Decision Making Framework for Greener Sheet Stamping Processes

Motivations and Opportunities

- Green sheet stamping processes can trigger a significant leverage effect throughout the vehicle life cycle

  - Stamping 80%
  - Coatings 6%

- Improving the manufacturing phase results in a more efficient material use and reduction of CO₂ in the use phase

Tailored Blanks (TB)

- Blanks of varying thickness, material alloys and grades enable a proper location of the material properties according to the product requirements

Problem Statement

- LW Manufacturing (LWM) is economically challenging (higher cost of material supply and tooling)

  - LW is technologically challenging (LWMs exhibit lower formability; hot stamping may be needed)

- LWMs primary production is high energy consuming

  - 0% - 10%
  - 10% - 20%
  - 20% - 30%
  - 30% - 40%
  - 40% - 50%
  - 50% - 60%
  - 60% - 70%
  - 70% - 80%
  - 80% - 90%
  - 90% - 100%

- Is LWM worth developing? Trade off analysis is required

Decision Making Framework – I

Life Cycle Assessment (LCA) of the stamping processes: environmental impact evaluation. Eco-impact mapping of the process and leverage effect evaluation

\[ \Delta LCA_{\text{LCA}} = \Delta m_{\text{part}} \times \text{V} \]

Life Cycle Cost (LCC) and Technical Evaluation

Weight reduction by LWMs

- A 6% to 8% fuel saving can be realized for every 10% reduction in weight by replacing steel with Light Weight Materials (LWMs)

  - Baseline Steel
  - 6%
  - 8%
  - 10%

- Decision Making Framework allows to:

  1. Harmonize economical, ecological and technical performances
  2. Evaluate the impact of design choices by “what if...?” analysis
  3. Guide design choices among alternative scenarios
  4. Identify eco-improvement drivers
  5. Address the material selection

Conclusions and expected results

- Processes causing the lowest possible eco impact, while still offering economical and technical viability, are needed

- A standalone LCA application does not allow a thorough evaluation of the process performances

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Eco-efficiency Analysis: trade off evaluation and scenario analysis combining green, economic and technical performances (uneven emphasis may be attributed by additional multi-criteria methods)

Data from:

1. LCA
2. LCC

Weights:

- 1. Environmental impact (Green performance)
- 2. Cost (Economic performance)
- 3. Technical performance

Eco-efficient solutions:

- LCA
- LCC
- Tech. Eval.

LCC - LCA

Cost

Material Consumption

Environmental Impact

Hazard Potential

Toxility

GHG emissions from material primary production

\[ G_{\text{CO}_2} \text{eq/kg material} \]

LWMs exhibit lower formability (LWMs exhibit lower formability: hot stamping may be needed)

Material use and reduction of CO₂ in the use phase

- 1.6 mm
- 1.65 - 1.85 mm
- 2.0 - 2.2 mm
- 2.4 - 2.6 mm

Life Cycle Cost (LCC)

1. Cost
2. Material Consumption
3. Emissions
4. GHG emissions from material primary production
5. Environmental impact
6. Hazard Potential
7. Toxility
8. LCC
9. LCA

Eco-efficiency Analysis

- Energy consumption
- Land Use
- Hazard Potential
- Toxility

Weight reduction by LWMs

- 4.3%)

- Hydraulic forming
- Rubber diaphragm
- Blank

Advantages

- Higher final stiffness with thinner blanks
- No reinforcement where higher strength required
- ≤13% weight reduction
- Efficient material use

Non conventional stamping processes

- Non conventional stamping processes enable the use of 40%-50% thinner blanks due to a more uniform elongation of the material. LWMs with impractical formabilities can be stamped at lower temperature than traditional methods

Hydro-forming

- Pressurized forming fluid
- Rubber diaphragm
- Blank

Super-plastic forming

- Pressurized forming gas
- Blank

LWTB with integrated reinforcement

- Door inner plus hinge reinforcement
- LWTB with integrated reinforcement

Rubber diaphragm

- Hydro-forming hood outer and door panels

Super-plastically formed to 50% the original length

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