Stainless Steel and Alloys in Transport

Recent developments and Aperam’s vision on tomorrow
Stainless Steel and Alloys in transport

Topics

• Introduction of Aperam
• Stainless steel in transport
• Examples (grade selection)
• Trends and solutions for the future
Aperam is a global player

Aperam is the spin off from ArcelorMittal of its Stainless Steel Division (since January 26, 2011)
2.5mT of flat stainless steel capacity & approximately 9500 employees worldwide

Aperam rankings (2012)
- Number 1 in South America
- Number 2 in Europe
- Number 6 in the World
Unique strengths
A large product range of specialties supported by strong R&D

- Stainless steel: 80%
- Electrical Steel: 11%
- Nickel Alloys & Specialities: 9%

115 employees in R&D
Isbergues (France): Stainless Steel
Timoteo (Brazil): Electrical and Stainless Steel
Imphy (France): Ni Alloys and Specialties

Corrosion resistance
(PREN = %Cr+3.3%Mo+16%N)

- FERRITIC
- DUPLEX
- 300 AUST
- 200 AUST

- Sea water 20 °C min. requirements: 31803
- Coastal Env. 20 °C min. requirements: 2304
- Water 20 °C min. requirements: 174 Cu

Nickel Alloys & Specialities 9%
Electrical Steel 11%
Stainless steel 80%
Stainless Steel and Alloys in Transport

Importance of stainless steel in transport
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Why stainless?

Growth of stainless steel in transport

• Aesthetical appearance (growing wealth)
• Economics
  – Growing emphasis on total life cycle cost
  – But… fear to leave comfort zone well-known materials
  – Move from short-term to long-term based decision making
• Increasing safety regulations
  – Crash & fire resistance
• More stringent emission regulations
  – Lower fuel consumption
  – Improve passenger capacity (increase payload)
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Market 2012
30.5 mT

- Catering / Appliances: 37%
- Transportation: 12%
- Architectural, Building & Construction: 17%
- Process / Resources: 19%
- Chemical / Petrochemical: 3%
- Others: 0%
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Some examples (grade selection)
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Passenger transport: car, bus, railway

Usage

- Decorative parts & trimming
- Structural & body parts
- Exhaust systems

Advantages

- Aesthetics
- Corrosion resistance (longer lifespan, less maintenance, …)
- Mechanical properties (crash resistance, lower weight, fuel consumption, …)
- Production cost (no need to paint all parts, only for decoration)

Grades used (typically)

- Ferritics (1.4003, …) as C-steel replacement (also for bulk wagons)
- Standard 304 (1.4301/1.4307), well known
- 301LN (1.4318) and 201LN (1.4371) for weight reduction and improved crash resistance (work hardened)
Stainless Steel and Alloys in Transport
Tank containers, trailers and wagons

Usage
• Inner shells and dished ends
• Outer cladding (2B or 2R-BA finish)
• Structural parts

Requirements transport of (dangerous chemical) products
• High corrosion resistance
• High surface quality (also colour)
• Dimensional tolerances for weight reduction (improved payload)
• Strict international regulations & standards

Grades used (typically)
• 1.4301/1.4307 (304/304L)
• 1.4404/1.4402 (316/316L), 1.4571 (316Ti)
• 1.4318 (301LN)
• New developments: duplex, 200-series, …
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Trends and solutions for the future

Important trends (in transport)

- Economics → cost reductions
- Environmental regulations

<table>
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<tr>
<th>In force</th>
<th>Regulation</th>
<th>Description</th>
<th>Author</th>
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<td>1 Jan 2010</td>
<td>2005/33/EC</td>
<td>Fuel Sulphur content &lt; 0.1% in EU ports &amp; waterways</td>
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<td>IMO Annex VI</td>
<td>NOx emissions reduced to Tier II limits, approx. 20% below Tier I limits</td>
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1 – SECA is Sulphur Emission Control Area
2 – ECA is Emission Control Area
3 – Subject to a technical review to be concluded 2013 this date could be delayed
Stainless Steel and Alloys in Transport
Lower cost alternative grades
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Trends and solutions for the future

Cost reductions

- Grades 304 and 316 are the most popular stainless steel grades
- But the price is volatile due to Nickel and Molybdenum price variations

When nickel price increases excessively, alternative grades become more attractive. Aperam is prepared
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Containerized LNG
Stainless Steel and Alloys for Transport
Trends and solutions for the future

LNG as marine fuel (and road)

• Driven by environmental restrictions for marine transport
• Storage infrastructure and containerized distribution for LNG (as marine fuel)
• Cryogenic environments (vacuum insulation) … and thus only austenitics into play.
• Weight reductions possible by improved mechanical properties

304 → Increase C to increase mechanical properties (incl. cold working)
1.4310 301

301LN (1.4318)

→ Substitute C by N to increase weldability, ductility and corrosion resistance
1.4318 301LN

304 → Nickel substituted by Manganese

= 201LN (1.4371)

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Trends and solutions for the future

Properties 301LN & 201LN vs 304(L)

- Corrosion resistance comparable to 304(L) (1.4301/1.4307)
  Reduced risk of intergranular corrosion due to low C → good weldability
- Improved strength to ductility ratio compared to 304(L)

<table>
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<tr>
<th>Grade</th>
<th>Aperam</th>
<th>ASTM</th>
<th>EN</th>
<th>Grade</th>
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<tr>
<td>18-9L</td>
<td>304L</td>
<td>1.4307</td>
<td>300</td>
<td>≥170</td>
<td>≥220</td>
<td>630</td>
<td>≥485</td>
<td>≥520</td>
<td>54</td>
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<td>18-7L</td>
<td>301LN</td>
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<td>360</td>
<td>≥240</td>
<td>≥350</td>
<td>765</td>
<td>≥550</td>
<td>≥650</td>
<td>50</td>
<td>≥45</td>
<td>≥40</td>
</tr>
<tr>
<td>16-5Mn</td>
<td>201LN</td>
<td>1.4371</td>
<td>360</td>
<td>≥310</td>
<td>≥330</td>
<td>720</td>
<td>≥655</td>
<td>≥650</td>
<td>55</td>
<td>≥45</td>
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(*) Values for cold rolled (2B) finish

- Higher work hardening rate allowing improved mechanical properties (finish 2H)
- Good toughness at low temperatures

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Trends and solutions for the future

301LN & 201LN for LNG tank containers

- Available as continuous rolled 2m wide at Aperam
- Pressure vessel standardization is important
- Proposal submitted to fully specify 301LN & 201LN (including toughness at -196°C)
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Exhaust Systems
Stainless Steel and Alloys for Transport
Trends and solutions for the future

Improved exhaust systems

- Evolution of stringent emission standards.
- Large fraction of energy lost as heat in exhaust system \(\rightarrow\) energy recovery!
- Stainless steel volumes per exhaust system will increase (no. of components), and all components will be in stainless steel.
- New corrosion conditions at cold parts, higher temperatures at hot end.
- New grades are being developed to resist up to 1000° C to offer products as an answer to anti-pollution norms and technologies.
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Trends and solutions for the future

Improved exhaust systems

- Aperam offers a wide range of grades dedicated to exhaust market.
- Hot End
  - Ferritic: K41X (1.4509), **K44X (1.4521)** for high temperature application
  - Austenitic: 1.4828
- Cold End:
  - Ferritic: **K33X (1.4513)** - (17% of Cr, stabilized Ti, with 0.9% of Mo)
  - Austenitic: 1.4301

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Summary & conclusions
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Summary & conclusions

- Economics focus more and more on life cycle cost
  - Lower production cost
  - Lower maintenance over (longer) lifespan
  - Fuel economy (energy recuperation)
  - Lower weight
- Environmental regulations
  - Lower emission standards and fuel consumption drives technology
- Safety standards
  - Improved crash resistance

… all favor using stainless steel solutions.

… Aperam is ready!
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The End