Production and Technology of Iron and Steel in Japan during 1984*

By Tsuneyo IKI**

I. Economic Situation Surrounding Iron and Steel Industry

In 1984 the Japanese economy showed a steady recovering trend and seemingly this trend will stay on until the end on the year, having the background of favorable international trade pattern arising from the lowering of the crude oil price and increased exports of highly sophisticated products as well as from recovery of significant economic activities in the United States, stability in domestic commodity prices and coming back of private demands stimulated by expanded exports and equipment investment.

Looking at the economic specifics, the personal consumption has shown a steady and unhitched growth caused by stable commodity prices and increased income resulting from revitalized production activities. The demands for fixed investment, for example, the number of housing start, are gradually turning upward, while the public investment remained inactive due to the tight financial and budgetary policy of the government. Yet in the private sector, the equipment investment is moving on from recovery toward expansion, particularly, in manufacturing industries, because of reviving demand and improved corporate profits.

The exports are growing by a large margin, while the imports also increase as the consequence of recovery of manufacturing activities in the country.

Summarizing these factors, the real economic growth rate for 1984 is expected to reach around 5%, that is, the first time during 1979~1984 period.

With these backgrounds, a glance is made on the demands for iron and steel. Among major iron and steel consumers, the demands from construction industry, which usually consists of a half of the total consumption, are expected considerably to grow. In the civil engineering works, however, the consumption decreased reflecting the tight control over public expenditure. On the other hand, the demands in the building sector appear to grow after a long stagnant period, owing to the recovery of private investment.

Among manufacturing industries, automobile and electric equipment industries are using more iron and steel. The industrial machinery industry which has been suffering from the persistent bearish market is also picking up recently. The shipbuilding industry traced a significant upward trend, owing to large orders of bulk cargo vessels. Thus, in general, the demands for iron and steel have tended to grow.

Although the economic climate surrounding the iron and steel industry indicates a steady recovering trend, as briefly mentioned above, the industry has never relaxed the efforts for more rational operation and streamlining. Particularly, the industry is continuing to pay serious attention for further automated and continuous operations of steelmaking and rolling processes, such as improvement in continuous casting and ladle metallurgy, fully computerized process and routing control, development and installation of energy recovering devices.

In terms of the equipment investment plan, the forecast for 1984 amounts to 716.1 billion yen, a decrease to 80% of 894.7 billion yen (construction basis) for 1983. The reasons for this decrease seem to be the continuing unfavorable investment climate caused by past sluggish demand, previous deteriorated corporate revenues and the end of an environmental investment cycle. These factors made some firms to put in shelf future large scale investment plans. As the outcome of this hesitancy, the investment will go down as low as 670 billion yen in 1985, despite the continuing economic recovery as a whole.

Major equipment investments in 1984 consisted of those for modernization of continuous casting facilities, installation for energy saving as well as repair and maintenance works. The investments were also extended to facilities of surface treatment of sheets and of upgrading of steels. The weight for energy saving facilities in total equipment investment is estimated to be 16.3% in 1984, compared with 17.7% in 1983.

II. Technology and Equipment

1. Ironmaking

As the result of the so-far stagnant condition in steel output, the blast furnace utilization rate in Japan has been kept as low as for the past several years. Comparing with the figure of 40 furnaces in operation out of 65 existing blast furnaces at the beginning of 1983, the number decreased to 39 at the end of 1983, and further down to 38 at the end of 1984. The only blast furnace newly fired in during 1984 was No. 2 BF (inner volume: 2,797 m³) of Sakai Works, Nippon Steel Corp., while two blast furnaces of the same firm, No. 1 BF (inner volume: 2,800 m³) of Sakai Works and No. 3 BF (inner volume: 3,246 m³) of Nagoya Works were closed down.

Another change in the blast furnace utilization was the replacement of No. 1 BF (inner volume: 2,040 m³)

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of Kure Works, Nisshin Steel Co., Ltd. with the new No. 1 BF (inner volume: 2,150 m³) late October. Despite this discouraging situation, the utilization rate of large blast furnaces with inner volume exceeding 4,000 m³ was kept rather high, that is, as in 1983, 13 out of 15 blast furnaces of this size were in operation during 1984.

The recent performance of blast furnaces are shown in Table 2. Along with the increase in crude steel output, the furnace productivity is turning up since March, 1983, the month recording the lowest point in date, over 1.9 t/d/m³ in April, 1984. Also due to the enhanced use of oil-less operation of blast furnaces, the fuel ratio went up to record 500 kg/t in March, 1983. However, various technological improvements, such as powder coal injection, contributed to somewhat lowering the fuel ratio, namely, to 490 kg/t in May, 1984.

The oil-less operation had been realized in all blast furnaces by 1982. In connection of powder coal injection improvement of furnace productivity and performance stability are expected in addition to its substituting benefit. While 3 blast furnaces, namely, No. 1 BF (inner volume: 4,158 m³) of Oita Works, Nippon Steel Corp., No. 3 BF (inner volume: 1,845 m³) of Kobe Works, Kobe Steel, Ltd. and No. 2 BF (inner volume: 3,845 m³) of Nagoya Works, Nippon Steel Corp. were utilizing this method in 1983, No. 1 BF (inner volume: 3,890 m³) of Nagoya Works, Nippon Steel Corp. in April, 1984, and No. 2 BF (inner volume: 1,650 m³) of Kure Works, Nisshin Steel, also adopted it.

Apart from the efforts for improvement of blast furnace operation mentioned already, one new attempt is worth reporting, that is, the research and development of so-called “smelting reduction processes,” in which ore reduction and melting functions of the blast furnace are separated into two vessels in order to meet the potential possibility of grade lowering of materials such as coking coal and iron ores, and also to implement energy saving and space saving.

2. Steelmaking

As shown in Tables 3 and 4, the recent notable trends in steelmaking are the increase in ratios of killed steel and continuously cast steel in total crude steel and improvement in ladle metallurgy. These trends are described in the following.

In order to respond to the increased demand for high grade steels, technologies relating to pretreatment of hot metal and ladle metallurgy have been developed and widely used. These technologies have rapidly come to usage, because the conventional methods of dephosphorization and desulfurization practiced inside steelmaking furnaces proved insufficient, in terms of productivity and cost to meet the growing demands of users for increasingly stringent specifications.

The pretreatment of hot metal consists of dephosphorization, desulfurization and de-siliconization in hot metal carriers or ladles prior to charging of it by means of the injection of lime or soda ash to obtain
Table 2. Operation performance for blast furnaces.

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<td>1615</td>
<td>1618</td>
<td>1620</td>
<td>1617</td>
<td>1615</td>
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<td>Coke ratio (average, kg/MT)</td>
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<td>Coke ratio (minimum achieved, kg/MT)</td>
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<td>1.75</td>
<td>1.77</td>
<td>1.83</td>
<td>1.83</td>
<td>1.79</td>
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<td>1.87</td>
<td>1.88</td>
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<td>Ratio of sintered ore pellets used (%)</td>
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<td>84.9</td>
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<td>84.5</td>
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<td>Fuel ratio (kg/MT)</td>
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Table 3. Operation performance for converters.

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<td>Productions per steelmaking hour (MT/h)</td>
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<td>Steelmaking time per tap to tap (min)</td>
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<td>Pig iron mixing ratio* (%)</td>
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<td>94.3</td>
<td>93.9</td>
<td>93.9</td>
<td>93.2</td>
<td>93.3</td>
<td>93.3</td>
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<td>Hot metal mixing ratio (%)</td>
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<td>92.3</td>
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<td>93.3</td>
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<td>91.9</td>
<td>93.3</td>
<td>91.4</td>
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<td>Oxygen blown (Nm^3/MT)</td>
<td>51.4</td>
<td>51.1</td>
<td>52.4</td>
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<td>51.9</td>
<td>51.8</td>
<td>52.6</td>
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<tr>
<td>Killed steel ratio (%)</td>
<td>79.5</td>
<td>86.5</td>
<td>93.1</td>
<td>92.6</td>
<td>91.2</td>
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<td>93.7</td>
<td>94.8</td>
<td>94.4</td>
<td>94.3</td>
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<tr>
<td>Ratio of continuous cast steel (%)</td>
<td>69.7</td>
<td>79.3</td>
<td>88.3</td>
<td>87.4</td>
<td>87.1</td>
<td>87.2</td>
<td>88.5</td>
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<td>88.7</td>
<td>90.0</td>
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<tr>
<td>Ratio of vacuum treated steel (%)</td>
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<td>42.3</td>
<td>48.3</td>
<td>48.2</td>
<td>49.0</td>
<td>48.4</td>
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<td>48.8</td>
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* Pig iron in pig iron mixing ratio means hot metal and cold pig iron and excludes scrap.

Table 4. Operation performance for electric furnaces.

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<tbody>
<tr>
<td>Productions per steelmaking hour (MT/h)</td>
<td>26.2</td>
<td>29.0</td>
<td>31.8</td>
<td>31.2</td>
<td>31.0</td>
<td>31.5</td>
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<td>32.9</td>
<td>33.8</td>
<td>35.3</td>
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<tr>
<td>Electric power consumption per ton of good ingots (kWh/MT)</td>
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<td>452</td>
<td>440</td>
<td>437</td>
<td>434</td>
<td>438</td>
<td>436</td>
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<td>425</td>
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<tr>
<td>Oxygen consumption per ton of good ingots (Nm^3/MT)</td>
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<td>24.5</td>
<td>26.0</td>
<td>26.0</td>
<td>25.9</td>
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<td>26.7</td>
<td>28.4</td>
<td>27.0</td>
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<tr>
<td>Pig iron mixing ratio* (%)</td>
<td>4.9</td>
<td>6.4</td>
<td>5.2</td>
<td>4.5</td>
<td>4.5</td>
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<td>5.1</td>
<td>4.7</td>
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<tr>
<td>Yield of good ingots (%)</td>
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<td>90.9</td>
<td>90.8</td>
<td>90.7</td>
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<tr>
<td>Ratio of continuous cast steel (%)</td>
<td>63.5</td>
<td>67.7</td>
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<tr>
<td>Ratio of alloy steel (%)</td>
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<td>29.7</td>
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* Pig iron in pig iron mixing ratio does not include scrap.
steels of high purity and high homogeneity. As this technology allows reduction of load to the converter process and consequently improvement of its productivity and possible contribution to the cost reduction, further research and development efforts are worthwhile.

Other significant technological developments are related to refining effects of stirring and various top and bottom blowing converter methods. In the field of ladle metallurgy, various methods of degassing, desulfurizing, deoxidizing and removal of non-metallic inclusions by using vacuum or inert gas and injecting desulfurizing agents into the ladles or other vessels already charged with molten steel, have been developed. All of them are effective in improvement of cleanliness of steel, precise alloying chemistry, low temperature toughness, hydrogen induced crack resistance, resistance against high temperature brittleness, superior weldment properties and D-I can formability. These advantages will certainly encourage their wider usages.

3. Continuous Casting and Blooming-Slabbing

The continuous casting, which has proved superiority to the conventional ingotmaking by shortening of steelmaking processes, better yield, energy effectiveness and high productivity, has been actively introduced to steel firms throughout the world. In Japan, the first continuous casting mill was installed about 25 years ago. At this initial stage, the facilities were used only for stainless steel and wire rods, because of the difficulty in application for rimmed steel. But, coming into the 1970s, integrated steelmakers have begun to make to use extensively this method for semi-products making of killed steel. As a result, the ratio of continuously cast semi-products in total crude steel output has increased rapidly from 21.5% in 1973, to 32.2% in 1975, 41.9% in 1977, 54.0% in 1979, 72.7% in 1981 and 86.7% in 1983. In addition, during this period pseudo-rimmed steels were also made successfully.

However, the method is not flawless. Comparing with the ingotmaking, the continuously cast products need smaller reduction rates of rolling and consequently show undesirable patterns of structure. That is why, this method was not so much used in manufacturing of high and low alloyed steels. In 1983, the continuously cast steel ratio in speciality steels of high purity and high homogeneity. As this technology allows reduction of load to the converter process and consequently improvement of its productivity and possible contribution to the cost reduction, further research and development efforts are worthwhile.

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With regard to direct rolling, the conventional method consists of reheating of cold semi-products before rolling in order to remove surface defects and to adjust scheduling between the proceeding process (blooming-slabbing or continuous casting) and the rolling process. In direct rolling method semi-products do not require reheating pass, but only through soaking zone of reheating furnace. The method is aimed at utilization of sensible heat of semi-products and uniform heating, hence, energy saving. This technology will be further refined by the development of reliable defects detectors in hot condition.

Another important subject is increasing demand for strict flatness of plates and sheets. As examples, a newly developed six-high strip rolling mill (H Mill) and hydraulically crown controllable rolls (VCR) are put into use to meet this need. Crown control and various in-line measuring devices are being developed.

Concerning the processes following rolling of sheets, the continuous annealing method, used already for tinplates and galvanized sheets, has become available in Japan for ordinary and high strength steel and magnetic steel, too. This technology consists of continuous treatments from cold rolling to skin passing and is particularly suitable for manufacturing of high strength sheets for automobiles and is becoming popular in and out of Japan.

Among large variety of the surface treated sheets,
galvanized sheets are grouped into hot dip coating and electrolytic coating. In Japan, the electrolytic coating started in 1943 and this method is applied to sheets destined to electric home appliances and auto-body. In accordance with increased demands for them most advanced new facilities are constructed. Particularly, the facilities which operate with high current density for thick coating has been developed and are commercially used.

Although the output of tin plates as a cannmaking material is rather sluggish, the demands for chromate coated tin free steel (TFS) are rapidly growing as a substitutive material for beverage cans.

Many other technological developments such as welding technology related to rolling are being pursued and efforts for new products are also continuing, although not specifically mentioned here.

5. Measurement and Control

Computers are extensively used in all facets of steel works operation from order receiving to shipping, such as material flow and quality control, energy distribution and consumption, shipping and various sales network information processing. The development and introduction of highly computerized measuring and controlling techniques have become truly indispensable. In order to meet ever increasing demands for high performance of steel products, on one hand, and other requirements in the entire processes from ironmaking to finishing, on the other hand, many development projects, such as automation, streamlining, energy saving and yield raising have been and are still being carried out. Most of these efforts are closely related to the advancement in measuring and controlling techniques.

The numbers of process computers classified by process as of January, 1984 were 60 for raw materials, 61 for ironmaking, 76 for steelmaking, 133 for semifinished product rolling and 467 for rolling (source: statistics of The Japan Iron and Steel Federation).

As an example, Fukuyama Works of Nippon Kokan K. K. put its new process control system into full operation in July, 1984. The scale of this system is 2,000,000 steps and the total investment was approximately 3 billion yen (2.3 billion for hardware and 0.7 billion for software). The system consists of the main steelmaking system integrally connected with those of hot strip, plate and long product rollings. This system is aimed at energy saving by extensive utilization of HDR (hot direct rolling) and HCR (hot charged rolling) as well as the effective use of resources and grading up of products resulting from the use of continuous casting facilities and ladle metallurgy techniques.

In September, 1984, Kawasaki Steel Corp. in cooperation with Mitsui Miike Works developed a no-man operation system for reclaimers in raw materials yards. This system was put into practical use at its Chiba Works. The system consists of a microcomputer and a multiple number of laser distance detectors. When an operator inputs the predetermined destination from the operation desk in the yard center, the distance to the destination is measured with the laser sensor set at the top of the reclaimer boom. Then the computer performs the computation to control the positioning of boom for automatic discharge and automatic storage pile changing operation.

The realization of the no-man operation of yard facilities provided the comprehensive yard control functions of a better performance such as making effective utilization of materials yards, improvement of quality control of mixed materials and reduction of work load.

6. Environmental Technology

Various environmental regulations were put into force recently. For example, numerical affluent standards were revised and in September, 1983, stricter NOx regulations came into effect following the dust and fume regulations established in June, 1982. Also because of increasing public concerns on hydrological problems related to enrichment of nutrition of lakes and ponds, the regulations over nitrogen and phosphorous discharge were established in December, 1982. On August 5, 1984, Water Quality Conservation Subcommittee of the Central Pollution Advisory Committee presented reports on water waste standards and is preparing the details of them with the target of bringing their enforcement in March, 1985.

With regard to assessment of environmental conditions, the Cabinet adopted the guideline of environmental assessment. It is a step forward to realize the environmentally secure society.

To supplement the industry's own efforts for the environmental protection, the Fund for Development of Environmental Protection Technology in Iron and Steel have been extending financial assistance to researches on atmosphere, water and solid wastes conducted by universities and other research organizations. The total amount of the assistance in 1983 was approximately 50 million yen for 24 researches. Since the establishment of the Fund in 1980, 350 million yen was extended to 60 research items. In addition, the Fund for Development of Technology for Removal of NOx in Iron and Steel Plants provided researchers with a financial assistance amounting to 1.74 million yen for 130 items.

III. Technology Transfer

The Japanese iron and steel industry has accumulated significant technical and knowhow assets owing to the import of advanced technology from industrially advanced nations together with its own innovations accentuated by the two oil crises. Nowadays the technological level of the Japanese steel industry is internationally reputed as one of the highest. Reflecting this evaluation the technological software export from Japan has been exceeding the import since 1974 in terms of the balance of trade.

In 1982 approximately 29 billion yen worth technology were exported against 24.5 billion yen in 1981. As regards the contents of the exports, the technical knowhow and other softwares toward industrialized nations has been rapidly increasing since 1975 and...
also the participation in large scale construction projects of developing nations has been frequently solicited. One noticeable trend in recent technical exports is the increasing number of requests for plant and equipment prognosis, operation guidance and general planning for construction of steel plants. In many cases the Japanese firms were requested to extend these technical advices without involving the exports of hardwares.

ISIJ made a survey on technological exports and imports and the analysis of results are shown in Tables 5 and 6. From these tables it is clear that technical exports were destined to considerable number of countries in various forms covering virtually all facets of steel industry.

IV. Effective Utilization of Energy and Oil-less Operation

With regard to the energy consumption structure of the iron and steel industry in Japan in 1983 on the basis of real heat generating standard and the statistical estimation, 461 trillion kcal (equivalent to 51.25 million kl of oil) consisted of 76.2 % of coal and its derivatives, 6.7 % of oil base fuels and 17.1 % of purchased electricity (including combustible gas supplied to joint venture power stations in the coal base category and excluding this gas from purchased electricity). The specific energy consumption in 1973 was 649 trillion kcal (equivalent to 72.13 kl of oil), 21 % of which came from oil. These figures indicate that significant progress has been made for energy conservation and on oil substitution. Each firm has been making continuing efforts for replacement of oil with other fuel resources such as by-product gases or LNG.

As to the energy conservation efforts measured by energy consumption per MT of crude steel output, the real specific consumption in 1983 was 81.2 % of the corresponding figure in 1973. This fact clearly indicates the effectiveness of the energy conservation measures.

Major energy consuming processes in iron and steelmaking are sintering, coking, ironmaking, steelmaking and rolling. The measures taken in each field are reviewed in the following.

(1) In the sintering process, the measures consist of combustion control of furnace, recovery of waste heat from exhausting gas and recovery of sensible heat from sintered ore.

In 1983 Sumitomo Metal Industries, Ltd. installed waste heat recovering facilities in its No. 2 Sintering Mill of Kokura Steel Works. In 1984 the company also installed the same facilities at No. 2 Sintering Mill of Kashima Steel Works. With these installations, the total recovered heat increased by 25 % and electricity requirement decreased by 1 000 kW.

(2) In the coking process, important measures are combustion control of coke oven, coke dry quenching (CDQ) and reduction of coal distillating energy. In 1983 new coke dry quenching facilities were installed at Kimitsu and Hirohata Works, Nippon Steel Corp. and Mizushima Works, Kawasaki Steel Corp. In

<table>
<thead>
<tr>
<th>Classification</th>
<th>Number of export items</th>
<th>Importing country</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Raw Materials, Ironmaking</td>
<td>2</td>
<td>U.S.A., U.S.S.R.</td>
</tr>
<tr>
<td>1) Coke making</td>
<td>3</td>
<td>The Netherlands, U.S.A.</td>
</tr>
<tr>
<td>2) Pellet making</td>
<td>10</td>
<td>U.K., Australia, Canada, U.S.A., Spain, Sweden, Taiwan, Finland</td>
</tr>
<tr>
<td>3) Ironmaking</td>
<td>2</td>
<td>U.S.A., Taiwan</td>
</tr>
<tr>
<td>4) Blast furnace operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(B) Steelmaking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Converter</td>
<td>5</td>
<td>U.S.A., Italy, Malaysia</td>
</tr>
<tr>
<td>2) Electric furnace</td>
<td>7</td>
<td>F.R. Germany, Indonesia, Brazil, Algeria, Malaysia, Turkey</td>
</tr>
<tr>
<td>3) Continuous casting</td>
<td>40</td>
<td>Australia, Canada, U.S.A., Italy, The Netherlands, Belgium, Algeria, New Zealand, Philippines, Indonesia, Switzerland, Sweden, Brazil</td>
</tr>
<tr>
<td>4) Ladle metallurgy</td>
<td>5</td>
<td>U.S.A., Malaysia, China</td>
</tr>
<tr>
<td>5) Ingot making</td>
<td>3</td>
<td>U.S.A.</td>
</tr>
<tr>
<td>6) Auxiliary facilities</td>
<td>3</td>
<td>Taiwan, Rumania</td>
</tr>
<tr>
<td>7) General technical services</td>
<td>1</td>
<td>U.S.A.</td>
</tr>
<tr>
<td>(C) Steel deformation and other processes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Bloom-slab conditioning</td>
<td>1</td>
<td>U.K.</td>
</tr>
<tr>
<td>2) Bars and wire rods</td>
<td>5</td>
<td>Brazil, U.S.A., Mexico</td>
</tr>
<tr>
<td>3) Pipes</td>
<td>17</td>
<td>F.R. Germany, U.S.S.R., Malaysia, U.S.A., United Arab Emirates, Canada, Ecuador, Australia</td>
</tr>
<tr>
<td>4) Plates</td>
<td>17</td>
<td>Australia, U.S.A., Brasil, Argentina, France, The Netherlands, Italy, Spain, New Zealand, Sweden</td>
</tr>
<tr>
<td>5) Surface treatment</td>
<td>14</td>
<td>Australia, The Netherlands, Belgium, Italy, France, Philippines, Peru, Spain, Taiwan, Malaysia, U.S.A.</td>
</tr>
<tr>
<td>6) Heat treatment</td>
<td>4</td>
<td>France, Belgium, The Netherlands, Korea, Indonesia</td>
</tr>
<tr>
<td>7) Welding rods</td>
<td>1</td>
<td>U.K.</td>
</tr>
<tr>
<td>8) Wire rod processing</td>
<td>1</td>
<td>Indonesia</td>
</tr>
<tr>
<td>9) Spring fabrication</td>
<td>1</td>
<td>Spain</td>
</tr>
<tr>
<td>10) Hot strip construction and operation guidance</td>
<td>1</td>
<td>Korea</td>
</tr>
<tr>
<td>11) Bright annealing line ind. construction and operation guidance</td>
<td>1</td>
<td>China</td>
</tr>
<tr>
<td>12) Forging operation guidance</td>
<td>1</td>
<td>Sweden</td>
</tr>
<tr>
<td>13) Autoparts fabrication</td>
<td>1</td>
<td>Belgium</td>
</tr>
<tr>
<td>14) Production and routing control</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Continued... | | |
Kashima Steel Works, Sumitomo Metal Industries, Ltd. also installed the coke dry quenching facilities,
also. At Oita Works, Nippon Steel Corp., coal moisture adjustment apparatus to utilize the waste heat from ascension piping and flue duct as the heat source for drying of coal to be charged is begun to be operated.

(3) The blast furnace process represents approximately 50% of total energy used in a steelworks. Although successful energy conservation measures in this field make significant contributions, due to the increasing fuel ratio resulting from the use of oil substitutes they make their effects not so apparently reflected in operation.

Affluent energy recovering methods in ironmaking include recovery of BF top pressure energy, recovery of sensible heat from alt to cool water, hot stove, and BF slag.

(4) In the steelmaking field, energy saving is made through improvement of converter gas recovery rate, increase of continuous casting ratio and preheating of scrap by waste gas of electric arc furnace. Researches for recovering the sensible heat of converter slag are also continuing.

(5) As to rolling and finishing, measures have been continuously taken for the modification of heat pattern in a reheating furnace, reinforcement of furnace wall insulation, automatic control of air-fuel ratio and heat recovery of exhaust gas. In addition, due to the extensive use of hot slab charging into reheating furnaces for rolling (HCR) and hot direct rolling (HDR), the specific heat consumption has been remarkably improving, for instance, hot rolling mills of Sakai Works, Nippon Steel Corp. recorded 29,400 kcal/MT in September, 1984.

(6) While oil-less operations are intensified in various fields, the transportation field still remains to be a conspicuous consumer of oil. Hence, the construction of energy saving vessels and reduction of bunker oil with bulk carrier accommodating facilities are getting forward.

(7) Research Association for Smelting Process Advancement established in September, 1982 has been studying to develop “smelting reduction process” and integrated recovery of sensible heat of liquid slag, including experiment at a pilot plant with the subsidy from the Ministry of International Trade and Industry’s project “Development of Common Basic Energy Technology for Oil Substitution.”

V. Lecture Meetings and Seminars

1. Semi-annual Lecture Meeting

- This meeting is one of the most important activities of ISIJ usually held in spring in Tokyo area and in autumn in some provincial city.
- The 107th Lecture Meeting

- It was held on April 1~3, 1984, in Chiba Institute of Technology, Narashino. 118 papers on ironmaking, 163 papers on steelmaking, 177 on plastic working and fabrication processes, 21 on chemical analysis, and 240 on properties of iron and steel, amounting to 719, were presented and discussed in 17 sections. Two prize earners’ lectures were also given.

- In addition, 5 symposia were held on the following themes.

  1) Reduction and Melting Mechanism of Iron Ore at High Temperature
  2) Steelmaking Technology of Alloyed Steels
  3) Strip Rolling Technology of Alloyed Steels
  4) Evaluation of Corrosion Resistance of Autobody Steel Sheets

1984 Kashima Steel Works, Sumitomo Metal Industries, Ltd. installed the coke dry quenching facilities, also. At Oita Works, Nippon Steel Corp., coal moisture adjustment apparatus to utilize the waste heat from ascension piping and flue duct as the heat source for drying of coal to be charged is begun to be operated.

(3) The blast furnace process represents approximately 50% of total energy used in a steelworks. Although successful energy conservation measures in

Table 5. Continued.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Number of export items*</th>
<th>Importing country</th>
</tr>
</thead>
<tbody>
<tr>
<td>(D) Iron and steel works in general</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Hole operation</td>
<td>1</td>
<td>Brazil</td>
</tr>
<tr>
<td>2) Steelmaking and cold rolling operation guidance</td>
<td>1</td>
<td>Spain</td>
</tr>
<tr>
<td>3) Computerized control</td>
<td>1</td>
<td>U.S.A.</td>
</tr>
<tr>
<td>4) Technical prognosis</td>
<td>3</td>
<td>U.S.A., Spain</td>
</tr>
<tr>
<td>5) Integrated technical guidelines</td>
<td>1</td>
<td>Spain</td>
</tr>
<tr>
<td>6) Steel foundry operation guidance</td>
<td>1</td>
<td>China</td>
</tr>
</tbody>
</table>


Table 6. Content of technology imports. (October 1, 1983—September 30, 1984)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Number of export items*</th>
<th>Exporting country</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Steelmaking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Continuous casting</td>
<td>1</td>
<td>France</td>
</tr>
<tr>
<td>2) Ladle metallurgy</td>
<td>1</td>
<td>F.R. Germany</td>
</tr>
<tr>
<td>(B) Steel deformation and other fabricating processes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Pipes</td>
<td>2</td>
<td>F.R. Germany</td>
</tr>
<tr>
<td>2) Plates</td>
<td>2</td>
<td>U.S.A.</td>
</tr>
<tr>
<td>3) Near-net-shaping process</td>
<td>1</td>
<td>France</td>
</tr>
<tr>
<td>4) Welding rods</td>
<td>1</td>
<td>Belgium</td>
</tr>
<tr>
<td>5) Spring fabrication</td>
<td>1</td>
<td>F.R. Germany</td>
</tr>
<tr>
<td>6) Centrifugal casting of rolling rolls</td>
<td>1</td>
<td>F.R. Germany</td>
</tr>
</tbody>
</table>

* Those of companies responding to the inquiry, namely, Kanto Special Steel Works, Ltd.; Kawasaki Steel Corp.; Kobe Steel, Ltd.; Mitsubishi Steel Mfg. Co., Ltd.; Nippon Metal Industry Co., Ltd.; Nippon Steel Corp.; Sumitomo Metal Industries, Ltd.
5) Recrystallization and Crystal Grain Boundary

2. The 108th Lecture Meeting

It was held on October 9-11, 1984, in Hiroshima University, Hiroshima Prefecture, and 772 papers consisting of 114 on ironmaking, 194 on steelmaking, 173 on processing and system, 269 on materials science, 22 on chemical analysis were presented in 18 sections. Two prize earners’ lectures were also given. In addition, 4 symposia were given on the following themes.

1) Model and Pilot Plant Works in the Field of Ironmaking
2) Science and Technology on Molten Iron and Slag Related to Steelmaking Processes
3) New Processes and Techniques for On-line Heat Treatment of Steel Products
4) Remaining Life Prediction of High Temperature Structural Materials

This meeting was followed by a plant visit to Fukuyma Works, Nippon Kokan K. K., Mizushima Works, Kawasaki Steel Corp., The pre- and during-war Naval Academy belonging to the Marine Self-Defense Force, and Matsuda Co., Ltd.

2. Nishiyama Memorial Seminars

The seminars were established by means of Nishiyama Fund with the objective of disseminating knowledge relating to steelmaking technology in professional technical staffs and researchers for keeping them abreast of recent technical innovations. Each seminar has a specific topic selected from various field of iron and steel technology, and lecturers are chosen from the industry as well as from academics.

In 1984, the seminars were held three times in Tokyo and three times in local towns on the following themes.

1) Development of Manufacturing Technology and Property Improvement on Free-cutting Steels
2) Recent Advancement of Long Products Production Technology
3) Current State of Art in Steelmaking by Means of Stirring (the 100th Occasion)

3. Shiraishi Memorial Seminar

This seminar was inaugurated in 1982 by means of Shiraishi Fund with the objective of disseminating knowledge relating to steelmaking technology in proper for not only technical but also business personnel who are working in the steel industry and the related industries.

In 1984, the 3rd Seminar was held in Tokyo and Osaka in June, 1984, on the following theme:

"Technical Advancement of Drilling, Transportation and Storage of Oil"

4. Iron and Steel Engineering Seminar

This seminar is intended to career education of young diploma-engineers, emphasis being put on basic theories of metallurgy. It is held once a year and lectures are divided into three sections, namely, ironmaking, steelmaking and materials science. The seminar was held on July 30 to August 4, 1984 at Zaoh Heights (a hotel), Yamagata Prefecture with 150 participants.

VI. Activities of Various Research Societies

1. Joint Research Society

The Joint Research Society consists of 18 committees (Ironmaking, Coke, Steelmaking, Electric Furnace, Special Steel, Steel Plates and Sheets, Sections and Wire Rods, Steel Pipes and Tubes, Rolling Theory, Iron and Steel Analysis, Refractory, Heat Economy Technology, Transportation, Instrumentation, Investigation, Quality Control, Plant Engineering, and Utilization of Nuclear Energy Committees), 18 subcommittees and 11 working groups. The activities of the Society are administered by Management Committee which deliberates on new establishment, and reorganization of existing committees and supervises budgetary control. Each committee and subcommittee activity has been regularly and steadfastly carried out and aiming at respective objectives. However, some particular events which are considered recordworthy are given in the following. This way of description does not correspond to the previous review. Readers are requested to keep this point in mind. As a common project, each committee reviewed the Word Glossary of Visually Inspected Defects and also extended cooperation for revision of textbooks of the Human Resources Development Center of Iron and Steel Junior College.

1. Steelmaking Committee

In order to prevent the loss of references on the open hearth furnace technology which used to be the principal steelmaking method, the committee has been compiling the bibliography of this technology since 1982 as historical assets and published its content in December, 1984. The compiled literature is to be kept at ISIJ’s library for good and all.

2. Mold Subcommittee, Steelmaking Committee

The subcommittee was established in 1954 to conduct researches on ingot mold jointly by users and manufacturers, and has achieved many fruitful results. However, since the continuous casting facilities were widely spread, the ingot output ratio in total crude steel output has been incessantly decreasing. Under these circumstances, the subcommittee agreed that its objectives have been fulfilled, therefore, decided to liquidate it. Its activities and achievements were recorded in the final report published in December, 1984.

3. Electric Furnace Committee

In melting and refining processes of electric furnace steelmaking, the energy consumption pattern has been changing due to the concurrent use of preheating of scrap and ladle refining. The committee made an investigation on total energy consumption and is now proceeding to the collection and compilation of the data.

4. Plates Subcommittee, Steel Plates and Sheets Committee

The special report of the subcommittee, “Recent Development of Manufacturing Techniques of Steel Plates in Japan,” was first published in December,
Various steel firms have been making reconstruction and revamping of hot strip facilities. Reflecting this situation, the subcommittee decided to re-edit its special report, “Recent Development of Equipment and Operational Technology of Hot Strip Mills in Japan” and established Editorial Working Group in August, 1984.

6. Cold Strip Subcommittee, Steel Plates and Sheets Committee

In the meeting held in December, 1984, the Subcommittee included in the agenda lecture on “Refreshing of Cold Rolling Mill at Keihin Works” as the commemoration of its 20th anniversary.

7. Sections and Wire Rods Committee

As Steel Bars and Wire Rods” and “Shape Steel” volumes in Bar Steel Manual of Steel Materials Manual Series no longer correspond to the existing situations, the committee decided to prepare the second editions covering the innovations during the past 12 years. In this re-edition Large Sections Subcommittee is responsible for the volume “Shape Steel”, while Small and Medium Sections Subcommittee and Wire Rods Subcommittee are for the volume “Steel Bars and Wire Rods.”

8. Steel Pipes and Tubes Committee

In the 43rd meeting held in December, 1984, the research theme “Introduction of Newly Built Seamless Mills” was adopted and the new seamless mills put into operation in 1983 and 1984 were presented in the form of panel discussion. The presentation included backgrounds for construction plans, focal points, range of product variety and grades for production and specifications of facilities.

9. Rolling Theory Committee

The committee’s publication titled “Theory and Practice of Flat Rolling” was published in September, 1984 after the series of preparatory works since 1983. The committee is planning to hold the 30th anniversary with the symposium on “History and Recent Progress of Rolling Technology” on March 6 and 7, 1985.

Since June, 1984 the Rolling Control Working Group has been studying theories of control.

10. Heat Economy Technology Committee

In March, 1984 Model Theory and Scale Up Study Working Group was newly established and got on to discuss the model theories and numerical simulations for ironmaking, steelmaking and reheating.

11. Refractories Committee

Following the previous meeting in November, 1983, the 2nd Meeting of “Germany–Japan Refractory Materials Committee” was held at the headquarters of Verein Deutscher Eisenhüttenleute (VDEh) in Düsseldorf in October, 1984. The principal subjects discussed at the symposium are as follows:

1) Torpedo car lining taking into account pretreatment of hot metal
2) Converter lining in conjunction with the top–bottom blowing and flame gunning repair
3) Lining of molten steel ladle.

12. Quality Control Committee

The 50th committee meeting was held in June, 1984 at Kashima Steel Works, Sumitomo Metal Industries, Ltd. with the memorial lecture on “Ways and Means of Quality Control in the Future” presented by Mr. Hajime Karatsu, Technical Adviser, Matsushita Electric.

13. Investigation Committee

Since June, 1983, the committee has been investigating 9 materials substitutive to steel (copper and copper alloys, fibers, aluminum, titanium, plastics, ceramics, glass, paper, wood and concrete) and in October, 1984 compiled its report as “Materials Substitutive to Iron and Steel.”

14. Iron and Steel Analysis Committee

The activities of this committee have been conducted by Chemical Analysis, Photoelectric Emission Spectroscopic Analysis, Fluorescent X-ray Analysis, Non-metallic Inclusions Analysis, and Analysis of Gas in Steel Subcommittees as well as two working groups on Fluorspar Analysis and Surface Analysis. In order to make these activities more effective, and simplified, an extensive review of the research program was made in such aspects as organization and operational methods.

Under the new organization, 2 subcommittees of Chemical Analysis and Instrumental Analysis were established and a few working groups may be established to make specific studies in a limited period from time to time. (2 working groups are to be organized for study of Non-metallic Inclusions in Steel and Surface Analysis.) This new operational system of the committee will come into force in 1985.

15. Plant Engineering Committee

The subcommittee of this committee has been conducting common researches on diagnosis of plant facilities in respective fields. To make the research results available for the interested engineers, the committee decided to publish manuals and appointed an editorial group for preparation of the publication.

16. Committee on Utilization of Nuclear Energy

Subcommittee on NIS Process Material Testing made investigation and experiments on candidate materials for thermochemical hydrogen generating system utilizing sensible heat of a multi-purpose high temperature gas reactor, which has been entrusted by the Research Institute of Nuclear Energy. The subcommittee compiled and submitted the report for 1983 and also got on the 1984 research program.

2. Basic Research Association on Specific Subjects

The objective of this Association is to carry out basic researches on specific subjects requested by the iron and steel industry to make the best use of the unique role of ISIJ as the forum of both industrial and academic circles.
1. Committee on Basic Behavior of Coal Carbonization
As 1984 is the last third year of the committee’s assigned research period, it held a report meeting on so far research achievements and presented an interim report on mechanism of coking and coke fracture.

2. Committee on Basic Research of Surface Properties of Steel
The committee during the last third year of its research period shifted its emphasis from the consolidation of surface analysis technology to its application and property analysis to commercially used steels. Also it published its interim report in Transactions ISIJ, 24 (1984), Nos. 7 and 8.

3. Joint Society on Iron and Steel Basic Research
This Society is managed jointly by Japan Society for the Promotion of Science, the Japan Institute of Metals and ISIJ, and has been promoting basic researches on iron and steel. During 1984 Committee on Wear in Steel and Committee on Non-metallic Inclusions Shape Control were terminated and compiled their research reports, while Rapid Solidification of Iron and Steel Committee and Committee on High Purity Steels were newly created and engaged in their respective activity.

1. Committee on Non-metallic Inclusions Shape Control
This committee has been carrying out its researches for the past 5 years and published its final report titled “Shape Control of Non-metallic Inclusions” in September, 1984. Although a significant progress has been made in the field of the reduction and shape control technology for the non-metallic inclusions in steel, the committee realized that basic research data are not sufficiently available, and consequently oriented its research focusing on the relations between shape control of inclusions and properties of steel.

2. Committee on Wear in Steel
In February, 1984, the committee published as “Wear in Steel” with emphasis on wear of rolling roll. The committee also held a symposium on wear of rolling roll in Japan.

3. Committee on Mechanics Related Behavior in Continuous Casting
In the final research year, the committee compiled its research report on mechanism of embrittlement, stress analysis of shell solidification, stress crack in continuously cast products, data sheets on mechanical properties of steel in high temperature and another report covering many photo illustrations of crack in continuously cast products. This report will be published in March, 1985.

4. Committee on Liquid Material Refining Reaction
The committee has been studying refining reactions covering a wide range such as dephosphorization, desulfurization and desiliconization of hot metal and molten steel in varied processes from BF tapping floor to transfer of hot metal, converter to ladle refining, in terms of chemical equilibrium, kinetics and materials transfer.

1984 being the final research year of the assigned 5 years, the committee set to prepare the report to be published in May, 1983 and is planning to hold a symposium on it in June, 1985.

5. Committee on Strength of Iron and Steel in Various Environments
During the third year of its research period, the committee continued the common testing on corrosion fatigue and stress corrosion crack of steel under marine environments and compiled and analyzed the data of testing. Its research activities also included the preparations for publication of “Fractography of Steel in Marine Environments” Vol. I to be published in July, 1985 and discussion on various research items proposed by member firms.

6. Committee on Rapid Solidification of Iron and Steel
This committee was organized in 1984 for the purpose of supplying basic data useful for development of new manufacturing process and new materials of iron and steel based alloys by applying rapid cooling technology. During the initial year the committee has evaluated existing literature.

7. Committee on High Purity Steels
Recently the cleanness and purity of steels for practical use have been significantly improved. On the other hand, the demands from various fields for steels with superior properties are also increasing. In order to meet these requirements for high purity steels, the committee was set up to analyze their characteristics in March, 1984 and began to deliberate its activity plan together with a report on evaluation of existing literature.

4. Other Technical Committees
1. Materials Science Committee
This committee is composed of representatives of steel manufacturers and compiled an interim report on “Effects of High Purity on Fracture Toughness of Steel”. The preparations for publication of the final report in March, 1985 are proceeding.

2. Research Committee for Hot Rolling Process Metallurgy
The committee held the 4th~7th meetings to study 7 research papers. In the spring of 1985, the committee will be holding a symposium on following subjects:
1) metallurgical phenomena of high temperature deformation
2) grain boundary and grain growth
3) phase transformation of austenite.

3. Low Carbon Sheet Steels Research Committee
This committee was created in January, 1984 for the purpose of analyzing physical behavior of low carbon steel sheets of multi-alloy system. During the initial year, the committee studied 10 research papers.

4. Japan Pressure Vessels Research Committee (JPVRC)
Operation Committee, consisting of ISIJ, Japan Society of Welding, Japan Association of High Pressure Technology, and Research Corporative of High Temperature Structure Safety Technology, supervises the activities of 3 committees namely, Material, Construction Work and Designing. ISIJ has been
taking charge of the researches of Material Committee.

Three subcommittees of the Material Committee, that is, Subcommittees on Hydrogen Embrittlement, Pressure Vessel Steels, and Non-Destructive Evaluation of Materials for Pressure Vessel Components, have been engaged in active research. To present the report on research achievements so far since the foundation of JPVRC, the committee held a symposium on “Reliability of Pressure Vessels” on October 22, 1984.

5. High Temperature Strength Research Committee

The committee itself and following subcommittees held research meetings.

1) High Temperature Thermal Fatigue Test Subcommittee
2) Data Sheet Preparation Subcommittee
3) National Research Institute for Metals’ (NRIM) Creep Data Sheet Subcommittee
4) Creep Strength Extrapolation Subcommittee
5) Notch Effects Testing Subcommittee
6) High Temperature Embrittlement Subcommittee

The High Temperature Thermal Fatigue Test Subcommittee completed the common testing on Alloy 800 and is preparing a report thereon. The Data Sheet Preparation Subcommittee also completed the compilation of data on high temperature strength of welded metal, welding metal and weldment, and is preparing a report now. The Notch Effects Testing Subcommittee is also preparing a report on “Common Testing on Notch Effects of SUS 304 Stainless Steel under Creep-fatigue Mutual Reaction on High Temperature Low Cycle Life”.

6. High Strength Line Pipe Research Committee (HLP)

In order to communicate the research achievements of the committee to interested organizations and individuals abroad, the committee held an technical meeting with the American Gas Association, one of the largest users’ organizations of line pipes in the world, in Columbus, Ohio, in September, 1984. Papers were presented for discussion on fracture behavior, corrosion fracture and other subjects.

Another activity of the committee during 1984 is the first simulation test to investigate the Hydrogen Induced Fracture Characteristics of Pipe Using Commercially Made Pipes at the British Gas Corporation in October, 1984. Also the results of two burst tests with natural gas of commercially made pipes, earlier made at the British Gas Corporation in 1982 and 1983, were compiled for analysis and published. The committee also prepared a documental film on these tests.

7. Material Measurement Evaluation Committee

With the research fund for promotion of science and technology from the Agency of Industrial Science and Technology, the committee was entrusted with the investigation of measuring techniques for prediction of life and remaining life of structural materials. During 1984 the committee, on the basis of findings and study up to 1983, compiled its final recommendations on (1) limitation of existing measuring techniques, (2) feasibility and problems of new technological development, (3) feasibility and problems of monitoring technology development and (4) issues to be solved and practical applications for industrial machines, in relation to creep damage, annealing embrittlement, stress corrosion including hydrogen attack and damage status of fatigue including corrosion fatigue.

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