Advancements in coatings:
Why are Zn-Al-Mg coatings getting more and more popular?
Dr. Thomas Koll

18th Galvanising & Coil Coating Conference
Munich, 10.09.2013
Advancements in Coatings for Steel

Agenda

- SZMF
- Status Quo
- Markets & applications
- Why ZM?
- What are the properties?
- Which benefits do they give?
## Advancements in Coatings for Steel

**Salzgitter Mannesmann Forschung GmbH**

### Products
- Hot and Cold Rolled Materials
- Tubes
- Heavy Plates
- Sections

### Market
- Automotive Industry (Body, Chassis)
- Consumer Goods Industry
- Building Industry (Roof, Wall, Climate)
- Automotive (Power Train)
- Mechanical Engineering and Construction
- Energy
- Building Industry (Bearing Structure, Pilings)

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**Interdisciplinary research to achieve your strategic goals - from simulation to the finished product**
## Advancements in Coatings for Steel

### R&D Equipment – Extracts I

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Induction Furnace 50 kg</td>
<td></td>
</tr>
<tr>
<td>Vacuum Induct. Furnace 100 kg</td>
<td></td>
</tr>
<tr>
<td>Vacuum Induction Furnace 300 kg</td>
<td></td>
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<tr>
<td>Hot Rolling 1.000 t</td>
<td></td>
</tr>
<tr>
<td>Hot / Cold Rolling 300 t</td>
<td></td>
</tr>
<tr>
<td>Skin Pass Rolling 550 t</td>
<td></td>
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<tr>
<td>Annealing SIM – 1.000 °C</td>
<td></td>
</tr>
<tr>
<td>Gleeble – $T_L$ variable</td>
<td></td>
</tr>
<tr>
<td>Dilatometer – 600 K/s</td>
<td></td>
</tr>
<tr>
<td>HDG SIM – Z50 … Z600</td>
<td></td>
</tr>
<tr>
<td>ELO SIM – 10 … 170 A/dm$^2$</td>
<td></td>
</tr>
</tbody>
</table>
## Advancements in Coatings for Steel

### R&D Equipment – Extracts II

<table>
<thead>
<tr>
<th>Degreasing – 0-5m/min</th>
<th>Erichsen – 60 t</th>
<th>CMT – smallest heat input</th>
<th>Phosphating – 7 steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coilcoating – 300 mm</td>
<td>Tryout – 1.000 t</td>
<td>Laser hybrid – higher process efficiency</td>
<td>Cataphoretic painting – leadfree paint</td>
</tr>
<tr>
<td>CAL SIM – PMT max. 450°C</td>
<td></td>
<td>Clinching – highest forces</td>
<td>Spray Painting – 9.000 m³/h</td>
</tr>
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Advancements in Coatings for Steel

Status Quo: Zn-alloy Hot-Dip Coatings

<table>
<thead>
<tr>
<th>Coating</th>
<th>Thickness range (µm)</th>
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<tr>
<td>Galvannealed (ZF/GA)</td>
<td>7 - 10 µm</td>
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c. 90 w. % Zn
ca. 10 w. % Fe
ca. 0,5 w. % AI
Mg / AI Contents vary
with adapted AI concentrations
c. 95 w. % Zn
ca. 5 w. % Al
c. 0,05 w. % Cer/Lanthan
c. 99,5 w. % Zn
ca. 0,5 w. % AI
1.3% Mg with adapted AI concentrations
c. 95 w. % Zn
ca. 5 w. % Al
c. 0,05 w. % Cer/Lanthan
c. 55 w. % AI
ca. 43 w. % Zn
c. 2 w. % Si
Advancements in Coatings for Steel

Typical applications of GI coatings

Hot-Dip Galvanised Steel Sheet GI / Z

- Automotive and Supplier Industry (Exposed and Structure Parts, Attachments)
- Building Industry (Frames, Rain Pipes, Vents, Doors, Iso- and corrugated sheets, …)
- Appliance Industry (White Goods, Brown Goods, …)

Advantages: High surface quality for exposed surfaces, excellent corrosion protection

Typical applications of ZA / AZ coatings

**GALFAN ZA**

- Heavily formed parts in car, engine and plant construction as well as in building and appliance industry

**Advantages:** Forming, paintability, corrosion protection

**GALVALUME AZ**

- Corrugated profiles for roofing and cladding, fittings and construction parts in the building industry, engine and plant construction with corrosive attacks in sour media

**Advantages:** Corrosion protection (unpainted: Korrosionsschutzklasse III after DIN 55928-8).

Photos: Charakteristische Merkmale 095: Schmelztauveredeltes Band und Blech, Stahl-Informationszentrum, Düsseldorf.
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Typical applications of AS coatings

Galvannealed Steel Sheet GA / ZF
- Automotive industry for exposed and inner parts as well as attachments (US & Asia)

Advantages: Weldability, Paintability / Paint Adhesion

Hot-Dip Aluminised AS
- Corrosion protection for hot stamping
- Automotive industry: Exhaust systems, thermal shields and gas tanks
- Apparatus engineering for construction elements for heating and drying units

Advantages: Corrosion protection (unpainted), temperature stability

Car body parts GA
Gas tank, AS
Hot formed B-Pillar, AS

Advancements in Coatings for Steel

The New Coating Family: Market Development

Introduction of metallic coatings into the European Market

Index of market growth for Zinc-Magnesium coated steel (2007 = 100)

Source: SIZ, "D566: Zinc-Magnesium Coated Steel Sheets" (2013) Düsseldorf
Advancements in Coatings for Steel

Why a new coating and why magnesium?

Effect of magnesium for zinc alloy coatings

Significantly positive influence of magnesium on corrosion protection (up to 8%)

Balance between corrosion protection and processing properties of the surface finished product

Zn with 1..3 % Mg and adapted Al concentrations (for building, appliances, car industry)

What is the difference of the new ZincMagnesium to existing European coatings?

- Newly developed coating with best corrosion protection
  Target: No change of processing properties

- 1st investigations on ZM by Salzgitter & others in 1996
- 1st serial production of Stroncoat® in Salzgitter in 2010
  with composition 1.6% Mg, 1.6%Al: ZM Stroncoat®

- All European Coatings: Zn + Mg (1-3%) + Al (1-3,7%)
  (Al necessary for series production)

- Varying contents of Mg and Al for different suppliers mainly effect amount of eutectic

- Production on HDG-lines: Pot equipment, campaign production

- Potential to save resources by lowering coating weight depending on corrosive attack

- Tribological properties open new potential in forming process
Advancements in Coatings for Steel

**Zn-alloy Coatings: Mg + Al**

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Corrosion Protection Blank Applications

Benchmark VDA new – Appearance of red rust

- Accelerated Cyclic Corrosion test
- Substrates Z, ZM, ZA, AZ (each 20µm)
- Blank corrosion: all cut edges sealed
- Surface unoiled, without passivation treatment

VDA new: High Corrosion protection by ZM

- 4-fold better than Z,
- 2-fold better than ZA
- Even better than AZ
German Building Industry underlies strong rules:

„DIBT Korrosionsschutzklasse“ necessary to sell into Roofing and Cladding

Outdoor applications: Korrosionsschutzklasse III fullfilled:
Z275 + 25µm PE  ⇒  ZM140 + 25 µm PE

SZMF: 10 cycles VDA 621-415 on Stroncoat® samples:
- scratch to zinc
- scratch to steel
- cut edge

ZM performs better at $\frac{1}{2}$ coating weight of Z

Can optimised pretreatments release more potential in corrosion protection?
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Paintability Automotive Industry

Phosphate layer crucial for painting as 1st conversion layer on metallic surfcaes

Phosphate layer appearance and coverage on ZM coatings comparable to GI
Could optimisations of treatments enhance corrosion protection of ZM even further?

Trication Phosphatation
Cleaning  GC S 5176
Activation  GN V 6513
Phosphating  GB R 2600
Phosphate weight  2 g/m²
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**ZM corrosion protection model**

- Cathodic protection
- Corrosion products form inhibition layers
- Slowing down zinc dissolution

Joining Behaviour ZM

- **Laser beam welding**
  - Test after SEP1220-3:
    - ZM Comparable to Z

- **Resistance Spot Welding**
  - Test after SEP1220-2:
    - ZM Comparable to Z

- **Adhesive Joining**
  - Tests after DIN EN 1465 and DIN EN ISO 11339,
    - Strength of joints comparable to Z
    - Fracture modes tend to be less cohesive / more surface near depending on glues
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Forming Behaviour ZM

ZM – Tribology and tool pollution better than established zinc coatings

Advantages for multi stage forming
Less tool pollution during deep drawing trials

Friction Resistance

Tool Pollution

Oiling: 2 g/m² Prelube
ZM – Roll forming with less efforts

Less motor power
Less emulsion
Less hair formation
Lower noise levels

Photos: Warnecke et al., stahl und eisen 129 (2009) 6, S. 53.
Supporting steel constructions

Using the good forming behaviour, especially in roll forming

- Rolled steel lightweight beams,
- High rise rack storages
- Supporting constructions for Greenhouses
- Framing for photovoltaic cells

Well protected.
Examples for ZM coated Applications

Bharati: Indian National Centre for Antarctic and Ocean Research (NACOR)

Salzgitter delivered the skin for: 1000t Steel Construction,
2000 m² Building,
25 People,
at -45°C. Well protected.

by Stroncoat ®

Photo: SIZ, "D566: Zinc-Magnesium Coated Steel Sheets" (2013) Düsseldorf
Properties of ZM coatings

- Very good corrosion protection depending on corrosive attack
- Corrosion protection potential possibly not fully used today
- Very good forming properties

- Fulfill German DIBT corrosion classes with reduced coating weights
- Standardised by SEW022 as appendix to DIN EN 10346

- Experience of series production for 7 years
- Established in building industry
- Testing in car industry ongoing
- Production numbers rising since 2007
## Advancements in Coatings for Steel

### Customer Benefits

<table>
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<th><strong>By enhanced corrosion protection</strong></th>
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<tbody>
<tr>
<td>Longer service life</td>
<td></td>
</tr>
<tr>
<td>Complementary to other corrosion protection measures</td>
<td></td>
</tr>
<tr>
<td>New applications, e.g. replacement of batch galvanising</td>
<td></td>
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<th><strong>By reducing coating weights</strong></th>
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<tr>
<td>Contribution to lightweight construction</td>
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</tr>
<tr>
<td>Area advantage</td>
<td></td>
</tr>
<tr>
<td>Sustainable contribution: Preservation of zinc resources</td>
<td></td>
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<tr>
<th><strong>By harder coatings</strong></th>
<th></th>
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<tbody>
<tr>
<td>Enhanced formability</td>
<td></td>
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</table>
Standards/Directives

The following standards and directives apply:

- DIN 55634: Paints, varnishes and coatings – Corrosion protection of supporting thin-walled building components made of steel
- DIN 55928-8 (replaced by DIN 55634): Corrosion protection of steel structures by paints and coatings – Part 8: Corrosion protection of supporting thin-walled building components (withdrawn)
- DIN EN 10143: Continuously hot-dip coated steel sheet and strip – Tolerances on dimensions and shape
- DIN EN 10346: Continuously hot-dip coated steel flat products – Technical delivery conditions
- SEW 022: Continuously hot-dip coated steel flat products – Zinc-magnesium coatings – Technical delivery conditions

The following publications of the Stahl-Informationen-Zentrum contain further information:

- Characteristic Properties 093 – E: Continuously Organic Coated Steel Flat Products
- Characteristic Properties 095 – E: Continuous Hot-Dip Coated Steel Strip and Sheet
Thank you for your attention!