High Performance Stainless Steel
Long Products & Production Process
of Daido Steel

ISSF-8 Seoul, Korea

May 17, 2004

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Daido Steel Co., Ltd
Consumption of Stainless Steel (SS) Long Products

- Rapid increase of consumption in Asia

(Thousand tons per year)

<table>
<thead>
<tr>
<th>Year</th>
<th>Asia</th>
<th>Western Europe</th>
<th>Others</th>
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</thead>
<tbody>
<tr>
<td>1998</td>
<td>699</td>
<td>597</td>
<td>1250</td>
</tr>
<tr>
<td>2001</td>
<td>731</td>
<td>662</td>
<td>800</td>
</tr>
<tr>
<td>2002</td>
<td>778</td>
<td>715</td>
<td>650</td>
</tr>
<tr>
<td>2005</td>
<td>1250</td>
<td>800</td>
<td>650</td>
</tr>
</tbody>
</table>

Daido Steel
Consumption & Production Capacity of SS Wire Rods in Asia

(Thousand tons per year)

<table>
<thead>
<tr>
<th></th>
<th>Capacity</th>
<th>Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1056</td>
<td>132 (192)</td>
</tr>
<tr>
<td>Taiwan</td>
<td>816</td>
<td>132 (+72)</td>
</tr>
<tr>
<td>Japan</td>
<td>168</td>
<td>168</td>
</tr>
<tr>
<td>Taiwan</td>
<td>888</td>
<td>132 (+168)</td>
</tr>
<tr>
<td>Korea</td>
<td>108</td>
<td>108</td>
</tr>
<tr>
<td>S.E Asia</td>
<td>96</td>
<td>96</td>
</tr>
</tbody>
</table>

Daido Steel
## Consumption & Production Capacity of SS Wire Rods in Asia

<table>
<thead>
<tr>
<th>Region</th>
<th>Consumption</th>
<th>Production Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>168</td>
<td>168</td>
</tr>
<tr>
<td>China</td>
<td>132</td>
<td>324</td>
</tr>
<tr>
<td>Taiwan</td>
<td>132</td>
<td>132</td>
</tr>
<tr>
<td>Korea</td>
<td>108</td>
<td>108</td>
</tr>
<tr>
<td>S.E. Asia</td>
<td>96</td>
<td>96</td>
</tr>
<tr>
<td>Total</td>
<td>636</td>
<td>828</td>
</tr>
</tbody>
</table>

(Thousand tons per year)
Current Conditions

Rapid increase of consumption in Asia

- Rapid increase of production capacity in China
- Increasing production of common grades in China

Overproduction and price competition in East Asia

Daido’s strategy

- Value added and high performance products
- Sophisticated production process & technology

From Volume to Value
SS Long Products of Daido Steel

Output: 178,000 t/yr (2003)

- Corrosion-Resistance
- Heat-Resistance
- Electro-Magnetic
- High-Hardness
- others
- Free-Cutting
- Cold-Heading

VALUE-ADDED
- 113Mt/yr (63.5%)
- COMMON
- 65Mt/yr (36.5%)
- 430
- 420
- 403 & 410
- 304,316 etc.
Typical Examples of High Performance Grades of Daido Steel
302HQ with Higher [Cu] Content

- 4mass% [Cu] contained 302HQ (18Cr-9Ni-Cu)
- Excellent cold workability (heading, drawing)
- Advanced process technology for poor hot workability SS

![Graph showing Cold Workability and Hot Workability vs. Cu contents (mass%)](image)

Daido Steel
303 Free Cutting SS with Higher [S] Content

- 0.4 mass% [S] contained 303 (19Cr-9Ni-S)
- Superior machinability and comparable corrosion resistance with conventional steel (0.3mass%S)
- Advanced process technology for poor hot workability SS

Cutting chip in drilling

High S [0.4mass%S]  Conventional [0.3mass%S]

Daido Steel
Clean SS for Ultra Fine Wire

- Super clean 304, 316 by remelting processes
- Drawability: 0.012mm

<table>
<thead>
<tr>
<th></th>
<th>Super Clean SS</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ AOD-VSR-VSR ]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Inclusions ( N / 3.75cm² )</td>
<td>2</td>
<td>115</td>
</tr>
<tr>
<td>Max. Dia. ( µm )</td>
<td>2.5</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Ultra fine wire [ø 0.012mm]

Fractured wire [ø 0.023mm] in drawing

Daido Steel
**WSR44K* / Ferritic SS Welding Wire**

- Fine grain microstructure
- Superior mechanical, oxidation and corrosion properties
- Application for exhaust systems

* Patent Pending

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### Tensile Properties at 950 degree C

**Conventional**

**WSR44K** (Ti, Al, N added)

Macrostructure of Weld Bead

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Daido Steel
# Production Process of High Performance Grades

<table>
<thead>
<tr>
<th></th>
<th>Melting (VCR-B/L CC)</th>
<th>Rolling Isothermal Temp. Control</th>
<th>Secondary Processing</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>302HQ High Cu</strong></td>
<td>VE (Low C,N)</td>
<td>VE</td>
<td>---</td>
<td>Cold Heading (Screw)</td>
</tr>
<tr>
<td><strong>303 High S</strong></td>
<td>---</td>
<td>VE</td>
<td>---</td>
<td>Free-cutting (Shaft, Pin)</td>
</tr>
<tr>
<td><strong>Clean SS</strong></td>
<td>VE (Triple-Melting)</td>
<td>---</td>
<td>VE</td>
<td>Ultra Fine Wire (LCD&amp;PDP, Mesh)</td>
</tr>
<tr>
<td><strong>WSR44K</strong></td>
<td>E</td>
<td>E</td>
<td>---</td>
<td>Welding Wire For Exhaust Muffler</td>
</tr>
</tbody>
</table>
Daido’s Advanced Process Technology
Daido’s Newly Designed/Developed Production Process & Technology

New Process for High Performance Stainless Steels

Conventional Process

Daido Steel
VCR® (Vacuum Converter Refiner)

- Higher efficiency of decarburization
  - Ultra low [C], [N] content
  - Shortening of refining time
- Saving of Argon gas consumption

Diagram:
- Vacuum pump
- Argon gas
- Vacuum level 5.3kPa
- Conventional AOD
- VCR

Graph:
- Grade: 302HQ
- Vacuum Time: 15min
- Pressure: 5.3kPa
- Before final de[C] stage
- After final de[C] stage

Daido Steel
### Vertical & Round Bloom CC

**Specification**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bloom size</td>
<td>350mm $\phi$</td>
</tr>
<tr>
<td>Type:</td>
<td>Vertical bloom caster</td>
</tr>
<tr>
<td>Capacity</td>
<td>57,000 ton/month</td>
</tr>
<tr>
<td>Number of strand</td>
<td>4</td>
</tr>
<tr>
<td>Ladle size</td>
<td>80ton</td>
</tr>
<tr>
<td>Tundish size</td>
<td>20ton</td>
</tr>
<tr>
<td>Casting velocity</td>
<td>0.65m/min</td>
</tr>
</tbody>
</table>

![Diagram of Vertical & Round Bloom CC](image)

**Daido Steel**
High Performance Wire Rod Mill

- High productivity by one heat rolling
- Seam free rolling
- Small size wire rod rolling (φ 4)

Billet (155mm sq, 145mm sq)

Reheating furnace
- Non-oxidation reheating furnace

Rough rolling (reversing)

Inline induction heater

3 roll mill (φ 500) [2std x 3]

Intermediate rolling mill [HV x 6std]

Block mill [10std]

New sizing mill [2std x 2]

Daido Steel
Non-Oxidation Reheating Furnace

Mechanism of induction reheating furnace

- Induction coil
- Nitrogen atmosphere: N₂
- Air atmosphere
- Drive roller
- 1700KW, 250Hz

Cross section of products

Daido Steel
Inline Induction Heater

Rolling temperature transition

Roughing  Intermediate  Finishing

With IH  Without IH
3 Roll Mill (φ 500)

3-Roll Position (120° degree)

Reducer & Distributer

Drive Motor

3-Roll Mill

Roll

Daido Steel
SUMMARY

Demand for High Performance SS

Daido’s Advanced Process Technology

R&D

Value Added & High Performance Stainless Steel

- Cold Heading Stainless Steel
- Free Cutting Stainless Steel
- Super Clean Stainless Steel
- Heat Resistant Steel

Daido Steel
# Introduction of Daido Steel (Domestic Major Works)

<table>
<thead>
<tr>
<th>Products</th>
<th>Works</th>
<th>Production (x1000 t / y)</th>
<th>Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specialty Steel</strong> (Long Products)</td>
<td>Chita Melting &amp; Rolling</td>
<td>918</td>
<td>Automobile</td>
</tr>
<tr>
<td></td>
<td>Hoshizaki Ti-Melting, Rolling</td>
<td>241</td>
<td>IT</td>
</tr>
<tr>
<td></td>
<td>Kawasaki Rolling</td>
<td>35</td>
<td>Industrial Equipment</td>
</tr>
<tr>
<td><strong>Die Forging</strong></td>
<td>Chita Die Forging</td>
<td>67</td>
<td>Automobile</td>
</tr>
<tr>
<td></td>
<td>Kimitsu Die Forging</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td><strong>Free Forging</strong></td>
<td>Shibukawa Melting, Remelting &amp; Free forging</td>
<td>62</td>
<td>Aerospace Power Generation</td>
</tr>
<tr>
<td><strong>Strip Products</strong></td>
<td>Chita Cold Strip Rolling</td>
<td>22</td>
<td>IT</td>
</tr>
<tr>
<td><strong>Castings</strong> (Stainless Steel)</td>
<td>Tsukiji Casting</td>
<td>5</td>
<td>Automobile</td>
</tr>
<tr>
<td></td>
<td>Nakatsugawa Precision Casting</td>
<td>4</td>
<td>Industrial Equipment</td>
</tr>
</tbody>
</table>
Miscellany
Specialty Steel Production by Steel Grade

- Alloy: 31%
- Carbon: 18%
- Free Cutting: 20%
- Stainless: 13%
  including Ni-base alloys
- Bearing: 12%
- Spring: 3%
- Tool: 3%

Total production: 138,400,000 tons/year

Daido Steel
New Pb-free Free Cutting Steels - Starcut TICS

Innovative free cutting element: Ti-carbosulfide
- Superior machinability by fine dispersion
- Excellent corrosion resistance

Microstructures
(base: Fe-16%Cr)

Machinability in turning/ base: Fe-16%Cr

Corrosion Resistance/ base: Fe-16%Cr
Salt Spray Test (35°C, 5% NaCl, 96h)

Daido Steel
New blooming and billeting process of Chita Plant

New Process

- Improvement of Internal Quality
- Improvement of yield

- Constant rolling temperature control (less surface defects)

Daido Steel
Schematic view of Inline Press (I/P)

- Hydraulic cylinder
- Accumulator
- Manipulator
- Ingot or CC bloom

Daido Steel
Photograph of Inline Press (I/P)
High-Performance Wire rolling mill in Hoshizaki Plant

Wire Rolling Press

Reheating Furnace

Non oxidation reheating furnace
(Ti,Ti-alloy,Superalloy etc)

Rough Rolling (reversing) → IH → Intermediate rolling

Block Mill

New Size Mill 4 φ Wire rod

Daido Steel
Melting Equipment of Shibukawa Plant

- Electric Arc Furnace:
  - 30t x 1
  - 20t x 2

- VCR (AOD):
  - 20t x 1

- Vacuum Ladle Furnace:
  - 30t x 2

- Vacuum Induction Melting:
  - 3t x 1
  - 9t x 1

- Ingot Casting:
  - 2.5~32.5 t

- ESRx6:
  - 0.5~10 t

- VARx7:
  - 2~15 t

- VSRx1:

**Quality of Special Remelted SS for Ultra Fine Wire**

- AOD
- AOD-VSR
- AOD-VSR-VSR

*Inclusion Size (µm)*

*Daido Steel*
Billet (155mm sq, 145mm sq)

Reheating furnace

Non-oxidation reheating furnace

Rough rolling (reversing)

Inline induction heater

3 roll mill (φ 500) [2std x 3]

Intermediate rolling mill [HV x 6std]

Block mill [X x 10std]

New sizing mill [2std x 2]