

## Japanese paper Industry after the Meiji Restoration: How technology helped its growth

### Part 3: Expansion of the industry

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#### Preface

Thirty years had passed since the Meiji Restoration and the paper industry entered into an expansive era.

#### 4. Expansion of the industry

##### 4.1 Evolution of paper machine

Istuki Niishi left reminiscences in which paper machines successively installed in Japan in the period from 1878 to 1939 were briefly introduced <sup>1)</sup>. Nishi himself was a mechanical engineer, had a chance to visit foreign paper mills while young, led technological developments in Japan and became the president of one of large paper companies. His briefing on paper machines described how paper machine was historically developed, and how Japanese paper industry took the developments in its operation. Texts between quotation marks are from his briefing.

##### 1879 Kobe Seishisho:

"Cylinder machine by Rice Barton (USA)

- Wire width: 80 in
- Drive: steam engine made by Jerome Wheelock Co., in MA.

Driving power was transferred by a belt to a relay equipped with bevel gears, through which the third shaft was rotated. The third shaft had 10 gears. Selecting a suitable size of gear fitting to each of them, the speed of whole machine was controlled. To adjust finely relative speeds among each part of machine, a piece of felt soaked with dissolved rosin was pasted on a pulley. Cone pulley was not available yet."

##### 1888 Senju Mill, Tokyo-itagami Co.:

"Fourdrinier machine for paperboard by J.W. Bertram in Scotland

- Wire width: 86 in
- Press: 2 sets
- Dryer: 18 drums of 4 ft diameter
- Calender: 2 stacks

In order to adjust a relative speed of each part of machine, sets of cone pulley were equipped. Sheets were pasted each other to get thicker board."

Cone pulley was developed as follows <sup>2)</sup>. Jouffray

Cadet & Sons of Paris invented to use sets of cone pulley and bevel gears for controlling paper machine drive. Then, George E. Marshall obtained an American patent in 1876, and Marshall Drive, using cone pulleys, became standard equipment after that. The machine imported in 1879 was not equipped with it. The machine imported in 1888 already had it. A cutting-edge technology was imported into Japan in only 10 years delay.

Senju-Seishi which succeeded Tokyo-itagami described in its website as follows <sup>3)</sup>. The company invited Onodera as a chief engineer in 1894, and improved productivity. It installed another Fourdrinier machine (2,790mm wide from Black Clawson) in 1896. Its business grew steadily and profitable. Onodera was introduced in Chapter 3 as one of pioneers. The market of paperboard seemed to be expanding those days, as mentioned in Part 1.

##### 1890 Iriyamase Mill, Fuji Seishi:

"Fourdrinier machine by Black Clawson

- Wire width: 84 in
- Press: 2 sets
- Dryer: 24 drums of 4 ft diameter

Besides the Fourdrinier machine, there was a cylinder machine with a wire width of 72 in, but the details are unknown. The mill manufactured groundwood pulp and sulfite pulp for its paperboard making."

The first mill based on wood pulp in Japan by Murata and Majima who had been introduced in Chapter 2.

##### 1890 Oji No. 2 Mill, Oji Paperi:

"Fourdrinier machine by Union Machine Co. in the US"

Nishi told that he worked for the machine as an engineer, first time in his career. Wire part of the machine is shown in Figure 1.

"A small piece of wet web slit by water jet as a lead was transferred from a dryer to a dryer by hands. It was work of a professional, as air jet was not available yet. When changing a wire, all attachments such as table rolls, wire rolls and save-all-boxes were carried out. It took much time and manpower. The

drive was controlled by Marshall System using cone pulleys. Power was from a steam engine, single cylinder with a four-way valve, which was very excellent."

He explained its drive and speed control system in details, which is not quoted in this paper.

"A pulp saver of Fullner type was equipped in 1912, first in Japan, by which sediment was recovered from white water."

**1899 Nakabe Mill, Oji Paper:**

"A mill was designed exclusively for newsprint production. It was powered by water wheels. The governor of the water wheel was not so powerful yet that the machine speed changed as load fluctuated. A machine was designed at the speed of 300 ft/min. With some modifications, it was operated at 400 ft/min. in 1912." Improvement by modification with later technology was typically Japanese.

**1908 No. 3 Mill, Fuji Seishi:**

"A board machine, first in Japan, made by Black Clawson

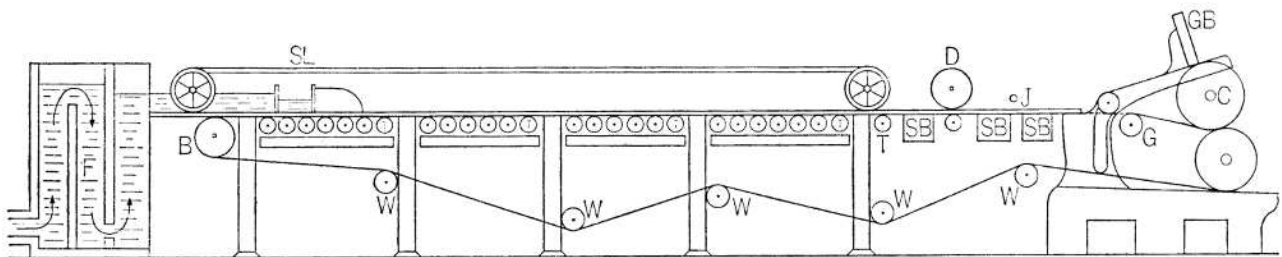
- Cylinder: 36 in x 88 in, 5 units
- Press: 3 units
- Dryer : 40 drums of 36 in diameter
- Calender : 2 stacks of 7 rolls

Almost at the same time, Nagaoka Mill, Hokuetsu Seishi installed a board machine made by Black Clawson.

- Cylinder: 36 in x 86 in, 6 units
- Press : 3 units
- Dryer : 35 drums of 36 in diameter
- Calender : 1 stack of 7 rolls

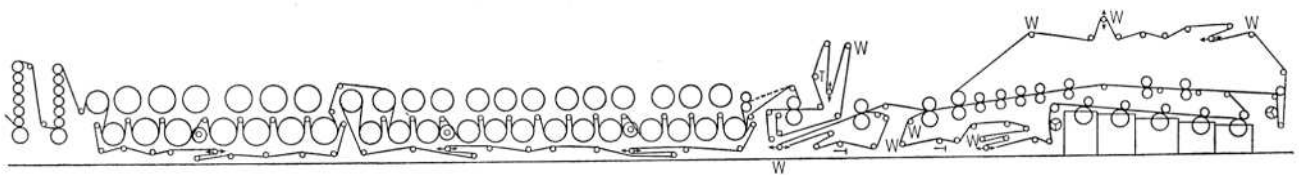
Domestic machine makers also supplied quite a few board machines."

The demand for paperboard finally took off in Japan.



- |                  |                 |                |                   |
|------------------|-----------------|----------------|-------------------|
| F : flow box     | B : breast roll | S L : slice    | DE : deckel strap |
| D : dandy roll   | J : water jet   | C : couch roll | GB : guard board  |
| G : guide roll   | T : table roll  | W : wire roll  | L : save-all box  |
| SB : suction box |                 |                |                   |

Fig. 4-1 Wire part of Foudrinier machine installed in Oji No.2 Mill.



Fug. 4-2 Paperboard machine installed in Fuji Seishi in 1908

**1910 Oji Paper built a new mill at Tomakomai:**

- "142-inch newsprint machine: 2 sets
- 100-inch book & newsprint machine: 2 sets
- 100-inch cylinder board machine : 1 set

142-inch newsprint machine was fairly leveled up, compared to a newsprint machine installed in Nakabe Mill 10 years before. Its design speed was up and was 550 ft/min."

The investment was a big project for Oji to regain a leadership in Japanese paper industry. The mill remained important in the history of the paper industry even after the World War II. The newsprint machine was one of the most advanced in the world in those days.

"The drive was a Marshall type. Each cone pulley was a quill type. A constant speed shaft was driven

by an electric motor and a variable speed shaft was driven by a steam engine by Collis. The machine stood on a sill plate made of iron. Air jet was used for sheet transfer for the first time in Japan."

**1910 Jujo Mill, Printing Bureau (later Jujo Mill, Oji Paper Co.):**

"106-inch Foudrinier machine for post card

The machine was made by James Bertram in England. Both constant and variable speed shafts were driven by steam engines. One for variable speed was by Ashworth Parker Co. Its governor was controlled by step and cone pulley. The first case of using a steam engine for variable speed control of paper machine in Japan."

Installing a paper machine specific to post card indicated that the demand was growing enough in 40 years since the post system was introduced in Japan <sup>4)</sup>.

**1913 Takasago Mill, Mitsubishi Paper Mills:**

"Cylinder machine for paper of thin thickness by Kato Sisakusho

- Wire: 65 in x 3 ft, 3 vats
- Couch roll: 1 unit "

The machine was supplied by a domestic maker.

**1914 Ohtomari Mill, Oji Paper in Sakhalin:**

"Sulfite pulp mill for market pulp, first in Japan. The pulp machine was by Karlstad Co. in Sweden.

- Wire: 108 in x 48 ft
- Press: 2 units
- Dryer: 14 drums of 49in diameter, later increased to 30 drums

Many other mills in Sakhalin, Toyohara, Esutori, Tomarioru, Noda, Shirutoru and Ochiai, followed and installed a machine of a similar size."

Pulp production in Sakhalin started and mills delivered pulp to domestic market in the home land.

**1915 Nakatsu Mill. Chuo-Seishi (Later merged to Oji Paper):**

"Foudrinier-Yankee machine

- Wire: 100 in
- Dryer: 10 ft diameter

The first of this type of machine in Japan. Then, not a few machines of the same type were installed"

Following paperboard, demand for paper of thin thickness grades such as cigarette wrapping paper began to grow. Oji Paper monopolized the business and got good profit.

**1917 Takasago Mill, Mitsubishi Paper:**

"76-inch cylinder machine made by Nishiyama Tekkosho"

The machine was supplied by a domestic maker.

**1919 Jujo Mill, Oji Paper:**

"86-inch Foudrinier machine for fine paper

- Drive: Marshall Drive Variable speed control by a steam engine of Ashworth Parker Co.
- Constant speed control by an electric motor Automatic speed recorder and automatic dryness controller were equipped for the first time in Japan"

**1919 Kameari Mill, Nipponshiki-seizo:**

"120-inch board machine

The machine had a suction couch, first time in Japan. Alexander Black of England invented suction couch and patented it in 1897. So, it took 22 years to be installed in Japan"

Why did it take so long time, as new equipment was usually introduced to Japan in about 10 years.

Kurt J. Haunreiter listed in his chronicle as follows <sup>2)</sup>.

- 1908: Suction couch patented by Millspaugh
- 1909: The first suction couch roll developed by Millspaugh was installed on a machine at Cliff Paper Company in Niagara Falls, NY.
- 1911: The first suction press roll developed by Millspaugh was installed on a machine at Cliff Paper Company.

Millspaugh pioneered a centrifugal casting process for manufacturing shells for his newly patented paper machine suction rolls <sup>5)</sup>. He made it racticable at around 1910. It was introduced to Japan exactly in 10 years after that.

**1920 Ebetu Mill, Fuji-Seishi:**

"180-inch newsprint machine by Barkley

Its size was of global standards."

**1924 Yatsushiro Mill, Karafuto-kogyo:**

"142-inch newsprint machine

- Drive: sectional drive by GE, first in Japan"

**1925 Esutori Mill, Karafuto-kogyo:**

"142-inch newsprint machine by Ohsima Seikosho

- Wire: 142 in
- Jacket couch
- Press; 3 units
- Dryer: 44 drums of 5 ft diameter
- Drive: Marshal drive  
Bevel gear of floor cone was cut off.  
Spiral gears were soaked in an oil bath.

It was designed by Ohkawa, the president of the company."

The machine, domestically made, was of a world standard.

**1926 Chitori, Fuji-Seishi in Sakhalin:**

142-inch newsprint machine by Voith

**1927 Kushieo, Fuji-Seishi:**

142-inch newsprint machine by Ohshima seikoshō

**1930 Noda Mill, Oji Paper:**

142-inch fine paper machine by Walmsley

Newly developed technologies were actively introduced into Japan.

#### **4.2 Paper machines of domestically made**

Though Japan was capable enough to copy a cylinder machine imported at around 1880, the trend of domestically made did not last. Twelve paper machines of Fourdrinier model, which started operation until 1893, were imported, and only two cylinder machines were domestically made at 1884. Then, as in the previous list by Nishi, domestically made machines appeared as time went on, and a trend of using a domestically made machine became common after the World War I. In 1925, a 142-inch newsprint machine by Ohshima Seikoshō was delivered.

Followings are quoted from the website of Minami-senju Seisakusho, an iron works <sup>6)</sup>. It was 20 to 30 years after the first copy machine was made.

"Many new paper mills started in the 1910s. Three mills in 1914, three mills in 1915, one mill in 1916, six mills in 1917 and three mills in 1918."

Okuda reported a list of imported paper machines in those years <sup>7)</sup>, and no machine was delivered to the mills mentioned above. Their machines probably were domestically made. The website continued as follows.

"The machine business was brisk, and nine domestically made machines were delivered and the total wire width of them was 746 inches in 1916. Minami-senju Seisakusho delivered one 100-inch Fourdrinier machine and one 87-inch Fourdrinier-Yankee machine to customers as a joint project with another company." Domestic suppliers were very active indeed <sup>6)</sup>.

At those years, the widest paper machine in the world was about 150 inches, and a Japanese machine maker could already deliver a machine of

100 inches wide. This activity reminds of American machine suppliers which were robust in the latter half of the 19th century.

Shinomiya summarized the movement toward domestically made machines as follows. <sup>9)</sup> "In the period of years from 1870 to 1939, a number of paper machines imported into Japan, Fourdrinier and cylinder mold included, was estimated to be 132, that of Fourdrinier being 109. Since around 1910, several Japanese machinery manufactures were interested in supplying paper machines, and expanded the business. In the period from 1870 to 1939, Japanese suppliers delivered 161 machines, 89 of which were Fourdrinier machines. Their number of the delivery was more than that of the imported." Big paper companies imported paper machines equipped with latest technologies, and domestic iron-works, taking them as models, developed their machines and sold them in domestic market. The demand was supported with rapidly growing paper consumption as in Fig. 1 in Chapter 1.

#### **4.3 A group of engineers of the second generation**

Persons of talent are essential for industries to grow. How did the paper industry recruit them? Nishi listed and introduced engineers, thirty persons in total, who worked in an early stage of the history of Japanese paper industry, though he selected most of them from employees of Oji Paper. A person listed first graduated a college of technology and joined Oji Paper at 1890. Nishi listed himself at the 26th and he also graduated a college and joined Oji Paper at 1906. The details on persons listed are omitted in this paper as they are too domestic <sup>10-1~10-6)</sup>.

Surprisingly however, most of them were graduates of mechanical engineering course of Tokyo College of Technology which was one of a few prestigious technical institutions, founded to educate leaders in technology by the Meiji government. The total number of graduates a year was not many and was about 80 at 1892 and was about 150 at 1902, of which mechanical engineering course was 60-70 <sup>11)</sup>. Oji Paper recruited one or a couple of graduates a year in most of those years. Why could it recruit them?

In 1885, the Ministry of Agriculture and Commerce published the first statistics on products it concerned. The products listed were fabric, floor cover, paper,

metal goods, China ware, lacquer ware, oil and leather. Modern industrial products were still in their infancies and were not listed yet. Probably, paper was the second most important after fabric. So, the industry could recruit graduates from the esteemed college. Furthermore, Dr. Sakata, a principal of the college, helped copy an imported cylinder machine which was mentioned in Chapter 1. This brought a close tie between the college and the industry.

The other interesting point is that many of the listed engineers (nine out of twenty engineers until 1907) visited Europe and America while young, just like pioneers introduced in Chapter 1 had done. It really took cost and time in those days, but the visits continued. Shimada visited Sweden and studied kraft pulping to build a mill in Sakhalin in 1924. Nishi made a world tour in 1925 to have information on pulp and paper industry in the world.

#### **4.4 Paper industry of each country in the 1920s**

Nishi made a world tour in 1925 to have information on technological aspect of pulp and paper industry <sup>12-1~12-7</sup>.

To begin with, how was the paper industry in Japan in those days? The demand for printing and packaging was growing vigorously, and investment on plant and equipment was actively going on. The output was increasing at a rate of 10% per year. The industry was competitive to imported products and supplied paper and paperboard to most of domestic demands. It already changed to wood pulp, and secured it by exploiting forest in Hokkaido and then in Sakhalin. While paper machines with latest technology were imported, domestic machine makers delivered paper machines more in number than the imported. Suppliers of auxiliary equipment of paper machine such as wire, wet felt and dryer canvas started businesses and they were domestically ready. The days when pioneers, amazed with paper machines, dreamed of producing paper in Japan had passed and the business was under control of capital so that such a mill of world standard size as Tomakomai Mill, Oji Paper was constructed.

It is interesting to know how an engineer in his thirties who experienced the transition of the industry would think of situations of paper industries in other countries. He left Japan on April 15, 1925

and arrived at San Francisco on April 30. He visited paper mills in the US and Canada. He crossed the Atlantic, which took days from July 11 to July 17. He visited mills in France, Belgium, Germany, Sweden and the UK. Arriving back at the US on October 24, he visited again mills in the US. He left the US on November 24 and arrived at Japan on December 11.

He published his memoirs in 1976, saying that his travel had been 51 years before, and comparing what he had seen to what they were now would make us understand how paper industry had progressed. Skipping the report on mills he visited, his remark on characteristic situation of paper industry of each country was excerpted. Texts between quotation marks are from his memoirs.

#### **(1) Paper industry in the US and in Canada**

"Migration of the center of paper industry: The US is already scarce in wood resource and needs supply from Canada. Canada, on the other hand, welcomes US investment and affords facility in Canada for the US. So, new newsprint mills are almost in Canada and it is now a center of newsprint production, replacing the US. Canada, however, has nothing particular in fine paper production, and the US is still leading it by constructing mills of big size, occasionally using imported pulp and deinked pulp"

It is interesting that deinked pulp was already used for fine paper.

"Trends of paper machine technology: Regarding operating speeds of newsprint machines, the fastest in the world is around 1,000 ft/min. It is about 700-800 ft/min. in new mills in Canada and is about 600-700 ft/min. in old US mills. Recently, machines for fine paper production are designed to be about 600 ft/min. They, however, do not run so fast. Actual running speed of making paper for Sunday Magazine is 400-500 ft. For manufacturing book paper, 350 ft is the maximum. For bond paper, it is about 100ft."

As paper machines of the newest model were imported into Japan in the 1920s, those in the US and Canada would not be a surprise to Nishi. Followings are details of imported machines in Japan <sup>13</sup>.

1917 Tomakomai No.3 newsprint machine: 142-inch, 850 ft/min.

1925 Tomakomai No.2 newsprint machine: 142-inch, 880 ft/min.

1926 Chitori No.1 newsprint machine: 142-inch, 1,150 ft/min.

1918 Jujo No.1 printing paper machine: 86-inch, 450 ft/min.

1922 Jujo No.3. Printing paper machine: 86-inch, 500 ft/min.

He also visited four mills in Holyoke where Japanese pioneers studied paper making.

"Four mills in Holyoke are manufacturing writing paper as follows.

- Fiber source: linen rag is the best. Cotton rags and white sheet are complimentary. Sulfite pulp is for the worst grade.
- Cooking: with lime or lime and soda liquor
- Cooking time: more than 14 hours for cotton rag
- Drying after tub sizing: Loft drying
- Seasoning: at least 2 weeks
- Calendering: plate calendering is for prestigious grades. Super calendering is for lower grades.
- Paper machine: equipped with Leith screen (by J. Bertram), suction couch, and 4 drum winders
- Water: spring water  
River water is only for first washing after cooking."

Bond paper of the highest grade was still manufactured by a method developed in Europe before wood pulp became available.

"Pulp resources for fine paper: Alkali pulp is the main in the US. In suburban mills where digesters cannot be located, not a few mills use deinked pulp as a substitute. In areas where water power and wood resource are affluent like Niagara area and Canada, using bleached groundwood pulp as a filler is under research."

Kraft pulping industry in the southern US did not start yet. His visit was down to Pennsylvania, the Mecca of alkali pulping. When he left Japan, he listed alkali pulping in his topics of concern, and did not mention on kraft pulping and wrapping paper. At the same period of time, Fuji Seishi planned to construct a mill manufacturing kraft pulp and wrapping paper in Sakhalin and dispatched an engineer to Sweden in order to introduce the technology. It was a project by Ohkawa, and Japanese paper industry was sensitive enough to trends of paper industries in the world.

"Our paper industry against those of the US and Canada: As paper products manufactured in Canada

can be imported into the US with free of tax, the US and Canada could be regarded one economic zone. Then, low-cost electricity and affluent wood resource in Canada would help US paper industry a lot. However, their wood price as well as coal price, not to mention labor cost, are far more expensive than ours, and it will not be impossible for us to compete them economically by improving technology"

His comment on wood and coal prices are unexpected. Currency exchange rate at that time might be involved. His comment of competitiveness suggests that Japanese paper industry had grown to be in such a level of performance.

## **(2) Paper industry in France and Belgium**

"France and Belgium do not have enough wood resources and their paper industries are not flourishing. Rice paper, photo printing paper and bond paper, however, are exported to neighboring countries as pulp resources for them such as linen and cotton rags and residual ropes are abundant. Mills are old and their equipment are also timeworn. Paper machines are narrow and newsprint machines are about 100 inches wide and are operated at slow speed. Even in a newest mill (Papetelli De La Senne), a 142-inch newsprint machine by Bagley runs at a speed of about 300 ft/min."

France whose paper industry was prosperous in the 18th century could not manage to find wood pulp resources in the country.

## **(3) Paper industry in Germany**

"As its domestic wood supply is not enough, Germany imported wood from which it manufactures pulp by itself. It puts effort into afforestation, and mills in southern areas are using those plantation wood. Main types of pulp are sulfite and groundwood, and soda pulp is not a major. It does not use esparto which England depends on and uses a small amount of straw."

"Their paper consists of sulfite pulp and groundwood pulp, and is relatively of low price. They are, however, smart to make high end products with it. Mills are modernized compared to those in France and Belgium. Their technology was interrupted by the war. It is recovering and seems to be as good as the USA. Paper machines they make are as large and

fast as those of the US and are exported to Scandinavian countries."

Germany was the biggest paper producer in Europe in the early 1920s. It exported paper machines also to Japan as follows. They are excerpted from the list by Okuda <sup>7)</sup>.

- 1908 73-inch machine for rice paper by Esher-Wiss
- 1914 73-inch machine for glassine paper by Esher-Wiss
- 1918 73-inch machine for condenser paper by Esher-Wiss
- 1916 44 and 1/4-inch machine for condenser by Esher-Wiss
- 1926 142-inch machine for newsprint by J. M. Voith
- 1936 175-inch machine for kraft paper by J. M. Voith

The market of paper of thin thickness grades was expanding steadily in Japan for which Germany supplied most of paper machines.

#### **(4) Paper industry in Sweden**

"Sweden manufactures sulfite pulp, kraft pulp and groundwood pulp from wood in its forest. Their paper products are paperboard, wrapping paper and newsprint. Total output of them is far less than that of pulp, which means that Sweden is a major exporter of wood pulp."

Nishi was interested in paper machines rather than wood pulp. Right at that time, Ohkawa dispatched Shimada to Sweden in order to introduce kraft pulping to Japan.

#### **(5) Paper industry in the UK**

"As the UK does not have forest for manufacturing wood pulp, most of its pulp is imported from Scandinavian countries. Regarding fine paper, it imports esparto grass and digests them to pulp for its own paper making. Mills manufacturing newsprint and printing paper with wood pulp are mostly located on the banks of the Thames in Kent, where pulp is imported conveniently and easy access to London is favorable. Mills manufacturing fine paper, on the other hand, are in central England and Scotland."

"Not a few newsprint mills in Kent are modernized, following progress in the US, and installed wide and

fast machines, of which operating speed about 600 ft/min., relatively slow. It may be inevitable because newspaper in the UK has many photos so that newsprint is asked to have good sheet formation."

"Many of fine paper machines in the UK are old and narrow in width, operated with very slow speeds, and unable to compete those in the US mills, though they are well equipped for labor saving."

The UK which had led technological developments in paper making in the 1800s lost its edges. The main cause of its decline was that it could not produce wood pulp by itself.

Nishi made a comment saying that it would be possible to compete the US and Canada economically by improving technology and production facility. Japanese paper industry had already made progress by the year of 1925 so as to make him feel so confident.

#### **4.5 Supplying auxiliary components of paper machine**

As more and more paper machines were operated in Japan, their auxiliary components such as machine wire, press felt and dryer canvas were domestically supplied, replacing imported ones.

Kunitake looked back on the history of supplying a wire component to Japanese customers as follows <sup>14)</sup>.

"Three wire suppliers were established from 1916 and they later merged to accelerate domestic production. At the beginning, equipment for weaving wire was imported from Germany and America. Only plain and triple weaves could be made, and their quality was immature. Splicing was done by hand weaving and was difficult to master, and those who could do it well were highly esteemed. In 1933, less than 20 years after the start-up, one of the suppliers succeeded in splicing by welding. Other suppliers were keen to know the know-how."

Wire suppliers themselves worked hard to develop their technologies in the 1930s.

Takahashi remembered the history of felt manufacturing in Japan as follows <sup>15)</sup>.

"First felt for paper machine was made in 1899 in Japan. The amount of the production in that year was as small as 694 kg. The start, however, was a memorial and the then Minister of Agriculture and Commerce praised the success. In 1917, a company specialized in felt production was established. But,

the level of manufacturing was poor and products could not compete imported ones. The volume of output was far less than what Japanese paper industry wanted."

"In 1928, I had an opportunity of visiting Hyke Felt Co. in the US which was the largest felt supplier in the world. The company gave me a chance of studying technologies with few obligations, as it might think friendly of me who was introduced by its longtime customers in Japan. It was really a great occasion for Japanese felt industry still in its infancy. In the course of returning back to Japan, I visited equipment suppliers in the US and Europe, and ordered several kinds of weaving machines, 8 units in total, 2 winders and 2 standbys. Our company, first in its history, could tune manufacturing lines of the world level in 1930, and its capacity was 146,000 kg per year."

In the 1930s, domestic felt suppliers became ready. Regarding dryer canvas, Mori remembered as follows<sup>16)</sup>.

"As paper machines were imported, their dryer canvases were also imported. Then, in 1908 one canvas supplier started to manufacture them. As paper industry increased its output, so the demand for dryer canvas grew. In 1908, a wide weaving machine (144-inch wide) was imported and its products were delivered to big paper companies such as Oji Paper, Fuji Paper and Karafuto Kogyo. Domestic products were gradually accepted in the market because of its good quality and at around 1914 little volume were imported. In those days, all canvases were of plain structure. Then, weaving machine for triple structure was imported, and in 1932 canvas of triple structure was delivered to the market. The industry grew steadily along with the paper industry. Then, the World War II began, and the business was under controlled economy."

Industries supporting paper making got matured. The stories mentioned above tells that every industry was eager to develop its technology and challenged to replace imported products. Their drive to grow came from the strong demand for paper which grew at a rate of 10% per year.

A coming issue will review pulp production in Japan.

## References

- 1) Itsuki Nishi: JAPAN TAPPI Journal Vol.32, No.5, p.2 (1978)
- 2) Haunreiter, K.J.: 200th Anniversary of the Paper Machine, TAPPI JOURNAL, Vol.80, No.10, p.86
- 3) Web site, Senju seishi Not available now
- 4) Post system, Wikipedia
- 5) <http://www.metaltek.com/divisions/sandusky-international/sandusky-papermachinery/>
- 6) website, Minamisanju seisakusyo <http://www.minamisenju.co.jp/>
- 7) Masanibu Okuda: JAPAN TAPPI Journal Vol.10, No.62, p.19 (1956)
- 8) deleted
- 9) Toshiyuki Shinomiya: [http://repository.ul.hirosaki-u.ac.jp/dspace/html/10129/911/AA11349190\\_13\\_61.pdf](http://repository.ul.hirosaki-u.ac.jp/dspace/html/10129/911/AA11349190_13_61.pdf)
- 10-1) Itsuki nishi: JAPAN TAPPI Journal Vol.29, No.5, p.1 (1975)
- 10-2) Itsuki Nishi: JAPAN TAPPI Journal Vol. 29, No. 6, p. 1 (1975)
- 10-3) Itsuki Nishi: JAPAN TAPPI Journal Vol.29, No.7, p.1 (1975)
- 10-4) Itsuki Nishi: JAPAN TAPPI Journal Vol.29, No.9, p.1 (1975)
- 10-5) Itsuki Nishi: JAPAN TAPPI Journal Vol.29, No.10, p.1 (1975)
- 10-6) Itsuki Nishi: JAPAN TAPPI Journal Vol.29, No.12, p.1 (1975)
- 11) The History of 60 years, Tokyo Institute of Technology <https://dl.ndl.go.jp/info:ndljp/pid/1711727>
- 12-1) Itsuki Nishi: JAPAN TAPPI Journal Vol.30, No.2, p.1 (1976)
- 12-2) Itsuki Nishi: JAPAN TAPPI Journal Vol.30, No.3, p.1 (1976)
- 12-3) Itsuki Nishi: JAPAN TAPPI Journal Vol.30, No.6, p.1 (1976)
- 12-4) Itsuki Nishi: JAPAN TAPPI Journal Vol.30, No.8, p.1 (1976)
- 12-5) Itsuki Nishi: JAPAN TAPPI Journal Vol.30, No.10, p.1 (1976)
- 12-6) Itsuki Nishi: JAPAN TAPPI Journal Vol.30, No.11, p.1 (1976)
- 12-7) Itsuki Nishi: JAPAN TAPPI Journal Vol.31, No.1, p.4 (1977)
- 13) Masanibu Okuda: JAPAN TAPPI Journal Vol.10, No.62, p. 9 (1956)



- 14) Michizki Kunitake: JAPAN TAPPI Journal Vol.26,  
No.8, p.1 (1972)
- 15) Ichizo Takahashi: JAPAN TAPPI Journal Vol.26,  
No.2, p.2 (1972)
- 16) Kikuzo Mori: JAPAN TAPPI Journal Vo.29, No.9,  
p.18 (1975)