# The Establishment of the State-Owned Yawata Steel Works(2) : The Integrated Steel Works That Promoted Japan's Industrialisation When the Country Entered the Modern Industrial World as a Latecomer (In Honor of Prof.Masanori Furukawa)


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# The Establishment of the State-Owned Yawata Steel Works (2)

—— The Integrated Steel Works That Promoted Japan's Industrialisation When the Country Entered the Modern Industrial World as a Latecomer

Norikazu Shimizu

With regard to steel materials for military weapons, substantial progress was made during and after the Russo-Japanese War. Facilities improved considerably in the thick steel plate mill, crucible steel mill (for the manufacture of gun barrels), bullet swaging mill and steel forging mill (for railway axles, tool steel, high speed steel and gun barrel steel forging). While, as of the end of Meiji era, 78,000 tons of iron and steel materials were demanded to the military, 35,000 tons were steel materials' demand, and the Yawata Works supplied 20,000 tons. It would be fair to say that, "around that time, this enterprise, at long last, grew to establish its status as a major production site of steel materials of military grade. It virtually accomplished the original goal to contribute to the Japanese military" "As for the warship building, this plant, at long last, grew to be capable of manufacturing most parts and components. They included armour plates of ironclad battleships and materials for cruisers." "As to the service for the army, the Yawata Works was able to supply high quality materials for the manufacture of rifles and artillery shells."

Around the end of Meiji era, 98 % of steel products of the Yawata Works were sold to its customers. One third of that sale was accounted for by rail products. 40 % of the rails were sold to railway undertakings. In those days, the National Railway Bureau was the largest customer for this business. On the other hand, the supply to the private sector was limited. Private sector companies were doing business in shipbuilding, machine manufacturing, civil engineering and construction. Among them, the civil engineering and construction companies were the largest customers. “Regarding construction materials, a large portion was represented by steel structural members, bridge materials and gas tank materials. Major customers were Ishikawajima Shipbuilding Yard, Nippon Railway Vehicle Manufacturing Company , Kawasaki Shipbuilding Yard and manufacturing plants adjunct to the National Railway Bureau. The annual production amounted to about 20 plus several thousand tons, the value of which was approximately 2 million plus several hundred thousand yen. Materials for this production were partially supplied by the Yawata Works itself. These internal supplies included steel plates, angle steel and others. Despite this effort, however, the supplies were never sufficient. As far as those materials were concerned, the demands of steel materials had to depend heavily on the import from abroad.” While there was an increasing domestic demand for steel materials, the domestic company could not satisfy all of it. The self-sufficiency rate of steel materials was accordingly limited to the level slightly over 30 % in those days.

It should be noted that, because the site of The Yawata Works was chosen in a remote underdeveloped as well as impoverished area of Kyushu, this project provided the villagers in the hinterland with tremendous economic benefits. When a large state-owned plant was constructed and operated with leading edge technology, huge influence and character were brought to this area and residents.

When construction works began, “construction workmen, steeplejacks, boilermaking, carpenters, blacksmiths and others came over to the site from various parts of Japan, seeking job opportunities.” By 1899, in terms of headcounts, 600,000 people had worked at the site. Once the operation started, because it was a state-run enterprise, the project was managed in a bureaucratic way, giving a high priority to the institutional organisation. Everything was controlled by the regulations. Three strictly defined ranks existed among the bureaucrats working in there. Those of the highest rank were senior officials, who were classified into two groups. Those in the first group were high ranking government officials and “imperial appointees”. They were directly appointed by the Emperor. Those in the second group were also high ranking government officials, who were approved by the Emperor. Employees in the second rank were junior officials. People in the third rank were engineers supervising the daily plant operation. Since plant

## Total number of employees

| | 1906 | | | 1907 | | | 1908 | | | 1909 | | | 1910 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | namber | total wages | wage per one employee | namber | total wages | wage per one employee | namber | total wages | wage per one employee | namber | total wages | wage per one employee | namber | total wages |
| Manufacturing Dep. | 753,774 | 444,726 | 0.590 | 1,035,405 | 650,425 | 0.628 | 724,956 | 518,181 | 0.715 | 594,660 | 455,374 | 0.766 | 673,839 | 524,362 |
| Ironmaking Dep. | 541,310 | 307,514 | 0.568 | 496,400 | 325,560 | 0.656 | 432,510 | 323,474 | 0.748 | 426,489 | 331,984 | 0.775 | 407,560 | 346,496 |
| Steelmaking and Product Dep. | 968,868 | 603,969 | 0.623 | 990,490 | 658,595 | 0.665 | 951,256 | 680,452 | 0.715 | 1,061,387 | 746,223 | 0.703 | 1,116,670 | 871,735 |
| Accounting Dep. | 183,764 | 87,718 | 0.477 | 200,563 | 100,144 | 0.499 | 201,721 | 108,950 | 0.540 | 201,554 | 114,337 | 0.567 | 187,010 | 114,634 |
| Controller Section | 49,042 | 24,889 | 0.508 | 63,669 | 34,258 | 0.538 | 64,653 | 37,446 | 0.579 | 67,220 | 41,372 | 0.615 | 67,402 | 43,199 |
| General Affairs Section | | | | | | | | | | 1,272 | 930 | 0.731 | 4,074 | 2,716 |
| Total | 2,496,758 | 1,468,818 | | 2,786,529 | 1,768,953 | 0.635 | 2,375,097 | 1,668,505 | 0.702 | 2,354,584 | 1,690,223 | 0.718 | 2,456,558 | 1,903,144 |

Number of Administration and Workers

| | Administration | Workers | Miscellaneous Part-time labourers |
|---|---|---|---|
| 1901 | 504 | 2,283 | 1,697 |
| 1902 | 438 | 1,763 | 1,440 |
| 1903 | 629 | 1,729 | 1,751 |
| 1904 | 704 | 3,610 | 1,973 |
| 1905 | 712 | 6,155 | 2,250 |
| 1906 | 829 | 7,263 | 2,725 |
| 1907 | 844 | 7,876 | 2,692 |
| 1908 | 879 | 7,602 | 3,323 |
| 1909 | 882 | 6,457 | 3,606 |
| 1910 | 810 | 6,380 | 3,390 |
| 1911 | 892 | 6,483 | 4,115 |
| 1912 | 914 | 6,949 | 3,854 |

workers were not government employees, they had no formally guaranteed posts. They were hired on a tentative basis according to the needs in operation. In 1904, about 6,000 plant workers were working. The number increased to approximately 10,000 in 1914. Plant workers' living and working conditions were pretty awful. Their working environment was often dangerous. Wages were low in both relative and absolute terms. They worked in a two shift system. One shift lasted for 12 hours. This shift system continued until a major labour dispute occurred in 1920. Because of high consumer prices and living costs, many plant workers lived in poverty. "Many of them were those who roam about from one job to another without settling in the same place." The retention rate of workmen was pretty low. Because of the geographical conditions of the site, it was inevitable that many workers came from agricultural communities. They had no knowledge or experience of iron making. In the initial phase, workers were still observing the conventional life style and custom of rural villages, without adapting themselves to the practice of modern industry. A daily log states, "There were quite a few absentees today. . . due to rainy weather and because it was the beginning of the month. The daily works as planned were barely finished." Absenteeism was very common, which was a headache to foremen and the management. In order to elevate the workers' retention rate, the management made effort to enhance the welfare for the employees. Specifically speaking, company accommodation, company-owned shop service and mutual aid association were offered for the furtherance of employees' well-being. On the other hand, the management embarked upon a scheme to nurture core skilled workers. In the post-Russo-Japanese-War period, it was understood that "there would be a severe shortage of skilled workers rather than of engineers in the forthcoming years." In order to cope with the anticipated labour shortage, the management decided to "provide workers with proper education to develop them as skilled workers." For this purpose, a training centre was established to educate the youth.

As the scale of plant operation expanded, the population increased in the surrounding area. Yahata Village became Yahata Town in 1901 with the population of 6,652. In 1917, it turned to Yahata City, the population of which was 84,682. Actually the City's population growth rate was the highest in Japan. According to Japan's first census data of 1920, the population of Yahata City was 100,235, the largest in Fukuoka Prefecture (Fukuoka City: 85,331, Moji City: 72,111, Wakamatsu City: 49,336, Kokura City: 33,954). While 18 % of Yahata citizens were born in the city, 53 % came from outside Fukuoka Prefecture. As for the age distribution of citizens, the youth accounted for a large portion. The age bracket between 20 and 24 represented 13 % of the total, the largest of all. Infants and toddlers accounted for 10 % of the total.

"Many workers were unmarried when they first came to Yahata. Only after they got employed, feeling fairly comfortable about their financial situation, they thought of marrying and getting children. After securing their income, many workers invited their parents and siblings to Yahata to live with them." Until they became financially stable, many were "staying at temporary accommodation here and there with their colleagues or friends". In those days, a large part of the city was occupied by the plant and government-owned residential accommodation for the senior/junior officials, engineers, those in clerical jobs and low ranking employees. In addition, "an increasing number of makeshift houses were being built here and there all over the city every day. The number increased at a rapid speed, continuing almost infinitely." "There was no city park, hospital, or citizens' hall. There was no sign of social welfare in here". "It was as if 110,000 people had simply gathered at this place purposelessly and merely for expedience." It was a "huge labour pooling city generated too abruptly with no specific plan". By 1910 or so, 136 chimneys had been erected at the central boiler zone in the premises of the Yawata Works, looking like a forest. Soot and dust released from the chimneys overcast the city. People were talking that "sparrows in Yahata were black, being covered with soot and dust".

The central boiler zone

The following summarises what was brought about by the launching of The Yawata

Works by the end of Meiji era to the beginning of Taisho era:

1. The original budget for this state undertaking worth 4.09 million yen swelled ten folds, eventually exceeding 40 million yen. It took the project 15 years to be fully grown, accomplishing the annual steel products of 180,000 tons, which was comparable with that of industrialised nations in the world. In addition to the capital expenditure, the total employment capital injected in this initiative amounted to 10 million yen. In those days, it was generally said that the global average of investment cost necessary for the launching of an integrated mill for both pig iron and steel production, which produced 150,000 to 200,000 tons of steel products a year, would be 12 to 15 million yen. Judging by that standard, Japan's government-led initiative was a quite inefficient investment. This programme had unique nature in that a certain mission was imposed on it. It was a state-owned undertaking. Because of this, the Yawata Works was obliged to accommodate a diverse domestic demand for steel materials. It had to put up with "inevitable disadvantages deriving from producing small volumes of many different products." It had to cope with the "financial burden and pressure when trying to respond to product orders given by the military". The enterprise was expected to keep a delicate balance between the two tasks, that is, "accommodating the military demand on the one hand, and surviving as an economically viable business on the other". After going through many ups and downs, the Yawata Works managed to depart from financial deficits, recording a surplus in the fiscal year 1910.

## Total investments for The Yawata Works in the founding period (1896~1910)

| | founding Budget | expenditure settlement | supplement settlement | temporary settlement |
|---|---|---|---|---|
| 1896 | 579,762 | 157,529 | | |
| 1897 | 1,741,621 | 709,223 | | |
| 1898 | 1,189,415 | 1,747,572 | | |
| 1899 | 2,845,168 | 3,011,008 | | |
| 1900 | 7,311,573 | 7,126,198 | | |
| 1901 | 5,335,155 | 5,853,334 | 322,762 | |
| 1902 | 100,000 | 490,117 | 495,428 | |
| 1903 | 1,056,463 | 820,011 | 20,453 | 98,000 |
| 1904 | 6,838 | 24,570 | | 3,566,143 |
| 1905 | 1,599,840 | 1,181,054 | | 2,590,640 |
| 1906 | 4,399,200 | 3,498,885 | | 111,443 |
| 1907 | 5,936,180 | 4,729,547 | | |
| 1908 | 2,980,323 | 4,407,073 | | |
| 1909 | 243,278 | 1,470,113 | | |
| 1910 | 248,500 | 255,427 | | |
| Total | 35,573,316 | 35,481,661 | 838,643 | 6,366,226 |

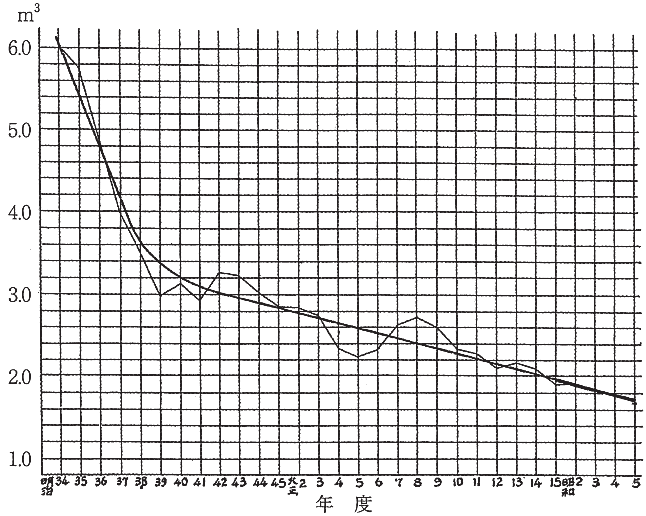
## Investment, Expenditure and Balance

| | founding investment | operation cost | employ-ment capital | Total | loan at the end of the fiscal year | revenue | operation cost | surplus | deficit |
|---|---|---|---|---|---|---|---|---|---|
| 1896 | 157,529 | | | 157,529 | | | | | |
| 1897 | 709,223 | | | 709,223 | | | | | |
| 1898 | 1,747,572 | | | 1,747,572 | | | | | |
| 1899 | 2,911,008 | 46,297 | 100,000 | 3,057,305 | | 8,322 | 46,297 | | |
| 1900 | 5,226,198 | 1,054,064 | 2,000,000 | 8,280,262 | | 201,686 | 1,054,064 | | 23,678 |
| 1901 | 3,692,971 | 3,410,871 | 4,500,000 | 11,603,842 | | 238,574 | 3,410,871 | | 1,267,252 |
| 1902 | 992,438 | 2,740,294 | 4,500,000 | 8,232,732 | 2,000,000 | 3,282,252 | 2,740,295 | | 1,349,778 |
| 1903 | 884,729 | 5,263,668 | 4,500,000 | 10,648,397 | | 2,096,772 | 5,263,669 | | 981,185 |
| 1904 | 1,866,468 | 5,070,551 | 4,500,000 | 11,437,019 | | 4,132,585 | 5,070,551 | | 990,175 |
| 1905 | 3,488,326 | 7,774,277 | 4,500,000 | 15,762,603 | 4,000,000 | 3,176,871 | 7,774,277 | | 963,194 |
| 1906 | 4,223,263 | 10,124,745 | 4,500,000 | 18,848,008 | 8,500,000 | 4,974,398 | 10,124,745 | | 1,697,247 |
| 1907 | 4,729,547 | 10,108,588 | 4,500,000 | 19,338,135 | 10,700,000 | 5,597,145 | 10,108,588 | | 1,694,247 |
| 1908 | 4,407,073 | 8,405,222 | 4,500,000 | 17,312,295 | 9,000,000 | 9,034,444 | 8,405,223 | | 1,280,683 |
| 1909 | 1,470,113 | 8,026,335 | 4,500,000 | 13,996,448 | 7,300,000 | 8,640,921 | 8,026,335 | | 880,963 |
| 1910 | 255,427 | 9,487,029 | 4,500,000 | 14,242,456 | 4,000,000 | 12,768,133 | 9,487,029 | 52,003 | |

2. It was indeed true that the production facilities of this plant, which comprised the blast furnaces with a daily production capacity of 160 tons, coke ovens with bi-product recovery mechanisms, basic open hearth furnaces with a daily production capacity of 25 tons, could well rival those in advanced nations in the world. While the technological infrastructure was quickly developed to a full degree

in the early phase, the company accomplished “technological adaptation”, thus integrating itself in the modern industrial world. It achieved technological transfer successfully.

Profit and Loss at The Han-Yey-P’ing kung-ssu
(yuan)




Inner volume per pigiron 1 ton ($m^3/t$)

3. The Yawata Works achieved and maintained autonomy through the process of technological transfer. Although, in the very beginning, Japanese engineers needed to depend on technical supervision by foreign engineers, they quickly grew to be skilled experts capable enough to operate the equipment themselves. They no longer needed to depend on foreign consultants. They obtained autonomy, continuing the expansion of enterprise. There were some reasons for that accomplishment. In the plant, intensive effort was being made every day for collecting and analysing the operational

data and information, so that the actual operational conditions were captured on a real time basis. Information and data were managed by a centralised command system, from which correct instructions were communicated with mill operators. The hierarchical management organisation as well as the strict rank differences among the employees contributed significantly to the orderly control of the enterprise. An underlying element was the availability of a large stable pool of human resources. The pool comprised efficient senior/junior government officials, competent scientists, engineers, civil servants and others. It is worth noting their contribution to the progress in Japan's industrialisation.

Senior engineering officials were all graduates from Imperial Universities or Imperial Institutes of Technology. Junior engineering officials in the second rank were apprentices for the senior engineering officials. Some of them were graduates from the Imperial University, Imperial Institutes of Technology or College of Engineering.

Note: The Imperial University of Tokyo College of Engineering, which was eventually transformed to the Faculty of Engineering, the Imperial University of Tokyo. Originally this institute was started as a College of Engineering under the Ministry of Public Works, Engineering Bureau, in 1871, being upgraded to the Imperial College of Engineering in 1877 before reorganised to become the Imperial University of Tokyo College of Engineering under the Ministry of Education in 1886.

Other junior officials were graduates from Imperial Institutes of Technology.

Note: One of them was established in Tokyo in 1881 as the Tokyo Shokko Gakko dedicated to practical engineering education, which became the Imperial Tokyo Institute of Technology later. In fact, it was the precursor to the current Tokyo Institute of Technology.

Furthermore, some junior officials were graduates from Japan's oldest private sector College of Engineering , which was established in 1887 in Tokyo.　The graduates from that institute had received more practical engineering training before joining the civil service. The 3rd rank of engineers were primarily graduates from the abovementioned private sector College of Engineering, who had had experience of working at modern private sector companies in the railway, mining and spinning industries. Some had worked at the Kamaishi Mines Tanaka Iron Works (Kamaishi Tanaka Works) previously, cumulating hands on knowledge and skill related to the modern iron making methods. Many of them were employed by the Yawata Works as medium to lower skilled engineers. Actually, the fact that the enterprise of Yawata could capitalise on such a large pool of competent engineers available in Japan was a very important element of success. Thanks to those people, the technological transfer from the west succeeded within a fairly short period of time. The Yawata Works assimilated modern technology from the west quickly, leading to the autonomy of operation and succeeding in the transplantation of the modern industry from abroad. Through the progress of industrialisation, an intensive commitment was made by the Japanese government to the furtherance of engineering education and industry technology. The Yawata Works could capitalise on those resources effectively, thus enhancing their management and technological approach. It is also worth noting that underlying all these achievements was the strict hierarchical class structure, which was endorsed in the Japan's modernisation history.

Another important feature of the Yawata Works was that most high ranking senior engineering officials who exercised leadership in project management had studied aboard and experienced iron and steel mill operations in Germany. In the area of advanced technological education especially, Bergakademie Freiberg played a valuable role for Japanese academics and engineers. Between 1873 and immediately before the outbreak of World War I, 44 Japanese engineers studied at that institute. After returning home, some of them were involved with the national project "Yawata Works". Included in this group were Michitaro Oshima, Fuyukichi Obana, Kageyoshi Noro, Tetsukichi Mukai and Kaichiro Imaizumi. Furthermore, others educated at Bergakademie Freiberg were indirectly involved with the Yawata Works as well. For example, some became committee members in preparation for the launching. Included in this group were Yoshinosuke Hasegawa, Wataru Watanabe, Ataru Matoba and Yoshitaro Watanabe. In Germany, these Japanese students engaged in research under the guidance of Prof. Adolf Ledebur. When Michitaro Oshima became a main technical officials of the Yawata Works, he chose to introduce the iron and steel making technology of GHH. The decision was made in accordance with a suggestion from Prof. Ledebur, Oshima's mentor. After returning to Japan, many of those Japanese academics /engineers became professors at Imperial Universities, where they taught metallurgy, taking the lead in Japan's scientific advancement. Kaichiro Imaizumi was one of Noro's students. He remembered that the contents of Prof. Ledebur's lectures were quite similar to what he had learned from Noro in Japan.

Before the finalisation of the "Launch Plan", three committees were involved in the preparatory stage. One of their tasks was to carry out surveys, experiments and pilot production under the leadership of Noro. Noro and Zouyou Kaneko conducted an experiment in a small rented open hearth furnace, owned by an arsenal adjunct to the Tokyo Regiment of the Army. They tested steel making methods using Kamaishi pig iron and iron sand. They also conducted a systematic experiment to produce wrought iron using a puddling furnace. That particular furnace had been operated by an iron works run by the Ministry of Industry previously. Because Japan did not have a large stock of scrap iron or steel, they conducted a trial production of crude wrought iron based on iron sand, trying to discover an alternative raw material of steelmaking. Sand iron was abundant in Japan. At Furukawa coking coal plant, they did an experiment to produce coke of commercial grade. Separately from Noro and Kaneko, Jintaro Takayama and Koroku Komura, also Noro's students, were involved in a series of systematic tests, in which they tested all refractory bricks available in Japan to identify those suitable for the iron and steel industry. Kaichiro Imaizumi tested steel making methods based on residual compounds collected after the copper extraction processes. He was interested in copper extraction, for which copper sulphide rich iron sulphide was used. Noro also started research to produce sponge iron from iron sand. All these efforts show that those Japanese scientists aspired to systematically discover the most suitable pig iron and steel making methods for the Japanese environment. Their experiments were ambitious in that they were keen on using natural resources readily available in Japan. They tried to establish innovative methods and apply them to the modern iron and steel industry. These systematic experiments and research were conducted at Army arsenals, the Kamaishi Tanaka Works and other places. The experience helped them enhance their knowledge and skills, helping them to be better prepared for future technology transfer. They could fulfil their task properly when working with foreign engineers invited to the Yawata Works. Through those experiences, Noro's academic talent and knowledge increased. Pragmatic skill was accumulated through his involvement with mill operations in Germany and Japan. Utilising that experience, he became the major driving force behind the project, ensuring that this state enterprise could move forward to its goal. In addition, that "group of young technocrats of high calibre", comprising academics and engineers, played an essential role in the early part of Japan's industrialisation as well. Most of them were educated at the Imperial College of Engineering founded by the Ministry of Industry or at the Imperial University of Tokyo. Many of them were sent abroad to further their expertise after graduation.

4. The first "Launch Plan" was revised to expand the scale of the State-owned Steel Works. The revision was made based on the awareness that demand for iron and steel was rapidly increasing and that international competition was intensifying at a great rate.

At the Yawata Works, once pig iron production started, the high productivity, low labour costs and low intermediate material prices favoured the business. Yawata's pig iron prices were much lower than the international standard. Utmost efforts were made to reduce steel production costs as quickly as possible. As a result, Japanese pig iron and steel became highly competitive in the international market. The economic viability of the Yawata Works as a commercial entity advanced dramatically.

1. The primary mission given to the Yawata Works was to respond to the increasing iron and steel demand in the public and private sectors in Japan. The problem, however, was that the speed of Japan's industrialisation and the increase in demand was much higher than the pace of increase in production capacity of the Yawata Works. The outcome was that the self-sufficiency rate was as low as 30%, which was far from satisfactory. As for quality, there were critical problems to overcome, symbolised by the occurrence of persistent defects in rail products. It was urgently needed to develop technology to produce low silicate pig iron, so that the basic open hearth furnaces would not be damaged. Improvement of the operation of blast furnaces was an urgent issue. When the "Phase II Expansion Plan" was prepared, it was decided that the scale of expansion should be sufficient and in line with the goal, that is, the production of 300,000 tons of steel materials. It was also decided to explore iron ore sources abroad. An important matter was to try to further scientific research in iron and steel making technology. The development of engineers' and workmen's skills was also im-

portant. For these purposes, a large delegation consisting of about 20 engineers and workmen was sent to GHH or Krupp in Germany to participate in educational courses.

A large delegation for Germany (1912)

| | Position at Yawata Works | eductional course in Germany |
|---|---|---|
| Ryuta Endo | assistant engineer | coordinater of group members |
| Harutaka Obara | assistant engineer | |
| Takahiko Enbu | assistant engineer | operation of blast fumace |
| Shingo Ujo | assistant engineer | |
| Kumakichi Tanaka | group leader of blast fumace | |
| Shozo Kubota | assistant engineer | operation of open-hearth |
| Matajiro Kaku | corporal of open-hearth | |
| Keichi Ban | assistant engineer | operation of converter |
| Ryukichi Katsuya | assistant engineer | making rail |
| Tatsuno | assistant engineer | making steel bars |
| Kyudayu Takahashi | corporal of rolling | |
| Ryuta Endo | assistant engineer | making steel sheets |
| Gichiro Hara | assistant engineer | |
| Kisuke Hayashi | group leader of rolling | |
| Harutaka Obara | assistant engineer | operation of electric steel oven |
| Kunpei Gondo | assistant engineer | making rollers |
| Toru Watanabe | assistant engineer | operation of gas engine |

Three Expansion Plans at the Yawata Works

| | investment (10,000yen) | terms | demand of steels (10,000tons) | productive scale of making steels (10,000tons) | notes |
|---|---|---|---|---|---|
| First | 1,088 | 1906~1909 | (28) | 18 | The third blast fumace (160t/d), etc |
| Second | 1,238 | 1906~1909 | 40 | 30 | The fourth blast fumace (250t/d). The second Steelmaking Plant, Electrification etc |
| Third | 3,451 (7,193) | 1906~1909 (1929) | 100 | 65 | large steel plates and sheets, abolishment of Bessemer Converters, 800,000tons of |

Japan's commitment to modern iron and steel technology started at the end of the Tokugawa era, when a reverberatory furnace was built in Saga. Later the State-owned Steel Works at Yahata was launched. The start up phase was concluded in 1910, when an integrated mill was firmly stabilised, producing both pig iron and steel successfully. This means that, while it took Europe 400 years to achieve such technological development, Japan acquired the same magnitude of advancement in less than half a century. Certainly it was an “extremely condensed and intensive modernisation process”. Here let us try to understand the historic meaning of the State-owned Yawata Steel Works in a wider global context. What was the significance of this national undertaking, when viewed from western and Asian perspectives?

The integrity of the production facilities at the Yawata Works could well rival that of advanced nations.

(1) The total internal volume of blast furnaces at the Yawata Works was 440$m^3$, slightly over the national average of the United States, 400$m^3$. The blast furnace production capacity per unit was 60,000 tons, which doubled that at the largest British iron works, Workington Iron and Steel Company, which recorded 30,000 tons. It would be fair to say that Japan had already surpassed the production levels of Britain and France, and was catching up with the USA.

The productive scale of the largest Steelmaking Company in the advanced countries

| | year | Pigiron | Crude Steel | Finished Steel |
|---|---|---|---|---|
| U.S. Steel Corp. (U.S.A) | 1913 | 14,100 | 16,600 | 11,900 |
| 〃 Gary Works (U.S.A) | 1913 | 1,090 | 1,670 | 1,190 |
| Phonix-Horder Bergswerk Huttenverein (Germany) | 1907 | | | 1,130 |
| Wakington Iron Co (U.K.) | 1909 | 600 | | 200 |
| Denan et d' Anzin (France) | 1913 | 335 | 396 | |
| Yawata Works | 1913 | 177 | | 217 |

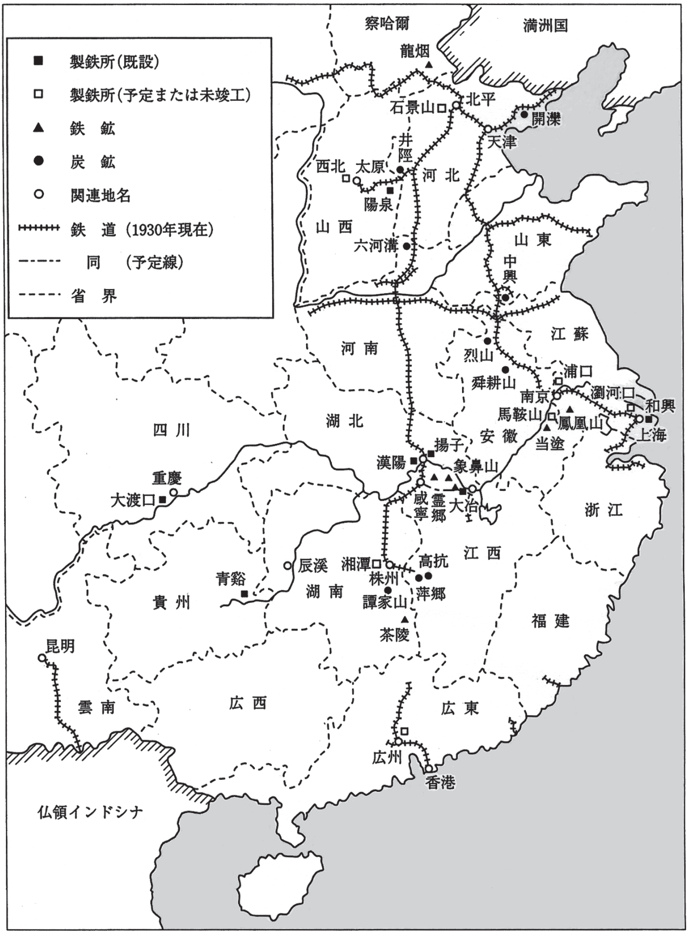
note: units are 1,000tons

The capacity of the Blast Furnace

| | Blast Fumace | ginning (year) | Volume (?) | Daily Production (tons) | Volume per daily 1 ton pigiron (?) |
|---|---|---|---|---|---|
| Yawata Works | No.1 | 1910 | 440 | 162 | 2.71 |
| Guetenhoffnungshutte | No.10 | 1912 | 610 | 420 | 1.45 |
| Gary Works, US Steel | No.10 | 1915 | 670 | 480 | 1.40 |

(2) As far as steel material production was concerned, however, Japan was far behind the west. The data recorded the volumes, 1.2 million tons produced by US Steel Gary Works in the USA, 1.1 million tons by Phoenix Iron Works in Germany, 1.0 million tons by Krupp AG in Germany and 700,000 tons by Workington Iron and Steel Company in the UK. The inferiority of the enterprise of Yawata, producing only 180,000 tons of steel materials, was obvious. Facing this challenge, Naonori Sumino, one of the then engineers in the steel department, who became head of the Yawata Works in 1946, serving in the post for the next 16 years, described those circumstances in his paper “Steel Production at the Yawata Works: Celebrating the 30th Anniversary of Foundation”. The report analysed the steel production facilities and op-

erational technology of the Yawata Works from a global perspective. Sumino compared the steel making performance of Yawata with the west, judging that it had been fairly well developed by then, and “good enough to be ranked in the middle of the international steel making community”.




Map of the Han Yeh-P’ing kung-ssu

Prior to World War I, as far as the construction of a modern integrated mill in Asia was concerned, effort had already commenced in China. It was several years ahead of Japan. The plan of the Han-yang Iron and Steel Works was announced in 1891. The first blow-in took place in 1894. Han-yang was Asia's first integrated mill producing pig iron, steel and steel products. Chang Chih-tung, a Chinese statesman, who was then governor-general of the region corresponding to present day Hunan and Hubei Provinces, commissioned H. Hobson, a British engineer, to supervise the construction of an integrated mill at Hanjiang (now Wuhan). The design production capacity was 100 tons per day. The plant was to consist of a blast furnace, a converter furnace, an open hearth furnace, 20 puddling furnaces and rolling mills. It was planned that iron ore would be supplied by the Ta-yeh Iron and Steel Works and that this state-run enterprise would produce steel materials for the manufacture of arms for the Chinese military as well as rails to construct railroads. In his work *"History of Iron V (4)"*, Ludwig Beck described how, before the Han-yang Iron and Steel Works was established, an arsenal founded by the army in 1867 at Fuzhou in Fujian Province had been the only iron works in China. The facility at that arsenal was a very small furnace with a height of 5 to 6 feet, into which air was blown by means of wooden bellows. Charcoal was used as fuel. All that was produced was a kind of pig iron based on sand iron. It is worth noting that, in its first step toward steel industry development, China embarked upon a most modern and sophisticated programme, that is, the construction of an integrated mill, capable of producing pig iron and steel simultaneously. China did not bother with less advanced technology such as the charcoal blast furnace or the older iron making process developed in the UK during the Industrial Revolution. The Han-yang Iron and Steel Works invited engineers and workmen from Belgium for technology transfer. Furthermore, about 80 Chinese workmen were sent to Belgium, where they received training at iron and steel works. The plant started up at the end of June 1894.

The Pigiron Production and Sale Abroad of Han-yang Iron and Steel Works

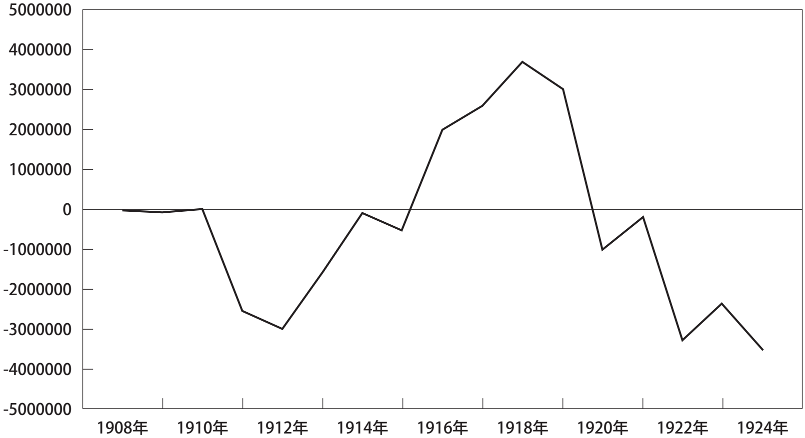
(Tons, % )

| | Domastic Production In China | Production of Hang-yang Works | (Pigiron) | (Steel) | Sale | Abroad | (%) |
|---|---|---|---|---|---|---|---|
| 1894 | 5,316 | 5,316 | 4,636 | 680 | ? | 2,965 | 33.0 |
| 1895 | 5,040 | 5,040 | 4,360 | 680 | | | |
| 1896 | 12,292 | 12,292 | 11,055 | 1,237 | - | - | - |
| 1897 | 32,440 | 32,440 | 24,002 | 8,418 | - | - | - |
| 1898 | 42,996 | 42,996 | 20,491 | 22,506 | Japan | 4,250 | 9.2 |
| 1899 | 45,470 | 45,470 | 25,483 | 19,987 | | | |
| 1900 | 48,026 | 48,026 | 25,892 | 22,134 | - | - | - |
| 1901 | 41,256 | 41,256 | 28,805 | 12,451 | - | - | - |
| 1902 | 38,731 | 38,731 | 15,825 | 22,906 | - | - | - |
| 1903 | 38,875 | 38,875 | 38,875 | 0 | Japan | 138 | 0.4 |
| 1904 | 38,771 | 38,771 | 38,771 | 0 | Japan | 12.334 | 31.8 |
| 1905 | 32,314 | 32,314 | 32,314 | 0 | Japan | 25,130 | 77.8 |
| 1906 | 50,622 | 50,622 | 50,622 | 0 | Japan | 34,326 | 67.8 |
| 1907 | 70,686 | 70,686 | 62,148 | 8.538 | Japan | 33,326 | 53.6 |
| 1908 | 89,036 | 89,036 | 66,410 | 22,626 | Japan | 30,890 | 46.5 |
| 1909 | 113,406 | 113,406 | 74,406 | 39,000 | Japan | 38,713 | 52.0 |
| 1910 | 169,509 | 169,509 | 119,396 | 50,113 | Japan | 65,362 | 54.7 |
| 1911 | 131,977 | 131,977 | 93,336 | 38,640 | Japan | 70,875 | 75.9 |
| | | | | | U.S.A | 19,164 | 20.5 |
| 1912 | 180,510 | 11,310 | 7,989 | 3,321 | Japan | 15,172 | 189.9 |
| 1913 | 310,150 | 110,149 | 67,512 | 42,637 | Japan | 14,800 | 21.9 |
| 1914 | 355,850 | 182,098 | 130,846 | 51,252 | Japan | 15,000 | 11.5 |
| 1915 | 385,016 | 184,900 | 136,531 | 48,369 | Japan | 50,936 | 37.3 |
| 1916 | 414,858 | 191,669 | 146,624 | 45,045 | Japan | 40,950 | 27.9 |
| 1917 | 400,966 | 192,582 | 149,929 | 42,653 | Japan | 49,684 | 33.1 |
| 1918 | 385,794 | 166,148 | 139,152 | 26,996 | Japan | 50,000 | 35.9 |
| 1919 | 442,594 | 170,947 | 166,096 | 4,851 | Japan | 60,000 | 36.1 |
| 1920 | 497,808 | 163,707 | 124,947 | 38,760 | Japan | 75,460 | 60.4 |

In December of the same year, however, coke supplies were disrupted, which forced the mill to suspend its operations for the next 10 months. Performance continued to deteriorate. Eventually, in 1895, the enterprise was placed under the auspices of the “kuan-tu shang-pan” system (official supervision and merchant management). The new organisation was led by the aforementioned Sheng Hsuan-huai. The biggest problem for Han-yang was the lack of a stable coke supply, so the unstable operation persisted. Rail production by the Bessemer converter process was hampered due to excess phosphorus in the raw materials. Up to that point, the situation at Han-yang was just the same as that of the Yawata Works in its initial period. However, the paths that the two integrated steel mills followed separated after that, and the gap between them widened over time. When exposed to financial shortage, the management at Han-yang resorted to an injection of foreign capital. The company borrowed money from a general trading house of German origin. Foreign capital made inroads into this Chinese enterprise. Under those circumstances, Gustav Toppe, a German engineer, who later became one of the consulting engineers for the Yawata Works, was invited in as head of the engineering division. Nevertheless, the inventory of defective rails continuously increased, urging Han-yang to embark upon a drastic reform programme. A Chinese delegation headed by Li Weige was sent abroad in 1904, examining the iron and steel making industry outside China. Following its report, the converter furnace was dismantled, and the basic open hearth furnace was enhanced. In order to fund this rehabilitation programme, the Han-yang Iron and Steel Works received a loan from Japan for the first time. It was designed in consideration of Ta-yeh iron ore exported to Japan. This arrangement was useful to Japan, because it secured the supply of iron ore for the Yawata Works. As time went by, Han-yang's loan from Japan snowballed rapidly. In 1908, the Ta-yeh Iron Mines and Ping-hsiang Coal Mines were combined, forming a new organisation called the Han-

Yeh-P'ing kung-ssu. In October of the same year, Sheng Hsuan-huai visited the Yawata Works. Later, commenting on the useful technical information he had gained during that visit, he referred to the duplex method, in which the converter and open hearth processes were combined. He also appreciated Yawata's coke oven, which incorporated a mechanism to collect by-products. If we compare the performance data of the two plants as of 1910, it is clear that the Han-Yeh-P'ing kung-ssu was plagued with serious problems in steel and steel materials.

Profit and Loss at The Han-Yey-P'ing kung-ssu
(yuan)




出典：湖北省冶金志編纂委員会編『漢冶萍公司誌』125頁

| | Pig iron | Steel |
|---|---|---|
| Han-Yeh-P'ing kung-ssu | 119,396 tons | 50,113 tons |
| Yawata Works | 126,894 tons | 153,491 tons |

In 1911, the Han-Yeh-P'ing kung-ssu began to deliver pig iron to Yawata, resulting in an upsurge in their loans from Japan. Seeking solutions to those problems, the Han-Yeh-P'ing kung-ssu accepted Japanese special advisers to the engineering and accounting divisions. The special adviser for engineering was Michitaro Oshima, the first main technical officials at the enterprise of Yawata. Despite such efforts, the persistence of poor performance in rail production prevented the Han-Yeh-P'ing kung-ssu from restructuring its business. It could not be free from deficits. In 1925, pig iron production was discontinued and the Ping-hsiang Coal Mines was requisitioned by the local government of Wuhan. In the end, all that was left of the enterprise was the business of selling Ta-yeh iron ore to Yawata. Asia's first integrated iron and steel mill collapsed after all.

Chinese data concerning demand and supply of steel shows a rapid increase in demand around World War I, when China relied heavily on imported steel. After that period, however, demand became sluggish. After the fall of Han-Yeh-P'ing kung-ssu, the traditional Chinese "Tufa" pig iron manufacturing method was restored. Afterwards, all that was left in China was "Tufa" pig iron manufacture.

Production and Import of Pigiron in China (1914~1936, tons)

| | Han-Yey-Ping | Liu-He-Gou | Bao-Jin | Tufa | Total Domestic Production | Imported |
|---|---|---|---|---|---|---|
| 1914 | 130,000 | — | — | 170,000 | 300,000 | 145,584 |
| 1916 | 149,930 | — | — | 170,000 | 319,930 | 180,187 |
| 1918 | 139,152 | — | — | 170,000 | 309,152 | 107,339 |
| 1920 | 126,305 | 7,624 | — | 170,000 | 309,929 | 181,016 |
| 1922 | 148,424 | 15,248 | — | 170,000 | 333,672 | 81,293 |
| 1924 | 26,977 | — | — | 170,000 | 196,977 | 104,491 |
| 1926 | — | 7,498 | 4,800 | 178,870 | 191,168 | 238,309 |
| 1928 | — | 5,814 | 4,814 | 178,870 | 189,498 | 374,614 |
| 1930 | — | — | 2,587 | 122,226 | 124,813 | 333,553 |
| 1932 | — | 19,283 | — | 135,000 | 154,283 | 441,106 |
| 1934 | — | 16,960 | 3,680 | 135,000 | 155,640 | 437,753 |
| 1936 | — | — | * | * | * | 344,474 |

Demand and Supply of Iron and Steel in China (1912~1934, tons)

| | Domestic Production | Import of iron and steel | Export if iron and steel | Domestic Consumotion |
|---|---|---|---|---|
| 1912 | 177,989 | 151,276 | 12,499 | 316,766 |
| 1913 | 267,513 | 244,739 | 67,086 | 445,166 |
| 1914 | 300,000 | 230,551 | 62,011 | 468,540 |
| 1915 | 336,061 | 125,658 | 102,123 | 359,596 |
| 1916 | 369,160 | 145,847 | 154,745 | 360,262 |
| 1917 | 357,635 | 123,268 | 163,283 | 317,620 |
| 1918 | 354,144 | 149,117 | 189,085 | 344,176 |
| 1919 | 446,588 | 325,158 | 166,424 | 635,322 |
| 1920 | 427,748 | 366,622 | 196,807 | 627,463 |
| 1921 | 402,787 | 272,782 | 162,680 | 542,879 |
| 1922 | 393,694 | 364,875 | 209,609 | 578,960 |
| 1923 | 343,442 | 309,817 | 213,539 | 469,720 |
| 1924 | 330,521 | 493,624 | 269,704 | 584,541 |
| 1925 | 369,617 | 405,266 | 161,329 | 643,554 |
| 1926 | 434,668 | 433,582 | 168,693 | 699,557 |
| 1927 | 441,148 | 389,061 | 200,832 | 629,371 |
| 1928 | 463,843 | 624,898 | 216,969 | 871,772 |
| 1929 | 463,458 | 634,192 | 202,145 | 895,505 |
| 1930 | 488,000 | 527,000 | 180,000 | 835,000 |
| 1931 | 493,000 | 558,000 | 247,000 | 804,000 |
| 1932 | 160,000 | 431,000 | 187,000 | 404,000 |
| 1933 | 176,000 | 526,000 | 7,000 | 694,000 |
| 1934 | 159,000 | 618,000 | 7,000 | 770,000 |

What about India? An iron ore seam was discovered in Bihar, West Bengal. In addition, the old Indian Mining Law was abolished in 1889, liberalising the mining industry. These developments propelled India to strengthen its commitment to advancing the iron and steel industry. India imported a series of western technological items encompassing reverberatory furnaces, charcoal blast furnaces (1830), coke blast furnaces (1875) and open hearth furnaces (1892). The open hearth furnaces were introduced into arsenals for steel production. Unfortunately, none of those attempts succeeded in establishing an economically viable business. Against this backdrop, in 1911, ten years after the launch of the Yawata Works, Jamsetji Tata, the founder of the Tata Group, started the Tata Iron and Steel Co. at Jamshedpur in Bihar

State. This was an integrated mill designed on the basis of American technology. The plant consisted of two blast furnaces with a daily production capacity of 170 tons each. It produced 100,000 tons of steel products per year. The scale of the plant was similar to that of Yawata. The strength of the Tata enterprise was that the iron ore mines were owned by the group, which enabled the company to produce pig iron at a low cost. The plant management and engineering matters were left in the hands of American experts hired by the company. By 1937, the company had hired six Americans in a row, who served contractual terms of office as head of the plant. In the mid 1910's Jamsetji Tata visited Japan, where he observed that Japanese iron works were "managed and operated by Japanese people only". With this discovery, it dawned on him that the "Indianisation" of engineers should be started. In order to develop Indian engineers and skilled labour, he founded an educational institute of technology on the premises of the company (1921). Between 1920 and 1924, he exercised leadership to materialise an innovation programme called the "Greater Extension" project. This brought about a drastic renovation of the plant, introducing blast furnaces with a capacity of 600 tons each. The company adopted the duplex method, in which converter and open hearth furnace processes were combined. The company diversified its product portfolio as well. While conventional products such as steel rails and wires for construction, which had been sold from the start, still remained as major items, new products were added. These were thick steel plates, thin steel sheets, steel bars & rods and other things. Tata made drastic progress with the increase in blast furnace capacity, the commitment to which was intensive, continuing until the beginning of the 1920's. In contrast, on the part of the Yawata Works, progress in blast furnace capacity was rather sluggish until the 1930's.

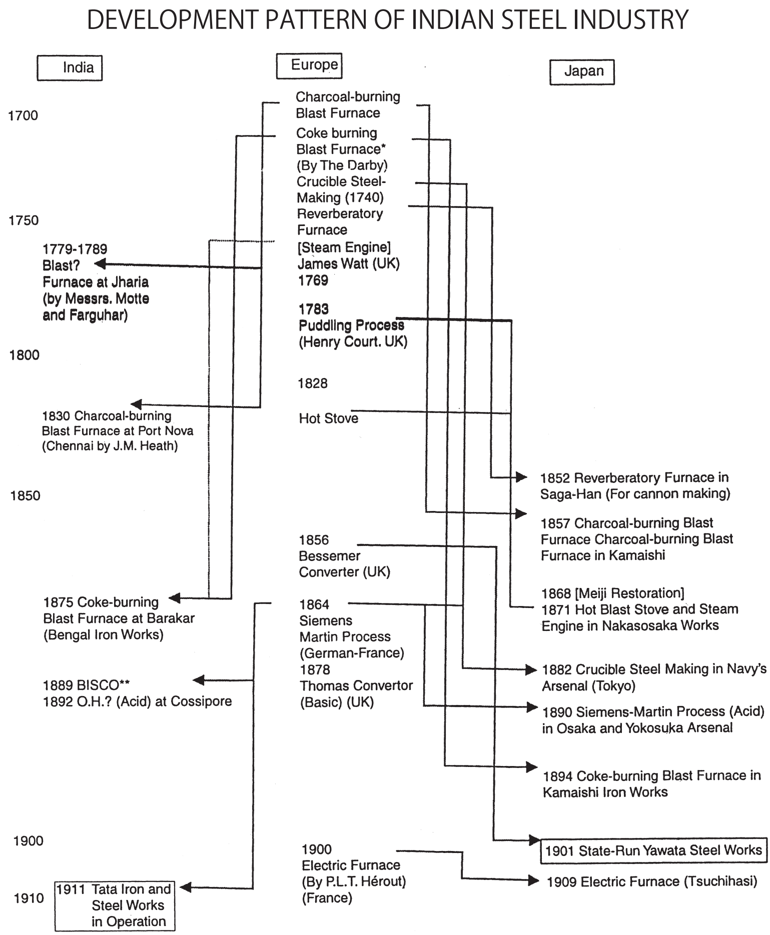
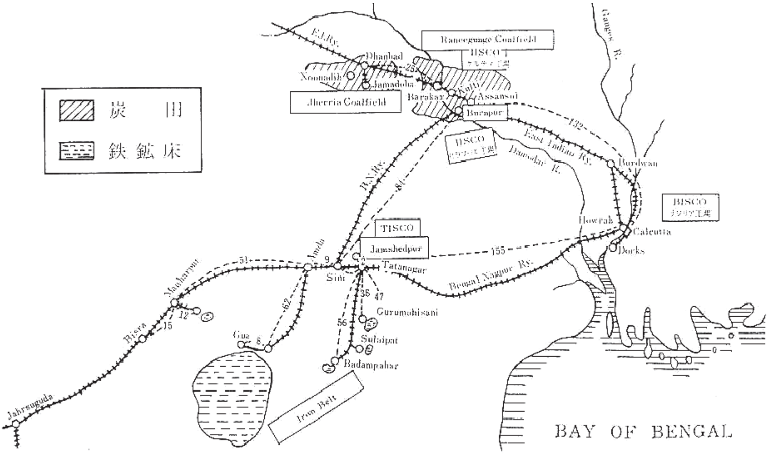



**Figure 2.1**
**Transfer of Modern Iron and Steel Technology into India and Japan**

*Sources:* Japan – S. Ohashi, Bakumatu-Meiji Seitetsu Shi. 1975.
India – Derived mainly from M.S. Krishnan, Iron Ores of India, 1955, pp. 49-64 & 151-159.

*Notes:* *1713: ** Bengal Iron & Steel Works




## Employees in Tisco

| | Pig-iron | Crude Steel making | Finished Steel making | Total |
|---|---|---|---|---|
| 1912 | 874 | 968 | 1,552 | 3,394 |
| 1915 | 925 | 1,112 | 1,665 | 3,702 |
| 1920 | 2,301 | 2,348 | 2,936 | 7,585 |
| 1925 | 2,016 | 2,411 | 5,626 | 10,053 |
| 1930 | 836 | 1,451 | 5,239 | 7,526 |
| 1933 | 529 | 1,299 | 5,271 | 7,099 |
| 1940 | 982 | | 6,469 | |

## Output Per Employee in Tisco Compared with Yawata Works

| | Tisco | | | Yawata | | |
|---|---|---|---|---|---|---|
| | Pig-iron making | Crude Steel making | Finished Steel making | Pig-iron making | Crude Steel making | Finished Steel making |
| 1912 | 146 | 32 | 12 | | | |
| 1915 | 170 | 111 | 55 | | | |
| 1920 | 110 | 73 | 42 | 69 | 223 | 80 |
| 1925 | 284 | 195 | 57 | 363 | 381 | 159 |
| 1930 | 854 | 431 | 85 | 682 | 409 | 169 |
| 1933 | 1,592 | 555 | 102 | 974 | 622 | 261 |
| 1940 | 1,202 | | 129 | 1,000 | 679 | 233 |

## Cost of Production in Tisco (Rupeees per ton)

| | Pig-iron | Steel Bar |
|---|---|---|
| 1921 | 34.5 | 151.2 |
| 1922 | 38.7 | 129.1 |
| 1923 | 36.6 | 126.5 |
| 1924 | 32.7 | 119.9 |
| 1925 | 28.5 | 115.2 |
| 1926 | 25.0 | 97.3 |
| 1927 | 22.9 | 86.1 |
| 1928 | 24.4 | 92.5 |
| 1929 | 22.7 | 93.3 |
| 1930 | 22.7 | 89.8 |
| 1931 | 20.8 | 76.9 |
| 1932 | 19.4 | 72.7 |
| 1933 | 18.6 | 69.9 |

## Production in Tata Iron and Steel Co. (Tisco, 1,000tons)

| | Iron-one | Pig-iron | Crude Steel | Finished Steel |
|---|---|---|---|---|
| 1911 | 135 | 36 | 3 | 1 |
| 1915 | 251 | 160 | 125 | 93 |
| 1920 | 409 | 258 | 174 | 124 |
| 1925 | 1,121 | 582 | 479 | 325 |
| 1930 | 1,190 | 725 | 635 | 450 |
| 1935 | 1,542 | 914 | 894 | 672 |
| 1940 | 1,867 | 1,199 | 1,101 | 847 |

## Foreign Technical Personnel Engaged in Tisco

| | |
|---|---|
| 1920 | 72 |
| 1921 | 74 |
| 1922 | 72 |
| 1923 | 98 |
| 1924 | 172 |
| 1925 | 150 |
| 1926 | 154 |
| 1927 | 150 |
| 1928 | 139 |
| 1929 | 125 |
| 1930 | 115 |

| Tata Iron and Steel Co. Ltd | The Yawata Works | Iron & Steel Works of Greatest Productivity In the USA |
|---|---|---|
| | | 1889: 347 tons(Edgar Thomson Steel Works in Pennsylvania) |
| | 1901: 160 tons | |
| 1911: 175 tons/day | | 1907: 504tons( Edgar Thomson Works ) |
| 1919: 315 tons | 1921: 300tons | 1919: 672tons( South Works ) |
| 1922: 600 tons | | |
| 1933: 700 tons | 1930: 500tons | 1929: 1,092tons( Ohio Works ) |

(By Oba)

Although the Tata Iron and Steel Co. Ltd. grew steadily in a sense, its success did not provide so much momentum for the iron and steel industry in India as a whole. Its influence was limited, and it failed to support the modernisation and industrialisation of the country in general. It did not benefit the Indian national economy to any large extent. Indian data concerning demand and supply of steel materials suggests that demand stagnated at around a level of 1.0 million tons during the 1920's and 1930's. Until 1930, imported steel accounted for about one half of total supply. Apart from the Tata Iron and Steel Co. Ltd., the Bengal Iron Corporation and the Indian Iron and Steel Company were considered major iron works in India. Both were pig iron manufacturers dedicated to pig iron export to Japan. Kishimoto Shoten, a Japanese trading house specialising in iron and steel trading, was involved in their transactions as an intermediary. Many Japanese steel manufacturers with open hearth furnaces and foundry businesses were supported by pig iron imports from India.

Demand and Supply Steel in India (1,000tons)

| | Production | Import | Export | Domestic Demand |
|---|---|---|---|---|
| 1920 | 124 | 782 | 1 | 905 |
| 1922 | 117 | 906 | 1 | 1,022 |
| 1924 | 252 | 956 | 2 | 1,186 |
| 1926 | 380 | 891 | 1 | 1,270 |
| 1928 | 293 | 1,184 | 1 | 1,476 |
| 1930 | 450 | 618 | 3 | 1,065 |
| 1932 | 438 | 329 | 30 | 737 |
| 1934 | 620 | 373 | 1 | 992 |
| 1936 | 701 | 366 | 3 | 1,064 |
| 1938 | 745 | 268 | 24 | 989 |

Production and Export of Pig Iron in India (tons, %)

| | Production of Pig Iron | | | | Export of Pig Iron | | | | | B/A (%) | Production of Crude Steel |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Foundry Pig Iron | Basic Pig Iron | Others | Total (A) | Japan | (%) | UK | Others | Total (B) | | |
| 1912 | | | | | 80,100 | 86.5 | | 12,514 | 92,614 | | |
| 1913 | | | | | 65,318 | 79.1 | | 17,274 | 82,592 | | |
| 1914 | | | | | 29,859 | 56.9 | | 22,196 | 52,055 | | |
| 1915 | | | | | 38,676 | 59.2 | | 32,702 | 71,378 | | |
| 1916 | | | | | 69,031 | 67.5 | | 33,298 | 102,329 | | |
| 1917 | | | | | 39,307 | 79.0 | | 10,475 | 49,782 | | |
| 1918 | | | | | 9,507 | 99.1 | 51 | 89 | 9,647 | | |
| 1919 | 136,145 | 181,062 | 2,777 | 319,984 | 40,093 | 96.0 | | 1,605 | 41,698 | 13.0 | 186,902 |
| 1920 | 149,373 | 161,424 | 1,642 | 312,439 | 47,368 | 97.8 | | 1,056 | 48,424 | 15.5 | 156,239 |
| 1921 | 178,420 | 189,054 | 3,588 | 371,062 | 58,565 | 98.4 | | 952 | 59,517 | 16.0 | 182,690 |
| 1922 | 221,910 | 115,992 | 3,334 | 341,236 | 112,511 | 94.9 | 424 | 5,610 | 118,545 | 34.7 | 150,475 |
| 1923 | 426,887 | 183,219 | 3,521 | 613,627 | 144,016 | 78.6 | 3,206 | 35,973 | 183,195 | 29.9 | 215,465 |
| 1924 | 644,789 | 222,146 | 9,873 | 876,808 | 171,665 | 50.3 | 19,024 | 150,637 | 341,326 | 38.9 | 335,442 |
| 1925 | 603,924 | 274,516 | 9,068 | 887,508 | 168,188 | 44.0 | 20,178 | 193,623 | 381,989 | 43.0 | 449,053 |
| 1926 | 559,721 | 326,439 | 14,253 | 900,413 | 234,529 | 75.8 | 16,159 | 58,817 | 309,505 | 34.4 | 521,753 |
| 1927 | 828,230 | 306,901 | 10,012 | 1,145,143 | 270,956 | 68.9 | 21,060 | 101,233 | 393,249 | 34.3 | 574,096 |
| 1928 | 816,613 | 229,955 | 8,549 | 1,055,117 | 353,581 | 78.8 | 5,522 | 89,843 | 448,946 | 42.5 | 409,710 |
| 1929 | 1,079,473 | 307,584 | 8,108 | 1,395,165 | 349,512 | 61.4 | 71,277 | 148,024 | 568,813 | 40.8 | 575,310 |
| 1930 | 873,221 | 301,625 | 4,999 | 1,179,845 | 160,584 | 36.6 | 98,950 | 179,601 | 439,135 | 37.2 | 618,922 |
| 1931 | 538,522 | 519,530 | 14,366 | 1,072,418 | 188,106 | 53.6 | 69,088 | 93,664 | 350,858 | 32.7 | 625,148 |
| 1932 | 283,661 | 629,556 | 366 | 913,583 | 71,371 | 32.7 | 75,802 | 71,211 | 218,384 | 23.9 | 569,810 |
| 1933 | 296,950 | 760,808 | 7,725 | 1,065,483 | 183,832 | 48.7 | 93,123 | 100,559 | 377,514 | 35.4 | 694,073 |
| 1934 | 471,149 | 854,790 | 5,536 | 1,331,475 | 245,552 | 58.9 | 98,481 | 73,026 | 417,059 | 31.3 | 797,569 |
| 1935 | 457,009 | 994,852 | 14,182 | 1,466,043 | 397,034 | 73.7 | 65,763 | 75,356 | 538,153 | 36.7 | 862,344 |
| 1936 | 541,700 | 998,356 | 3,263 | 1,543,319 | 306,173 | 53.3 | 182,334 | 85,803 | 574,310 | 37.2 | 865,770 |

These observations on the steel making industry in other Asian countries clearly show the unique features of the Yawata Works:

## (1) Technology transfer with autonomy

There were some common features among the iron and steel works in China, India and Japan in the way in which they started their businesses. All three enterprises carried out programmes

i) to introduce the most advanced facilities and technology from the west,

ii) to invite consulting engineers from abroad to receive technical guidance and

iii) to enhance the knowledge and skill of engineers and workmen by sending them abroad for training. When it comes to the question of "eventual independence from supervision by foreign engineers, thus establishing autonomy", however, it was only the Yawata Works that succeeded in doing so.

Comparision of the Productive Facilities with Hanyang, Tawata and Tata Works

| | Hanyang Works | | | Yawata Works | | | Tata Works |
|---|---|---|---|---|---|---|---|
| | 1891 | 1910 | 1917 | 1901 | 1906 (before the first Expansion) | 1916 (after the second Expansion) | 1911 |
| Blast Fumaces | 100t×2 | 100t×2<br>250t×1 | 100t×2<br>250t×1 | 160t×1 | 160t×2 | 160t×1<br>235t×1<br>200t×2 | 175t×2 |
| Open Hearthes | 12t×? | 30t×7 | 30t×7 | 25t×4 | 25t×8 | 25t×12<br>10t×1<br>50t×4<br>15t×1 | 40t×2 |
| Bessemer Converters | 5.5t×2 | | | 10t×2 | 10t×2 | 10t×2 | |
| Coke Ovens | | Coppee 114 | | Beehive 460 | Beehive 460<br>Haldy 90<br>Coppee 120 | Coppee 60<br>Semet-Solvay 150<br>Koppers 120 | ? |

## (2) Contribution to progress in both national and local industrialisation

Yawata's dramatic progress had significant repercussions on the whole nation, driving the Japanese iron and steel industry to move forward. It contributed significantly to Japanese industrialisation. At the end of the Meiji era, other integrated mills sprang up in various parts of Japan. These were Kobe Steel, Ltd. in Kobe, Kawasaki Steel Corporation in Kobe, Muroran Ironworks in Hokkaido, Nihon Kokan Kabushiki Kaisha (NKK) in Kawasaki City, Kanagawa, and Sumitomo Metal Industries, Ltd. in Osaka. Around World War I, a series of iron and steel manufacturing businesses were launched along Dokai Bay near the Yawata Works. These were Asano Ironworks(now Sumitomo Metal Industries Ltd.), Toyo Ironworks(now Nippon Steel Tobata Works), Nippon Pig Iron , Kyushu Steel (now Yawata Nishi Works), Nippon Steel and Tokai Kogyo. The increase in demand for steel materials was driven not only by the military but also by the private sector. Great progress was made in metal processing, machine manufacturing, railway development and construction works. The Yawata Works was characterised by its capability to manufacture a wide variety of steel materials for diverse customers. The German technology that Yawata chose was most suitable for this policy, enabling them to encompass a wide range of products, and thus responding to the national policy. In the 1920's and onward, the majority of Yawata's business was accounted for by sales to the private sector. This fact is strong evidence that Yawata played a pivotal role in Japan's industrialisation, which started in the Meiji Restoration.

In fact, the iron and steel industry was supported by modern technology. Its scale was the largest and its nature most complicated of all industries. As for import substitution, many developing countries succeeded fairly quickly in launching consumer goods and light industries. However, steel was a completely different story. Intermediate goods such as steel materials and capital goods had to be manufactured by heavy industry. Many developing nations experienced great difficulties in initiating substitution industries for such manufactured goods. While import substitution was delayed, it was inevitable that those countries would accumulate current account deficits in the international balance of payments. This aggravation of the international balance of payments hampered economic development. It is to be understood, therefore, that Japan was much more fortunate in its progress of industrialisation, although such efforts started rather late in the world. While Japan endeavoured to advance industrialisation, aspiring to enter the industrial world community, the Yawata Works provided essential support for it. It functioned as a locomotive for that undertaking. Indeed that was the very meaning of the Yawata Works.

## ACKNOWLEDGEMENTS

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Compared to the Japanese version, the English text here has been shortened in parts, not all diagrams and tables are shown, and the list of references has been omitted.

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