Inhoud

- Inleiding Tatasteel R&D
- Licht gewicht in de autoindustrie
  - Super light Car project
  - Future Steel Vehicle project
Tata Sons

- Indiaas industrieel concern opgericht door JN Tata
  - Een historie van meer dan 140 jaar
- Totale omzet $ 70.8 miljard (boekjaar 2009)
- Actief in 7 bedrijfssectoren
  - Consumentenproducten
  - Dienstverlening
  - Chemie
  - Energie
  - IT
  - Engineering
  - Materialen
- Meer dan 350 000 medewerkers in 80 landen
Tata Steel Group – a diversified Global Steel Player

**Tata Steel Group**
- One of the world’s top ten steel companies in terms of crude steel production volume
- Crude steel capacity of approx. 28 Mn tonnes*
- A balanced global presence in over 50 markets and manufacturing operations in 26 countries
- 81,000 fte across 5 continents
- Investments in Minerals Assets improving Raw Material Security
- Group turnover (FY10): US$23bn
- Group EBITDA (FY10): US$2.1bn

**Tata Steel Europe**
- Crude steel capacity:
  - 18 mtpa
  - 2nd largest steel producer in Europe
- 35,000 employees
Locaties Tata Steel Group R&D

TTC: Teesside Technology Centre
STC: Swinden Technology Centre (Rotherham)
AEG: Automotive Engineering Group (Coventry)
IJTC: IJmuiden Technology Centre

VK totaal 350 FTE
IJmuiden 445 FTE
India R&D + SS 450 FTE

(*) FTE: Full Time Equivalent
R&D-organisatie Europa: Products & Applications

- Steel Metallurgy
- Coated Products

Applications:
- Automotive
- Industrial & Construction
- Packaging

* Thermo-Mechanical Treatment Simulator IJmuidenTC
Licht gewicht in de autoindustrie
Requirements on Automotive materials

Process Chain: Press Plant – Body Shop – Paint Shop

Functionality
- Handling Perform.
- Ductility during crash ($R_{p0.2}$, $R_m$, $A_{80}$, ...)
- Fatigue strength
- E-Modulus (stiffness)
- Weight (density)
- Damping
- Performance
- Acoustics

Surface
- Class A surface
- Adhesive Bonding
- Paint Adhesion
- Contact – Corrosion
- Gap-Corrosion

Joining
- Spot Welding RP
- RP-Adhesive bonding
- MIG welding
- MIG brazing
- Laserwelding
- Laserbrazing
- SP Riviting
- Clinching

Forming
- Formability
- Punch Force
- Forming limited Diagram
- Cutting
- Cutting Forces
- Spring back
- min. Operations Sequence
## Drivers in automotive development

<table>
<thead>
<tr>
<th>Category</th>
<th>Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Add more material: <strong>more weight</strong></td>
</tr>
<tr>
<td>Comfort</td>
<td>Larger cars, more gadgets, <strong>more weight</strong></td>
</tr>
<tr>
<td>Performance</td>
<td>Acceleration, speed, cost of ownership: <strong>less weight</strong></td>
</tr>
<tr>
<td>Environment</td>
<td>Fuel consumption, CO2 reduction: <strong>less weight</strong></td>
</tr>
<tr>
<td>Costs</td>
<td>Incremental changes</td>
</tr>
</tbody>
</table>

- Increased use of High Strength Steels and other light weight materials
EU-Project „Super Light Car“

Sustainable Production Technologies of Emission Reduced Light weight Car body concepts

Motivation

- Weight reduced vehicle structure suitable for large series productions
- Development of economically producible multi-material vehicle structures
- Pre-competitive technology screening (EU-Project)
- Light weight car body contributes to a reduction in CO₂ emissions and fuel consumption

Objective

- Reference BIW<sub>VW350</sub> 280 kg; Objective BIW<sub>SLC</sub> 196 kg
- Weight reduction of body structure: ≥30 % (≥85 kg)
- Cost reduced multi-material manufacturability
- High volume capability
- Light weight part costs: ≤10 €/kg
- Fulfilling automotive requirements (crash, static …) for today’s mass-produced vehicle structures made from steel
# Preliminary SLC body structure concepts

**Steel intensive**
- **Weight reduction:** 55 kg (20%) *
- **Additional costs:** < 2,5 €/kg
- **Highlights:**
  - Strut tower in austenitic steel
  - Tunnel in hot-formed steel
  - Bodyside and B-pillar in dualphase-steel
  - Roof in steel/polymer compound
  - Fender in steel/polymer compound
- **Motivation:**
  - Weight reduction with increased utilisation of high strength steels

**ULBC**
- **Weight reduction:** 74 kg (27%) *
- **Additional costs:** ~ 5 €/kg
- **Highlights:**
  - Longitudinal rail in austenitic steel tailored welded blanks
  - Suspension-strut mount as Al-diecast
  - Tunnel in austenitic steel
  - Rear wheelhouse in Al-diecast
  - Inner B-pillar in Al-diecast
  - Roof in Al-sheet
- **Motivation:**
  - Multi-material design weight reduction
  - Steel in the loading paths
  - Lightweight design materials such as aluminium for the front end and roof
  - Cast parts including high-integration

**SLBC**
- **Weight reduction:** 116 kg (38%) *
- **Additional costs:** ~ 10 €/kg
- **Highlights:**
  - Longitudinal rail in Trip800 tailored welded blanks
  - Strut tower as Mg-diecast
  - Floor panel in Al- and Mg-blank
  - Wheelhouse and rear longitudinal rail in Al-blank
  - Inner B-pillar in hot-formed steel
  - Roof in Mg-sheet
- **Motivation:**
  - Priority 1: Weight reduction through multi-material design
  - Priority 2: Number of parts and cost targets

* Structural performance not equal for all concepts
Results of final SLC body concept ($\Delta m$: -101kg)

Weight SLC BiW: 180kg

Materials
- Aluminium sheet
- Aluminium cast
- Aluminium extrusion
- Steel
- Hot-formed steel
- Magnesium sheet
- Magnesium diecasting
- Plastics
- Glashere thermoplastic

Percent by weight
- Aluminium: 96kg (50%)
- Steel: 66 kg (36%)
- Magnesium: 11 kg (7%)
- Plastics: 7 kg (4%)

Group Research / Dr. Goede (K-EFFCO)

TATA STEEL
Toekomstvisie VW

Werkstoff Einsatz:
95 % Stahl, kaltgeformt
5 % Stahl, warmgeformt

VW Golf VI

Werkstoff Einsatz:
80 % Stahl, kaltgeformt
20 % Stahl, warmgeformt

- 23 kg

VW Golf VII

Werkstoff Einsatz:
4 % Stahl, kaltgeformt
32 % Stahl, warmgeformt
53 % Aluminium (Blech + Guss + Profil)
7 % Magnesium (Blech + Guss)
4 % Faserverstärkte Kunststoffe

- 100 kg

VW Golf VIII

Abbildung 4: Mischbaukonzepte und Potenziale

M.Goede, ICAFT, 13 en 14 november 2012, Chemnitz
FutureSteelVehicle
Leading Edge Innovations for Steel Body Structures
WorldAutoSteel Membership

Automotive Group of the World Steel Association

Ansteel  NUCOR
ArcelorMittal  POSCO
Baosteel  Severstal
China Steel  Sumitomo
Tata Steel  ThyssenKrupp
JFE  USIMINAS
Hyundai-Steel  U. S. Steel
Kobe  voestalpine
Nippon Steel

More than US$60 Million
Facts and goals of the study

• Facts
  • FSV is the successor of the recognized lightweight studies ULSAB 1998 and ULSAB-AVC 2001
  • Electrical vehicles are currently more demanding regarding weight saving so they are more challenging to prove that steel is the best choice

• Goals
  • Development of a smart lightweight steel BIW for an electrical vehicle (and 3 derivates) projected in 2020 at large volume (100,000 p.a.)
  • Demonstration of latest steel grades and steel part manufacturing technologies
  • Development of sustainable and cost-effective solutions

Why FutureSteelVehicle?

Automotive CO₂ Emissions Regulations

Source: International Council on Clean Transportation
Why FutureSteelVehicle?

Early Introductions of Dedicated Platform Advanced Powertrain Vehicles

- Honda Clarity FCX
- Mercedes E cell Plus
- BMW i3
- Volkswagen
- Renault Twizy

From www.bmw-i.nl
From www.renault.nl
Phase 1: Advanced Powertrain Options

New Electric Drive Trains change the **value of lightweighing:**

- BIW mass will have a **smaller** impact on CO₂ emissions
- BIW mass will have a relative **higher** impact on:
  - Vehicle performance:
    - Driving range
    - Acceleration
  - Drive train and battery cost

**value of mass saving increases & pushes demand for higher strength & lighter materials**
FSV Design Drivers

- Mass reduction
- Cost
- Total vehicle carbon footprint reduction
Raising the Bar in Vehicle Mass Reduction

Mass Targets

Baseline: former, mild steel design
-25%

ULSAB, ULSAB-AVC

FutureSteelVehicle (FSV)
-35%
## Phase 1: Advanced Powertrain Options

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Details</th>
<th>BEV Range and Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSV 1</td>
<td>4-door hatchback 3700 mm</td>
<td>Total: 500km&lt;br&gt;Max Speed: 150km/h&lt;br&gt;0-100 km/h: 11-13 s</td>
</tr>
<tr>
<td>FSV 2</td>
<td>4-door sedan 4350 mm</td>
<td>Total: 500km&lt;br&gt;Max Speed: 161km/h&lt;br&gt;0-100 km/h: 10-12 s</td>
</tr>
<tr>
<td>PHEV20</td>
<td>Electric Range: 32km</td>
<td>Total: 500km&lt;br&gt;Max Speed: 150km/h&lt;br&gt;0-100 km/h: 11-13 s</td>
</tr>
<tr>
<td>PHEV40</td>
<td>Electric Range: 64km</td>
<td>Total: 500km&lt;br&gt;Max Speed: 161km/h&lt;br&gt;0-100 km/h: 10-12 s</td>
</tr>
<tr>
<td>BEV</td>
<td>Total Range: 250km</td>
<td>Max Speed: 150km/h&lt;br&gt;0-100 km/h: 11-13 s</td>
</tr>
</tbody>
</table>

**BEV**

**PHEV**

**FCEV**

**FCS**

**T1**

**T2**

**T3**

**T4**

**Body Structure Sub-System Optimization**

**Powertrain Layout**

**Styling & CFD**

**Low-Fidelity 3G Design Optimization**

**Occupant Package**

**TATA STEEL**

**WorldAutoSteel**
Design Optimization Process

Topology optimization

LF3G design optimization*

Subsystem optimization

Complete model optimization

Submodel selection
- Front rail
- Shotgun
- Rocker
- B-pillar
- Rear rail
- Roof rail
- Tunnel reinf.

*Low Fidelity Grade, gauge & geometry
FSV Steel Portfolio

| Mild 140/270 | DP 350/600 | TRIP 600/980 |
| BH 210/340 | TRIP 350/600 | TWIP 500/980 |
| BH 260/370 | SF 570/640 | HSLA 700/780 |
| BH 280/400 | HSLA 550/650 | DP 700/1000 |
| IF 260/410 | TRIP 400/700 | CP 800/1000 |
| IF 300/420 | SF 600/780 | MS 950/1200 |
| DP 300/500 | CP 500/800 | CP 1000/1200 |
| FB 330/450 | DP 500/800 | DP 1150/1270 |
| HSLA 350/450 | TRIP 450/800 | MS 1150/1400 |
| HSLA 420/500 | CP 600/900 | CP 1050/1470 |
| FB 450/600 | CP 750/900 | HF 1050/1500 |
| HSLA 490/600 | | MS 1250/1500 |

Material portfolio ULSAB-AVC

Additional Steel grades FSV

Nomenclature:
Type of material minimum yield strength/minimum tensile strength

Expected to be available until 2020

State of the art steel grades and developments for the near future were applied for the project.
Comparison of Subsystem Results

**Cost / Weight comparison**

- **Aluminum**
- **Hot stamped LWB**
- **Cold stamped LWB**

Cost (USD) vs Weight (kg)

- Cost: 22 USD
- Weight: 4.98 kg per part

Lines of constant value = 9.39 USD/kg

**Selected solution**

- Diagram showing selected solution with lines indicating cost and weight comparison.
FSV Crash Safety Analysis

Global crash requirements

- US NCAP
- EURO NCAP
- FMVSS 301 Rear
- ECE R32
- IIHS Side
- FMVSS 214 Pole
- EURO NCAP Pole
- FMVSS 216a, IIHS Roof
- RCAR/IIHS Low Speed

Evaluation

- EURO NCAP
Additional Structural Analysis

- **Static and Dynamic Stiffness**
  - Torsion Stiffness
  - Bending Stiffness
  - Global Modes

- **Noise, Vibration and Harshness**

- **Durability, Ride and handling analysis**
  Fish-hook test, double lane change maneuver (ISO 3888-1), 3g pothole test, 7g constant radius turn test, 0.8g forward braking test)
Forming, Cost and LCA

Manufacturing simulation:
- One step forming simulation
- Incremental analysis for complex parts
- Hot stamping simulation

Manufacturing planning and cost study

Life Cycle Assessment
Material Classes

Comparison with state of the art compact cars

- Significant increasing share of AHSS, UHSS and hot forming steels

Source: Eurocarbody 2009
ATZ extra 06/2010
Life Cycle Assessment (LCA) of Greenhouse Gases

LCA is needed to avoid Unintended Consequences

Source: Argonne National Laboratory
Impact Well-to-Wheel on CO₂ Emission

Mid-size vehicles

Vehicle production | Use Phase | Recycling

BEV

Gasoline

Lifecycle CO₂ Emissions [kg CO₂e]

Material production greenhouse gas (GHG) emissions:

GHG from Production (in kg CO₂e/kg of material)

- Steel: 2.0 – 2.8
- Aluminium: 11.2 – 12.6
- Magnesium: 18 – 45
- Carbon FRP: 21 – 23
## FSV vs. typical EU B-car (VW Polo 2010)

<table>
<thead>
<tr>
<th></th>
<th>Contact area (m²)</th>
<th>Body Structure Mass (kg)</th>
<th>Powertrain mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FSV</strong></td>
<td>3.71</td>
<td>190 (target)</td>
<td>329</td>
</tr>
<tr>
<td><strong>VW Polo</strong></td>
<td>3.6</td>
<td>231</td>
<td>233</td>
</tr>
</tbody>
</table>

### Dimensions:
- **Length**: 595 mm
- **Width**: 839 mm
- **Height**: 701 mm
- **Wheelbase**: 2470 mm
- **Track**: 2524 mm
- **Contact area**: 3.6 m²

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*Images and data sourced from Tata Steel and WorldAutoSteel.*