Production and Technology of Iron and Steel in Japan during 2003

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

1. Overview of Conditions in Japanese Steel Industry

During 2003, the Japanese economy continued to make a gradual recovery. In spite of a contraction in public works spending, sentiment in the business community improved in response to rising stock prices and sustained high growth in East Asia, where the effects of SARS were confined to a limited area, and the economy achieved a clear-cut recovery in capital investment. Consumer spending showed a firm trend, and exports also remained strong. As a result, the government now projects a real GDP growth rate of +2.0% for the fiscal year, with the nominal growth rate also turning positive, at +0.1%. On the other hand, the economy has not overcome the problem of deflation. Although the national consumer price index rose in October against the same month in the previous year, marking the first increase in 5 years and 6 months, overall, prices continued to fall during the year. Employment also remained problematic. The total unemployment rate declined to 4.9% in December, but as an annual average, unemployment continued high, at 5.3%, and the average of totally unemployed for the year was 3.5 million, exceeding 3 million for the 5th consecutive year.

Looking at domestic steel demand in 2003 in terms of statistics for orders received, in construction works, demand increased modestly due to a recovery in private-sector capital investment in the non-residential sector. However, housing starts remained on the same level as in 2002, and civil engineering was affected by a large drop in public works projects. Thus, on balance, construction overall demand showed a declining tendency. In manufacturing industries, in addition to strong shipments to the auto industry and a continuing high level of new keels laid in the shipbuilding industry, industrial machinery also continued its recovery, particularly in construction machinery and metal processing/machine tools, which are enjoying strong external demand. As a whole, shipments to manufacturing industries registered a plus from the previous year.

Total iron and steel exports were affected by cautious sales policies at all mills, and fell below the previous year for the first time in 7 years, declining by 5.1% from 2002, to 34.46 million tons. Nevertheless, exports remained high, centering on strong shipments to China.

In this connection, it should be noted that Chinese crude steel production exceeded 200 million tons in 2003, making China the first country in history to achieve this level. Chinese steel demand also showed extremely rapid growth of 26% from 2002, reaching 266 million tons.

On the other hand, Japan’s total iron and steel imports increased for the first time in 3 years, reaching 5.96 million tons, or an increase of 13.3% from 2002. However, the level of imports was low for flat rolled products, particularly plates and wide hot rolled sheets. Among main suppliers of ordinary steel products (primary processed plain carbon steel products), imports from Taiwan declined for 11 consecutive months, while those from China increased for 10 consecutive months.

Japan’s crude steel production rose by 2.6% from 2002, reaching a cumulative 110.51 million tons for the year, exceeding 100 million tons for the 4 consecutive years, supported by strong sales to domestic manufacturing industries and a firm tone in exports to Asia, and particularly China. Among notable trends, by process, the share of electric furnace steel fell for the 7 consecutive years, declining to 26.4%, and by product type, special steels, which are enjoying strong sales in the automotive industry, rose by 8.8% from 2002, to 22.19 million tons. Table 1 shows the trends in domestic pig iron and crude steel production and actual production results of main steel products.

Profits improved as a result of cost reductions and other rationalization measures, rapidly increasing demand in China, and improved domestic prices for steel products, both in sales to the market and under fixed contracts. Supported by this combination of factors, a substantial improvement in earnings is expected at all mills.

Although these positive results depended to a certain extent on external demand, 2003 was a good year in terms of production, prices, and corporate performance. As one negative factor, increasing production in China triggered substantial, across-the-board increases in raw material prices, including iron ore, coal, ferroalloys, scrap, and others. In particular, the Japanese market price of steel scrap reached around ¥20,000/ton, forcing an electric furnace mill to close the door.

Even though the industry appears to have extricated itself from a temporary crisis, the business environment in Japan remains difficult, as can be seen in steel industry employment figures. Total employment continued to shrink, and has fallen by more than 10,000 since the end of 2002, now standing at approximately 155,000.

To strengthen corporate fundamentals and ensure a stronger global presence, the Japanese steel industry is undergoing a broad reorganization and has also established a series of new arrangements with foreign companies. Among notable developments in the reorganization process, domestically, in April 2003, NKK and Kawasaki Steel consolidated their steel operations to form JFE Steel Corporation as one of five new operating companies created in the
second stage of their merger under JFE Holdings, which was established as a holding company in September 2002. JFE Steel now ranks with the Japan’s largest crude steel producer, Nippon Steel Corporation. At the same time, Nippon Steel, Sumitomo Metal Industries, Ltd. and Kobe Steel, Ltd. have also formed a 3-company alliance, thus realigning Japan’s integrated steel industry into two large groups.

In another epoch-making business event during the year, Sumitomo Metals and China Steel Corporation (CSC) announced a new joint-venture project involving the upstream processes at Sumitomo Metals Wakayama Works. In July 2003, Sumitomo, CSC, and the trading company Sumitomo Corporation created a holding company for this project, followed in November by the establishment of a subsidiary, Sumikin Iron & Steel Corporation, under the holding company as an operating company for the Wakayama plant. This arrangement allows Sumitomo Metals to achieve more effective use of its facilities, while giving CSC a stable source of semi-finished iron and steel products.

As another important move, in November 2003, Nippon Steel and Sumitomo Metals split off their stainless steel businesses to create Nippon Steel & Sumikin Stainless Steel Corporation, which is now Japan’s largest stainless steel manufacturer.

In addition to developments in the steel industry itself, a reorganization is also underway at trading companies which handle steel products. In January 2003, Mitsubishi Corporation and Nissho Iwai consolidated their steel product business divisions to form a new company called Metal One, and during the year, Sumitomo Corporation acquired Nichimen’s steel product business.

This was also a year when Japan’s steel makers began full-scale implementation of strategies to respond to the rapidly growing Chinese market. Nippon Steel concluded agreements with Baoshan Iron & Steel Co., Ltd. and ARCELOR establishing a joint venture to manufacture and sell automotive steel sheets at Baoshan Works, while JFE Steel signed an agreement with the Guangzhou Iron & Steel Enterprises Group creating a joint venture which will manufacture and sell hot dip galvanized steel sheets for automotive panels.

Although capital investment in the Japanese steel industry had been shrinking for several years, 2003 saw across-the-board increases in investment (construction base) at all mills, reaching double-digit levels or higher in comparison with the previous year. In addition to rationalization projects expected to have practical benefits at an early date and renovation projects at superannuated facilities, which are indispensable for continuing business, Japan’s steel makers invested aggressively in projects to enhance production technology capabilities and improve competitiveness. Investment in new blast furnace construction and BF revamping projects aimed at increasing furnace inner volume were particularly noteworthy.

The Japanese steel industry is undertaking further research and technical development intended to maintain the world’s highest level of technology. Examples include technical development to improve productivity and conserve energy in all production processes and R&D for production of new environment-friendly high value added products. The industry is also promoting research and development of innovative materials under the “Super Metal” and “Ultra-Steels” programs. The basic research stage has already been completed, and research on practical applications is now in progress.

A number of important results have been achieved in the national project, “SCOPE 21 Project (Coke Production with Advanced Conversion Process)”, which was entrusted to the Japan Iron and Steel Federation and is scheduled for completion at the end of fiscal year 2003 (March, 2004). The results of this project have already been presented at
the Fall 2003 Conference of the ISIJ. Another national project entrusted to the ISIJ, “Research Project on Innovative Ironmaking Reaction in New BF Aiming at Half Energy Consumption and Minimum Environmental Load,” is also scheduled for completion at the same time, March 2004, concluding 5 years of activities. Because a succession of major R&D projects carried out by the steel industry as a whole will soon reach completion, it is important that the industry identify significant new projects in cooperation among industry, academia, and government agencies.

In safety, overall, the manufacturing sector had a less-than-perfect record in 2003. A series of major accidents occurred during the year, including the explosion of a coke oven gas holder at a steel works and serious fires at a tire plant and an oil refinery. The steel industry had a larger number of labor accidents than in average years, and on two occasions, in May and July, members of the Japan Iron and Steel Federation were requested to take measures to prevent labor accidents by the Ministry of Health, Labour and Welfare through the Federation.

On the other hand, the Japanese steel industry is playing a leading role in environmental issues. In 1996, the industry adopted a Voluntary Action Plan for Global Warming and is diligently working to solve this major social problem through a multi-faceted approach which includes reduction of CO₂ emissions, energy saving, and recycling.

Among examples of steel industry achievements in the environmental field, Nippon Steel received the National Commendation for Invention “Invention Prize” from the Japan Institute of Invention and Innovation for fiscal 2003 for “Recycling method of chlorine-containing waste plastics in coke oven.” In 2002, the ISIJ created a Special Committee for Study of the Future Prospects of Iron and Steel Technologies for the Environment consisting of 17 persons from industry, academia, and government agencies. This Committee proposed the concept of the “Ecological-Industrial Complex” with the aim of realizing high-efficiency material/energy recycling by cooperation across industry lines and with regional society. This concept was adopted in “Environment/Energy” in the National Strategy for Identifying Potential Industries.

Continuing growth in 2004 will depend on policies which maintain a positive tone and improve conditions as a whole, with capital investment and external demand as the two engines driving demand. A slight decrease in steel products for construction is foreseen due to the recession in public works, as in recent years. However, because manufacturing industries will maintain a strong tone, a high level of domestic steel demand is expected to continue from 2003.

As mentioned previously, negative factors in 2004 will include a sharp rise in raw material prices due to the rapid expansion of domestic demand in China continuing from 2003, as well as higher freight charges for ship transportation, higher distribution costs accompanying new regulations on trucking, and other unstable conditions, requiring a prudent response.

2. Technology and Equipment

2.1. Ironmaking

In 2003, pig iron production increased by 1.4% from 2002, reaching 82.09 million tons, and exceeded 80 million tons for the 2nd consecutive year. The average productivity ratio also increased, from 1.97 t/m³·day in 2002 to 2.04 t/m³·day in 2003.

Among new ironmaking technologies, Kobe Steel constructed a pilot plant for a new reduction-melting ironmaking process using a rotating hearth furnace in Minnesota (USA). The plant is now performing smoothly in continuous operation (see Topics).

Continuing into 2004, construction of a new BF (No. 1 BF) at Sumitomo Metals Kashima Works and revamping of 2 BFs each at Nippon Steel Oita Works, No. 2 BF and JFE Steel East Japan Works (Keihin), No. 2 BF are scheduled in order to meet increasing iron demand and improve productivity.

At JFE Steel West Japan Works (Kurashiki), No. 2 BF (blown-in March 20, 1979, blown-out August 29, 2003) set a new world’s record for furnace life at 8,929 days.

The blast furnace pulverized coal injection (PCI) ratio in 2003 averaged 125.4 kg/t, it decreased rather than last year (Fig. 1).

Among new ironmaking technologies, Kobe Steel constructed a pilot plant for a new reduction-melting ironmaking process using a rotating hearth furnace in Minnesota (USA). The plant is now performing smoothly in continuous operation (see Topics).

2.2. Steelmaking

As an indicator of conditions in steelmaking in 2003, the production index per unit of steelmaking time reached a high level with both converters and electric furnaces, reflecting high productivity, as shown in the results of converter operation in Table 3 and electric furnace operation in Table 4. In response to higher quality requirements, the vacuum treatment ratio for converter steel exceeded 70%.
The ratio of continuous cast slabs in ingots for rolling is shown in Fig. 2. The trend was basically flat from the previous year, at 99.8% for plain carbon steel and 93.5% for special steel.

As an important new steelmaking technology, Sumitomo Metals Kokura Works developed a sensor which enables quick on-site measurement of the size distribution of non-metallic inclusions by suction sampling of molten steel from the continuous caster tundish and measurement of electric potential. In addition to improving product quality, this is particularly important in responding to move by automakers, who have adopted policies requiring elimination of lead from steel products in order to reduce burdens on the global environment. To meet this requirement, Japanese steel makers are developing various morphology control technologies for non-metallic inclusions, which make it possible to improve machinability without using lead in the refining process. New substitute products for Pb-added steel were developed by 3 companies in 2003, following development of Pb-free products by 3 companies in 2001 and 4 companies in 2002.

New equipment construction to meet high demand and improve productivity included continuous caster equipment at Chubu Steel Plate Co., Ltd., and vacuum degassing equipment (2RH) at Nippon Steel Kimitsu Works.

2.3. Plates, Tubes, and Shapes and Bar Steel

In plates, JFE Steel West Japan Works (Kurashiki) installed a high accuracy on-line accelerated cooling device (Super-OLAC) at its plate mill, establishing a more efficient production system for high quality plates, which meets re-
quirements for high strength/high toughness and excellent weldability. Since the former NKK installed the first Super-OLAC at its Fukuyama Works (now JFE Steel West Japan Works (Fukuyama)) in 1998, application of this technology has been expanded to the large shape steel mill and hot strip mill, and it is now possible to handle wide materials up to 5,350 mm. JFE Steel has also announced a HAZ Toughness Improving Technology in High Heat Input Welded Joints, JFE EWEL, using a combination of the Super-OLAC and micro-alloying design for HAZ structure control.

In shapes and bars, the stainless bar and wire rod mill at Nippon Steel Hikari Works (now Nippon Steel & Sumikin Stainless Hikari Works) introduced a 3-roll type precision rolling mill, which improves product dimensional accuracy and enables size-free rolling of large diameter wire rods and bars. Sanyo Special Steel Co., Ltd. revamped its large shape rolling mill (shifting reverse type mill) and substantially improved productivity and quality by developing a quick-changing device for rolls and guides, while reducing manpower requirements by applying multi-functional equipment.

In powder manufacturing, Daido Steel Co., Ltd. announced the Levi-Atomize process. As a mass production technology for alloy powders containing Ti, which is an active metal, this process features melting of Ti alloys in a levitation melting pot, tapping through a bottom nozzle, and atomizing with high pressure gas. Sanyo Special Steel established a production technology for Cu–Ni–Fe alloy wire rod material using a new process comprising gas atomizing–hot extrusion–hot rolling–cold drawing, and has begun mass production.

In steel tubes, there were no particularly noteworthy items in connection with technology and equipment.

2.4. Steel Sheets

Nippon Steel established the world’s first production technology for tensile strength 590 MPa and 780 MPa TRIP galvannealed steel sheets with both high strength/formability and satisfactory coating quality. This combination of properties, which was impossible with conventional technology, was achieved by optimization of the steel sheet composition, sheet surface control in the annealing furnace, and selection of proper alloying conditions. These high strength sheets are now being applied in mass production automobiles.

JFE Steel West Japan Works (Kurashiki) is installing TWB (tailored welded blank) equipment which is scheduled for startup in the summer of 2004. Although TWB equipment has been used by automakers and coil centers for some time, JFE will be the first Japanese steel mill with an in-company TWB capability. This technology makes it possible to reduce auto body weight and apply the optimum arrangement of materials to parts by laser-welding sheets of different thicknesses and material properties before press-forming.

In the field of coated steel sheets, rapid progress has been achieved in chromate-free materials as a environmental response for electrogalvanized (EG) steel sheets used as materials in electric appliances and office equipment. Chromate-free materials are estimated to account for approximately 60% of all EG in 2003.

2.5. Measurement, Testing, and Analysis

The leading Japanese steel makers have been extremely positive in applying ultra-microscopic observation techniques at the nanometer level using high accuracy analytic electron microscopes, and have established practical applications for nano-analysis of steel by developing characterization technologies and specimen preparation/modification technologies. For example, JFE Steel laboratories developed an observation technology for high accuracy evaluation of the size and distribution of fine carbides of nanometer size, and Nippon Steel Advanced Technology Laboratory developed a pinpoint specimen fabrication technology which enables nano-size analysis of fracture and transformation initiation points.

JFE Steel Chita Works developed an ultrasonic multi-probe flaw detection method for welds as a defect inspection technology for ERW tubes accompanying production of heavy-wall products. The tandem-probe method developed for this technology provides an improved flaw detection capacity in the thickness center in comparison with the conventional oblique-angle single-probe method.

2.6. Environment

In 2003, all Japanese steel mills redoubled their efforts to solve environmental problems in a variety of areas.

From the viewpoint of Zero Emissions, Nippon Steel Kimitsu Works carried out technical development to enable recycling of high polymer sludge as blast furnace feed material using a direct treatment technology based on the ro-
In slag utilization, research results were compiled for the ISIJ’s Research Group on Enhancement of Photosynthetic CO$_2$ Fixation by Marine Photoplankton with Steelmaking Slag as a Nutrient Source and Research Group on Slag Use for Prefabrication Building Material. Nippon Steel and JFE Steel, in cooperation with companies in other industries, made efforts to promote R&D of slag utilization techniques through publication of a Manual on Steelmaking Slag Carbonation Technology.

With the national government and local governing bodies in all parts of Japan promoting recycling-based town-building programs, there is an increasingly active tendency for steel makers to participate in new environmental businesses utilizing production equipment in the existing steel works infrastructure and land owned by mills. As one example, in April 2003, the Hyogo Eco-Town Concept was approved as a business by the national government. The core businesses in this project will include a scrap tire recycling business using infrastructure started by Nippon Steel’s Hirohata Works. The methods of effective utilization of waste plastic in steel manufacturing processes have been developed since several years ago by Nippon Steel and NKK (now part of JFE Steel). In this area, a process using the coke ovens at Nippon Steel received “Recycling authorization” from the national government in March 2003. This type of authorization eliminates the need for waste treatment business licenses and approval of waste treatment facilities, and thus encourages an expansion in the treatment of used plastic, for example, by making it possible to recycle industrial waste plastics and plastics other than packaging and containers. At Kobe Steel Kakogawa Works, equipment for dechlorination and recovery of Cl from polyvinyl chloride (PVC) and other Cl-containing plastics by a separation, melting, and gasification process is scheduled for commercial startup in April 2004.

3. Technology Exports/Imports

A breakdown of technology trade during the year 2003 is shown in Table 5, which presents the results of a survey of supporting members of the ISIJ (74 companies). The number of technology exports fell sharply during the year, from 93 in 2002 to 58 in 2003, but was larger than the 37 in 2001. Imports were basically flat, at 2 (compared with 4 in 2002). Among export destinations, Asia accounted for 33% of the total, followed in order by North America, Australia, and Europe. Although the percentage of exports to North America increased in 2002, this remained basically flat in 2003. Exports to Australia, which had been limited to 2 cases in 2002, showed a large increase to 11 and accounted for 19% of the total in 2003.

By technical field, processing/treatment accounted for 57% and steelmaking-related technology for 29%, totaling 86% of all technology exports.

Figure 3 shows the steel industry’s balance of trade in technology up to fiscal year 2002. Receipts for technology exports were basically the same as in 2002, while payments for technology imports decreased somewhat.

4. Research Expenditures and Number of Researchers

The trends in the ratio of research expenditures relative to corporate sales revenues, research expenses per full-time researchers, and the number of full-time researchers per 10,000 employees according to the “Report on Scientific and Technical Research” issued by the Statistics Bureau, General Affairs Agency are shown in Figs. 4–6. Research expenditures as a percentage of sales revenues showed a declining tendency in fiscal 2002, both in all industrial sectors.

Table 5. Contents of technology export and technology import.
(Term: January 1, 2003–December 31, 2003)

| Field | Asia | North America & South America | Europe | Oceanic | Africa | Total |
|-------|------|--------------------------------|--------|---------|--------|-------|
| (A) Raw Materials, Ironmaking | 2 | 2 |
| 1) Blast furnace operation |
| (B) Steelmaking | 1 | 1 | 1 | 1 | 3 |
| 1) Converter |
| 2) Electric Furnace |
| 3) Continuous Casting, ingotmaking | 2 | 2 | 1 | 9 | 13 |
| (C) Shaping, Processing | 1 | 2 | 1 | 1 | 6 |
| 1) Bar and wire rod | 3 | 3 | 1 | 7 |
| 2) Pipe and tube | 1 | 1 | 2 |
| 3) Plate | 8 | 4 | 1 | 14 |
| 4) Sheet | 2 | 1 | 1 |
| 5) Surface treatment |
| (D) Other Operation Know-how (incl. Research related) | 1 |
| (E) Iron and Steel Works in General | 1 | 1 |
| 1) Operation Know-how |
| 2) Maintenance |
| 3) Others | 1 | 1 | 1 |
| Total | 19 | 15 | 3 | 8 | 11 | 2 | 58 |

(Coverage: 74 sustaining member companies of ISIJ)
Industries and in the steel industry. In the steel industry, the amount of research expenditures also registered a further decline in fiscal 2002, falling from ¥135,345 million in fiscal 2001 to ¥129,660 million in fiscal 2001.

The number of researchers in the steel industry declined slightly, from 4,224 in 2002 to 4,204 in 2003, while the number of full-time researchers per 10,000 employees continued to show a gradual increase.

Although research expenses per full-time researchers in the steel industry exceeded those for all industries, the steel industry continued to show a declining trend, as in past years.

---

**Fig. 3.** Balance of technology trade of steel.
Source: “Report on the Survey of the Research and Development”, Statistic Bureau, Ministry of Public Management, Home Affairs, Post and Telecommunications.

**Fig. 4.** Trend of the ratio of sales to research expenditure.
Source: “Report on the 2003 Survey of the Research and Development”, Statistic Bureau, Ministry of Public Management, Home Affairs, Post and Telecommunications.

**Fig. 5.** Trend of the number of researchers per 10,000 employees.
Source: “Report on the 2003 Survey of the Research and Development”, Statistic Bureau, Ministry of Public Management, Home Affairs, Post and Telecommunications.

**Fig. 6.** Trend of the expenditure of R&D per regular researcher.
Source: “Report on the 2003 Survey of the Research and Development”, Statistic Bureau, Ministry of Public Management, Home Affairs, Post and Telecommunications.
5. ISIJ Activities for New Technology Creation

5.1. New Activities (Strengthening of Environmental Field)

To date, environment-related topics have been studied individually in the ISIJ in respective divisions and committees of the Academic Society and Technical Society within ISIJ. To ensure that the ISIJ continues to play a key role in the environmental field, a Working Group for Study of Strengthening of the Environmental Field in June 2003 was established. Based on questionnaires distributed to ISIJ members, the WG proposed the creation of a new interdisciplinary organization capable of pursuing scientific originality and allowing new participation by specialists from different fields. This proposal was approved, and the Division of Environmental and Energy Technology was established as an interdisciplinary division in the Academic Society. The aims of this Division, which set to begin full-scale activities in April 2004, are to conduct more active investigation and research on environmental technologies based on iron and steel technologies and positively disseminate information to society. The new organization is expected to achieve a high level of activity in environment-related technologies through cooperation among university-affiliated people, engineers and researchers in steel companies, and engineers and researchers in other fields.

The Fall 2003 Conference of the ISIJ included a symposium entitled “The Future Outlook for Iron and Steel Technologies for the Environment: Aiming at the Ecological–Industrial Complex,” which was the final report of the aforementioned Special Committee for Study of the Future of Iron and Steel Technologies in Environmental Fields, and was the scene of intense discussion of the potential of steel industry technologies for solving global environmental problems and contributing to a recycling-based society.

5.2. Technical Committees

Activities in the ISIJ are broadly divided between the Academic Society and the Technical Society. Research on iron and steel production technologies and activities to increase awareness of important issues are carried out mainly by the Technical Society. The classification and content of these activities are shown in Table 6. Because the Technical Committee promotes activities proper to the ISIJ as such, Committees are divided into groups depending on the content of activities, with correspondence to the Technical Divisions in the Academic Society, and interchanges are encouraged to achieve a higher level of activity in exchanges between industry and academia and proposals for technical development topics. Various programs to strengthen industrial–academic cooperation with the goal of creating new technologies, such as participation in Technical Committee Meetings by university researchers and joint planning with the Technical Divisions in the Academic Society, mutual involvement of personnel on the technical and management sides, and similar exchanges are continuing to take root. For example, important exchanges in 2003 included the following: (1) Joint seminar with the Refining Forum, Technical Division of High-Temperature Processes (Academic Society) held by the Steelmaking Committee (Technical Society), (2) advance plant tours for university researchers participating in the committee conferences conducted by the Special Steel Committee (Technical Society), and (3) joint symposium with the Technical Division of Instrumentation, Control and System Engineering (Academic Society) held by the Control Technology Committee (Technical Society).

Technical Committees also maintained a high level in regular internal activities and held the Committee Meetings in fiscal 2003 to consider important current issues as common/priority topics, as shown in Table 7. During fiscal 2003, 28 Technical Subcommittees for joint study of technical issues also conducted activities and positively developed new technology creation programs. These Subcommittees included 11 which were newly organized during the year. For example, the Subcommittee in the Heat Economy Technology Committee carried out an investigation and analysis of the status of efforts to achieve zero emissions in the iron and steel industry to date, as well as technical problems which must be overcome in the future.

The Committees are reorganized when necessary to achieve a higher level of activity in programs. In March 2003, the Medium and Small Section Committee and Wires and Rods Committee were consolidated to improve the efficiency of committee activities and enable more complete technical discussions, and began new activities as Bars and Wire Rod Rolling Committee.

The number of the Technical Committees which have introduced a commendation system to improve the quality of presentation papers and train young engineers increased to 15 of the current 19 committees. In Bars and Wire Rod Rolling Committee, two persons who received awards for excellent presentations at the Committee Meeting were also invited to make presentations at the Report Meeting of the
### Table 7. Activities of the Technical Committees.

| Technical Committee | Description |
|---------------------|-------------|
| Ironmaking          | (1) “Stable, high productivity sintering (agglomerating, ore feeding, and baking)”; Special lecture “Interim report of Research Group on Porous Microspheric Structure Sintering”; “Design of material-charging structure for controlling pore structure of sintering cake” |
| Coke                | (1) 8th Reporting of Production Technology; (2) “Measures for coke oven life prolongation”; Open topic research presentation: Special lecture “Fundamental significance of introducing hydrogen and sophistication of hydrogen systems utilizing multiple functions”; “Progress made by Research Group on Development of New Cokemaking Technology for Non-or Poorly-coking Coals” |
| Steelmaking        | (1) “Operational improvement in steelmaking process by automation, remote control, and enhanced controllability”; Technical Subcommittee report “Development and utilization of on-line sensing technology” (2) “On the current status and future improvement measures of CC surface quality”; Open topic research presentation: Special lecture “Future development of solidified structure control technology” |
| Electric Furnace   | (1) “Failure preventive measures”; Special lecture “Re-use of knowledge on failure”; (2) “On environmental issues at steelmaking shops”; Open topic research presentation: Special lecture “Electric furnace operation and environmental problems” |
| Special Steel      | (1) “On operational improvement of ladle refining”; Special lecture “Properties and applications of high-temperature molten fused oxides”; Final reporting on YIS (Young Engineer Session); (2) “On recent cases of improvement made in stainless steel production”; Open topic research presentation: Guest lecture “Fixation of hazardous elements in slag, dust, and sludge”; Lecture “Effective use of by products of iron and steelmaking process”; “Problems in gas-injection refining process” |
| Refractories       | (1) Panel discussion “Ladle repairing method”; Special lecture “On the transition of refractories” (2) Presentation of papers jointly organized with The Technical Association of Refractories, Japan |
| Heavy Plate        | (1) “Multi-functional workers”; Plant operation status report; Superintendent Gr. discussion; (2) Plant operation status report; Staff Gr. discussion “Inventory control”; Foreman Gr. discussion “Line skill transfer”; Special lecture “How to learn from failure; Re-use of knowledge on failure” |
| Hot Strip          | (1) Plant operation status report; Foreman Gr. discussion; Special lecture “Recent thin-slab CC and leading-edge mini-mill”; “Surface flaw deformation analysis in rolling” (2) Plant operation status report; Open topic research presentation; Foreman Gr. discussion “Skill transfer”; Technical Subcommittee report |
| Cold Strip         | (1) Plant operation status report; Foreman Gr. discussion “Pickling and rolling; Activities for improving the operating rates of rolling mills”; “Annealing and finishing; Activities for improving the line yields” (2) Plant operation status report; Open topic research presentation; Foreman Gr. discussion “Activities for preventing trimmer troubles” |
| Coated Steel       | (1) “Quality assurance”; Plant operation status report; Foreman Gr. discussion “Safety”; Special lecture “Recent trend in environmental regulations on surface treatment” (2) Plant operation status report; Technical Committee report |
| Sheet              | (1) Plant operation status report; Foreman Gr. discussion “Safety”; Special lecture “Recent trend in environmental regulations on surface treatment” (2) Plant operation status report; Technical Committee report |
| Large Section      | (1) “Improvement in rolling size and shape (steady and non-steady portions)” jointly organized with Shape Engineering Forum (2) Plant operation status report; Common subject (case study report); Special lecture “Recent trend in technologies for using steel products in marine and port structures” |
| Bars and Wire Rod Rolling | (1) Plant operation status report; Technical seminar (Introduction of transition in technology) (2) Plant operation status report; Common subject “Reduction in production cost”; Special lecture “On needs for automotive structural steel”; “Transition of rolling technology centering on bar and wires” |
| Steel pipes and tubes | (1) Plant operation status report; Information exchange with Pipe Engineering Forum (2) Plant operation status report; Technical Committee report |
| Rolling Theory     | (1) Development of rolling, forming, and other related technologies for steel sheet, plate, bar, rod, section, and pipe”; Technical Subcommittee report; Special lecture “Current status and future prospect of steel sheet development”; “Recent trend in control theory and technology; Accuracy of model forecast by hybrid systems” (2) “Development of rolling, forming, and other related technologies for steel sheet, plate, bar, rod, section, and pipe”; Research Group report; Special lecture “Fuel-cell vehicle” |
| Heat Economy       | (1) Research presentation (R&D), (Construction and maintenance); Special lecture “Theory and practice of technology and skill transfer in equipment maintenance”; “Transition and future issues in plate and sheet rolling control theory” (2) Special lecture “Measures for network security in production control systems”; Research presentation |
| Technology Control | (1) (NDI Division) Periodical survey report on steel sheet NDI; Technical Subcommittee report; Special lecture “Evaluation of microscopic defect by non-linear ultrasonic wave” (2) (Machinery Testing Division) Regular report of work performance; common subject research report; Case study report on automation and efficiency enhancement; Technical Committee report; Special lecture “Tester inspection by JCSS and NK” |
| Plant Engineering  | (1) Plant operation status report; (2) Plant engineering for environmental equipment in steel mills”; Technicalological lecture “Steel mill toward recycling-oriented society: To establish an ecological Industrial complex”; Lecture by Plant engineering company; Special lecture “Trend and technology toward zero-emission society” |
| Quality Control    | (1) Plant operation status report; (2) Open topic research presentation: Special lecture “Life-long extension technology for wear parts used in ironmaking process”; “Design and development of material-charging structure for controlling pore structure of sintering cake” |
| Analysis Technology| (2) Transfer (questionnaire survey, case study report); Technical Subcommittee report; Research Group report |
Bars and Wires Forum of the Technical Division of Product Geometry/Function Generation in the Academic Society. The spirited questioning of these presentations reconfirmed the importance of communication from the industrial side to the academic side.

5.3. Interdisciplinary Technical Committee

Work in the Interdisciplinary Technical Committee on Control of Second-phase Particles in Structural Steels for Improved Properties began in fiscal 2003. The Committee plans to examine how the effects of multiple addition of alloying elements influences properties related to reliability, safety, and reduced environmental loads.

The Interdisciplinary Technical Committee on Desirable Steel Materials for Automobiles completed its Phase III activities in fiscal 2003. As the issues for automotive materials identified in its work have laid the foundation for joint study with the Academic Society, the Committee is now proceeding to Phase IV activities.

5.4. Research Groups and Others

In fiscal 2003, 21 research groups (including voluntary research groups) conducted activities. Of these, 6 groups ended their work in March 2004. An outline of the research in these research groups is presented in Table 8. As one example, the Research Group on Coating Microstructure and Properties of Galvannealed Steel Sheets achieved positive results in research on the mechanism of the alloying reaction, modeling of the film structure, and elucidation of the film destruction mechanism.

In fiscal 2004, 7 new research groups will begin activities, as shown in Table 9. Their research activities will cover a diverse range of fields, including iron and steel processes, new iron and steel materials, titanium materials, environmental technologies, by-product utilization, and business innovation/creation.

Expanding on the base laid by research groups in past work, the ISIJ carried out active research on two national projects entrusted to it. One of these was research on “Function of Hydrogen in Environmental Degradation of Advanced Structural Materials” (research representative: Michihiko Nagumo), which completed 5 years of activities at the end of March 2003. In terms of both basic research and practical applications, this effort produced numerous concrete results, including, for example, the discovery of a dynamic interrelationship among the surface reaction-state of hydrogen existence-degradation process and proposal of new material design guidelines for suppressing hydrogen penetration and securing high cracking resistance.

The second of these national projects was entitled “Research Project on Innovative Ironmaking Reaction in New BF Aiming at Half Energy Consumption and Minimum Environmental Load” (research representative: Kuniyoshi Ishii). This project concluded successfully with an international workshop (sponsored by the Ministry of Education, Culture, Sports, Science and Technology: MEXT) in November 2003, which was attended by many of

| No | Research Group | Research period | Division | Group leader | Purpose |
|----|----------------|----------------|---------|--------------|---------|
| 1  | Creating Innovative High-Efficiency Mixing-separation Reactor | April 00 to March 04 | High-Temperature Process | S. Yokoya, Nippon Institute of Technology | The research aims at creating an innovative reactor that makes the molten metal refining reaction highly efficient by performing fluidization, agitation, mixing, and separation. Technological seeds that lead to an innovative reactor are pursued without being bound by conventional concepts. |
| 2  | Development of New Structural Materials Using Slag for the Improvement of Urban Infrastructure | April 00 to March 04 | Social Engineering of Iron and Steel Industry | S. Haru, Osaka Univ. | The research aims at developing technologies for designing and producing new structural materials based on iron and steelmaking slag by adding other ingredients, mixing and reforming it. It also aims at developing technologies for using these slag-derived structural materials in combination with steel. Social engineering approaches are adopted for facilitating the use of these materials for the improvement of urban infrastructure. |
| 3  | Coating Microstructure and Properties of Galvannealed Steel Sheets | April 00 to March 04 | Microstructure and Properties of Materials | M. Yamaguchi, Kyoto Univ. | The research aims at (1) proposal of Fe-Zn-Al ternary equilibrium diagram and (2) modeling of the coating microstructure for grasping the mechanism of its fracture and facilitating the development of excellent galvannealed steel sheets. |
| 4  | Development of Skill-free Technology for Chemical Analysis Employed in Iron and Steelmaking Process | April 00 to March 04 | Process Evaluation and Material Characterization | T. Yamanishi, Yamanashi Univ. | For the purpose of facilitating the effective transfer, maintenance, and development of technology for chemical analysis that is essential in future iron and steelmaking, the research aims at developing FTA-based, skill-free technology for chemical analysis that eliminates the need for experienced engineers and technicians. |
| 5  | Prediction of Surface Defects in Rolling Process | April 00 to March 04 | Creating New Products and Quality | T. Ishikawa, Nagoya Univ. | For the purpose of developing computer software that assists the production of defect-free steel, the process of defect generation, development, and extinction is tracked through collecting actual rolling data and performing model experiments. The expected outcome is a numerical model that can simulate the actual phenomena. |
| 6  | Efficient Utilization of sensible heat from molten slags | April 03 to March 04 | High-Temperature Processes / Social Engineering of Iron and Steel Industry | Y. Kashiwayama, Hokkaido Univ. | The purpose of the research group is the efficient utilization of sensible heat of molten slags from the ironmaking and steelmaking process. The heat can be recovered as a hydrogen by the methane reforming reaction with water. More stable slags can be designed using TTT diagrams which should be developed in the future research group, and the heat could be recovered through the ideal cooling path indicating by TTT diagrams. |
the world’s leading ironmaking researchers and engineers. Numerous research results were achieved from the 1st Subcommittee, which was responsible for research on high speed in the reduction and gasification reactions to the 4th Subcommittee Activities, which carried out research to establish the process image of a new ironmaking process and quantify the ripple effect.

Acknowledgements
The authors wish to express their deep appreciation to the Steel Production Planning Section, Iron and Steel Department, Bureau of Manufacturing Industries, Ministry of Economy, Trade and Industry (conditions in the iron and steel industry), the Japan Iron and Steel Federation (conditions in the industry and statistical data), and all those concerned in the ISIJ for their generous cooperation at all stages of the drafting of this report.

### Table 9. New research groups started in fiscal 2004.

| No | Research Group | Division | Group leader | Outline |
|----|----------------|----------|--------------|---------|
| 1  | Active Control of Solidified Structure for Fine γ-grains | High-Temperature Processes | H. Esaka, National Defense Academy | Experimental and theoretical approaches will be made in dealing with nucleation for solidification and γ-grain growth in steel in order to obtain a guideline for controlling the structure of steel. Through developing a universally applicable model of solidified structure, the research aims at establishing technology for controlling the structure of steel starting from solidification. |
| 2  | Model Development for Assessing Environmental Impacts by Cyclic Use of Iron Scrap for Sustainable Society | Social Engineering of Iron and Steel Industry | Y. Matsuo, Univ. of Tokyo | A dynamic model for assessing environmental impacts by cyclic use of iron scrap in Japan during 2000-2030 will be developed, in which the steel demand, iron scrap supply, and their quality are taken into account. This model will be useful for analyzing the future transition of the total environmental impacts induced by steel production and optimizing the recycle ratio of iron scrap. |
| 3  | Value Addition to Byproducts in Iron and Steelmaking Plant Using Hydrothermal Synthesis Process | Social Engineering of Iron and Steel Industry | T. Tanaka, Osaka Univ. | The research aims at producing advanced construction materials with some functions from by-products such as slag in iron and steelmaking process by applying the hydrothermal synthesis process that effectively utilizes unused waste heat and carbon dioxide gas discharged from an iron and steelmaking plant. |
| 4  | Knowledge Creation and Management for Collaborative Production Process Innovation | Instrumentation, Control and System Engineering | H. Fujimoto, Nagoya Institute of Technology | For the purpose of promoting knowledge creation and management toward collaborative production process innovation, the research aims at developing comprehensive systems for (1) extracting, (2) accumulating, (3) utilizing, (4) creating, and (5) sharing and upgrading the technological knowledge. |
| 5  | Analysis on Micro-plasticity in Tempered Sheet for Steel Sheet | Creating New Products and Qualities | I. Yarita, Chiba Institute of Technology | Through experiments and microanalyses such as FEM, the research aims at clarifying the stress-strain behavior, roughness-forming mechanism and generation mechanism such as cross buckle in temper rolling that performs uneven elastoplastic deformation. Industrial application of the findings from this research is expected to make a contribution to quality improvement of steel sheets and development of new products. |
| 6  | New Revolution in β-type Titanium Alloys | Microstructure and Properties of Materials | M. Hagiwara, National Institute for Materials Science | Focusing on β-type titanium alloys, the research will be performed over the possibility of obtaining enhanced properties by controlling the composition and microstructure, clarifying the mechanism through which certain properties are obtained, and evaluating the formability of resultant materials. In particular, the research aims at obtaining basic data that contribute to the development of new, revolutionary alloys applicable to structural and heat-resistant members of transportation machinery. |
| 7  | Availability of Nitrogen on Improvement in Steel Properties | Microstructure and Properties of Materials | Y. Katada, National Institute for Materials Science | Focusing on nitrogen as an alloying element for steel material, properties of high-nitrogen steel produced by various methods of nitrogen addition will be investigated for evaluating the possibility of industrial application of high-nitrogen steel. It is also intended to open a new field in materials science focusing on the interaction between steel and nitrogen. |
1. Environment

Recycling Plant of High Water Content Sludge

Nippon Steel started the operation of No. 2 dust recycling plant that could recycle high water content sludge at Kimitsu Works in December 2002. It has been operated smoothly since then.

Iron containing sludge, which is difficult to be recycled because of its high water content, had been remained as a waste. Nippon Steel, however, developed a new technology of directly processing the sludge for feedstock of the rotary hearth furnace (RHF). No. 2 dust recycling plant adopting this technology has recycled the sludge in addition to the dust, easier material for recycling. The technology consists of a new type of dehydration, and production of a wet feedstock compact that could be directly charged into the RHF without a drying process. This “wet processing” for RHF is the first in the world.

We have already developed new technology of producing high-strength DRI pellets for blast furnace by processing “dirty dust” that contain zinc, alkaline metals and other impurities with RHF. No. 1 plant applied this technology, started its operation in May 2000. Consequently, recycling carbon and iron from waste dust produced significant effect of resource and energy conservation. This technology was awarded the Minister Praise of the Ministry of Economy, Trade and Industry at the 2001 Excellent Performance Assembly of National Energy Saving Convention.

By applying these technologies, we have become to be able to recycle almost 100% of iron containing waste as excellent raw material for blast furnace.

2. Ironmaking

New Ironmaking Process—ITmk3® Demonstration Plant Starts Up

Kobe Steel, Ltd.

ITmk3® (Ironmaking Technology mark 3) is a new ironmaking technology which can produce pure iron particle (Iron Nuggets) directly from fine ore and coal using rotary hearth furnace (RHF). Agglomerates of fine iron ore and fine coal are quickly reduced, melted and separated from slag to produce high purity iron nuggets of 96 to 98% within a very short time (around 10 min) in RHF. The capital investment is estimated less than half of conventional ironmaking process by eliminating raw material pretreatment system, furthermore ITmk3® is evaluated to reduce CO2 emission by 20%, which can contribute to the global environmental protection.

In 1996, fundamental research for process development was started, followed by the successful operation of the pilot plant (3,000t/y) installed in Kakogawa Works of Kobe Steel, Ltd. in 2000, a demonstration plant of annual capacity 25,000t was constructed on May 2003 by Mesabi Nugget, LLC established with Ferrometrics Inc. and subsidiaries of Cleveland-Cliffs Inc. and Steel Dynamics, Inc. as well as Kobe Steel, Ltd. under the financial support of Minnesota state government. The operation started by the support of DOE of US federal government, and on May 24 the first iron nuggets were successfully produced. Keeping a stable operation, a monthly average availability of 99% was achieved in December 2003.

3. Heavy Plate

“NSGP-1,” Pitting Resistant Steel for Tanker Tank Bottom Plate

Nippon Steel Corporation

Nippon Steel Corporation successfully developed, in 2003, for the first time in the world a new plate steel, named “NSGP-1” (Nippon Steel’s Green Protect-1), which is very effective against pitting in cargo tank (COT) bottom plates of VLCC (Very Large Crude oil Carrier) and other crude carriers. Nippon Steel has since been developing the application of this steel to actual ships.

Traditionally, COT bottom plates of crude oil carriers used to be bare, but the harshness of their service environment resulted in severe pitting at a rate as fast as 3 to 4 mm a year (the maximum depth of corrosion, ordinarily, is 9 to 10 mm at inspections conducted at two-and-a-half year intervals). In recent years, the main measure against pitting has been the application of heavy coat to COT bottom plates. Realistically, however, execution control is very difficult to exercise during painting operations, so much so that perfect coating is nearly impossible, and deep pitting still continues to occur. Thus, pitting measures, inspections and repair controls have been a persistent headache for shipowners.
The newly developed NSGP-1 is a revolutionary pitting-resistant steel capable of reducing pitting-growth rate to one-fifth of that of conventional steels. In its development, Nippon Steel first studied various corrosive environments of actual carriers through joint research with shipowners, then marshalled its corrosion resistance and protection technologies amassed over the years to develop and establish ingenious, non-conventional design principles, thus succeeding in the development of NSGP-1. This steel satisfies the classification society’s rules for chemical composition, possesses mechanical properties, weldability, formability and other properties equal to or even better than those of the conventional plate steels for hull construction, while also conforming with the classification rules for service performance with no problem. In other words, NSGP-1 has now emerged as plate steel capable of dramatically improving pitting resistance of COT bottom plates, without the need to make any changes whatsoever in the traditional ship construction process.

NSGP-1 is scheduled to be loaded aboard the VLCC now under construction and placed in service in 2004. Plans are to verify effects after the vessel is commissioned. But, we have high expectations that by the adoption of NSGP-1, even in the two-and-a-half-yearly inspection usually conducted while ships are in dock, only slight pitting less than 2 mm will be observable, eliminating the need for touch-up, welding or other pitting repairs. At the same time, we are confident that NSGP-1 offers the possibility of a total departure from the coating of the COT inside, which imposes high environmental loads. NSGP-1 is a significant step and contribution toward environmentally friendly shipbuilding.

**Abrasion Resistant Steel Plate for Construction and Industrial Machinery “JFE-EH500LE”**

**JFE Steel Corporation**

High abrasion resistant steel plates are used for the bed of dump trucks and bucket of excavators in order to reduce damage under severe service condition in the mines. Especially in the case of use in the cold districts such as the highlands in which many mines are located, it is expected that decreasing in toughness of the steel plate. Under such environment, cracks are occurred at the surface of the steel plates under low toughness due to the damage by the repeated collision of rocks and the ores, and that causes the life duration of those parts shorter. When the abrasion resistance of the steel plate is improved, generally toughness of the steel deteriorates.

In order to overcome this obstacle, JFE Steel corp. has applied the microalloying and the controlled heat treatment technology in the controlling of the steel microstructure. “JFE-EH500LE” has been developed as the steel which has the highest hardness (Brinell hardness over 477HBW), and has guaranteed the Charpy impact energy at $-40^\circ$C simultaneously. By using of “JFE-EH500LE” which has excellent abrasion resistance and high resistance against the crack damage by the collision in considerable use in the cold district, as the bed of dump trucks and bucket of excavators, it makes the life duration of those parts will be extended. Furthermore, it makes possible to reduce the thickness of the steel plate for those parts, and the weight of machinery. As a result, “JFE-EH500LE” contributes the effective reduction in environmental pollution by the improvement in the fuel efficiency and an increase in the carrying capacity.

“JFE-EH500LE” is expected to spread in the construction and industrial machinery use as well as “JFE-EH360LE (with Brinell hardness over 361HBW)” which is developed previously.

**610 MPa Class High-tensile Heavy-Gauge Steel Plates for Hydraulic Pipes of the World’s Largest Power Plant—The Three Gorges Dam in China—Sumitomo Metal Industries, Ltd.**

Sumitomo Metal Industries, Ltd. won the entire order for the third phase of the Three Gorges Dam Project in China after successful supply of steel plate for the second phase. The order consists of 610 MPa class high-tensile heavy-gauge steel plates (SUMITEN610F) for hydraulic pipes, which was awarded by China Yangtze Three Gorges Development Corp.

The Three Gorges project is said to originate from a suggestion made by Sun Yat-sen in 1919. It is a world-class national project, sometimes referred to as “the Largest Construction Program since the Great Wall of China,” with a construction cost of over 3 trillion yen that will yield 18.2 million kilowatts of power. The project has been under development since 1993 and is designed to meet three funda-
mental needs: power supply, coal transport and flood control.

Including eight installations in the second phase, Sumitomo Metal Industries, Ltd. have provided the steel plates for 20 installations out of a total of 26.

The 610 MPa class high-tensile heavy-gauge steel plates for hydraulic pipe, supplied for this order, are a masterpiece of engineering, produced from the most advanced manufacturing technologies developed by Sumitomo Metal Industries, Ltd., which exhibit high strength and excellent weldability and toughness. This product does not require preheating, which must normally be applied before welding, accordingly simplifies welding work and leads to substantial savings in the construction cost.

9% Ni Steel Plate Produced by Continuous Casting Applied to the Primary Structural Members of a Large LNG Tank for the First Time in Japan
Sumitomo Metal Industries, Ltd.

Sumitomo Metal Industries, Ltd. (SMI) manufactured 2 400 tons of 9% Ni steel plate produced by continuous casting for a domestic 160,000 kL PC-LNG tank and all of them were formed into shell plates, annular plates and knuckle plates. This is the first time to apply continuous casting to 9% Ni steel plate for primary members of domestic LNG tank. The wall thickness of the knuckle plate, 48.3 mm, is the thickest record of 9% Ni steel plate produced by continuous casting

In the late ‘90s, continuous casting process were applied to manufacturing 9% Ni steel plate up to 30 mm in thickness for overseas LNG tanks, nevertheless only ingot casting process has been applied to domestic tanks because of severe requirements for toughness and arrestability at the cryogenic temperature up to 50 mm in thickness.

SMI’s integrated technology for manufacturing heavy wall 9% Ni steel plates and excellent state-of-the-art technology of continuous casting resulted in winning owners approval for domestic large volume LNG tank.

4. Cold Rolling Steel—Surface Treatment

New Film Laminated Steel Sheet for Food Cans—Universal Brite Type F—
JFE Steel Corporation

The world’s first film laminated steel for food can has been commercialized by JFE Steel Corporation under the trade name of “Universal Brite Type F”, satisfying the requirements for DRD (drawn-redrawn) food cans, especially strict formability and content release property. Demands for paint free alternatives for food cans have been rapidly growing, as the emission of a large amount of harmful organic solvents and CO2 gas becomes increasingly serious problems. “Universal Brite Type F” has been developed to meet the demands, and features the following superior properties.

(1) Formability: Homo polyethylene terephthalate (Homo PET: non-copolymerized PET) film is not suitable for can forming use because of its rapid crystallization deteriorating its formability. The breakthrough of the advanced two-layered film has made homo PET film available due to a combination of a new unique-structured PET and an original laminating process, inhibiting the crystal generation markedly.

(2) Excellent Content Release Property: Due to an addition of original surface-modifying additives to the upper layer of the film, the property has been obtained by effectively reducing the surface free energy of the PET film. The additives cover the film surface, which leads to sharp decrease of the polar component of the surface, thus reducing the surface free energy.

(3) Elimination of Painting Process: The new sheet can be processed on standard can manufacturing lines without alterations. Additionally, elimination of the painting process
contributes not only to lowering of manufacturing cost but also to huge reduction of environmental burden substrates.

“Universal Brite Type F” has been marketed mainly among major can manufacturers in North America, where its properties and quality have been highly appreciated.

780 and 980 MPa Grade High Strength Steels with High Reliability of Spot-welded Joints
JFE Steel Corporation

JFE Steel Corporation succeeded in developing new 780 and 980 MPa high strength cold-rolled and galvannealed steels applied to the members and impact energy absorbing parts of automobile body. The new steels feature excellent galvanizing quality and high reliability for spot welding.

In general, the addition of alloying elements for strengthening the steels deteriorates the reliability of spot-welded joints. Because the addition of elements, such as C, Si and Mn, to strengthen the steels, make hardening too much and embrittling in weld metals, the production of high strength steels with high reliability of spot-welded joints has been thought to be difficult.

Based on the knowledge that was obtained by developing the 590 MPa grade high strength cold-rolled and galvannealed steels, JFE Steel succeeded in developing the new 780 MPa and 980 MPa grade high strength steels. The technological key points are as follows.

1. To select the alloying elements, such as Ti and Nb, which hardly deteriorate the spot weldability.
2. To refine a grain size.
3. To apply the new galvanizing technology.

By using the developed steels, the strength of spot-welded joint (cross tensile strength) has been improved about 50% in 780 MPa grade and about 70% in 980 MPa grade as compared with the conventional steels. And the range of optimum spot welding condition was expanded.

The application of these new developed sheet steels to automobile bodies will be expected to bring the advantages shown as follows.

I. Since the reduction of sheet gauge is attained with the expanded use of high strength steel, it contributes to the weight reduction of automobile body.
II. Since improving the reliability of spot welding expands the range of suitable spot welding condition, the stable operation is expected in spot welding.
III. Since the coating quality is improved, the corrosion resistance of the automobile body is improved.

Sheet Steel for Hot Press Forming (Semi-Quench)
Sumitomo Metal Industries, Ltd.

In these days the improvement in automotive fuel economy is urgently needed to reduce CO₂ in the exhaust gas. For this purpose automotive body weight has been reduced by the application of high strength sheet steels (referred as HSS below). However it is not easy to apply HSS to parts with complicated shapes. Especially brakeage and large spring back at stumping shop cause severer problems, when tensile strength exceeds 1.0 GPa. Furthermore hydrogen embrittlement should be taken into account, when tensile strength exceeds 1.2 GPa.

Hot-press-forming is sometime referred to as die-quenching. In the process as shown in the figure below, sheets are heated at a temperature as high as 1 273 K, press-formed at the temperature, and consequently quenched by touching chilled die and punch. Because the flow stress at 1 273 K is as low as 50 MPa and residual stress in final products is negligible small, the troubles mentioned above don’t occur. Hot-press-forming has been applied since early 1990s in Europe. In Japan it has just come into the market recently.

Sumitomo Metal Industries Ltd. has developed sheet steels for hot-press-forming and succeeded in commercial application of the process in cooperation with automotive parts companies. The chemistry of steels was modified to form a thin and adhesive scale during heating and to obtain enough quench hardenability even in the portion cooled at the smallest cooling rate. In case of side intrusion beam in door, the hot-press-formed beam is 30% stronger and 10% lighter than the conventional press-formed beam of HSS. Furthermore the hot-press-formed beam exhibits shape accuracy as good as press-formed parts of mild steel. The beam has already been applied to several types of passenger car.

Prepainted Steel Sheet for High Temperature Applications of up to 500°C
“500°C-Resistant Prepainted Steel Sheet”
Nisshin Steel Co., Ltd.

Conventional prepainted steel sheets have widely been used in various fields including building components, home electric appliances and electronic equipment for the merits of cost saving through the elimination of coating process, improvement in productivity and reduction of environment load. Cooking or heating apparatuses are sometimes heated in working up to over 300°C. Thus, development of a heat-resistant prepainted steel sheet for these high temperature
usages has been desired. However, even if the heat-resistant paints with such materials as polyimide or silicone resin are applied, the limit temperature was about 300°C.

Nisshin Steel has developed “500°C-Resistant Prepainted Steel Sheet” with the following characteristics: 500°C-resistance and high workability in bending, drawing or press-forming. The newly developed product do not generate disgusting smell, smoke and detrimental gas when heated, and thus it can be safely used in a wide thermal environment ranging from room temperature to 500°C. Moreover, the product excels in such properties as anti-contamination, corrosion resistance, paint film adhesion, anti-scouring, far-infrared radiation, deodorization and black design. These properties have been achieved with the original design of binder and pigments in paint and the application of heat-resistant aluminized steel sheet (Fig. 1).

“500°C-Resistant Prepainted Steel Sheet” has been used for components of microwave oven (Fig. 2), and is expected to find its way in various applications in heat-resistant fields including a number of other home electric appliances.

5. Miscellaneous

Grain-oriented Steel ‘JGE’ with Good Punchability and Low Iron Loss in Various Directions

JFE Steel Corporation

Grain-oriented electrical steel with excellent magnetic properties in the rolling direction has been long years contributed to the reduction of energy consumption mainly applied to the core material of transformers. Conventional grain-oriented steel has a forsterite (Mg2SiO4) base ceramic coating on its surface. Another in-organic insulation coating is applied onto the forsterite coating. Since the forsterite coating is very hard, users of grain-oriented steels found the difficulty in punching such as short life of stamping dies.

JFE Steel Corporation recently developed grain-oriented steel ‘JGE’ without forsterite base coating. JGE has two characteristics described in the following.

One is better punchability. JGE has an insulation coating which is commonly applied to non-oriented electrical steel that insure the good punchability. The life of stamping dies in using JGE is ten times longer than in using conventional grain-oriented steel sheet with forsterite coating. The adhesion strength of the insulation coating is also improved in JGE.

Another is the improvement in the iron loss in various directions other than rolling direction shown in Figure. This characteristic is suitable for the application to EI core that is widely used in small transformers. The iron loss of EI core stamped from JGE sheet is 10% superior to that using conventional one. This comes from the excellent iron loss in the transverse direction that consists part of the magnetic circuit in the EI core.

Due to improved punchability and iron loss in various directions, JGE is suitable for the application to segmented core motors or power generators in which non-oriented electrical steel is currently used. As mentioned above, JGE widen the application of grain-oriented steel.