Global Fuel Efficiency Automotive Trends
  - Lightweighting
  - Powertrain
  - Aerodynamics
  - Closing Remarks
LANXESS –
A globally operating specialty chemicals company

Specialty chemicals company
- Spin-off from Bayer in 2004
- Specialty chemicals portfolio: chemical intermediates, additives, specialty chemicals and plastics

Global success story
- 60 production sites worldwide
- Approximately 15,500 employees in 33 countries
- Global sales of EUR 7.2 billion in 2018

Strategy of profitability and resilience
- Strengthening of leading position in medium-sized markets
- Consolidation in Europe, expansion in USA and Asia
High Performance Materials at a glance – Leading supplier of engineering plastics

**Key figures**
- Sites: 9
- Employees: ~1,600
- Customers: ~600

**Brands**
- Durethan®
  - PA6 and PA66
- Pocan®
  - PBT
- Tepex®
  - COMPOSITES
- HiAnt®
  - Engineering

**Applications**

**Markets**
- Automotive UTH
- Automotive Structural
- Electrical / Electronics
- Appliances

**Global Presence**
- Global compounding network
- Backward integrated supply
- Product and application development
Typical Polyamide ("Nylon") applications in Automotive
Wide range of lightweight and durable components

<table>
<thead>
<tr>
<th>Functional area</th>
<th>Automotive Components with LANXESS contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body/Structure</td>
<td>Roof/door frame, Front end, Spare wheel well, Door Systems, Structural insert, Cross car beam, Module/Electronics Housings</td>
</tr>
<tr>
<td>Drivetrain</td>
<td>Engine oil pan, Cylinder head cover, Fan/Shroud, Gearbox oil pan, Fuel Delivery System, Pulleys, Air Systems</td>
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<tr>
<td>Interior</td>
<td>Airbag housing, Bracket, Actuator Housing, Seat pan, Pedal / pedal bracket, Rear Vision (interior), Window Surround</td>
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<tr>
<td>Chassis</td>
<td>Steering rod, Air Spring Systems, Chassis Space Frame, Steering Control System, Connectors/Housings</td>
</tr>
</tbody>
</table>
Agenda

- **LANXESS Overview**

- **Plastics & Composites for Global Fuel Efficiency Automotive Trends**
  - Lightweighting
  - Powertrain
  - Aerodynamics
  - Plastic & Composite Innovation Highlights
Fuel Economy

- Improving Fuel Efficiency through:
  - Lightweight
  - Powertrain
  - Electrification
  - Aerodynamics

Fuel efficiency regulations are a global trend
Lightweighting
Across all vehicle classes

- Entertainment, comfort & safety features all increase vehicle weight
- 10% weight reduction improves fuel efficiency by estimated 6-8%
- Polymers make up 50% vehicle volume, but only 10% vehicle weight.
- Latest CFRP further reduce part weight by 70%

Challenges:
- Weight reduction without negative effect on performance, safety and cost.
- Metal replacement, as well as density reduction and thickness optimization of existing plastic parts
- Noise-Vibration-Harshness (NVH) considerations

Technologies @ LANXESS
- High Modulus / High Flow materials for thinwall components, including CF Polyamide and composites
- Plastic Metal Hybrid for lighter components: Cross car beam, Front End Modules,
- All plastic composite components
Mechanical Properties of Metals vs. Thermoplastics

Weight Specific Comparison

- Steel: $\rho = 7.8$
- Aluminum: $\rho = 2.7$
- PA6GF60: $\rho = 1.7$
- PA6CF30: $\rho = 1.26$
- PA6 GF Woven Sheet*: $\rho = 1.8$
- PA6 CF Woven Sheet: $\rho = 1.45$

* 47 vol.-%, dry, woven, 50/50
Increasing requirements on stiffness (e.g. NVH)

- Plastic Metal Hybrid
- Plastic Composite Bumper Beam
- Tepex® Composite Hybrid
- Hollow Profile Hybrid
- Full Plastic

Increasing requirements on strength (e.g. crash)
Lightweight Front End
Use of localized composites

SUV Front End Module

Tepex® Composite Technology

- Free of sheet-metal – even at top cross-member extending to the fender carriers
- Withstands hood latch and head lamp loads without sheet-metal reinforcement
- 50% weight reduction vs Steel
- Wall thickness 1.8 – 4 mm
- Cost savings through smart use of composites:
  - Localized Tepex composite only used where it is needed.
Lightweight examples
In production today – Future developments ongoing

**Rear Bumper**
- Part weight ~3.6 kg
- Weight reduction ~50% vs aluminum/steel
- One shot process
- Meets all US standards for rear crash performance

**Cross Car Beam**
- High stiffness
- Functional integration
- Lightweight
- Cost reduction
- Meets all US standards for crash performance
Powertrain
Turbo is here, Electrification is coming

- Powertrain know-how is main focus for fuel efficiency
  - Accounts for ≈ 25% of vehicle mass
- Turbo charged and EGR (Exhaust Gas Recovery)
- Powertrain electrification
- Global Platforms

**Challenges:**
- Increased engine temperatures
- Compact engine design
- Lightweight electric systems with new requirements:
  - Cooling, flame resistant, EMS …

**Technologies @ LANXESS**
- Next Generation High Heat PA grades (“XTS”) for AIM.
- Hot Side air ducts with improved heat stability
- High temperature Hydrolysis Resistant (HR) grades for cooling systems.
- Metal replacements in Engine and Transmission components
Battery System –
Various applications for Engineering Plastics

Critical Requirements
- Impact / Strength
- Flammability
- Lightweight
- Surface Quality
- Durability
Improved Aerodynamics
Active Grille Shutters (AGS) and Underbody Protection

- Aerodynamics essential, even for EVs
- Just removing roof rack improves fuel economy by 5%
- AGS not implemented “across the board”
  - Depends on engine size, fuel efficiency strategy
  - Improves FE by 2g CO$_2$/km = 1.1 MPG (0.4 km/l)

Challenges:
- Optimization of AGS (weight / flatness / strength)
- Underbody components with unique requirements:
  - Impact resistance, engine accessibility, heat management

Technologies @ LANXESS
- New Extreme Flow PA grades for reduced warpage (BKV30XF) and improved cycle times
- Next generation of UV-stable PA grades with improved surface quality
- Tepex® composite sheet for underbody protection
Tepex® compression molding (LWRT)
Under body protection

Direct Compounded Long Fiber Thermoplastic

- Compression molding Low Weight Reinforced Thermoplastic LWRT
- Tepex® composite surface and metal inserts
- 3 times higher strength and energy absorption in comparison to other non-composite solution
- Improved acoustics / sound absorption
- Impact Resistant: excellent durability on rough roads
- Fast cycle times for mass production (<1 min)
Polymer Materials Improving Fuel Economy

- Safely Reducing Weight
- Reducing Cost & Consolidating Parts
- Improving Aerodynamics
- Enabling Electrification & More