Production and Technology of Iron and Steel in Japan during 2016

The Technical Society, The Iron and Steel Institute of Japan.

1. Overview of the Japanese Iron and Steel Industry

Reviewing the economic condition of Japan during 2016, according to government economic reports and other sources, the employment and income environment improved, and a basic tone of gradual recovery continued, but weakness could be seen in overseas economies during the first half of the year. In addition, in the Japanese economy, individual consumption and private-sector capital investment lacked strength in comparison with the growth of incomes and profits. As a result, a real GDP growth rate of approximately 1.3% and a nominal GDP growth rate of approximately 1.5% are forecast for FY 2016.^{1,2)}

According to the Japan Iron and Steel Federation (JISF), domestic iron and steel demand was largely stagnant during FY 2015, but in FY 2016, there was on a track to recovery in public- and private-sector civil construction and residential construction in the construction market. On the other hand, industrial machinery and electrical machinery, which are related to capital investment, *etc.* in manufacturing industries, generally lacked strength. Although automotive demand was sluggish until mid-year due to the effect of the Kumamoto Earthquakes, improvement could be seen in the second half due to recovery production, and the effect of new models. Where external demand was concerned, world iron and steel demand slightly exceeded that of the previous year as a result of a turn to a gradual recovering tendency

in both the advanced nations and the emerging economies.

Reflecting these situations, crude steel production in Japan in 2016 (calendar year) was 104.77 million tons, which was roughly the same level (0.3% decrease) as the 105.13 million tons of the previous year (**Fig. 1**).^{3,4)} As trends in the domestic steel industry, Nippon Steel & Sumitomo Metal Corporation (NSSMC) began a study of making Nisshin Steel Co. Ltd. a subsidiary, and equipment shutdowns and equipment consolidation advanced at both integrated steel makers and electric furnace steel makers. In response to the problem of excess iron and steel production capacity, beginning with China, the G20 member countries and others formally launched the Global Forum on Steel Excess Capacity in December.

The prices of iron ore and metallurgical coal, which are the main raw materials for iron and steel, have shown a downward trend since peaking in 2011, and that trend continued in 2016 (**Fig. 2**).⁵⁾ However, from the second half of 2016, the price of metallurgical coal spiked to more than 3 times its previous price due to operational problems at a leading coal mine in Australia, regulations on coal mine operation in China and other factors, raising concerns about the trend in and after 2017 as a factor in higher costs.

As in past years, in 2016, steel makers invested or established operations overseas in Southeast Asia, Brazil, Mexico, *etc.* in various product fields in line with the overseas strategies of each company. On the other hand, in a

Fig. 1. Transition of crude steel production in Japan (calendar year).^{3,4)}

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Fig. 2. Transition of world pig iron production and unit price of imported iron ore & metallurgical coal (calendar year).⁵⁾

national referendum in the United Kingdom in June 2016, the UK voted to leave the European Union (EU), and a new administration was born in the United States in November as a result the Presidential election in that country. These developments gave rise to concerns about future protectionist tendencies in the US and European countries among steel makers and others.

The year 2016 also saw new developments in global warming countermeasures. Internationally, the Paris Agreement was ratified by the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21) in December 2015. Based on that development, the Japanese Cabinet approved the Plan for Global Warming Countermeasures in May 2016. Subsequently, the Paris Agreement took effect in November 2016.

The Japanese steel industry reaffirmed that it will steadily implement the Commitment to a Low Carbon Society, and is already engaged in efforts, centering on the JISF.

As conditions surrounding the Japanese iron and steel industry in 2016, the following presents an overview of trends in raw materials for iron and steel, trends in steel-consuming industries, the condition of crude steel production in Japan and worldwide, *etc.*

1.1. Trends in Raw Materials for Iron and Steel

As trends in iron ore, the basic conditions of increased production and oligopolization by the three major iron ore producers (Vale, Rio Tinto and BHP Billiton) also continued in 2016, and production was at record high levels at all companies. According to the Metal Resources Report⁶⁾ of the Japan Oil, Gas and Metals National Corporation (JOGMEC), seemingly a continuation of fierce share competition using cost-competitiveness achieved by thoroughgoing cost reduction measures is seen at all companies. On the other hand, world crude steel production was flat from the previous year, and the basic tone of pig iron production has also been flat since around 2012. Because ore producers have maintained a high level of production, resulting in excess supply, the downward tendency in iron ore prices has continued since peaking in 2011. The supply-and-demand equation was also similar for metallurgical

coal until around September 2016. However, according to published values of the contract price of metallurgical coal announced by steel makers, contract prices rose sharply beginning in October 2016.⁷⁾ This was reportedly triggered by a decrease in supply due to operational trouble at a metallurgical coal supplier in Australia.⁸⁾ Figure 2 shows the transition of world pig iron production and the unit prices of imported iron ore and metallurgical coal according to World Steel Association and Japanese Ministry of Finance customs statistics.⁵⁾ This shows that the peak prices in 2011 were US\$167/t for iron ore and US\$229/t for metallurgical coal, but in 2016, those prices had declined to US\$56/t for iron ore and US\$89/t for metallurgical coal, and were on roughly the same level as 10 years earlier. It should be noted that the jump in the contract price of metallurgical coal did not affect the unit price of imports due to the time lag between contracts and actual imports.

1.2. Trends in Steel-consuming Industries

According to the quarterly steel supply-and-demand report⁹⁾ of the JISF and the related websites including the Japan Automobile Manufacturers Association, Shipbuilders Association of Japan, and Japan Electrical Manufacturers Association, the trends in steel-consuming industries during 2016 were generally as follows.

For details, please refer to the original Japanese text or the websites of the JISF, Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and the respective industrial associations.

[Civil engineering] In civil construction during FY 2016, the scale of the budget for public works spending on public civil works (total of supplementary budget for FY 2015 and initial budget and first/second supplementary budgets for FY 2016) increased from the previous fiscal year. In September 2016, a large-scale order was received for the Tokyo-Gaikan Expressway, and the order for the New National Stadium was also received. As a result, public civil engineering projects increased substantially in the first half. There also appeared to be a continuing rising trend from the second half, as disaster recovery and reconstruction work following the Kumamoto Earthquakes, and Typhoon

No. 10 and upgrading of social infrastructure, related to the Tokyo Olympics were expected. In private-sector civil works, a continuation of the favorable tone through the year was foreseen, supported by redevelopment of railway station plaza areas, particularly in the Tokyo Metropolitan area, the start of construction of the Linear Chuo Shinkansen (Tokyo-Nagoya section) and other positive developments.

[Construction] In FY 2016, residential construction showed a trend of moderate recovery, supported by a last-minute surge in demand in anticipation of the consumption tax increase. By use, privately-owned houses followed a recovering trend, backed by low interest home loans, while high growth continued in rental housing, including construction as an inheritance tax strategy, and this was a driving force in the housing market. In non-residential buildings (offices, stores, and factories), the start of Olympic-related projects could be seen in the second half of the fiscal year. For various reasons, however, capital investment by companies continued to lack enthusiasm. In addition to unstable movements of currency rates, negative factors included stagnation in the emerging economies and uncertainties about the future direction of the world economy, spurred by the United Kingdom's decision to leave the EU, the change of Presidential administrations in the United States.

[Shipbuilding] In addition to excess global overtonnage and sluggish conditions in the marine transportation market, there was also a reactionary decrease in shipbuilding in response to strengthening of regulations on NOx emissions in January 2016. Given those conditions, the environment for order acceptance was extremely difficult, and shipyards drew down work already in hand. Ship owners also requested delayed delivery, and in addition to this decrease in orders, there was also a change in the composition of ship types, as the construction share of large-scale container ships and LNG carriers with long fitting times increased. As a result, decreases in the amount of new ship starts and consumption of steel materials were foreseen. On the other hand, as a trend in export ship contracts, a surge in orders ahead of the strengthening of regulations on ship hull structures in July 2015 and strengthening of regulations on NOx emissions in January 2016 could be seen. Although many shipyards secured work in hand until around 2018, sluggish conditions continued in and after 2016.

[Automobiles] Looking at domestic unit sales of new automobiles in 2016, the effects of the fuel economy falsification problem in light cars dragged on. Among registered vehicles, although passenger cars in particular increased due to the effect of new models, there was a slight decrease through the year as a whole.¹⁰⁾ While exports of complete vehicles to the Middle East and Africa were sluggish, exports to the European and Asian markets recovered, and there also moves by some auto makers to utilize domestic production facilities. Underpinned by these trends, an increase in exports is expected. As a result, the outlook is for an increase in production of completed automobiles and a slight increase in consumption of steel materials. According to the Japan Automobile Manufacturer Association, unit production of 4-wheeled vehicles in 2016 was 9 204 590, which was a decrease of 73 731 units, or approximately 0.8%, from the 9 278 321 units of the previous year.¹¹⁾

[Industrial machinery] Increases were seen in demand

for chemical equipment for replacement of aging facilities and higher performance, in transportation equipment-related fields accompanying the growth of internet mail-order businesses, and for energy-saving/labor-saving in distribution equipment. Conversely, there was a decreasing tone in internal combustion engines, agricultural machinery and industrial vehicles, beginning with construction machinery, which has a large weight of steel consumption, due to the reactionary downturn following a late surge in demand ahead of stricter exhaust gas regulations. Likewise, in boilers and motors, moves to postpone installation of power generating equipment due to the delay in the recovery of the business climate in Japan could be seen. Metal processing and machine tools were also affected by unstable movements of exchange rates and the fact that the demand for smartphones in the Chinese market failed to meet expectations. Thus, industrial machinery as a whole is expected to fall below the level of the previous year. Overall, in spite of increases in private demand, government and public demand, the value of orders received for industrial machinery in 2016 decreased by 4.9% in comparison with the previous year due to a large drop in external demand.

[Electrical machinery] In addition to a firm trend in home electrical appliances supported by demand for energy-saving and high value-added products, consumer electronics also maintained the level of the previous year due a strong trend in car navigation systems accompanying the recovery in automobile production. In heavy electrical machinery, there was a firm tone in generators for domestic thermal power plants, but external demand was weak, and increased caution regarding capital investment in manufacturing industries was a downward factor. Telecommunications decreased due to the completion of the renewal of central office switching equipment for the transition of landline telephones to the IP network.

In response to these trends in steel-consuming industries, the Sustaining Members of the ISIJ also developed new products in 2016, centering on the civil engineering and construction fields, and automotive fields.

1.3. Crude Steel Production in Japan

Crude steel production in Japan during 2016 (calendar year) was 104.77 million tons, which was a decrease of 0.3% from the 105.13 million tons of the previous year. Following the financial crisis of 2008, Japanese crude steel production exceeded 110 million tons in 2013 and 2014. However, while keeping the 100 million-ton level, in 2016, production fell below the previous year for the second consecutive year. By furnace type, production of converter steel was 81.51 million tons (0.5% increase from previous year) and production of electric furnace steel was 23.26 million tons (3.3% decrease from previous year), and the ratio of electric furnace steel was 22.2% (0.7 point decrease from previous year) (Fig. 1). By type of steel, production of plain carbon steel (mild steel) was 80.74 million tons (1.2% decrease from previous year) and that of special steel was 24.03 million tons (2.5% increase from previous year).

According to the Japan Iron and Steel Federation's Forecast of Iron and Steel Demand for FY 2017, expansion of construction investment is foreseen due to acceleration of urban redevelopment and improvement of transportation

infrastructure, beginning with construction related to the Tokyo Olympics, and a firm tone in labor- and energy-saving investment is also expected in manufacturing industries. As a result, an overall increase in comparison with the previous year is seen. However, where external demand is concerned, while a gradual recovering tendency will continue in the world economy, slackening of global supply-and-demand due to an increase in exports from China and frequent occurrence of trade problems are concerns, and for this reason, iron and steel exports are assumed to be on the same level as in the previous year. As a result, although crude steel production in FY 2017 is expected to exceed that in FY 2016, worldwide political risks, the risk of a downturn in external demand due to sudden exchange rate fluctuations, and rises in the raw material prices must be borne in mind.¹²⁾

1.4. World Crude Steel Production

According to the World Steel Association (WSA), world crude steel production in 2016 (calendar year) was 1 628.52 million tons, or an increase of 0.8% in comparison with the 1 615.37 million tons of the previous year.¹³⁾ The year before last, in 2015, world crude steel production decreased from the first time in 6 years due to a decrease in Chinese crude steel production, which had continued to increase until then, but in 2016, production increased once again. As features of the crude steel production of the main countries, in the Top 10, China's production turned to an increase again, while India shows a continuing increasing tendency (Table 1).¹³⁾ On the other hand, the average operating rate of the main 66 countries in 2016 was 69.3%,¹³⁾ which was a 0.4 point decline from the 69.7% of the previous year (2015).

Although China's crude steel production turned to an increase against the previous year, the growth which had exceed an annual rate of 10% until now has peaked, marking the end of period. The Chinese government announced a rationalization plan for excess production capacity for the first time at the beginning of 2016, and in line with that policy, the nationally-owned majors, the Baosteel Group (Shanghai) and Wuhan Iron and Steel Corporation (Wuhan), conducted talks on reorganization and held the meeting

commemorating the establishment of the China Baowu Steel Group Corporation in December. Considering these developments, it can be said that large-scale moves to reorganize China's steel industry have begun in earnest.

In India, crude steel production also grew at a high rate exceeding 7% against the previous year in 2016. Continuing growth of crude steel production is also expected in the future, as well as continuing growth of steel demand from the heavy industry and the construction market for social infrastructures, the automobile industry, and the electrical machinery industry, is expected accompanying the population growth in the future.

2. Technology and Equipment

2.1. Technical Environment of the Japanese Iron and Steel Industry

Last year (2016), a series of equipment consolidations and consolidation plans were announced in upstream processes, and all steel makers are promoting productivity improvement and strengthened competitiveness by constructing the optimum production systems. Nippon Steel & Sumitomo Metal Corporation (NSSMC) idled Kimitsu Works No. 3 blast furnace (2016) and also announced a change of policy in plans to construct the optimum system for the iron source processes at Yawata Works. With the aim of improving the productivity and enhancing product availabilities of bar and wire rod products and rail products, Yawata will also install a new bloom continuous caster (CC) in its Tobata Area (target: end of FY 2018), stop operation of Kokura No. 2 blast furnace (target: end of FY 2020), stop operation of the Kokura steelmaking shop (refining, CC; target: end of FY 2020) and stop one CC in the Tobata Area (target: end of 2020). As part of structural reforms in its steel products business, Kobe Steel announced in 2013 that it will consolidate the upstream process equipment from Kobe Works to Kakogawa Works, targeting implementation in FY 2017. The company has also established a plan to shut down upstream processes, beginning with the blast furnace at Kobe Works, after constructing new bloom continuous casting equipment and hot metal treatment equipment at

Table 1. Top 10 crude steel production countries (Source: WSA; Unit: Mt).¹³⁾

	Top 10 2016	2013	2014	Growth rate from previous year 2014/2013 (%)	2015	Growth rate from previous year 2015/2014 (%)	2016	Growth rate from previous year 2016/2015 (%)
1	China	822.0	822.8	0.1	798.8	▲2.9	808.4	1.2
2	Japan	110.6	110.7	0.1	105.1	▲5.1	104.8	▲0.3
3	India	81.3	87.3	7.4	89.0	1.9	95.6	7.4
4	US	86.9	88.2	1.5	78.8	▲10.7	78.6	▲0.3
5	Russia	69.0	71.5	3.6	70.9	▲0.8	70.8	▲0.1
6	Korea	66.1	71.5	8.2	69.7	▲2.5	68.6	▲1.6
7	Germany	42.6	42.9	0.7	42.7	▲0.5	42.1	▲1.4
8	Turkey	34.7	34.0	▲2.0	31.5	▲7.4	33.2	5.4
9	Brazil	34.2	33.9	▲0.9	33.3	▲1.8	30.2	▲9.3
10	Ukraine	32.8	27.2	▲17.1	23.0	▲15.4	24.2	5.2
	World total	1 650.4	1 669.9	1.2	1 615.4	▲3.3	1 628.5	0.8

Kakogawa Works and making investments to increase the capacity of the Kakogawa No. 2 blooming mill. As part of this plan, two mechanical-stirring type desulfurization units and a dephosphorization furnace were started up in April 2014, and construction of a second dephosphorization furnace was also carried out in FY 2016, with commercial operation scheduled to start during FY 2017. The company aims to eliminate excess equipment capacity in the upstream process and strengthen cost competitiveness by these moves. In February 2016, NSSMC and Nisshin Steel announced that they would study a plan under which NSSMC will make Nisshin Steel a subsidiary, targeting March 2017, and as a precondition for this, would also study structural measures, including a rationalization of iron sources. Under that plan, Nisshin would stop its Kure Works No. 2 Blast Furnace, and NSSMC would provide a continuous supply of slabs to Nisshin as a substitute for the output from Kure.

All Japanese steel makers are grappling with improvement of productivity and advance prevention of trouble by maintenance of aging equipment and operation and maintenance (O&M). As a countermeasure for aging of coke ovens, steel makers are promoting new construction or repair by the pad-up rebuild method, in which the foundation part of the existing coke oven is reused. During 2016, NSSMC completed three such projects, and JFE Steel Corporation completed one.

In 2015, the Ministry of Economy, Trade and Industry (METI) compiled “Plans on Competitiveness Improvement of Metallic Materials” as a policy for strengthening the competitiveness of the metallic materials industry. The plan consists of the three strategies of I. Strategy for technology development, II. Strategy for strengthening domestic manufacturing infrastructure, and III. Global strategies.¹⁴⁾ As part of this plan, the following were mentioned as issues that confront the metallic materials industry: i) Sophistication and diversification of user needs for materials, ii) Threat of competitors overseas catching up, iii) Decrease of domestic demand, and limiting factors in business, such as energy and environmental restrictions, and human resource and equipment restrictions, iv) Impact of digitalization on reform. As directions for I. Technology development, the strategy presents development of material design technologies, development of manufacturing technologies, development of analysis and evaluation techniques, development of human resources, preventive maintenance utilizing digital data, development of effective utilization technologies for resources and energy, and development of materials considering environmental loads. As II. Strengthening domestic manufacturing infrastructure, strategies include prevention of industrial accidents, strengthening of competitiveness by business reorganization, response to energy/environmental problems, and response to the impact of digitalization. As one item of III. Global strategies, the plan mentions circulating use of resources, including recycling, as a response to of raw material supply risk.

In response to increasing competition between materials, the Japanese steel industry is working to enhance its technological level in collaboration with industry, universities and government agencies so as to steadily promote the development of products that answer user needs, for example, ultra-high strength steels with high formability,

and prevail in international competition, while continuing to consider cooperation between materials, *e.g.*, by pursuing new value by combinations of different materials. The following introduces the main technology trends in iron and steel technology by field, together with technology topics of Sustaining Member companies of ISIJ.

2.2. Iron-making

Pig iron production in calendar year 2016 was 80.19 million tons, which was a decrease in comparison with the 81.01 million tons of 2015.¹⁵⁾ As NSSMC stopped operation of Kimitsu No. 3 BF (inner volume: 4 822 m³) on March 12, 26 blast furnaces were in operation at the end of 2016. Kobe Steel carried out a relining of Kakogawa No. 3 BF during a work period from September 25 to December 23, and increased the inner volume from 4 500 m³ to 4 844 m³. The number of blast furnaces with inner volumes of 5 000 m³ or larger was unchanged at 14. Average productivity increased to 1.92 ton/m³-day from 1.86 ton/m³-day in 2015.

In the iron-making field, moves to repair coke ovens and stop blast furnaces have attracted attention in recent years. Repairs of aged coke ovens are progressing successively. NSSMC enlarged battery F of Kashima No. 1 coke oven and battery E of No. 2 oven, and relined batteries A/B of Kimitsu No. 4 coke oven and began relining of Kimitsu No. 5 coke oven in 2016.¹⁶⁾ At West Japan Works (Kurashiki District), JFE Steel enlarged battery B of No. 6 coke oven and carried out repairs at battery A of No. 1 coke oven, batteries A/B of No. 3 coke oven and batteries A/B of No. 2 coke oven, and at East Japan Works (Chiba District), the company carried out repairs of battery A of No. 6 coke oven, and began repairs of battery B of the same coke oven.¹⁷⁾ Shutdowns of blast furnaces to improve cost competitiveness in the iron-making process are also progressing. During 2016, NSSMC shut down Kimitsu No. 3 BF, resulting in a two blast furnace production system at Kimitsu Works.¹⁶⁾ In 2017, Kobe Steel plans to shut down Kobe No. 3 BF.¹⁸⁾ Nisshin Steel announced that it plans to shut down Kure No. 2 BF from 2019, creating a one blast furnace production system at Kure Works.¹⁹⁾ NSSMC also announced that it will stop operation of Kokura No. 2 BF in 2020.¹⁶⁾ Although shutting down blast furnaces with comparatively small inner volumes will reduce the number of blast furnaces in operation, the company plans to increase the average inner volume per blast furnace.

While there were no moves to repair or construct new sintering machines, JFE Steel developed a high efficiency jet burner for use in the sintering machine ignition furnace, and introduced this technology at the sintering machine at West Japan Works (Kurashiki) in November 2015. This burner reduces fuel gas consumption by 30% in comparison with the conventional type, thereby reducing CO₂ emissions by 2 100 t/yr.

2.3. Steelmaking

Crude steel production in calendar year 2016 was 104.77 million tons, which was a decrease in comparison with the 105.13 million tons of 2015 (Fig. 1). The ratio of continuous casting slabs in slabs/ingots for rolling is shown in Fig. 3.¹⁵⁾ The continuous casting ratio of special steels was 95.2%, for a slight increase from 94.9% in the previous year.

Fig. 3. Ratio of continuous casting slabs in slabs/ingots for rolling.¹⁵⁾

To reduce electric furnace operating costs, Aichi Steel Corporation began construction of equipment which will recover the waste heat of the electric furnace as steam and supply part of that steam to power generating equipment.²⁰⁾ Nakayama Steel Works, Ltd. decided to introduce a “next-generation environment-friendly high efficiency arc furnace” which utilizes the waste heat of the electric furnace for scrap preheating. An improved version of the “environment-friendly high efficiency arc furnace (conventional furnace)” which was introduced at JFE Bars & Shapes Corporation Himeji Works, realizes the same energy-saving effect as the conventional type. This expands the use range of the existing equipment, and reduces the initial investment and costs and shortening the construction period. Although all conventional furnaces were A.C. type arc furnaces, this is the first example of application to a D.C. arc furnace.²¹⁾

Equipment consolidation is progressing as part of efforts to improve cost competitiveness in the steelmaking process. In March 2016, Kyoei Steel, Ltd. closed its Osaka Mill, Hirakata Division, which had produced billets as material for rolling.²²⁾ In the same month, Osaka Steel Co., Ltd. consolidated its steelmaking processes by shutting down the steelmaking process at Osaka Okajima Works and moving production to Sakai Works.²³⁾ Yawata Works of NSSMC announced that it will construct a new bloom continuous caster in the Tobata Area, foreseeing startup in 2019, and will stop operations at the Kokura Area steelmaking shop in 2021.¹⁶⁾ Kobe Steel plans to shut down the steelmaking shop at Kobe Works in 2017 in order to consolidate the upstream process, and is currently constructing No. 6 continuous caster, hot metal treatment and dephosphorization equipment at Kakogawa Works.¹⁸⁾ After the steelmaking process is stopped, these plants are scheduled to produce final products by using ingots for rolling produced at other works in its rolling process.

2.4. Steel Products

2.4.1. Sheets

NSSMC realized practical application of a high functionality stainless spring sheet for exhaust gas gaskets. In this product, the company developed and applied a stainless spring sheet with high heat resistance that can maintain practical strength up to a temperature of around 600°C in gaskets used in automotive exhaust gas systems, which are now operated at higher temperatures. This development

received the Technology Award of the Japan Society of Spring Engineers in November 2016.

JFE Steel developed a 1 470 MPa class ultra-high strength cold-rolled steel sheet which was adopted for use in bumper reinforcements. This product features the world's highest strength level in an automotive structural part produced by cold working. Both high strength of 1 470 MPa class and delayed fracture resistance characteristics were satisfied by absolutely minimizing the addition of alloying elements, which have an adverse effect on delayed fracture, by utilizing the extremely high cooling rate (1 000°C/sec or more) of the JFE Steel's original water-quenching (WQ) type continuous annealing process.

Toyo Kohan Co., Ltd. developed a surface reforming technology for use when performing nonelectrolytic plating (electroless plating) of Au, Pt, Pd and other noble metals on stainless steel substrates. This technology enables plating film forming with high coverage and extremely thin thicknesses. High coverage plating is achieved with this technology, even in the extremely thin film thickness region, by performing surface reforming before nonelectrolytic plating of noble metals on stainless steel substrates, which enables easy progress of displacement plating by (1) removing inert Cr oxides and (2) realizing an Fe radical-, Ni radical-enriched surface layer having an active metal bonding state.

Nihon Yakin Kogyo Co., Ltd. developed a technology that makes it possible to produce wide coils of high nickel alloys, which are used under severe corrosion environments. There is a high need for wide coils of high Ni alloys in order to improve efficiency in welding work. However, because their high temperature strength is extremely high, production of coils with a width of 1 m had been the limit with hot rolling mills. Nihon Yakin incorporated the developed technology in its manufacturing process and succeeded in producing 4 ft wide coils by reducing the rolling load during hot rolling.

2.4.2. Plates

In response to the use of heavier thickness steel products accompanying the increasing size of ships, NSSMC raised the issue of brittle crack propagation arrest characteristics (arrestability) of heavy high strength steel plates with thicknesses of 80 mm or less for ship hulls. NSSMC took the lead in the standardization of arrest performance, and also commercialized the world's first high arrestability plate con-

forming to those standards. Subsequently, the company also contributed to clarification of the arrestability performance of heavy high strength steel plates with thicknesses exceeding 80 mm, responding to further increases in ship size. NSSMC also developed a new corrosion-resistant weathering steel which makes it possible to extend the repainting cycle of painted steel. Under the same paint conditions and use environment, this product greatly reduces the corrosion rate and paint film peeling area at paint film defects in comparison with the conventional steel by utilizing the effect of trace addition of tin (Sn) to the steel material. This improved corrosion resistance realizes a reduction in Life Cycle Cost (LCC).

JFE Steel developed a high strength, high ductility heavy steel plate with enhanced collision safety for ship. As a result of optimum control of the microstructure, this plate has high elongation characteristics in comparison with the conventional steel, and increases the absorbed energy until fracture during a ship collision by 20% or higher compared to the conventional steel, while also maintaining the same level of weldability. JFE Steel also developed a TMCP (thermomechanical control process) type medium thickness YP 460 MPa class heavy steel plate for high heat input welding. This plate makes it possible to secure the strength and toughness of the heat affected zone (HAZ) under various types of high efficiency large heat input welding.

Nihon Yakin expanded its range of NORSOK certification for super duplex plate forms. In 2015, the company received certification under NORSOK standards for the plate and hot strip forms of ordinary duplex, super duplex and super austenite stainless steels. In 2016, it expanded the certification range for the super duplex type by expanding the plate thickness range of the plate form of S32750 from 31 mm and less to 40 mm and less, and also received certification for plate form S32760 as a new steel grade. Expanded application in the oil and gas fields can be expected.

2.5. Systems

Recently, there have been many cases of falsification of the mill sheets that steel companies supply when shipping products and inquiries from customers, centering on overseas. JFE Steel began operation of a mill sheet falsification judgment system for iron and steel products. This system makes it possible to compare the content of the authentic mill sheet by using a smartphone to read the matrix-type 2-dimensional code printed on the sheet to prevent falsification, and inquiries can also be handled directly from that screen. The system was introduced for mill sheets of steel pipes produced by JFE's Chita Works in March 2016.

In December 2015, JFE Steel started operation of a ship allocation cost processing system for transportation of steel products by ocean-going ships. In transportation of steel products by ocean-going ships, changes in conditions such as the time, quantity, *etc.* occur frequently, and the cost difference is settled on paper after the fact. JFE Steel implemented a system which enables real-time processing of costs by related persons in or outside the company, including trading companies and ship companies, by using a cloud service via the internet. As a result, the time required for processing was cut in half.

2.6. Environment and Energy

2.6.1. Government Efforts

The 22nd session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP22) and the 12th session of the Conference of Parties serving as the Meeting of the Parties to the Kyoto Protocol (CMP12) were held in Marrakech, Morocco from November 7 to 18, 2016. As the Paris Agreement came into effect on November 4, the first session of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA1) was also held from November 15 to 18.²²⁾

Through this COP22, the three main targets of Japan, namely, statements on (i) securing decision-making based on inclusiveness, (ii) promoting discussions surrounding the implementation policy of the Paris Agreement and (iii) international cooperation of Japan in the field of climate change, are evaluated as generally having been achieved. Moreover, together with the early effectuation of the Paris Agreement and welcoming the holding of CMA1, the fact that future negotiations can be conducted in a form in which all nations participate was also highly evaluated. From the viewpoint of promoting discussion on implementation policy, the decision to limit ratification to 2018 was also an important achievement. However, differences in the claims of various parties became clear in this meeting, as some developing nations repeated claims made prior to the adoption of the Paris Agreement that only the advanced should be required to make efforts. Thus, how quick and constructive discussions can be promoted in the future will be an issue.²⁴⁾

2.6.2. Efforts of the Japanese Steel Industry

The Japan Iron and Steel Federation (JISF) is continuing the "Voluntary Action Programme for the Iron and Steel Industry" which it implemented during the First Commitment Period of the Kyoto Protocol, and is currently promoting "Commitment to a Low Carbon Society-Phase I" targeting FY 2020. In November 2014, the JISF also established Phase II of the same program targeting FY 2030, anticipating the setting of Japan's Intended Nationally Determined Contribution (INDC) for greenhouse gas emissions (target: FY 2030). The basic concepts of these voluntary efforts are the three environmental friendly approaches of "Eco-Processes," "Eco-Products" and "Eco-Solutions," together with "Innovative Technology Development."²⁵⁾

Eco-Processes are process with the aim of energy-saving and CO₂ reduction efforts in iron and steel production processes, Eco-Products contribute to reductions in the product use stage by supplying high functionality steel products, and Eco-Solutions are solutions that contribute to reductions at the global scale by transfer and dissemination of energy-saving technologies that have been developed and applied practically by the Japanese steel industry. As Innovative Technology Development, the Japanese steel industry is grappling mainly with the Development of Innovative Steel-making Process (COURSE50: CO₂ Ultimate Reduction in Steelmaking Process for Cool Earth 50) and Development of Innovative Iron-making Process (Ferrocake). **Table 2** shows the targets of the Commitment to a Low Carbon Society."²⁵⁾

The COURSE50 project was launched in FY 2008. In Phase I, Step 1 (FY 2008–2012), development of element

Table 2. Targets of JISF Commitment to a Low Carbon Society.²⁵⁾

		Phase I	Phase II
Eco-Processes		Reduction target of 5 million t-CO ₂ vs BAU*1	Reduction target of 9 million t-CO ₂ vs BAU*1
Eco-Products		Contribute to reduction of approx 34 million t-CO ₂ (estimated)	Contribute to reduction of approx 42 million t-CO ₂ (estimated)
Eco-Solutions		Contribute to reduction of approx 70 million t-CO ₂ (estimated)	Contribute to reduction of approx 80 million t-CO ₂ (estimated)
Innovative Technology Development	Development of Innovative Steelmaking Process (COURSE50)	30% reduction of CO ₂ emissions in production process by reduction of iron ore by hydrogen and separation and recovery of CO ₂ from blast furnace gas. Start of commercial operation of No. 1 unit around 2030*2, aiming at wide adoption by around 2050, based on the timing of replacement of blast furnace-related equipment.	
	Development of Innovative Steelmaking Process (Ferrocake)	Innovative technology development with the aim of satisfying both energy saving in the ironmaking process and expanded use of low grade raw materials by development of ferrocake, which accelerates the reduction reaction in the blast furnace and realizes the low temperature function of the reduction reaction in the blast furnace, together with its operating technology.	

*1 BAU: Abbreviation of “Business as Usual”; in these target values, it means the CO₂ emission assuming crude steel production using FY 2005 as the baseline.

*2 Preconditioned on creation of infrastructure for CO₂ storage and securing economic rationality for commercial equipment.

technologies was carried out, involving mainly reduction of iron ore by hydrogen, separation and recovery of CO₂ from blast furnace gas, *etc.* As a main achievement, the CO₂ reduction effect (−3%) of hydrogen reduction was confirmed. In addition, a technology that reduces the amount of energy required for CO₂ separation and recovery by half, *i.e.*, 2 GJ/ton-CO₂, was also developed.²⁶⁾ Continuing from that work, Phase I, Step 2 was begun in FY 2013 with a schedule of 5 years. In Step 2, a pilot level total demonstration test combining the various element technologies will be carried out. For continuity with Phase II, in which a demonstration test will be carried out, the following targets have been set: a) As a technology for reduction of CO₂ emissions from the blast furnace, establishment of a technology which reduces CO₂ emissions from the blast furnace by using a 12 m³ test blast furnace and b), as a technology for CO₂ separation and recovery from blast furnace gas, establishment of a technology which enables CO₂ separation and recovery from blast furnace gas at a cost of ¥2 000/ton-CO₂.²⁶⁾

The 12 m³ test blast furnace was constructed at NSSMC Kimitsu Works, and the first tapping of pig iron in hot test operation was carried out in December 2015. In July 2016, the first round of test operation was conducted over a period of about 3 weeks, and a dismantled examination of the blast furnace was carried out from the late in August. Although the target of a 10% reduction of CO₂ emissions by hydrogen reduction was not achieved, a reduction of the carbon input was confirmed, basically as initially expected. In addition, good agreement was obtained between the results of a 3D numerical simulation by a numerical model of the interior of the blast furnace and the results of operation of the test blast furnace, confirming the high accuracy of the simulation.²⁶⁾

The ferrocake project was carried out over a 3 year period beginning in FY 2006 by a joint industry-academia project of the Ministry of Economy, Trade and Industry (METI) called “Leading Research into Innovative Ironmaking Processes” and as the project “Technological Development of Innovative Ironmaking Process to Enhance Resource Flexibility” of METI and the New Energy and Industrial Technology Development Organization (NEDO) over a 4 year period beginning in FY 2009. Although this project was provisionally completed in FY 2012, a decision was

made in 2016 to construct a demonstration plant for ferrocake production with a production capacity of 300 t/d scale, and carry out a project for the purposes of establishing a long-term operating technology and confirming the energy-saving effect in the iron-making process. NEDO made a preliminary announcement of an invitation to participate in “Environmentally Harmonized Steelmaking Process Technology Development (Iron-making Process Technology Using Ferrocake)” with a 5 year schedule from FY 2017.

Ferrocake is a type of high reactivity formed coke containing fine metal powder, which is produced by forming and carbonizing low grade coal and iron ore as the raw materials. Because the reduction reaction rate of metallic iron in the blast furnace is accelerated, iron oxide can be reduced with a smaller amount of coke (carbon) than in the conventional process, and as a result, a reduction of CO₂ emissions and energy savings can be achieved. The targets are a maximum energy saving of approximately 10% in comparison with current blast furnace operation and a reduction of about 20% in consumption of high grade coal.

In a project that began in FY 2009, a 5 day use test was carried out at JFE Steel East Japan Works (Chiba District) No. 6 blast furnace in FY 2012 using 2 100 tons of ferrocake produced by 30 t/d scale production equipment installed mainly at JFE Steel East Japan Works (Keihin District), and the effect on blast furnace operation when about 10% of the coke used in the blast furnace was replaced with ferrocake was evaluated. This test demonstrated that the reducing agent rate (RAR) and coke rate are reduced as planned, and as a result of optimization of the blast furnace charging method, there were also no adverse effects on operation.²⁷⁾

As efforts by individual steel companies, JFE Steel developed a high efficiency burner for ignition of sintering raw materials in the sintered ore production process. Because this burner simultaneously achieves high flame stability and high speed by combining two burners, high energy efficiency can be obtained by promoting heat transfer at the heating surface. JFE Steel introduced this technology at the sinter plant at West Japan Works (Kurashiki District) in November 2015. In comparison with the conventional process, fuel gas consumption was reduced by about 30%, contributing to a CO₂ reduction of approximately 2 100 t-yr.

This technology received the Minister of the Environment Award for the Prevention of Global Warming for FY 2016.

Daido Steel Co., Ltd. developed an energy-saving combustion system using indirect heating for the heat treatment annealing furnace. In this system, a newly-developed high heat radiation material and high efficiency heat exchanger are installed on the tube flue gas side of the radiant tube heater, enabling high efficiency radiative transfer of the sensible heat of the flue gas, and the sensible heat of the flue gas is recovered by heat exchange between the flue gas and the combustion air. The material adopted in the high heat radiation material and the high efficiency heat exchanger is silicon carbide, which has high thermal conductivity and high thermal shock resistance, and the heat exchanger has a large heat exchange area thanks to a complex shape that had been difficult to manufacture conventionally, but was produced for this application by using 3D printer technology. As a result, energy-saving performance is achieved by reducing the material thickness in the regenerative burners, and the energy-saving effect of a 10.2% reduction in fuel gas unit consumption was confirmed in comparison with the conventional system.

2.7. Construction and Civil Engineering

Nippon Steel & Sumitomo Metal developed a mechanical joint which makes it possible to join steel pipe piles in a short time in comparison with the conventional field welding method. Compact size and light weight were realized by adopting a 4-stage gear structure in the joint structure. The range of application includes pipe diameters from 400 mm to 1 600 mm and strength of 570 MPa class in addition to SKK490. This product received construction technology review certification from the Public Works Research Center in February 2016, and was first applied in actual construction at Yawata Works in August of the same year.

JFE Steel developed a seismic damping device for

building structures which can reduce damage due to giant earthquakes and long period ground motion, particularly in super high-rise buildings, by using low yield point steel for building structure use as steel plate panels that absorb seismic energy. This product received a performance evaluation by the Building Center of Japan. In addition, the fireproof covering (blown rock wool) on cold roll-formed square steel pipes for construction was reduced by 40% or more, and has received approval as a fireproof structure by the Minister of Land, Infrastructure, Transport and Tourism (MLIT).

In products for civil engineering, JFE Steel, in joint work with Obayashi Corporation and Gecoss Corporation, developed a construction method for underground walls in which the permanent composite underground wall is constructed by integrating special steel sheet piles that are used as the temporary retaining wall during construction of the wall, and the reinforced concrete of the actual wall. This method received construction technology review certification from the Japan Institute of Country-ology and Engineering (JICE). In this method, the bond strength between the steel sheet piles and reinforced concrete is increased by using steel sheet piles for composite structure use, which are produced by welding T-shape steel and steel reinforcement for anchorage to a hat-shaped steel sheet pile in advance. As advantages, it is possible to reduce the wall thickness, *etc.* JFE Steel also developed a large-diameter composite structure caisson construction method in which steel rings for civil engineering works are assembled at the site in a double-walled structure, and the space between the rings is then filled with concrete.

3. Technology Trade and Development

3.1. Technology Trade

Figure 4 shows the transition of the balance of technology trade in the steel industry up to FY 2015.²⁸⁾ Payments

Fig. 4. Balance of technology trade of steel.²⁸⁾

received for technology exports increased by 13% in comparison with the previous fiscal year, while payments for technology imports increased by approximately 4 times.

3.2. Research Expenditures and Number of Researchers

The following three items were arranged using the data in **Table 3** Research Activities in Companies in the Summary of Results in “Statistical Survey of Researches in Japan” published by the Statistics Bureau, Ministry of Internal Affairs and Communications. The results are shown in **Figs. 5–7**.²⁹⁾

[Ratio of Research Expenditures to Sales] In all industries, this item had been essentially flat for 5–6 years, but in FY 2015, it increased to the highest level in the past 20

years, and the ratio of expenditures in the steel industry also increased to the level of FY 2002.

[Number of Regular Researchers per 10 000 Employees] In all industries, this index turned from the increasing tendency that had prevailed until FY 2013, and there were slight decreases in the last two years. In the steel industry, there was an increasing tendency until FY 2011, when the industry recorded its highest number, but this has continued to drop since FY 2012.

[Research Expenditures per Regular Researcher] In FY 2015, all industries increased from its low in FY 2004 to the level of FY 1999. The steel industry has increased steadily each year since the sharp drop due to the financial crisis of 2008 and recovered to the level of FY 2007.

Table 3. Examples of R&D topics with public funding in iron & steel industry.

Class	Name of project	Source of funds and commission	Fiscal year started	Fiscal year ending
Processes	CO ₂ Ultimate Reduction in Steelmaking Process by Innovative Technology for Cool Earth 50 (COURSE50), Step 2	NEDO	2013	2017
	Strategic Energy Technology Innovation Program	NEDO	2014	2016
Element technologies	Grants-in-Aid for Development of Element Technologies for Practical Application of Advanced Ultra-Supercritical (A-USC) Thermal Power Generation	METI	2008	2016
	Heterogeneous Structure Control: Towards Innovative Development of Metallic Materials	JST	2010	2019
	Elements Strategy Initiative (Research Center Creation Type) for Structural Materials	MEXT	2012	2021
	Zero-Emission Coal-fired Power Plant Technology Development Project	NEDO	2014	2017
	Strategic Innovation Promotion Program (SIP) : Structural Materials for Innovation	Cabinet Office	2014	2018
Products	Technology Development Project of Advanced Ultra-Supercritical (A-USC) Thermal Power Generation	METI	2008	2016
	Development of Magnetic Materials for High Efficiency Motors for Next-generation Automobiles	METI	2012	2016
	Development of Innovative Structural Materials Technology	METI	2013	2022
	R&D Project on Hydrogen Energy Utilization Technology	NEDO	2013	2017
Others	Technological Development for Next-Generation 3-D Printers for Industrial Use	METI	2014	2018
	Infrastructure Technologies for Ultra-Fast Development of Super-Advanced Materials Project	NEDO	2016	2020

NEDO: New Energy and Industrial Technology Development Organization, METI: Ministry of Economy and Industry, MEXT: Ministry of Education, Culture, Sports, Science & Technology, JST: Japan Science and Technology Agency

Fig. 5. Trend of ratio of R&D expenditures to sales.²⁹⁾

Fig. 6. Trend of the number of researchers per 10 000 employees.²⁹⁾

Fig. 7. Trend of R&D expenditure per researcher (M yen/person).²⁹⁾

3.3. Trends in Research and Development Utilizing Public Funds

Among iron and steel-related technical development projects, the NEDO project “Research and Development of Core Technologies for Next-Generation 10 MW Class Ocean Thermal Energy Conversion Power Plant” was completed in FY 2015, but a new METI project, “Infrastructure Technologies for Ultra-Fast Development of Super-Advanced Materials Project” (FY 2016–2020, budget for FY 2016: ¥1.95 billion, managing organization: NEDO) was started during FY 2016. The aims of this project are to support the development of unprecedented new design simulation techniques and development of materials by utilizing artificial intelligence, mainly for organic materials, and to induce signs of reform in the materials development culture based on “experience and intuition” until now and promote the superiority of highly-competitive Japanese materials industries, by carrying out both development of innovative prototyping processes and development of characterization (evaluation and measurement) techniques.

The main continuing projects are i) MEXT: “Heterogeneous Structure Control: Towards Innovative Development of Metallic Materials” (FY 2010–2019, managing organization: Japan Science and Technology Agency (JST)), ii) METI: “CO₂ Ultimate Reduction in Steelmaking Process by Innovative Technology for Cool Earth 50 (COURSE50), Step 2” (FY 2013–2017, managing organization: NEDO), iii) METI: “Development of Innovative Structural Materials Technology” (FY 2014–2022, budget for FY 2016: ¥4.35 billion), iv) Cabinet Office, Japan: “Strategic Innovation Promotion Program (SIP) : Structural Materials for Innovation” (FY 2014–2018, managing organization: JST), etc.

The main projects on iron and steel-related research and development topics being carried out with public funds are shown in Table 3. Many of these topics are in the fields of processes, environment and energy, and materials development, etc.

4. Development of Human Resources in Technical Fields

The Iron and Steel Institute of Japan (ISIJ) conducts corporate human resource training programs (Iron and Steel Engineering Seminars, Iron and Steel Engineering Seminar

special courses, Advanced Iron and Steel Seminars) and human resource training programs for students on an ongoing basis for the purpose of developing cross-industry human resources.

As human resources development programs for students, in addition to “Student Iron and Steel Seminars,” the ISIJ took over the Industry-Academic Partnership for Human Resources Development in FY 2011 and conducts “Introduction to Iron and Steel Engineering Seminar” for master’s level graduate students and the “Experiential Seminar on Advanced Iron and Steel” for undergraduates under this program. The “Introduction to Iron and Steel Engineering Seminar” is a 3.5 day course consisting of lectures on the fundamentals of iron and steel engineering and technical development at the site by teachers from universities and companies, and a plant tour on the final day (in FY 2016, JFE Steel’s East Japan Works (Chiba)). In FY 2016, 26 students from 15 universities participated. The “Experiential Seminar on Advanced Iron and Steel” is a 1-day course consisting of an introduction to iron and steel-related technology and the outlook for the future as well as a plant tour. This seminar was held at three locations, Nippon Steel & Sumitomo Metal’s Kashima Works, JFE Steel’s West Japan Works (Fukuyama) and Kobe Steel’s Kakogawa Works. A total of 73 persons participated.

As other activities, “University Special Lectures by Top Management” by members of the top management of steel companies were held at 10 universities and “Special Lectures on Iron and Steel Technology” by speakers from METI or companies were held at 15 universities. A total of approximately 1 800 students attended these events. The ISIJ also supported the cost of bus transportation for steel works tours planned by universities.

5. Technology Creation Activities in the ISIJ

The ISIJ conducts activities in which it surveys technical information related to iron and steel production technologies, identifies issues for technology development and conducts activities to solve those issues, centering on Technical Committees and Interdisciplinary Technical Committees, which are affiliated with the Technical Society (Table 4).

5.1. Technical Committees

Technical Committees, which promote activities in designated fields related to iron and steel production, hold regular Committee Meetings, where key issues at the present point in time are energetically discussed as common/important topics (Table 4). As in FY 2015, 35 Committee Meetings (17 Spring Meetings, 18 Fall Meetings) were held in FY 2016. The total number of participants was 2 798 (including a total of 66 researchers from universities, etc., which was a decrease of 5 from FY 2015). The total number of participants increased by about 50 persons from the 2 744 in FY 2015.

Collaboration with the ISIJ’s Academic Division has also taken firm root. Technical Committees encourage exchanges such as participation by university researchers in Committee Meetings and programs for training young persons, and joint programs with the Academic Division. International exchanges activities are also continuing to increase, includ-

ing participation in international conferences, surveys of technology in other countries, and tours of plants, receiving of visiting groups from overseas, depending on the Committee. Technical Subcommittees, which conduct joint studies of designated technical problems as priority issues in each Technical Committee, carried out activities on 19 themes. An increasing number of Technical Committees are also planning new lecture meetings for young engineers and plant tours and lecture meetings with other industries as on-going activities from earlier years.

5.2. Interdisciplinary Technical Committees

Interdisciplinary Technical Committees study interdisciplinary and inter-industry technical issues, in principle within a 3-year timeframe (Table 4). In FY 2016, the new Interdisciplinary Technical Committee “Pursuit of ultimate properties of practical structural steels and improvement of the reliability of practical structural steels by manufacturing by integrated production process” began activities.

The Interdisciplinary Technical Committee on “Desirable steel materials for automobiles” conducted plant tours, and submitted topics to the Society of Automotive Engineers of

Japan (JSAE), while continuing to explore the proper form of a new cooperative relationship with auto makers.

Continuing from FY 2015, in the Interdisciplinary Technical Committee on “Pressure vessel materials,” the “Working Group on Study of Standards for Steel Materials,” “Working Group on Evaluation of Hydrogen Embrittlement of Steel Materials for Chemical Plants” and “Working Group on High Strength Heat-Resistant Steels” carried out survey research, experimental research, *etc.* in their respective areas, and The “Working Group on High Strength Heat-Resistant Steels” completed its report.

5.3. Research Grants and Research Groups

The content of activities related to research grants of the ISIJ is shown in Table 5. In “Grants for Promotion of Iron and Steel Research,” 36 new projects (including 11 by young researchers) were selected as recipients of grants beginning in FY 2016. Together with the 36 projects which began in FY 2015, a total of 72 projects were carried out with the support of this program.

In FY 2016, 21 Research Groups were active, of which 7 concluded their activities during the same fiscal year. During

Table 4. Main organization in technology creation activities of Production Technology Division.

Class	Content of activities
Technical Committees	<ul style="list-style-type: none"> Object: Designated fields related to iron and steel production as a whole. Classification of committees: Iron-making, Coke, Steelmaking, Electric Furnace, Special Steels, Refractories, Plates, Hot Rolled Steel Strip, Cold Rolling, Surface Treatment, Large Sections, Bar and Wire Rod Rolling, Pipes, Rolling Theory, Heat Economy, Control Technology, Equipment Technology, Quality Control, Analysis Technology (total of 19 Technical Committees). Participants: Steel company engineers and researchers, staff of universities, <i>etc.</i> Purpose of activities: Technical exchanges related to iron and steel production for improvement of production site technology levels, identification and solution of technical of technical problems in various fields, training of young engineers, improvement of technology by industry-academic collaboration, technical exchanges with overseas. Activities: Committee meetings (1–2 times/year), Interdisciplinary Technical Committees, lecture meetings for training of young personnel, and various other types of plans.
Interdisciplinary Technical Committees	<ul style="list-style-type: none"> Object: Interdisciplinary and inter-industry technical subjects spanning various fields of the iron and steel production process. Classification of committees: Interdisciplinary Technical Committees on “Desirable materials for automobiles (7th Period),” “Pursuit of ultimate properties of practical structural steels and improvement of the reliability of practical structural steels by manufacturing by integrated production process,” and “Pressure vessel materials (total of 3 Interdisciplinary Technical Committees). Content of activities: Technical study for technological directions and problem-solving, surveys and other types of research, information exchanges with other associations, <i>etc.</i>

Table 5. Research grant system of ISIJ.

Class	Content of activities
Grants for promotion of iron and steel research	<ul style="list-style-type: none"> Purpose: Activation of iron and steel research, support for basic and infrastructural research related to iron and steel, training of young researchers. Application process: Selected each year based on public offering; grant period is 2 years. Features: Object is individual researchers, establishes a framework for young researchers. Number of projects: 72 (number of aid recipients in FY 2016).
Research Groups	<ul style="list-style-type: none"> Purpose: Activation of iron and steel research, creation of foundations for technical innovation, creation of human research network by industry-academic collaboration. Application process: Selected each year based on proposals, public offering; in principle, period of activity is 3 years. Features: Two types of Research Groups, a) “Research Group I” which treats “Seeds” led basic/advanced themes proposed by universities and other research institutions, and b) “Research Group II” which treats “Needs” led applied/industrial themes from iron and steel companies. Number of projects: 21 (number in progress at end of Dec. 2016).
ISIJ Research Projects (name changed from former Industry-originated Project Development Iron and Steel Research)	<ul style="list-style-type: none"> Purpose: Solution of technical problems of iron and steel industry, research on areas which are both important and basic, development of research to National Projects, <i>etc.</i> Application process: Selected by public offering; in principle, period of activity is 3 years. Features: Projects focus mainly on needs from steel companies. Number of projects: 1 (number in progress at end of Dec. 2016).

FY 2016, 8 new activities were begun in each of Research Group I (“Seeds”) and Research Group II (“Needs”). For FY 2017, 5 new activities in Group I and 2 new activities in Group II were selected. Although no new “ISIJ Research Projects” were selected in FY 2016, activities are currently in progress on one theme that was selected in FY 2015 under the former program name “Industry-originated Project Development Iron and Steel Research.”

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