Recent technology and advanced products in the steel production for energy development and shipbuilding

1. Introduction
2. Outline of Steel as the functional material
3. Manufacturing Process of High performance steel
   (1) Newest Steel Making Process & Plate mill
   (2) Thermo Mechanical Controlled Rolling Process
4. Recent advanced products in the steel
   (1) For Ship-building
   (2) For Offshore structures and Wind power structure
   (3) For Building & Bridge Construction
   (4) Atmospherics Resistance
   (5) Anti-Severe Environment
5. Processing Technology System of steel structure
6. Conclusion
"Earth" is born as a star of iron

Earth consists of oxides of iron, silicon and magnesium. The most amount of is covered with iron, it accounts for 34.6% of the total weight. In this way the earth lump of iron.

Creating the Best Steelmaker with World-Leading Capabilities

Maximize the potential of steel through utilization of world-leading technology. Contribute to the growth of global economies and the improvement of global society.

Globalizing the Steel Business

The Best Steelmaker with World-Leading Capabilities
Nippon Steel & Sumitomo Metal Corporation

Utilizing the World’s Leading Technologies

Improving Cost Competitiveness

NSSMC Group will pursue world-leading technologies and manufacturing capabilities, and contribute to society by providing excellent products and services.
Expand Local Production in Emerging Countries

- Continue to produce in Japan as the core base
- Supply high quality products in growth markets
- Produce in Japan as the core base
- Develop and manufacture leading-edge products

Re-organize and Expand the Bases including Integrated Steelworks e.g. in ASIA / AMERICAS

Target: 60 - 70 million tons of global production

Supplying a wide range of product types

NSSMC will pursue manufacturing strength based on steelmaking.

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Net Sales*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat Products Unit</td>
<td>JPY1,870bn, US$24bn</td>
</tr>
<tr>
<td>Bar &amp; Wire Rod Unit</td>
<td>JPY590bn, US$7bn</td>
</tr>
<tr>
<td>Pipe &amp; Tube Unit</td>
<td>JPY580bn, US$7bn</td>
</tr>
<tr>
<td>Plate Unit</td>
<td>JPY480bn, US$6bn</td>
</tr>
<tr>
<td>Construction Products Unit</td>
<td>JPY270bn, US$3bn</td>
</tr>
<tr>
<td>Stainless Steel (NSSC)</td>
<td>JPY230bn, US$3bn</td>
</tr>
<tr>
<td>Railway, Automotive &amp; Machinery Parts/ Titanium &amp; Specialty Stainless Steel Unit</td>
<td>JPY170bn, US$2bn</td>
</tr>
</tbody>
</table>

*Except for semi-finished products
NSSMC’s Plate Mills; Kashima, Oita, Kimitsu, Nagoya

Kashima170kt
100×4500×25000

Nagoya75kt/M
300×4500×22000

Oita210kt/M
100×5300×27000

Kimitsu155kt/M
200×4500×25000

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Requirements for development of high performance steel

Metallurgical Core Technology
- TMCP
- HAZ microstructure
- Micro-alloy

Advanced process technology
- Cooling process
- Temperature control
- Gauge and shape control

High performance steel development

Precision process control throughout production
- Process metallurgy
- Slab quality control
- Quality control system

Industry collaboration
- Japan Maritime
- Joint development
- Ministries Collaborative Project

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TMCP Process and NSSMC&USIMINAS’s ACC Equipment

TMCP (Thermo-Mechanical control process)
On-Line controlled water cooling just after rolling

Thermo-Mechanical Control Process

Controlled rolling + Accelerated cooling

fine grain microstructure without heat-treatment

Accelerated cooling equipment

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TMCP process (thermo-mechanical control process)
Highly control of chemical composition, reheating, rolling, & cooling in order to get very fine microstructure → High toughness & good weldability.

Various Microstructure for TMCP

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Microstructure of TMCP plates

Conventional

TMCP

TMCP steel shows much finer microstructure compared with conventional steel.

→ TMCP improves strength and toughness, and can decrease the amount of additional alloy.
Latest topics of steel plates for ship building

Direction of development

Basically; Reducing Ship Building Cost (for Ship Yards)
- High-Tensile Strength Steel
- For Large Heat-input, Automatic-Welding
- Easy Fabrication; No Pre/Post-Heating While Welding
⇒ TMCP Steel for Easy Fabrication and Automatic Large Heat-input Welding

Recently; Improving Ship Performance (for Owners)
- Higher Arrestability, Anti-Brittle-Crack Steel
⇒ Microstructure Control Technology
- Anti-Fatigue
⇒ Peening Technology
- Anti-Corrosive Steel for Cargo Tank of Oil Tanker
⇒ Corrosion Resistance Technology
- Higher Safety at Collision
⇒ Impact absorption Technology

Specific examples of the collision deformation at serious Impact accident

Collision ship (large oil tanker) crude oil loading state

Bombarded ship (bulk Carrier) cargo full state

Impact Speed: 5not
Conventional Steel Break Out
NSafe™—Hull Steel Non-break
Micro-Structure of Developed Steel

Conventional  Developed NSafe®Hull Steel

- Extra-low carbon cont. & highest purity
- Most-advanced rolling technology to improve strength & toughness

• Same yield strength as that of conventional steel
• Lower work-hardening
• Large elongation

NS-Ship-Safety235 has high deformability.

High ductility steel (NSafe™ over Hull) application point

- Fuel tank
- Engine room section
- Fuel tank Top-side section
- Cargo wing-side section
Example of Brittle Fracture

The brittle crack goes through the base plate.

Crack Speed: usually over 1000m/sec
It came suddenly

Test temperature: -10℃
Grade: Conventional EH40
vE-40℃: 170J

Base plate with 170J at -40℃
can not arrest the brittle crack.

NSSMC & USIMINAS Solution for High Grade

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New advanced steel material for **Jack up Rig**

**Solution**
- Expansion of the foundation area
- Weight reduction
- Reduced life-cycle costs
- Shortening of lead time/Reduction of manufacturing costs

### High Strength Thick Steel Plates for RACK & CHORD (YR690)
Extra thick high strength steel plates with high toughness that meet classification society requirements.

### For Cantilevers/TMCP-type/EF51 Steel Plates
High-strength steel plates with shortened manufacturing lead times made possible through adapting the TMCP.

### For Jacking System/High Tensile Strength Steel Plates for Cantilevers (YR500-690)
A wide range of high strength steel plates with high toughness that meet classification society requirements.

### Low Temperature High Strength Tough Steel Plates for FLOATING/HULL Use (F-grade steel/YR355-420)
Steel plates that meet classification society requirements and impact test standards at -60°C.

### High Strength Pipe for Bracing
High strength material for bracing (Jack Up Rig).

New advanced steel material for **Platform**

**Fixed Platform**

**NSHYPER BEAM**
Saves fabrication cost and time to build up beams.

### Low Temperature CVN H-shapes
Up to -40°F/°C.

### Steel Plates for -40°C (ARCTIC) Usage Environments
YP420 grade steel plates suited for use in -40°C (ARCTIC) environments/maximum plate thickness 4" (world first).

### Steel Plates for -20°C (ARCTIC) Usage Environments
YP420 grade steel plates suited for use in -20°C (ARCTIC) environments.
New advanced steel material for FLNG

High Corrosion Resistant Alloy for Heat Exchanger Tube and Piping
531134, 110170: stainless steel with excellent corrosion resistance to seawater.

Duplex Stainless Steel for Heat Exchanger Tube and Piping
DPSW, 328750: super duplex stainless steel with excellent corrosion resistance to seawater.

Mariloy™
Excellent corrosion resistance to seawater and equal weldability to carbon steel.

Wind Power structure

Offshore Wind Technology Development

Current Technology

Land-Based

Shallow Water

Transitional Depth

Deepwater Floating

0 m–30 m
430 GW

30 m–60 m
541 GW

60 m–900 m
1533 GW

No exclusions assumed for resource estimates
Types of foundation (Monopiles & Jackets)

Review Progress of Steel for Bridge

1910 Amarube, West Japan Railway Corp.

1923 Eitai Bridge
Tokyo

1994 Trans-Tokyo Bay Highway

2010 Tokyo Gate Bridge
BHS500 Applied

Fine Grain in Microstructure
HT780Mpa Steel for Bridges
(SBHS:Bridge High performance Structure)

To guarantee the yield strength is the same value up to maximum thickness.

SBHS has good weldability (low Pcm)

Point: Using of BHS500 reduce the total weight of steel materials for the bridge by 3% and cut the total cost of construction by 12%.

In addition, We can supply Weathering Steel as well.

NSSMC’s steel plate used for building structure

Thin & lighter structure by taking advanced high design steel. The reduction of the pillars, provides flexible open space. And, transportation and processing of CO2 emissions at each stage.
Atmospheric corrosion resistant steel

Corrosion-resistant material is present in accordance with each corrosive environment

High
- hydrochloric acid solution
- Tanker
- S-TEN
- NSGP-1
- Crude oil carrier
- ARU-TEN

Medium
- Thermal power plant
- MARILOY
- WELACCS
- Weathring steel

Low
- LNG power plant
- Bridge, Building
- pH7

Development of corrosion resistant steel plates in NSSMC

Historical background
- Rapid Economic Growth
- Globalization
- National Resilience
- Safety and Security

Market size of low alloy corrosion resistant steels

- Demand for Minimum Maintenance
- Market Expansion of Weathering steel
- Obligation of Dioxin Countermeasure
- Lowering flue gas temperature
- HCl Dew Point Corrosion

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Corrosion resistant steel for pitting corrosion on cargo oil tanks of crude oil carrier (NSGPTM-1)

NSGPTM-1 provides superior corrosion resistance (NaCl 10% of part weight at 0.8 pH) NSGP-1(Nippon Steel’s Green Protect-1)

corrosion-resistant steel ; S-TENTM

→It’s a sulfuric acid (S-TEN1 & S-TEN2) and hydrochloric acid (S-TEN1) dew-point corrosion-resistant steel

Waste treatment plant (plastics)  Thermal power plant of coal (spray seawater against dust)  Cement plant (receiving waste)
Microstructure of Welded joints

Coarsened Grain shows deteriorated toughness

Base materials  HAZ (Heat Affected Zone)

Problem of HAZ (Heat Affected Zone) toughness

Progress of HAZ toughening technology HTUFF in NSSMC

HTUFF: super High haz Toughness technology with Fine microstructure imparted by Fine particles

(a) Conventional steel  (b) TiN steel  (c) TiO steel  (d) HAZ fine grain steel

Prevent grain coarsening by pinning and/or intra-granular ferrite formation

HTUFF Technical Example

HTUFF steel show fine grain microstructure even on large heat input conditions of EG welding (~40kJ/mm).

HAZ Microstructures (EGW)

Conventional Steel

HTUFF Steel

Available plate products & Characteristics

<table>
<thead>
<tr>
<th>Type of Steel</th>
<th>NSSMC Brand(TM)</th>
<th>International Standards</th>
<th>Japanese Standards(JIS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General structure</td>
<td>-</td>
<td>&lt;ASTM&gt;A283</td>
<td>SS340~540</td>
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<tr>
<td>Welded structure</td>
<td>-</td>
<td>&lt;ASTM&gt;A36,A572,A709,</td>
<td>SM400~520</td>
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<td></td>
<td></td>
<td>5LX52~X65,&lt;UK&gt;BS4360</td>
<td></td>
</tr>
<tr>
<td>Building structure</td>
<td>BT-HT325~620,</td>
<td>&lt;ASTM&gt;A1043</td>
<td>SN400,490</td>
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<tr>
<td></td>
<td>BT-LYP100,225,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NSFR400~520</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ships</td>
<td>NSGP-1,2,3</td>
<td>&lt;NK,LR,AB,BV,CR,GL,NV,KR etc&gt;, A-F Gr.,YP24~70</td>
<td>-</td>
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<tr>
<td>High Strength</td>
<td>WEL-TEN590,610 Series, WEL-TEN780 950 Series, &lt;ASTM&gt;A537,A514,A517, 5LX70,X80</td>
<td>SM570,SHY685</td>
<td></td>
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<tr>
<td>Abrasion Resistance</td>
<td>WEL-TEN AR 235~500, WEL-HARD400 500 ABREX Series</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Low-temperature</td>
<td>N-TUF 295~570,</td>
<td>&lt;ASTM&gt;A537,A203,A553,</td>
<td>SLA235~360,SL2N255,</td>
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<tr>
<td></td>
<td>N-TUF CR130,196</td>
<td>&lt;NK,LR,AB,NV,GL etc.&gt;</td>
<td>SL3N255,~440,SL9N590</td>
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<tr>
<td>Medium-temperature</td>
<td>-</td>
<td>&lt;ASTM&gt;A285,A516,A537,</td>
<td>SPV235~490,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BS1501, &lt;EN&gt;10028</td>
<td>SGV410~480</td>
</tr>
<tr>
<td>Medium-to-High temperature</td>
<td>-</td>
<td>&lt;ASTM&gt;A299,A302,A387,A542,A543, BS1501, &lt;EN&gt;10028, &lt;NK,LR,AB,NV,GL etc.&gt;</td>
<td>SPV410~480M,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SBV1<del>3, SQQV1</del>4</td>
</tr>
<tr>
<td>Atmospheric corrosion to resistance</td>
<td>COR-TEN 0,490,570, NAW400,490, 3%Ni-added</td>
<td>&lt;ASTM&gt;A588,A709</td>
<td>SMA400~570</td>
</tr>
<tr>
<td>Sulphic acid resistance</td>
<td>S-TEN Series</td>
<td>-</td>
<td>S10C~SS5C,SCM440</td>
</tr>
<tr>
<td>Machine structural</td>
<td>-</td>
<td>&lt;AISI&gt;1008,1015,1020,1021</td>
<td></td>
</tr>
</tbody>
</table>
### Available plate products & Characteristics

**1. Large application range for various environment**
- Tensile strength: **200~1200Mpa**
- Using temperature: **-196°C~500°C**
- Thickness: **<100μm up to 300mm**
- Width: up to **5,300mm**
- Unit weight: up to **30t**

**2. Advanced manufacturing facilities and process**
- **High precision control** for chemical composition
- Developed continuous casting machine for clean & defect free.
- **Microstructure control** with TMCP.
- **Oxide metallurgy** for improving HAZ toughness.

**3. High ability of Solution offering for customers**
- Courteous cooperation with customers, and technical support for application the materials