

How the paper industry in Japan has technologically responded to the paradigm shifts of the Japanese society

Part 2-1: The Paper Industry in the 1970s --- Environment Preservation, Fiber Resource, Production Technology and Key Technology

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Introduction

The period of time from 1970 to 1975 was substantially transitional in the history of Japanese society as well as of the Japanese economy. How the paper industry managed to respond to the transition is reviewed in this issue. The chapter starts from 2, following the previous issue. Figures, tables and references are also sequential in number from Part 1.

2. The paper industry in the 1970s

The paper industry which expanded its production at a full throttle began to slow down in the 1970s. The slowdown corresponded to that of GDP as mentioned in the part 1. Then, what caused the slow down? It is explained as follows. The price of oil which had been a basic material for various goods, one of which is energy, hiked, the Rome Club warned that resources on the earth were limited, and environmental deterioration caused by precedent economic growth became very serious. These induced the change in a way of thinking in society, and then the social structure itself changed¹⁰⁾. To review how the paper industry understood the situation, new-year remarks addressed every year by the then president of Japan TAPPI who were the highest rank executives of technology division of big paper companies are quoted in excerpts.

2.1 Common understandings in the 1960s

Nishi mentioned as follows in 1962¹¹⁾. "It is a year of free trade this year. --- The freeing of trade will cover 95% of goods by the end of 1962, and rayon pulp, softwood kraft and sulfite pulp and some paper products will surely be imported. We have to work hard to compete imported products. Regarding to wood supply, utilizing hardwood, instead of softwood, is under study. At present, hardwood is mostly used for making fine paper, and it should be used for printing papers of lower grades as well."

Following is a new-year speech by Shinoda in 1965¹²⁾. "The last year was exactly the year of liberalization of the Japanese economy, completing free trade agreements and joining the member of IMF and OECD. So, we have to be responsible to doing everything from an international viewpoint." His concern was free trade and menace of imported paper products.

Eda made a speech in 1968 as follows¹³⁾. "Large pulp mill projects in B.C., Canada, which intended to export to Japan, are now in operation, and their pulp will soon arrive at our country. Importing newsprint is a topic in the news. Now, we are facing to real international competition. Environment Pollution Prevention Act passed the congress last year. We will have to deal with this law and will be annoyed." Though environmental problems and competition with import are in the sight, his remark was not with the sense of urgency.

Nishi told in 1970 as follows¹⁴⁾. "Though freeing trade, started in 1962, was afraid of, industries in Japan have made steady progress. The paper industry experienced sharp rise of wood price, its index being 189 against that in 1960. The whole sale price index, on the other hand, is 106 against that in 1960. So, the paper industry is promoting wood chips import and investing overseas to secure pulp resource. New technologies such as producing kraft pulp with continuous digester, installing CGP and RGP, speeding up paper machines, installing Vertiformer and automatizing sorting and packaging operations have been introduced. The paper industry, however, is less profitable than other industries, and much effort is needed."

Though he expressed his concern for low profitability, scarce wood supply and competition with overseas producers, he was not so pessimistic and not in the sense of urgency. Technological developments Nishi listed up made the industry efficient and made it possible to supply products to

increasing demand without price increase as shown in Fig. 1 and Fig. 8 in the part 1 of this series ¹⁵⁾.

2.2 The crisis in the 1970s

Then, Inoue addressed in 1970, quoted "At the beginning of the year, let us consider how we should do" ¹⁶⁾. He continued: "The net profit margin of the paper industry was 6.33% in 1952, and was almost twice of the average of other industries which was 3.80%. It was a favorable period for the industry, called "the boom of the white three". Then, our profit gradually went down, influenced by ups and downs of business climate, and now is, sadly to say, 1.61% in the first half of 1969, which is about one third of the average of other industries." To cope with, he introduced cases of paper companies in the UK as models. (Author's note: Though the UK had been a major in the world paper business until that time, they were trying to survive from oppression by Scandinavian paper companies which had affluent wood supply.) Bowater was moving overseas, and Reed and Wiggins were interested in high end products and supplied them domestically as well as internationally. He suggested that Japanese paper companies could do the same by cooperating with each other. As wood supply was the most important concern, he recommended to use tropical hardwood, promote plantation of softwood and use non-wood fiber stuff like Kenaf. Then, his topic went to synthetic paper. Being afraid of its threat as a competitor, he estimated that the price of plastic fiber would be balanced to that of wood pulp in 1980 and plastic paper would be marketed in Japan. He also mentioned that pollution would be a big problem to be dealt with.

Inoue further addressed in 1972 ¹⁷⁾. He was afraid of impact by revaluation of the yen which would be more than 10%. The GDP growth rate which had been more than 10% in the 60s would quickly decrease, and cautions for depression had to be prepared. The serious problem was various kinds of pollution caused by the paper industry, for which the industry had already spent 10 billion yen and would further invest 70-80 billion yen in the years to come. The total cost of this investment, capital cost and variable cost combined, would be 20 billion yen per year, which was equivalent to the profit of the whole paper industry. Waste disposal was also problematic

and coordinated approach with other industries would be needed

The new-year address by Kawashima in 1973 was full of urgent crisis ¹⁸⁻¹⁾. Scarce wood resource, environmental pollution, international competition and low profitability were now difficult problems to deal with, and, moreover, they were inter-related with each other. "Industrial areas and residential areas are existing side by side in the narrow coastline in Japan. It is extremely necessary for us, engineers, to calm down blame on us by residents and to get their understanding."

Kawashima made an address further in 1974 ¹⁸⁻²⁾, saying that the investment in pollution control was more than 70 billion yen and was oppressing the industry's profit, the industry had to be interested in wood resource overseas and a piece of good news was the founding of a joint company between Japan and Brazil on wood resource exploitation.

Seki, in 1975 ¹⁹⁻¹⁾, reviewed disturbed economy and sharp commodity price increase since 1973, and said "Though the economy was relatively good in the first half of 1974, it slowed down in the second half, and demand decreased more than expected, product inventory which had been decreasing turned to increase, and the outputs of some grades of paper have to be voluntarily reduced in significant volumes. It is seriously critical indeed." As for wood resource, wood chips import was going steadily and covered 35% of the total wood consumption. The joint project in Brazil and use of recycled paper were very important. The investment on environment preservation shared 29% of the total investment in the paper industry, while that in the whole manufacturing industries was 16% of the total investment. He said: "The environment problems will definitely ask capital and research".

Seki, in 1976 ¹⁹⁻²⁾, mentioned that cutting back output was unavoidable, which ironically helped to restrict wood consumption, and recycled pulp from wastepaper was going to be used for newsprint production besides conventional use for paperboard. Oil price hike was still problematic, the investment on environment preservation summed up to 84.6 billion yen in 5 years from 1974 to 1977 (23% of the total investment) and regulations on BOD, COD, NO_x would be more stringent. He concluded "Let us, all of the members, help each other, and move forward

and challenge difficulties."

In the 1960s, though the industry was growing steadily, its output volume was still small, and wood supply was managed by using domestic hardwood for kraft pulp and chem-ground wood pulp, and environmental pollution was not becoming a problematic issue yet. But, in the 1970s, four problems, wood supply, environment pollution, international competition and low profitability, which Kawashima had listed, became apparent and the industry's existence itself was threatened. Synthetic or plastic paper was also a worry, though it turned out to be inexistent.

I had worked for ten years in a paper company by that time, and was afraid of the industry's future. How was the paper industry imaged in Japan then? Following is a remark by Ohnishi in 1977²⁰.

"In the Conference for Industrial Economy and Industrial Structure Council, some members regard the paper industry as a slow-down one or put it in the negative list, as its future will be pessimistic. That opinion is common even among those who are key personnel of the paper industry. The main reasons are uncertain wood supply and troublesome environment. The industry already imports 40% of its wood consumption from abroad, and its share will increase year by year. Wood supply in the world, on the other hand, is becoming scarce and wood will be one of commodities for resource nationalism, which will make Japan even weaker. Regarding to environment, the industry consumes a lot of water and pollutes rivers and sea water. Moreover, it expels dust, SO_x, NO_x and even bad odor around. Though it does not cause direct health problems yet, the industry which pollutes land, sea and air would not be acceptable anymore. Those are the standpoint of the negative opinion." In other words, the paper industry was told not to stay in Japan anymore.

2.3 Countermoves to environment pollution

Just as Kawashima said, quote it is extremely necessary for us, engineers, to calm down their blame on us and get their understanding unquote, the industry made intensive investment on pollution control to get understanding from society. Fig. 11 is the sum of money it invested²¹.

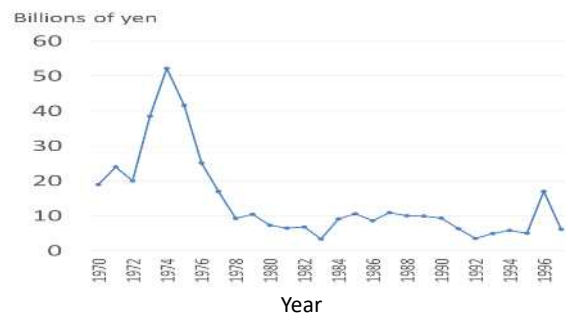


Fig. 11 The investment on pollution control

The industry installed effective equipment by all possible means. Followings are the excerpt of news for pollution control from the chronology of industry news cited in the website of JAPAN TAPPI²²). They tell how the problem was nation-wide.

1973: Paper sludge dispute in Iyo-Mishima, order for improvement issued to 13 mills. Tertiary treatment of paper sludge in Tagonoura. Agreement on pollution prevention among Sanyo-Kokusaku Pulp, Nihon shigyō, Yamaguchi Prefecture and Iwakuni City. Agreement on pollution prevention between Daio Paper and local community. Agreement on odor pollution specified by numerical values by Toyo Pulp. Introduction of Pollution fund system by Kanzaki Paper (Tomioka). Kitakami River designated as an environmental standard zone. 57 mills in Fuji district changed heavy oil to town gas. Wakayama Prefecture announced the regulation of severe additional requirement. Daishowa Paper (Suzukawa) completed the construction work for controlling odor from kraft pulp plant (350 million yen). Ehime Prefecture ordered 6 mills to shut down their operation. Shizuoka Prefecture ordered more than ten mills to shut down their operation. Mitsubishi Paper (Hachinohe) installed PDP for recovering white water.

1974: Honshu Paper (Kushiro) made an agreement for pollution control (Sox, dust and effluent) with Kushiro City. Sanyo-Kokusaku Pulp (Iwakuni) installed a pilot plant for getting clear water from effluent of bleaching pant (300t/day). Co-op of pulp companies in Ehime Prefecture started a plant of incinerating pulp sludge and manufacturing activated carbon. Emission standard for sulfur oxides intensified. Surprise inspections for 80 mills by Ehime Prefecture. Oji Paper (Kasugai) recycled mill water and cleared BOD of 70 ppm. Jujo paper (Ishinomaki) installed No.4 clarifier of which diameter was 108 m.

Mishima-Kawanoe of Iyo and Takaoka of Fuji operated co-op incineration plants for PS. 73% of effluent from pulp and paper mills was treated by sedimentation (statistics by MITI).

1975: 15 mills in Fuji City organized a co-op venture for solidifying PS. Fuji Film (Fujinomiya) installed a desulfurizing plant for flue gas. SO_x emission was regulated with 8 levels. The investment for pollution control planned in 1975 was 63 billion yen (30.8% of the total investment). Air pollution control law was enacted. Okayama Paper treated PS with earthworm. Daido Oxygen developed an air bubbling process with pure oxygen.

This immense investment on environment preservation later offered significant return to the paper industry. As in Fig. 11, the effluent treatment occupied the largest share in the total investment for pollution control. A large number of coagulation sedimentation equipment like clarifier were installed. They not only removed suspended solid but also helped to reduce BOD and COD in effluent to the levels which cleared the regulations before leaving mills. It is believed that these measures helped the Japanese paper industry to stay cleared from dioxin debacles in 1990, which other countries suffered.

In the latter half of the 1800s, environmental pollution by dioxins was detected in the North America and the Scandinavian countries. Then, its pollution was found to be of high levels around paper mills, and became the crisis of existence for paper industries in the world.

As paper mills in Japan were suspected to be polluters like those in the world, the Environmental Agency investigated the problem and reported its survey research in October, 1991²³⁾. It said that dioxin levels in fish and of atmosphere around paper mills were almost the same to those of ordinary environment, and would not be hazardous to human health. Some of its data are quoted in Table 4. Dioxin values are expressed as its equivalent toxicity.

Table 4 Survey on dioxins pollution by the Environment Agency (Nov. 25, 1991)

	Waters around pulp mills	Waters in general
	Fish and shellfish	Fish and shellfish
Number of samples	75	35
Range detected	0.0 - 3.5 ppt	0.0 - 8.5 ppt
Average value	0.23 ppt	1.19 ppt

Why was the paper industry of Japan free from the debacle? In Japan, paper companies produced mainly LBKP, different from the North America and the Scandinavian countries which produced lots of NBKP, and active chlorine charge at bleaching in Japan were much less than those in the other regions. Moreover, Japanese companies had already installed oxygen bleaching and further reduced their chlorine charge rates. However, if Japanese companies discharged effluent without strict treatment like sedimentation, they would have positively polluted areas around with dioxins and would have been in troubles and be asked to shut down operation.

In the North America, many mills were regulated by COD, and they discarded effluent only after treating with air bubbling, instead of sedimentation used in Japan. So, more amount of organic chlorine compounds, one of which was dioxins, drained from mills to environment. In fact, fishing in rivers polluted with them was prohibited²⁴⁾.

Baltic Sea was also polluted and the volume of fish that could be taken to body was limited by regulation. After the debacle, the paper industry switched the bleaching process to one in which less chlorine was used like ECF and TCF²⁴⁾.

2.4 Fiber resource management

How did the Japanese paper industry manage fiber resource supply? In 1985, Ohnishi summarized the situation as follows²⁵⁾. "How is our situation? The managing domestic forestry is at a turning point, and relying imported wood will ask us to have right understanding on world trend. If we make an error in judgment on future strategy, we would face severe shortage of wood supply. Our utilization rate of waste paper is already 50 percent, which is close to the limit. So, how to have enough fiber resource is still the most important subject for the future of the Japanese paper industry"

What kinds of measures has the industry taken? Its efforts were reviewed in my papers listed in references from 26 to 28. They were using hardwood²⁶⁾, importing wood chips^{27-1), 27-2)} and maximizing to use recycled pulp^{28-1), 28-2), 28-3)}. Please refer to original papers, but, as excerpt, following figures were cited to give an overview.

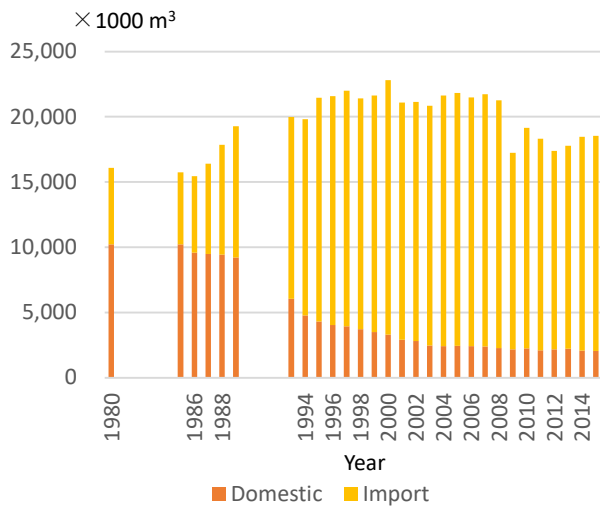


Fig. 12-1 Hardwood chips delivered

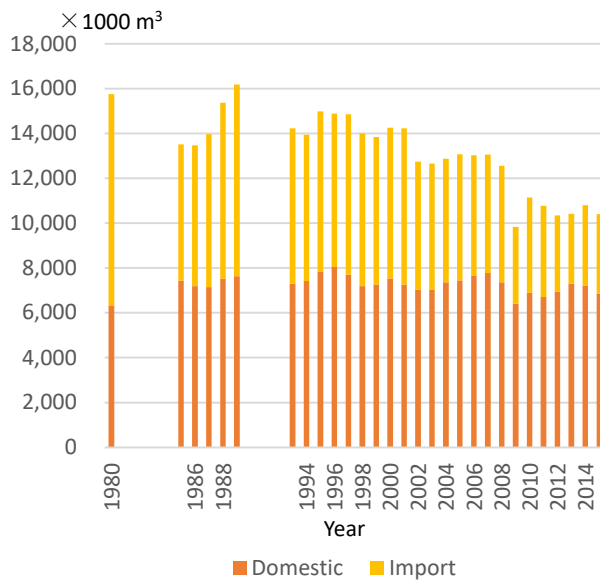
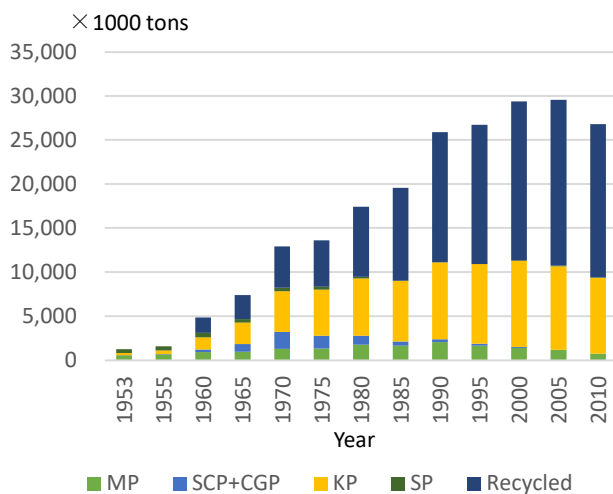


Fig. 12-2 Softwood chips delivered



Recycled: mostly wastepaper reclaimed for recycled pulp
Fig. 13 Fiber resources by grade

In the 1970s, no one could have imagined that fiber supply would be affordable in future. Personally, I believe that successive fiber resource development such as hardwood, imported chips and recycled fiber have survived the Japanese paper industry.

2.5 Production technology

How did the Japanese paper industry deal with developing production technology? Ohnishi mentioned in 1985 as follows ²⁵⁾. "There are still many cases in which equipment is operated with blind guess, as it is not scientifically understood. When some changes are taken in paper machine operation, such as stock composition, machine accessories, running speed and operating crew, product quality fluctuates uncontrollably. Even among paper machines of the same configuration, one machine, despite elaborate churning, cannot manufacture acceptable product, while another machine can do it quite easily. Paper quality is evaluated by terms sounding unscientific like jiai (sheet formation), fuuai (feeling by hand) and kamiguse (paper curl), which researchers are working to make scientifically understandable.----- My request is to make the production technology scientific enough from a present immature condition, which is like an art, by applying recent scientific and technological developments.

There is a common understanding in the industry that modernizing mills could be economically accomplished by just installing equipment which has been proved to be excellent in some mills in the world as fast as possible and operating it well by ourselves. This understanding will lead to a short-sighted opinion that the paper industry will not need basic research as it is a kind of process industries. It may be partially valid, but it has to be changed to survive in the future.-----"

His assessment on the technology of those days was critical and severe. Paradoxically, however, the industry could survive by installing new equipment vigorously, improving operations from art to science, responding the social paradigm shift in the 1970s and coping to imported products by improved and better cost performance. As will be reviewed, the ratio of profit to sales was more than the average of the all industries in the 1980s. The details were reviewed in references ²⁹⁾ and ³⁰⁾. Let me quote some

part from them as summary below.

After around 1960, equipment developed in Europe and the US was introduced to Japan by Japanese licensees which were already big machinery builders in Japan. The relationship between the paper industry and them were very unique in the world. Since those days, Japanese licensees were capable enough, delivered machinery which was reliable enough and offered good after-services to their customers. Paper companies in Japan believe in them and installed equipment before its reputation was established in the world market. The correspondence and cooperation between them were vividly described in the memorandum by Endo³⁰⁾. In those days (1965-1970), as in Table 5, many new paper machines were installed and started running. Though this expansion met the economic slow-down starting from 1970 and the industry fell in the severe depression, it was an opportunity for engineers to challenge new technologies and improve their capability.

The industry also had an ability of evaluating the potential of new technologies and making them practicable. Moreover, it had an intention of taking risk of investing on them. Their performance was demonstrated in cases such as the installation of No. 6 newsprint machine in Kushiro Mill, Jujo Paper Co^{31-1) 31-2)}, and the introduction of twin-wire formers and hybrid formers in Japan. Though these formers were developed in Europe and America, the cooperation between Japanese licensees and Japanese paper companies for making them practicable contributed greatly to implement them.

For example, Duo-former Type D which was developed by Voith was a best seller machine in Japan, to which IHI, Japanese licensee of Voith, was credited with distinguish services. The experience and know-how established in Japan spread in the world. Though it was not proved by quantitative data, I am certain of it with hearings from persons concerned. Japan was already the second largest paper producer in the world at that time, and its production volume was still increasing at the rate proportional to that of GDP, which was close to 4% per year. This was a background which made the investment shown in Table 5 possible and gave an opportunity of improving technologies.

As a summary, the uniquely friendly and tight cooperation between the industry and Japanese licensees of technologies developed overseas boosted Japanese production technology to the top level in the world along with highly active investment.

But, since around 1990, equipment suppliers oligopolized in the world and only two European companies offered a complete paper machine. They strengthened their technological leadership. Japan, on the other hand, had fewer opportunities of having new equipment in their use than before due to the stagnation of economy, and contributed less to technological development in the world. News items on investment on paper machines were counted from the news of the industry section of JAPAN TAPPI Journal between 1993 and 2000. Only 21 items were counted, including remodeling, a number of new machines were far less than those in Table 5. This drastic reduction of new investment made executives in charge of technology afraid of losing technological edges in the future.

Table 5 Paper machines installed in the period from 1965 to 1970, listed by their width

	(unit: mm)			
	Newsprint machine	Printing paper machine	Coater	Paperboard machine
1965	3710, 6960	2910, 2710	1830, 2160, 1620 and two other coaters	3000, 2840, 1880, 5280 and one other machine
1966		3700	3700, 3355, 1710	3700, 1850, 2900, 1960, 1450 and one machine
1967		3800, 3050	3480	
1969	6960	3780, 1230, 3800 and two other machines	Two coaters	1900, 2900
1970	3710, 3610, 3700, 6900	3800, 2230, 2240, 3800, 5625, 6000, 1650	1150	3610, 6350, 4150, 3600, 3610
1971	8640, 3610, 3610, 3700	3900, 6100, 3600, 4070	3355	2860, 6900, 3650, 4000, 5100

As in Figures 1, 2 and 3 in the part one, economic growth of Japan after the World War II could be divided into three stages which were 1945-1969, 1970-1994 and after 1995. The paper industry was very aggressive until the end of the second stage, as reviewed in this chapter. It was not only the paper industry but also Japanese manufacturing industries themselves that were shining in the world those days.

2.6 Key technology

Then, what kind of technology did help Japan's success? In the history of technology, there was always a new key-technology for each evolution. In the Industrial Revolution led by the UK, it was mechanical engineering which fabricated iron and steel to machines and tools. Chemistry helped the German expansion in the late 19th century. In the 20th century, the USA developed electric energy and telegraphy. I think that Japan made remarkable progress of the same scale in the first two stages, sometimes called Japanese miracles. Then what was a key-technology of Japan? I believe that it was solid state technology, and I discussed on it in my paper²⁹⁾.

The word "solid state technology" was born in the 1960s, and it caused revolution in technology by replacing vacuum tubes used at that time. Though the term is used in few occasions at present as all products are of solid-state, it was representing a newly born technology from around 1960 to 1980. Though its basic invention was not done in Japan, why was it a key-technology for the Japanese miracle?

Center of the History of Industrial technology, National Museum of Nature and Science is publishing survey reports in a series, each one of which took a specific industrial product, important for Japanese economy, and described its history of technological development³²⁾. In those surveys, every industry started with introducing and imitating a product overseas, improved and refined its product to an acceptable quality and then, exported it worldwide, its cost performance being advantageous. When they started after the war, processes and equipment were manually controlled and asked lots of experience. Then, the solid state technology was invented, which Japanese industries quickly mastered and applied in their products as well as in their manufacturing processes. As an

example, thermal head for thermal paper was invented in 1968 in the USA, and in 1971 many Japanese companies began to sell thermal paper commercially. By the solid state technology, they gave their products fresh restarts (electric commodities), improved productivity and reliability by instrumenting processes (steel industry as well as paper industry), manufactured products with less cost by which they expand their market globally. While maintaining traditional craftsmanship before the war, they established unique manufacturing system, Japanese style, by making actively use of new-born solid state technology, and sold products worldwide (auto industry).

JAPAN TAPPI reviewed important technological developments in the paper industry. The details were presented in papers^{33), 34)}, which told that solid state technology was a key technology. In the series entitled "Technological developments in the paper industry for recent thirty years"³⁵⁾ published by JAPAN TAPPI, in which every experienced engineer reviewed the history of his specialized area, newly developed equipment was of solid-state and was controlled by instrumentation by solid-state.

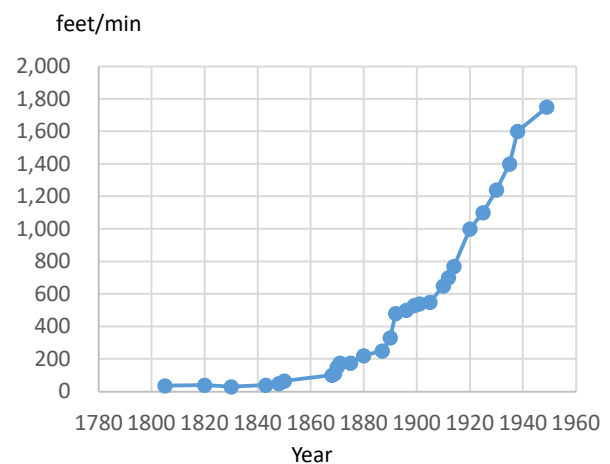


Fig. 15 Transition of paper machine running speed (designed) till 1950 (Fig. 14 is deleted.)

Being in a sidetrack a little, paper machine has a history of almost 200 years. Fig. 15 was prepared by Seki³⁶⁻¹⁾, and shows the increase of paper machine design speed till 1950. He elaborately picked up data from journals and literatures overseas, and presented them in JAPAN TAPPI Journal in 1951. As the graph was hand-written, it was rewritten as Fig. 15. He did the same work on

paper machine width. It is a surprise that he did it in Japan in the year of 1951, which was shortly after the war.

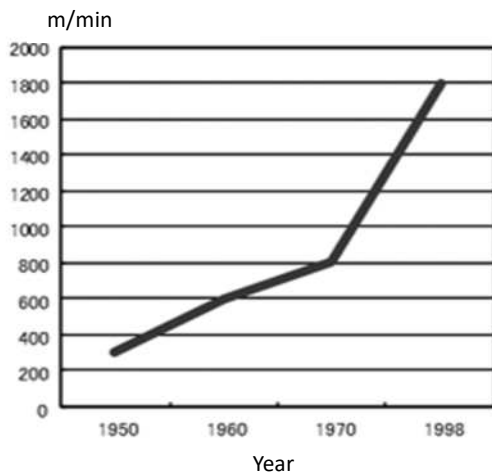


Fig. 16 Transition of paper machine running speed (designed) in Japan ³⁶⁻²⁾

Fig. 16 was prepared by myself by picking up data in the same way as Seki did from the news chronicle by JAPAN TAPPI

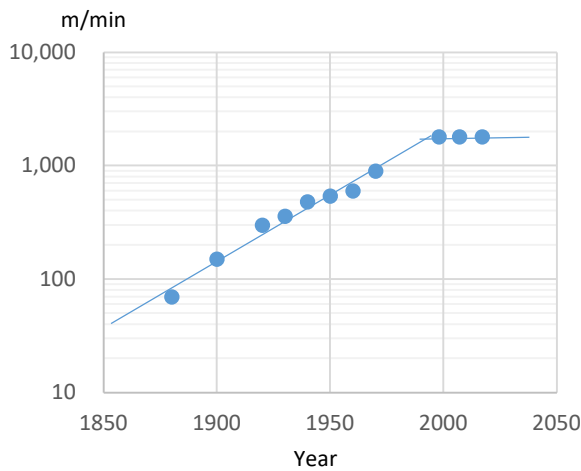


Fig. 17 Transition of paper machine running speed (designed)

When the two graphs are connected and depicted in one graph, Fig. 17 is obtained. Surprisingly, the annual increase rate of machine speed can be approximated to a linear line in a logarithmic scale from 1870 to around 1990-2000, though it is leveling off at 2000 m/min after 2000. It means that the paper machine speed was increasing at the same rate from the time of the Industrial Revolution to 2000. If something fundamental in technology changed, the increase rate may deviate from the approximated straight line. So, it is reasonably

concluded that the increasing occurred in the same technological paradigm. It is understood that solid state technology invented in 1960 was not revolutionary but one of evolutions in the history of mechanical engineering starting at 1800. The fact that the machine speed leveled off at 2000 suggests that the conventional engineering reached its limit and the interest of society on technology turned from mechanical engineering to some other thing, probably information engineering, which belonged to a new kind of paradigm.

Fig. 18 was on paper machine width, prepared in the same way as Fig. 17 from data by Seki ³⁶⁻¹⁾ and myself ³⁶⁻²⁾. Its yearly rate of increase declined, leaving the year around 1960 as a turning point. Solid state technology contributed to maintain the annual rate of increase of machine speed, in which instrumentation by it was very helpful, while it did not do so for machine width in which quality of construction materials played an important role than instrumentation.

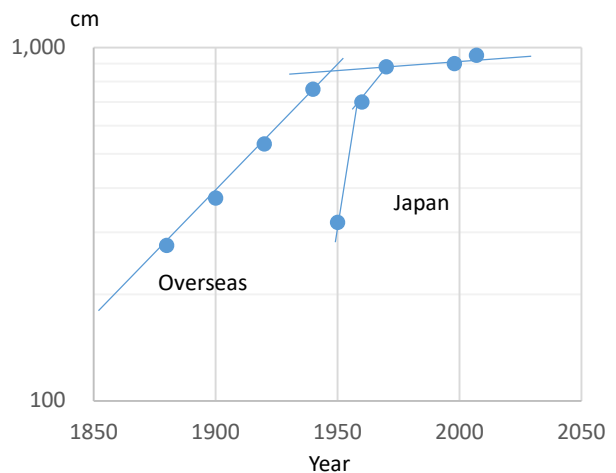


Fig. 18 Transition of paper machine width (designed)

My understanding is that the technology developed since the Industrial Revolution might reach its physical limit and the era of new replacing technology has started which is called the Information Revolution.

The next issue will review the other technological developments in the 1970s, as follows.

2.7 Energy saving

2.8 International competitiveness

2.9 One episode

2.10 Summary on the period of time from 1970 to 1990

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