Lasers in Automotive – Innovations for Lightweighting and Fuel Economy

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Future Lightweight Vehicle Structures
• **Major global automotive trends are leading to changes in materials**
  − Mega trend: Lightweighting
  − Continuous improvements in emissions and performance, with increased safety standards and political pressure leading the way

• **Various materials and new alloys will be employed**
  − Next generation steels and aluminum alloys, resins and plastics, magnesium, carbon fiber, etc.
  − OEM’s are trending towards a mixed material solution
  − More material mixes will be used in the coming decade as automakers move to meet increasing fuel economy, emissions and safety regulations

• **Joining of these new materials is the key to future assemblies**
  − Processes and businesses will change, and products will be combined into subassemblies and modules
  − There will be significant manufacturing challenges/differences compared to today
  − The automotive industry must develop the technical expertise to successfully manufacture products joining various materials
Enablers for Growth

• Both of the aluminum and steel industries next generation materials will move towards the upper right quadrant increasing strength and elongation.

• Casting alloys are following this trend with addition of increased temperature and fatigue life.

Typical and Next Generation Sheet Products
Multi-Material Body Structures

PHS ultra high-strength steel safety cage

Die cast aluminum shock towers joined to steel

Gen3 steel multi-piece cross members and rails with varying material thickness for improved energy management

Mixed-material underbody

Die cast aluminum longitudinal and cross members joined to steel body
Material Distribution

<table>
<thead>
<tr>
<th>Material</th>
<th>2015</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEEL</td>
<td>60</td>
<td>54</td>
</tr>
<tr>
<td>ALUMINUM</td>
<td>11</td>
<td>17</td>
</tr>
</tbody>
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Source: Ducker Worldwide
Multi-Material Body Structures

• By 2020, the next generation materials will start to appear on vehicles with wide acceptance anticipated for 2025
  - Companies that understand the methods to achieve the targeted properties will have a strategic advantage:
    - Effect of cutting, blanking and piercing on edge properties
    - Joining
    - Forming and lubrication requirements
    - Casting and grain structure
    - Corrosion effects

• Key technical development is required to be ready to navigate through this period
Summary

• Increasing safety, emissions and fuel economy regulations are driving the lightweighting megatrend
• New materials required for lightweighting will be more expensive
• New products must be designed as effective as they need to be
• New processes are required to manufacture products as efficiently as they can be
• New technology applications are required to produce affordable vehicles
Lasers
Enablers for Efficient
State-of-the-art Manufacturing
Lasers in Manufacturing

• Its unique properties make the laser an enabling tool for state of the art manufacturing
  – No mechanical forces
  – No inertia
  – High precision
  – Low thermal influence
  – Fast control
  – Easy automation
  – Adaptable to different processes
  – Adaptable to different materials
Laser Applications in Automotive

- **Remote applications**
- **Laser welding and brazing**
- **Welded blanks**

**Body Shop**

- **Cutting**
  - Cutting/trimming
  - Softening/hardening
  - Laser blanking from coil

- **Interior and Assembly**
  - Day/night designs
  - Marking
  - Drilling
  - Surface treatment

- **Short Pulse Laser Ablation & Drilling**

- **Lightweight Design**
  - Flange reduction
  - Integrated functions
  - Joining new materials

- **E Drives**
  - Battery production
  - Electric engines
  - Fuel cells

- **Powertrain**
  - Gear welding
  - Clutches
  - Differentials
  - Shifting forks

- **Powertrain**
  - Gear welding
Lightweight Designs

- The precision of remote laser welding enables new design opportunities:
  - Reduction of weight
    - Reduced flanges or flangeless designs
  - Integrated functions
    - Tailored parts possible, using different materials and thicknesses
Lasers in Manufacturing

• Laser Processing of Advanced Materials
  – Laser Cutting and Trimming
  – Laser Blanking
  – Annealing and Heat Treating
  – Laser Joining

• Ultra Short Pulse Laser
  – Laser Ablation
  – Marking
  – Drilling

• Additive Manufacturing
Lasers in Manufacturing

• Cutting
  – CFRP, Air Bag Fabrics
  – Castings and Extrusions
  – Laser Coil Blanking
Lasers in Manufacturing

- Softening of sectional areas for bending operations
- Improved crash performance of flange area
- Softening of belt at upper part of B-pillar
- Hardness adjustable to requirements
Lasers in Manufacturing

• Remote Laser Welding
Lasers in Manufacturing

Trifocal laser brazing for hot dipped zinc coating

- Very good gap bridge ability
- Very good appearance (Class A body)
- Higher process speed
- Low heat input
- Low pore and spatter rate
- Smooth surface
Lasers in Manufacturing

• Short Pulse Lasers

Short laser pulses of extremely high power produce an energy density so high that the material undergoes a rapid transformation from a solid to a combination of vaporizing boiling liquid or gas that expels material, usually in the form of a vapor plume.
Lasers in Manufacturing

- Short Pulse Lasers
  - Marking/Perforating
  - Ablation of surface coatings/films
  - Drilling/Surface structuring
Lasers in Manufacturing

• Laser Cleaning
  – Fastest growing new application
  – High processing speeds
  – Very successful in weld preparation
  – Effective in cleaning:
    – Oils (machining/fingerprints)
    – Soaps/cleaning agent residue
    – Rust inhibitors
    – Oxidation
    – Phosphate layers
Lasers in Manufacturing

Surface structuring for thermal joining of plastics to metallic parts without any adhesives!
Additive Manufacturing

- Additive Manufacturing (AM) is a process in which a three-dimensional object is created out of a digital model. The additive process builds up parts layer by layer.
- Several methods are available for this technology
  - Laser Metal Deposition (also known as direct metal deposition)
  - Laser Metal Fusion – LMF (commonly known as powderbed or 3D printing)
Additive Manufacturing

- Tooling produced with AM
  - Stamping dies
  - Conformal cooling tools for castings
  - Investment/sand casting masters

- Low volume modification of components

- Repair of tools, molds and components
Technical Advancements Enabling State-of-the-art Manufacturing

- Advances in laser technology
  - Lower cost/kW of laser systems
  - Higher beam quality
  - Short pulse width (nanosecond)
  - New process monitoring and controls
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