LIGHT WEIGHTING IN AUTOMOTIVE INDUSTRY

Automotive Manufacturing Solutions India Conference

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Presentation Layout

Need for Light Weighting

Light Weighting Benefits

Opportunities & Trends

Challenges in Manufacturing
Need for light weighting

Vicious Cycle of Weight

Increasing Customer Requirements on:
- Safety
- Performance
- Luxury

- Enhanced Rigidity
- Powerful Engine
- Larger Fuel Tanks and other adaptations
- Heavier Structure
- Resulting in heavier new generation vehicle

Need for light weighting
Need for light weighting

- Environmental aspects - emissions end-of-life vehicle
- Importance of fuel economy
- Heavier vehicles due to luxury, safety and electrical equipment addition to standard vehicles

Environmental aspects
Enhanced fuel efficiency
Enhanced payload carrying capacity
Passenger and pedestrian safety
Weight Reduction
Presentation Layout

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Benefits of light weighting

Lesser CO\textsubscript{2} emissions due to:

- Direct weight saving because of lighter material usage
- Indirect weight saving due to downsizing of some components
- Lower energy demand and so lesser fuel requirement
- For the same power-to-weight ratio, saving weight allows downsizing of powertrain
- Shortens braking distance for same brake power constant
Benefits of light weighting

• Enhanced fuel consumption
• Improvements in vehicle performance
• Smaller mechanical parts including engine, brakes, gear box, and other mechanical and structural parts
• Weight saving in the structure facilitates substitution by other luxury or safety accessories
• Improved road handling
Benefits of light weighting

- As vehicle weight directly impacts fuel consumption, light weighting is necessary to reduce CO$_2$ emissions.

- 100 kg mass reduction achieved on a car saves 8 grams of CO$_2$ per km at the exhaust pipe.

Source: Report of European Aluminium Association
Presentation Layout

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Opportunities in light weighting

Reduced Vehicle Weight

Lightweight Materials
- High Strength Steels
- Aluminium, Magnesium
- Unreinforced and reinforced Plastics

Structural lightweight Construction
- New structures and complex geometries

Optimizing of Production Process
- Light joining techniques
- New manufacturing processes (Hydroforming)
Trends in light weighting

INNOVATIONS:
- Advanced material technologies
- New Modular Architecture
- Advanced functional integration
- Affordability & Costeffectiveness
- Multi-Material-Joining
- Multi-Material Simulation
- Multi-Material Recycling

SLC Multi-Material Concept
- Design Simulation
- Construction guidelines
- VR Engineering
- Crash-Simulation
- Repair strategies
- Recyclability
- End of Life Assessment

Breakthrough low weight Vehicle Concepts

Affordable Manufacturability

Multi-Material-Technologies
- Fibre reinforced Composites
- Advanced Steels
- Lightmetals Aluminum Magnesium

Applied Material Technologies
- Material concepts
- Semi finished products
- Materials combination
- Surface quality
- Durability
- Material simulation
- Material properties

Manufacturability / Cost analysis
- Production of Parts
- Modelling & Simulation

Testing and Validation
- LC Analysis / EL Assessment

2006 2007 2008 2009 2015

SuperLightCar

ARAI
Progress through Research
Light weight materials – Advanced High Strength Steel (AHSS)

Strength-formability relations for mild steel, conventional HSS and AHSS

Engineering Stress-Strain curves for various Dual Phase and TRIP steel

TRIP 780 steel showing islands of austenite (bright) and bainite (dark) in ferritic (blue) matrix. 500X

Probable applications:
- Paneling
- Pillars, bumpers, semi-structural or structural components
Light weight materials – Aluminium Alloys

- Low density (2.7 g/cm³)
- Aluminium-specific fabrication techniques, such as complex, multi-hollow extrusions can make further weight reduction
- Several alloy systems are well established for various usage
- Recyclability

Probable applications:
- paneling
- for semi structural components, with honeycomb structure - aluminum hybrid
- Hybrid of aluminum foam and aluminum or AHSS for structural or semi-structural components
- For roofing, flooring and door panels with or without AHSS for reinforcement
**Light weight materials – Magnesium Alloys**

- Highest specific strength
- Almost equal specific stiffness
- High strength to weight ratio

**Probable applications:**
- Steering wheel,
- Steering column,
- inner doors,
- seat frame,
- instrument panel,
- transfer case etc.

**Major issues restricting its use:**
- Corrosion resistance,
- creep resistance,
- poor formability,
- high cost
Light weight materials – Polymers

- Light weight
- Easy to mould, good flexibility of manufacturing
- Fire retarding nature
- Complicated or intricate shapes can be molded easily
- Electrical and thermal insulator

Probable applications:
- Paneling
- Fire retardant floor and/or roof
- Seat back plate, structure

Few of the auto-applications of engineering plastics.

Source: DuPont
**Light weight materials – Composites**

**Currently in use:**
- Polymer Matrix Composites (PMC)
- Metal Matrix Composites (MMC)
- Ceramic Matrix Composites (CMC)

**Further prospective:**
- Fiber Reinforced composites
- Glass Fiber Reinforced Composites (GFRP)
- Direct-Long Fiber Technology (D-LFT) and Long Glass Fiber technology (LGFT)

Glass fiber reinforced plastic air intake manifold

Engine with Sheet Molding Compound (SMC) oil sump and valve cover
Light weight materials – Composites for Bus Components

Roof Structure

Complete Structure

Side Structure

Door, Hand Rails or Windows Safety Rails
Design Aspects

Various Materials in BIW
In recent view of increasing vehicle fuel efficiency, weight reduction has become a necessity, but not compromising on strength at the same time.

Thus, possibility of multi-material joints and structures arises, thus leading to CAE based validations for their structural integrity.
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Challenges in Manufacturing
Challenges in Manufacturing – Materials

With AHSS:
• Formability of the material
• Optimization of manufacturing processes
• Availability of material in India

With Plastics and Composites
• Data on fatigue and creep behavior of these materials
• Environmental issue: Recycling of waste material
• Safety related: inflammable characteristics
With Aluminium

- Profile making is difficult with Aluminium than MS
- Joining technology
- More number of joints required due to lack of weldability thereby, affecting the coach rigidity
- Tensile strength of Aluminium is very less compared to MS, implying coaches are susceptible to frequent breakdowns
- Lesser wear resistance and so consumption of parts made of Aluminium is higher as compared to steel
- High material cost with respect to steel
Challenges in Manufacturing – Body Design

- Steel Unibody
- Advanced LM-Spaceframe
- Al-Spaceframe
- High strength Steels
- Steel thin wall casting
- Composites
- Advanced Composites (FRP)
- Stainless Steel Spaceframe
- Advanced Steel body
- Coil-coated shell

Materials
- > 2012

Design

Affordability of weight reduction

Processes
Challenges in Manufacturing – Durability

- Full vehicle Life cycle assessments (From Cradle to Cradle i.e. Generation to recycling) to be performed to assess the benefits of light weight material
- Challenge to keep vehicle repair costs low (Dent, Scratch removal, Structure repairs)
- Infrastructure and skills development of technicians for handling multi material joineries
- Requirement of widespread competence base among the value-chain partners
Conclusion

- **Light weighting is beneficial & essential, but it has issues which need to be addressed at various levels, i.e.**
  - Material
  - Design
  - Process
  - Use

- **Hence, addressing the ‘Manufacturing Challenges’ is very vital and requires involvement of all stakeholders**
Thank you