Magnificent Magnesium

Magnesium, in its purest form, is comparable to aluminium. Its strength and lightness make it a highly valuable material for several high-volume part manufacturing applications.
Magnificent Magnesium: Historical Applications in Automotive Industry

**Mercedes-Benz 300 SLR**
It used a magnesium-alloy (Elektron) bodywork, which has a specific gravity of just 1.8, contributing to a dry weight of just 880 kg (1,940 lb).

**Porsche 917/053**
Porsche’s quest reduced race car weight led to the use of magnesium alloy frames. Porsche 917 is the one that gave Porsche its first overall win at the 24 Hours of Le Mans in both 1970 and 1971.

**Volkswagen Group Engines**
Volkswagen Group has used magnesium in its engine components for many years.

**2006 Corvette Z06**
The application of magnesium AE44 alloy in the 2006 Corvette Z06 engine cradle has advanced the technology of designing robust automotive parts in magnesium.

**BMW engines**
The BMW engine uses an aluminium alloy insert for the cylinder walls and cooling jackets surrounded by a high-temperature magnesium alloy AJ62A.
Magnificent Magnesium: Historical Applications in Defense Industry

**B-36 “The Magnesium Wonder of the World”, 1946**

The B-36 incorporated 8,620 kg of Magnesium, of which 5,555 kg of sheet, 700 kg magnesium forgings and 300 kg of magnesium castings.

**M274 Truck “Mechanical Mule”, 1959 - 1975**

The use of Magnesium in the “Mechanical Mule” helped reduce its weight to only to 394 kg and yet, enable it to carry up to a 1/2 ton off-road.

**M-116 Husky Amphibious Personnel Carrier, 1960**

Its 30 kg Magnesium floor covering 2.3 sq.m. was made up of 11.1x1.0 in AZ31B extrusions – making it fit for all types of terrains.

**HMMWV Run-flat wheels 2013**

Run-flat Magnesium wheels perform better than regular wheels. Some designs have a 20% higher rolling resistance, in part due to their added structural material and mass.

**Expeditionary Fighting Vehicle (EFV)**

EFV is capable of transporting a full marine rifle squad to shore through water with speed 72.41 km/h (45 mph) and over the ground with speed 46 km/h (28.6 mph) (water).
Magnificent Magnesium: Historical Applications in High Tech Industry and Aerospace Industry

Magnesium is widely used for manufacturing mobile phones, laptop and tablet computers, cameras, and other electronic components due to its low weight and good mechanical and electrical properties.

Historically, Magnesium was one of the main aerospace construction metals and was used for German military aircraft as early as World War I and extensively for German aircraft in World War II.

Alloyed with zinc, Magnesium is used to produce sheets used in photoengraving plates in the printing industry, dry-cell battery walls and roofing.
SMW Engineering (SMW) holds top expertise in the field of Mg and Al wrought products and technologies for lightweight applications. The Company implements improvements to existing magnesium production facilities, has established R&D partnerships with research institutes, leading laboratories and manufacturing facilities across the globe, produces Mg and Al alloy forgings and extrusions. SMW develops advanced state-of-the-art technologies and offers best in class engineering services.
SMW was established in 1996 in Russia as a sister company of the Russian Institute of Titanium and Magnesium, both affiliated with Solikamsk Magnesium Works, Russia’s largest and oldest magnesium smelter and research facility - producer of magnesium and alloys, titanium sponge, tantalum and niobium oxides and rare-earth derivatives.

Since then SMW team of professionals was joined by the specialists from the magnesium engineering department of the Russian National Aluminum-Magnesium Institute, renowned for their numerous international engineering projects across the world. This esteemed team of experts is responsible for nearly all technical design and EPC work within the construction of Dead Sea Works and other projects such as numerous improvements made at Solikamsk Magnesium Works, Avisma, UTMK and other facilities.
Feasibility studies for magnesium plants around the globe
incl. United Arab Emirates, Australia, Saudi Arabia, Iceland, Congo, Russia and South Africa

SMW holds professional expertise in the development and completion of large international and Russian projects such as:

- Kransnoyarsk Aluminium Works reconstruction – with Bechtel engineering company
- Magnesium plant in Australia – with HATCH and BHP engineering companies
- Magnesium plant in Israel – with Bateman and HATCH engineering companies
- Magnesium plant in Congo – with Salzgitter and HATCH engineering companies
- Khakas Aluminium Smelter (Russia) – with SNC Lavalin and HATCH engineering companies
- Solid municipal waste processing plant in Israel – with Ludan engineering company
- Volgograd Magnesium Works – with MAN Ferrostaal engineering company

over 15 years of world-wide experience
Smelter design and process engineering
SMW completed projects examples

Dead Sea Works construction
Implementation of all engineering and technology transfer works

Avisma Facility
Chlorine facilities reconstruction to increase Ti production capacities

Volgograd Magnesium Works
Completion and overview of smelter design works

MagForming and AEROMAG
The only Russian-based participant in these projects funded by the EU
Research and Development

SMW of today is defined by proprietary alloys, state-of-the-art technological processes and forward-thinking industry-leading products.

SMW is a metallurgical fabricator serving:

- Automotive Sector
- Aerospace Sector
- Technological and Engineering Solutions

The Company specializes in the development, manufacture and supply of lightweight applications deploying proprietary and generic magnesium alloys, aluminum-magnesium-scandium system alloys and other specialized alloys, hybrid and reinforced materials, including powder metallurgy.

SMW is the global leader in large-sized forged magnesium components, supplying fabrications derived from cast billet, extruded bar, plate, sheet. Having a strong R&D Department, SMW regularly participates in various international research projects funded by the European Commission.
MagForming and AEROMAG Projects

In cooperation with Airbus and others

As a participant in AEROMAG and MagForming projects, in cooperation with Airbus, Chemetall and others, SMW has developed and manufactured magnesium window frame for Airbus 340 aircraft.

The analysis of both projects demonstrates large-scale magnesium forging that can be used for perspective production of secondary structure components in civil aircraft.
ALMASCAN Project

SMW has developed a new powder-metallurgical process, **ALMASCAN**, for production of best in class Al-Mg-Sc system alloys possessing superior mechanical properties, unparalleled by any of the currently available. Project was funded by the Russian Foundation for Technological Development.

SMW is a trusted international partner for a number of loyal clients and conducts numerous R&D initiatives entailing development of new components with improved characteristics and reduced weight.
PowderBond Project

The PowderBond research project is being supported by the European Commission (FP7-SME) with the aim of developing a joining technology that allows the bonding of dissimilar materials for use within the Automotive and A.C.E. sectors.

The project looks to combine multiple new technologies and offer material engineers and designers greater scope to use the best material for the intended application whilst at the same time reducing carbon emissions in the production environment and beyond. Project focus is bonding steel, aluminium, magnesium, plastics and composites for use in the Automotive and A.C.E fields.

PowderBond project includes a consortium of organizations working together to develop and prove this innovative technology with each member bringing expert knowledge or capabilities to the group.

SMW is one of the Consortium Members and its work done thus far includes attending consortium meetings (in November – “month 6 meeting”, in February – month 9 meeting, in April – month 12 meeting), involvement in technical discussions, reviewing technical progress & reports, research and contemplation of possible solutions.

More information visit the official website: http://powderbond.worldsecuresystems.com/
Process flow

1. Selection of lightweight materials and alloys
2. Component analysis and definition of requirements
3. Design, computer modeling and engineering analysis of designed component
4. Manufacturing specifications
5. Prototype production
6. Prototype testing
7. Design correction (optional)
8. Design, computer modeling and engineering analysis of designed component
Key to success

SMW R&D department is close to commercialization of:

- Components for the Russian aviation industry (UAC, Irkut, etc.)
- Several components for the European aerospace industry (Selex, Thales, etc.) in Al-Mg-Sc alloys
- Components for LG in Mg-Li alloys, deploying former SMW experience in Mg-Be and Mg-Li alloys for the Russian space program
- Speed-skating blade by highly advanced technology resulting in professional skaters success results
- Special tubing components by powder metallurgy for a Russian military supplier
- Seat components for fast trains
- Three most important bicycle components for the world’s top-rated racers
- Most advanced bonding technology for magnesium alloys, allowing for chemically joining of magnesium components with aluminum components, corrosion-free (deploying the technology to Jaguar Land Rover)
- Wheels for amphibious tanks
# Overview of Mechanical Properties in Wheel Forgings

<table>
<thead>
<tr>
<th>Alloy grade</th>
<th>UTS (MPa)</th>
<th>YTS (MPa)</th>
<th>Elongation (%)</th>
<th>Hardness (HB)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZK60A (spokes)</td>
<td>265</td>
<td>-</td>
<td>6</td>
<td>60</td>
<td>Minimum</td>
</tr>
<tr>
<td>ZK60A (rim)</td>
<td>255</td>
<td>-</td>
<td>6</td>
<td>60</td>
<td>Minimum</td>
</tr>
<tr>
<td>ZK60A (hub)</td>
<td>245</td>
<td>-</td>
<td>6</td>
<td>60</td>
<td>Minimum</td>
</tr>
<tr>
<td>ZK60A</td>
<td>290-315</td>
<td>170-230</td>
<td>11-14</td>
<td>72</td>
<td>Typical</td>
</tr>
<tr>
<td>MA2-1</td>
<td>255</td>
<td>-</td>
<td>7</td>
<td>-</td>
<td>Minimum</td>
</tr>
<tr>
<td>MA2-1</td>
<td>260-275</td>
<td>165-200</td>
<td>11-15</td>
<td>52</td>
<td>Typical</td>
</tr>
<tr>
<td>AZ80A</td>
<td>275-310</td>
<td>160-220</td>
<td>5-9,5</td>
<td>73</td>
<td>Typical</td>
</tr>
</tbody>
</table>

Testing direction is indicated by arrows.
# Measured Properties in SMW Wheel Forgings

Test results for a 3,5” X 17” forged motorcycle wheel blank made from ZK60A alloy

<table>
<thead>
<tr>
<th>Location</th>
<th>UTS (kgf/mm²)</th>
<th>YTS (kgf/mm²)</th>
<th>Elongation (%)</th>
<th>Hardness (HB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Rim</td>
<td>30,7</td>
<td>22,6</td>
<td>13,8</td>
<td>71,2</td>
</tr>
<tr>
<td>2 Spoke</td>
<td>29,9</td>
<td>20,9</td>
<td>11,7</td>
<td>71,2</td>
</tr>
<tr>
<td>3 Hub</td>
<td>28,9</td>
<td>16,6</td>
<td>14,3</td>
<td>71,2</td>
</tr>
</tbody>
</table>
## Measured Properties in SMW Wheel Forgings

Test results for a 13” X 13,5” forged wheel blank made from AZ80A alloy for F1

<table>
<thead>
<tr>
<th>Specimen#</th>
<th>Location</th>
<th>UTS (kgf/mm²)</th>
<th>YTS (kgf/mm²)</th>
<th>Elongation (%)</th>
<th>Hardness (HB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rim</td>
<td>30,3</td>
<td>21,9</td>
<td>7,6</td>
<td>76,3</td>
</tr>
<tr>
<td>2</td>
<td>Spoke</td>
<td>27,6</td>
<td>18,3</td>
<td>8,8</td>
<td>76,3</td>
</tr>
<tr>
<td>3</td>
<td>Hub</td>
<td>29,4</td>
<td>21,7</td>
<td>6,8</td>
<td>76,3</td>
</tr>
</tbody>
</table>
Equipment and Facilities

- Hydraulic & mechanical presses 1,000 – 30,000 tons
- Rolling presses
- Extrusion presses
- CNC machining tools
- ISO and TUV certified
Machining and finishing operations to be implemented in Europe

- New production in Bulgaria and in the UK complying with automotive OEM customers in Germany and England
- High-performance CNC lathe and turning machines
- Proprietary coating technology manufacturing facilities
- Innovative ceramic-reinforced powder painting facility
SMW – highly respected for world’s top quality wheels
Prime choice of Formula 1, MotoGP and SuperBike champions

SMW wheels:
- alloy modification for grain reduction
- proprietary 3D forging process
- superior microstructure
- optimized metal flow fibers
- resulting weight-reduction and top characteristics

All magnesium wheels for Ducati are produced by SMW – including Superleggera and other models
Benefits Of Forged Magnesium Wheels

- improved vehicle performance
- faster acceleration
- shorter braking distance
- improved safety and maneuverability
- fuel savings (up to 5-7%)
- increased service life and reliability of suspension components
- reduction of CO2 emissions
- improved performance and service life of brake system
- higher driving comfort due to reduced vibrations
Benefits of SMW ventilated brake discs

- Weight reduction by 100 g
- Patented ventilation channels geometry
- Disc temperature reduced to 700°C due to airflow
- Special dense material used for manufacture of aviation brake discs
- Maximum operational temperature of 1500 °C
- Maximum compression pressure up to 200 MPa
- Compression pressure of up to 100 MPa at temperatures above 1000°C
- High friction coefficient of up to 0.5
# Titanium suspension components for F1 and other applications

## Chemical composition in % of the SMW-6 alloy

<table>
<thead>
<tr>
<th></th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
<th>Ti</th>
<th>Al</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 - 11</td>
<td>4 - 5</td>
<td>6</td>
<td>75 - 77</td>
<td>3</td>
</tr>
</tbody>
</table>

## Mechanical properties at $T=20^\circ$C

<table>
<thead>
<tr>
<th>Form/Sort</th>
<th>$s_b$ (MPa)</th>
<th>$s_T$ (MPa)</th>
<th>$d_5$ (%)</th>
<th>Thermal treatment</th>
<th>Hardness after quenching &amp; tempering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheet/bar</td>
<td>1580-1635</td>
<td>1520-1590</td>
<td>5.5-6</td>
<td>Quenching/tempering &amp; aging</td>
<td>341 - 444</td>
</tr>
</tbody>
</table>

### Designations:
- $s_b$ - Tensile strength, [MPa]
- $s_T$ - Proportionality limit (yield strength at permanent deformation), [MPa]
- $d_5$ - Elongation at break, [%]
SMW Wheels used for Formula 1 highest demands
SMW products selected by world’s top three racers

They all and many other motorsports professionals ride on SMW forged wheels

Jorge Lorenzo  Valentino Rossi  Pol Espargaró
Customer loyalty and long-standing relationships

Successful partnerships

SMW has long-standing customer relationships with some of the leading multinational companies such as:

- United Aircraft Corporation (Russia)
- Brembo (Italy)
- BBS International GmbH (Germany)
- OZ Racing (Italy)
- Honda R&D Americas (USA)
- Dymag (UK)
- Motegi Racing (USA)
Lightest F1 wheels:

- At least 100 grams lighter than now -- leading to > 400 g weight-savings in aggregate rotating mass
- SMW proprietary technology for billet preparation and deeper deformation forging process
- Increased stiffness through superior material properties and special hollow-spoke design
- Less energy consumed during braking and acceleration
- Lap time improvement aggregating to ~5 seconds per 60 laps
The benefits of reducing weight of Formula 1 car wheels:
- unsprung weight reduction;
- improvement in dynamics (reduction of rotational inertia at braking/accelerating).

<table>
<thead>
<tr>
<th>Speed, km/h</th>
<th>Acceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>0.85</td>
</tr>
<tr>
<td>200</td>
<td>1.7</td>
</tr>
<tr>
<td>300</td>
<td>2.55</td>
</tr>
<tr>
<td>400</td>
<td>3.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Race Track</th>
<th>Distance</th>
<th>Laps</th>
<th>Turns</th>
<th>Average Speed</th>
<th>Best Time</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Great Britain (Silverstone 2015)</td>
<td>306.2 km</td>
<td>52</td>
<td>18</td>
<td>~200 km/h</td>
<td>5487 sec</td>
<td>10 sec</td>
</tr>
</tbody>
</table>

Single wheel weight reduction, kg | 0.1 |
Reduction in rotational inertia, % | 0.08 |
Race time improvement, s | 5.03 |

1 - determined by the method of equivalent mass;
2 – assuming braking and speeding-up cycle (250 km/h to 150 km/h and back to 250 km/h) at every turn.
Some of SMW clients include…
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