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Latest application of Niobium in stainless steel
Outline

• Niobium;

• CBMM;
  – Company Overview;
  – Technology Development Program;

• Stainless steel with niobium:
  – History;
  – Latest applications;

• Conclusion
Niobium element: 1801 Charles Hatchett

- Atomic Number: 41
- Electronic Configuration: [Kr]4d³5s²
- Atomic weight: 92.9064
- Melting Point (°C): 2,468
- Density (20°C) (g.cm⁻³): 8.57
• 1954: discovery of deposits in Brazil, Araxá.

• Average of 2.5% of \( \text{Nb}_2\text{O}_5 \);

• Company is managed by the Moreira Salles Group since 1965;

• In 2011: 15% share of CBMM was sold to a Japanese-South Korean consortium and another 15% stake was acquired by a group of Chinese companies;
CBMM’s Niobium Technology Program Adds Value To The Supply Chain By:

- Improving material performance.
- Increasing product life cycle.
- Reducing total cost in the value chain (processes & products).
- Enhancing perceived value in the market (market value of product).
CBMM’s Niobium Technology Program Adds Value To The Supply Chain

Use of Niobium microalloyed steels in structures

17% Savings

Weight Reduction

CO₂ reduction

Energy Consumption

22%

21%

21%

Innovate, Respect, Compete
CBMM’s Niobium Technology Program

- Includes cooperation projects, technical assistance and visits by specialist teams.

- Currently over 140 projects are underway around the world with partners such as customers, research centres and universities.
CBMM’s Niobium Technology Program

Innovate, Respect, Compete

1975
5,448 tons of ferroniobium

38 years
2013
61,692 tons of ferroniobium

~ x 10

 Nb in stainless steels has maintained its share over the years but substantially changed its application.
Niobium in Stainless Steels

• 1933: first application
  – Stabilizing element in austenitic stainless steel 304 = grade 347 → higher intergranular corrosion resistance for heat resistant materials;
  – Improved creep resistance of austenitic stainless steels: power generation;

• 1973: drop in the use of niobium as a stabilizing element
  – Introduction of AOD converters in stainless steel production: C levels lower than 0.03% hindered the precipitation of chromium carbides in the temperature range of 350-800°C;

• 1988: use of ferritic stainless steels with niobium for the exhaust system of light vehicles
  – New legislation in Europe: maximum levels of CO, NOx and hydrocarbons in car emissions;
  – Exhaust systems needed to withstand a minimum life of 80,000 km;
  – Transfer of the ferritic grade 409 (used in USA since the 70’s) to Europe failed due to the higher temperatures at the front end of the exhaust system (above 750°C)
  – Austenitic grades have been considered but a competitive ferritic stainless steel with niobium, the grade 441, started to be an option in the market;
Exhaust System

KARA ferritic stainless steel offers:
grade K44X

<table>
<thead>
<tr>
<th>Elements</th>
<th>C</th>
<th>N</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Nb</th>
<th>Mo</th>
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<tbody>
<tr>
<td>%</td>
<td>0.015</td>
<td>0.015</td>
<td>0.60</td>
<td>0.30</td>
<td>19</td>
<td>0.6</td>
<td>1.9</td>
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</table>

Typical values
The principal characteristics of our K44X are:
- Elevated hot mechanical properties without risk of σ phase formation at intermediate temperatures
- Resistance to high temperature oxidation and creep up to 1050°C
- Good durability in thermal fatigue
- Good corrosion resistance in exhaust gas environment
- Greater thermal conductivity than austenitics and a lower thermal expansion coefficient
- Good weldability
- Ease of forming


Cold Part

• Corrosion resistance

Hot Part

• Creep
• Oxidation
• Thermal & Low Cycle Fatigue
• 439, 441, 444, 308, 304, 321;

1050°C

T (°C)
Turbo & smaller engines

650 < T < 950°C
Exhaust System

- Very limited corrosion resistance (11%Cr);
- Failures specially in welded areas;
- Next alternatives: higher Cr containing grades;
- However: 409 Ti+Nb (0,15-0,31%) can be an alternative
  - 40% higher corrosion resistance (Mazda B Method);
  - Better performance at higher temperatures (up to 650°C);
- Better cost effective alternative for some applications when compared to higher Cr grades;
- Grade under field trials;
High Temperature & Corrosion Resistance
Other Applications

- Atmospheric corrosion resistance;
- Direct contact with potable water;
- 70<T<100°C;

- Ferritic grades have better SSC resistance;
- Inner tank Material: 445J1 (22%Cr, 1%Mo, 0.15%Nb);
- Collect plate: 444BA (20%Cr, 2%Mo, 0.25%Nb);

Source: ISSF – Stainless Steel in Solar Energy Use
High Temperature & Corrosion Resistance  
Other Applications

- Water tubes:
  - Corrosion resistance to maintain water quality – specially in the case of hot water;
  - Laser welding technique guarantees the quality needed for this application;
  - Ferritic stainless steel tubes are in use in Germany, Italy and Switzerland;
  - In 2007 DVGW (German Technical and Scientific Association for Gas and Water) and SVGW (Switzerland Water and gas industry association): official equivalence between grade 444 and 316 for potable water applications;
  - Application also possible in gas supply system;
  - 444 grade is the main one used in this application;

Source: ISSF
Corrosion Resistance & Surface Finish

Grades developed...
- 430 LN (17%Cr +Nb):
- 430LNT (17%Cr, Nb+Ti):
- 443NT (21%Cr, Cu+Nb+Ti);

For clothes and dish washing machines, refrigerators...

Source: Baosteel presentation in the 9th Asian Stainless Steel conference – Hong Kong, 2014
Elevators:
- Ongoing developments in China to substitute grade 304 by ferritic stainless steel grade 443 (21%Cr+Nb, 0.8-1.2mm);
- Niobium addition + process control: improved surface finish able to be applied in elevator pannels;

Exterior panels:
- Grades 444 and 445 are the ones widely in use;
- Process control and close work with customers allow correct application, resulting in uniform façades;
Conclusions

• Niobium has been in use by the stainless steel industry for more than 80 years but its use is in constant evolution;

• First application was in heat resistant stainless steels (which continues until today) but the increase seen in the last years can be mainly attribute to the ferritic stainless steel development;

• Nowadays niobium bearing ferritic stainless steels are well established in the hot part of exhaust systems and niobium is helping to achieve higher temperature performance grades. Nevertheless, grades with this element are also increasing its application in the cold part, as they present a safer option when considering life cycle assessment;

• Solar heaters, water tubing and home appliances are also increasingly using niobium bearing grades as they are an alternative to the austenitic family, providing good corrosion resistance and surface finish. The improved surface finish and the corrosion resistance also bring new possibilities of application in elevator panels and building façades;

• Niobium has an important role in the development of stainless steel family since it adds value by improving final properties such as high temperature resistance, corrosion resistance in welded areas, improved drawability and better surface finish.
Questions?

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