Environmental assessment of light weighting solutions for automotive components: results, trade-off and challenges from real case studies

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Summary

- Magneti Marelli SpA: Business line & Products
- Magneti Marelli Commitment for a Sustainability Development
- Magneti Marelli Products Portion of Incidence on a Vehicle
- Automotive Sector: Improvement Drivers From Environmental Perspective
- LCA: A Product-Oriented Method for Sustainability Analysis
- LCA Development Projects and Lightweigh Drivers
- LCA Projects: Alternative Technology for Product Manufacturing
- LCA Projects: Alternative Raw Materials
- LCA Projects: Alternative Technology and Raw Materials
- Results and Consideration
Magneti Marelli is an international Group committed to the design and production of hi-tech systems and components for the automotive sector.
Magneti Marelli Commitment for a Sustainability Development

Magneti Marelli is committed to develop its product with the aim of reducing the impact caused by the effect of its products on the environment.

Towards a Green Automotive Industry

- Technical Feasibility
- Performance characteristics
- Properties of eco compatibility

R&D Concept Design
### Magneti Marelli Products Portion of Incidence on a Vehicle

<table>
<thead>
<tr>
<th>Component Type</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic Components</td>
<td>35 Kg</td>
</tr>
<tr>
<td>Automotive Lighting</td>
<td>10 – 12 Kg</td>
</tr>
<tr>
<td>Mechanical Control Systems</td>
<td>5 Kg</td>
</tr>
<tr>
<td>Powertrain</td>
<td>10 – 11 Kg</td>
</tr>
<tr>
<td>Exhaust Systems</td>
<td>20 Kg</td>
</tr>
<tr>
<td>Shock Absorbers</td>
<td>20 Kg</td>
</tr>
<tr>
<td>Suspension Systems</td>
<td>60 Kg</td>
</tr>
</tbody>
</table>

If all the components of a midsize vehicle were produced by Magneti Marelli, therefore the total contribution would be **170 kg weight**.
Automotive Sector: Improvement Drivers from Environmental Perspective

Reduction of exploitation of fuel consumptions

Lightweighting

Reduction of Green Greenhouse Gas Emissions (GHG)

Case study highlight on a bulk component: crossmember

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight reduction</th>
<th>GWP$_{100}$ reduction over lifetime of 150000 km</th>
<th>Fuel Consumption over lifetime of 150000 km (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>-18%</td>
<td>-19%</td>
<td>-19%</td>
</tr>
<tr>
<td>Plastic Composite</td>
<td>51%</td>
<td>51%</td>
<td>51%</td>
</tr>
</tbody>
</table>

Graph showing:
- GWP$_{100}$ over lifetime of 150000 km for Steel, Aluminium, and Composite materials.
- Fuel consumption over lifetime of 150000 km for Aluminium and Plastic Composite materials.

Graph indicates:
- Steel has the highest GWP$_{100}$ over lifetime and fuel consumption compared to Aluminium and Plastic Composite.
- Aluminium and Plastic Composite show significant weight reduction with comparable GWP$_{100}$ and fuel consumption reductions.

- Steel: GWP$_{100}$ increases with distance.
- Aluminium: GWP$_{100}$ and fuel consumption decrease with distance.
- Plastic Composite: GWP$_{100}$ and fuel consumption decrease with distance, showing improved sustainability over lifetime.
**LCA: A Product-Oriented Method for Sustainability Analysis**

LCA System Boundaries: «Cradle to Grave» approach

**LCA Impact categories: CML 2001 – April ‘15**

<table>
<thead>
<tr>
<th>INPUT:</th>
<th>OUTPUT:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abiotic Depletion Elements (ADP elements) [kg Sb-Equiv]</td>
<td>Global Warming Potential (GWP 100 years) [kg CO2-Equiv.]</td>
</tr>
<tr>
<td>Abiotic Depletion Fossils (ADP fossils) [MJ]</td>
<td>Acidification Potential AP) [kg SO2-Equiv.]</td>
</tr>
<tr>
<td></td>
<td>Eutrofication Potential (EP) [kg Phosphate-Equiv.]</td>
</tr>
<tr>
<td></td>
<td>Ozone Depletion Potential (ODP, catalytic) [kg R11-Equiv.]</td>
</tr>
<tr>
<td></td>
<td>Freshwater Aquatic Ecotoxicity Potential (FAETP) [kg DCB-Equiv.]</td>
</tr>
<tr>
<td></td>
<td>Human Toxicity Potential (HTP) [kg DCB-Equiv.]</td>
</tr>
<tr>
<td></td>
<td>Marine Aquatic Ecotoxicity Potential (MAETP) [kg DCB-Equiv.]</td>
</tr>
<tr>
<td></td>
<td>Photochemical Ozone Creation Potential (POCP) [kg Ethene-Equiv.]</td>
</tr>
<tr>
<td></td>
<td>Terrestrial Ecotoxicity Potential (TETP) [kg DCB-Equiv.]</td>
</tr>
</tbody>
</table>

✓ Primary energy demand from renewable and non renewable resources (gross cal. value) [MJ]
LCA Development Projects and Lightweigh Drivers

Choice of materials...

Production Technology
Materials Substitution
Production Technology and Materials Substitution

Economic constraints
Technological Constraints
Material Properties
LCA Projects: Alternative Technology for Product Manufacturing

2K Fuel Tank

Extrusion Blow-molding VS Injection (Weight reduction -33%)

Results

- Global Warming Potential (GWP 100 years) [kg CO2-Equiv.]
- Abiotic Depletion (ADP elements) [kg Sb-Equiv.]
- Primary energy demand from ren. and non ren. resources (gross cal. value) [MJ]
- Ozone Layer Depletion Potential (ODP) [kg R11-Equiv.]
LCA Projects: Alternative Raw Materials

Dashboard

PP + Talcum VS PP + Hollow Glass Spheres (Weight reduction -30%)

Results

Global Warming Potential (GWP 100 years) [kg CO2-Equiv.]

Abiotic Depletion (ADP elements) [kg Sb- Equiv.]
LCA Projects: Alternative Technology and Raw Materials

**Throttle Body Housing**

**Secondary Aluminum (Die Casting) VS PET+ Glass Fibers (Injection Moulding)**

*(Weight reduction -22%)*

**Results**

- **Global Warming Potential (GWP 100 years)**
  - [kg CO2-Equiv.]
  - Raw Material
  - Transport
  - Manufacturing
  - Use Phase
  - Total

- **Marine Aquatic Ecotoxicity Pot. (MAETP)**
  - [kg DCB-Equiv.]
  - Raw Material
  - Transport
  - Manufacturing
  - Use Phase
  - Total

- **Primary energy demand from ren. and non ren. resources**
  - (gross cal. value) [MJ]
  - Raw Material
  - Transport
  - Manufacturing
  - Use Phase
  - Total
Vehicle End of Life process flowchart: ISO 22628:2002

«What are the material implication associated with the vehicle weight reduction on ELV treatments?»

Material’s typology affect process efficiencies and hence their recoverability expressed in % of mass fraction through the following indices:

\[
R_{\text{cyc}} (%) = \frac{m_p + m_D + m_M + m_{Tr}}{m_{tot}} \times 100
\]

\[
R_{\text{cov}} (%) = \frac{m_p + m_D + m_M + m_{Tr} + m_{Te}}{m_{tot}} \times 100
\]
Results and Consideration

**Lightweighting** approach significantly reduces the environmental impacts during the **products** utilization on vehicle

**But ...**

Light weight materials (fillers for plastic compound), could worsen the effect on Raw Materials Impact

Reduce the quantity of impacting plastic filler or replace with less impacting filler

**Balance between...**

**Raw Materials** and **Use Phase** account for ~ 90% portion of incidence on life cycle total impact

Replace **Virgin Materials** with **Recycled**

Consider Product End of Life Recovery and Reuse
Thank you for your attention

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