Production and Technology of Iron and Steel in Japan during 2002

Tetsurou OHASHI
Chief of Production and Technology Division, The Iron and Steel Institute of Japan, Kanda-Tsukasacho, Chiyoda-ku, Tokyo 101-0048 Japan.

1. The Economic Circumstance of the Japanese Iron and Steel Industry

The outlook for the Japanese economy for the year 2002 was projected to be extremely severe from the beginning, as there seemed to be no progress in liquidation of bad loans, low stock prices continued, the consumer price index fell for 37 months consecutively, and the cycle of deflation entered its fourth year.

In terms of employment, the unemployment rate was 5.4%, which was higher than 2001, the first year to record such a poor figure since 1953 when the survey was started. Unemployment rates were 5.2% or higher during every month of 2002. The number of unemployed was at its highest ever at 3.59 million, surpassing the 3 million mark for four years consecutively, and these severe conditions continue to persist. The number of employed was 63.3 million, which was 0.82 million less than in 2001, and this was the fifth consecutive year of decrease.

In terms of the business sectors, the service industry grew, the manufacturing industry declined for its tenth consecutive year, the construction industry marked a five-year consecutive decline, and the transport and communications industries showed a two-year consecutive decline.

For the iron and steel industry, the number of employed compared to 2001 as of year-end 2002, was 165,960 employees, which was 15,000 fewer workers (an 8.2% decrease), and the rate of decrease marked 5% or more per year for nine years consecutively since 1994. The particulars were: 7.3% in iron and steel, 12.1% in processing, and 8.7% in other fields.

Investments in public investment continued to decline, and not much development was seen in residential investment or facilities investment by the private sectors. Personal consumption gradually but surely recovered, while overseas demand increased mostly in products for Asia, and these two factors propelled the economy.

Looking at the demand and supply of iron and steel in the above circumstances, for construction, consumption of domestic iron and steel products remained low in public construction work, residential construction failed to reach the 2001 level, and non-residential construction would fall into negative compared to previous year although urban re-development and store construction improved solidly. Steel orders for building construction overall was lower than in the previous year’s levels.

In manufacturing, high-level production continued as reflected in increased exports mainly to the United States and good sales of small cars. Shipbuilding also increased slightly compared to the previous year, as solid building activities continued with the current project volume amounting to two years. In this domestic demand environment, inventory adjustment advanced rapidly, and domestic inventory of ordinary steel products contracted to almost appropriate levels.

For export of iron and steel products, because the volume for China was high until autumn and demand mainly from Southeast Asia was active, all iron and steel products greatly increased their export levels in 2001. However, safeguard measures were invoked in China and the EU, so increases in exports are expected to slow down in the future due to cautious export policies.

In terms of production, due to the dramatic increase of overseas demand in 2002, crude steel production greatly exceeded the initial projection of around 95 million tons. It saw a 107.75 million tons or 4.88 million tons (4.7%) increase compared to 2001, and the 100-million-ton level was maintained for three years consecutively.

By furnace type, steel production at converters was 78.53 million tons (a 5.5% increase), and at electric furnaces was 29.21 million tons (a 2.8% increase). The electric furnace ratio was 27.1%, indicating a decrease for a sixth consecutive year.

By steel type, ordinary steel production was 87.35 million tons (a 4.0% increase), and special steel was 20.40 million tons a 7.9% increase. However production of special steel made a highest record.

In terms of materials, production of hot-rolled ordinary steel was 80.86 million tons (an increase of 1.94 million tons or 2.5%) compared to 2001, so the 80-million-ton level was recovered.

By product type, production of heavy-medium plates decreased 2.5%, while wire-rod products showed a double-digit decrease, H-sections decreased 4.7%, and the figures fell compared to 2001. On the other hand, production of hot-rolled special steel products was 17.44 million tons (an increase of 1.61 million tons or 10.1%) compared to 2001, maintaining the 15-million-ton level over three years consecutively. This was a highest record surpassing the 16.81 million tons produced in 1991.

Therefore, total production of both steel products was 98.31 million tons (an increase of 3.55 million tons or 3.7%), and the 90-million-ton level was maintained for a third consecutive year (Table 1).

Export of all iron and steel products was 36.32 million tons (an increase of 5.84 million tons or 19.2%) compared to 2001, and this was the sixth consecutive year of increase. Pig iron, ordinary steel ingots, ordinary steel products, spe-
cial steel products, and secondary products increased. Ferroalloy and special steel ingot semi-products decreased. For ordinary steel products, heavy plates, steel pipes, and main product steel sheets (hot-rolled wide strips, galvanized sheets, cold-rolled wide strips, and electrical sheets) increased. Among steel sheets, tinplates decreased slightly.

In terms of the international market, Korea and China increased their exports for the fourth consecutive year, while the United States showed a significant decrease. Taiwan showed an increase for the first time in three years, and Thailand increased in 2002.

Imports were 5.26 million tons, a significant decrease of 0.83 million tons or 13.6% compared to 2001. Looking at the details, while secondary products and ferroalloy increased, pig iron, semi-products, ordinary steel products, and special steel products decreased. Particularly, among ordinary steel products that are major products, heavy plates, hot-rolled wide strips, cold-rolled wide strips, and galvanized sheets decreased.

The main importers—Korea, Taiwan, and China—all failed to surpass the 2001 level.

In this severe environment, following 2001, the blast furnace industry withdrew from unprofitable products, engaged in cooperative work on products, strengthened collaboration with supplementary divisions including distribution, maintenance, and procurement, and participated in technological cooperation with overseas iron and steel industries in light of the globalization movement.

Specifically, NKK Corp. and Kawasaki Steel Corp. established a joint holding company, JFE Holdings, Inc., on September 2002. Also, three companies including Nippon Steel Corp., Sumitomo Metal Industries, Ltd., and Kobe Steel, Ltd. agreed on capital cooperation in the form of holding each other’s stock to strengthen their cooperative relationship on November 14, 2002. In such developments, Nippon Steel Corp. and Sumitomo Metal Industries, Ltd. agreed to integrate their stainless business on October 2003. Also, Nittetsu Steel Sheet Corporation was established in October through a merger of Daido Steel Sheet Corp. and Taiyo Steel Co., Ltd. The restructuring of the distribution industry occurred rapidly starting in 2001, and following the establishment of Marubeni-Itochu Steel Inc., Metal One Corporation, an integrated trade company for iron and steel, was established by Mitsubishi Corporation and Nissho Iwai Corporation in January 2003.

Such developments are positioned as structural reforms for strengthening the Japanese iron and steel industry to deal with increased competition due to further economic globalization as well as supplier selection policy due to customer choice and concentration, and this is expected to continue for the next few years.

2. Technology and Facilities

2.1. Ironmaking

Pig iron production in 2002 was 80.98 million tons, or a 2.7% increase compared to 2001, and the 80 million ton mark was recovered for the first time in two years. Average pig iron productivity was 1.97 t/m³·day, which was a slight increase compared to the previous year’s 1.94 t/m³·day.

Activities for individual blast furnaces were as follows. The furnace capacity of Mizushima No. 4 BF, Kawasaki Steel Corp. was expanded from 4.826 m³ to 5.005 m³ and was blown-in on January 8, 2002, after a while Mizushima No. 1 BF was blown-out on January 23. Kokura No. 2 BF, Sumitomo Metals Kokura, was blown-out on March 31, 2002, underwent 10-day short-term renovation to expand its capacity from 1.850 m³ to 2.150 m³, and was re-blown-in on April 10. The renovation of Kashima No. 1 BF, Sumitomo Metal Industries, Ltd. was started on May 1 (scheduled to be blown-in at end of September 2004). Funamachi No. 1 and No. 2 BFs, Nakayama Steel Works, Ltd. were blown-

| Table 1. Transition of iron, steel and steel main goods production. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Total | Total | Jan.-March | April-June | July-Sept. | Oct.-Dec. | (%) |
| Crude steel | 94,192 | 106,444 | 102,863 | 107,745 | 25,055 | 27,287 | 27,342 | 28,062 | 5.7 |
| By B.O.F | 65,452 | 75,784 | 74,442 | 78,533 | 18,182 | 19,725 | 20,304 | 20,322 | 5.5 |
| By E.A.F | 28,740 | 30,660 | 28,421 | 29,212 | 6,873 | 7,562 | 7,038 | 7,740 | 2.8 |
| Pig iron by B.F | 74,518 | 81,068 | 78,833 | 80,979 | 19,395 | 20,242 | 20,689 | 20,654 | 2.7 |
| Hot-rolled ordinary steel | 73,221 | 83,044 | 78,789 | 80,864 | 19,428 | 20,167 | 20,513 | 20,766 | 2.6 |
| Large H sections | 6,652 | 7,235 | 6,206 | 5,914 | 1,504 | 1,509 | 1,407 | 1,495 | -4.7 |
| Medium and Small sections | 1,636 | 1,752 | 1,558 | 1,576 | 403 | 416 | 370 | 387 | 1.2 |
| Small bar | 11,850 | 12,247 | 11,908 | 12,430 | 3,066 | 3,172 | 3,038 | 3,154 | 4.4 |
| Wire rods | 2,896 | 2,736 | 2,401 | 2,056 | 560 | 528 | 494 | 473 | -14.4 |
| Medium & Heavy plate | 7,629 | 8,618 | 9,301 | 9,066 | 2,313 | 2,131 | 2,167 | 2,455 | -2.5 |
| Wide hot strip | 36,873 | 44,529 | 41,724 | 44,152 | 10,193 | 11,021 | 11,626 | 11,313 | 5.8 |
| Hot-rolled special steel | 14,224 | 15,748 | 15,828 | 17,443 | 3,953 | 4,330 | 4,555 | 4,605 | 10.2 |
| Structure steels | 5,430 | 6,209 | 6,087 | 6,688 | 1,527 | 1,638 | 1,711 | 1,812 | 9.9 |
| Stainless steel | 2,651 | 3,021 | 3,138 | 3,096 | 740 | 762 | 815 | 779 | -1.3 |
| Spring and bearing steels | 1,008 | 1,172 | 1,009 | 1,099 | 232 | 265 | 295 | 307 | 8.9 |

Source: Research and Statistics Dept., Economic and Industrial Policy Bureau, Ministry of Economy, Trade and Industry, "Monthly of Iron and Steel Statistics"
out on July 10 and 23, respectively. As listed, operation of blast furnaces in 2002 shifted from 31 operating at the beginning of the year to 29 by the end of the year. Mizushima No. 2 BF, Kawasaki Steel Corp. (blown-in on March 20, 1979) continues to hold the world record for furnace lifespan.

As shown in Fig. 1, the average ratio of pulverized coal injection (PCI) was 132.2 kg/t, which remained almost unchanged from the previous year. For new ironmaking technologies, NKK Corp. put into practice technology for continuous online measurement of grain size of coal transported on conveyer belts.

In slag use technology, NKK Corp. developed technology to improve ocean environments in which “marine blocks” for the construction of artificial reefs from steelmaking slag and “sand capping” made from granulated blast furnaces slag deployed last year. Kawasaki Steel Corp. developed “permeable pavement” to prevent a “heat island effect” using blast furnace slag. This is an application technology for paving material that lowers road surface temperature.

2.2. Steelmaking

For steelmaking, as shown in the work performance of converter in Table 2 and work performance of electric furnace in Table 3, the productivity index per steelmaking hour continued to improve for converters and recovered for electric furnaces.

The ratio of continuously cast steel billet among hot-rolled steel products is shown in Fig. 2. Ordinary steel remained almost same compared to 99.7% in 2001, while special steel increased to 93.6% from 92.8% in 2001. As regards activities in steelmaking technology and facilities, companies engaged in measures to deal with increased sophistication and tightening of market demand, work to maintain international cost competitiveness, and technological research to reduce impacts on the earth’s environment.

Table 2. Operation performance of converter.

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<tr>
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<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>Jan.-March</th>
<th>April-June</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity index per steelmaking hour*</td>
<td>102</td>
<td>105</td>
<td>106</td>
<td>108</td>
<td>110</td>
<td>109</td>
</tr>
<tr>
<td>Steelmaking time index per tap to tap*</td>
<td>98</td>
<td>98</td>
<td>100</td>
<td>100</td>
<td>99</td>
<td>100</td>
</tr>
<tr>
<td>Pig iron mixing ratio(%)</td>
<td>93.6</td>
<td>92.1</td>
<td>92.5</td>
<td>92.9</td>
<td>91.6</td>
<td>92.3</td>
</tr>
<tr>
<td>Hot metal mixing ratio(%)</td>
<td>92.8</td>
<td>91.1</td>
<td>91.7</td>
<td>91.9</td>
<td>90.0</td>
<td>91.0</td>
</tr>
<tr>
<td>Oxygen consumption (Nm³/t)</td>
<td>60.4</td>
<td>59.5</td>
<td>59.5</td>
<td>58.8</td>
<td>57.9</td>
<td>58.4</td>
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<tr>
<td>Ratio of continuous cast steel(%)</td>
<td>99.3</td>
<td>99.3</td>
<td>99.3</td>
<td>99.1</td>
<td>99.1</td>
<td>99.1</td>
</tr>
<tr>
<td>Ratio of vacuum treated steel(%)</td>
<td>62.4</td>
<td>63.3</td>
<td>65.5</td>
<td>68.0</td>
<td>68.2</td>
<td>68.1</td>
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</table>

* The index is based on the average of 1996~1998, 100
Source: The Iron and Steel Federation

Table 3. Operation performance of electric furnace.

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<thead>
<tr>
<th></th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>Jan.-June</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity index per steelmaking hour*</td>
<td>93</td>
<td>94</td>
<td>94</td>
<td>99</td>
</tr>
<tr>
<td>Electric power consumption per ton of good ingot (kWht)</td>
<td>406.8</td>
<td>407.3</td>
<td>415.5</td>
<td>415.7</td>
</tr>
<tr>
<td>Oxygen consumption per ton of good ingot (Nm³/t)</td>
<td>20.8</td>
<td>20.3</td>
<td>19.9</td>
<td>19.7</td>
</tr>
<tr>
<td>Yield of good ingots (%)</td>
<td>91.4</td>
<td>91.4</td>
<td>91.3</td>
<td>91.9</td>
</tr>
<tr>
<td>Ratio of good continuously cast steel (%)</td>
<td>88.2</td>
<td>87.2</td>
<td>87.9</td>
<td>89.0</td>
</tr>
<tr>
<td>Ratio of alloy steel (%)</td>
<td>35.9</td>
<td>37.7</td>
<td>37.8</td>
<td>35.5</td>
</tr>
</tbody>
</table>

* The index is based on the average of 1996~1998, 100
Source: The Iron and Steel Federation

Fig. 1. Increase in pulverized coal rate injected into blast furnace in Japan.
Source: The Japan Iron and Steel Federation.
As regards steelmaking processes, Muroran Works and Oita Works, Nippon Steel Corp. developed a multifunctional converter method to enable slag reduction of volume and heat loss through continuous desilification, dephosphorization, and decarbonization processes in one furnace (see Topics).

In continuous casting, Wakayama Works, Sumitomo Metal Industries, Ltd., achieved improvements in quality and productivity through development of technology to add rotary flow in immersion nozzles for continuous casting, based on the basic research conducted at the Nippon Institute of Technology and Osaka University.

Other activities include the following: the development of injecting oxygen device which automatically connects consumable lance in the electric furnace of the Headquarter Plant, Sanyo Special Steel Co. Ltd.; and development of an automatic production system for production diagrams from converter to continuous casting, utilizing genetic algorithms, at Keihin Works, NKK Corp.

2.3. Plates; Pipes and Tubes; Sections, Wires, and Rods

For plates, Mizushima Works, Kawasaki Steel Corp. developed a technology for producing high quality heavy plates by new processes in which forging draft in two directions is applied before ordinary rolling using continuous casting slab.

Kobe Steel Ltd. succeeded in reducing unevenness in materials (YP) to less than half by completing a new Plate ROLLing system for MEnchanted property control technoloGY (PROME system) where the pass schedule for plate rolling can be set from property projection technology and fine adjustments can be made online for each pass.

For bars and wire rods, Headquarter, Sanyo Special Steel Co., Ltd. expanded its new refining line which allows from cutting to binding and weighing by combining the double level run out table and reverse table to accommodate space limitations.

Tobu Plant, Daiwa Steel Corp., commenced operations of a continuous rolling facility for steel bars which involves a method for welding rough-rolled 45Ø bars.

Regarding other activities, the Steel and Iron Research Center, Nippon Steel Corp., presented the critical diffusible hydrogen method for evaluating delayed fractures in high tensile bolts, and published material on the evaluation and application technology.

2.4. Sheets

Fukuyama Works, NKK Corp., installed a high-precision super online accelerated cooling system for hot strip mills (Super-OLAC H) as the run out cooling system in No. 1 Hot Strip Mill, to control sheet heat history, to maintain even temperature across the width and length, to produce finer crystal grains, and to even out material quality.

In April, Yawata Works, Nippon Steel Corp., started operation of G.A.P.L. (Galvanizing, Annealing and Processing Line) for cold-rolled steel sheets and alloying galvanized sheets. The annual production capacity was 0.46 million tons, and it would mainly produce high quality automobile parts.

The General Research Center, Sumitomo Metal Industries, Ltd., developed a visible light responsive photocatalyst which showed 10 times more photocatalyst action indoors than conventional products. In the future, this product will be developed into paint and applied to various building materials, interior materials, and electric household appliances.

2.5. Miscellaneous

In plant and measurement activities, NKK Corp. developed a next-generation plant diagnostic online monitoring system. While achieving down-scaling, this is a system with added sophisticated functions such as abnormality criterion where abnormality of the plant is detected from a data trend, even if appropriate threshold values are not set. It also has a system aging diagnosis function for maintenance purposes, and a web function which allows continuous remote monitoring of the plant.

Regarding analytical techniques, the Technical Research Center, Kawasaki Steel Corp., developed a rapid analysis method which allows dioxin analysis in half the time where conventionally about 10 days were necessary. Using two-step column chromatography, a one-step continuous processing method was accomplished in the clean-up process, where the samples had previously had to be melted several times.

3. Technology Export and Import

For the particulars of technological trade in the year 2002, the results of a survey conducted among the support-
The number of technology exports increased significantly to 93 cases compared to 37 cases in 2001, while the number of technology imports were four cases which were almost the same as previous year (five cases in 2001). Exports went done primarily to Asia, which dominated by 49%, followed by North America, Central and South America, and Europe. While there was only one case of export to North America last year, the number increased greatly to 22 cases (24%).

By technological field, 54% were process and treatment, 25% were steelmaking, 13% were ironmaking, and these three dominated 92% of the total. Overall operation, which dominated by 18% in 2000, remained at a low level as in
the previous year. Figure 3 shows the balance of technology trade of the iron and steel industry to 2001FY. Technology imports against payment receipts were 28% less compared to the previous year, but technology exports against payment receipts remained almost the same.

4. Research Expenditure

Figures 4 through 8 show the corporate research expenditures and changes in number of researchers according to the “Survey on Science and Technological Research” of the Statistics Bureau, Ministry of Public Management, Home Affairs, Posts and Telecommunications.

The total company-use research expenditure for the whole industry increased in 2001 after having remained level for the previous few years. The decrease trend has continued in the iron and steel industry since 1992FY (Fig. 4).


Fig. 5. Trend of the ratio of sales to research expenditure. Source: “Report on the 2002 Survey of the Research and Development”, Statistics Bureau, Ministry of Public Management, Home Affairs, Posts and Telecommunications.


Fig. 8. Trend of the number of researcher per 10 000 employees. Source: “Report on the 2002 Survey of the Research and Development”, Statistics Bureau, Ministry of Public Management, Home Affairs, Posts and Telecommunications.
The ratio of research expenditure against sales for the whole industry turned upward in 2001FY, but for the iron and steel industry, the decrease trend has continued since 1999FY (Fig. 5).

The number of dedicated researchers for the whole industry decreased in 2001FY, but recovered subsequently. In contrast, the iron and steel industry saw a continued decrease trend except in 1998FY (Fig. 6).

Research expenditure per dedicated researcher was higher for the iron and steel industry as compared to industry as a whole, but industry as a whole showed a slight increase, while the iron and steel industry showed a decrease, and the difference between the two diminished (Fig. 7).

The number of dedicated researchers per 10,000 workers tended to increase for the whole industry, but the increase rate for the iron and steel industry was smaller in comparison, and the difference between the two widened (Fig. 8).

5. Creation of New Technology at the ISIJ

At the ISIJ, research and topic search activities for iron and steel production technology were conducted mainly by the Technical Society, and categories and contents of the activities are listed in Table 5.

As one of the notable points of ISIJ’s topic search in 2002, suggestions pertaining to iron and steel environment technology were presented to the government (detailed in Sec. 5.4).

(Academic research into iron and steel is conducted in the Technical Division of the Academic Society, as well as in Forums, the subordinate organizations of the Academic Society.)

5.1. Technical Committees

In the Technical Committees, the committees were grouped according to their activities, so they would correspond to the Technical Divisions of the Academic Society, for the purpose of vitalizing exchanges between industries and universities, as well as promoting suggestions in technological development issues.

As shown in Table 6, the Committee Meetings in 2002FY concentrated on common and focus subjects which were considered significant at that point, and active discussion were engaged.

Participation of university researchers in the Committee Meetings, which were started to strengthen links between industries and universities for technology creation, as well as joint organization and two-way participation with the Technical Divisions of the Academic Society, are being established as standard activities.

For the Committees which convened twice a year, one of the meetings was arranged as a one-day meeting dedicated to research discussion, and an award system was introduced to promote the activities of the Committee and to improve the quality of papers. Each Committee, while attempting to lighten its load in accordance with its activities, worked to revise its mode of operation to create greater productivity.

The following 12 Subcommittees were created in

<table>
<thead>
<tr>
<th>Table 5. Technology creation activities of Technical Committee, Interdisciplinary Technical Committee, and Research Group.</th>
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<tbody>
<tr>
<td><strong>Technology creation activities</strong></td>
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<tr>
<td>Technical Committee</td>
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<tr>
<td>Interdisciplinary Technical Committee</td>
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<tr>
<td>Research Group</td>
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### Table 6. Activities of the Technical Subcommittees.

<table>
<thead>
<tr>
<th>Technical Subcommittee</th>
<th>Common Subject</th>
<th>Particular Subject</th>
<th>Report from Technical Subcommittee</th>
<th>Special Lecture</th>
<th>Spring Meeting</th>
<th>Autumn Meeting</th>
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<tbody>
<tr>
<td>Ironmaking</td>
<td>Raw fuel quality design and PCI operation: Open topic research presentation: Special lecture “On compact blast furnace project”</td>
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<td></td>
<td>5th Reporting of Production Technology</td>
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<td></td>
<td>Measures against abnormal operation of coke oven and human resource education: Open topic research presentation: Special lecture “Environmental recycling in iron and steel industry”</td>
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<tr>
<td>Steelmaking</td>
<td>Improvement of injection system mainly in tandish mold</td>
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<td></td>
<td>Improvement of primary smelting process function taking into consideration environmental existence: Open topic research presentation: On cooperation with TC on High Temperature Process: Special lectures “Presentation of Research Group on High Temperature Property Values of Fused Oxides” “Basic research on iron and steel and environment”</td>
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<tr>
<td>Electric Furnace</td>
<td>“CC operation and quality”: Open topic research presentation: Work survey table: Special lecture “On CC plant and quality”</td>
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<td></td>
<td>“Champion data and its analysis”: Open topic research presentation: Work survey table report: Special lecture “On environment responsive high efficiency arc furnace (EcoArc)”</td>
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<td>Special Steel</td>
<td>Surface quality improvement for automotive CC material: Open topic research presentation: Special lecture “Work on development of advanced automotive metal material at Toyota Research Center”</td>
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<td>“Recent quality improvement in stainless steel and others”: Open topic research presentation: Special lecture “Interim report of Research Group for creation of Innovative High-Efficiency Mixing/Separating Reactor”, “On rotary flow nozzle and inter-metal flow control”</td>
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<td>Refractories</td>
<td>Panel discussion “Recycle of refractories”: Special lecture “Relationship between high-temperature interfacial phenomenon and technological issues in wear of refractories”</td>
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<td></td>
<td>Joint organization with Refractories Society: Presentation of papers</td>
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<tr>
<td>Heavy Plate</td>
<td>Plant operation status report: “Skill transfer”</td>
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<td></td>
<td>Plant operation status report: Staff Gr. discussion “Improvement of productivity,” Foreman Gr. discussion “Overall workplace management and productivity”</td>
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<td></td>
<td>Special lecture “On distortion behavior of surface flaw in rolling”</td>
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<tr>
<td>Hot Strip</td>
<td>Technical Subcommittee report: Foreman’s seminar: Special lecture “Surface flaw analysis in rolling with FEM simulation technology”</td>
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<tr>
<td>Cold Strip</td>
<td>Plant operation status report: Foreman Gr. discussion: Case study presentation</td>
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<tr>
<td></td>
<td>Plant operation status report: Foreman Gr. discussion: Case study presentation: Special lecture “Elastoplastic FEM analysis in rolling”</td>
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<tr>
<td>Coated Steel Sheet</td>
<td>Common subject (worker and operation status survey): Open topics presentation</td>
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<td></td>
<td>Plant operation status report: Technical Committee report “Improvement of productivity (high speed production)”: Common subject (operation status survey)</td>
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<td>Large Section</td>
<td>Joint organization with Shape Engineering Forum: Topics “Tribology (roll wear, lubrication, seizure, etc.)”</td>
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<td></td>
<td>Technical Subcommittee report: Special lecture “Current status and issue for section steel rolling analysis”</td>
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<tr>
<td>Medium and Small Sections</td>
<td>Plant operation status report: Open topics “Quality control system”: Foreman Gr. discussion: Special lecture “Current status and future of material and texture control”</td>
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<td>Plant operation status report</td>
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<td>Wires and Rods</td>
<td>Plant operation status report: Open topic research presentation</td>
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<td></td>
<td>Plant operation status report: Common subject topics “Improvement of productivity”: Special lecture “History of secondary wire processing (drawing) and technical trend”</td>
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<td>Steel Pipes and Tubes</td>
<td>Plant operation status report: Exchange with Pipe Engineering Forum: Special lecture “Environmental energy and regeneration of Keihin Ocean Front Metropolitan Region”</td>
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<td>Technical Subcommittee</td>
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<tr>
<td>Rolling Theory</td>
<td>Technological developments in rolling of sheet/plate/wire rod, rolling/forming of steel pipe, and related technology: Interim reports of Technical Subcommittee and Research Groups: Special lecture “Advances in STX21 Project and perspectives in processing technology”</td>
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<td>Heat Economy Technology</td>
<td>Latest heat/fluid measurement and analysis technology in iron and steel processes: Topics report from companies: Special lecture “Recent analysis technology in heat/fluid process”</td>
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<tr>
<td>Control Technology</td>
<td>Presentation of technical papers: Special lecture “R&amp;D case studies in measurement and testing technology in railroads”, “On the role and potential of control technology”</td>
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<td>Presentation of topics (measurement, system, construction and maintenance): Special lecture “Data use technology in design work: introduction of response surface method”</td>
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<td>Plant Engineering</td>
<td>Technical Subcommittee report: Case study presentation: Open topic research presentation: Special lecture “Some issues in hot texture control”</td>
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<td></td>
<td>Common subject “Plant technology and management using IT (information technology)”: Lecture by specialist company (Technological lecture “Manufacturing technology and information technology”: Special lecture “Introduction of Corus compact hot strip mill DS9”</td>
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<td>Quality Control</td>
<td>NDI Division: Regular report of work performances: Technical Subcommittee report: Special lecture “Recent trends in testing accreditation”</td>
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<td>Analysis Technology</td>
<td>Technical Subcommittee report: Reports of Academic Division’s activities</td>
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<td></td>
<td>Technical Subcommittee report: Reports of Academic Division’s activities: Technical transfer</td>
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Table 7. Objectives of new Research Groups and results of Research Group that completed activities in 2002FY.

<table>
<thead>
<tr>
<th>Research Group</th>
<th>Objective/Results of Activity</th>
<th>Activity term (Fiscal Year)</th>
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<tbody>
<tr>
<td>New Group Development of new coke-making technology for non- or poorly–cooking coals</td>
<td>This group is studying the mechanism of coking behavior of non- or poorly-cooking coals in order to achieve higher usable ratios of non- or poorly-cooking coals for manufacturing high-quality coke. Specifically, the mechanism of coke structural formation, new method to evaluate coke strength, and modeling of coking behaviors of coals were examined in 2002.</td>
<td>2002-2005</td>
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<td>High-temperature property values of fused oxides</td>
<td>Major and latest data on high-temperature property values for viscosity of fused slag, surface tension, and heat conductivity are surveyed and evaluated; case studies for development of estimation method, measurements, and measurement methods are collected; and these materials will be published as books.</td>
<td>2002-2005</td>
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<td>Control of blast furnace limiting phenomenon to minimize production of CO₂</td>
<td>With the objective of achieving low fuel ratio operation to reduce CO₂, researches are done to comprehensively improve accuracy of blast furnace model analysis by extracting and controlling the factors that limit migration inside the blast furnace, as well as by solving instability under low fuel ratio.</td>
<td>2002-2005</td>
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<tr>
<td>Control of iron and steel materials through phase transformations in high magnetic field</td>
<td>The effects of high magnetic field on solid/solid phase transformation behavior and structures in iron and steel materials are investigated to clarify the mechanism of the formation of microstructures and orientation in high magnetic field.</td>
<td>2002-2005</td>
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<tr>
<td>Completed Group Advanced Application of Electromagnetic Processing of Materials</td>
<td>As results that lead to specific practical application, electromagnetic separator for inclusions, shifting magnetic field mixer, and refining efficiency in cold crucible were suggested, and their application were presented concretely. Also, technologies such as electromagnetic acoustic wave and electromagnetic interface surface are continuing in the direction of practical application. In technologies using high magnetic field, applications such as magnetic levitation technology, production of new functional films, achieving high performance in fuel cell, and production of high strength carbon fiber and anisotropic special materials were presented. In simulation technology, electromagnetic flow around inclusion particles in electromagnetic field and convection current in gas and liquid phases by magnetizing force were clarified.</td>
<td>1999-2002</td>
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<td>Enhancement of Photosynthetic CO₂ Fixation by Marine Phytoplankton with Steelmaking Slag as a Nutrient Source</td>
<td>The CO₂ in atmosphere is fixed by increasing the phytoplankton using steelmaking slag as a nutrient source. The approaches include the following: 1) developing technology to elute the constituents from steelmaking slag as a nutrient source into seawater, 2) investigating elution apparatus for photosynthesis of marine phytoplankton and utilization of the enhanced plankton, and 3) establishment of assessment method for the impact on ecosystem and the environment. Based on these results, estimation was also conducted for the practical amount of CO₂ fixation using steelmaking slag.</td>
<td>1999-2002</td>
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<tr>
<td>Advanced Diagnosis and Control Techniques for Labor-Saving Based on a Large Quantity of Data</td>
<td>The following studies were conducted: complete automation of manual task by advancement and computerization of measurement control system, centralized monitoring of plant and operation, optimization of maintenance status by computerization of plant degradation diagnosis, achievement of comprehensive operation safety system, and consideration of methodology for transmission and support of expert skill and knowledge by developing and utilizing information data modeling technology, and establishment of foundation of such technology.</td>
<td>1999-2002</td>
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<tr>
<td>Elucidation of Behavior of Boron and Promotion of Its Usage in Steel</td>
<td>The behavior of trace boron in iron and steel materials was examined to promote further usage of boron to improve steel properties as formability, surface hot shortness due to Cu, hardenability, creep strength, weldability, delayed fracture etc. of high carbon, low carbon, ultra low carbon, ferritic stainless, martensitic heat resistance and high strength low alloy steels. Techniques for observation of boron in steel were also examined to be revised or developed.</td>
<td>1999-2002</td>
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<tr>
<td>Precipitation Control in Steels</td>
<td>Research and discussions were conducted on various topics as follows: thermodynamics of precipitation; nucleation and growth kinetics; modeling; relationship between precipitation and mechanical property; interaction among precipitation, transformation, recrystallization and grain growth; development of materials using precipitates; and analysis technology of precipitates. Based on the latest information on these topics, deeper understanding was obtained for the fundamentals of precipitation, and material quality, and future topics of investigation were organized.</td>
<td>1999-2002</td>
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2002FY, and together with Subcommittees that completed activities in the fiscal year, 29 Subcommittees were active.

- The Optimum total energy for Electric Arc Furnace (Electric Furnace)
- Refining and heating of ladle furnaces (Special Steel)
- Refractory Maintenance for steel ladles (Refractories)
- Current status of worker rationalization and future issues (Hot Strip)
- Productivity improvement with high speed operation in CGL (Coated Steel Sheet)
- Prospect and task for zero emissions in steel industries (Heat Economy Technology)
- Achieving high precision in interior defect detection by ultrasonic methods (Control Technology)
- Achieving high precision in interior defect detection by magnetic methods (Control Technology)
- Life Extension Technology of Wear Parts in Iron Making Process (Plant Technology)
- Periodical Research of equipment for NDI of steel plate (Quality Control)
- Text revision: magnaflux testing methods for iron and steel products (Quality Control)
- Text revision: ultra sonic testing methods for seamless steel tubes (Quality Control)

5.2. Interdisciplinary Technical Committee

The “Interdisciplinary Technical Committee for Phase-Control Metallurgy and Properties of Modern Structural Steel” completed its activities. The “Interdisciplinary Technical Committee for Desirable Steel Materials for Automobile” continued its activities for the third period (to 2003FY).

5.3. Research Group

In 2002FY, four Research Groups were created and five completed their activities. The objectives and results of each Group are shown in Table 7. Table 8 shows the activities of continuing Research Groups (excluding those which started or finished in 2002).

5.4. Committee for Future Perspectives for Iron and Steel Environment Technology

The Committee was established at the end of July 2002 with 17 experts from industries, universities, and government, and reviewed: 1) technology focusing on the environment and energy based on iron and steel technology, 2) its future perspective, 3) national system design, 4) the scope of education and research for environmental technology at universities, 5) the role of academic societies, and 6) the necessity for an academic society for environmental technology. The results were prepared as a report. In this report, suggestions were made to the government to develop focal technology in three fields pertaining to the environment and energy utilizing an ironmaking platform as “eco-kombinat” which circulates resources and energy in cooperation with industries and communities, as follows:

1. Technological development of supplier industry of clean energy (hydrogen and electricity)
2. Contribution to solution of CO₂ problem (CO₂ reduction, fixation, separation; eco-products)
3. Utilization of platform and ironmaking infrastructure linked to intra-industry resource circulation as social system

Acknowledgements

The Author would like to acknowledge: the Ironmaking Planning Office, Iron and Steel Division, Manufacturing Industry Bureau, Ministry of Economy, Trade and Industry (The economic circumstance of the Japanese iron and steel industry); The Japan Iron Steel Federation (The economic circumstances of the Japanese iron and steel industry and various statistical data); and members and staffs of the ISIJ.
Technologies, facilities, and products of the supporting member companies of ISIJ to pay attention from January to December 2002 are as follows.

1. Converter · Secondary Refining

New Refining Process by Multi-refining Converter Method

Nippon Steel Corporation

Conventional hot metal pretreatment methods had such problems as heat loss, increased process time and retention time related to multi-step refining. NSC has developed MURC (Multi-refining Converter) technology in which such pretreatment processes as desiliconization and dephosphorization are integrated in a converter and all of the processes which include desiliconization, dephosphorization, deslagging, and decarbonization are completed sequentially in a single converter. This new method is in operation at NSC Muroran Works and Oita Works, with remarkable improvements in thermal tolerance, drastically reduced process time and retention time, while the pretreatment effect is secured as required.

This method, using a converter, performs high-speed dephosphorization by using low-basicity, high (%T, Fe) slag. In the desiliconization phase and dephosphorization phase, the (%T, Fe) concentration is increased intentionally to maintain the slag in foaming condition. The converter is then tilted for natural deslagging. After subsequent decarbonization, steel is tapped. Slag after the process of decarbonization is partially maintained in the converter to be used in the next desiliconization and dephosphorization blowing process as hot-recycled material. With a converter type dephosphorization method employed, high oxygen gas rates are obtained and improved thermal tolerance is possible with hot-recycled slag. As a result, a high ratio of hot metal dephosphorization treatment can be achieved without decrease of scrap ratio.

Since a series of processes are performed sequentially, the time required to complete these processes at Oita Works, for example, is about 38 min. The total processing time, including such processes as desiliconization, dephosphorization, and decarbonization has been dramatically shortened.

2. Hot-rolling Strip Mill

Super-OLAC H Introduced at Hot Strip Mill at Fukuyama Works

NKK Corporation (JFE Steel Corporation)

NKK’s Fukuyama Works (now JFE Steel West Works Fukuyama Mill) has completed installation of the Super-OLAC H (On-line accelerated cooling for hot strip mill) system at the runout-cooling zone of its No. 1 strip mill. The Super-OLAC system has already been installed at the plate mill in 1998, enabling both the ultra-rapid and uniform cooling for the production of high quality steel.

Until now, installation of the OLAC system at the runout-cooling zone of a hot strip mill has been hampered by several technical difficulties. An extremely high cooling rate exceeding 70 km/h made it hard to achieve ultra-rapid cooling without hindering continuous strip rolling. JFE Steel overcome this hurdle by incorporating a unique driving device into the table rolls, in addition to making other improvements in the new Super-OLAC H system, thereby maximizing the system’s cooling accuracy while securing continuous strip rolling. The newly attained cooling rate of 700 K per second for a sheet thickness of 3 mm is the highest in the world.

Start-up of Super-OLAC H at No. 1 hot strip mill of Fukuyama has enabled stable production of high-tensile-strength steel sheet with use of various thermo-mechanical control processes, winding up a series of facility renovation, such as reinforcement of all regenerative burners at the reheating furnace, installation of a new solenoid induction-coil heating system for rough bars and expansion of roughing and finish-rolling mill.

Hyper Burring High-carbon Steel Sheet

NKK Corporation (JFE Steel Corporation)

NKK has developed a new type of formable high-carbon hot-rolled steel sheet named “Hyper Burring High-carbon Steel Sheet” suitable for the application for automotive high-strength transmission parts, in which forming burring is one of the important forming mode. Super-OLAC H (on line accelerated cooling for hot strip mill), that is the accu-
rate and rapid cooling device installed at Fukuyama No. 1 hot-rolling mill in April 2002, has greatly contributed to its microstructural control. Although conventional forming processes of automotive transmission parts are forging and casting, press forming has been recently applied to the forming of those parts in view of cost reduction. However, poor burring formability of conventional high-carbon steel sheets leads to cracking during press forming process and has difficulty in its application for press forming because partial increase in flange wall thickness in press forming requires high burring formability.

Super-OLAC H can provide the highest cooling rate in the world of 700°C/s in 3 mm thick sheet. This high cooling rate effectively improves homogeneity and control accuracy of hot band’s microstructure, which can’t be achieved by conventional equipments. Sheet products after annealing has excellent burring formability due to more homogeneous and fine dispersion of spheroidized cementites than those of conventional high-carbon cold-rolled steel sheets.

The Hyper Burring High-carbon Steel Sheet with both excellent burring formability and hardenability can contribute much more to cost reduction of automotive transmission parts by applying this product to the press forming and the partial strengthening of complicated shaped parts.

BHT Sheet Steel

A new high strength hot-rolled sheet steel with significantly increased tensile strength induced by strain age hardening using the element N, trade-named BHT (Bake Hardenable steel with Tensile strength increase), was developed by JFE Steel Corporation. The new sheet shows a remarkable increase in tensile strength as well as yield strength after strain age hardening. The increase in TS is substantially greater than that which can be achieved with conventional BH steels. The new sheet possesses excellent crashworthiness and high fatigue strength, and also shows good formability, equal to that of conventional high strength sheets.

The increase in TS observed in the developed steel is attributed to the fact that the dislocations introduced during press forming become strongly and densely locked during paint baking. Therefore, plastic deformation applied after paint baking encourages multiplication of these dislocations. The increased TS after paint baking is considered to be a result of the higher external force required for movement of a dislocation through this higher density of dislocations.

The developed sheet is produced by a hot rolling process utilizing a proprietary high accuracy cooling technology to secure solute N in the steel and simultaneously refine the crystal grain size. This process makes it possible to satisfy both of the mutually contradictory requirements of a high strain age hardening capacity and an anti-aging property at room temperature.

Because the developed sheet has a large energy absorption capacity in high strain rate deformation and high fatigue strength, it is considered suitable for application to structural parts of vehicles requiring crashworthiness and/or durability. An evaluation of the improvement in crashworthiness when the developed sheet is used as a vehicle structural member showed that the contribution of strain age hardening corresponds to a sheet thickness increase of approximately one-half gauge (0.1 mm) or a tensile strength increase of approximately 60 MPa. BHT steel sheets have already been adopted in actual vehicle structural members, achieving a 10% weight reduction.

The newly developed sheet can contribute to weight reduction by enabling the automaker to reduce material thickness without sacrificing safety, or to securing the formability of hard-to-form parts by reducing the material strength level before forming. This innovative product is expected to make a large contribution to safety and to the solution of environmental problems, which are now required in automobiles.
3. Cold Rolling Steel—Surface Treatment

New Facility: Cold-rolled, Plated Steel Sheet Production Line G.A.P.L. (Galvanizing, Annealing and Processing Line)

Nippon Steel Corporation

Nippon Steel Corporation (NSC) constructed its new G.A.P.L. (Galvanizing, Annealing and Processing Line) at Yawata Works in order to increase the production capacity for high-grade steel sheets mainly supplied for automobile applications and to improve and integrate their old annealing facilities and a hot-dip galvanization line. The new line started operation in April 2002.

This facility is the world’s first line capable of producing both cold-rolled steel sheets (CR) and galvannealed steel sheets (GA) having a thickness in the range of 0.4 through 2.3 mm and a width of 600 mm to 1880 mm (which is almost the greatest width achieved by a facility of this kind). The annual production capacity of the facility is as high as 460,000 metric tons.

The individual component equipment of the facility includes an electrolytic type cleaning system combined with brushing equipment for cleaning the cold-rolled coil as raw material, an all radiant tube type furnace as an annealing furnace, and an induction heater as a plated-layer alloying furnace for GA production. In addition to these engineering features, NSC’s accumulated know-how in the production of automobile-use steel sheets is fully employed in each process. The line can efficiently produce automobile steel sheets of high quality, without poorly alloyed parts, dross defects (on the surface of GA), or roll marks (on either CR or GA) caused by the hearth rolls inside the furnace.

Ever since operations started, the facility has continued stable production and helped us to obtain high ratings from our customers. We expect that the products emerging from this new facility will expand the number of orders placed by our customers in and out of the country.

Thin-gauge High-efficiency Electrical Steel Sheets for Energy Saving

Nippon Steel Corporation

Electrical steel sheet are an important material which is widely used in iron cores of motors and various other electric appliances. The degree of electrical steel sheet power loss greatly affects the energy efficiency of the appliances. For the reduction of energy loss of motors (core loss), gauge reduction of the electrical steel sheets used is effective. Nippon Steel has now added even higher-performance, higher-strength thin-gauge electrical steel sheets to the existing 0.15–0.2 mm-thick products. The new range also includes sheets with higher torque and workability.

When motor rotors revolve at high speed, a great centrifugal force comes into play. Therefore, if the strength of electrical steel sheets is insufficient, fracturing can result. Particularly with the type of motors in which magnets are inserted in holes in rotors made of electrical steel sheeting, it is important to ensure the strength of the parts that support the magnets. The high-strength thin-gauge electrical steel sheets have realized a strength more than twice that of the conventional sheeting, while minimizing the increase in core loss.

Comparison with conventional grades in core loss

Comparison with conventional grades in flux density
Along with the increase in the production of HDD motors, improved punching quality (low hardness) is also demanded to prevent die wear. To meet these requirements, Nippon Steel has developed thin-gauge electrical steel sheets which feature high torque (high flux density) and high workability (low hardness), while maintaining the core loss within the tolerable range.

Using these new products, trial manufacture is already in progress for high-speed spindle motors whose revolutions amount to tens of thousands per minute, magnetic bearings, and motors for electric cars. It is expected that these new products will contribute greatly to environmental protection and energy saving through their use in increasingly compact mobile equipment and innovative electrical cars.

**Ultra-highly-formable Ferritic Stainless Steel Sheets**

Nippon Steel Corporation

Nippon Steel has developed ferritic stainless steel sheets with vastly improved formability and deep-drawability, utilizing the high-efficiency vacuum-refining technology and the metallic-microstructure control expertise in the integrated manufacturing process ranging from casting to hot and cold rolling.

Conventional ferritic stainless steel was inferior to austenitic stainless steel which contains nickel in the area of formability because of the relatively smaller elongation up to fracture. The press-formability of the newly developed ultra-highly-formable ferritic stainless steel sheets has been greatly improved by reducing (through a high-efficiency vacuum refining process) the impurities that hamper elongation and minimizing titanium addition. Compared to the conventional SUS430 steel, the elongation has been improved by about 10% and the Lankford value up to approximately 2.0.

The purification of ferritic stainless steel by reducing impurities is accompanied by the problem that the cast metallic microstructure coarsens and surface irregularities (“ridging”) grow when the steel is press-formed. With the newly developed ultra-highly-formable ferritic stainless steel sheets, ridging is scarcely observable even after press-forming thanks to the optimally controlled integrated manufacturing process from casting to hot and cold rolling.

The newly developed product, used mainly in the manufacture of burner appliances, battery jackets, automotive parts, kitchen utensils and building interior finishing, is expected to help reduce parts production cost because it simplifies welding of parts, integrated press-molding and press-forming processes.

**New Film Laminated Steel Sheet for General Purpose Can—Universal Brite Type E—**

**NKK Corporation**

NKK has launched the new product, “Universal Brite Type E (Ecology)”, which is environmentally friendly, low in cost, and suitable for a wide variety of contents.

Conventional 18-liter cans or pail cans are generally painted inside with lacquers to prevent steels from corroding against contents. However, as problems of the lacquered cans are gradually recognized in that the painting cost holds a high proportion of the entire can making costs and that the emission of a large amount of organic solvents and CO\textsubscript{2} gas is inevitable in the process, demands for paint free alternatives have been rapidly growing.

“Universal Brite Type E” developed to meet the demands, is the tin free steel sheet (TFS) laminated with newly designed two layered polypropylene (PP) film, and has the following superior properties.

1. A wide pH range of contents from strong acid to alkali can be stored owing to the excellent chemical stability of the PP film.
2. Emissions of environmental burden substances such as organic solvents or CO\textsubscript{2} gas are substantially reduced by cutting the painting process.
3. Outsides of the cans are printable because the PP film has a melting point (approx. 160°C) high enough to resist the baking heat of printing (up to 150°C).
4. Excellent corrosion resistance and pressure resisting strength are achieved because the film is strongly adhered to the TFS substrate. The adhesion is due to the adhesion layer of the film, which has the optimized composition of carboxylic acid modified PP and carboxylic acid modified polyethylene (PE) that has superior wettability.

Since it is confirmed that the cans made of “Universal Brite Type E” are available for various contents such as de-
tergents and chemicals, and can replace conventional double painted cans, the products have been commercialized by major 18-liter can makers and further demands are expected to grow.

**Development of High Durable 11% Cr Steel with 400 MPa Tensile Strength and Approval of the Steel as Architectural Structure Steels**

**Kawasaki Steel Corporation (JFE Steel Corporation)**

Usually electrophoretic deposited steels and zinc-plated steels are used for housing structure use. Lately more durable steels have been required for long life housing and reuse of structure steels.

Kawasaki Steel Corporation developed a 11% Cr steel for architectural structure use with excellent durability. The same design and forming processes as that for usual architectural structure steels are applicable to the newly developed steel.

Chemical composition of R410DH is 0.01%C–11%Cr–1.5%Mn–0.3%Cu. The newly developed steel is designed to form fine martensitic structure in welded part by lowering C and adding Mn to 1.5% and shows good toughness. The mechanical properties of the steel are controlled to the same as that of 400 MPa-carbon steels by adjusting production processes. Consequently, popular structure design and forming processes can be applied to the newly developed steel.

R410DH shows excellent durability in atmospheric environment by containing 11% Cr. Results of field exposure test are shown in the figure. Corrosion loss of R410DH is about one eightieth of that of a 400 MPa-carbon steel and R410DH is expected to have extremely long life.

For the first time among 11% Cr steels, R410DH got the assessment of the steel structure performance evaluation committee of the building center of Japan (H13/12/14: BCJ-ST0101-01) and the approval of the minister of land, infrastructure and transport (H14/1/28: MSTL-0071). The development and the approval as a architectural structure steel of 400 MPa-R410DH enable to use the low cost and high durable Cr-bearing steel for architectural structure use.

**Heat Releasing Steel Sheet KOBEHONETSU™**

**Kobe Steel, Ltd.**

Recent demands for improved performance of home electric appliances and electronic equipments such as DVD and LCD monitor are increasing the heat generation of IC, semiconductor, etc. Conventional countermeasures against the excessive heat generation including the forced cooling by fans and air vents in the equipments may lead to the increase of process cost and the deterioration of airtightness and EMI shielding.

In order to contribute to the solution of this problem Kobe Steel, Ltd. developed a new steel sheet KOBEHONETSU™ which has heat releasing ability higher than 7 times of that of conventional electrogalvanized steel. The surface of this steel sheet has an emissivity up to the limit that is achieved by coating a proprietary layer containing high thermal-emissivity particles. By using KOBEHONETSU™ as a cabinet material it is possible to lower the inside temperature of a closed structure (Fig. 1) so that the reduction of the fan capacity or even the removal of the fan may be realized and the needs such as speeding up, improved performance, and downsizing of electronic equipments can be met. In consideration of environmental burdens KOBEHONETSU™ is made free from chromate materials.

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Fig. 1. Heat releasing property. (Replacement of aluminum plate with KOBEHONETSU in one side of rectangular parallelepiped box with heat source kept at 120 degrees Celsius lowers the inside temperature by about 5 degrees Celsius—measured by Kobe Steel, Ltd.)

Photograph 1. An forming example of KOBEHONETSU.
black finished surface providing good adaptability to various industrial designing, and 4) high corrosion resistance.

4. pipe

X100 Grade Linepipe

NKK Corporation (JFE Steel corporation)

NKK has developed X100 grade (Specified Minimum Yield Strength, SMYS: 690 MPa) linepipe and completed first mass-production of the linepipe in the world.

X80 is the grade having the highest strength has been specified in API (American Petroleum Institute) standard at the moment. On the other hand, X100 grade is planned to specify in the standard. CSA (Canadian Standards Association) has already specified grade 690, which has equivalent strength as API X100 in CSA Z245.1. JFE Steel has manufactured and evaluated the linepipes in accordance with the CSA standard.

Applications of higher grade linepipes, such as X70 and higher, for long distance pipelines have been watched with keen interest. A recent study indicated the significant advantages of using higher strength linepipes in constructing long distance pipelines, because it can improve transportation efficiency of gas and oil pipelines by increasing internal pressure. In addition, material cost can be saved by reducing wall thickness of pipe bodies and consumables for girth welding. Approximately 5 and 8% of total cost including pipe lying and operation are expected to be reduced, when X80 or X100 grade linepipes are employed instead of X65.

The AcC (Accelerated Cooling Process) technique gives significant advantages in improving strength and toughness of parent materials. Beneficial effects of increasing in the cooling rate of the AcC process in terms of mechanical properties have been recognized. To utilize the those advantages, new AcC system, Super-OLAC, enabling to cool hot rolled plates in extremely high cooling rate without bringing any inconsistencies in mechanical properties and shape has been developed and installed in former NKK Fukuyama works (now JFE Steel West Works Fukuyama Mill) in 1998. Applying the new AcC system, X100 grade linepipe has been manufactured. Establishing pipe forming and straight seam welding processes improved exclusively for X100 grade linepipe are also crucial factors for the development.

As constructing long distance pipelines is expected to increase its numbers, JFE Steel intends to continue its efforts to increase the number of applications of the high strength linepipes, such as X80 and X100.

New Active Control Bogie for Railway Vehicle

Sumitomo Metal Industries, Ltd.

Sumitomo metal has developed some kinds of active controlled railway bogie trucks which have computer controlled suspension systems.

Among them, Sumitomo active suspension system which improves the ride quality of railway vehicle has been put to commercial use in 2001 for the first time in the world.

This system was applied to JR East Tohoku Shinkansen. The devices are equipped to the both end cars and green car (1st class) in the train ‘HAYATE’ and ‘KOMACHI’.

A conventional railway vehicle suspension consists of mechanical elements (pneumatic spring and hydraulic damper for instance) in order to absorb vibration. However today’s high level requirement of ride quality on high speed Shinkansen is far beyond its ability.

Sumitomo new active suspension consists of accelerometers which is equipped on the car body, controller and pneumatic actuators which generate the optimal control force according to $H^\infty$ control theory. By the benefit of this system, cabin lateral acceleration is reduced successfully to below half or 1/3 of conventional vehicles. And we made a great contribution towards the comfortable Shinkansen.

Construction of a Pilot Plant of Hi-QIP Process

Kawasaki Steel Corporation (JFE steel Corporation)

Hi-QIP process, the first reduction and smelting process on the carbon bed has been developed to produce iron pebble directly from the mixture of iron ore fine and non-coking coal at a low cost. A thin layer of carbon fine is laid on the rotating hearth as shown in Fig. 1. Then, hollows are formed with the roller. The layer of the mixture is charged and heated by the radiation from the furnace roof and burner. The mixture is reduced and melted on the carbon bed.
Molten materials move and gather to the hollows and separate to slag and metal. Solidified slag and metal particles are discharged from the bed after cooling.

The advantages of the process are:

1) No coke oven and sintering machine. One of the best solutions for the problem of aging coke ovens.
2) Complete combustion (C+O_2=CO_2) and high heat utilization ratio. Reduction of CO_2 emission in the steel industry.
3) Slag-free and high quality product. The Hi-QIP stands for the 'High Quality Iron Pebble'.

The project of 15 tons/day pilot plant for five years period is funded by the Key Technology Research Promotion Program of the New Energy and Industrial Technology Organization, NEDO. The first stage of the construction started in October, 2002. Whole plant will commence its operation after the second stage construction during 2003.

**Warm Compaction Method with Die Wall Lubrication for Iron Powder Metallurgy**

KAWASAKI STEEL developed a new compaction method ‘Warm compaction method with die wall lubrication’ in order to obtain a high density green compact for powder metallurgy.

The requirement of the fatigue strength improvement of iron sintered parts comes to the surface, since the stress to automobile parts tends to increase with the improvement of the automobile engine performance. The increase in density of sintered parts is the most effective way for the improvement. However, the conventional double-pressing, double-sintering method for the high density have some problems that this method is costly and is regulated only for the production of the small sized parts. On the other hand, the density obtained by the warm compaction method, in which used iron powder as well as a die should be heated at 100–150°C, is not sufficient to realize high fatigue strength of sintered parts.

Then the new compaction method, which is a combination of the warm compaction and die wall lubrication using charged powdery lubricants, is developed for realizing a higher density than the warm compaction method. By this method, the inner lubricant content can be decreased and the density increases about 0.1 Mg/m^3 in comparison with the warm compaction method. For instance, the green compact at the density of 7.4 Mg/m^3 can be achieved at a compaction pressure of 686 MPa. By sintering this green compact, the density reaches to 7.5 Mg/m^3 and the fatigue strength increases by about 8%.

In the future, it is expected that this new compaction method will be widely applied to the production of high fatigue strength automobile parts by powder metallurgy.

**Water-retaining Material Made by Blast Furnace Slag and Its Application to a New Type of Pavement for Reducing Urban Heat Island Phenomena**

KAWASAKI STEEL (JFE Steel Corporation)

As cities grow, buildings and paved surfaces replace the natural landscape and they can soak up heat to raise air temperatures by as much as 10 degrees. This bubble of heat is known as urban heat island phenomena. Heat island phenomena have become a big object of public concern and so a government and local self-governing bodies are making extensive efforts to solve it.

We have developed a “water-retaining material made by blast furnace slag” and its application: “new pavement both reducing urban heat island phenomena and having drainage ability”, the latter being done under collaboration with KAJIMA ROAD corporation.

The water-retaining material, which is given by hardening of special cement mainly containing blast furnace slag, has sharp ca. 1 μm pore-size distribution and can retain...
water up to about 50% of it. When a paved surface is heated by sunbeam, it discharges retained water gradually and the surface is cooled off by latent heat of vaporization. To attain drainage ability and water retention at the same time, a new construction technique, partial injection of special cement slurry into voids of pavement, has been developed. As the pavement has many paths in it, water on the surface is rapidly drained into the body and absorbed by the water-retaining material. The existence of these paths is effective to reduce the noise generated when cars pass on the pavement.

After confirming its performance in Chiba Works of KAWASAKI STEEL CORPORATION, this technology was applied for bus lanes (in Chiba city, 2680 m², 5 cm thick) in front of JR Chiba station in March, 2002. Temperature drops of 15 and 10°C were observed compared to conventional asphalt pavement on the current and the next day of water spray, respectively in July, 2002.

We would like to encourage a broad use of this technology and contribute to the solution of “urban heat island phenomena”.