Advanced high strength steel technologies in the 2016 Volvo XC90

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AGENDA

• Background
• The All-New Volvo XC90
• Material Mix & Hot-Forming
• Design Solutions & Attributes
• Summary
“Cars are driven by people. Therefore the guiding principle behind everything we make at Volvo is – and must remain – safety”

Assar Gabrielsson & Gustaf Larsson, founders of Volvo (1927)

**Vision**
Design cars that should not crash

**Target 2020**
Nobody should be killed or seriously injured in a new Volvo
- 503,127 cars sold (2015)
- ~29,000 employees (2015)
- 2,300 retailers in 100 countries
THE NEW VOLVO XC90 / A NEW GENERATION

Signature LED head lights – 'Thor’s hammer'

Volvo shoulder line & rear lights

Shortened front overhang

Good proportions through long wheelbase

Steel Matters

Great Designs in Steel Seminar

Demand Nothing Less

www.autosteel.org
### THE NEW VOLVO XC90 – MAIN DIMENSIONS

<table>
<thead>
<tr>
<th></th>
<th>XC90 Gen II</th>
<th>XC90 Gen I</th>
<th>Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>4950</td>
<td>4807</td>
<td>+143</td>
</tr>
<tr>
<td>Width</td>
<td>2008</td>
<td>1898</td>
<td>+110</td>
</tr>
<tr>
<td>Height</td>
<td>1775</td>
<td>1784</td>
<td>-9</td>
</tr>
<tr>
<td>WB*</td>
<td>2984</td>
<td>2857</td>
<td>+127</td>
</tr>
</tbody>
</table>

*) WB = Wheel base. All measurements are in mm.

### Results
- Improved interior space
- Improved luggage space
- Improved design proportions
THE NEW VOLVO XC90 / A NEW GENERATION

- First out on the new Volvo architecture (SPA*)
- All-new vehicle from inside to outside
- Designed and produced in Sweden

The Promise

- Safety leadership
- Scandinavian design
- Class leading HMI**
- Class leading fuel efficiency

*) Scalable Product Architecture
**) HMI = Human Machine Interface
SPA / SCALABLE PRODUCT ARCHITECTURE

- Enables flexibility – only Heel-Point to wheel center is fixed
- Covers S60 to XC90 PHEV
- AWD, FWD and Twin Engine capability
- Spring and Air Spring suspension available
SPA / PHEV* ADAPTION

New parts for PHEV*

- Tunnel reinforcements
- Tunnel
- Longer & stronger sill extrusions
- Li-ion battery
- Spare wheel well

No differences in the upper body

*) PHEV = Plug-In Hybrid Electrical Vehicle
THE NEW VOLVO XC90

Material mix & Hot-Forming
MATERIAL MIX IN THE NEW VOLVO XC90
MATERIAL MIX IN THE NEW VOLVO XC90

Gen II:
- 33% Boron steel
- 6% Hot-formed steel
- 27% Mild steel
- 21% High strength steel
- 9% Very high strength steel
- 3% Ultra high strength steel
- 3% Aluminium

Gen I:
- 15% Boron steel
- 7% Hot-formed steel
- 1% Mild steel
- 34% High strength steel
- 43% Very high strength steel

Remarks:
- Boron steel 33%
- Hot-formed steel 38%
HOT-FORMED STEEL

Why hot-formed steel?
- Strength
- Mass reduction
- Formability for complex shapes
- Cost

Change introduced in SPA
- Hot-formed steel also in the floor
- Further new techniques with hot-forming
- In-house production introduced

Conclusion
- High cost/kg => No!
- Mid cost/kg => Borderline!
- Low cost/kg => Yes!
HOT-FORMING TECHNIQUES USED

An overview of the different hot-forming techniques in the new Volvo XC90:

- Tailor Welded Blanks (TWB)  
- Tailor Rolled Blanks (TRB)  
- Tailored Tempering (Soft Zone)  
- Patch Technology

New!

Partially new!
DESIGN SOLUTIONS WITH HOT-FORMING

Tailor Welded Blanks (TWB) in Sidemembers and B-pillar reinforcement:

Driver
- Front sidemember – front offset crash
- B-pillar – side barrier impact
- Rear sidemember – rear offset crash
- Mass

B-pillar reinforcement

Front sidemembers

Rear sidemembers

Boron steel AlSi-coated
HSLA AlSi-coated
DESIGN SOLUTIONS WITH HOT-FORMING

Tailor Rolled Blanks (TRB) in B-pillar reinforcement:

- **Driver**
  - Side barrier impact
  - Mass
  - Cost

**Material Options**
- Boron steel AlSi-coated
- HSLA AlSi-coated
DESIGN SOLUTIONS WITH HOT-FORMING

Tailor Tempering (Soft Zone) in A-pillars:

- Transition zone ~15mm
- A-pillar inner upper
- A-pillar reinforcement.

Driver
- Side pole impact
- Mass

Boron steel AlSi-coated
Soft Zone
DESIGN SOLUTIONS WITH HOT-FORMING

Reinforcement with patch:

A-pillar reinf. upper t=1.5
Patch t=1.5

C-pillar reinf. t=1.0
Patch t=1.2

Floor beam t=1.0
Patch t=1.2

Sill inner t=1.4
Patch t=1.5

Driver

- Belt pull
- Front crash
- Side pole impact
- Mass
THE NEW VOLVO XC90

Design principles and attributes
MASS WALK – VOLVO XC90

XC90 Gen I

XC90 Gen II

Mass [Kg]

Improved safety

Improved NVH

Larger car

Optimization

423

15

14

9

60

401

40 kg from hot-formed parts

40 kg from hot-formed parts
GLOBAL STIFFNESS

Structural principles
- Stiff ring structures
- Stiff spring tower
- Bolted front subframe
- Lateral floor crossmembers
- Sidemembers with high sections

Performance BIG*

Global stiffness

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<tr>
<td>$K_{TG}$ [kNm/deg]</td>
<td>25.0</td>
<td>21.4</td>
<td>+3.6</td>
</tr>
<tr>
<td>1st mode [Hz]</td>
<td>37</td>
<td>34</td>
<td>+3</td>
</tr>
</tbody>
</table>

*) BIG = Body In Grey, KTG = Global Static Torsional Stiffness
Structural principles:
- Floor and tunnel - thin panels.
- Large connecting reinforcements
- Subframe attachments
- Longitudinal members.
- Transversal members.
- Crossmembers on the interior side to close load paths.

Driver
- NVH
- Durability
- Driving dynamics
DESIGN PRINCIPLES – ATTACHMENT STIFFNESS

NVH-performance of chassis attachment point
→ Substantial performance increase!

Point Mobility: Subf. attach Z-dir

NTF: Subf. attach. Z-dir → Driver ear

Point Mobility [dB]

Noise Transfer Function [dB]

Fz

50 100 150 200 250
50 100 150 200 250

5dB

XC90
XC60

XC90
XC60

50 100 150 200 250
50 100 150 200 250
Structural principles

- Crash optimized E/W-engine installation
- Multiple load paths
- Lower load path for compatibility
- Pre-determined deformation modes (bend lines)
- Safety cage designed for overload
**DESIGN PRINCIPLES – SMALL OVERLAP**

**Structural principles**
Same basic principles since the early 1990s*:
- Slide away from obstacle
- Strong safety cage
- Restraint systems adapted for small overlap

**Performance**
- Low structural deformations on all models
- IIHS TOP SAFETY PICK on all current models
- Example: IIHS Small overlap, 40 mph, 25% overlap

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DESIGN PRINCIPLES – SMALL OVERLAP

CAE

TEST
THE NEW VOLVO XC90 – SUMMARY

- SPA – A brand new generation of architecture
- Body structure with mass efficient concepts and extensive use of Advanced High-Strength Steel
- 38% hot-forming steel to meet safety demands and enable mass saving with approximately 40 kg
- Volvo in-house production of hot-forming steel, with first supply to the new XC90
- Increased body stiffness both global and local for NVH and driving performance – Stronger, stiffer, larger & lighter!
- One of the safest car in the world!
Acknowledgements
Best in class overall
EuroNCAP – 2016

Top Safety Pick
IIHS – 2015

North American
Truck of the Year – 2016
THE NEW VOLVO XC90

THANK YOU FOR YOUR ATTENTION!