Implementing environmental friendly smart surfaces in steel sheet production

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Outline

- OCAS in the ArcelorMittal R&D network
- E-Passivation: worldwide Cr(VI) elimination
- ‘Smart water’ concept
- Easyfilm E: the ‘smart water’ in practice
- Synthesis
- Outlook
OCAS in the ArcelorMittal R&D network

General Industry: 1 R&D Centre on 2 sites ⇒ in Gent and Liège

Packaging: 1 R&D Centre ⇒ in Maizières lès Metz

Automotive: 1 R&D Centre on 2 sites ⇒ in Maizières lès Metz and Montataire

Industrial operations: 1 R&D Centre ⇒ in Maizières lès Metz + 1 satellite ⇒ in Avilés

Knowledge Innovation: 1 R&D Centre ⇒ in Avilés

Stainless & Plates: 2 R&D Centres in Isbergues and Le Creusot
Long Carbon: 2 R&D Centres in Esch-sur-Alzette and Gandrange

USA&Canada: 2 R&D Centres in East Chicago and Hamilton
R&D General Industry

ArcelorMittal R&D Industry Gent/OCAS
- New substrates and metallic coatings
- **Surface functionalization**
- Steel solutions & design
- Product safety

ArcelorMittal R&D Industry Liège
- Organic coatings
- New coating technologies
- Steel solutions & design (construction)
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E-Passivation: worldwide Cr(VI) elimination

- “Chemical passivation” protects the surface against humidity and reduces the risk of formation of corrosion products during storage and transportation. (extract of EN-standards)”

The film Erin Brockovich, highlighted the discussion about chromium VI problematic.
E-Passivation: worldwide Cr( VI) elimination

Hexavalent chromium is being classified as a hazardous substance in European directives.

**Appliances market**
(No hexavalent chromium allowed)

**Automotive market**
(Limit value 0,1 Weight %)
E-Passivation: worldwide Cr(VI) elimination

- Brief history

2000
- Lab testing of available technologies

2003
- Pilot line testing on ZE, Z, ZA, AZ and AS

2004
- Industrialisation
- Customer validation
- Technology improvement: in-use and end-use properties optimisation

2008
- Worldwide deployment
E-Passivation: worldwide Cr(VI) elimination

- Lab/pilot line performance
  - Accelerated corrosion testing for technology screening
    - e.g. salt spray testing
  - Determination of the processing parameters
    - Coating weight
    - Drying temperature/process
    - Concentration of the bath
    - Allowed bath pollution
    - …

![Graph showing white rust percentage over time for different Cr(VI) concentrations](image-url)

- 20 mg/m² Cr
- 35 mg/m² Cr
- 50 mg/m² Cr

**Graph Details:**
- X-axis: time (h)
- Y-axis: % white rust
- Data points show an increasing trend in white rust percentage with time for different Cr(VI) concentrations.
E-Passivation: worldwide Cr(VI) elimination

- E-Passivation morphology
  - Constant thickness at the tops, valleys are filled
  - Higher coating weight (> 50 mg/m²) does not imply increasing corrosion protection

![FIB + FE-SEM image]

Zn

E-Passivation

- Cr(III) thickness (nm)
- Coating weight (mg/m²)
E-Passivation: worldwide Cr(VI) elimination

- E-Passivation morphology
  - layer build up: FIB slice + TEM imaging
E-Passivation: worldwide Cr(VI) elimination

- Formulation improvement towards in-use properties
  - Via high through-put screening
E-Passivation: worldwide Cr(VI) elimination

- Formulation improvement towards in-use properties
  - Via high through-put screening
    - E.g. adhesive bonding
      - 144 formulations
      - 3 model adhesives
      - Up to 500 pull off tests
      - Analysis via data mining tools
    - Selection of 2 additives for further macro-screening
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‘Smart water’ concept

Coil sheet

Cut punch

Scrap

Forming Additives

Form join

Waste

Cleaners Pre-treatment E-coat

Paint

VOC

Temporary corrosion protection: oiling, passivation
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Easyfilm E: the ‘smart water’ in practice

Anti-Fingerprint → Welding Bonding → Corrosion Resistance
Forming Ability → Dry and clean
Visual looking → Safety → Paint Adhesion
Easyfilm E: the ‘smart water’ in practice

- Traditional steel processing flow chart:

  storage → decoiling → handling → re-oiling → cutting → drawing → bending → degreasing → pre-treatment → painting

- Using Easyfilm®:

  storage → decoiling → handling → re-oiling → cutting → drawing → bending → degreasing → pre-treatment → painting

- Gains:

  - cleanliness
  - no corrosion, AFP
  - no cost
  - performance
  - no cost, no rejects
  - no cost, no rejects
  - performance
Easyfilm E: the ‘smart water’ in practice

Cross section

Possible customer top coat (with TiOx paint pigments)

Easyfilm®
metallic coating

Lacquered Easyfilm

1 year tropical exposure in Guyana: excellent paint adherence
Synthesis

- Environmental friendly smart surfaces for steel sheet aim towards:
  - Ready-to-use semi-finished products
  - Environmental friendly processing
    - By adapted chemistry
  - Environmental friendly product finishing
    - By a reduced amount of production steps
    - By adapted chemistry
  - By means of
    - In depth surface analysis/characterisation
    - Advanced technologies like HTE, ...
Outlook

Solvent free surface functionalisation of steel sheet

- UV-curing 100% solvent free systems
  - Production at industrial scale

- (UV) EB-curing 100% solvent free systems
  - Pilot line testing

- Chemical vapour deposition CVD
  - Pilot line testing

- Physical vapour deposition PVD
  - Pilot line testing
    - Industrial unit under construction