Outokumpu Experience
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Outokumpu high Cr low roping ferritic alternative

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Nobody loves roping

- Unfavorable surface roughening that causes higher polishing costs
- Strong directional stripes become visible only after forming
- May limit the use of ferritic stainless steel grades for applications where drawing or stretching is required
Roping originates from melting

- Roping is caused by an unfavorable grain orientation (texture) that forms already during slab casting
- Only metals with body centered cubic structure (bcc) are affected (e.g. ferritic stainless steels)
- Metals with face centered cubic structure (fcc) are not affected (e.g. austenitic stainless steels)
Roping Index indicates polishing need

- Traditional sample evaluation technique cannot anticipate roping intensity
- Outokumpu has developed a Roping Index (RI) that is based on advanced surface profile measurements
- RI is the most sophisticated technique for roping intensity evaluation today
- RI is used for process development, benchmarking, customer support and quality control purposes
Outokumpu knows how to avoid roping

Change the casting texture of ferritic stainless steel to avoid columnar grains
  • Fine tuned chemical composition and casting conditions
  • Strong electromagnetic stirring (EMS) during casting

Break the columnar casting texture during rolling
  • Unique controlled hot rolling practice
  • Number of cold-rolling and annealing cycles (RAP5)
Outokumpu Core range

For corrosive environments
PRE 17 to 22
## Key products

### Typical applications
- Household appliances and consumer goods
- Indoor and outdoor cladding, handrails, and window frames
- Food and beverage industry
- Storage tanks
- Pipes
- Automotive applications
- Chemical and pharmaceutical industry
- Heat exchangers
- Tank containers

### Product forms
- Hot rolled Quarto plate (P)
- Hot rolled coil and sheet (H)
- Cold rolled coil and sheet (C)
- Bar (B)
- Rod (R)
- Semi-finished (S)
- Pipe (T)
## Nickel-free stainless steels

<table>
<thead>
<tr>
<th>Typical applications</th>
<th>Product forms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor claddings, restaurant equipment and appliances, pipes, heat exchangers</td>
<td>H, C, S</td>
</tr>
<tr>
<td>Household, catering, and architectural applications (indoor and outdoor),</td>
<td>H, C</td>
</tr>
<tr>
<td>automotive tubular products, process equipment such as heat exchangers</td>
<td></td>
</tr>
<tr>
<td>Automotive trim</td>
<td>H, C, S</td>
</tr>
</tbody>
</table>

- Core 439/4509
- Core 4622
- Core 434/4113
Comparable to austenitic grades 1.4301 (304) and 1.4307 (304L) 21% Cr content + 0.4% Cu + stabilization

Ideal for deep-drawing applications with high R-value Ideal for deep-drawing applications with high limiting drawing ratio (LDR)

Virtually roping-free for easy polishing Improved surface properties due to low Ti content

Excellent cost stability compared to Ni-alloyed austenitic grades
Good corrosion resistance
Core 4622 performance

Elongation vs. corrosion resistance

![Graph showing elongation vs. corrosion resistance for various stainless steel grades.]
Excellent corrosion resistance witnessed

Core 4622 before cyclic salt spray test

Core 4622 after 7 days cyclic salt spray test
Better than typical non-Outokumpu 443

Typical 443 before cyclic salt spray test

Typical 443 after 7 days cyclic salt spray test
Enhanced deep-drawability
Superior in deep-drawing applications

Higher R-value ensures material is ideal for deep-drawing

<table>
<thead>
<tr>
<th>Core 4622</th>
<th>443 Max</th>
<th>4301</th>
<th>443 Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>1.4</td>
<td>1.2</td>
<td>0.7</td>
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</tbody>
</table>

R-value
Superior in deep-drawing applications

Limiting Drawing Ratio (LDR)

- Core 4622: 2.3
- 4301: 2.1

Higher LDR ensures material is ideal for deep-drawing.
Easy polishing
Virtually roping free while RI below 1

Lower RI ensures less polishing is needed after deep-drawing
Core 4622
customer case

Success in APAC
Background information

Customer profile

- One of the biggest stainless steel cookware OEMs in Shanghai, China
- Produces millions of deep-drawn items annually
- Half of stainless steel consumption in grade 304 and the rest in various ferritic grades

Core 4622 introduction

- Initial contact made in June 2014
- First samples sent in July 2014
- Full scale production test in March
  - Deep drawing capability
  - Polishing performance
  - Food contact test
Core 4622 passed test with flying colors

<table>
<thead>
<tr>
<th>Deep drawing capability</th>
<th>✔</th>
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<tbody>
<tr>
<td>• No cracking</td>
<td></td>
</tr>
<tr>
<td>• No visible flaws</td>
<td></td>
</tr>
<tr>
<td>• No losing shape</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Polishing performance</th>
<th>✔</th>
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<tbody>
<tr>
<td>• Significantly less roping visible after deep-drawing</td>
<td></td>
</tr>
<tr>
<td>• Elimination in number of polishing cycles</td>
<td></td>
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<tr>
<td>• Reduced polishing time</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Food contact test</th>
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</tr>
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<tbody>
<tr>
<td>• Harmful substance precipitation conforms to EU regulation</td>
<td></td>
</tr>
<tr>
<td>• Purchasing company approval received</td>
<td></td>
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</tbody>
</table>
Customer identified Core 4622 benefits

- Decreases time
- Reduces process phases
- Cuts costs
- Increases profit
- Optimizes production
- Increases competitiveness
Summary

Outokumpu high Cr, low roping ferritic alternative
Core 4622 enables win-win

Technical victory for customers who use ferritic grades and struggle with roping

Commercial victory for customers who use austenitic grades and struggle with price volatility
Read more at outokumpu.com/core
Outokumpu
working towards a world that lasts forever