British Iron and steel Technology's Transfer in Early Modern East Asia: The Case of Qingxi Iron Works, China and Kamaishi Iron Works, Japan

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Kamaishi (釜石) National Iron Works, founded in 1874, was the first modern iron works in Japan, also Qingxi (青溪) Iron Works in Guizhou province founded in 1885 was the first modern iron works in China. It is worth noting that both the two enterprises choose Britain as their technology supplying nation, which means that it is Britain transferred the earliest modern iron and steel technology into East Asia. But the processes of technology transfer at Kamaishi and Qingxi can't be considered to be successful because of the failure of the two enterprises. In order to find out the characters of the early modern western technology transfer in East Asia, and make some theory construction in such field, it is valuable to discuss the details of such technology transfer process happened in Kaimaishi and Qingxi and do some comparative study between these two enterprises.

1. The construction of Qingxi Iron Works and its failure

It was in 1885 that the design and construction of Qingxi Iron Works started. From plan making, location selecting, machines purchasing to getting into operation, it lasted 5 years. The leader of such pioneering project was Pan Wei (潘霨, 1815-1894), the Governor of Guizhou province (贵州巡抚). Pan Wei was a doctor with high medical skill before he became an official. He fortunately caught a chance to cure the wife of YI Xin (奕䜣), and began to get into official career. In 1885, Pan Wei was appointed as the Governor of Guizhou province. In order to solve the financial difficulties, he decided to set up a western style mining and metallurgy company to provide raw materials to the modern companies of Nanyang and Beiyang (南北洋) because of the rich mineral resources in Guizhou province, especially the iron mines of fairly good quality.

In spring of 1886, the Guizhou Bureau of Mines (贵州矿务总局) was set up. To find out the quality of the mineral resources of Guizhou, Pan Wei sent 4 kinds of mineral, including coal, iron ore, saltpeter and sulphur, to the factories of Nanyang and Beiyang.[1] According to the reports from Nanyang and Beiyang, only the iron ore suit for the modern production.[2] So

Pan Wei decided to build up a modern iron works at Guizhou province.

Construction of a modern iron works was entirely a pioneering project in the late of 19th Century's China. It was almost impossible to find a professional expert in the field of modern iron and steel making. There were mainly 4 persons Pan Wei could rely on to make the main technical decisions, such as the choice of the factory's site, the import of machines.

The first one was Pan Lu (潘露, 1827-1890), the Younger brother of Pan Wei. Pan Lu was an experienced manager of Yangwu companies. He was involved in the start-up of Guangdong Bureau of Military Equipment (广东军装机器局) and Guangdong Bureau of Gunpowder (广东火药局) from 1873 to 1875, and worked as an manager in these companies till 1883.[3] In 1883, Pan Lu was appointed as the general manager (总办) of the Kiangnan Arsenal (江南制造局) by Zuo Zhongtang (左宗棠, 1812-1885), the Governor of Jiangxi and Jiangsu (两江总督), who appreciated his ability in western weapon manufacturing very much.[4] The rich experience in western arsenals and the family relative to Pan Wei make Pan Lu to be the most suitable person when Pan Wei selected the general manager of the Guizhou Bureau of Mines and the iron works. It was in the beginning of 1887 that Pan Lu formally took the post of the general manager of the Guizhou Bureau of Mines. However, in order to choose the site of the iron works, he had already traveled to Guizhou to carry on an investigation before, and choose a town locate by the side of River Wuyang (舞阳河) called Qingxi as the site of the factory.

In addition to the location, the machine's purchase is another most important matter. From a historical point of view, the initial purchase of machine sometimes may determine the track of technology development.

In the late of 1886, Pan Wei decided to send persons to Britain to study and purchase equipment of the iron works when he knew that the equipment can't be purchased in Shanghai. According to the historical data we can find currently, at least three persons were sent to Britain: Pan Zhijun (潘志俊, 1857-1919), who was the son of Pan Wei; Xu Qinruan (徐庆沅, 1854-?), an manager of the iron works; Qi Zhuyi (祁祖彝, 1863-?), an interpreter.

Pan Zhijun was the second son of Pan Wei, he passed the provincial-level examination in 1876. From then on he got into his official career. Being appointed as an third-class counselor by Ambassador Liu Ruifen (刘瑞芬, 1827-1892), Pan Zhijun arrived in London in the spring of 1886 together with Liu Ruifen and other colleagues of the Chinese embassy in London.[5] According to a letter written by Li Hongzhang (李鸿章, 1823-1901) in 1889, it is certain that to study and purchase machines for Qingxi Iron Works was one of his most important mission in Britain.[6]

The other two persons who were sent to UK were Xu Qinruan and Qi Zhuyi. Xu Qinruan was appointed as a manager of the Qingxi Iron Works by Pan Wei, under the command of Pan Lu in around 1886. From then on, He worked for Qingxi Iron Works till 1896, when left

Guizhou to join the Hanyang Iron Works（汉阳铁厂） as an iron and steel engineer. Qi Zhuyi was a member of the third batch of Chinese educational mission students（留美幼童） in 1874. He has been in United State for 10 years, studied western manufacture engineering. He joined the Kiangnan Arsenal when he returned to China, and was appointed as an interpreter by Pan Lu in around 1886 to go to UK together with Xu Qinruan. The only historical data which mentions these two young man's experience in UK is a memoir of Eugene Ruppert, the chief engineer of Hanyang Iron Works from 1904 to 1912. In this article, Ruppert has written down what he heard from his colleague Xu Qinruan:

> The two young men learned a wide range of knowledge about the construction, management and operation of an iron works in a short period of time. Afterwards, they brought a lot of advanced equipments back to China. Under the leadership of Pan Wei and Pan Lu, they devoted what they learned to make the pioneering iron works get into operation, entirely without the help of foreign experts. (von Eug. Ruppert. Chinesischer Bergban und Eisenindustrie)

According to the memoir of Eugene Ruppert, the Equipments of Qingxi Iron Works were purchased from the Tees-side Company of Middlesbrough in north England.

From the details described above, a structure of the personnel relations in the process of the technology import of the Qingxi Iron Works can be drawn out as below, which shows some characters of the initial iron and steel technology import in early modern China.

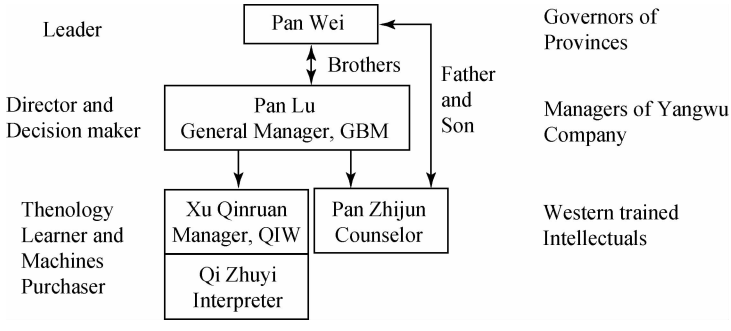

Fig. 1 The structure of the personnel relation in the process of the technology import of Qingxi Iron Works

Firstly, it is a network of relationship composed of three levels of personnel: the governors who engaged in the Yangwu Movement（洋务派督抚）; the officials in the Bureau of Yangwu enterprise; and the intellectuals in Yangwu enterprise. It is worth noting that none in such personnel network really mastered the iron and steel technology.

Secondly, it is a decision-making system totally composed by Chinese, which is quite different from the Kiangnan Arsenal and the Fuzhou Shipyard（福州船政局）.

Thirdly, on the side of China, the process of technology information receiving was of very accidental. Lack of the systematic professional knowledge made the decision-maker could not select equipments depend on the applicability of technology.

Under such situation, a 25 tons blast furnace, two 1ton bessemer convertors, fourteen puddling-furnaces, and a rolling mill were imported to Qingxi. The construction of the iron works completed in 1890. The furnace got into operation on 17th of July, 1890. However, the fuel used in the melting process was obviously unsuitable for the blast furnace. According to Ruppert's memoir, it was a blend of bad coke and anthracite. Such poor fuel caused the accidents of the furnace happened continually. The melting process only lasted for around 50 days and stopped in the middle of August. Pan Lu died on the 31st of August, 1890. The furnace never reopened from then on. The initial technology transfer was end in failure of the Qingxi Iron Works.

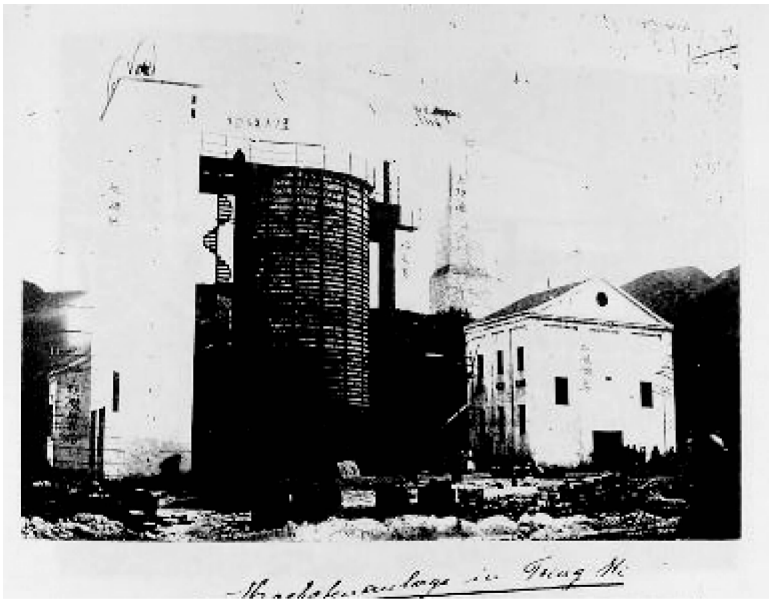

Fig. 2 The 25tons blast furnace of Qingxi Iron Works

It worth noting that the failure of Qingxi Iron Works hasn't ended the British iron and steel technology transfer into China. The Hanyang Iron Works imported the equipments from the same company in UK a few years later.

2. The construction of the Kamaishi National Iron Works

Although the Kamaishi National Iron Works was the first modern iron works in Japan, ten western-style blast furnace had already been built at Kamaishi by Oshima Takato (大岛高任, 1826-1901), the father of Japanese modern iron and steel industry before 1868. However, these furnaces were quite small as their product ability per day was only 1-2 tons. The tradition waterwheels were used as the power equipment of the furnace. Strictly speaking, these ten furnaces were not the real modern blast furnace.

After the Meiji Restoration, the Japanese government pursued the modernization of military and industry firmly. However, Japan didn't have a modern structure of society which suit for

industrialization yet. The new government then played the key role in the industrialization process through construction of the national enterprises. The Kamaishi Iron Works was one typical case of the national enterprise at that time.

The decision to build an iron works at Kamaishi was based on recommendations in a foreign adviser's report. J. G. H. Godfrey (1841-?), hired as the Chief geologist and mining engineer for Meiji government from 1871 to 1877, went to the Tohoku region of north Japan in the summer of 1872 to inspect the iron mines in the region where Kamaishi is located, he noted that the supply and quality of the iron ore was good and that working these mines should be profitable. His estimate was confirmed by the further survey carried by Japanese government. [7] During his tour, Godfrey scrutinized every detail of iron production in the region. He observed that there were a number of problems with production including the expense and difficulty of transporting raw materials through the mountainous area. He recommended the construction of larger furnace closer to the sea in his report. [8]

Based on Godfrey's report, the Meiji government decided to requisition the Kamaishi deposit in 1873. Then a proposal for an iron works at Kamaishi was submitted by Yamao (山尾庸三, 1837-1917) and Ito Hirobumi (伊藤博文, 1840-1909) to the Council of State and Ministry of Finance on 15 February 1874. [8] The plans include a railroad from the mines to Kamaishi harbor and three modern blast furnaces deemed capable of producing 12 000 tons of pig iron per year. There would also be a refinery at Nagasaki (长崎), with 12 furnaces. On 21 May 1874, the Meiji government established the Kamaishi branch office of the Ministry of Public Works Mining Department. Oshima Takato and another technologist, Koma Rinosuke, were appointed as Kamaishi's managers. A ground-breaking ceremony for the new iron works was held on 10 August 1874, and the actual construction began in January of the following year. [9]

The process of deciding the blast furnace's location was accompany with dispute between two technologists, Oshima Takato and Louis Bianchi, the Meiji government's foreign adviser for mining and metallurgy at the iron works. Bianchi was a German who studied at the Freiberg Mining Academy from 1856 to 1859. He remained in good standing at the academy before he was hired by the Meiji government in 1874. During late spring and early summer of 1874, Bianchi surveyed the Kamaishi region with Oshima Takato in an effort to find the best location of the iron works. It is said that the two men could not come to an agreement and fought bitterly.

Bianchi proposed a site at a location named Suzuko (铃子). Selection criteria were based on the site's proximity to transportation, access to water, proximity to ore and fuel, available land, and cost. For Bianchi's opinion, Suzuko was an ideal site for large modern iron works. Oshima proposed the site Otadagoe, which was surrouded by mountains on three sides: north, west, and east. In Oshima's opinion, there are no rainstorms throughout the four seasons, the cold will not stop production day and night. Moreover, Oshima suggested building 5 small blast furnaces similar to those he built at Kamaishi before. It is obvious that Oshima's proposal violated every convention of nineteenth century iron works. It was "traditional" and "backwards" and

unacceptable from the Meiji government's perspective. The Meiji government accepted Bianchi's proposal finally. In October 1875, Oshima was sent to the Ikuno and Kosaka silver mines and the Sado gold mine where he would serve out his days in the Ministry of Public Works as Executive Mining Director.

The equipments of the iron works were all purchased from England based on Bianchi's recommendation. Actually, Bianchi was not the person responsible for designing Kamaishi, his job was to oversee construction. The design of the furnaces and related equipment, based on the public works ministry's demands, was the project of David Forbes, a British consulting mining engineer who never actually visited Kamaishi.

When Bianchi's contract expired in March 1877, he left his position because that he did not like the working conditions and the British staffs with whom he worked. Furnace construction was the job of William H. B. Casley, a British iron works manager from Stockton-on-Tees, who arrived at Kamaishi with the furnace components in early 1876. A Japanese manager, Yamada Jun'an (山田淳庵) who had studied in the London Mining College, was also responsible for daily operation. [10]

Based on the details presented above, a structure of personnel relations in the process of technology import of the Kamaishi iron works can be drawn out as below (Fig. 3), which shows some different characters from Qingxi Iron Works. Most importantly, the decision-making system was a network composed of both Japanese and foreigners. Foreign experts were involved in every level of the decision-making in the technology import's process. Secondly, a careful survey had been carried on before the project started. Thirdly, the Japanese involved in the process were not just the officials who had little knowledge of iron and steel. On the contrary, many of them are had studied related knowledge in Europe. Even senior official such as Yamao Yozo toured with the foreign expert survey the mine. All the characters shows the eagerness of Meiji government to learn western technology and realize industrialization.

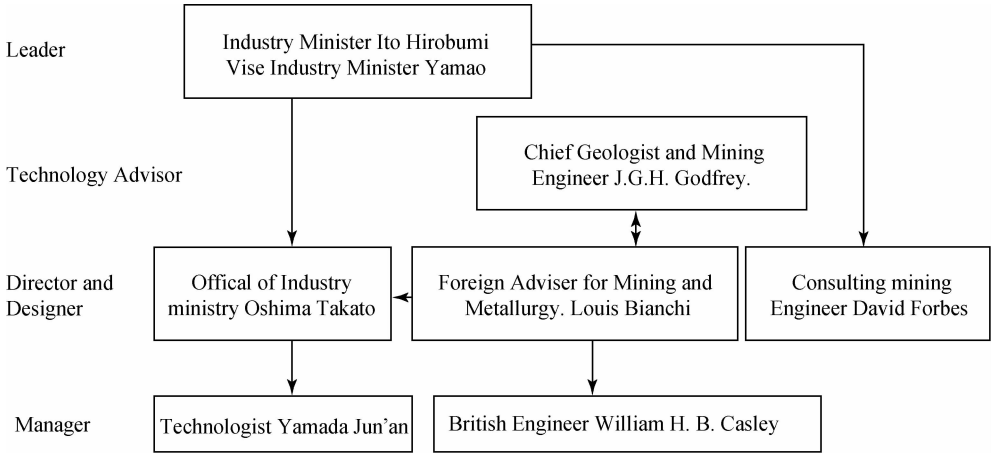

Fig. 3 The structure of personnel relations in technology import of Kamaishi National Iron Works.

Forbes designed two blast furnaces for Kamaishi Iron Works, each of which was configured to produce approximately 75 to 80 tons of charcoal pig iron per week. According to Forbes, "the contract for the iron and brickwork fittings is placed in the hands of Messrs. Head, Wrightson and Co., of the Teesdale Iron Works, Stockton-on-Tees, whose patent hydraulic arrangement for lowering the bell will be employed as well as Whitwell's hot-air stoves, Lurmann's closed breast, and all the most modern improvements"[11]. It is obvious that the new iron works at Kamaishi was to be large and modern.

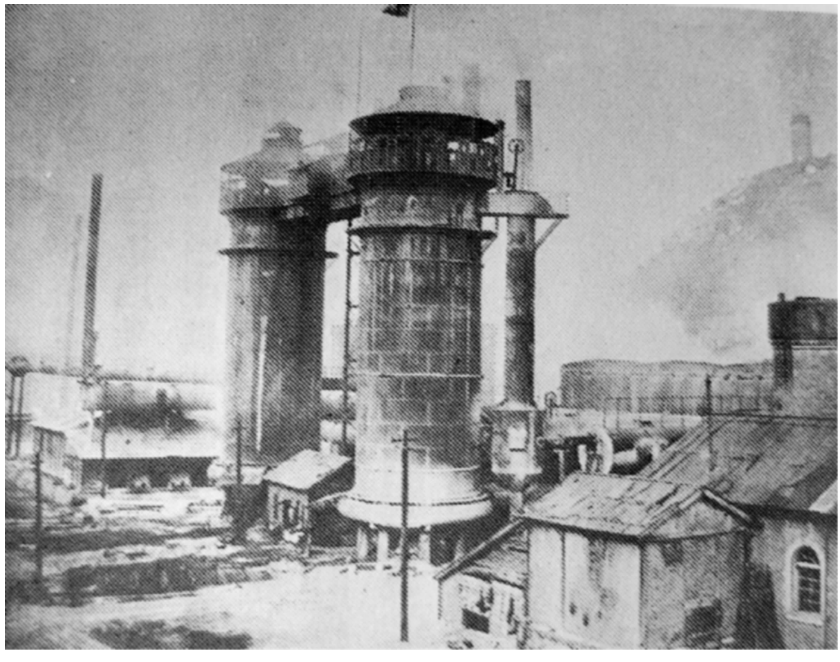

Fig. 4 The blast furnace of Kamaishi Iron Works

The construction of the iron works completed in 1880, one furnace was blown-in on 10 September 1880. Three years later, the iron began to flow. On 9 December 1880, less than three months after the beginning production, a fire destroyed the Kogawa (小川) charcoal facility, the majority of Kamaishi's fuel reserves. The shortage of charcoal forced managers to shut down operations on 15 December.

Kamaishi's furnaces were restarted in March 1882. During the month prior to resuming operations, Kamaishi's managers had brought 10 000 tons of coal to the iron works and ordered the construction of 48 coke ovens. It was said that at least one furnace made the transition to coke. When the switch was made to coke, little changed within the furnace, and output steadily decreased because the furnace was chilling. At first the furnace started forming clinkers, partially smelted agglomerations of iron ore, fuel, slag, and flux. Later the charge fused into one solid mass. Shortly thereafter, the facility was declared a failure. Within a few months, the Meiji government abandoned its first modern iron works.

It was around 1885 when Kamaishi Iron Works was sold to a business man named Tanaka Chobei (田中长兵卫). The Kamaishi Tanaka Iron Works was then founded in July 1887, and developed gradually throughout the 1890s with the technical assistance of Professor Noro Kageyoshi (野吕景义, 1854-1923) of the Imperial University of Tokyo and his disciple, Komura Koroku (香村小録).

3. Conclusion

To compare the two first entrepreneurial ventures in iron industry, some related questions can be discussed.

Firstly, sometimes the selection of technology supplier is an important factor may affect the further development of technology, especially at the initial stage of the technology transfer. Why did both Japan and China select Britain as their first supplier of iron and steel technology? It is nearly impossible to find an undoubted answer just based on the historical data. However, it is certain that the strong desire of "civilization building" made Meiji government want to build a large and modern iron works to support the new growth of rail and sea transport, military and other industry. Therefore, it is reasonable for Japanese government to select Britain, the largest steel producer in the world, as its preferred technology supplier. On Chinese side, to exploit the local mine resource and stop the money flowing out was the main purpose of the first entrepreneurial venture of iron works. The decision makers didn't have enough knowledge of such complicated technology. I prefer that it is more like an occasional decision for Chinese to select Britain as the technology supplier.

Secondly, unlike other industry, many of the design and much of the smelting process in nineteen-century iron production relied on trial and error. Once in-blast, a furnace still required constant adjustments to compensate for variations in the fuel and ore. The experience of furnace operation is of much useful, sometimes it may become a key factor in a new iron works. This is what Japan and China lacked in nineteenth Century. Therefore, we can not say that the failure of Qingxi Iron Works and Kamaishi Iron Works was just a result of an improper technology selection.

Thirdly, further development of the two countries presented different scene. China continued to import the British equipment for the Hanyang Iron Works shortly after the close of the Qingxi Iron Works, presented a strong technological dependency at the early stage of the technology transfer. On the contrary, the early failure make Japan gave up Britain soon. When Yawata Iron Works was built, German equipments became the main content of its plants. Thereafter, Japan went on a way to technology independent gradually in a half century development of iron and steel industry.

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