

IPPTA



**Silver Jubilee International Seminar & Workshop
Appropriate Technologies For Pulp & Paper Manufacture
In Developing Countries.**

New Delhi - 1989

**WORKING OF THOUSANDS OF
MINI PAPER FACTORIES IN CHINA**

P.J. Manohar Rao

National Federation of Cooprative

Sugar Factories Ltd.

82, Nehru Place

New Delhi - 110 019

Abstract

The paper industry in the People's Republic of China (PRC) is unique in many respects and is of great interest to the paper factories and paper technologies in other countries. But, unfortunately, for many years, the People's Republic of China was somewhat veiled to the outside world. No statistics about this industry were properly maintained and even if available, were not disclosed to the public in other countries for almost twenty years. It was only from the year 1980 onwards, that the People's Republic of China started inviting experts from other countries and got interested in developing contacts with the outside world. For years together, all the literature including the information on paper industry was only in Chinese language and as such, there was no opportunity for outsiders to know anything about Chinese paper industry.

In July, 1988, the China Technical Association of Paper Industry (CTAPPI) sponsored an international conference on "Non-wood Fibre Pulping & Paper Making" at Beijing, the capital of People's Republic of China. This conference was co-sponsored by the United Nations Industrial Development Organisation (UNIDO) and China Association of Science & Technology (CAST).

The author of this article, who is a Chemical Technologist, participated in this conference and presented a paper on 'Modern Practices of Handling & Storage of Bagasse.' After the conference, the representatives of the China Technical Association of the Paper Industry and Guangdong Cane Sugar and Paper Industries Corporation, organised an elaborate tour to show this author, a few paper factories, sugar factories, research institutes on paper and sugar industries and other Organisations. Thus, the author had a wonderful opportunity to study the paper and sugar industries in People's Republic of China and had many discussions with the experts in both these industries and collected lot of literature on the activities of the sugar and paper factories. As the entire literature was in Chinese language, the author got this translated into English. On the basis of his study and literature collected, the author has prepared this article for the benefit of the paper and sugar factories in other countries.

Historical Background

Even in China, there is a controversy on the issue as to who exactly invented paper? One version¹ is that in A.D. 105, Cai Lun of the Eastern Han Dynasty invented the first paper in the world using bark, rags, flax and fishing nets, as raw materials. Some Chinese scholars say that paper was invented by Tsai Lun, an official of the East Han Dynasty (25-220 AD). During the current century, many archaeological excavations in China revealed the presence of paper in the tombs of the West Han Dynasty, dating from 149-49 B.C. the most important found is a piece of paper sample excavated near Xian (capital of Shaanxi Province). This paper was found behind a copper mirror and was presumably used as a wadding material. A copper sword was also found and the archaeologists have dated both these items to the West Han Dynasty, possibly in the year 140-87 B.C. Therefore, it was believed that paper was known in China from the years 140 to 87 B.C. From that time onwards, hand made paper is very well known in China.

In the year 1950, the total production of hand made paper reached a peak of 239,000 tonnes per annum and by the year 1985, the production declined to 196,000 tonnes per annum.

Status of the Chinese paper industry:

In the year 1958, there was a mass movement in China for setting up small paper mills in order to solve the problem of shortage of paper and board in each country (district). They desired to have one small paper plant in each country to produce different types of papers required by the population in that county. As the investment for setting up a small paper mill is low and it can be established in a short time, a number of small paper mills were established at the rate of one for each county. Thus, an unique feature

of the Chinese paper industry today, is the existence of as many as 4200 paper plants. the break-up of these factories on the basis of their annual production capacity is as follows:-

- a) 30 mills - 30,000 to 120,000 tonnes per annum capacity.
- b) 100-mills - Over 10,000 tonnes per annum capacity.
- c) 4000 mills - Less than 10,000 tonnes per annum capacity.

The paper factories at Sr. No. (a) & (b) above contribute 40 to 45 % of the paper production in China and the balance is contributed by the small paper mills at Sr. No. (c) above.

There was a sudden spurt in the installation of small paper plants during the year 1958 to 1960, as a result of the Government Policy to establish at least one paper mill for each county and there are more than 2000 counties in China. The capacity of the mills was only 2 to 5 tonnes of paper production per day in the beginning. The equipment was simple, consisting of a small rotary digester, a Hollander Beater, a Single Cylinder Vat, a Single Dryer Paper Machine. All these small paper plants were based on wheat straw, rice straw, reeds and waste paper. The main products were wrapping paper, toilet paper, writing and printing paper etc., to meet the requirements of the county in which the paper mill is located. The small paper plants could survive for over 3 decades and are still working successfully due to the following reasons:-

1. Wheat straw, rice straw and reeds are abundantly available in each county and at a very low prices.
2. The labour is cheap.
3. The total investment in small paper mill is very low and local Government could solve their financial problems.
4. The plant and machinery and technology are locally available.
5. The production cost is low and there is a ready market for the different kinds of papers within the county itself in which the paper mill is located.

By this, the paper mills enjoy a protected market for their products.

Small paper mills proved to be instrumental for developing the counties in different ways and are major units for supporting the local Government's funds. they could eliminate the shortage of paper in a very short period. That is the reason, why a number of small paper mills were established in the subsequent years also. For instance, in the year 1952, the total production of paper and boards in Shangdong province was only 10,800 tonnes per annum and by establishing more and more small paper mills, by the year 1987, the paper production in this province went up to 700,000 tonnes. Similarly, in Henan province, there was no paper production at all in the year 1957, but by setting up small paper mills in the counties, and even villages, the production of paper and board is at present over one million tonnes per

annum. These two examples show how powerful are the small plants in China for the development of the industry and country in general. From the year 1961 onwards, slightly bigger mills with a daily production capacity of 10 to 20 tonnes of paper were established and in some mills, Fourdrinier paper machines were also installed.

Problems and prospects of small paper mills in China:

Small paper mills, as one can visualise have many problems, some of which are listed below:-

1. Poor technology for producing paper with inefficient machinery and management.
2. Low efficiency of production and high consumption of raw materials.
3. Production of a few grades of paper only of poor quality.
4. High energy consumption.
5. High pollution due to absence of chemical recovery system and discharge of large quantity of liquid effluents, which is almost 1/10th of the total effluents of the whole country.

In order to get over these problems, lot of research and development work is going on in China to introduce low cost new equipment and process. Some of these developments are as follows:-

1. Development of Horizontal Belt Vacuum Washer for Non-Wood Fibres, which has an extraction efficiency of more than 95%.
2. Desilication of black liquor by using flue gases to precipitate the silica from black liquor at optimum pH of 10.3, before evaporation and the precipitated sludge is separated by a special centrifugal machine.
3. Development of an unique type of recovery furnace in which a moveable smelter handles high viscosity and low heating value black liquor.
4. Using Ammonium Sulphite as cooking chemical, which is made from the waste flue gases obtained in the fertiliser factory and sulphuric acid plants.
5. Using the waste liquor from the pulping unit, as organic fertilizers to irrigate the fields.
6. Building up large pulp mills to produce market pulp and supplying the same to small paper mills, whereby the small paper mills stop pulping operations and avoid installation of capital intensive equipment for chemical recovery and pollution control.

Production and planning for paper production in China:

According to the stastical publications², the total production of machine made paper and paper boards in China was only 90,900 tonnes in the year 1936 and 108,690 tonnes in the year 1949, when the People's Republic was

founded in China. In the subsequent years, the rate of growth in the production of paper was of the order of 8 to 10 % per year. The production figures of paper and paper boards during the last few years are shown in Table No. 1:

TABLE - 1

Year	Production Machine made paper ('000 Tonnes)	Growth Rate (%)
1936	90	—
1949	108	1.5
1950	141	30.0
1952	293	54.0
1955	573	32.1
1957	913	29.4
1960	1802	32.5
1965	1731	—
1970	2414	7.9
1975	3410	8.3
1980	5344	11.3
1981	5402	1.1
1982	5890	9.1
1983	6613	12.3
1984	7560	14.3
1985	9112	20.5
1986	9986	9.6
1987	10080	1.0

The production of pulp in China always lagged behind the demand for the production of paper and boards by about 10-15 %, leading to import of market pulp, mainly from Scandinavian countries and Canada.

During the year 1987, the total production of paper and boards including hand made paper was of the order of 11.41 million tonnes (6.62 million tonnes paper and 4.79 million tonnes of boards). The population in China is around one billion. Thus, the average consumption of paper and boards per capita was about 12 kg. But, the consumption in the urban areas is 30-40 kg with as high as 70 kgs in Beijing and in rural areas as low as 3 kgs. Thus, China is the 5th largest producer of paper and paper boards in the world,

next to the major producing countries like USA, Japan, Canada and USSR. But, due to the large population, the per capita consumption of paper is very low in China.

The targeted production of paper and boards in China by the year 2000 is expected to be of the order of 15.6 million tonnes, by which for an expected population of 1.2 billion by the year 2000, the per capita consumption of paper and paper boards would be 13 kgs. This targetted production is proposed to be achieved by the expansion and modernisation of the existing paper mills.

Apart from writing and printing paper, quite a good number of mills are producing speciality papers and paper products like, wall papers, decoration papers, absorbent papers, tissues, recording paper, computer papers, carbonless paper, food wrapper, milk and soft drink cartons, paper cups and different kinds of coated papers.

Fibrous Raw Materials

Another unique feature of the Chinese paper industry (apart from the existence of huge number of small paper mills) is that the paper industry is depending on non-wood fibres to a great extent. China is relatively poor in forest resources, and, therefore, a wide variety of non-wood fibres are used in the paper industry, though, wood is used to a very limited extent. The availability of different raw materials is as follows:--

1. Annual & Perennial Wild Plants and grass like Reeds, Beard Stems, Sesbania, Chinese Alpine Rush, Chinese Amur Silver Grass, Splendid Aschnatherum, Bamboo and Shell of Bamboo Shoots.
2. Agricultural residues like wheat straw, rice straw, sorghum stems, cotton stems, bagasse.
3. Bast fibres like Hemp, Sisal Hemp, Flax, Jute, Ramie, Bark of Cotton stems and Mulberry bark.
4. Rags & Waste Cotton.

Out of the total tonnage of pulp produced in China, not more than 25 to 27% is wood based and the balance being non-wood fibres. Of the non-wood fibrous raw materials, about 50% is straw, mostly wheat straw and 10% is reed. Large quantities of rice straw and wheat straw are available in each province of China, particularly in South China. A small quantity of straw is used as cattle feed, household fuel, fermented organic fertiliser. A major portion of the straw is used as raw material in the pulp and paper industry. Better utilisation of the cereal straw is the main problem in China. Utilisation of secondary fibres has been given proper attention during the recent years. The re-cycling rate is now close to 20%. In the recent years, substantial quantity of waste paper was imported from USA.

The percentage of various types of pulp produced in the Chinese paper mills during the year 1986 on the total production of pulp in China is shown in Table No. 2:-

TABLE - 2

Variety of Pulp	('000 Tonnes)	%age on total pulp
1. Chem Wood pulp	1020	11.4
2. Mech. pulp	400	4.5
3. Reed pulp	710	8.0
4. Bagasse pulp	260	2.9
5. Bamboo pulp	110	1.2
6. Cotton/Jute pulp	410	4.6
7. Straw pulp	3860	43.3
A. Total Machine made pulp	6790	76.0
B. Uncooked pulp	2130	24.0
	8920	100.0

Thus, China is the world's largest producer of non-wood pulp with about half of global production⁵ during the year 1986, as can be seen from Table No.3:-

TABLE - 3

Variety of pulp	World Production (in '000T.)	China's Prod. (in '000T.)	%age of China's prod. on world Prod.
1. Straw pulp	5000	3761	75
2. Reed pulp	1400	704	50
3. Bagasse pulp	2000	257	13
4. Bamboo pulp	1300	114	9
5. Rag/Jute pulp	1300	147	11
Total	11000	4983	45

In China, the exploitation of kenaf resources and study of the special equipment for kenaf pulping and paper making are as yet at the preliminary stages⁶. Though, China's kenaf resources are plentiful its availability is unsuitbale and not everlasting unless they have an appropriate price policy. For successful use of kenaf in the paper industry, the Chinese paper mills should have their own captive plantation of kenaf.

Present status of process & equipment in Chinese paper industry:

Most straw pulp lines are in integrated mills. A typical treatment process in China can be outlined as follows⁷. From the storage yards, wheat straw is taken by belt conveyer to a rotary cutter and the cut straw goes through a duster to remove dust and fines. The method of handling dust and fines usually consists of a cyclone, a battery of water jet cleaners and a dust chamber. Cleaned straw is conveyed to a mixing screw for uniform mixing with cooking liquor before the digesters. These are usually directly-heated rotating spherical units of 25-40 m. Continuous digesters are used in a few mills.

Digestion is by sulfate, soda-anthra-quinone or alkaline sulfite process, usually sodium or ammonium, and is carried out at a pressure of 0.7 MPa. At about 164 C, the total cooking cycle is around 4 hours and the pulp is blown to a 150 m³ tank. Blow vapor is condensed and used in the brown stock washer for which a new horizontal belt type vacuum filter is now commonly used instead of four-stage vacuum washers. Using counter current washing, the filter unit gives a high and uniform washing efficiency, with a water requirement under 10 m³/tonn of pulp.

Black liquor extraction as high as 95% has been claimed. Black liquor with an incoming concentration of about 10-12% TS is treated in steam-heated, four-effect rising film evaporators in a cascade arrangement to reach a discharge consistency of heavy black liquor in the range of 44-48%. It is further concentrated through a system of venturi and cyclone evaporators using hot flue gases from the recovery furnace. Because the heat value of black liquor from wheat straw pulp is lower than woodpulp, some losses of sodium cannot be restored by adding salt cake to the furnace. The conventional Tomlinson type of recovery boiler is mainly used. An electrostatic precipitator of extremely high voltage is usually connected to the recovery furnace to recover particulates.

Green liquor is then pumped to a slaker-classifier, where slaked lime is introduced to react with the sodium carbonate. Three of these units in series permit continuous causticization. Lime mud is washed on vacuum filters. The silica content of washed lime mud is too high to be sent to a lime kiln. There are three screening stages, comprising Johnson screens, followed by centrifugal screens and a three-stage Centricleaner system, after which pulp is thickened on deckers.

Bleaching is usually in four stages C-E-H-H. Apart from the chlorination stage, bleach towers are of the down-flow type. Washers in all stages are vacuum filtes. Bleached pulp is usually slightly defiberized by double disc refiners (inside diameter 450 mm) and cleaned by two-stage Centricleaners and a centrifugal screen. The average speed of paper machine (PM) is more than 100m/min., running on a furnish of 10-20% woodpulp. A few run at over 200 m/min. with a furnish of 50-60% wood pulp making printing and writing papers.

Consumption of water, power, and steam is higher for straw than for wood fibres. Water requirement is 200m³/ton of pulp and 90m³/ton of paper; while steam is 3.5 ton/ton of pulp and 4.2 ton/ton of paper. Power consumption is from 250-400 kWh/ton of pulp and 700 kWh/ton of paper.

To start with, from the year 1930 onwards, reeds are generally pulped by using Magnesium Sulphite as cooking liquor, but cooking time is long and the quality of paper produced is inferior with low yields. In order to improve this process, Sodium Monosulphite process was adopted in the year 1950 for reed pulping.

So far as the equipment is concerned, batch type of spherical rotary digesters are predominantly used in all Chinese paper mills. Similarly Jonsson Knotters and Cowan Screens are still in use. In small paper mills, most of the paper machines are of cylinder type. Single stage bleaching of the pulp is very common feature in many Chinese paper mills, at present. In order to achieve brightness of above 70 with single stage bleaching, mills have to adopt over cooking or over bleaching. There is no chemical recovery system in the majority of the paper mills working in China.

Modernisation of Chinese Paper Industry:

Existence of thousands of small paper mills in China and the inadequate availability of fibrous raw materials, particularly, long fibre materials have been hampering the modernisation programme in the Chinese paper mills, though, they are aware of the anticipated increase in demand for paper and the need for modernisation with a view to solve effluent problem.

Modernisation of the Chinese paper industry means upgrading the quality of paper produced, as well as increasing production. To achieve these objectives, the small paper mills are being encouraged to expand to at least 10,000 tonnes production per annum and installation of chemical recovery units etc. Rebuilding of the paper machines is given first priority in the Chinese paper industry, but eventually, pulping units also will have to be modernised.

In 1984, Jiamusi Paper Mill[®] in Heilongjiang Province (North East China) rebuilt its 5.5 meter wide Valmet fourdrinier paper machine through a contract with Mitsubishi-Beloit. The major element of the rebuild included a

Converflo headbox and a two-nip Nipco press, together with an extension of the wire section and improvements to the paper machine drives. A Measurex computer system was also added to the machine. The rebuild took the Chinese crew only 30 days.

Qingzhou Paper mill in Fukien Province (South Eastern China) is rebuilding its Voith fourdrinier machine, adding a Converflow headbox, a four-roll tri-nip press section and a Clupak installation. Modernisation of the wire section with foils and a cantilever beam wire-chaning system are also included. Another Measurex computer will be installed on this paper machine the contractor for the Qingzhou project is Beloit.

Both machines in Jiamusi and Qingzhou are expected to have their operating speeds increased from about 400 m/min. to 650 m/min.

It may be interesting to note that a third Measurex computer system has been installed on an old 2 m wide fourdrinier in Jilin Paper Mill (Jilin Province, North Eastern China) and has been working to the satisfaction of all concerned.

Contracts have been signed recently, again with Beloit for the reconstruction of two 4.5 m trim Wartsila fourdrinier paper machine at Liuzhou Paper Mill (Guangxi Province, south China) and Yueyang Paper Mill (Human Province), respectively. The major items involved here include Bel-Bond headboxes, foils to replace table rolls in the wire sections, tri-nip press sections, four-roll machine calenders and rewinders. The operating speeds of both machines are expected to increase to 550 m/min after rebuilding. AccuRay Computer systems will be used on both these machines.

Pollution Control Measures

The Chinese pulp and paper industry is currently consuming about one million tonnes⁹ of Caustic Soda per annum for cooking, out of which only 300,000 tonnes are being recovered. Out of all the pulp and paper factories working in China, only 47 mills are equipped with chemical recovery system. This means that large quantities of black liquor containing Caustic Soda and organic compounds are being let out into the sewage. Fortunately, these effluents are discharged by thousands of small paper mills spread all over the vast country like China and the heavy burden of environmental impact is, therefore, greatly attenuated by dint of natural self-purification.

Some of the small paper mills try to use Ammonium Sulphite as cooking chemical, instead of Caustic Soda so that, the waste liquor can be used as irrigation water. But the handicap in this matter of disposal of black liquor is that, that the paper factory works round the year producing liquor continuously, but the agricultural fields require irrigation water occasionally and as such, the liquor has to be stored for a long time, which is impracticable.

Since the year 1973, the Government of People's Republic of China imposed certain restrictions on the discharge of industrial waste. In the year 1985, new standards for the disposal of waste liquor from the pulp and paper mills were promulgated for tentative use. According to this, the small paper mills are required to collect, evaporate and incinerate the waste liquor to eliminate aqueous discharge.

The small paper mills in China feel that though these regulations are not very stringent, it is very expensive for them to instal pollution control equipment. Therefore, with a view to introduce simple and cheap chemical recovery system to suit the small paper mills, research is being conducted on several approaches to solve this problem. Firstly, the black liquor is collected at high concentration with a high pulp washing efficiency for which, simple, small and cheap washing equipment has been developed. A horizontal belt vacuum washer has been developed and extraction efficiency of black liquor can reach more than 95%. The washing efficiency of a small wheat straw pulp mill is now 80 to 90%, while the washing efficiency and chemical recovery efficiency of a 150 tonnes per day sulphate reed pulp mill are 90-95% and 80-85% respectively. Normally, the sulphite reed pulp mills, concentrate the waste liquor and make use of this concentrate as a binder for firebricks and zinc ore sintering. For desilication of black liquor, flue gas from the boilers is used to precipitate the silica at optimum pH of 10.3.

Research work is being conducted to evolve a most effective pollution abatement system with a view to increase chemical recovery and energy recovery and decrease, the waste water discharge from non-wood fibre pulp and paper mills. Systems like without caustization or direct caustization processes, wet combustion membrane process, transition oxide direct caustization are under laboratory test. Ways and means of reducing water consumption in the paper mills are being explored to reduce the quantity of waste water to be let out. Some policy measures are being adopted.

In the case of big paper mills with chemical recovery system; silica contamination, particularly when rice straw is used as fibrous raw material is the major problem. Foaming and fouling of evaporators are also common problems in the paper mills. To be economically feasible for non-wood pulping chemical recovery, the plant capacity of 10,000 to 15,000 tonnes per annum, seems to be a reasonable size in China. Generally, most of the big paper mills are equipped with primary treatment installation to reduce the suspended solids contents in the discharged effluents. Recently, some paper mills have installed aerated lagoons to treat the effluents. Delinking of waste paper has been practised in the traditional washing process and the effluents discharged directly into sewage.

Summary

People's Republic of China is unique in the paper industry, as this is an ancient industry and there are as many as 4200 paper plants, most of which are small paper plants with less than 5 tonnes of paper production per day. Apart from this, a major portion of paper produced in China is based on agricultural residues. The thousands of mini paper plants in China are working successfully due to the use of these agricultural residues, which are very cheap in China and the different types of papers produced by these small paper mills have a protected market in the counties (district) in which the paper mills are located. But, with the introduction of Pollution Control Regulations, these mini paper plants are facing lot of difficulties, as they cannot instal capital intensive equipment for chemical recovery and pollution control. Research and development work is being conducted in China with a view to develop low cost chemical recovery and pollution control equipment. Increasing the daily production of these mini paper plants and modernisation of these plants are receiving utmost attention at present in China.

References

1. China Daily — September 12, 1987.
2. Xiang Ju Zhong — Modernisation of the Chinese Paper Industry.
3. Ren Yue Chen — Non-wood fibre pulp in China — The environmental aspect — Japan Pulp & Paper, 1985.
4. Hy Shouzu — Small paper mills in People's Republic of China.
5. Hu Shouzu — Small paper mills in Peoples Republic of China.
6. Su You Cheng — The exploitation and utilisation of Kenaf whole stock-Proc. 1988 - International Congress on Non-Wood fibre pulping and paper making.
7. Xue Haifeng — More and better use of China's Straw-Pulp & Paper International - March 1988.
8. Xiang Ju Zhong — Modernisation of the Chinese Paper Industry.
9. Ren Yue Chen — Non-wood fibre pulping in China —The environmental aspect — UNEP Industry & Environment — jan to March, 1985.