The potential of High Pressure Die Casting for the production of highly stressed components in automotive applications

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KSM Castings Group GmbH
KSM Castings Group

Agenda

- KSM Castings
- Motivation
- Controlled Vacuum Casting (CVC™)
- Potential Applications
  - Chassis
  - Body
**KSM Castings Group**

*Key Figures*

Turnover: ~ 450 Mio. EUR

Employees: ~ 2,900

**Production Technologies:**
- High Pressure Die Casting
- Gravity Die Casting
- Counter Pressure Casting
- Multi-Tilt Casting
- Low Pressure Sand Casting
- Machining & Assembly

**Development Capability:**
- Simultaneous Engineering
- Technology Engineering
- System Development
KSM Castings Group
Global Footprint

Hildesheim
- Headquarters
- High Pressure Die Casting
- Gravity Die Casting
- Machining & Assembly

Wuppertal
- High Pressure Die Casting
- Machining & Assembly

Radevormwald
- High Pressure Die Casting
- Machining & Assembly

Wernigerode
- Gravity Die Casting
- Machining & Assembly

Hrádek nad Nisou
- High Pressure Die Casting
- Machining & Assembly

Changchun
- High Pressure Die Casting
- Gravity Die Casting
- Machining & Assembly

USA
- High Pressure Die Casting
- Permanent Mould Casting
- Machining & Assembly

USA
- High Pressure Die Casting
- Gravity Die Casting
- Machining & Assembly

GERMANY
CZECH REPUBLIC
CHINA

USA
GERMANY
CZECH REPUBLIC
CHINA

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Product Portfolio

Steering gear box
Front axle subframe
Knuckle
Pedal bracket
Pillar - prototype
Cross member (Variostruct)
Cylinder head cover
Transmission housing
Pump housing
Valve body
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Every OEM has the need to reduce weight

Source: Roland Berger
Chassis: potential for weight saving by design optimization of aluminum components

Body: potential for weight saving by substitution of steel components
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Main objectives

- No restriction concerning process stability
- No restriction concerning OEE
- Welding of cast parts without surface treatment
- Optimized heat treatment concerning distortion
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Controlled Vacuum Casting (CVC™)

Heat Treatment

<table>
<thead>
<tr>
<th></th>
<th>UTS [MPa]</th>
<th>YS [MPa]</th>
<th>elongation [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVC T6</td>
<td>312</td>
<td>245</td>
<td>8.3</td>
</tr>
<tr>
<td>CVC T7</td>
<td>215</td>
<td>138</td>
<td>14.1</td>
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Welding

<table>
<thead>
<tr>
<th>sample</th>
<th>porosity [%]</th>
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<tbody>
<tr>
<td>29</td>
<td>10.0</td>
</tr>
<tr>
<td>30</td>
<td>9.0</td>
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<td>31</td>
<td>8.0</td>
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<td>32</td>
<td>7.0</td>
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<td>33</td>
<td>6.0</td>
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<td>34</td>
<td>5.0</td>
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<tr>
<td>35</td>
<td>4.0</td>
</tr>
<tr>
<td>36</td>
<td>3.0</td>
</tr>
<tr>
<td>37</td>
<td>2.0</td>
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<tr>
<td>38</td>
<td>1.0</td>
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<tr>
<td>39</td>
<td>0.0</td>
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</table>

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Controlled Vacuum Casting (CVC™)

- knuckles
- subframes
- BIW

Yield Strength [MPa]

Elongation [%]

- HPDC
- Gravity Die Casting
- Controlled Vacuum Casting (CVC™)

Graph showing the potential of High Pressure Die Casting for the production of highly stressed components in automotive applications.
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Subframe BMW 5, 6, 7 series 4WD

Product Information
Process: Controlled Vacuum Casting
Material: Aluminum
Alloy: Al Mg5 Si2 Mn
Weight: 7.82 kgs
Volume: 60,000 parts p. a.

Characteristics
- Weldable die casting for chassis components
- Weldability without any surface treatment
- Mechanical properties are achieved in as cast condition

Mechanical Characteristics
- Yield strength: YS >270 MPa
- Tensile strength: UTS >150 MPa
- Elongation: A5 >5 %
Subframe BMW 5, 6, 7 series 4WD

UTS, YS [MPa]

<table>
<thead>
<tr>
<th>Sample</th>
<th>UTS [MPa]</th>
<th>YS [MPa]</th>
<th>elongation [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>290.2</td>
<td>170.3</td>
<td>9.9</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>8.8</td>
<td>5.7</td>
<td>1.8</td>
</tr>
</tbody>
</table>

UTS [MPa]  YS [MPa]  elongation [%]
Rear Knuckle (load per axle ~1.000 kg)

Design space

Target: minimizing mass
Boundary condition: stiffness

Target: minimizing stresses
Boundary condition: mass, stiffness
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Chassis Applications

Rear Knuckle (load per axle ~1.000 kg)

Series application

CVC concept

Cast aluminum knuckle

Weight -22%

Redesigned CVC knuckle

3.2kg
Aluminum/Steel Hybrid Wheel Hub
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Chassis Applications

Aluminum/Steel Hybrid Wheel Hub

<table>
<thead>
<tr>
<th>Material</th>
<th>UTS  [MPa]</th>
<th>YS  [MPa]</th>
<th>Elongation [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>AlSi10MnMg T6</td>
<td>340</td>
<td>243</td>
<td>3.7</td>
</tr>
</tbody>
</table>

UTS, YS [MPa]
Elongation [%]
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**Body Applications**

**ASAC** (Advanced Scalable Aluminum Casting)

Variants:
ASAC (Advanced Scalable Aluminum Casting)

- Mass comparison: 63% for ASAC vs. 100% for Steel

Body Applications
Cross section stabilization using ribs in the hybrid structure

Conventional Stamping assembly (B)

Hybrid structure (H)

Potential enhancements in buckling strength

Compressive stress

$\sigma_{\text{maxH}}$ = critical buckling strength

$\sigma_{\text{maxB}}$ = maximum buckling strength

$b$ = section profile dimension

Lightweight potential with very high structural performance
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Body Applications

Material: Steel Stampings
Construction: 3 piece design
Assembly: Spot-welding, Laser-welding, Adhesive Bonding

Material: Al/steel Hybrid
Construction: 1 piece design
Assembly: Hybrid Casting (Force- and Form-fit)
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**Body Applications**

3-point central bending

<table>
<thead>
<tr>
<th>Force</th>
<th>VarioStruct</th>
<th>Original</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fmax</td>
<td>117%</td>
<td>100%</td>
</tr>
<tr>
<td>Energy Absorption</td>
<td>135%</td>
<td>100%</td>
</tr>
<tr>
<td>Weight</td>
<td>72%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**VarioStruct** multi-material-components

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Weight reduction by target-oriented distribution of mass

Possible weight reduction: app. 20%