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SEMINAR ON COMPARATIVE PULPING PROCESSES

INCLUDING THE MONOPULP PROCESS

Bangkok, 2 - 6 December 1985

US/RAS/84/238

Prepared by the  
Chemical Industries Branch  
Division of Industrial Operations

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SUMMARY

The discussions revealed that there is a need for such conferences where new ideas are presented and where under a neutral chairmanship, an objective discussion takes place on the pros and cons of such new technologies and their benefits for developing countries. UNIDO can play a vital role here in disseminating up-to-date information from engineering companies and research organizations.

It was realized that very often new processes are tested or are developed only for one or two raw-materials exclusively wood-based, and that such new processes, in order to be accepted by developing countries, do need to be further developed, incorporating the raw materials mostly available in developing countries, i.e. non-woody fibres.

For the low-cost integrated paper mill process, there was only theoretical interest, because the work was based on eucalyptus plantation wood only, and in many Asian countries, such wood is not available or not favoured. The proposal to make an energy-autark mill was supported by the participants but the idea to use wood/wood-waste as fuel to produce steam and generate back-pressure power in countries where deforestation is already a major problem, did not find any sympathy. The high electrical power consumption per ton and the peroxide bleaching recommended were criticized. There is an urgent need to have non-woody materials tested and the peroxide bleaching should be replaced by the orthodox bleaching methods like two-stage sodium hypo-chlorite in order to really evaluate the possibility of these high-yield pulping processes for starting small pulp/paper mills in developing countries.

The participants, very much impressed by the Government of Sweden's willingness of financing such studies, asked whether such non-woody studies could again be financed by donors, e.g. Sweden.

There was also great interest to avoid the classical pulping chemicals sodium or sulphur-based and to learn whether oxygen, if possible, produced indigenously in a pulp mill, could do an excellent pulping/bleaching job in small pulp mills using non-woody materials.

More research should be done in this field.

The recovery of chemicals, often not done in small mills, is of greatest importance to reduce production costs and to avoid pollution of rivers.

There is an urgent need for a low-cost, easy-to-operate process. The discussions showed that the DARS process has some potential but it was also called a knife-edge process which means that the process is very difficult to control under practical conditions. First experiences of a full-scale production unit in Australia have to be awaited and evaluated.

The wet-cleaning of fibrous non-woody materials before pulping, although high in energy-consumption, brings many advantages, like:

- removal of sand, of salts (from salty soils or plant intake of fertilizers) silica;
- more uniform and faster penetration of cooking liquors, thereby equalizing the moisture variations in the raw-materials, thereby guaranteeing more uniform pulp.

More appropriate pulping machinery for cooking and washing are recommended for future mills.

The use of non-sulphur pulping chemicals should be favoured.

The principle of selective pulping for non-woody materials, as now been described and practically carried out in the NACO process for straws, needs more research comprising other non-woody fibres like bamboo, bagasse, cotton stalks etc.

UNIDO is very thankful for the foresight of SIDA to allow UNIDO to organize such specialized small technical seminars with experienced mill personnel in Asia, thereby bringing forward the consolidated know-how and the science of pulping and paper-making of non-woody materials.

Many questions have been raised which demand further research and developing work of the international community.

The special conditions existing in Asia must be remembered and considered in future research & development programmes.

There is a great future in pulp/paper making in developing countries of Asia, because, as the latest FAO statistics show, the expansion of the pulp/paper industry in many of these developing countries will be double to triple the expansion rate, now existing in many developed countries.

In general, it was felt that good new ideas have come to the attention of the participants from developing countries but the basis for the research work was always very small and only of interest to developed countries, (e.g.: eucalyptus plantations which often do not exist or are not favoured in developing countries).

Therefore, a plea goes again to researchers and developers in developed countries, whenever they bring out new processes or new machinery, they should also incorporate in their testing non-woody materials (e.g. straws, reeds, bagasse, bamboo, kenaf, jute, cotton-stalks...) which still, in most developing countries, are the fibre basis for the pulp mills.

OBJECTIVES

The objectives of this Technical Seminar were:

- 1) To come to a better understanding of the various pulping processes suitable for small-scale pulp/paper mills in developing countries;
- 2) To have a better guidance for future technical research and development work appropriate for developing countries;
- 3) To establish a closer link and co-operation between developers and researchers and users of such new pulping processes, e.g. the NACO process in pulp/paper making.

The participants were very thankful (See Annex 1) for this Technical Seminar and the speakers also were very pleased to have much time for discussing their work with the participants, who often, very critically, demanded more information or further research work (See resolutions).

UNIDO benefitted greatly during this Seminar by obtaining a lot of first-hand information from the mills in Asia. A number of new project proposals for further down-to-earth research and development work for the mills or in the countries were the result of the Technical Seminar.

RECOMMENDATIONS

- 1) a. Need new ideas on how to produce low-cost pulps and improve the operating efficiency of existing mills.  
b. Need new ideas for the development of low-cost pulping processes that could be applied for non-wood fibre mills.
- 2) Development work is needed on the application of the DARS and/or similar recovery systems for non-woody materials.
- 3) Development work is needed on the possible application of the NACO pulping system, replacing certain equipment components of non-wood pulp mills.
- 4) Further continuation work is recommended on the desilication and removal of silica in processing non-wood fibre based black liquors. This is based on the progress so far made with the kraft process and the need to extend this work for soda and neutral sulphite process.
- 5) Development work is needed for the processing of black liquor from neutral sulphite chemical process of non-wood fibre mills.
- 6) Development work is needed to recover chemicals from semi-chemical pulping of non-wood fibres.
- 7) Development work is needed on the application of membrane filtration techniques for the recovery of chemicals from black liquor, which are not responsive to traditional treatment methods.
- 8) Development work is needed on the application of oxygen for delignification and ozone bleaching for non-wood fibres.



- 9) Development work is needed on improving the efficiency on brown stock and bleach washers. One possible consideration is the use of horizontal washers.
- 10) Development work is needed on the revival of the old lime process for the manufacture of corrugating medium and paper boards from non-wood fibrous materials.
- 11) Development work is needed for the efficient collection, handling and baling of straw from the farm to the mills (Example: handling of short-stem wheat straw after thrashing as in the case of Pakistan).
- 12) Development work is needed on the application of fibre fractionation methods to separate the long bast fibre from the short woody portion of certain annual plants such as kenaf, hemp and sun-hemp.
- 13) Development work is needed to investigate whether non-wood fibres react positively under the application of the OFCO Process.
- 14) Development work is needed on the application of CMP, CTMP Process for non-wood fibres using relatively low energy inputs for fiberization.
- 15) Due to the non-uniformity of annual plants it is recommended the principle of applying selective pulping needs for further study.

PREPARATION OF THE CONFERENCE

1) PROJECT HISTORY

The project idea was discussed by SIDA and UNIDO in Vienna in October 1982. The draft project proposal was submitted in July 1983. Activities were finalized in Stockholm in May 1984. The project document was signed on 13 July 1984. Small changes were agreed upon on 21 November 1984. PAD was issued on 19 March 1985.

2) UNIDO'S ACTIVITIES

April/May 1985 - The consultant, Mr. P. Bleier, was hired part-time, to assist Headquarters in preparing the technical programme and contacting potential speakers.

17 July 1985 - Letters were sent out, inviting the following consulting firms to contribute technical papers to the seminar:

- BABCOCK & WILCOX Co, U.S.A.
- SUNDS Defibrator AB, Sweden
- Kraftanlagen Heidelberg, F.R.G.
- Swedish Forest Products Research Laboratory, Sweden
- ZIMPRO, U.S.A.
- EKONO, Finland
- BETZ, U.S.A.
- NALCO, U.S.A.
- SENER, Spain
- CELPAP Int., Sweden

- FAO Rome was also informed about the Seminar and invited to participate.

- 17 July 1985 - The following consultants/speakers were also invited by letter to provide contributions:
- Mr. Basu, Chemical Engineering Dpmt., India
  - Mr. Bleier, Desilication Expert, Austria
  - Mr. Pant, Central Pulp/Paper Research Institute, India
  - Mr. Keswani, Chemprojects Design & Eng. Ltd., India
  - Mr. Jeyasingam, UNIDO Expert, U.S.A.
- End July 1985 - Mr. Judt, backstopping officer of the project, IO/CHEM, undertook mission to Bangkok to investigate hotel/conference facilities, discuss technical programme and initiate visit of seminar participants to Phoenix Mill in Khon Kaen. On 31 July 1985 he attended a meeting with Ms. Naiyana Niyomwan, Head, Fibre Research Laboratory within TISTR (Thailand Institute of Scientific and Technological Research) to clarify above points.
- 28 August 1985 - Letter was sent to Phoenix Pulp Mill with request to assist in arranging mill visit for seminar participants.
- 2 September 1985 - First informative telex on Seminar was sent to the following countries:
- Bangladesh
  - India
  - Indonesia
  - Iran
  - Pakistan
  - Philippines
  - Sri Lanka
  - Thailand
  - Turkey
  - Vietnam

- 1 October 1985 - Official Invitation Letter and Aide-Memoire were sent to countries mentioned above.
- 4 November 1985 -- Invitation received from Mr. Davidson, Mill Manager of Phoenix Pulp Mill, for mill visit planned for Thursday, 5 December 1985.
- 5 November 1985 - Expert, Mr. Jeyasingam (Expert in Critical Analysis of Straw Pulping Methods World-wide) was recruited.
- 13 November 1985 - Additional speakers, Messrs. Vihari and Kauppi were nominated by Mr. Kyrklund, FAO, Rome.
- 13 November 1985 - Technical Programme and Aide-Memoire were sent to the following consulting firms and speakers:
- SUNDS Defibrator AB
  - Kraftanlagen Heidelberg
  - BABCOCK & WILCOX
  - Mr. Vihari
  - Mr. Kauppi
  - Mr. Jeyasingam
  - Mr. Bleier
- By 27 November 1985 - Nominations of 15 candidates from 8 developing countries were received, namely from:
- Bangladesh (2 participants)
  - India (3 participants)
  - Indonesia (2 participants)
  - Pakistan (2 participants)\*
  - Philippines (1 participant)
  - Turkey (1 participant)
  - Vietnam (1 participant)
  - Thailand (organizing country - 2 participants submitted)

\* Please note that an additional participant from Pakistan was present at the meeting due to the fact that he had attended another UNIDO Workshop on Wastepaper Utilization in Bangkok, the week before, and expressed interest to extend his stay.

All nominated candidates were accepted by UNIDO.

Iran and Sri Lanka did not send representatives.

3) CONFERENCE

The following background papers were supplied by UNIDO to the participants and were used during the technical seminar:

- Alternative Pulping Processes - by M. Judt
- Research Problems in developing countries using non-woody fibres as seen by UNIDO - by M. Judt
- Low-cost Integrated Paper Mill - A Swedish Concept for Developing Countries - Kenneth Sjörgren, SUNDS
- Appropriate Industrial Technology for Paper Products and Small Paper Mills (ID/232/3)
- Small Scale Paper Making - ILO

LIST OF PARTICIPANTS

1. Mr. Syed Amjad Ali  
Production Manager  
Century Paper and Board Mills Ltd.  
7 - Aurangzeb Block  
New Garden Town  
Lahore  
PAKISTAN (Tel: 852-653)
  
2. Ms. Nursjamsu Bahar  
Researcher for Pulp Division  
Institute for Research & Development of Cellulose Industries  
Jl, Raya Dayeuh Kolot 158,  
Bandung  
INDONESIA (Tel: 50623/39812)
  
3. Mr. Subhash Chandra Bajaj  
Assistant Development Officer  
D.G.T.D. Ministry of Industry  
Government of India  
INDIA (Tel: 301-0291 Ext. 378)
  
4. Mr. Kemal Cankaya  
Assistant Mill Manager  
SEKA Akdeniz Mill  
SEKA Akdeniz Müess  
Silifke/Igel  
TURKEY (Tel: 7591-1555)
  
5. Mr. Preecha Cherdkiatikul  
Production Engineer  
Thai Union Paper Mill  
131 Poochaosamingprai Rd.  
Samrongtai, Phrapradaeng  
Samuthprakarn 10130  
THAILAND (Tel: 3940622-4)

6. Mr. Alan R. Dimzon  
Technical Superintendent  
United Pulp and Paper Co. Ltd.  
Fifth Floor Phinma Bldg.  
166 Salcedo Street, Legaspi Village  
Makati, Metro-Manila  
PHILIPPINES (Tel: 874-061)
  
7. Mr. Anwarul Haque  
Deputy Chief Operation Manager  
Khulna Newsprint Hills Ltd., BCIC  
Town Khalishpur, Khulna  
BANGLADESH (Tel: - )
  
8. Mr. Suraporn Homchean  
Manager-Bleaching Section  
Siam Pulp and Paper Co., Ltd.  
19, Sang-Xuto Road,  
Ban Pong, Rajburi (Tel: 211388-90)  
THAILAND
  
9. Mr. Vo Quoc Lam  
Process and Development Vice Manager  
Union of Paper No. 1  
Hanoi  
VIETNAM (Tel: 57702)
  
10. Mr. Saiful Malook  
Plant Superintendent  
Century Paper and Board Mills, Ltd.  
19/23 Canal Park  
Lahore  
PAKISTAN (Tel: 870-554)
  
11. Mr. P.V. Mehta  
Development Officer  
D.G.T.D. Ministry of Industry  
Government of India  
INDIA (Tel: - )

12. Ms. Naiyana Niyomwan  
Head of Fibre and Textile Chemical Lab.  
TISTR  
196 Phaholyothin Road  
Bangkhen  
Bangkok 10900  
THAILAND (Tel: 579-8591)
  
13. Mr. Wisit Pitivattanakul  
Scientist  
SIAM Kraft Paper Co., Ltd.  
19 Sang-Xuto Road  
Ban Pong  
Rajburi  
THAILAND (Tel: 211388-90)
  
14. Mr. Perapat Pongvorawat  
Chemical Recovery Section Manager  
Siam Pulp and Paper Co., Ltd.  
19 Sang-Xuto Road  
Ban Pong  
Rajburi  
THAILAND (Tel: 211388-90)
  
15. Ms. Wieke Pratiwi  
Researcher of Pulp Division  
Institute for Research & Development of Cellulose Industries  
Jl. Raya Dayeuh Kolot 158  
P.O. Box 194  
Bandung  
INDONESIA (Tel: 50623/59812)
  
16. Mr. Sirisak Suebsiri  
Technical Advisor and Project Manager  
Thai Scott Paper Co.  
293 Silom Rd. 9th Floor  
Bangkok  
THAILAND (Tel: 3940983 - Factory  
2331093 - H.Q.)



LIST OF SPEAKERS

1. Mr. P. F. Bleier  
Consultant  
UNIDO  
Rathaus Strasse 13/25  
A-1010 Vienna  
AUSTRIA (Tel: 421-0282)
  
2. Mr. G.H. Covey  
Manager DARS Technology  
APM Ltd.  
P.O. Box 1643 N  
Melbourne  
Victoria, 3001  
AUSTRALIA (Tel: 490-3359)
  
3. Mr. T. Franzén  
Process Manager  
SUNDS Defibrator AB  
Sundsvall  
Sweden (Tel: 060-165000)
  
4. Mr. T. Jeyasingam  
UNIDO Expert  
P.O. Box 425  
Longview  
Washington, 98632  
U.S.A. (Tel: 206-425-6858)
  
5. Mr. M. Judt  
UNIDO Senior Ind. Dev. Officer  
P.O. Box 300  
A-1400  
Vienna  
AUSTRIA (Tel: 2631-3942)

6. Mr. P.K. Kauppi  
Engineer  
Fledic Engineering Ltd.  
430-1155 West Georgia Street  
Vancouver, B.C.  
CANADA (Tel: 604-688-3025)
  
7. Mr. B. Kyrklund  
Chief, Pulp & Paper Branch  
Food and Agriculture Organization (FAO)  
Via delle Terme di Caracalla  
Rome  
ITALY (Tel: 579-74132)
  
8. Mr. Brian Orgill  
Regional Director  
SUNDS Defibrator AB  
21 Collyer Quay, # 18-02, A  
Hong Kong Bank Building  
Singapore 0104  
SINGAPORE (Tel: 225-0182)
  
9. Mr. P. Vihmari  
Sales Manager  
15 Shamrock PDE., Killarney Hts.  
2087 NSW  
AUSTRALIA (Tel: 451-0065)

TECHNICAL AGENDA

Monday, 2 December 1985

Chairmanship: UNIDO

- 08.30 - 09.30 Registration
- 09.30 - 10.00 Opening Ceremony by H.E. Deputy Prime Minister  
Bhichai Rattakul  
Welcoming Address from TISTR, FAO, UNIDO
- 10.00 - 10.30 Coffee Break
- 10.30 - 12.00 Alternative Pulping Processes by Messrs. Bleier/Judt,  
UNIDO  
and  
Discussions
- 12.00 - 14.00 Lunch Break
- 14.00 - 17.00 Survey of Straw Pulping Methods by Mr. Jeyasingam,  
UNIDO  
Discussions

Tuesday, 3 December 1985

Chairmanship: FAO

- 09.00 - 10.30 Small Scale Pulping  
FAO's Activities in Small Scale Pulping, by  
Mr. B. Kyrklund, FAO  
NSCMP - High Yield Pulping Process for Small Pulp  
Mill by Mr. P. Kauppi
- 10.30 - 11.00 Coffee Break
- 11.00 - 12.00 Different Application of OPCO Pulping Process by  
Mr. P. Vihmari
- 12.00 - 14.00 Lunch Break
- 14.00 - 15.30 Low-cost Integrated Paper Mill - A Swedish Concept  
for Developing Countries (Monopulp Process)  
Recent Developments in Chemical Pulping and Bleaching  
by Mr. B. Orgill and L. Vasman  
Non-woody Materials Pulping  
Discussion
- 15.30 - 16.00 Coffee Break
- 16.00 - 17.00 Research Work on Kenaf Oxygen Pulping, By Ms. N. Niyomwan, TISTR  
Discussion

Wednesday, 4 December 1985

Chairmanship: UNIDO

09.00 - 12.00 Country Paper TURKEY

Country Paper PHILIPPINES

NACO Process by SUNDS, Sweden:

"The NACO Process - A Selective Pulping Process for Annual Fibre Raw Material" by Mr. T. Franzén, SUNDS Defibrator AB

Discussion on NACO Process

12.00 - 14.00 Lunch Break

14.00 - 15.30 Country Paper BANGLADESH

DARS Process by BABCOCK & WILCOX

Fluidized Bed Recovery and Causticizing for Soda Black Liquor by Mr. Matthys and C. Covey, BABCOCK & WILCOX Co.

15.30 - 16.00 Coffee Break

16.00 - 17.00 DARS Process by BABCOCK & WILCOX contd.

Country Paper INDONESIA

Country Paper INDIA

Discussions

Thursday, 5 December 1985

Visit to the Phoenix Pulp Mill in Khon Khaen

Friday, 6 December 1985

Chairmanship: UNIDO

09.00 - 10.30 Country Paper PAKISTAN

Country Paper VIET NAM

Country Paper THAILAND

Desilication of Bamboo Black Liquor, by Mr. P. Bleier, UNIDO Expert, Report on UNIDO/SIDA project in India (US/IND/79/206)

10.30 - 11.00 Coffee Break

11.00 - 12.00 Summary of Conference

Final discussions, recommendations by participants

12.00 - 13.00 Lunch Break

13.00 - 17.00 Visit to the Thailand Institute for Scientific and Technological Research (TISTR) main laboratories and pilot plants: oxygen pulping, handmaking of paper, pyrolysis of rice husks, briquetting of rice husks, alcohol from cassava.

OPENING ADDRESS

to

THE SEMINAR ON COMPARATIVE PULPING PROCESSES  
INCLUDING THE MONOPULP PROCESS

by

H.E. DEPUTY PRIME MINISTER BHICHAJ RATTAKUL

on

MONDAY, DECEMBER 2, 1985

Mr. Minister, Representatives of the United Nations Industrial Development Organization, the Swedish International Development Authority, the Food and Agriculture Organization of the United Nations, Governor of the Thailand Institute of Scientific and Technological Research, Participants, and Distinguished Guests.

I am greatly honoured to inaugurate today this Seminar on Comparative Pulping Processes including the Monopulp Process hosted by the Royal Thai Government with the cooperative efforts of the Thailand Institute of Scientific and Technological Research (TISTR), the United Nations Industrial Development Organization (UNIDO), the Swedish International Development Authority (SIDA) and the Food and Agriculture Organization of the United Nations.

This is the second time that I have officiated at the opening ceremony of a seminar on paper and pulp industry. The preceding one, addressing the subject of utilization of waste paper in pulp and paper making, was held just this past week in this very place.

Though I am but a mere politician and therefore have but a limited layman's knowledge of this particular subject, I wholeheartedly support this cooperative activity as it furthers the frontiers of applied science and technology to serve mankind. The Government of Thailand keenly recognizes the vital importance of science and technology in the economic and social development of this nation and has accorded them a prominent role in our national development plan.

I would like to recognize at this point the late Minister of Science, Technology and Energy, H.E. Damrong Lathapipat, who successfully encouraged the organization of the First National Science Assembly on Economic and Social Development through Science and Technology in March 1984. This meeting was purposely to mobilize force of ideas and considerations for application of science and technology for the national development in industry, agriculture, energy, environment and resource management, including national defence. The resolutions adopted by this Assembly have received full support from the present Minister of Science, Technology and Energy H.E. Lek Nana and myself.

It is believed that the rate of paper consumption of a country can serve as an indicator of the degree of progress of that nation. The more advance is the economic and social development the greater is its paper consumption rate. For Thailand the demand for paper has been increasing yearly while the local pulp production is not enough to feed paper mills, the country therefore has to import pulp valued at over 1,000 million baht each year. The Royal Thai Government therefore recognizes the importance of the pulp and paper industry. UNIDO, I understand, has placed the pulp and paper industry in the first order of priority for industrial development.

In Thailand, raw materials applicable to the pulp industry are in abundance; both trees which provide long fibre such as the tropical pine and fast growing trees which provide short fibre. The Giant Ipil Ipil, the Casuarina, the Eucalyptus and the Acacia mangium are some examples. Bamboo and non-wood produces, for example, kenaf, bagasse, rice straw and Burma grass may also serve as raw material. Thus the prospect of increasing pulp production from these mentioned raw materials for self-reliance in industry is bright.

I am therefore very pleased that UNIDO has earmarked the pulp and paper industry for special development and promotion and has actively organized various technological workshops on pulp processes in several developing countries. Now the same contribution is extended to the Royal Thai Government to organize the seminar on Comparative Pulping Processes Including Monopulp Process, through the courtesy

of the Thailand Institute of Scientific and Technological Research. This seminar will address the subject of exchange and transfer of technology in relation to pulp processes including chemical recovery systems for small-scale pulp industry.

On behalf of the Royal Thai Government, I would like to express my deep appreciation to UNIDO for supporting and promoting this seminar and to SIDA for its financial contributions and assistance.

Now at this auspicious moment, I hereby declare open the technical Seminar on Comparative Pulping Processes including the Monopulp Process, and wish it every success.

WELCOMING ADDRESS

to

THE SEMINAR ON COMPARATIVE PULPING PROCESSES  
INCLUDING THE MONOPULP PROCESS

by

PROFESSOR DR. SMITH KAMPPOOL

GOVERNOR, THAILAND INSTITUTE OF SCIENTIFIC AND TECHNOLOGICAL RESEARCH

on

DECEMBER 2, 1985

Your Excellency, Distinguished Participants, Ladies and Gentlemen,

On behalf of the Thailand Institute of Scientific and Technological Research and the Organizing Committee, I have great pleasure in welcoming you all to the Seminar on Comparative Pulping Processes including the Monopulp Process being held in Bangkok for five days from December 2 to 6. This Seminar is the second meeting on paper industry organized in succession to the Technical Workshop on Waste Paper Utilization in Pulp and Paper Making, just completed here on November 29, 1985.

It is well aware that in the paper industry a problem now facing our country is the shortage of pulp production, though the matter of waste paper recycling has been taken into account.

Since natural resources and agricultural products are bound in abundance in our country, these are considered sufficient to serve as raw materials for pulp industry. Thus, the opportunity to develop this industry is regarded high.

During the course of this seminar, all the participants, I am sure, will have a great chance to exchange the know-how and experience in pulping process of small-scale paper mills as well as in non-wood pulping. In my opinion, developing countries should pay special interest to this technology including the so-called clean technology, about which every nation ought to keep abreast for the sake of world environment preservation.



As for the results of the seminar, I earnestly hope to see strengthening cooperation among the developing countries in improving skill and expertise of personnel of paper and pulp mills. The participants will also be provided with relevant information and papers on case study of each pulp and paper mill, which could be technologically applied to your respective plants.

Besides, I am confident that the seminar participants, specially those who come from abroad, will have a happy time and opportunity to visit many Thai attractive spots and explore our arts, culture and custom, different from what you have seen before, and of which we are very proud.

Our deep appreciations are hereby expressed to UNIDO, SIDA and FAO for their kind support and contributions to this valuable seminar. And in the name of the Thai Government and the Thailand Institute of Scientific and Technological Research, I wish to wind up by pledging our ready cooperation in hosting other technical meetings or workshops to be organized by international agencies in the future.

REPORT  
to  
H.E. DEPUTY PRIME MINISTER BHICHAJ RATTAKUL  
by  
MRS. UBOLSRI CHEOSAKUL  
SPECIALIST, THAILAND INSTITUTE OF SCIENTIFIC AND TECHNOLOGICAL RESEARCH  
at  
THE OPENING CEREMONY  
of  
THE SEMINAR ON COMPARATIVE PULPING PROCESSES  
INCLUDING THE MONOPULP PROCESS  
on  
DECEMBER 2, 1985

Your Excellency,

On behalf of the Thailand Institute of Scientific and Technological Research, I wish to express to Your Excellency my deep gratitude for sparing your time to preside over the Seminar on Comparative Pulping Processes Including the Monopulp Process today. Also my sincere thanks are extended to the representatives of the United Nations Industrial Development Organization (UNIDO), the Swedish International Development Authority (SIDA), the Food and Agriculture Organization of the United Nations (FAO), and all the distinguished guests for honouring this function with your presence here.

For Your Excellency's information on the background and objective in holding this seminar, please permit me to present to you the following report.

At the Third General Conference of UNIDO held in New Delhi, India, in January 1980, it was recommended that UNIDO institute a system of continuing consultations between developed and developing countries and among developing countries themselves.

The objective of these consultations is to help the developing countries to achieve their industrial goals established in 1975 by the Lima Declaration and Plan of Action, in particular, the target of attaining at least 25 % of the world's total industrial output by the year 2000 A.D. In pursuing its mandate to render technical assistance, UNIDO has made plan for various technical workshops to upgrade the qualifications of engineers in many industrial sectors, of which the pulp and paper making is allocated high priority.

Apart from these reasons, this technical seminar is held as a continuation of the Working Group Meeting on Technical Cooperation in Four Specialized Fields in Pulp and Paper Making jointly organized by UNIDO and the Pulp and Paper Manufacturers Association of the Philippines, in Manila, the Philippines, in November 1980. Attended by 120 delegates from various agencies and organizations both within the Philippines and from abroad, the meeting passed a resolution that one of the Asian countries host a seminar on Comparative Pulping Processes including the Monopulp Process. The objective of the said seminar is to exchange knowledge and technology of various pulping processes, such as mechanical, chemi-mechanical, and chemical pulping including chemical recovery processes for small-scale pulp mills in developing countries, so that non-wood fibrous materials can be used with more efficiency in pulp and paper making. It is a great honour for Thailand to be entrusted with the function of hosting this seminar. In implementing this obligation the Government of Thailand assigned the Thailand Institute of Scientific and Technological Research to act as executing agency in collaboration with UNIDO for the organization of this seminar.

This technical workshop is held for the purpose of raising the potential capability of personnel selected from the technical staff, numbering about 24, particularly production engineering supervisors of pulp and paper companies from 10 developing countries. These participants are expected to learn more of the know-how or to be enriched with experience in pulp and paper making from non-wood fibrous materials. Also they will be provided with technical papers, check lists, mill case stories, etc. from which they can learn how to apply the know-how in their respective plants.

To attend this seminar, each of the 10 participating countries were invited to send up to 3 representatives, most of whom are engineering supervisors with no less than 5 years experience in pulp and paper making. These representatives will present to the meeting their technical papers on pulp and paper making of their respective mills including unorthodox pulping methods and chemical recovery systems which might have already been invented for their own applications.

Also being aware of the vitality of the pulp and paper industry, the Swedish International Development Authority (SIDA) has kindly rendered financial contribution in cooperation with UNIDO for the organization of this seminar so as to accomplish the objective as planned.

It is anticipated that all the participants will gain from this seminar not only knowledge but also valuable cooperation, both from the developed and developing countries, in the technology of comparative pulping processes and monopulp process.

At this propitious moment, may I ask Your Excellency to deliver your address opening the Seminar on Comparative Pulping Processes Including the Monopulp Process, for its grace and honour.

WELCOMING ADDRESS  
to  
THE SEMINAR ON COMPARATIVE PULPING PROCESSES  
INCLUDING THE MONOPULP PROCESS  
by  
MR. MANFRED JUDT  
SENIOR INDUSTRIAL DEVELOPMENT OFFICER, UNIDO  
on  
DECEMBER 2, 1985

Your Excellency, Ladies and Gentlemen,

It is a great privilege for me to welcome you on behalf of UNIDO to this International Seminar on Comparative Pulping Processes including the Monopulp Process here in Bangkok.

You may know that my organization, the United Nations Industrial Development Organization, is expected to play a principal role in, and be responsible for reviewing and promoting the co-ordination of all activities of the United Nations system in the field of industrial development. In fulfilling this task UNIDO activities are of two fundamental types - operational and supporting. Whereas the operational activities normally are carried out in the field by experts engaged in the industry, the supporting activities are also in organizing technical meetings with the purpose of examining the present state of knowledge in pulp and paper technologies and then promoting and transferring technical know-how in and among developing countries. This pulp and paper meeting is therefore part of UNIDO's supporting activities in this field.

Reviewing the development - on an international scale - of pulping over, say, the last decade, one finds, that the pulp industry has continued on its path of "economy of scale" i.e. towards an ever-increasing size of single industrial units. Without radically departing from established technology, the successful search for more efficient and more reliable processes and installations, has brought forth advances towards higher specialization and sophistication.

World-wide there is a trend to make pulping processes simpler, lower in energy-consumption, to make pulps with higher yields and use more and more low-cost wood waste materials and in developing countries, specially here in Asia, agricultural waste materials in pulp and paper making. Of course, as discussed a week earlier, in an international workshop, the recycling of waste paper into the paper furnishes is increasing and has become for many countries of utmost importance.

The Swedish Government and UNIDO/FAO agreed and SIDA was kind to finance this Technical Workshop that a critical review of the present art of pulping, especially high yield pulping methods and chemical recovery systems used would be worthwhile to be discussed together with pulp makers of 10 Asian countries.

It is hoped that during this conference the developing countries may benefit after adaption from a quicker transfer of some of the existing pulping and chemical recovery know-how and thereby be supported in their endeavours to increase and strengthen their pulp and paper making facilities at, if possible, lower production costs.

It is hoped that during this conference a number of recommendations will be made on how by joint efforts also with the help of the UN-organizations new initiatives in pulping research, in raw material development, in desilication, in small-scale pulping and chemical recovery, to name a few possibilities, might be started.

UNIDO is very grateful to the Government of Thailand who volunteered to host this conference here in Bangkok and I am very thankful for the excellent work done by the Thailand Institute of Scientific and Technological Research, especially to the team under Mrs. Naiyana Niyomwan, in preparing and organizing this workshop.

The discussions, participation, and your resolutions on which action you might expect in the future, to be made during this meeting, will be the most important contributions, specially from the representatives from the 10 developing countries.

I am sure that this meeting will reach satisfactory conclusions regarding the best ways and means of promoting industrial development in the pulp and paper sector in developing countries, especially here in Asia. I trust you will give us your opinion as to the most effective way in which UNIDO could implement these conclusions. We value your advice and we shall do our best to carry out your suggestions and thereby benefit the developing countries.

I would like to thank the Thailand Institute of Scientific and Technological Research for hosting this meeting in this country. Without your organization, this meeting would not have been possible. A special thank you goes to all the speakers who will present papers which will guide us during this meeting.

In conclusion, I would like to thank you all for accepting our invitation to this meeting. I wish you every success in your deliberations.

## ALTERNATIVE PULPING PROCESSES

by

P. Bleier and M. Judt

Reviewing the development - on an international scale - of pulping over, say, the last decade, one finds that the pulp industry has continued on its path of "economy of scale", i.e. towards an ever increasing size of single industrial units.

Without radically departing from established technology, the successful search for more efficient and more reliable processes and installations has brought forth advances towards higher specialization and sophistication.

The second industrial revolution of computer control and regulation of all industrial activities has completely reshaped paper-making and somewhat slower also pulping; new methods to measure process parameter permit electronic engineers to design systems for controlling the complex chemical events in fibre production and in chemical recovery.

Today's giant pulping units require enormous financial efforts and a highly developed infrastructure of material resources, of transportation, of labour qualification and of marketing. Such demands, however, cannot be met by non-industrialized countries, eager to develop their resources to cater for the need of their growing population. They require adequate, but certainly smaller and simpler pulp and paper-making units, in accordance with modest infra-structure and markets and with the completely different local material and labour resources.

Experience has shown that western R&D concentrating on optimization or large scale pulping is only of limited help for problem solving for developing countries' pulping.



Here approaches are demanded that may appear to the western eye to be "unconventional", more likely to be attended to by "outsiders", either by qualified but unbiased academics or by people from the mill floor, conversant with everyday pulp and papermaking reality.

Unfortunately, little assistance to developing countries is forthcoming from the highly competent teams of cellulose chemistry, electronic engineers, chemists, biologists and others assembled by the potent suppliers to the western pulping industry.

All the same, it is important to carefully scrutinize all pulping development becoming public for their possible significance and application in developing countries.

With this perspective in view the pulp and papermaking unit in UNIDO, Vienna, has attempted to collect relevant publications over a period of years. A list of pertinent literature is available to participants of this Seminar.

Allow us now to make a few remarks of a more general nature on some of the points under discussion in this seminar:

#### FIBRE SOURCES

About 95 % of the world pulp production still is wood-based. The largest portion of fibres still is derived from conifers with their comparatively long fibres, ease of penetration and ease of defibration. The utilization of deciduous wood has made great strides, particularly from plantations of non-indigenous eucalypts, gmelina etc. in tropical rainbelt locations. Indigenous hardwoods are mostly harder and harder to pulp, also because of being mixtures of species with variable properties.

With available forest area diminishing due to population pressure in developing countries (the bulk of wood still serves as firewood, mainly for cooking), future fibres supply will increasingly have to rely on annually renewable non-woody sources,

i.e. on agricultural residues. Fertile soils are increasingly in demand for food production, leaving little room for industrial crops. Instead of taking up the challenges posed in pulping this special type of material, to them of "insignificant importance" at present, the industrial world has chosen to discontinue its utilization. Non-wood pulping has become almost exclusively a concern of the developing world. This seminar should supply evidence of much of the work done so far in this field in non-industrial tropical countries.

The open structure of straws and other annuals is advantageous for speedy penetration by cooking chemicals, but - unless vapour phase pulping can be practiced - it requires large amounts of liquor, rendering recovery uneconomic due to high dilution. Other troublesome features needing special attention are low paper strength, problems of storage, of handling and of grit and of chemical recovery because of difficult brown stock washing, of silica and of low black liquor heat content.

#### ENERGY

The defibering of plant tissue is energy consuming. In mechanical pulping most energy required is converted into heat, with only a minor fraction utilized for fibre separation; the industrial high temperature chemical pulping processes are crude and heavy fisted in comparison to the soft paths taken by nature. However, biotechnological pulping is still far from practical applicability because of the slow action of natural fungal enzymes. By applying the powerful tool of genetic engineering for enzyme production, advances in bio-technical defibration are likely.

Small pulping units should not try to generate their own electricity inspite of the advantages of heat/energy coupling or utilization of excess heat in black liquor combustion or in thermo-mechanical pulping. In a world of diminishing or costlier fossil fuels, the use of spent liquor organics and of other renewable agricultural or forestry resources becomes increasingly important.

Direct use of solar energy for evaporation in dry countries is under consideration although solar ponds can hardly be economic wherever space is not cheaply available.

For most industrial processes higher temperatures are required than can be directly supplied by the sun.

#### CMP AND CTMP (CHEMO-MECHANICAL PULP AND CHEMO-THERMO-MECHANICAL PULP)

Mechanical pulping is attractive from the point of view of maximal yield and of reduced effluent load. The price to be paid for this is the high energy demand mentioned earlier and also breakage of fibres with loss of strength and increased fines. The advancing CMP and CTMP processes attempt to find an optimal compromise between purely mechanical and purely chemical pulping. Treatment before refining generally is alkalisation and sulfonation for swelling and for partial solution to weaken the interfibre material of plant tissue.

Up to now the main application of chemo-mechanical pulping is with softwoods that lend themselves for this technology but unfortunately are often not available in tropical countries. Some species of eucalyptus and poplar are equally candidates for CMP/CTMP and some units have started operating.

In hardwood the penetration of chips with pre-treatment chemicals is critical, but seems to come under control with pre-steaming and treatment in helical presses.

Very little information is available on the theoretically attractive application of chemo-mechanical pulping on agricultural residues; no industrial operation is known. Possibly, it is the grit contaminating all material harvested in the fields that prevents easy adoption; without grit removal the working-life of refiner disks is uneconomically short. Because of the eminent importance of opacity for newsprint and for other light weight printing stock CMP (e.g. Enzo Gutzeit) has advantages over pressurized pulping.

The traditional image of mechanical and high yield pulps being inferior - "only good enough for packaging" - is no more justified. Modern technology of bleaching and of fibre cleaning permits production of high yield pulps for printing; reduction in paper brightness should be acceptable for all printing base except for four-colour work.

The use of some mechanical pulp in coating base has become accepted practice.

The economic and ecologic advantages of high yield pulping are obvious.

#### NO SULFUR PULPING AND NO CLORINE BLEACHING

The accepted practice in chemical pulping is the sulfur aided kraft process and bleaching with varying oxidized chlorine-compounds. Both classes of materials are highly corrosive for chemical plant and without the use of expensive and complex equipment, pollute the atmosphere and effluents.

These drawbacks of conventional pulping can easier be avoided when agricultural crops are used as fibre source. In alkaline oxygen pulping of wood a major hinderance is the difficult penetration of the active chemical into the wood chip; this is much less problematical with the open-textured agricultural stalk material.

Therefore oxygen pulping of non-woody fibre sources will be an interesting alternative technology, whenever small and reliable oxygen generators become available to the industry.

On the debit side of oxygen pulping - up to the present - is decreased mechanical strength. This problem might be solved by better control of chemical oxygen transfer as evidenced by the good results of soda/hydrogenperoxide pulping. The proposed application of dry strength resins with better effects on soda/oxygen pulps than on conventional material because of increased carbonyl and carboxyl groups also should be followed up.

Medium consistency oxygen bleaching applied in primary bleaching stages has made great strides recently.

The announced Italian Naco process, utilizing ozone and oxygen in series for pulping and bleaching also may turn out to be a valuable contribution to oxygen delignification.

It is obvious, that spent liquors from oxygen delignification in pulping and bleaching permit simplified and less corrosive chemical recovery.

#### UTILIZATION $\text{Na}_2\text{CO}_3$ (NOT CAUSTICIZED SODA) IN PULPING

The use of sodium carbonate i.e. of so called "Non Active Alkali" mixed to caustic soda in a proportion of 60 : 40 has proven beneficial also for improved opacity of the pulp obtained. <sup>\*/</sup> The patent situation, being somewhat restrictive in this field, should not be permitted to hold back advances easing simplified chemical recovery. Caustification of green liquor is a heavy burden on investment and on operational costs. Lime sludge separation and lime burning stands in the way of most attempts to simplify chemical recovery operations.

#### ORGANOSOLVPULPING

New recent efforts, partly on pilot plant scale, document renewed interest and shed new light on alcohol pulping. Whilst alkaline pulping causes condensation and polymerisation reactions of lignin increasing its insolubility, it is stated, that the treatment of lignocellulose material with slightly alkaline aqueous alcohol mixtures at elevated temperature depolymerize native lignin and render it soluble. The solid ligninous residue

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<sup>\*/</sup> A number of authors have found the admixture of some sodium carbonate useful in soda pulping. It also can be assumed that the non-caustic portion of white liquor has some positive function. It has to be seen whether pulping can be conducted with only the make up part being in the form of caustic soda.

after distillation of alcohol for reclaiming should find interesting applications. Organosol pulp has been proven to have acceptable papermaking properties. From the point of view of chemical recycling the non-corrosive alcohol process appears to be most attractive.

#### MEMBRANE SEPARATION, UTILIZATION OF PULPING BY-PRODUCTS

The last few years have witnessed the entry of membrane separation, i.e. reverse osmosis and ultrafiltration into many different fields of chemical technology.

In theory, membrane filtration should be economic compared to separation by evaporation, because it does not require elevated temperatures and avoids the loss of latent heat of evaporation. In practice, technical advances in selectivity and in stability of the ultrafiltering membranes have made this technology a promising contributor to chemical recycling in pulping. It is feasible to separate high molecular organics - mainly alkali lignins - from inorganic salts and organic monomers and oligomers; the latter can also be concentrated, separated from pure water available for re-use.

The problem of eventual disposal of the lignin fraction is still open. To start with, it will probably have to be dried and burned. Similarly to organosolve lignin, it is a potentially valuable material - and one of the most abundant in nature. Becoming available separated from pulping chemicals, new efforts for its intelligent utilization are called for.

#### BROWN STOCK WASHING

The first step in the recovery of pulping chemicals is the separation of fibres from spent pulping liquor. For this, adequate technology is available in conventional wood pulping. This is not the case for straw pulping: the higher proportion of fines, i.e. parenchyma cells, in combination with silica clog the screens and

slow down drainage so much, that conventional equipment only can be used with greatly reduced efficiency. Still, one must assume, that the vast experience in filtration, dealing at times with much more refractory materials, once applied to the problem of fibre separation in straw pulping, should provide adequate solutions. The aim must be displacement of the spent liquor contained in the fibre mat with the least dilution in order to reduce the load on chemical recovery.

#### DESILICATION

Grasses and straws take up from the soil 10 to 100 times more silica than does pulp wood. Such silica dissolves more or less completely in alkaline pulping and its presence in spent liquor interferes by complications in all stages of conventional chemical recovery. Without removal it accumulates in closed systems so that even wood pulpers need to "bleed out" i.e. reject siliceous material. In non-wood pulping the graver situation - at present - is met by complete rejection and deposition of siliceous lime mud. This, of course, is unsatisfactory, also because it does not help with difficulties in earlier recovery stages.

Earlier unsuccessful attempts at desilication and the low priority of non-wood pulping have resulted in acceptance of the silica problems. In recent years some hopeful work has commenced to tackle this key problem of non-wood pulping chemical recovery. A report on the UNIDO project of desilication is included in the programme of this seminar.

#### COMBUSTION; CAUSTIFICATION

The relieving feature in burning valuable organic substances is that next to the disposal of material that cannot be applied usefully, it saves fuel by providing a major part of the process energy. Superior materials used in recovery boiler design, permitting higher steam pressures will permit higher energy yields in black liquor combustion. Investigations to gain insight in the highly

complex course of chemical events in the different zones of recovery boilers of conventional installation units could also help to assist in the construction of simplified combustion units as required by pulpers in developing countries.

The present day recovery boiler is the costliest and the most complicated unit in chemical pulping and requires qualified labour not always available. Therefore, simplification, for instance by separating the burning and the steam raising units has high priority also if some efficiency has to be sacrificed.

Fluidized bed combustion is well accepted in the paper and pulp industry mainly for burning forest residues like bark. Although fluid bed combustion can be conducted at lower temperature and is easier to control, initial optimism as to its application in soda spent liquor incineration has been dampened. potassium salts, chlorides and other impurities lower the melting temperature; with over agglomeration of molten slag a fluid bed cannot be maintained. Separation at low temperature prevents rapid and complete combustion.

Fluid bed incineration in the ferrite process nicely avoids the problem of adhesion by the speedy reaction of molten sodium carbonate with iron oxide under formation of sodium ferrite. Development work in a number of countries seems to have succeeded to bring this process to the stage of technical applicability.

A major advantage of the ferrite process is, that it makes a special caustification step superfluous. In contact with hot water, sodium ferrite hydrolyses under formation of caustic soda of higher causticity than obtained in conventional lime caustification. It is hoped that the ferrite or DARS process (DARS standing for direct alkali recovery system) will become a true and practicable alternative in chemical recovery also under the special conditions prevailing in developing countries; it is hoped that the licensing conditions will not seriously impair its wide-spread application.



EFFLUENT TREATMENT

Legal enforcement of effluent treatment standards is expected to become reality in most developing countries. In the past a certain negligence has acted as restraint for research and development work in this field. Applying present-day biotechnological methods, should make it possible to find practicable systems of aerobic and anaerobic BOD reduction under tropical conditions.

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CRITICAL ANALYSIS OF STRAW PULPING METHODS -  
WORLD - WIDE

by

Thampoe Jeyasingam

Once upon a time straw was an important material for the paper industry in the developed countries of the world such as USA, West Germany, Holland, France, Italy, etc. What is now known as Corrugating Medium and is now largely produced from the semi-chemical pulp of hardwoods was then produced as straw paper from straw in USA and West Europe. The grey rigid board of today produced from recycled paper was then produced from straw as yellow straw board. Mills in Holland used to specialize in this particular type of yellow straw board and this was exported to several countries of the world to produce rigid book covers and rigid boxes. Will straw then eventually phase out due to the encroachment of woody materials and secondary fibre? The indications are that straw will continue to be an important raw material for a number of countries world-wide. This, in particular, is true in many countries in Asia, Africa, East Europe and Latin America.

The main reason that supports the use of straw as a raw material is its ready availability as a residue of food crops, namely wheat, rice, barley, oats etc. Besides its ready availability, the other factors that will continue to make straw an important raw material for developing countries are as follows:

- The world is heading towards a shortage of woody material for the paper industry.
- Strict environmental laws and protective measures are being adopted to prevent the indiscriminate cutting of wood.
- The so-called green revolution has given emphasis to agricultural production in most developing countries.
- The incentives being offered for the promotion of agricultural based industries such as paper in developing countries.
- An increased demand for cultural grades of paper in developing countries because of emphasis given to eliminate illiteracy.

- An increase in demand for industrial grades of paper in developing countries due to the switch over from traditional packaging materials made out of wood and leafy materials to paper packaging materials.
- Hard currency is becoming more and more scarce for developing countries and there is a need to produce paper using indigenous materials, particularly straw.

On account of the above reasons, the developing countries of the world will continue to depend on agricultural residues and the most popular choice appears to be straw. Progress in the application of straw is being hindered because of the shortcomings related to this raw material and the inadequacy of today's pulping technology to combat these problems. The emphasis in today's pulp and paper technology is for the promotion and development of wood based raw materials. It is important to realize the pulping technology and equipment needed for straw pulp mills cannot simply be a copy of wood pulping technology. The chemical composition and the morphological structure of straw require equipment and technology that are best suited to this type of material.

This paper will therefore analyze the problem areas of today's pulping technology related to straw pulping. Steps taken to remedy these problems would no doubt enhance the greater use of straw for the paper industry.

#### STORAGE OF STRAW

Generally speaking what happens inside the pulp mill has a direct relationship to the condition of the raw material and this in particular has to be greatly emphasized for straw and its storage prior to processing.

The moisture content of the straw should be generally kept under 15 % and the optimum range is somewhere between 10 to 12 %. With higher moisture content straw is subject to microbiological degradation and decay. Straw thus affected has the following disadvantages:

- Consumes more chemicals;
- Poor yield;
- Poor physical strength properties;
- Poor brightness.

Besides the above problems there is a great danger of slow combustion developing in the stack creating a potential fire hazard.

One of the problems in straw pulp mill management is obtaining good quality straw with an optimum range of moisture for the processing of paper pulp. This problem is now more severe than a decade ago because farmers are gradually giving up bale production in preference for cylindrical rolls which are difficult to store unlike the convenient rectangular bales that could be built up into stacks and protected with a layer of loose straw to prevent moisture penetrating into the stack. Although some efforts have been made to cover stacks made up of rolls with polyethylene sheets, this idea has not been well accepted. The mills continue to clamour for a supply of straw in bales and the farmers prefer to get away from bales to rolls. The most economical way of handling storage and supply of straw from the fields to the mill is therefore still open for further improvements.

#### STRAW PREPARATION

##### 1) Dry Preparation Method

This is the most common method adopted for the preparation of straw prior to digestion. Disc or rotary drum type of cutters are used to reduce the length of the straw. The cut straw is then conveyed pneumatically to screens and cyclones to separate grain, sand and dust present along with the straw.

##### Advantages of the System

It is a simple system that requires less energy to operate and requires relatively low capital cost.

### Disadvantages of the System

It could only work satisfactorily if the moisture content of the straw is less than 15 %. The pneumatic conveying system gets choked up with straw and the dust screens get plugged up when operating with moist straw. In consequence the dry preparation systems do not work satisfactorily in areas where there is much rainfall or snow unless the straw is stored under cover and transported into the mill in dry conditions. Mills do not like the idea of providing storage sheds to overcome these difficulties on account of the high cost of providing buildings. Here is an area open for further development as to how straw could be efficiently collected, handled and stored up prior to processing. Some newsprint mills in USA that are working on deinked waste paper have developed simple, low cost storage sheds that cost about 50 % of the cost of conventional buildings. These buildings are dome shaped and are constructed out of light steel and covered with vinyl. This could be a possibility for straw pulp mills. Another alternative that could be applied is to use the hot flue gases of boilers to dry the straw to suitable moisture content prior to processing. The techno economics of applying these possibilities have to be worked out.

### 2) Wet Preparation Method

The wet preparation system essentially is based on the use of a hydra pulper. The hydro pulper that is used for this purpose is fitted with an extraction plate and a rotor that are specially designed. On account of the mechanical forces created inside the pulper the sand, grit and leafy materials are separated and eventually escape out of the pulper through a valve. The straw thus cleaned contains much lower percentage of leafy material which does not contribute much anyway to the fibre content of the straw pulp. About 25 % of the total weight of rice straw and about 10 % of the weight of wheat straw is lost through this method.

#### Advantages of this System

This system is suitable for the processing of straw with moisture content higher than 15 % which cannot be satisfactorily handled by the Dry Process. It is more suitable for rice straw which has a high amount of loose sand, grit and leafy materials. The rubbing action provided in the pulper helps to remove a fair amount of silica prior to further processing. It is estimated that about 20 to 25 % of the silica is removed by this cleaning method.

#### Disadvantages of this System

It requires a relatively higher capital investment and requires more energy for processing compared with the dry system.

#### 3) Caustic Pre-treatment Preparation Method

This is a new system being developed as part of the NACO Process. Here again the essential part of this pre-treatment is a specially designed hydra pulper with junk trap. Bales of straw are delivered into the pulper where it undergoes cutting and slicing in the pulper. Following the hydra pulper is a DKP disc press for dewatering the straw and a system for cleaning the waste water to be recycled back to the pulper. This pre-treatment is conducted in the pulper and about 1½ to 2 % caustic soda is used. A substantial portion of unwanted materials is removed and the silica content of straw gets reduced by about 40 %.

#### Advantages of the System

It is possible to feed straw to the system with high moisture content. There is a reduction in the silica content of the straw prior to the processing into pulp on account of caustic treatment. It is reported that the silica content of wheat straw is reduced from 7.5% to 3 %.

### Disadvantages of the System

Compared to the Dry System of cleaning there is additional capital cost for the pre-treatment equipment. A higher energy cost is also involved because of the electric energy needed for the pulper drive and heat energy needed for the cooking of straw with higher moisture content.

### CONVEYING OF STRAW

Most pulp mill designers provide mechanical screw conveyors for the straw after it has been reduced in length by the straw cutter. Several mechanical problems are experienced in the straw pulp mill on account of mechanical screws being applied for such a task. Straw, unlike wood chips has a tendency to rope. This results in frequent mechanical breakdowns and interruptions to production.

Experience indicates mechanical screws if applied for such a purpose could be used only for short distances of 2 to 2½ metres without intermediate supports. When the distances to be conveyed are higher, the preferred choice would be the use of rubber conveyor belts in place of screw conveyers.

### WEIGHING OF STRAW

Several mills have adopted the system of weighing straw using the principle normally employed for wood chips by using a belt weightometer. Experience in working with this measuring instrument indicates inaccuracies in relation to the input of straw to the digester. Due to these inaccuracies the measurement of straw using such type of weightometers is ignored and the digester feeding is then controlled mostly by relying on operator judgement or on an approximation of weight by counting the bales fed into the digester.

New ideas and new development using more accurate type of weightometers are needed for straw pulping.



### MOISTURE OF STRAW

In most mills, the measurement of the moisture content of straw is based on random sampling by the oven drying method which is slow, laborious and not quite representative.

New accurate and fast on line measuring devices are needed for a better control on the pulping of straw. Very few mills have adopted such a new system to control pulping conditions.

### PULPING SYSTEM: (Batch and Continuous.)

#### Batch System of Pulping

The high bulk of straw accounts for a special design for the cooking vessel. To obtain uniformity of cooking, spherical digesters or tumbling digesters are used. The solid: liquid ratio for cooking has to be maintained high in order to obtain uniformity in cooking. Normally cooking is done by direct steam. Pressure is built in these digesters generally around 5 - 7 kg/cm<sup>2</sup>. On account of the bulky nature of the material the digesters take considerable time for packing. To improve packing as well as to help uniform cooking some form of pre-impregnation is done prior to the raw material being admitted into the digester. Packing densities of 150 - 190 kg/m<sup>3</sup> OD straw are obtained, compared with 180-270 kg/m<sup>3</sup> for wood chips. The total cooking cycle in batch digesters could vary between 6 - 8 hours.

Some of the well-known pulping systems that apply to the batch process are: The Lime process, Soda process, Neutral Sulphite process and Kraft process.

#### 1) The Lime Process (By Batch System)

This process is one of the oldest processes for the production of corrugating medium, and yellow straw board from straw. Cooking with lime is still practiced by some mills as this has no adverse effects to the environment as in the case of caustic soda cooking. The effluent in some mills is used for irrigation of food crops.

Cooking is done using either spherical rotary digesters or tumbling digester.

Typical Cooking Conditions:

Chemical	-	lime 7 to 10 % as CaO
Temperature	-	130 <sup>o</sup> to 140 <sup>o</sup> C
Time	-	3 to 5 Hours
Solid to Liquid		
Ratio	-	1:2

Advantages

- Simple process to produce corrugating medium;
- Cooking with lime has no adverse effects to the environment as in the case of caustic soda and neutral sulphite cooking.

Disadvantages

- In some mills the pulp due to improper washing causes problems on wires and wet felts. The felts and wires get easily blinded unless proper showers are used on both wires and felts.

2) Soda Cooking (By Batch System)

Soda cooking for straw by batch process is widely applied all over the world. Both spherical rotary digesters as well as rumbling digesters are used. The amount of caustic soda needed for producing bleachable grade of paper ranges from 10 to 25 % on the dry weight of straw. The temperature of cooking could be varied depending on the time allowed for cooking, as for example a low temperature of 140<sup>o</sup>C will require a longer time and a high temperature of 170<sup>o</sup>C will require a shorter time for cooking.

Typical Cooking Conditions:

Chemical	-	NaOH 10 to 12% on OD Wt
Temperature	-	150° to 170°C
Solid to Liquid		
Ratio	-	1:2 to 3
Time	-	2½ to 4 Hours
Yield (Bleached		
Grades)	-	35 to 40 % on OD Straw

Advantages

- Chemical recovery and heat recovery is possible with certain limitations due to silica.
- A well established process for producing bleached grades of pulp using batch digesters.

Disadvantages

A good effluent disposal system is needed if chemical recovery is not practiced.

3) Kraft Process (By Batch System)

For the cooking of straw, Kraft process or Sulphate process is not so popular as in the case of Soda. This is because the increase of strength properties obtained by Sulphate process is marginal compared with the Soda process. In most parts of the world Salt Cake is an expensive chemical compared to Caustic Soda and it also adds to the air pollution due to sulphur compound emissions. However, there is a mill in Calarasi (Romania) producing about 50 000 TPY of bleached straw pulp by the Kraft process.

Typical Cooking Conditions:

Chemical	-	NaOH - 10 to 12% } Na <sub>2</sub> S - 2 to 2 % }	on OD straw
Temperature	-	150 to 170°C	
Solid to Liquid Ratio	-	1:2 to 3	
Time	-	2½ to 4 Hours	
Yield	-	35 to 40 %	on OD Straw

Advantages

- Chemical recovery and heat recovery is possible with certain limitations due to silica.

Disadvantages

- A good efficient disposal system is needed if chemical recovery is not practiced.
- Additional capital investment is needed on account of the use of Sodium Sulphide and the problems related to air emissions containing sulphur compounds.

4) Neutral or Mono-Sulphite Process (By Batch System)

The acid sulphite process is not suitable for cooking straw. There is loss of strength as well as yield when the acid sulphite process is used as compared with the soda, kraft or neutral sulphite processes.

The sodium sulphite used for cooking straw is normally buffered using either caustic soda or sodium carbonate to obtain a neutral pH. However, some of the mills prefer a slightly alkaline pH of 8 to 9. This process of cooking gives a milder reaction to the straw compared with the soda process and the resulting pulp therefore contains more ash than in the soda process.

**Typical Cooking Conditions:**

Chemical	- $\text{Na}_2\text{SO}_3$	- 8-12 % on OD straw
	- NaOH or $\text{Na}_2\text{CO}_3$	- 2-4 % on OD straw
Temperature		- 160 - 170°C
Solid: liquid Ratio		- 1:3 to 4
Yield (For Bleached Grade)		- 35 - 40 % on OD straw

**CONTINUOUS SYSTEM OF PULPING**

Some of the continuous type of systems applied for straw pulping are as follows:

- Pandia
- Kamyrr
- Celdecor-Pomilio
- Mechano-Chemical Process
- Escher-Wyss MCP Digester
- HF
- SAICA Digester
- NALCO

1) **Pandia Digestion System**

The Pandia type of continuous digester basically consists of the following:

- A screw feeder which also functions as an impregnation unit.
- A pair of horizontal cooking tubes fitted with screw conveyors and joined together by inter-connecting tubes.
- A rotary discharger for pulp.

### System of Operation

The raw material is conveyed to a pre-impregnator when a digester is installed with one, otherwise it goes directly to the screw feeder. The feeding to the digester is regulated by a metering device. A certain percentage of the cooking liquor is added to the fibrous material in the pre-impregnator to soften the raw material. The raw material is then compressed through the screw feeder. The principle of the screw feeder is to densify the material by compression so that a plug could be formed. This plug is expected to form a seal and prevent the escape of steam as well as blow backs. The compressed material gets decompressed when it leaves the screw feeder and enters the vertical chamber (or reaction tube) that connects the screw feeder to the first digester tube. The decompression of this material is made easier when it gets in contact with the steam and cooking liquor in the reaction chamber. The continued cooking of the material in the digester tubes is facilitated by the intimate mixing of the chemicals and the heat produced by the steam. For a satisfactory operation a solid to liquid ratio of 1:3 is generally maintained. The cooking time in the digester could be regulated by changing the speed of the conveyor screws that carry the material through the digester tubes.

### Design Variables

The digester could be designed for an output as low as 15 TPD to a maximum output of 200 TPD. This would depend on the following:

- Diameter of the tubes
- Number of tubes
- Speed of conveyor drives

### Typical Cooking Conditions for Straw

	<u>Wheat Straw</u>	<u>Rice Straw</u>
Pulping Process	- Soda	Soda
Chemical as Na <sub>2</sub> O %	- 10	10
Dwell time (minutes)	- 8	5.5
Pressure (PSI)	- 80	100
Yield %	- 50	39

Advantages

- Economy in steam usage.

Disadvantages

- Problem of blow back.
- Heavy maintenance on screw feeder due to the abrasive nature of straw due to silica.
- Uniform feeding is critical to the digester.

2) Kamyr Digestion System

This is a well-known and well-applied system for wood but is not so well applied for non-woody materials. For wood pulping the cooking liquor is pre-heated using pre-heaters and is pumped into the digester by a forced circulation system. In the case of non-woody materials direct steam is used. The writer is aware and familiar with one single application of the Kamyr system for straw and this is in the AFYON Mills in Turkey.

The straw is introduced through a rotary valve to the pre-impregnator where it is thoroughly mixed with hot cooking liquor and with the flash steam from the blow tank. From the pre-impregnator the material is then discharged through a low pressure (LP) rotary feeder to a low pressure inter-connecting tube prior to admission to the high pressure (HP) rotary valve. The pressure inside this connecting tube is generally around 15 - 35 psi. The material then passes through the HP rotary feeder which has three openings. The feeding of the material, the discharge of the material and the steam admission takes place through these 3 openings depending on the position of the openings based on the rotary movement of the valve. When the valve is aligned in the vertical position the pocket of the valve gets positioned with the other two openings, namely the openings to the asthma valve and to the digester. When this happens, steam gets released from the asthma valve and forces the straw from the pocket of the rotor valve into the digester. It is estimated that 80 % of the steam required is admitted to the digester by the asthma valve. The pulp gets discharged from the digester through an adjustable orifice to the blow receiver.

Advantages

- Efficient utilization of flash steam.
- Effective control on cooking time that could be varied from a few minutes to up to 3 or more hours.
- Two stage arrangement with low pressure cooking and high pressure cooking which is helpful to delignify with minimum damage to fibre.
- The design arrangement of LP and HP feed valves that prevent blow back problems.

Disadvantages

- Heavy maintenance problems on the LP and HP feeder valves due to the abrasive nature of the straw.

3) CELDECOR - Pomilio Process

The chief chemicals used in this pulping process are Caustic Soda and Chlorine. This process is advantageous to countries that do not have a well established chemical industry.

The Caustic Soda and Chlorine required for pulping are produced and consumed in proportions to the output of the electrolytic cell. What the mill requires therefore is common salt (NaCl) as the starting chemical.

The pulping is conducted in three operations, namely:

- Mild digestion with Caustic Soda up to 115 to 130°C in an open digestion tower.
- Chlorination in the gas phase. This is conducted in a down flow chlorination tower. Chlorine is admitted as gas through orifices in the tower walls and through a central pipe so that the penetration is uniform
- Alkalization is conducted at room temperature.



Typical Chemical Consumption for Producing  
Bleached Wheat Straw Pulp

Yield	-	48 %
Consumption to produce 1 ton AD pulp		
NaOH for digestion	-	17.4 %
NaOH for Alkaline Wash	-	<u>3.1 %</u>
Total NaOH	-	20.5 %
Chlorine as gas for direct use	-	14.5 %
Chlorine for Hypo	-	<u>0.7 %</u>
Total Cl <sub>2</sub>	-	15.2 %
Power Requirement Pulp Mill	-	425 KWH
(Straw Preparation and Pulping)		
Steam for cooking and bleaching	-	2.2 Tons

Advantages

- Useful for some developing countries where transport of Caustic Soda and Chlorine is difficult and expensive.

Disadvantages

- It is an obsolete system with problems related to corrosion, but there are some mills in Vietnam and Italy still operating with this system. However, no new mills have been built within the last two decades applying this process.

#### 4) Mechano-Chemical Process

This process is based on the development at the Northern Regional Research Laboratory, Peoria, Illinois, as a result of work done by LATHROP and ARONOVSKY. The process is not widely in use and as far as the writer is aware there were a few mills employing this process in Holland to produce corrugating medium from straw but these mills are not functioning at present.

The essential equipment for this process is a hydropulper. The pulping of straw is conducted at atmospheric pressure and at a temperature of 95 - 100°C. The chemicals used for cooking are either caustic soda or a mixture of caustic soda and sodium sulphite. Straw from the cutter is fed to the pulper by means of a conveyor belt. Fresh cooking liquor is mixed with the spent liquor and then added to the pulper to obtain a solid : liquid ratio of 1:15 - 1:12 range. The required temperature of 95 - 100°C is obtained by using direct steam to the pulper. The mechanical action provided by the pulper helps delignification by opening up the straw and exposing an increased surface area for reaction with the chemicals.

The degree of pulping depends on the following:

- Percentage of chemicals used
- Consistency
- Temperature
- Amount of mechanical action inside the pulper

#### Typical Cooking Conditions

Chemical	-	NaOH 5-6 % on OD. Wt
Temperature	-	95 - 98 %
Consistency	-	10 %
Time	-	45 - 60 Minutes
Yield	-	70 to 78 %

Advantages

- Simplicity of operation;
- Low capital investment.

Disadvantages

- High chemical consumption;
- High power consumption;
- High steam requirement.

According to the writer the pulp produced is only suitable for unbleached grades such as corrugating medium (It is claimed bleached grades could be produced.)

5) Escher-Wyss (France) and MCP Process

This is a continuous type of cooking process applied to straw. There are only three mills using this process, one in each of these countries - France, Spain and Yugoslavia. The cooking system produces an unbleached grade of pulp mainly for the manufacture of unbleached grades such as corrugating medium. The chemicals used for cooking could be either caustic soda alone or a combination of caustic soda and lime or lime alone.

The digester used for cooking is designed to work at atmospheric pressure and is essentially made up of four tubes and an extractor as outlined below:

- An impregnator tube
- A pre-cooking tube
- A cooking tube
- A disintegrator tube
- An extractor

Cut straw entering the impregnator tube is sprayed at the mouth of the tube with both white liquor and spent liquor. In the impregnator tube the straw is mixed with the chemicals by the movement of the screw. The temperature in this tube is generally in the range of 80 - 85°C and the consistency is between 20 - 25 %. From the impregnator tube the straw is discharged into the pre-cooking tube where the temperature is raised to 100 °C. From here the straw is discharged into the cooking tube where the temperature is still maintained at 100°C but there is more intense mechanical action provided by using two screws rotating in opposite directions. (All the other three tubes have only a single screw used principally for conveying. The final phase of the mechanical and chemical action is completed in the fourth tube - the disintegrator tube. The temperature in the disintegrator tube is in the range of 90 - 95°C. From this tube the straw is discharged into the extractor which extracts the spent liquor thereby increasing the consistency from about 25 to 35 %.

#### Typical Cooking Conditions

Chemicals	-	NaOH or lime or combination of NaOH and lime NaOH alone 6 - 7 % on OD straw as claimed by supplier but mills experience 8 % NaOH
Consistency	-	20 - 25 %
Temperature	-	95 - 98°C
Pressure	-	Atmospheric
Cooking Time	-	2 to 2½ hours
Yield (for unbleached grades)	-	70 % (designed value claimed by supplier) 55 % (mills actual performance)

#### Advantages

This process is claimed to use less chemicals and less steam as compared to pressure cooking.

Disadvantages

- Frequent mechanical problems related to the conveyor screws of the digester tubes.
- To prevent plugging inside the digester tubes more chemicals have to be used compared to pressure cooking.
- On account of increased chemical usage the yield drops from 70 % (which is common to semi-chemical pulping) to about 53 %.
- Due to the low temperature of 95 - 98°C the chemical penetration is poor and this results in heavy screen rejects.

6) H.F. Process (Højbygaard Fabrik)

This process was developed in Denmark for the production of semi-chemical pulp from straw to produce corrugating medium. This method essentially uses a DIFFUSER where the pulping takes place. The diffuser works on the counter current principle so that the residual chemicals and heat could be efficiently utilized. The diffuser is made up of 3 zones. The first pass is the impregnation zone where the straw is admitted and residual chemical and heat is used up. Then the straw ascends up by the screw conveyor to the second zone for digestion at a temperature of 95 to 98°C. The final zone is the washing zone where the lignin and pentosans are washed away and the heat is transferred to the washing water. The digestion time is 4 hours.

Typical Cooking Conditions

Chemical	- NaOH 6 to 7 %
Temperature	- 95 to 98°C
Time	- 4 hours
Yield	- 75 to 78 %
Stock Consistency at Discharge end	- 12 to 18 %

Advantages

- A simple type of operation working on atmospheric pressure.
- Steam requirement is estimated to be low.
- Water requirement is estimated to be low.

Disadvantages

- The process is suitable only to produce corrugating medium.
- Requires relatively high defibering energy since the cooked straw fibres are still joined together to form the straw stem. This would mean high input of energy is needed in the pulper and refiners for defibration.
- Requires waste paper usage as an essential integral part for operation on the paper machine.

7) The SAICA Process

(Sociedad Anonima De Industrias Celulosicas Aragonesas)

The processing of straw by this system is nearly similar to HF process. The SAICA mill is located in Zaragoza in Spain and is using this process to produce semi-chemical pulp that is blended with corrugated container waste to produce corrugating medium.

The cooking of straw takes place in a continuous digester of special design developed by SAICA. The digester is of cylindrical shape and is inclined at an angle of 5° to the horizontal. Straw is conveyed through the digester at a constant rate by means of two parallel screws rotating at low speed in opposite directions. The digester, as in the case of the HF process, performs three basic functions:

- Pre-impregnation
- Cooking
- Counter current washing

Pre-impregnation is done at the digester entry and at the lowest position of the digester. The straw that is hammer milled is fed to the impregnation zone where it is mixed with a regulated quantity of spent cooking liquor.

In the cooking zone the straw gets cooked at atmospheric pressure and the heating is indirect through a steam jacket. Cooking is done with caustic soda admitted at mid point to the digester and mixed with a controlled amount of black liquor.

In the washing zone the pulp washing is done using white water from the paper machine consuming about 8 m<sup>3</sup> of water per ton of pulp. The spent liquor is collected from the digester and is pumped back to the feed chute for pre-impregnation. The excess spent liquor is pumped out for disposal. The pulp discharged from the digester is fed into a screw press and raised to a consistency of 37.5 %. The extracted liquor is then returned to the digester.

#### Typical Cooking Conditions

Chemicals	- NaOH - 5 % on OD straw
Consistency	- 20 - 25 %
Temperature	- 98°C
Pressure	- Atmospheric
Yield	- 71%

#### Advantages

It is a simple processing system to produce semi-chemical pulp.

#### Disadvantages

Due to the low temperature in the digester the penetration of the chemical used is poor. Therefore more mechanical action is needed to defiber the pulp. This increased mechanical action decreases the strength properties and makes it necessary to use more waste paper to produce corrugating medium. The paper machines' runnability as well as the desired physical properties of the corrugating medium are well developed using only a maximum of 25 to 30 % semi-chemical pulp for this

process. The mill uses about 70 to 75 % of corrugated container waste with the straw pulp.

8) NACO Process

This is a new process for the continuous pulping of straw. The pulping system is based on an Italian patent using caustic soda and oxygen for delignification followed by ozone bleaching.

A 100 TFD plant for chemical pulp production is now under construction for commercial production in Foggia, Italy, complete with a chemical recovery system. This mill is expected to be in full operation by about the end of 1985.

The NACO process is considered to be the technological solution to some of the major problems caused by cooking and bleaching chemicals. This is because the NACO process does not use chemicals such as sulphur and chlorine in the process.

The NACO process as applied to the first commercial plant is essentially made up of the following sections:

- Pre-treatment Section
- Delignification Section
- Bleaching Section

Pre-treatment for straw is conducted in a pulper where it is treated with 1½ to 2% NaOH. After treatment in the pulper the straw gets dewatered in a SUNDS DKP press prior to delignification.

Delignification

The delignification section is made up of a pressurized single disc refiner, a turbo pulper, an oxygen mixer and a combined up flow-down flow oxygen reactor.

The turbo-pulper performs an important function in the process.



Due to the spherical shape of the pulper, a very intensive mechanical action takes place in the pulper. The mechanical action provided inside the pulper results in fibre separation and increases the surface of the raw material. At the same time the oxygen that is admitted into the turbo-pulper gets well mixed with the alkali-fibre suspension. The turbo-pulper is operated at a pressure of 6 to 8 kg/cm<sup>3</sup>.

The pulp is continuously pumped out from the turbo-pulper to the oxygen reactor. The oxygen reactor that follows the turbo pulper is provided with an up-flow - down-flow arrangement. Excess of oxygen is brought from the top of the reactor to the turbo pulper. After the pulp passes through the oxygen reactor it is washed on a displacement wash press.

#### Bleaching

At the time of the writer's visit to this plant a possible bleaching process to be integrated to the delignification section was under consideration. Trials with a two stage system using 2 % hydrogen peroxide (100 % H<sub>2</sub>O<sub>2</sub> basis) and 3 % hypochlorite (Active Cl<sub>2</sub> basis) resulted in a brightness of higher than 80. The possibility of bleaching with ozone as an alternative was also under consideration.

#### Chemical Recovery System

The chemical and heat recovery system for the NACO process was being supplied by Lurgi. The spent liquor after evaporation on multiple effect evaporators will be subjected to combustion in a Lurgi designed recovery boiler. The smelt is then dissolved to produce a sodium carbonate solution which is directly used in the turbo pulper without causticizing.

#### Typical Processing Conditions

- |             |  |
|-------------|--|
| Chemicals   | - NaOH 1½ % OD straw for pre-treatment<br>NaOH 6 % OD straw for delignification      |
| Temperature | - 130°C in Turbo Pulper<br>- 75°C temperature of pulp discharged from oxygen reactor |

- |             |   |
|-------------|---|
| Consistency | - Turbo pulper 10 %   |
|             | - Oxygen reactor, 7 %   |
| Yield       | - 60 % on pre-treated straw<br>(i.e. 20 % loss during pre-treatment.) |

#### Advantages

- There is reduced pollution because chlorine and sulphur are not used in the pulping and bleaching processes.
- Less capital investment is required for the chemical recovery system.
- It is economically feasible to operate small sized plants using this process. (Mills that require a conventional recovery system have to operate their pulp mills at a minimum capacity of 200 TPD to be economically feasible).
- Sodium carbonate is directly used for processing thus avoiding the use of a recausticizing plant.

#### Disadvantages

- The heat recovery from the black liquor is poor.
- In the case of countries where oxygen cannot be obtained, additional capital is required to produce oxygen for pulping at the mill site.

### BATCH VERSUS CONTINUOUS PULPING METHODS

In the preceding pages the various well-known and commercially applied cooking process systems have been discussed. At this point it may be worthwhile to examine the advantages and disadvantages of both the batch and continuous cooking systems.

#### Batch Systems: Advantages

- They are simple and easy to operate and maintain;
- High flexibility to all cooking conditions based on raw material conditions;
- Flexibility to operate mill at reduced capacity without shutting down the entire mill due to maintenance problems;
- Uniformity of feeding not critical.

Batch Systems: Disadvantages

- Require more operating personnel;
- Require relatively more steam and electric energy.

Continuous Systems: Advantages

- Require relatively less steam and energy;
- Require fewer operating personnel;
- Claimed to produce more uniform pulp.

Continuous Systems: Disadvantages

- Less flexible to operate and maintain;
- The whole pulp mill is likely to be shut down for maintenance problems and breakdowns;
- Uniform feeding is critical;
- High maintenance upkeep standards are required;
- The availability of spare parts is crucial.

OTHER MINOR PROCESS SYSTEMS

There are various pulping process systems which are patented and are either in the process of development or ready for commercial application but not yet well applied commercially.

1) Nitrocell Process

This process depends on the use of Nitric Acid as the cooking chemical.

Advantages

- Claimed to have low effluent discharge with useful by-products.

Disadvantages

- Special engineering required to work with nitric acid.

2) Ammonia Process (Thillaimuttu Patent)

This process depends on the use of Ammonium Hydroxide as the cooking chemical.

Advantages

- Ammonia has the advantage of simple recovery by steam stripping.
- This process is also environmentally accepted.

Disadvantages

- Requires further study to determine its commercial viability;
- The ammonia process could have problems due to poor bleaching and poor strength properties.

Comments

- Besides the Thillaimuttu process, there are other ammonia process systems being claimed on the basis of lab work and pilot scale trials which are not yet commercially applied.

3) Hopes Process

This process for cooking straw is based on the use of sodium hydroxide plus oxygen delignification applied in two stages.

Advantages

The use of oxygen has advantages as it is not polluting to the environment.

Disadvantages

Requires further study for making the process commercially viable. Oxygen in combination with other alkalies has been investigated and the first commercially designed plant is the NACO process described earlier.

4) Soda-Chlorite Process

This process depends on the use of sodium hydroxide plus sodium chlorite in separate stages.

Disadvantages

The use of chlorine compounds could make chemical recovery difficult.

5) Soda-AQ Pulping

The cooking of straw using caustic soda and AQ is not yet well established. However, there is one positive report from a mill in the People's Republic of China. According to this report the use of AQ has the following advantage:

- Faster delignification accompanied by lower alkali consumption and higher pulp yields.

PRINTING AND WRITING PAPERS BASED ON CHEMI-MECHANICAL  
PULPING - AN ECONOMICALLY VIABLE PROPOSITION

by

B. Kyrklund <sup>1/</sup>

INTRODUCTION

One of the major constraints for establishment of pulp and paper mills in developing countries is the small size of the potential market in most of these countries. An economically viable integrated pulp and paper mill in an industrialized country needs to have a production of 100 - 150,000 tons per year, but production from such a mill would be at least ten times too large for most developing countries.

Efforts have been made on several occasions to scale down the minimum viable size of a pulp and paper mill to be more in balance with domestic market demand. As a general rule, it can be said that chemical pulp production from wood integrated with papermaking can, under certain conditions, be viable at a capacity of about 35,000 tons per year. Efforts to further reduce the minimum capacity of this type of mill have not in general been successful, except where very special conditions exist combined with incentives. The reason for this has usually been the marked economies of scale of chemical pulp production. A great part of the investment in such a mill also refers to investments in a recovery boiler plant, a steam plant, power supply, effluent treatment, etc.

A chemi-mechanical pulp mill has the advantage over a chemical pulp mill inasmuch as the economies of scale are not quite as marked. In addition, the investment in the actual fibre line a chemi-mechanical pulp mill is about 50 percent of the total investment requirement, compared to about 25 percent in a chemical pulp mill. The reduction of investment requirement and, accordingly, in the minimum viable size of a mill would, therefore, seem more easily achieved with that type of process than when chemical pulping is employed, concentrating on efforts to simplify the design of the fibre line.

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<sup>1/</sup> Chief, Pulp and Paper Branch, Forest Industries Division, FAO

A study was, therefore, undertaken by FAO in 1982 into the possibilities of establishment of viable small pulp and paper mills based on chemi-mechanical pulping. In the following, a review will be presented of a mill producing 15,000 tons <sup>2/</sup> per year of wood-containing printing and writing paper.

#### The Pulp and Paper Mill Studied

Figure 1 presents a block flow-sheet of the integrated pulp and paper mill which was taken to be studied. Following chipping, screening and chip washing, the chips would be impregnated with caustic and peroxide solutions which form the pulping agents. After the pre-treatment with chemicals, the chips would be refined in two stages with peroxide bleaching employed in the second-stage refiner. The resulting pulp would be agitated in a chest for latency removal and, thereafter, thickened for high-density storage. No screening or cleaning would be employed in the pulp mill. These operations would be carried out in conjunction with the stock preparation for the paper machine which would be of simple, slow-speed design. The mill would include a finishing department with facilities for cutting all of the production into sheets. As regards the ancillary departments, the steam supply would be based on wood-fired low-pressure boiler and the power would be supplied from the national grid.

In the design of the mill for costing purposes, it was assumed that the wood raw material - hardwood- would be delivered debarked to the mill. The layout of the pulp mill is such that gravity flow is used to the extent possible in order to benefit from the considerable cost reduction from elimination of high-density stock transport systems. This was done to the extent that gravity flow was used from the impregnation stage in the pulp plant to the latency chest. Further details of the mill design are provided in the original report on the study.

Capital cost estimates for the mill were prepared on the basis of information obtained from equipment suppliers on major items of equipment and from cost data available in FAO files. All costs reflect the level of mid 82.

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<sup>2/</sup> Metric tons are used throughout this paper.

### Capital Cost Estimates

For the economic evaluation of the mill the estimates were prepared to reflect two cases:

- 1) A pulp mill producing 13,000 tons per year of chemi-mechanical pulp established in conjunction with an already existing paper mill producing 15,000 tons per year of printing and writing paper. In this case, cost estimates both as regards capital costs and manufacturing costs reflect the additional cost over and above those of an already existing mill with its service departments;
- 2) A greenfield, fully integrated printing and writing paper mill producing 15,000 tons per year of paper from 100 percent chemi-mechanical pulp from hardwoods.

A summary of the plant capital estimates for the two cases is shown in Table 1. Thus the total plant capital for the pulp mill alone would be US\$ 8.3 million whereas a new, integrated pulp and paper mill would require a plant capital of US\$ 32.3 million. The total investment, as shown in Table 2, would then amount to US\$ 9.0 million for the pulp mill and US\$ 38.0 million for the integrated mill.



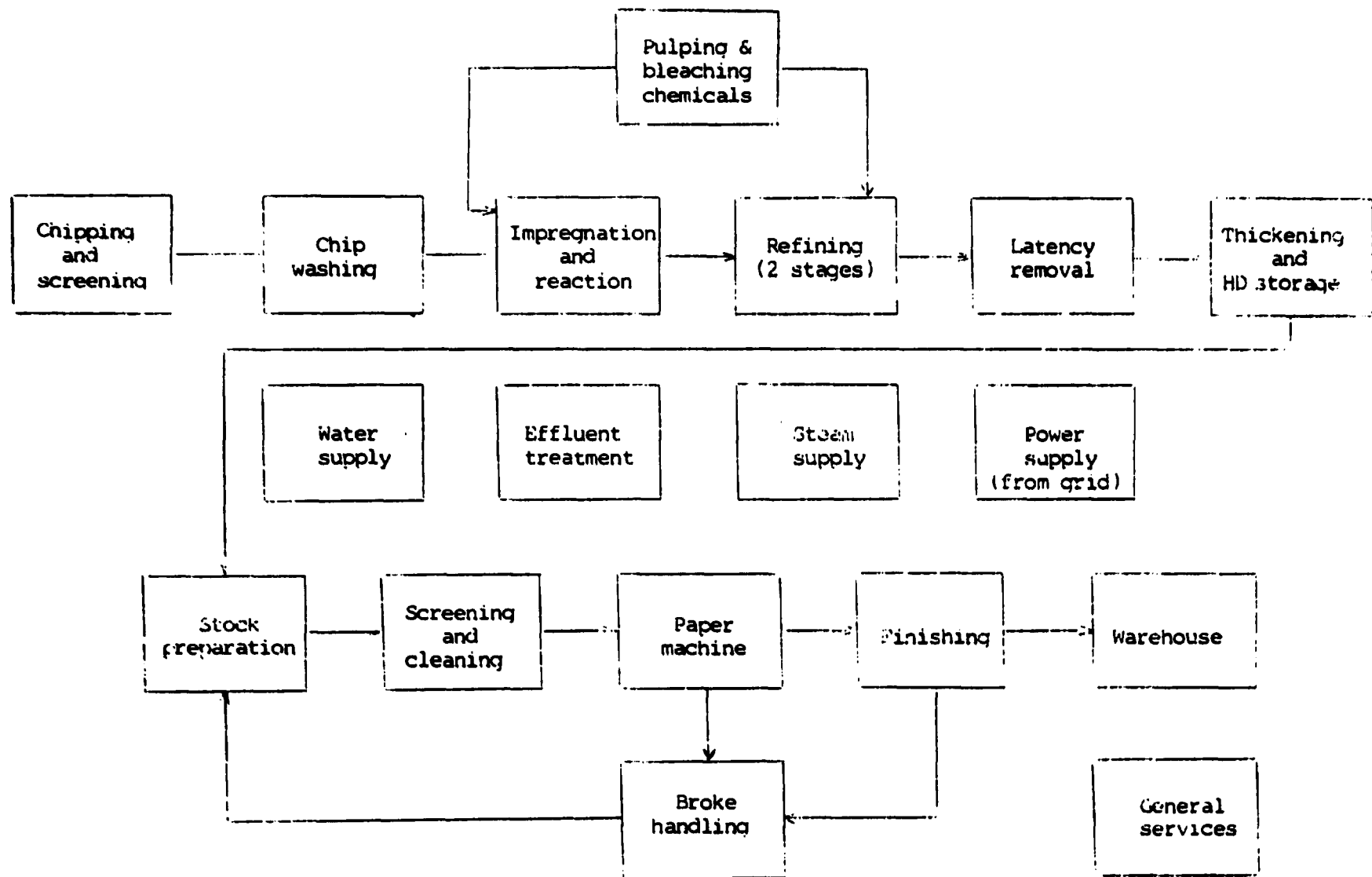


Fig. 1 - Block flow sheet of mill

Table 1  
Plant Capital Estimate

<u>Item</u>	US\$ Million	
	<u>Pulp Mill</u>	<u>Integrated Mill</u>
Structures	1.4	4.4
Equipment		
- material	4.0	17.4
- installation	<u>1.2</u>	<u>4.0</u>
Total direct cost	6.6	25.0
Engineering	0.6	2.2
Construction overhead	0.3	1.3
Contingencies	<u>0.8</u>	<u>3.0</u>
Total Plant Capital	8.3	32.3

Table 2  
Total Investment Estimate

<u>Item</u>	US \$ Million	
	<u>Pulp Mill</u>	<u>Integrated Mill</u>
Plant capital	8.3	32.3
Working capital	0.6	1.4
Pre-operational and start-up expenses	0.2	0.5
Interest during construction	<u>1.1</u>	<u>3.8</u>
Total investment	9.0	38.0

Manufacturing Cost Estimate

The manufacturing cost estimates and the mill design concept were based on alkali-peroxide pulping of hardwoods. Thus the yield of pulp on pulping would be 85 percent with a specific refining power consumption of 900 kWh per bone-dry ton. The target brightness of the pulp after bleaching in the second-stage refiner would be 70. The most important unit costs for inputs are given in Table 3.

Table 3  
Most Important Unit Costs Used

<u>Item</u>	<u>Unit</u>	<u>Price</u>
Pulpwood	US\$/m <sup>3</sup> s <sup>1/</sup>	25
Hydrogen peroxide	US\$/MT <sup>2/</sup>	860
Fuelwood chips	US\$/m <sup>3</sup> s	22
Electric power	US\$/MWh	30

In general, these unit costs reflect the prices which are charged in a number of developing countries. However, great variations may be found in the costs of hydrogen peroxide and electric power.

A summary of the manufacturing costs for the two cases is shown in Table 4. The cost of chemicals is the major component both in the pulp mill as such and in the integrated mill. The cost of pulpwood is also a major component in the manufacturing cost of the pulp mill but it is of relatively little importance in the costs of the integrated mill. The total annual manufacturing cost estimates are, accordingly, US\$ 3.5 million for the pulp mill and US\$ 7.8 million for the integrated mill. It could be mentioned

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1/ m<sup>3</sup>s = cubic metres solid

2/ MT = metric ton

that the relatively high labour cost of the integrated mill reflects the high degree of employment provided in the finishing department.

Table 4  
Manufacturing Cost Estimates

Item	Pulp Mill		Integrated Mill	
	US\$ million/A	%	US\$ million/A	%
Pulpwood	0.7	20	0.7	8
Chemicals	1.1	31	2.1	27
Fuelwood	-	-	0.6	8
Electric Power	0.5	14	0.9	12
Other Materials	0.2	6	0.6	8
Labour	0.4	11	1.3	17
Administration and Overheads	0.3	9	0.9	12
Contingencies	<u>0.3</u>	<u>9</u>	<u>0.7</u>	<u>8</u>
	3.5	100	7.8	100

Sales Price Requirements

When a study of this kind is prepared for a specific location, it is customary to evaluate the return on investment starting from a sales price which is fixed by the local conditions. In this case, however, such an approach cannot be used since the estimates do not refer to any specific location, not even a specific country. For this reason, the evaluation of the viability of the mills is based on the price required for the product to obtain 12 percent compounded interest on the investment over a period of twenty years. The results arrived at in this way are US\$ 362 per air-dry ton of pulp (in slush form for pumping to the paper mill from high-density storage) and US\$ 860 per finished ton of paper in sheet form.

As regards the price requirement for the paper, US\$ 860 is frequently paid in many developing countries and even considerably higher prices are charged in some countries. As regards the pulp price, the acceptability of US\$ 362 per air-dry ton in a specific mill depends entirely on what alternatives raw materials are available and at what cost.

Nevertheless, the price seems to be within or below the price range of high-grade waste paper for printing and writing paper production, although its relative competitiveness would have to be established in each case specifically. It may, nevertheless, be concluded that both cases seem to have prospects for viable production of pulp and paper on a comparatively small scale in many developing countries.

#### Sensitivity Analysis

Figure 2 illustrates the sensitivity of the pulp price at a constant capital recovery rate or internal rate of return of 12 percent to changes in manufacturing cost or total investment. Thus an increase of investment from US\$ 9 to 11 million would increase the price requirement from about US \$ 360 per air-dry ton to about US\$ 385 at constant manufacturing cost. It can, therefore, be concluded that the viability of the pulp mill would not be seriously sensitive to increases in the total investment, since an increase of over 20 percent in the investment requirement would only require a price increase of slightly over US\$ 20 per ton at constant rate of capital recovery.

The sensitivity to changes of manufacturing cost, on the other hand, is far more marked since an increase of 20 percent in manufacturing cost calls for the price to increase up to about US\$ 410 per air-dry ton.

The same kind of diagram is shown in Figure 3 for the sensitivity of the integrated paper mill. It can be concluded also in this case that the paper price required for a capital recovery rate of 12 percent on the investment is more sensitive to changes in manufacturing costs than to changes in investment cost.

Table 5 presents the sensitivity of the two cases with regard to variation in the most important cost and price parameters. From the data shown, it can be concluded that the viability of neither the pulp mill nor the integrated mill is significantly sensitive to variation in the cost of pulpwood.

As mentioned in the beginning of this paper, there are great variations in developing countries in the cost of peroxide and electric power. Increasing the cost of peroxide from US\$ 860 per ton in the base case to a price as high as US\$ 2,000 per ton would increase the cost of pulping chemicals by 60 percent. This would reduce the rate of capital recovery from 12 percent of 1.8 percent for the pulp mill or the pulp price at capital recovery rate retained at 12 percent would have to be increased to US\$ 414 per air-dry ton. However, such an increase in pulping chemical cost would not by any means affect the viability of the integrated paper mill to the same extent.

Similarly, if the power consumption in the pulp mill was increased by 100 percent at a constant price of US\$ per MWh, the rate of capital recovery would reduce to 4.7 percent or the pulp price would have to be increased to US\$ 400 per air-dry ton to maintain a rate of 12 percent. Again, the effect on the integrated mill would be less serious. Assuming, on the other hand, that the increase in overall power cost, rather than being caused by increased consumption, were due to a 100 percent price increase to US\$ 60 per MWh, the rate of capital recovery of the integrated mill would fall below 10 percent to 9.1 percent and the price of paper required for 12 percent rate of recovery would be US\$ 921 per finished ton.

Finally, it can be noted that a reduction in sales price by 10 percent from the base price arrived at in this study would have serious consequences on the viability of both the pulp mill and the integrated paper mill.

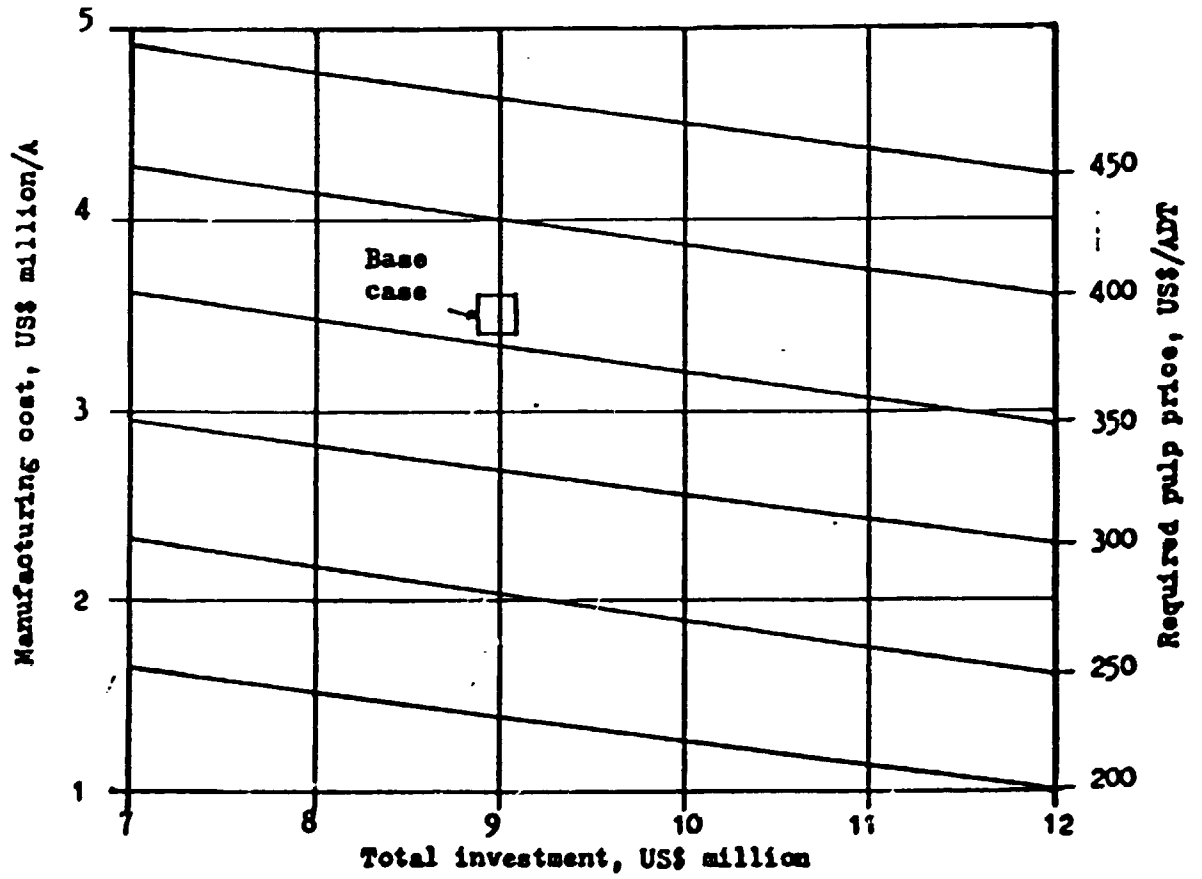


Fig. 2 - Pulp price at constant capital recovery rate (12%)

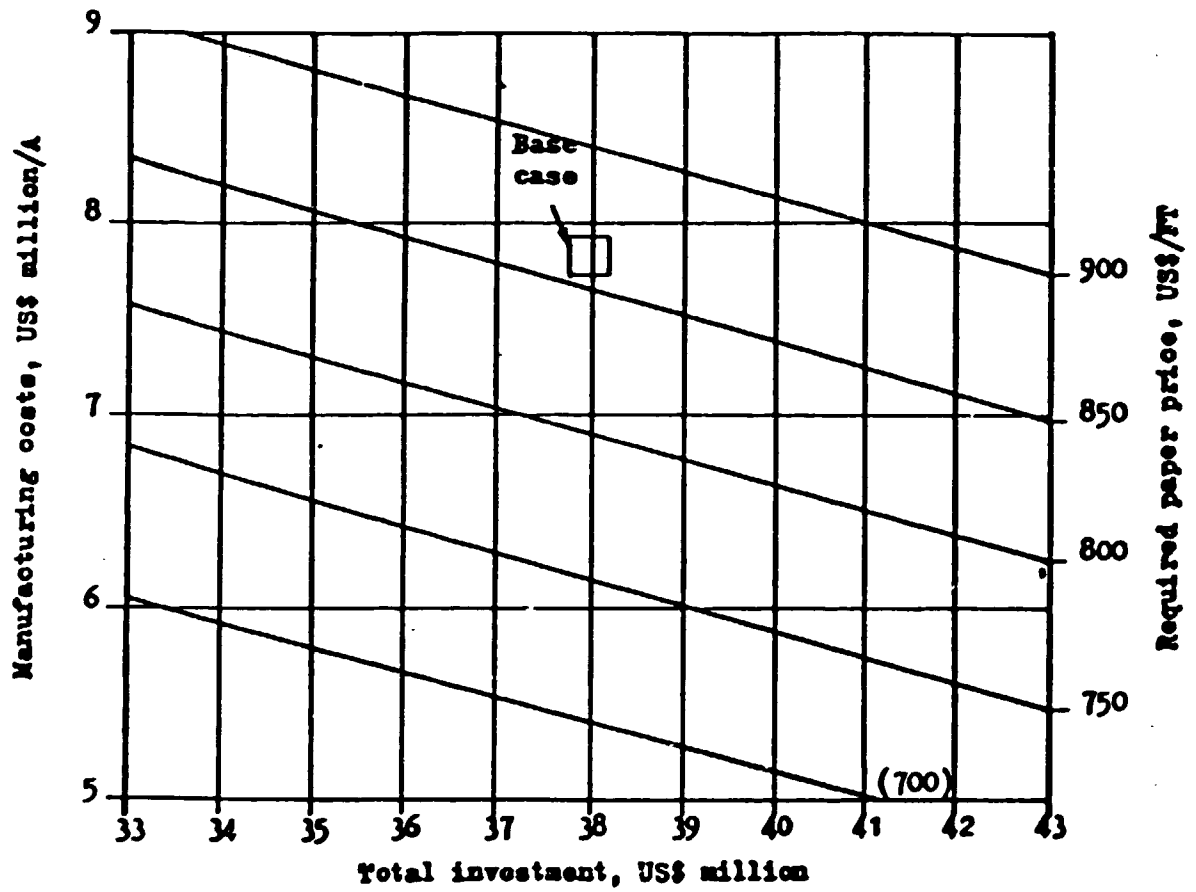


Fig. 3 - Paper price at constant capital recovery rate (12%)



Table 5  
Sensitivity of Cases to Variations in Most Important Price Parameters

Item	Change, %	Pulp mill		Integrated mill	
		Rate of capital recovery, %	Pulp price at 12% US\$/ADP	Rate of capital recovery, %	Paper price at 12% US\$/PI
Pulwood	+ 20	10.1	373	11.6	869
Pulping chemicals	+ 60	1.8	414	10.0	904
Power					
- in pulping only	+ 100	4.7	400	10.5	893
- in all departments	+ 100	4.7	400	9.1	921
Sales price	- 10	5.2	362	7.7	850

Concluding Remarks

Although the present study has used certain assumptions regarding the process of pulping, it should be mentioned that there are a number of various options which are more or less covered by the same cost estimates insofar as total manufacturing cost and investment are concerned. In order to establish the most appropriate process to be used, due consideration has to be given to the raw material, availability of certain chemicals and at what cost, as well as the cost of wood and electric power under specific conditions. Only then can the final answer be given as to whether or not a project of this kind is viable under the actual prevailing conditions in a country. Nevertheless, it can be concluded from the data presented here that production of printing and writing paper based on chemi-mechanical pulping of hardwoods can be a viable proposition in many developing countries at a production rate as low as 15 000 tons per year.

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NSCMP<sup>R</sup> - HIGH YIELD PULPING PROCESS  
FOR SMALL PULP MILLS

by  
P.K. Kauppi

INTRODUCTION

Of all the process variables present in pulping of woody materials, chemicals have perhaps the most significant impact to the capital and operating costs of a pulp mill. The chemicals influence selection of construction material for the equipment, need for environmental pollution control, and design of the chemical recovery system. The type and rate of chemicals used in pulping determine the energy requirements for the mechanical fibre separation following the chemical treatment stage.

The most dominating force in the development of the Non-Sulphur Chemimechanical Pulping (NSCMP) process has been the commitment to develop a high-yield process which is environmentally sound and simple enough for implementation in small pulp mills. In order to achieve this objective, it was believed that sulphur free pulping chemicals would be most desirable. Sufficient weakening of fibre bonding with sulphur free chemicals was sought to minimize the energy requirements for mechanical fibre separation, as well as to reduce, or completely eliminate, the requirements of chemical recovery.

PULPING

The NSCMP process (6) is covered by a U.S. patent (5) and other patent applications (Assignee: New Fibres International Inc.). The process description together with results of the pulping and paper-making trials have been presented in several publications.

The NSCMP, a high-yield (80 - 90 %) process, is suitable for small and medium-size pulp mills pulping hardwoods, mixtures of woods, and non-wood fibres. This straight-forward and environmentally promising process demonstrates good fibre separation and low refining energy consumption. These highlights of the process are created due

to the affinity of the NSCMP chemicals towards the fibre structures of wood. Impregnation of chemicals into fibre structures followed by vapour-phase cooking appears to be ideal for the NSCMP. The impregnation liquor is a mixture of monoethanolamine and ammonium hydroxide in dilute water solution.

The initial pH, at the start of the cook, is normally below 12.0 and the actual pH depends on the chemical charge and ratio of the chemicals. The latest work has revealed that the pH at the end of the cook is not as critical to the pulp properties as first believed. With a low pH at the end of the cook, only a trace of residual (active) chemicals remain in the digester. This way the pulping chemical consumption can be kept very low and the need for the chemical recovery is practically eliminated.

Over 90 % yield aspen NSCMP pulp was produced (1,2,3,4) with good pulp properties at 350 - 500 ml, CSF and the total refining energy consumption of only 250 kWh/t. A high freeness aspen NSCMP paper was produced on a pilot paper machine with excellent sheet formation and good runnability characteristics. Table 1 compares the pulp properties and Table 2 the refining energy consumptions respectively, of various high-yield hardwood pulps, including NSCMP. Figure 1 illustrates a schematic diagram for aspen NSCMP pilot plant pulp and papermaking trials. The test results clearly confirm that the high-yield NSCMP has excellent fibre separation, extremely low refining energy consumption without heat recovery and good properties at high freeness levels. None of the aspen NSCMP pulp samples were screened.

Table 1 Typical Properties of Various Hardwood Pulps

	NSCMP	NSCMP	NSSC	CMP	SCMP	CTMP	TMP
Wood Species	Aspen	Aspen	Aspen	Aspen	Poplar	Aspen	Aspen
Treatment Time, min.	15	15	21	15	30	60	15
Pulping Yield, %	88.8	91.7	82.9	84.6	90	89.3	90.5
CSF, mL	420	405	400	393	350	80	80
Density, g/cm <sup>3</sup>	0.60	0.58	0.46	0.34	0.49	0.62	0.52
Breaking Length, km	5.10	4.85	3.97	2.26	4.8	5.23	3.
Tear Index, mN.m <sup>2</sup> /g	6.15	6.63	8.08	3.89	7.1	3.18	2.18
Burst Index, MN/kg	2.79	2.49	2.15	1.10	1.5	2.23	1.16
Ring Crush, kN/m	1.68	1.34	1.06	0.96	-	-	-

Table 2. Typical Refining Energy Consumptions of Various Hardwood and Softwood Pulps.

	NSCMP	SCMP	CTMP	TMP	PGW	GLSC
Wood Species	Aspen	Spruce-Balsam	Black Spruce	Black Spruce	Soft-Wood	Hard-Wood**
Pulping Yield, %	91.6	89-92*	94	96	95-97*	74-76
CSF, mL	365	300-400	100	125	100	342
Total Refining, Energy MWh/t	0.25	1.4-1.5	2.2	2.7	1.4	0.33

\* Approximate yield

\*\* Predominately oak and gum

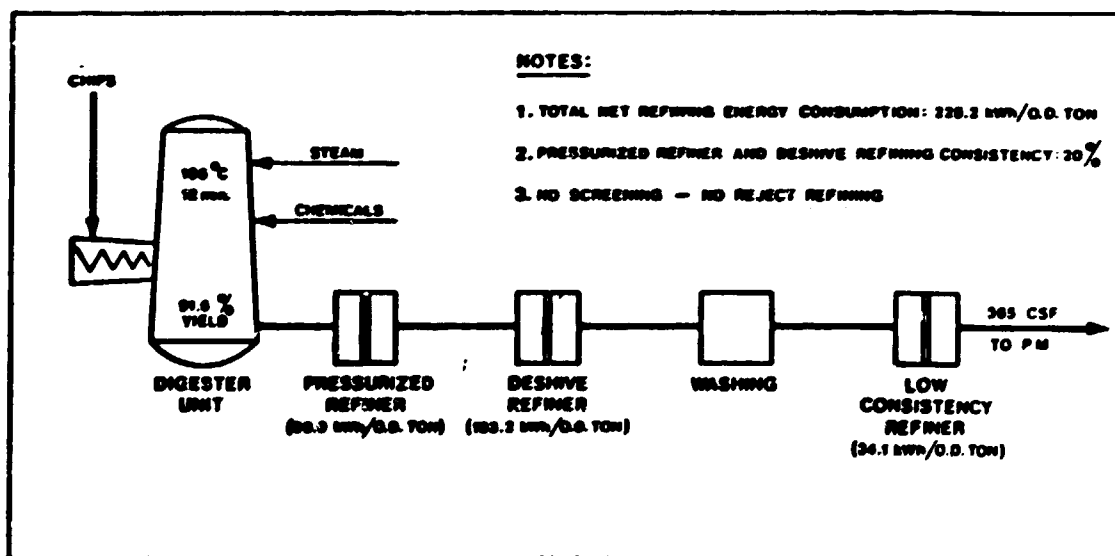


Figure 1. Simplified Pilot Plant Pulping Flow Diagram.

Mixed Southern U.S. hardwoods have been successfully pulped by the NSCMP process. Table 3 shows the results on handsheet testing of three unscreened NSCMP pulp samples of which one sample was mixed with 25 % waste clippings, and a commercial NSSC pulp sample mixed with 30 % clippings. The chips for the NSCMP cooks were atmospherically presteamed for 10 minutes, impregnated with chemicals and vapour phase cooked for 15 - 25 minutes at 170°C. Liquor to wood ratio of 3:1 was maintained in the impregnation stage, and the impregnation liquor was prepared by mixing fresh chemicals and water. The cooked NSCMP chips were defiberized in the Sprout-Waldron Model 105 refiner and beaten to the final freeness in a Valley beater. TAPPI handsheets were made and the physical properties of handsheets were determined in accordance with TAPPI Standard Methods.

Table 3. Typical Handsheet Properties of Mixed Southern Hardwood \* NSCMP and NSSC Pulp Samples

	NSCMP 1	NSCMP 2	NSCMP 3	NSSC
Pulping Yield, %	83.7	83.4	86.0	72-78
Amount of Pulp, %	100	100	75	70
Amount of Clippings, %	-	-	25	30
GSF, mL	300	320	403	222
Density, g/cm <sup>3</sup>	0.49	0.4	0.49	0.46
Stretch, %	2.63	1.70	2.39	2.10
Tensile Index, kN.m/kg	36.6	30.0	33.5	33.14
Tear Index, mN.m <sup>2</sup> /g	5.85	4.40	8.83	6.61
Burst Index, kPa.m <sup>2</sup> /g	1.74	1.48	1.69	1.69
Concora, N	273	235.7	237.5	217
Ring Crush, kN/m	1.35	1.42	1.33	1.59

\* Predominately Oak

The impregnation liquor of the NSCMP contains only a small amount of chemicals on O.D. fibre basis. The impregnation and cooking conditions can be varied considerably, as was the case between the NSCMP 1 and the NSCMP 2 samples shown in Table 3. The pulping tests confirm good

flexibility of the process with these two chemicals. The optimum pulping conditions, including the ratio of the impregnation chemicals, can be determined on the basis of wood species, desired pulp properties and other conditions.

The preliminary laboratory work on the production of 82-88 % yield kenaf and wheat straw NSCMP pulp has revealed encouraging results. The bleaching work on various wood and non-wood NSCMP pulps indicate that the pulp is bleachable and that pulp properties are considerably improved by bleaching.

#### RECOVERY

When, for one reason or another, pulping is carried out under conditions where recoverable residual cooking chemicals remain in the digester at the end of the cook, chemicals may be recovered from the process relief vapours. A small amount of residual chemicals could remain in the waste pulping liquor discharged from the pulp washing. A portion of the weak waste liquor may be reused in the pulping. The balance could be evaporated to produce strong waste liquor and burned in a boiler as a high-heat-value (10,000 BTU/lb) liquid fuel, or used as a base (sulphur and sodium free) for the production of lignin by-products. If the NSCMP mill is located on the same mill site of an existing Kraft or Soda mill, it would be possible to dispose of the NSCMP waste pulping liquor in the existing recovery boiler without upsetting the chemical balance of the existing mill.

#### ENVIRONMENTAL

The gaseous emission from the NSCMP pulping process, including evaporation and liquor burning, are sulphur and sodium free.

Disposal of the NSCMP waste pulping liquor through the existing mill effluent treatment system is possible, but will depend on the current mill operating conditions, and the existing regulations governing the characteristics of the treated effluent discharges entering into receiving waters. Since the NSCMP is a high-yield process, the BOD<sub>5</sub> generated in an NSCMP mill may be reduced to an acceptable level with modern effluent treatment techniques.

CONCLUSIONS

After completion of several years' extensive laboratory and pilot plant work, the development of the NSCMP process is sufficiently advanced for full-scale mill use on the production of high-yield (80 - 90 %) pulps from hardwoods, mixtures of woods and non-wood fibres. The process can use conventional alkali-resistant pulping equipment and, therefore, is suitable for not only new pulp mills, but also for existing mills requiring modifications and/or expansions.

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## DIFFERENT APPLICATION OF OPCO PULPING PROCESS

by

P. Vihmari

### THE OPCO PROCESS

The OPCO process is a patented process for the manufacture of chemi-mechanical pulps and is the property of the Ontario Paper Company. The process is available for license.

### WHO MIGHT BE INTERESTED?

The advantages of the OPCO process should be evaluated within the context of the particular mill. Some examples follow.

- 1) A mill with a pollution problem could replace a chemical pulping operation with OPCO to bring its effluent within regulations.
- 2) A mill purchasing SBK could switch to OPCO to reduce furnish costs.
- 3) A TMP operation forced to excessive power consumption to combat a bulk or linting problem could reduce power costs and improve drainage with the OPCO process.
- 4) In a case of a constrained woody supply, OPCO could be used to extend wood resources.
- 5) A machine with drainage or runnability problems could be improved by replacing a part of the TMP with OPCO pulp.
- 6) The OPCO processes should be of interest to anyone running a high speed newsprint machine on a groundwood or groundwood-TMP based furnish, and who wishes to reduce wood or energy costs or to ameliorate an effluent disposal problem.

### WHAT DOES IT DO?

The OPCO process produces a new kind of paper making fibre, characterized by the following:

- Environmental acceptability
- High wet web stretch
- High freeness and rapid drainage

- High pulp yields
- Increased brightness
- Increased burst and breaking length
- Reduced refining power
- Reduced bulk and linting

#### WHAT IS IT?

The OPCO process is a thermo-chemical treatment applied to mechanical pulps, particularly TMP, either after refining or between stages.

It may also be incorporated as an add-on process in existing mechanical pulp lines.

#### UNDER WHAT CONDITIONS IS THE PROCESS CARRIED OUT?

The process has the flexibility to tailor pulp properties to a wide range of needs. The best configuration involves a number of trade-offs and should be established separately for each application. Some of the factors involved are considered below.

##### 1) Paper Machine Demands

A machine which imposes low stress on the unsupported webs will be satisfied with a less developed pulp.

##### 2) Pulp Development Requirements

Pulp development increases with refining power and with cooking severity. Generally a cook of 160°C for one hour will reduce yield to about 90 % and produce an effluent BOD of around 130 lb/ODT. In most applications milder conditions would be preferred. Maximum refining power is set by the drainage requirements of the furnish.

##### 3) Interstage vs. Post Treatment

Post treatment can yield a pulp with a higher and more permanent wet stretch, for a paper machine which requires this additional stretch for stable operation.

## WHAT ARE THE CRITICAL PROCESS REQUIREMENTS?

### 1) Starting Material

The required starting material is a mechanical pulp consisting mostly of single fibres in a well fibrillated state. RMP can be used but TMP is preferred.

The process is not applicable to:

- TMP produced well above the glass transition temperature of the lignin.
- Pulps produced by refining cooked and chemically softened chips.
- Products derived from species unsuited for mechanical pulp production, such as high density hardwoods.

### 2) Chemical Requirements

Enough sodium sulphite must be used to leave some residual at the end of the reaction, and to prevent the pH from dropping below about three. Normally between 5 % and 10 % on wood will be used.

Uniformity of mixing is critical; each fibre must be protected by its share of chemical before reaching reaction temperature. This requires particular attention to higher reaction consistencies.

## HOW IS THE PROCESS CARRIED OUT?

### 1) First Stage Refining

Any refiner suitable for mechanical pulp production can be used. Pressurized refiners yield a better product. For interstage treatment, only enough power to separate the fibres need be applied in the first stage - normally under 40 HPD/T. There are some advantages to refining systems which discharge pulp at higher temperatures.

### 2) Chemical Addition

Two modes of addition are recommended as capable of giving the required uniformity of mixing:

- Addition in the dilution water in the eye of the refiner.
- Addition of excess chemical prior to a screw plug feeder ahead of the reactor.

3) Heating to Reaction Temperature

The insulating properties of a fluff TMP are phenomenal. The modes of conduction and diffusion are normally not adequate to transfer heat to the pulp mass and must be augmented mechanically. There are a number of alternate ways of achieving this.

4) Reactor Configuration

Essential requirements are a pressure vessel equipped with some means of moving pulp in and out, and of such size as to provide a retention time of 30 - 60 minutes, for a bulk density of about 4 lb./cu. ft. Perfect plug flow is not a requirement; unlike lower yield processes, fairly wide variations in time of reaction can be tolerated. Once the pulp is brought to temperature, no heat need be added in the reactor. In a gravity flow system, it must be recognized that this pulp is very prone to bridging.

Although a variety of reactor designs might meet these requirements, we are in the process of designing a system specifically for OPCO application.

5) Second Stage Refining

Second stage refining may be either pressurized or atmospheric. To maximize wet stretch in the product, refining consistency should be high. Energy savings in inter-stage treatment are somewhat greater when most of the refining power is applied in the second stage.

Alternatively, the process may be applied to a single stage TMP as a post-treatment.

EXAMPLES

Thorold spruce chips were refined in a commercial pressurized refiner at a specific energy of 38 HPD/T. A portion of this pulp was reacted at 150°C for 60 minutes with  $\text{Na}_2\text{SO}_3$  at pH 9 in a commercial continuous digester, and then refined further in a commercial open discharge refiner.

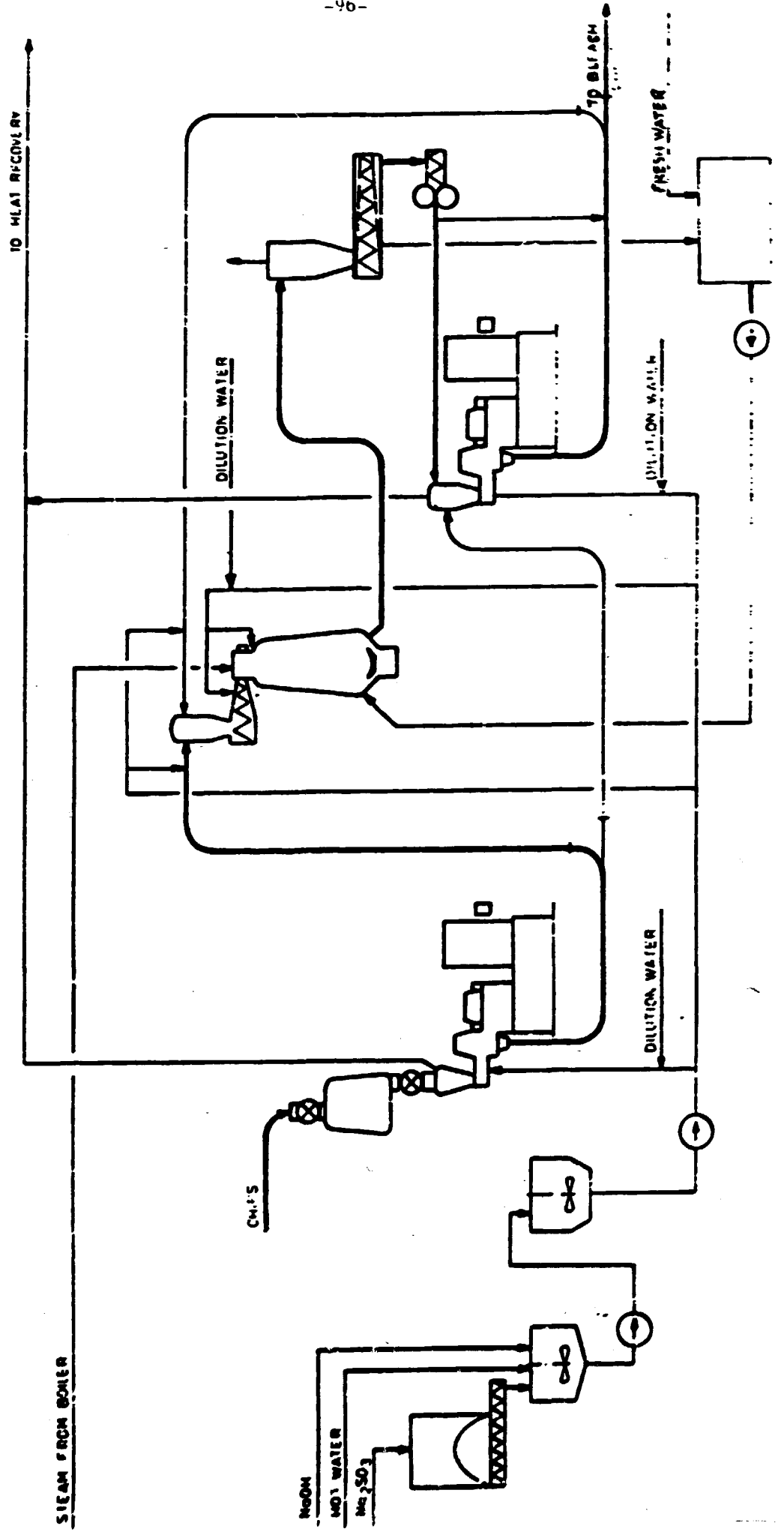
Another portion of the untreated first stage pulp was further refined in the open discharge refiner and a portion of the product reacted at 160°C for 60 minutes in the continuous reactor. The resulting pulps had the following properties, after standard delatency treatment.

<u>Treatment</u>	<u>Untreated TMP</u>	<u>Interstage Treated</u>		<u>Post Treated</u>
Refing Power Total HPD/T	88.1	76.0	88.8	88.1
CSF	136	133	79	161
Drainage Time, Sec.	1.45	2.42	5.16	1.47
Wet Stretch, %	4.8	5.8	6.2	10.6
Wet Tensile, N/m	83	112	126	75
Wet Caliper, mm.	.351	.282	.273	.323
Bulk	2.78	1.89	1.70	2.03
Burst Factor	23	38	42	30
Breaking Length	3900	6200	6900	5200
Tear Factor	85	68	60	64
Dry Stretch	1.9	2.3	2.2	2.2

These data illustrate the salient points of the process.

- Compared to TMP, all OPCO pulps show a markedly reduced bulk and wet caliper.
- Interstage treated pulps refine with less energy to yield pulps with greatly improved wet and dry strength properties.
- Post treated pulps are characterized by exceptional wet stretch which is retained through normal delatency treatments.

OPCO REACTOR TRIAL PLANT  
50 BDMTPD



THE OPCO PROCESS - CHEMI-MECHANICAL PULPS WITH UNIQUE PROPERTIES

PART I

The OPCO process was developed to provide a reinforcing fibre at yields in the 90% range, which could be used, in mixture with stone ground-wood, as a furnish for newsprint machines running at high speeds. Some of the requirements of such a pulp are listed in Figure 1. In this list, as in the real world, the bottom line is paper machine runnability - the most important single factor affecting profitability, and the one most often ignored, possibly because it is the least understood.

To understand the relationship of stock properties to machine runnability, look at the web as the paper machine sees it. The pull required to carry the web across an open draw is proportional to  $mv^2$  (1). The higher the speed, and the heavier (wetter) the web, the greater the stress. Why then do breaks not occur exclusively in the first draw where the stress is highest and the sheet is wettest and weakest? In reality, breaks are more frequent in later draws.

Figure 2 shows the stress-strain curves at first press moisture content, of two furnishes actually run on Q.N.S. #3 machine, with an SBK curve included for comparison. In normal operation with HYS furnish, Q.N.S. #3 stretches the web 1.67 % in the first draw. From the graph, the tension required to carry the web across this draw must be about 70 N/m. This same tension, applied to the UHY furnish would stretch the web to its breaking point. On this basis, the UHY furnish should be impossible to run on Q.N.S. # 3. In an actual mill trial, this pulp made paper for only 10 minutes out of 7 hours. SBK, noted for its excellent runnability is distinguished by its high extensibility, not its high wet web strength.

This dependence of runnability on wet stretch, proposed originally for HYS (2,3) has been supported by a survey of 14 mills which showed a striking correlation of machine speed with wet stretch and drainage rate (4), and has been further confirmed and elaborated by studies with a variety of furnishes on an experimental paper machine (5).

The essence of runnability is simply this: as the web is carried through the machine, stretch is traded off to supply the required tension at each point. Traded stretch is not regained when tension is relaxed. When the web runs out of stretch, it breaks. Unused stretch provides the safety margin to absorb perturbations, and to carry and equalize strains around defects. How then to create a pulp with high stretch?

The OPCO process is a thermo-chemical treatment with sodium sulphite, applied to mechanical pulps, which maximizes wet stretch by stabilizing and permanently setting the curl in the pulp fibre. This is illustrated in the microphotographs of Figure 3. Pulp A is a lightly refined TMP with the high stretch and low strength typical of latent pulps. Pulp B is the same pulp with latency removed. Stretch has been traded for improved strength. Pulp C is derived from Pulp A by OPCO treatment, retaining both stretch and strength. Delatency treatment of Pulp C yields Pulp D in which a small increment of stretch is traded for further increases in strength.

The OPCO reaction is normally carried out at a temperature between 130° and 180°C at pulp consistencies over 10 %, using 7 - 10 % sodium sulphite based on wood. Duration of reaction is usually between 15 minutes and 2 hours. Longer reaction times result in lower yield, drainage rate and scattering coefficient. However, product quality is not highly sensitive to reaction time. This has important implications in the design of the reactor; design is greatly simplified when perfect plug flow is not essential, and variations of  $\pm$  50 % in retention time can be tolerated.

The process may be applied between refining stages or as a post-treatment; each mode has advantages and disadvantages.

In attempting to compare the basic properties of pulps produced under various conditions, a serious difficulty arises; the properties of the pulp are highly dependent on the amount of curl in the fibre, i.e. latency. As the fibre is straightened out, the amount the web can



be stretched before it breaks decreases, while the force required to break it increases. Simply straightening the fibres can reduce the freeness of the same pulp by over 100 CSF, half the wet stretch and double the tensile and dry strength. Clearly comparisons made on the basis of such measurements are meaningless unless the pulps are first brought to a common standard state of latency - an impossible task. However, we can measure the properties of a pulp in two different states of latency, and use the line connecting these two points to characterize the pulp. This is illustrated in Figure 4, in which wet tensile vs. wet stretch at rupture are so plotted for a variety of pulps. Quality improves as the line is displaced upward and to the right.

By progressively straightening the fibre we can move upwards along the line defining a particular pulp, but we cannot move off the line. To a first approximation all the lines have the same slope. Pulps can therefore be ranked according to the intercepts of their line at some arbitrary value of stretch to rupture, say 5%. The resulting value corresponds to the wet tensile strength at rupture which would be measured, if the pulp latency were first so adjusted that the web breaks at 5% elongation. Note that the 5% stretch at rupture defines a standard latency condition solely for purposes of comparison; the stretch of the actual furnish may be varied anywhere along the line, depending on the demands of the paper machine.

Benefits of OPCO processing are apparent from Figure 5; under some conditions, equal levels of wet tensile and stretch can be reached at 100 points higher freeness and 40% less power compared to TMP. Alternatively at equal freeness, or equal power, higher levels of stretch and tensile can be obtained. The process has the flexibility to tailor pulp properties to a particular application.

Improved stress-strain properties are accompanied by, and probably partly a consequence of increased fibre flexibility, which in turn manifests itself in improved consolidation of the web. Better consolidation results in lower caliper in the wet web, and lower bulk in the dry sheet.

Better bonding as well as better consolidation results in lower linting tendencies and probably contributes to the improvements in dry strength obtained by OPCO processing. Thus at equal wet stress-strain properties, OPCO pulps average about  $1 \text{ cm}^3/\text{g}$  lower bulk and over 1000 m higher breaking length, and these benefits are obtained at higher freeness and with less power. Figures 6 and 7 illustrate these effects.

OPCO processing increases the brightness of TMP by about 4 points, with a brightness loss of less than 1 point after three months' aging. Scattering coefficient is decreased about 15 %. The process is without a consistent effect on tear.

The special properties of OPCO pulps are the result of optimizing fibre morphology, as well as fibre chemistry - both are necessary. For example, if wood chips are heated with sulphite under OPCO conditions and then refined, the chemistry of the OPCO fibre is duplicated, but not the morphology. This chemically softened chip separates in the refiner to yield a stiff smooth-walled fibre showing little fibrillation. The resulting pulp is characterized by poor consolidation of the web, as revealed by high wet caliper, bulk and air permeability, by picking on the paper machine rolls, and by low wet stretch and runnability. Improvements possible through further refining are limited by the pulp's low capacity to absorb refining power; at normal plate separation, specific energy is low, and attempts to increase it by increasing plate pressure result in pad collapse and plate clashing, or in unacceptably low plate clearances, fibre cutting and loss of tear. The morphology of this pulp is contrasted with that of a typical OPCO pulp in Figure 8. Note that the fibres of the latter are highly kinked, curled, flexible, and well fibrillated. This morphology is established at the moment of fibre separation and is quite unrelated to the effects of subsequent chemical processing. Optimum morphology can be obtained under conditions of thermomechanical refining.

The role of subsequent chemical treatment is to maintain wet stretch by stabilizing curl in the fibre, and to increase fibre flexibility and bonding resulting in lower bulk and higher wet and dry tensile strength.

The salient features of the OPCO process are:

- 1) Yields over 90 % with BOD loadings of the order of 100 lbs/ADT.
- 2) Energy requirements comparable to groundwood.
- 3) Chemical requirements of around 200 lb. of sodium sulphite/ODT.
- 4) A continuous process suitable for automatic control with minimum labour.
- 5) Pulp properties optimized for newsprint manufacture, particularly in the areas of linting, opacity, brightness, reversion, and paper machine and pressroom runnability.

The process economics are probably more dependent on paper machine runnability than on all other factors combined! Good runnability is indicated but not proven by these laboratory investigations. In the final analysis, the only fully reliable instrument for measuring runnability is a commercial high speed machine, and the final test of quality is still the pressroom and ultimately the marketplace. The performance of OPCO pulp in these most demanding of tests is the subject of the following paper.

#### THE OPCO PROCESS - CHEMI-MECHANICAL PULPS WITH UNIQUE PROPERTIES

##### PART II

To prove conclusively that a groundwood based furnish could be run efficiently on a commercial high speed paper machine using OPCO pulp as the sole reinforcing fibre was our next task. The inexpensive, low risk route of trials on experimental paper machines was explored, and yielded valuable information (5), but not the conclusive proof sought. A pilot plant to manufacture OPCO pulp for trials on our own machines was unattractive because of both the expense and the time delay. The remaining alternative was a trial in borrowed or rented commercial equipment adapted for our purposes. To make the jump from laboratory to full scale operation in commercial equipment, much of it designed for different purposes, was a high-cost - high-risk decision; it offered no opportunity to learn from experience, and all key parameters had to be guessed right the first time. However, no other option was available.

The requirements for a commercial trial with borrowed or rented equipment were a high-speed paper machine, preferably a fourdrinier with open draws, in proximity to a TMP plant; a groundwood plant; a continuous reactor capable of processing the required 50 - 100 tons of pulp in a reasonable time, and lastly, a willingness on the part of the owners of this equipment to participate in this venture.

Facilities throughout North America and Europe were surveyed and only one really satisfactory combination was located. We were fortunate indeed to secure the cooperation of the United Paper Mills in Finland. Their assistance was vital to the success of the enterprise.

Using our best guesstimate of the degree of refining needed to produce the required stress-strain properties in the OPCO product, TMP was produced in the Kaipola tandem system at a target freeness of 250 CSF, blown to trucks and shipped to the Tampella mill at Heinola for reaction. The reactor was designed to make fluting stock from a chip feed. Only through the heroic efforts of the Tampella crew was it possible to adapt it to our purpose in the available time.

The treated pulp, trucked back to Kaipola, was not screened because the freeness was already a little below target, and a short trial indicated that a freeness drop of another 30 points could be anticipated after screening. The pulp appeared clean, with a low shive content. It was centri-cleaned in a regular 3-stage system at a reject rate of 1.5 %.

The resulting product was a typical OPCO pulp. Figure 9 compares latent and delatent stress-strain properties of this pulp with some OPCO pulps produced in other equipment and regarded as typical, and with the TMP starting material. Other points in the figure indicate the inferior properties of an UHY pulp, and the superb properties of the Kaipola chemical pulp furnish which the OPCO pulp was intended to replace. It concluded that the OPCO pulp prepared in Finland was representative of the process, and in no way exceptional. Table 1 shows the latent and delatent properties of the pulp and compares them with the properties obtained on the untreated pulp.

Our original intention was to use a mechanical pulp furnish of 100 % groundwood in the trial but this was not possible because of the mill set-up; the highest percentage which could be supplied was 70 % groundwood with 30 % TMP. However, Table II shows that the properties of Kaipola groundwood produced on Roberts grinders, in mixture with 30 % TMP, are comparable to 100 % groundwood, produced on Waterous magazine grinders at Q.N.S.

The final test of all our theories came at 1400 hours, September 5, 1979 at Kaipola, Finland, when chemical pulp consisting of 9 % LYS and 9 % SBK was replaced in a single step with 33 % OPCO pulp on # 5 fourdrinier machine running 30 lb. B.W. at 2400 ft./min. This moment went completely un-noticed by the paper machine, which continued to run as though nothing had happened. OPCO content was reduced to 28 %. There was no change in dry line, in vacuums or in steam consumption. Draws were reduced slightly - a sign of a strong well drained sheet. After about 3 hours, a single break occurred. The tail rethreaded on the first try and the machine was reeling paper again in 6 minutes. Duration of the trial was about 7 hours. More important than the test data, recorded in Table III, was the reaction of highly qualified observers from both companies. There was unanimous and unqualified agreement that our goal of replacing low yield chemical pulp in a newsprint furnish had been achieved.

Most companies feel that being able to sell paper is at least as important as being able to make it. Pressroom acceptability was assessed on both continents.

Offset printing was assessed in a small run at Koillis-Hame, and in a 20,000 copy run at 26,000 i/hr run at Aamulehte in Finland, followed by 218,000 copies at 45,000 i/hr at Ft. Lauderdale. There were no breaks due to paper in any run. Linting was not a problem; at Ft. Lauderdale the lint was considered about equal to that of an ordinary twin wire sheet. Print quality was at least equal to normal production.

At the Washington Star, 131,000 copies were printed by Letterflex, without breaks, wash-ups, or problems. Print quality was marginally better than normal Q.N.S. production. Showthrough was normal and set-off was not a problem. The OPCO sheet meets the demands of the modern press-room in the critical areas of strength, linting, opacity and print quality.

A solution is now at hand to one of the major problems facing the North-American industry - what to do with the groundwood mill. This capacity is installed, paid for, and proven. Groundwood is the major component, and the cheapest component of our newsprint, but traditionally it has required reinforcement with chemical pulp. If chemical pulp is retained, we are faced with huge expenditures for recovery and pollution abatement processes. Often we cannot even be sure in advance that these processes will work. The past decade's record of mill closures in the East is testimony to the gravity of this problem.

If the chemical pulp is abandoned, and the switch made to TMP, the groundwood capacity is rendered obsolete and a host of new problems appear centered on bulk, opacity, linting, and energy. It is worth repeating that the OPCO process, in a mill trial, yielded a low linting sheet from an unscreened pulp prepared from a 250 CSF TMP, at a specific refining energy of only 75 HPD/T. The Finnish trial showed that by substituting OPCO pulp for chemical pulp, we can retain our groundwood mills, reduce pollution to manageable proportions, and reduce our wood requirements without penalty in energy costs or in paper machine or pressroom runnability.

The OPCO process offers an economically attractive way of satisfying the various demands of the paper makers and printers, as well as the conservationists and environmentalists.

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ENVIRONMENTAL ACCEPTABILITY

QUALITY

Brightness & Reversion

Opacity

Linting

Printability

ECONOMY

Wood

Labour

Energy

Chemical

Capital

RUNNABILITY

Pressroom

Papermachines

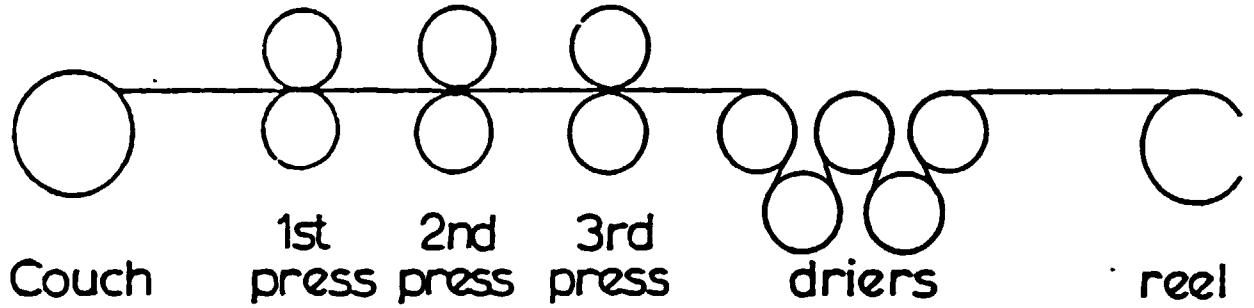


FIGURE 2

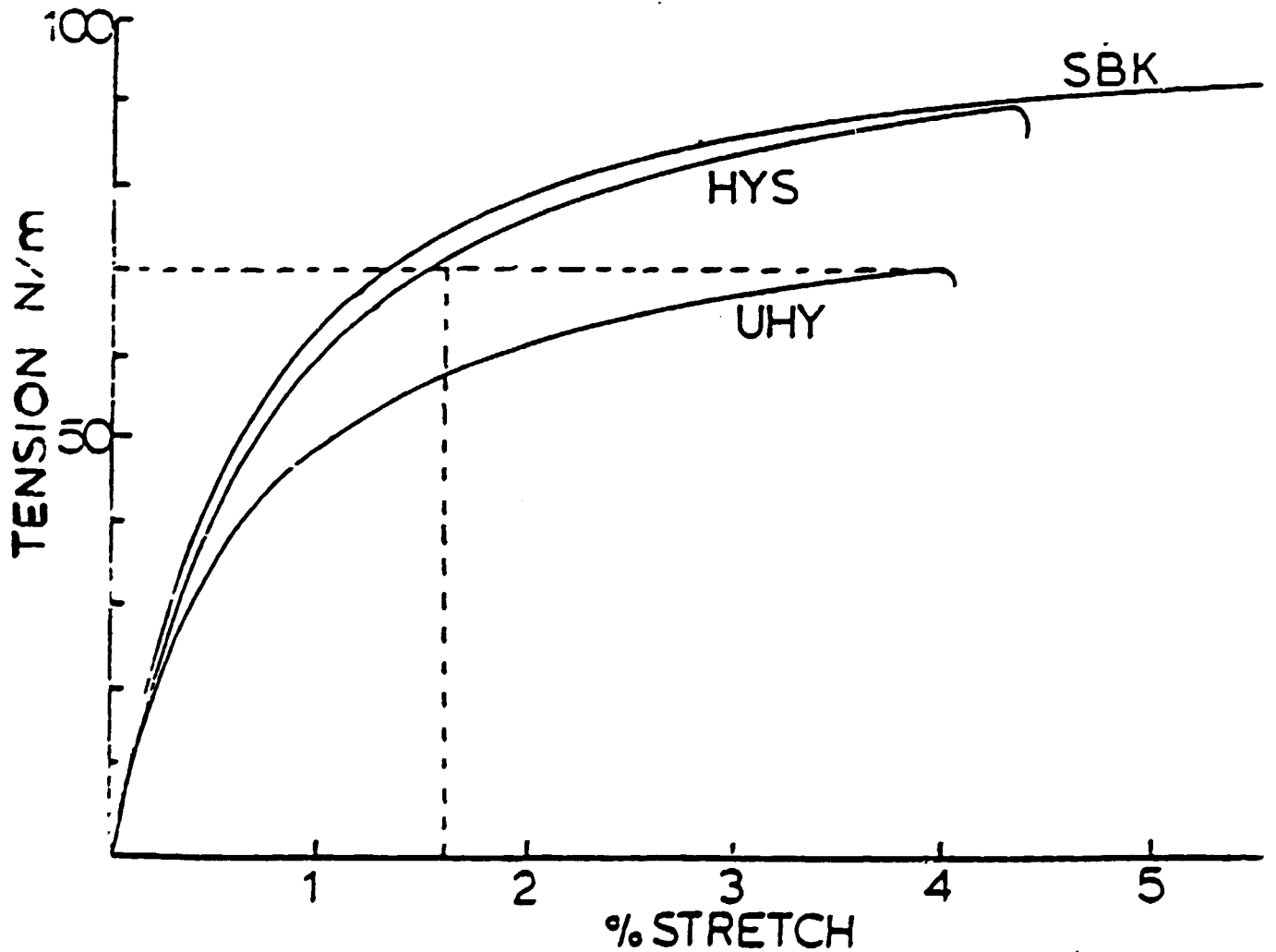
QNS no 3

Solids 15%    30.2%    34.3%    36.5%                    93.1%

Draws 0.4%    1.6%    0.7%    0.3%



Mixed Stock Wet Web Properties



A

Stretch	10.0%
Tensile	23
Burst	6
B.L.	700
Tear	46

B

Stretch	4.5%
Tensile	57
Burst	14
B.L.	2500
Tear	98

C

Stretch	9.9%
Tensile	39
Burst	15
B.L.	2600
Tear	102

D

Stretch	7.8%
Tensile	57
Burst	28
B.L.	4600
Tear	73

FIGURE 4

COMPARISON of WET WEB  
PROPERTIES

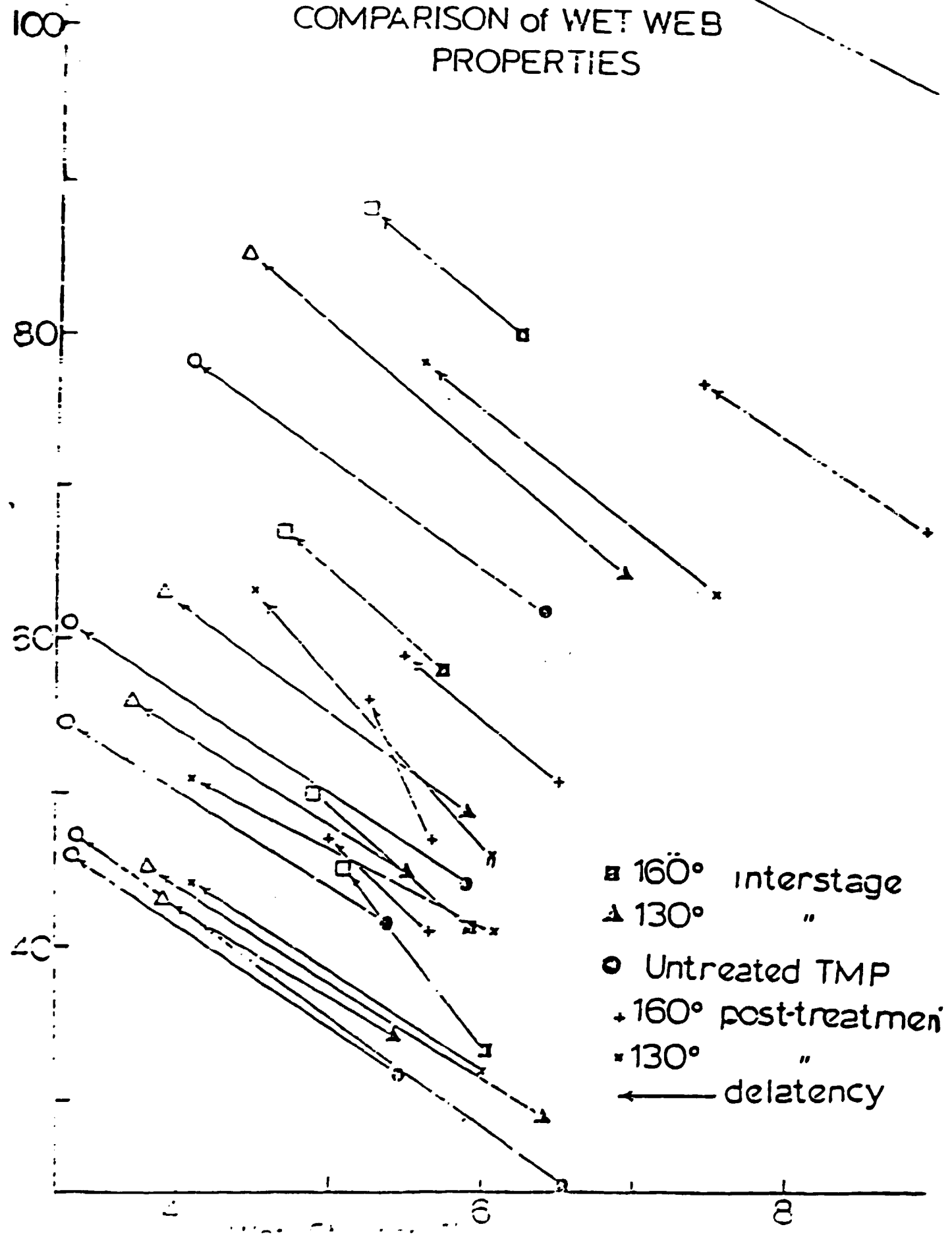




FIGURE 6

REFINING of Opco PULP

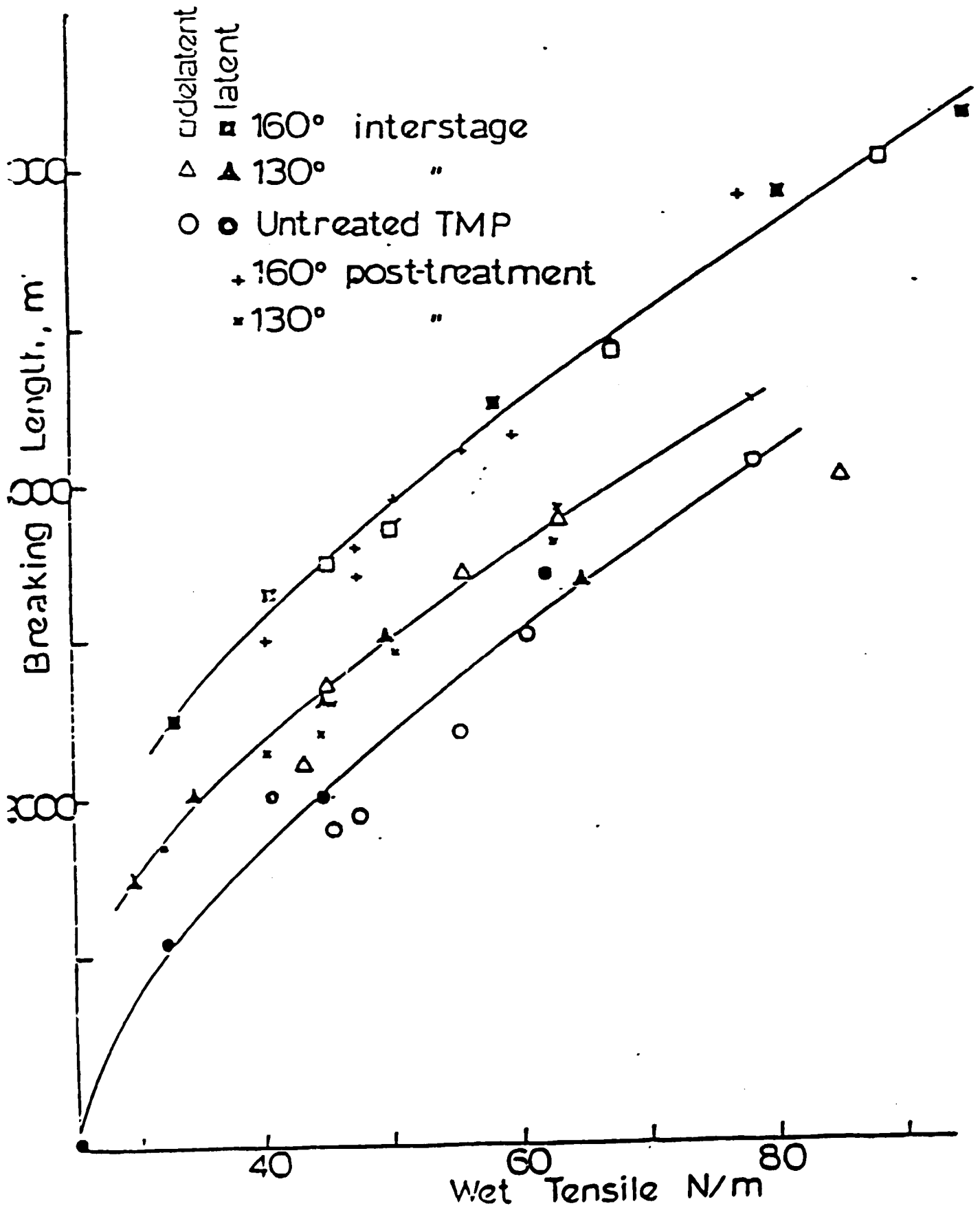
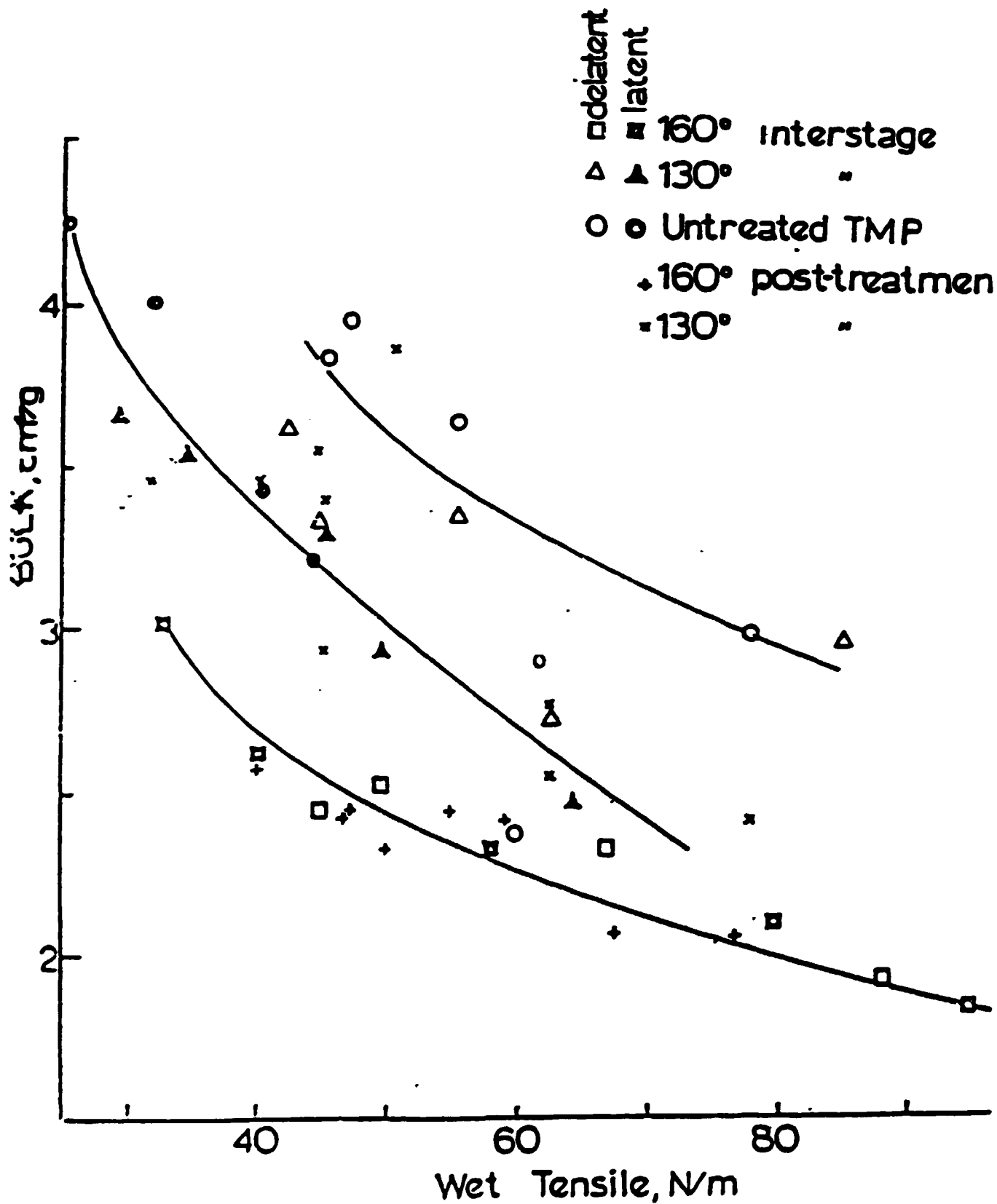


FIGURE 7

REFINING of Opco PULP



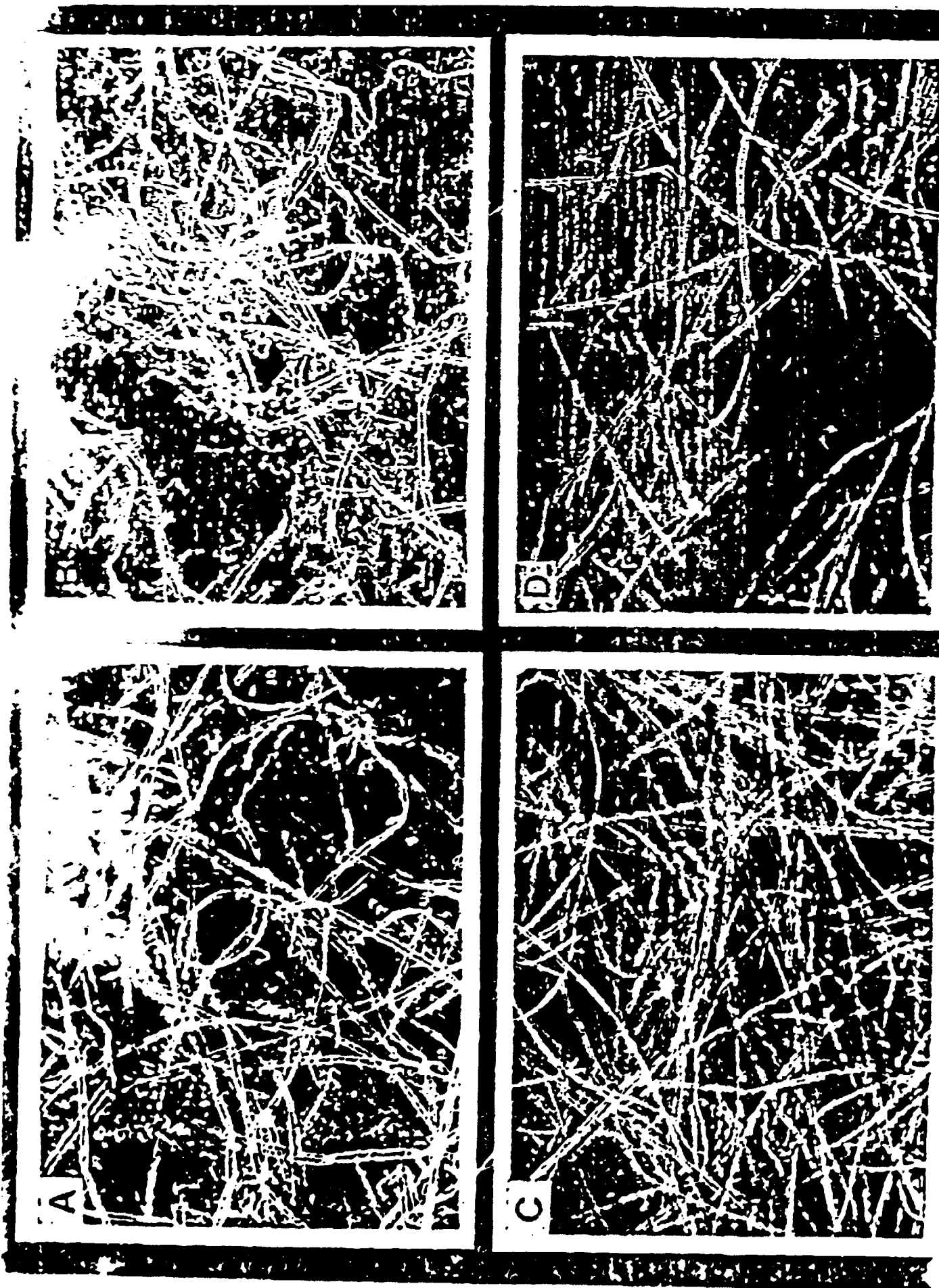


FIGURE 9 - COMPARISON of PULPS

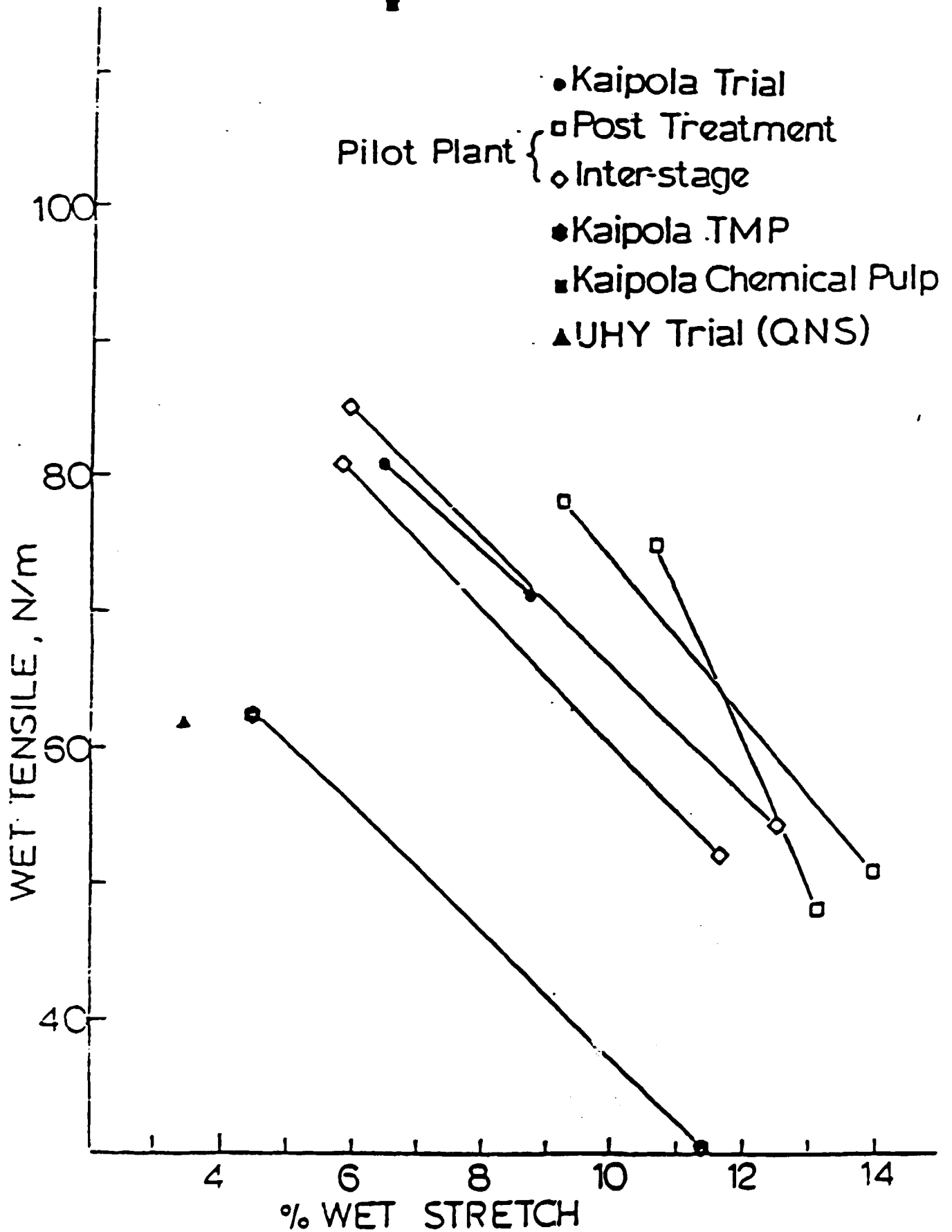




TABLE I

Opco Pulp

	<u>Untreated</u>		<u>Treated</u>	
	<u>Latent</u>	<u>Delatent</u>	<u>Latent</u>	<u>Delatent</u>
Freeness, CSF	493	265	186	178
Drainage, secs.	0.59	0.74	1.19	1.31
<u>Wet Web Properties</u>				
Tensile (N/m)	30	62	71	81
Stretch (%)	11.3	4.4	8.7	6.5
Caliper (mm)	0.450	0.387	0.335	0.318
<u>Dry Properties</u>				
Bulk	3.55	3.20	2.17	2.02
Burst Index	0.8	1.7	2.9	3.3
Breaking Length	1300	3000	4600	5300
Stretch (%)	1.7	1.6	2.2	2.4
Tear Index	8.3	11.5	9.0	8.0

TABLE II

Mechanical Pulp

	<u>Kaipola</u>	<u>Q.N.S.</u>
Freeness (CSF)	100	72
Drainage (secs.)	2.30	2.56
Wet Tensile (K/m)	67	67
Wet Stretch (%)	5.6	5.0
Burst Index (kPa m <sup>2</sup> /g)	1.7	1.6
Tear Index (mN m <sup>2</sup> /g)	5.8	4.9

TABLE IIIPaper Machine Trial

		<u>Before</u>	<u>During</u>	<u>After</u>
<b>Furnish</b>				
Groundwood	(%)	57	50	58
MP	(%)	25	22	26
Semibleached kraft	(%)	9	0	8
Unbleached sulphite	(%)	9	0	8
Opco pulp	(%)	0	28	0
<b>P.M. Conditions</b>				
Wire speed	(m/min)	693	694	695
Reel speed	(m/min)	724	724	724
Headbox pressure	(kPa)	63.2	63.8	63.3
Slice opening	(mm)	10	10	10
Supercalender speed	(m/min)	700	700	700
Linear pressure	(K N/m)	190	190	190
<b>Paper Characteristics</b>				
Basis weight	(g/m <sup>2</sup> )	48.1	49.8	48.7
Bulk	(cc/g)	1.56	1.57	1.56
Tensile Index M.D.	(Nm/g)	44.5	41.9	41.2
Stretch M.D.	(%)	1.05	1.13	1.11
Tear C.D.	(mN m <sup>2</sup> /g)	222	196	203
Burst Index	(kPa m <sup>2</sup> /g)	1.43	1.31	1.32
Roughness 1 kg T.S.	(m/min)	86	101	87
W.S.		97	104	92
Brightness I.S.O.	(%)	60.9	59.2	61.2
Opacity I.S.O.	(%)	93.9	93.6	93.6
Porosity	(m/min)	224	213	216
Caliper uncalendered	μm	120	127	123
calendered	μm	75	78	76

LOW-COST INTEGRATED PAPER MILL -  
A SWEDISH CONCEPT FOR DEVELOPING COUNTRIES  
( MONOPULP PROCESS)

INTRODUCTION

The feasibility study on operating the 100 tpd pulp and paper mill, focusing on developing countries, was made possible by financial support from the National Swedish Board for Technical Development, the Swedish International Development Authority and the Swedish Export Council.

The LCI (Low-Cost Integrated) project is based on new pulping and bleaching technology which permits the manufacture of hard-wood chemi-mechanical pulp for writing and printing papers, as well as for news-print. The study has been carried out by Swedish consultants and suppliers comprising Celpap in Norrköping, KMW in Karlstad and Sunds Defibrator in Stockholm.

The main advantages of the LCI Mill can be summarized as follows:

- Comparatively low investment cost - 20 to 30 percent less than for a conventional integrated kraft mill;
- Comparatively short time from planning to start-up;
- Wide range of paper grades - produced from one pulp quality only, eliminating the need to import long fiber;
- High yield pulping process - 90 percent yield;
- Reduced pollution - environmentally safe;
- Compact mill layout.

PART 1 - THE CMP PULP MILL

Summary

Paper is one of the most common everyday materials. However, many countries wishing to establish domestic paper production, have been constrained by the high construction and operation costs of a conventional pulp and paper mill.

The LCI Mill Concept (Fig. 1) refers to a mill designed for integrated production of finished paper from hardwood. It involves the whole process, from woodyard to finishing, wrapping and storage.

The intention has been to provide a complete LCI Mill, based on the very best that Sweden has to offer in terms of equipment, detailed engineering, construction techniques, start-up know-how and management services.

#### Wood Handling

The LCI Mill Concept uses the Eucalyptus tree (*Eucalyptus Globulus*) as the raw material for pulp production, but any other suitable hardwoods could be used. At the mill, the logs will either be piled or sent directly to a conveyor deck (Fig. 2). Manual barking directly after felling is recommended, but if mill barking is preferred, a barking drum and a conveying system has to be installed. A log washing unit is installed in front of a horizontal feed chipper, followed by a chip screen. Over-sized chips are rechipped and rescreened. Accepted chips are deposited in a chip pile with an average volume of  $3,500 \text{ m}^3$ , corresponding to one week's consumption.

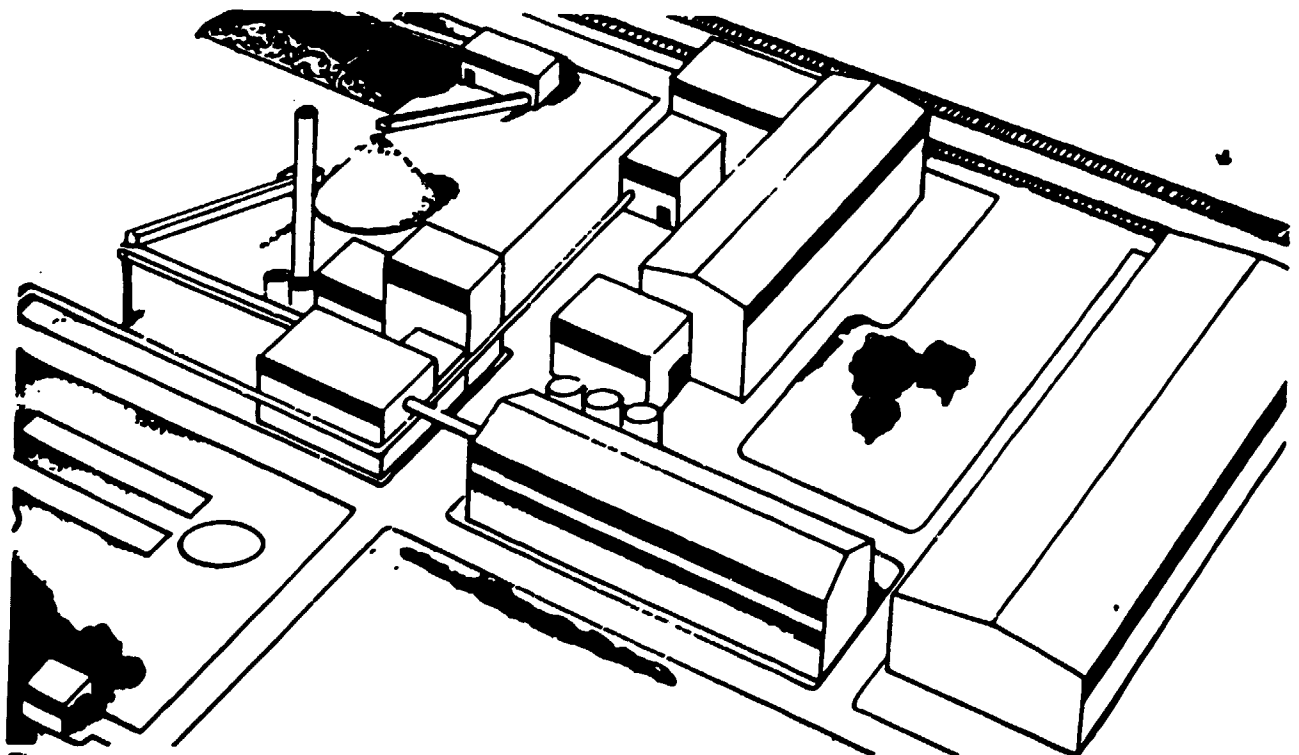
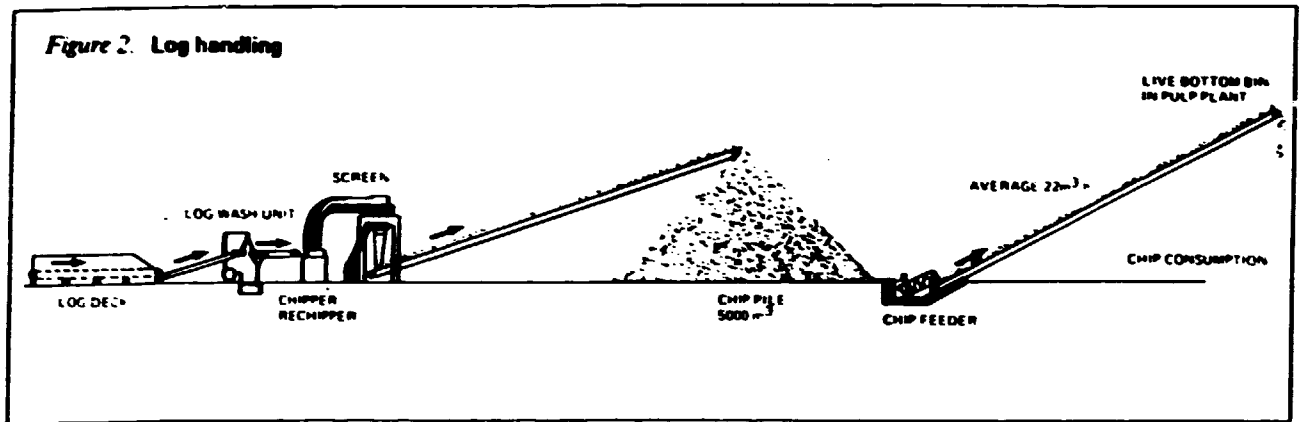


Figure 1. LCI Mill Concept



### Pulping and Bleaching

Basic data for the integrated mill is calculated on the basis of 333 operating days per year. Design capacity for the CMP plant is 41,600 BDMT per year, or 125 BDMT per day.

The flow diagram for the entire CMP plant is shown in Fig. 3. Chips are fed from the chip pile to a 10 m<sup>3</sup> live-bottom bin prior to chip washing and presteaming. Atmospheric steam generated in the primary stage refiner, at a temperature of about 100<sup>o</sup>C, is used for heating the chips before PREX-impregnation. The hot chips are compressed in an ADI-12 plug feeder (Fig.4), which feeds them into the bottom of the up-flow atmospheric impregnation vessel. The retention time, around 10 to 15 minutes, is controlled by the speed of the lifting screw and the liquor level.

A pure caustic soda liquor is preferable when using Eucalyptus, and the charge will be in the order of 30 to 50 kg per ton of wood (Fig.3). After excess superficial liquor has drained from the chips in the top section of the vessel, the chips are fed to a surge bin where they undergo alkaline swelling for 10 to 15 minutes.

Primary stage refining (Fig.5) incorporates a second plug feeder, a pressurized feed chute and the RGP 60 Raffinator, the first in a new generation of refiners from Sunds Defibrator. The Raffinator (Fig.6) is pressurized and powered by a 7.5 MW, 1500 rpm, synchronous 10 kV motor. The refiner is operated at a steam pressure of 0.25 MPa-x corresponding to a temperature of 138<sup>o</sup>C. Compared with atmospheric refining (Fig.7), the pressurized concept offers improved operational stability without any adverse effect on pulp quality.

Prior to the secondary refining stage (Fig.3), the pulp is dewatered in a screw press to approximately 30 percent consistency together with screen and centricleaner rejects. Refining power consumption is estimated at 1900 kWh/BDT, including rejects. After single-stage pressurized screening, the accepted pulp is centri-cleaned in three stages and pre-dewatered in a disc filter before washing in a twin-roll VPE-200 press (Fig. 8).

The VPE Press operates according to the counter-current principle, washing out dissolved organic substances, thus avoiding excessive consumption of bleaching chemicals. Very little liquid is carried forward to the bleaching system since the pulp is discharged at a consistency of 45 percent.

Hydrogen-peroxide bleaching (Fig.3), is carried out according to the HEP-process (High Efficient Peroxide) developed by SCA (Svenska Cellulosa Aktiebolaget). The most important process parameters are:

- Prewashing of the pulp in order to remove dissolved organic matter;
- High chemical concentration in the bleaching tower;
- "Closed"bleaching chemical loop with recirculation of residual chemicals.

For newsprint, a final brightness of 50 to 55 percent ISO is anticipated, while the pulp for printing and writing will be bleached to a brightness of 60 to 65 percent ISO. The hydrogen peroxide consumption will be 10 and 20 kg/ton respectively. A post refiner following the bleaching tower will reduce the freeness level further to 100 ml CSF, adding some 500 kWh/ton to refining power consumption. A process-water treatment plant will supply the mill with all the required water. Other facilities such as media supply, maintenance and services are included to ensure smooth mill operation.

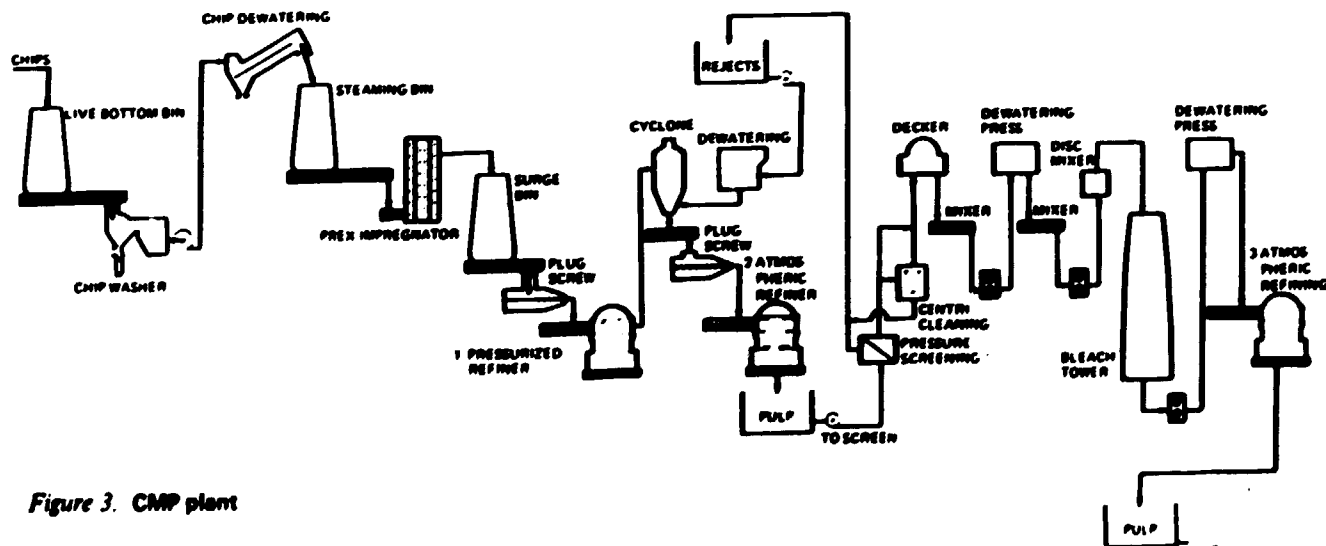


Figure 3. CMP plant

Figure 4. ADI-12 plug feeder

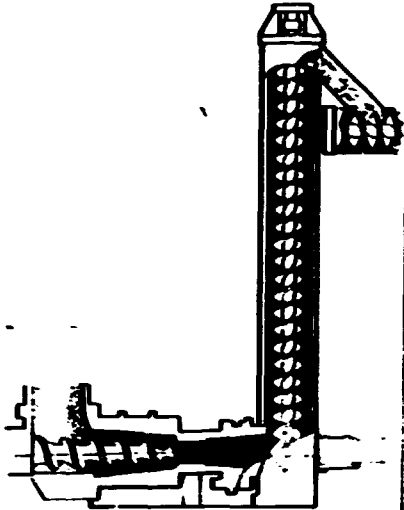


Figure 7. Eucalyptus Globulus pulps produced by pressurized and atmospheric refining respectively

		Thermofiner	Atmospheric
Chemical Charge, NaOH	kg/t:	51	54
Yield	%:	90.5	91.0
Refining Power Consumption	kWh/t:	2350	2750
Density	kg/m <sup>3</sup> :	535	575
Tensile Index	Nm/g:	52	52
Tear Index	mN.m <sup>2</sup> /g:	6.4	6.4
Scattering Coefficient	m <sup>2</sup> /kg:	45	42
Brightness, Unbleached, ISO	%:	47.0	49.5
Brightness, Bleached, ISO	%:	55	55
Peroxide Charge H <sub>2</sub> O <sub>2</sub>	kg/t:	5	3
Brightness, Bleached, ISO	%:	75	75
Peroxide Charge H <sub>2</sub> O <sub>2</sub>	kg/t:	50	46

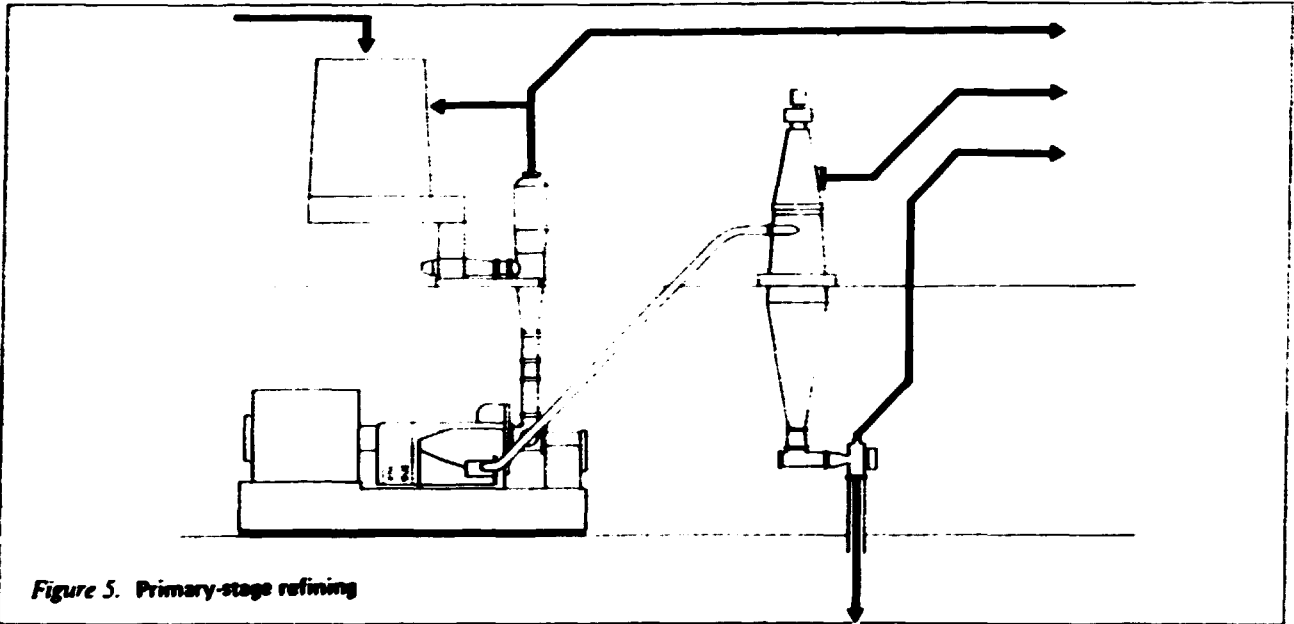


Figure 5. Primary-stage refining

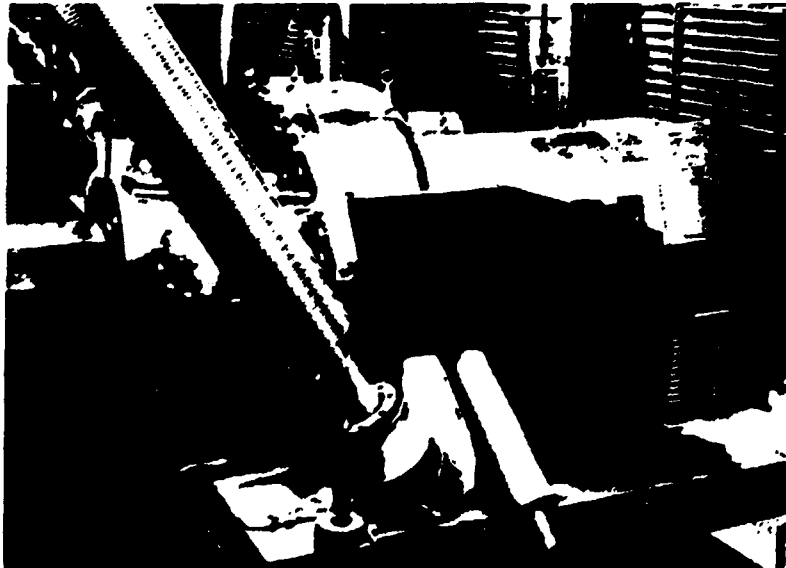


Figure 6. "New generation" RGP 80 refiner

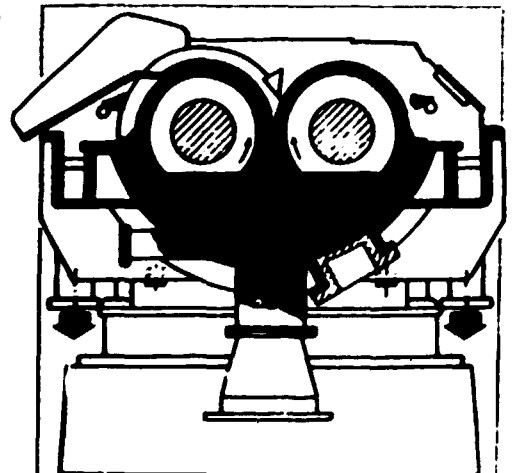


Figure 8.

Twin-roll VPE-200 dewatering press



### Pulp Quality Versus Energy

All high-yield pulps consume substantial amounts of electric energy. To be independent from the community grid, electric energy will be generated by the mill's own power plant, a coal- and wood-residue fired steam boiler with a radial type condensing extraction turbine, yielding 22.5 MW at a power factor of 0.9.

The refining power consumption for a given freeness level depends on the pulp yield (Fig. 9). At a yield level of 90 percent, power consumption is nearly 2000 kWh/ton while a yield drop of 5 units to 85 percent reduces power demand to some 750 kWh/ton. For mechanical pulps, used for printing and writing grades, suitability is determined largely by opacity and strength (Fig. 10). The scattering coefficient should exceed 45 m<sup>2</sup>/kg, corresponding to a yield level of 90 to 91 percent, resulting in a power consumption of 2000-2500 kWh/ton.

The Eucalyptus pulp will then have properties slightly inferior to a Scandinavian newsprint furnish. Lowering the yield in order to save energy reduces the scattering coefficient to an unacceptably low level.

The low opacity might be controlled by filling the paper with clay, but only to a certain extent. Lowering the yield also generates new problems, such as increasing the amounts of organic and inorganic substances in mill effluent. The best solution is to optimize results by adapting the yield and the characteristics of the pulp to the specific requirements of the paper produced.

Figure 9

Eucalyptus Globulus: Refining power versus yield

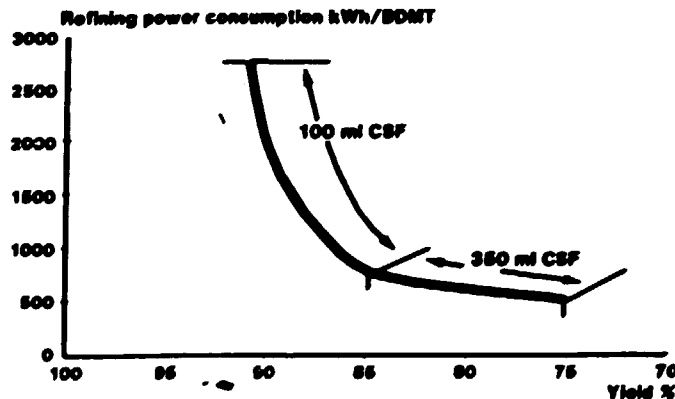
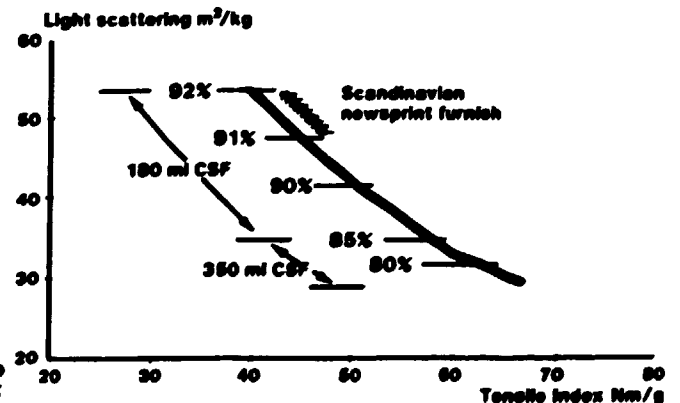


Figure 10

Eucalyptus Globulus: Pulp properties



PART II - THE MARKET FOR THE LCI MILL CONCEPT

The market for the LCI Mill Concept is not limited to developing and newly-industrialized countries. Many industrialized countries have also shown great interest, including the US, Germany, the United Kingdom and Canada.

Although the feasibility study concentrates on developing countries, the LCI Concept will also enable other countries to produce paper economically (Fig. 11).

The mill covered by the study has a design capacity of 100 tpd. A mill of this size is appropriate in a developing country, but would prove uneconomical in an industrialized country.

Countries for which the LCI Concept is particularly suitable due to their large import of writing and printing papers include Indonesia, Malaysia, Brazil, Nigeria, India, Pakistan, Mexico and Argentina (Fig.12.)

Countries that import 30,000 tons or more per annum of newsprint, which therefore represent potential markets for the LCI Mill, include Mexico, Venezuela, Peru, Ecuador, Colombia, Brazil, Argentina, Thailand, Taiwan, Malaysia, Israel, Indonesia, India and China (Fig. 13). A number of these countries, such as Venezuela, Thailand and Israel, are also major pulp importers. Moreover Bolivia, Burma, the Dominican Republic, Guatemala, Malawi and Tunisia are planning to export paper and therefore the LCI Mill Concept is particularly suitable for these countries as well (Fig. 14).

The LCI Concept involves technical modification of the mill, as well as adapting its size. Much of the equipment installed in large pulp and paper plants cuts labor costs. In the relatively small LCI Mill, it would be uneconomical to install advanced operating control equipment. Instead, alternative solutions have been adopted which contribute to economical mill operation and optimization of product quality.

Figure 11. Layout of an LCI Mill

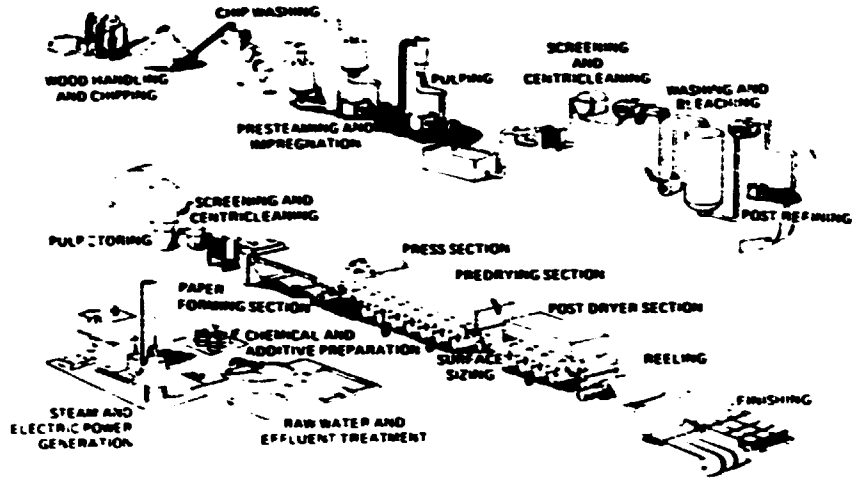


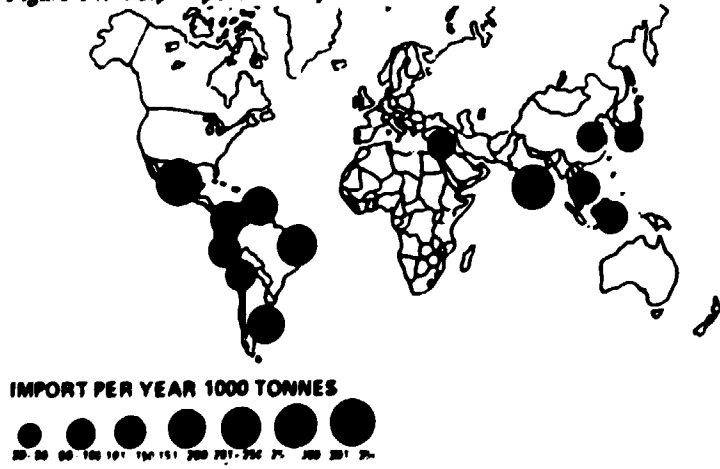
Figure 12. Importers of printing and writing papers



Figure 13. Importers of newsprint



Figure 14. Pulp importers are potential market



### The Paper Quality

The chemi-mechanical hardwood pulp produced by the LCI Mill permits the manufacture of many grades of uncoated cultural paper, eliminating the need to import softwood pulp. Pulp grades can be varied by using different amounts of bleaching agents, by adding china clay or by varying power input to the refiners.

The paper machine's basis weight range is between 45 and 100 g/m<sup>2</sup>. The process is suitable for the production of printing and writing papers as well as newsprint and magazine papers.

The properties of the paper produced by the LCI Mill compare favourably with paper produced by "conventional" methods in the developed countries.

The brightness of newsprint produced according to the LCI Concept is comparable to that of conventional newsprint.

Although the light-scattering coefficient and the opacity of the paper produced from Eucalyptus pulp (LCI) were below levels given for reference samples (Fig. 15), the levels were still quite satisfactory: opacity 94.5 percent ISO at a brightness of 57 percent ISO.

In Fig. 16, LCI-paper is compared to normal printing and writing paper (P&W), made from chemical pulp.

Newsprint produced exclusively from chemi-mechanical pulp derived from Eucalyptus has a tensile index well above that of a Scandinavian newsprint furnish (i.e. 85 percent softwood and 15 percent kraft pulp), given the same density for both papers. The tear index was only marginally lower than the reference sample (Fig. 17).

Print-through depends very much on the opacity of the paper. However, pigment penetration and the separation of the vehicle are also important factors. Letterpress printing tests showed a higher ink requirement for the Eucalyptus-pulp paper when compared to the reference sample, but the same print-through properties, as shown in Fig. 18.

**Figure 15. Comparison of optical properties.  
LCI vs Newsprint**

Paper grade		LCI	Newsprint
Basis weight	g/m <sup>2</sup>	52	52
Brightness	% ISO	66 (54)	55
Opacity	% ISO	94	96
Light scatt coeff	m <sup>2</sup> /kg	51	97

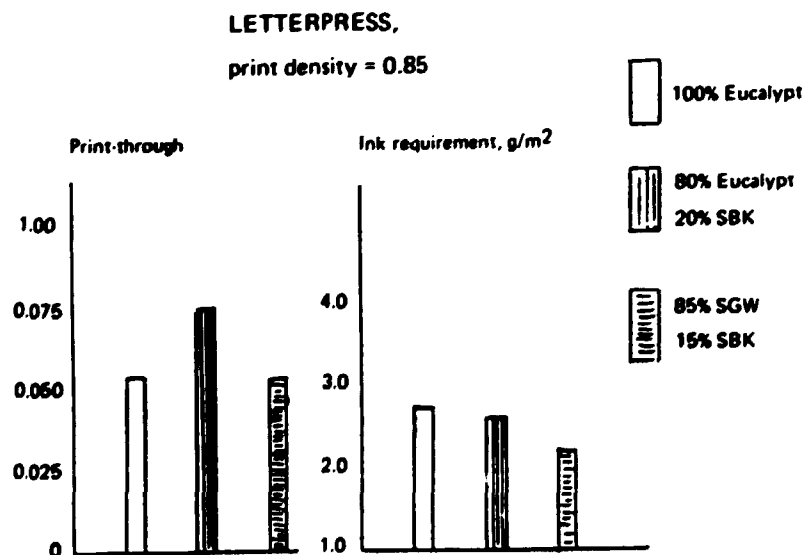
**Figure 16. Comparison of optical properties.  
LCI vs P&W.**

Paper grade		LCI	P&W
Basis weight	g/m <sup>2</sup>	69	60
Brightness	% ISO	75	80
Opacity	% ISO	86	82
Light scatt coeff	m <sup>2</sup> /kg	51	-

**Figure 17. Comparison of strength properties.  
LCI vs Newsprint and P&W.**

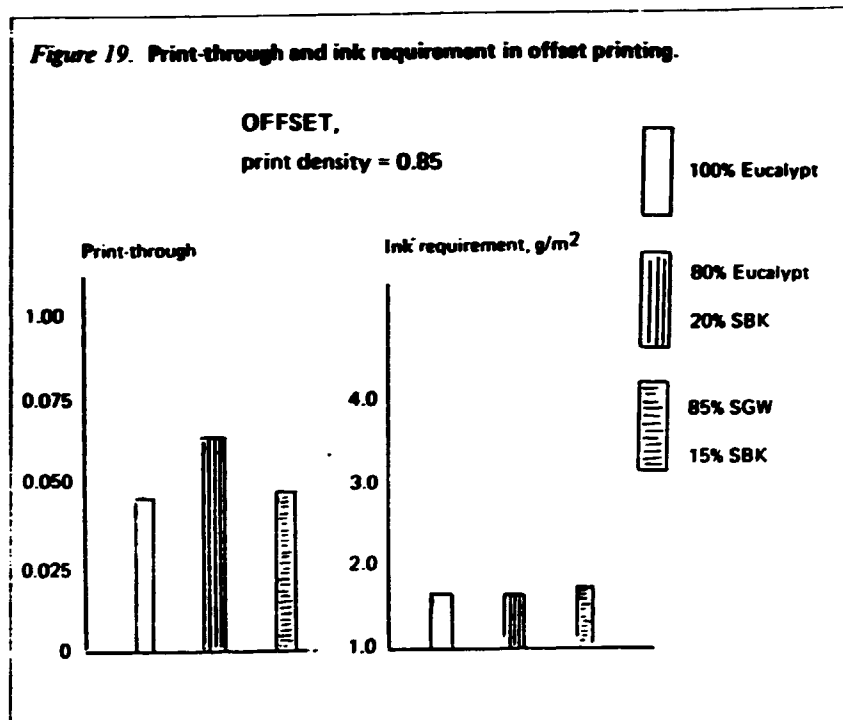
Paper grade		LCI		Newsprint	P&W
Density	kg/m <sup>3</sup>	470	625	473	750
Basis weight	g/m <sup>2</sup>	52	60	52	60
Tensile Index	Nm/g	61	50	39	41
Tear Index	mNm <sup>2</sup> /g	5,2	4,9	5,4	7,7

**Figure 18. Print-through and ink requirement in letterpress printing.**



Offset printing tests revealed no differences in ink requirement or print-through at a print density of 0.85. At a print density of 1.0 the Eucalyptus pulp paper required somewhat more ink, but the difference in print-through was minimal (Fig. 19).

All the printing tests confirmed that pigment penetration was higher and the vehicle separation lower for paper manufactured from Eucalyptus pulp. Reduction in print-through was noted following the addition of kraft pulp to the furnish.



**Figure 20. Investment costs**

**FIXED INVESTMENT COST: Approximately US\$ 61 million**

<b>INCLUDED</b>	<b>32.0</b>	<b>Machinery, equipment and vehicles</b>
<b>IN THE</b>		<b>incl freight, insurance and erection</b>
<b>INVESTMENT</b>	<b>3.5</b>	<b>Electrical and instrumental installations</b>
<b>COST:</b>	<b>11.0</b>	<b>Buildings, roads and railroads</b>
	<b>1.8</b>	<b>Spare parts</b>
	<b>5.4</b>	<b>Engineering and project management</b>
	<b>1.5</b>	<b>Recruitment and start-up expenses</b>
	<b>5.8</b>	<b>Contingencies</b>

**ANNUAL TURNOVER: US\$ 25.2 million**

**INTERNAL RATE OF RETURN: 13 %**

### Investment Cost

Most countries want a domestic pulp and paper industry. A major problem with new large pulp and paper mills - in developed as well as developing countries - is the heavy investment cost. Today the cost for a new greenfield plant is so high that a pulp price of about US\$ 650 per ton is needed to break even. The current market price is around US\$ 400 per ton.

This is one of the key strengths of the LCI Concept. Investment cost is low, approximately 70 percent of that for a sulphate mill of the same size. These savings are achieved through component standardization and package design.

The fixed investment cost has been estimated at approximately US\$ 61 million at 1983 price levels. The fixed investment budget includes machinery, equipment, electrical and instrument installations, buildings, roads and railroad at site, spare parts, engineering and project management, recruitment and start-up expenses (Fig. 20).

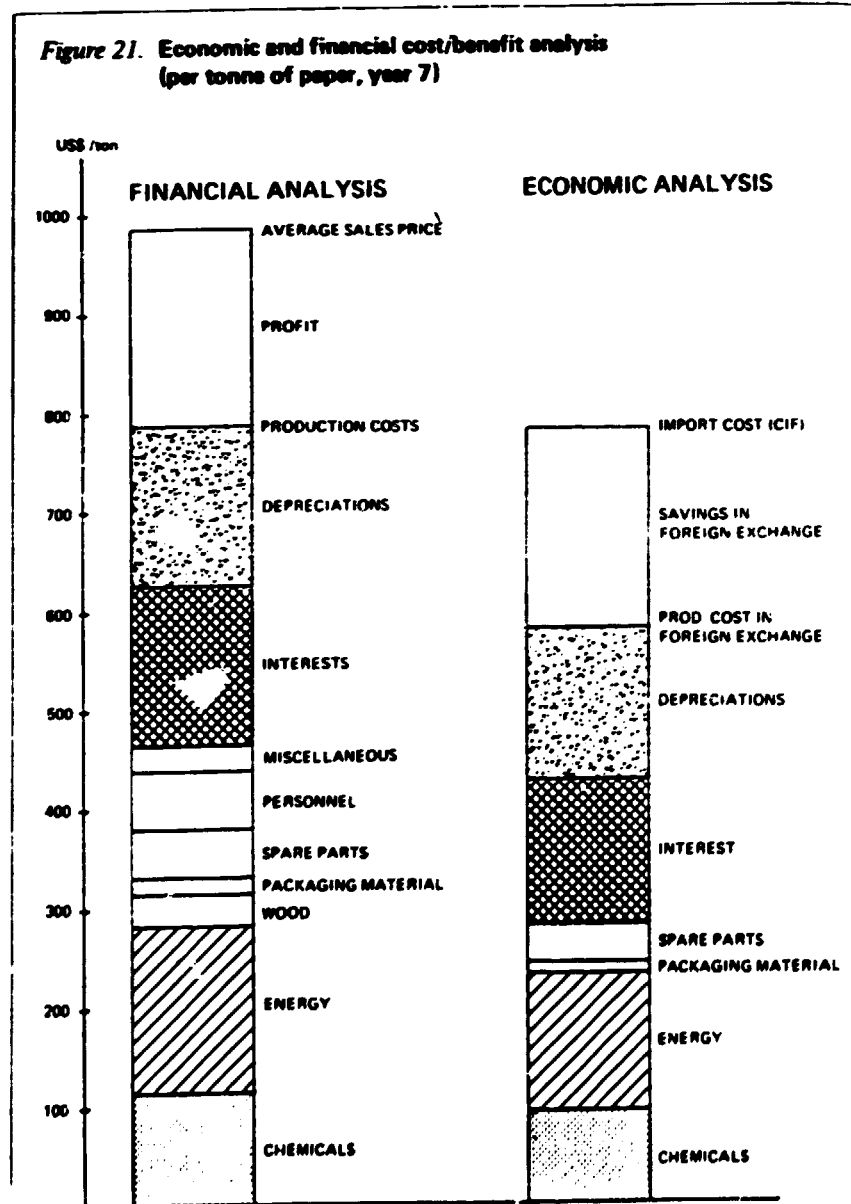
The fact that many countries are suffering from high unemployment has been taken into account when designing the mill. Parts of the mill, which requires a work-force of 475 persons, are labour-intensive.

### Cost/Benefit Analysis

An analysis of the economic and financial costs/benefits per ton of printing and writing paper, calculated for the first year of full production, is given in Fig. 21. The first histogram defines production costs and profit for the LCI Mill. The second histogram shows the costs of domestic paper production and the savings to be made in terms of foreign exchange. Most of the chemicals, the fuel for power generation and the loans are from other countries, leading to an outflow of foreign exchange. However, wood and personnel costs are entirely domestic. If the country imports paper, it may have to pay US\$ 700 per ton in foreign currency. Domestic production reduces this figure to approx. US\$ 500 per ton. The sales price is the same as for imported paper, and considering that the market price in developing countries is normally considerably higher than the world market price, the benefits are obvious.

The import of energy also deserves closer consideration. In Fig. 21 the cost of coal per ton of paper is US\$ 166, equivalent to an annual total of almost US\$ 5 million. Assuming 7,500 hours of production annually, the cost is US\$ 30 per MWh, which is quite reasonable and well below the cost of power from a national grid.

It has been calculated that steam production virtually balances capital and operating costs, although these factors have not been detailed specifically. These figures naturally vary from country to country, depending on how many raw material inputs are available locally, upon prices and other factors. However, it is evident that LCI paper production would have a positive effect on the balance of trade. Any country with sufficient fibrous raw material wishing to establish domestic production of pulp and paper, or to boost exports, would benefit from the construction of one or more LCI Mills.





RECENT DEVELOPMENTS IN CHEMICAL PULPING AND BLEACHING

by

Brian Orgill, Sunds Defibrator Pty. Ltd., Melbourne, Australia

and

Lars Nasman, Sunds Defibrator A.B., Sundsvall, Sweden

ABSTRACT

This paper summarizes the major developments Sunds Defibrator has made in recent years, in the field of chemical pulping and bleaching. These include the low energy batch cooking system, medium consistency oxygen delignification, and short sequence bleaching.

INTRODUCTION

During the last decade the capital and operating costs of a chemical pulp mill have increased dramatically, due partly to stricter environmental regulations, and higher energy costs. For the future mill to be viable, it will be necessary to simplify the process and mill design. Sunds Defibrator have therefore concentrated their efforts on the low-energy batch cooking system, medium consistency oxygen delignification and short sequence bleaching. A summary of these developments is as follows:

THE LOW-ENERGY BATCH COOKING SYSTEM

The modern fully automated batch cooking system has a number of advantages over the continuous cooking alternative for the kraft pulping process. These include higher operating reliability, greater flexibility, reduced sensitivity to chip quality, lower K. No. variations, less maintenance and higher availability. However, batch cooking had the disadvantages of a relatively high steam consumption, and greater air pollution. To overcome these problems, Sunds Defibrator began the development of a heat recovery system for batch digesters. The aim of this work was to reduce the heat consumption to a level equal to that of continuous cooking, while retaining the simplicity and reliability of the batch system.

During 1981 - 82, prototype trials were carried out on a 60 m<sup>3</sup> digester at the ASSI Karlsborg mill in Sweden, based on draining off the hot strong black liquor at the end of the cook, and collecting it at full cooking temperature in a liquor accumulator. The heat conserved in the accumulator was then utilized for preheating the charge liquors, and for the blowing operation.

The results of these trials were excellent, as steam demand was reduced by 40 - 50 %, and the cooking cycle decreased by 10 - 20 %. Based on these results, two 125 m<sup>3</sup> digesters were converted to the new system.

By draining the digester, about 75 % of the black liquor solids content in the cooking liquor is removed before the blow. This gives an improved washing efficiency, resulting in a decrease in subsequent washing requirements, equivalent to one wash filter.

The addition of cold liquor to the digester stops the chemical reactions, and over-cooking of the pulp is avoided. The cold blow also gives a significant improvement in pulp viscosity.

With low-energy batch cooking, the blow heat recovery system is much simpler, and the sulphurous compounds remaining in the hot liquor accumulator are fed to the evaporators. Should it be necessary to vent the accumulator, the gases are taken to the turpentine system, together with the gases released from the digesters during the cook. Further details on the low-energy batch cooking system were reported earlier (1).

#### MEDIUM CONSISTENCY OXYGEN DELIGNIFICATION

High consistency oxygen delignification has become well established, since it was discovered that magnesium is an efficient inhibitor of pulp degradation. By extending the delignification with oxygen, and completely closing the brown stock system, the pollution load from the bleach plant can be reduced by about 50 %.

To reduce the capital cost, Sunds Defibrator extended their development of oxygen delignification to medium consistencies, i.e. 10 - 15 %. The main problem was to find a method for dispersing the oxygen through the pulp suspension, to ensure that each fibre received the correct amount of gas. This led to the development of the SMA mixer .

The new mixer fluidizes the pulp in the mixing zone, providing the required micro-scale mixing of pulp fibres and oxygen.

A medium consistency oxygen delignification plant for 100 T/D of kraft pulp rejects was started-up at the Korsnas-Marma mill in Sweden at the end of 1983.

All rejects from the three screen rooms are refined, dewatered, and then stored in a H.D. tower. From this tower the reject pulp is taken through the oxygen delignification plant, and then back to the two parallel pulp lines, where it is finally washed and screened together with the normal pulp.

Further developments are the twin-roll dewatering press, centrifugal type thick stock pump, oxygen mixer, the bottom of the reactor with pulp distributor, and the top of the reactor with the discharger. As there is no gas volume in the reactor, and as ignition is impossible at 10 - 12 % consistency, no system for bleeding and destruction of built-up flammable vapours and gases is necessary.

After six months operation of the first commercial medium consistency oxygen delignification system for up-grading of kraft pulp rejects, the following conclusions were reached:

- The plant has worked very well mechanically, and is very easy to start and stop.
- A Kappa number reduction from about 80 to 50 is reached when charging about 50 kgs alkali/ton, and about 30 kgs oxygen/ton.

- This delignification gives a reduction of shive content of about 50 %.
- It seems that magnesium not only decreases the degradation of the cellulose, but also decreases the rate of delignification.
- By treating the kraft screen rejects with oxygen, it has been possible to use the rejects in the bleach plant, with no noticeable change in pulp quality.

Further information on the Korsnas-Marma plant was reported earlier (2).

#### SHORT SEQUENCE BLEACHING

Following the development of medium consistency oxygen delignification, Sunds Defibrator continued to investigate further applications of oxygen addition to other bleaching stages. The use of the SMA mixer made it possible to add oxygen to the first alkali extraction stage, and a number of bleaching sequences were tested on unbleached, as well as oxygen pre-bleached softwood and hardwood pulps.

The first full-scale trials with an oxygen reinforced extraction stage took place at the SCA Ostrand softwood bleach plant in 1980. The mixer was installed ahead of the upflow extraction tower, where 4-5 kgs of oxygen per ton of pulp were used. This installation reduced the  $\text{ClO}_2$  consumption by 9 - 10 kgs/ton (as active chlorine), in comparison with an unmodified parallel line, with the sequence DC-E-D-E-D (3).

One of the main advantages with the addition of oxygen to the extraction stage is the possibility of producing fully bleached market pulp in only three bleaching stages, i.e. DC-EO-D. The Ostrand mill also served as a pilot plant for three-stage bleaching trials, and the final E and D stages in the bleach line containing the oxygen extraction stage were shut-down. The bleach plant was then run on the short sequence for one week during each trial period.

These tests confirmed the laboratory results, and the feasibility of the short sequence process. It was possible to reach high brightness levels in only 3 stages, while maintaining a pulp viscosity greater than  $900 \text{ dm}^3/\text{kg}$  (4).

The first 3-stage bleach plant based on this concept was started-up at Norrsundet in Sweden early in 1983. In 1981, a decision was made to increase the bleached pulp capacity of the mill by 420 T/D, by installing an additional continuous digester, a completely new closed screen room, a high consistency oxygen delignification stage, and a new 3-stage bleach plant.

In the new bleach plant, with the sequence DC-EO-D, each bleaching stage is equipped with the same type of high intensity shear mixer.

After running the plant for 12 months, the following conclusions were drawn:

- There is no difficulty to obtain 90 % ISO brightness;
- The pulp viscosity has remained high, thus giving good strength properties;
- The pulp cleanliness is better for the DC-EO-D sequence compared to the DC-EP-D-EP-D sequence at the same brightness level;
- The bleach chemical costs are very similar for the DC-EO-D and DC-EP-D-EP-D sequences;
- These results can also be obtained with higher Kappa number pulps, i.e. 35-45.

Further details on short sequence bleaching were reported earlier (5).

Based on the above commercial experience, we would recommend that any new bleached kraft mill, with stringent environmental regulations should incorporate the low-energy batch cooking system, medium consistency oxygen delignification and short sequence bleaching.

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NEWSPRINT FROM BAGASSE AND HARDWOOD PULPS

by

Brian Orgill  
Regional Director  
Sunds Defibrator A.B.  
Singapore

This paper will summarise the current developments in bagasse and hardwood pulping for newsprint, and give details of laboratory and pilot plant trials for the manufacture of newsprint from a mixture of bagasse chemical pulp, and eucalypt C.M.P. pulp. Information will also be given on laboratory testing of different hardwoods by the C.T.M.P. process.

Many countries have a very limited wood supply, but have sufficient coal, oil or gas to replace a substantial amount of bagasse in their sugar mill boilers. Bagasse contains about 65 % fibre and 35 % pith, which is of an amorphous nature, and gives very poor drainage, strength and opacity. The usual method of processing the raw bagasse is to moist depith at the sugar mills, in either hammer mills or vibrating screens, and the pith is burnt in the boilers. At the pulp mill, the pre-depithed bagasse is wet cleaned to remove sand, rocks and foreign material, together with some additional pith. The fibre is then ready for processing.

In 1957, Sunds Defibrator started-up their first continuous digester for the chemical pulping of bagasse, at the W.R. Grace mill at Paramonga in Peru. Since that time, we have continued to work with different mills and consultants to further develop and adapt our process equipment to their particular needs. Most of this work has been in the chemical and semi-chemical pulping fields, but this interest has also moved into the chemi-mechanical, chemi-thermo-mechanical and thermo-mechanical pulping areas. Through the years, many companies such as Crown-Zellerbach, K.M.W. and De La Rosa tried to develop processes for producing good quality newsprint from bagasse. The old problem remained of obtaining good machine runnability together with acceptable opacity, as you will note from Figure 1.

The first commercial bagasse newsprint mill started-up at Induperu in Peru in 1977, and the second at Mexicana de Papel Periodico in Mexico in 1978. Both of these mills are based on the Cusi process, and Sunds Defibrator supplied the major part of the pulping equipment. The Cusi process involves extensive impregnation in atmospheric towers, followed by light cooking, and fractionation of the pulp. The rejects are re-cooked and refined under pressure in a separate digester. The Cusi process is an elegant solution for pulping a non-homogeneous raw material but the process was modified, and simplified when the third newsprint mill was installed at Tucuman in Argentina. Bagasse pulp produced by the Cusi process has good strength properties, and the opacity was improved by the addition of clay, and small amounts of stone ground-wood, T.M.P. or R.M.P. wood pulps.

More recent plants have aimed to produce a pulp similar to traditional mechanical wood pulp, with a higher power input and yield, than that obtained from the Cusi process.

The first such installation is presently starting-up at P.T. Kertas Letjes in Indonesia. This plant comprises three pulp lines, together with the addition of a small amount of imported chemical pulp. There is a 75 T/D rice straw chemical pulp line, a 100 T/D semi-chemical bagasse pulp line and a 150 T/D T.M.P. bagasse pulp line. The two bagasse pulp lines use the Peadco two-stage pressure refining process, and there is a common chemical recovery system for the rice straw and semi-chemical bagasse pulp lines. At this stage of the commissioning period the newsprint furnish comprises about 40 % bagasse T.M.P. pulp, 40 % bagasse semi-chemical pulp, and 20 % long fibre chemical pulp.

In India, Tamil Nadu Newsprint and Papers Ltd recently made trial quantities of newsprint with various mixtures of bagasse chemical pulp, bagasse T.M.P. pulp, and hardwood chemical pulp. Present indications are that an acceptable quality newsprint can be made from a furnish comprising 50 % bagasse T.M.P. pulp, 35 % bagasse chemical pulp, and 15 % hardwood chemical pulp. Some clay is added to improve opacity.



The Beloit process is used for bagasse mechanical pulping, and this involves producing a T.M.P. pulp followed by fractionation, and refining of the chemically treated rejects. Sunds Defibrator supplied the two bagasse chemical pulp digesters as shown in Figure 2, and a significant amount of the mechanical pulping equipment.

A further process developed for pulping bagasse for newsprint is the Cuba-9 process. Extensive work has been done in the pilot plant at the Research Centre in Cuba, and this was also aimed at producing a higher yield bagasse pulp. Basically, the Cuba-9 process consists of atmospheric treatment with chemicals, followed by pressing, and two stage atmospheric refining. It was found that the ideal newsprint furnish was 80 % C.M.P. bagasse pulp, 10 % stone groundwood pulp, and 10 % semi-bleached Kraft pulp. This process will be of interest for smaller mills due to the relatively low capital cost.

As can be seen from the above comments, bagasse pulping for newsprint is an evolving process, and it will be very interesting to follow the progress at Letjes and Tamil Nadu. For countries such as India, with both bagasse and plantation hardwood available, the solution is much easier, as newsprint can be made from a mixture of bagasse chemical pulp and C.M.P. hardwood pulp. The bagasse pulp provides the strength, while the opacity comes largely from the C.M.P. hardwood pulp. Both processes are well proven and have a common chemical recovery system. The bleaching processes, i.e. C-E-H, and hypochlorite are also more economic than the alternate peroxide bleaching.

To prove that an acceptable newsprint quality could be achieved from these two pulps, we obtained some chemical bagasse pulp from Kimberley-Clark de Mexico, Orizaba mill, and mixed it with eucalypt globulus C.M.P. pulp produced in our pilot plant in Sweden. Newsprint was made on the pilot paper machine at the Norwegian Institute of Technology in Trondheim, under the direction of Dr. H.W. Giertz, and was tested for strength, optical and printing properties. Figure 3 shows the relationship between light scattering and tensile index for various mixtures of bagasse chemical pulp and C.M.P. hardwood pulp.

Based on these results, the optimum opacity and runnability properties were reached with a furnish of about 60 % bagasse chemical pulp, and 40 % eucalypt C.M.P. pulp. Figure 4 shows the influence of clay addition on this furnish. Figure 5 shows that an acceptable newsprint could be manufactured with a furnish of 60% bagasse chemical pulp, and 40 % eucalypt C.M.P. pulp, together with about 5 % clay.

Figure 6 shows a C.M.P. plant for pulping of hardwoods. A similar plant is installed at the Hindustan Paper Corporation mill at Kerala in India, for pulping eucalypt grandis and hybrid. Bleaching is done with sodium hypochlorite, and the newsprint furnish is 75 % C.M.P. eucalypt pulp, and 25 % reed chemical pulp. There is a common chemical recovery system. A second plant will soon start-up at the Nigerian Newsprint Manufacturing Co., based on gmelina. The furnish will comprise 80 % C.M.P. pulp and 20 % chemical pulp.

To obtain the benefits of energy recovery, we now recommend pressurized refining of hardwoods as shown in Figure 7. Figure 8 and 9 give results obtained from testing of various hardwood species by the C.T.M.P. and B.C.T.M.P. processes. Figure 10 shows the influence of alkali charge on tensile index, and Figure 11 shows the relationship between light scattering coefficient and tensile index for different hardwoods.

Probably the only mill in the world producing newsprint from 100 % hardwoods is the Paper Industries Corporation of the Philippines. The furnish comprises about 55 % R.M.P. and T.M.P. pulp and 45 % chemical pulp all of which is produced from *albizzia falcata*.

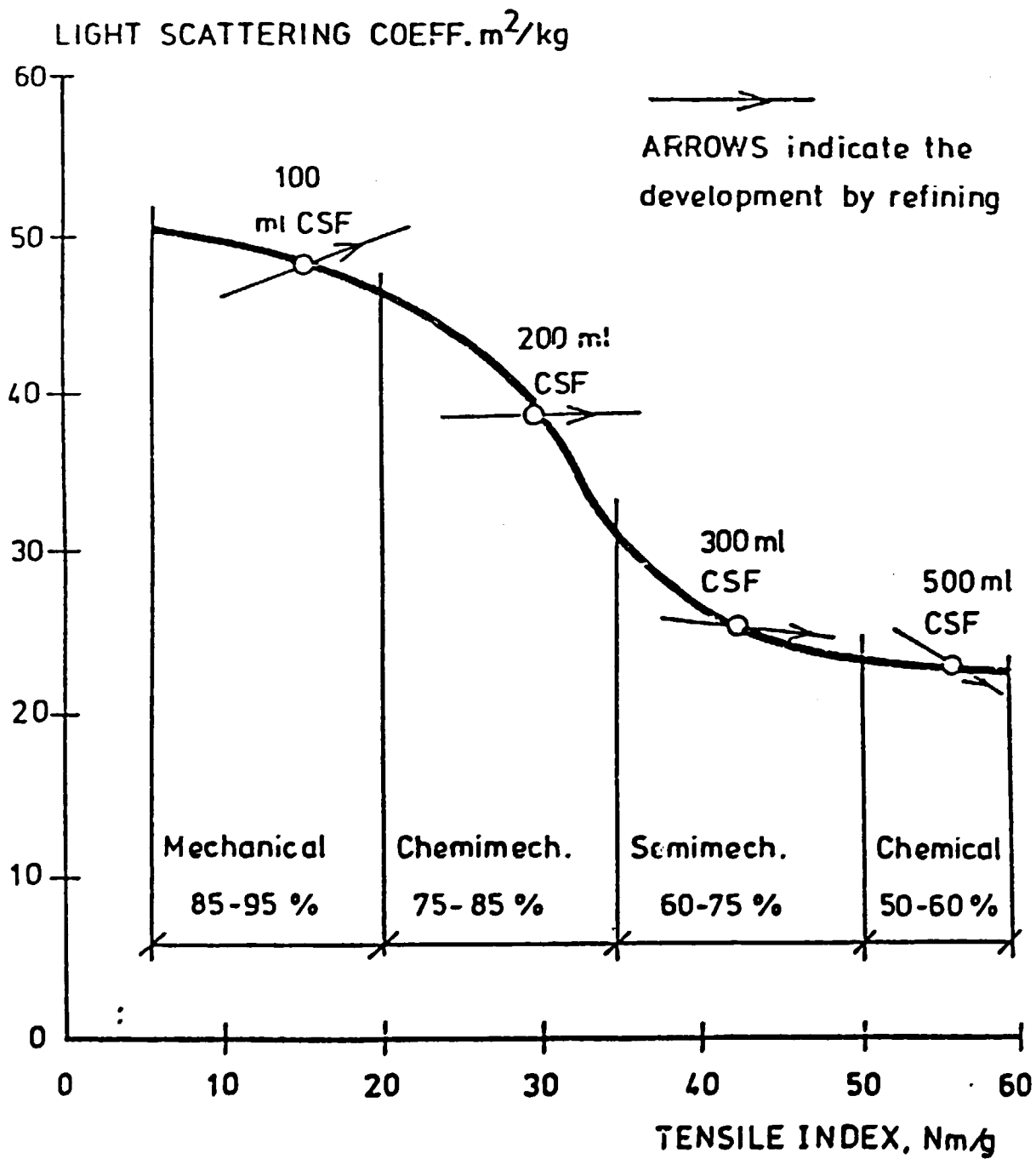
As can be seen from the preceding comments, bagasse and hardwood pulps have been used to manufacture newsprint for a number of years, and we see great potential for the use of these raw materials in countries with little, or no softwood resources.

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# BAGASSE PULPS OF VARIOUS YIELDS

## Light scattering vs tensile index



**FIGURE 1**

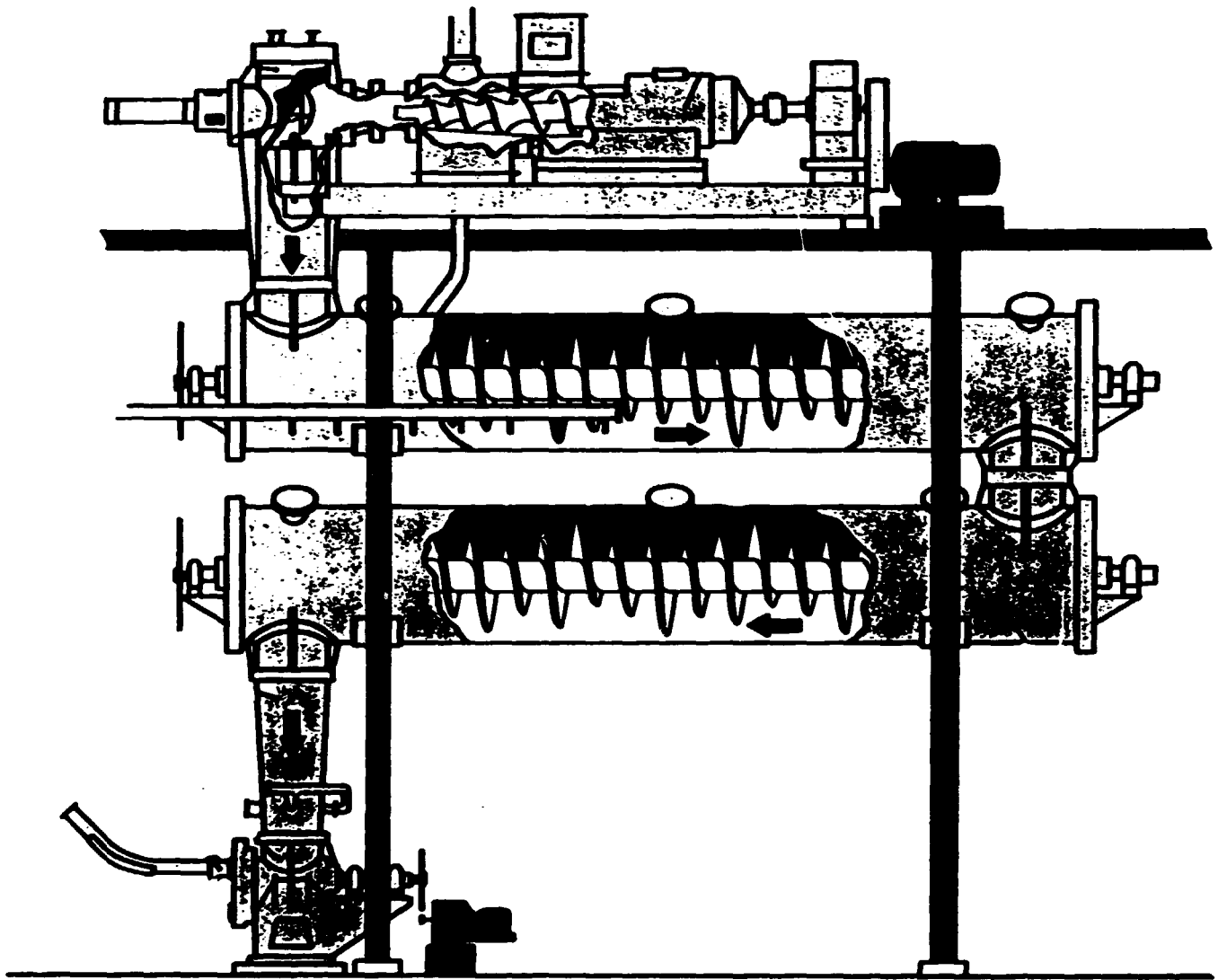


FIGURE 2

XPM trials

Various ratios of CP Bagasse and CMP Eucalypt

Grammage 52 g/m<sup>2</sup>

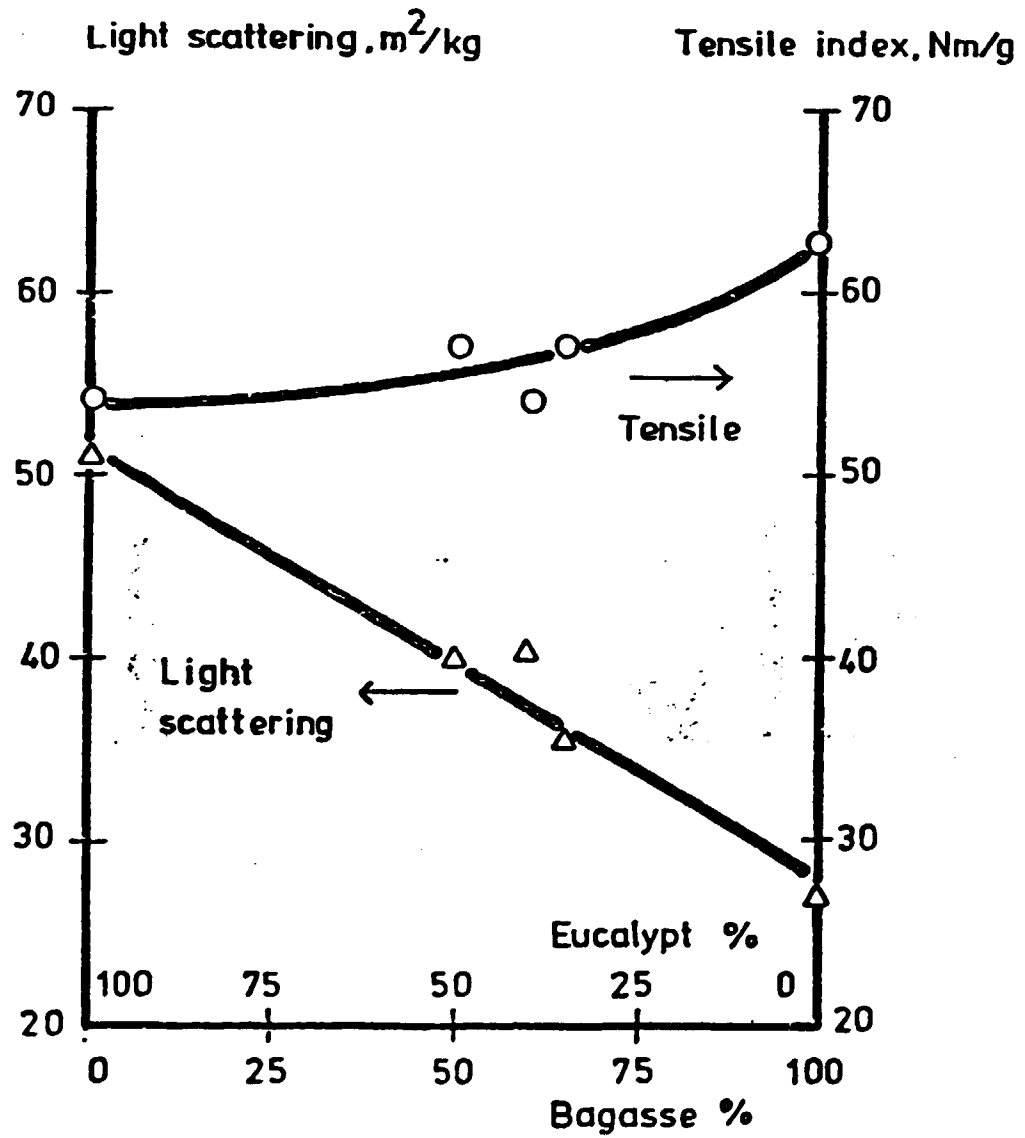
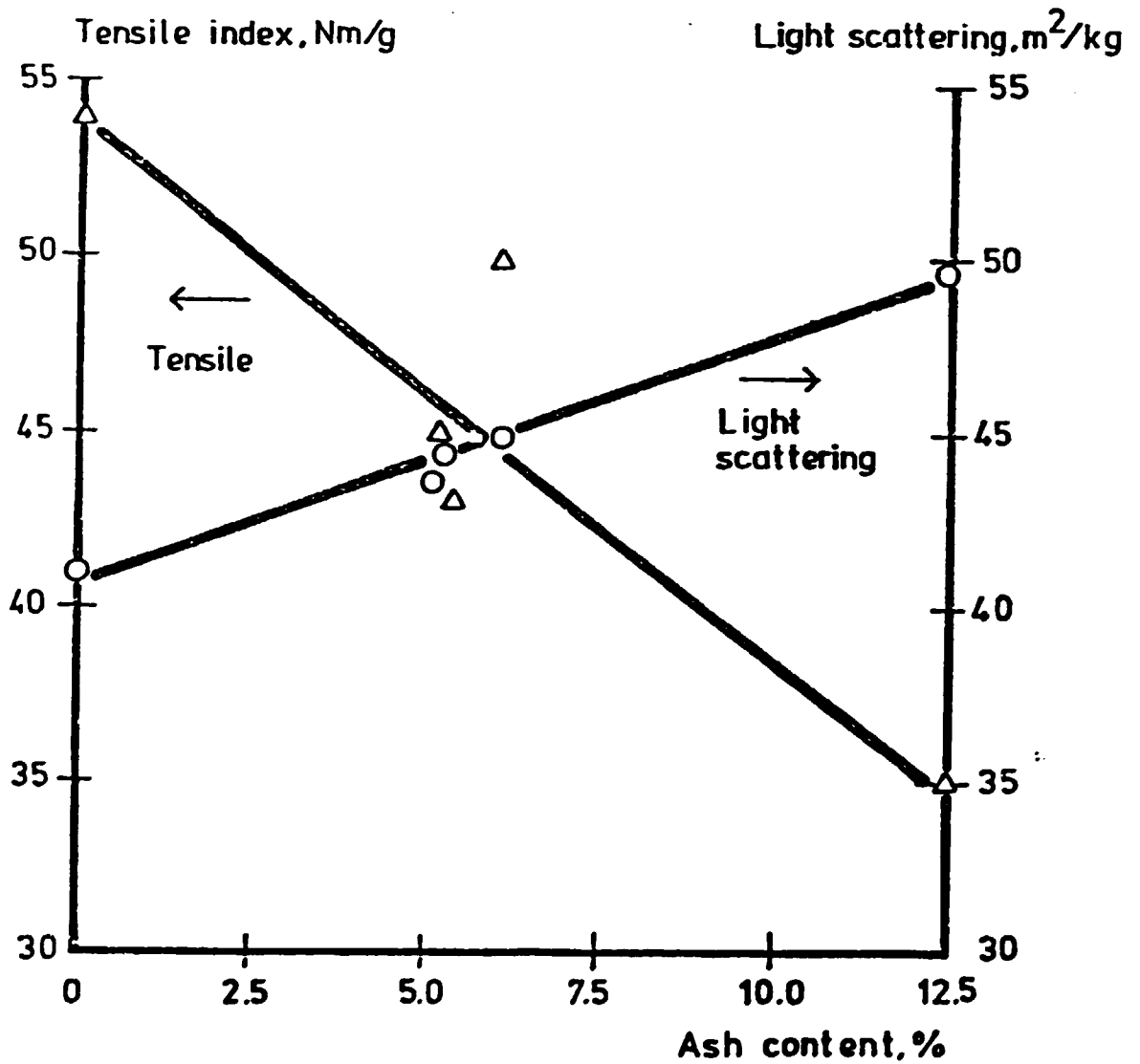


FIGURE 3

XPM trials  
60% CP Bagasse and 40% CMP Eucalypt  
Influence of clay addition



**FIGURE 4**

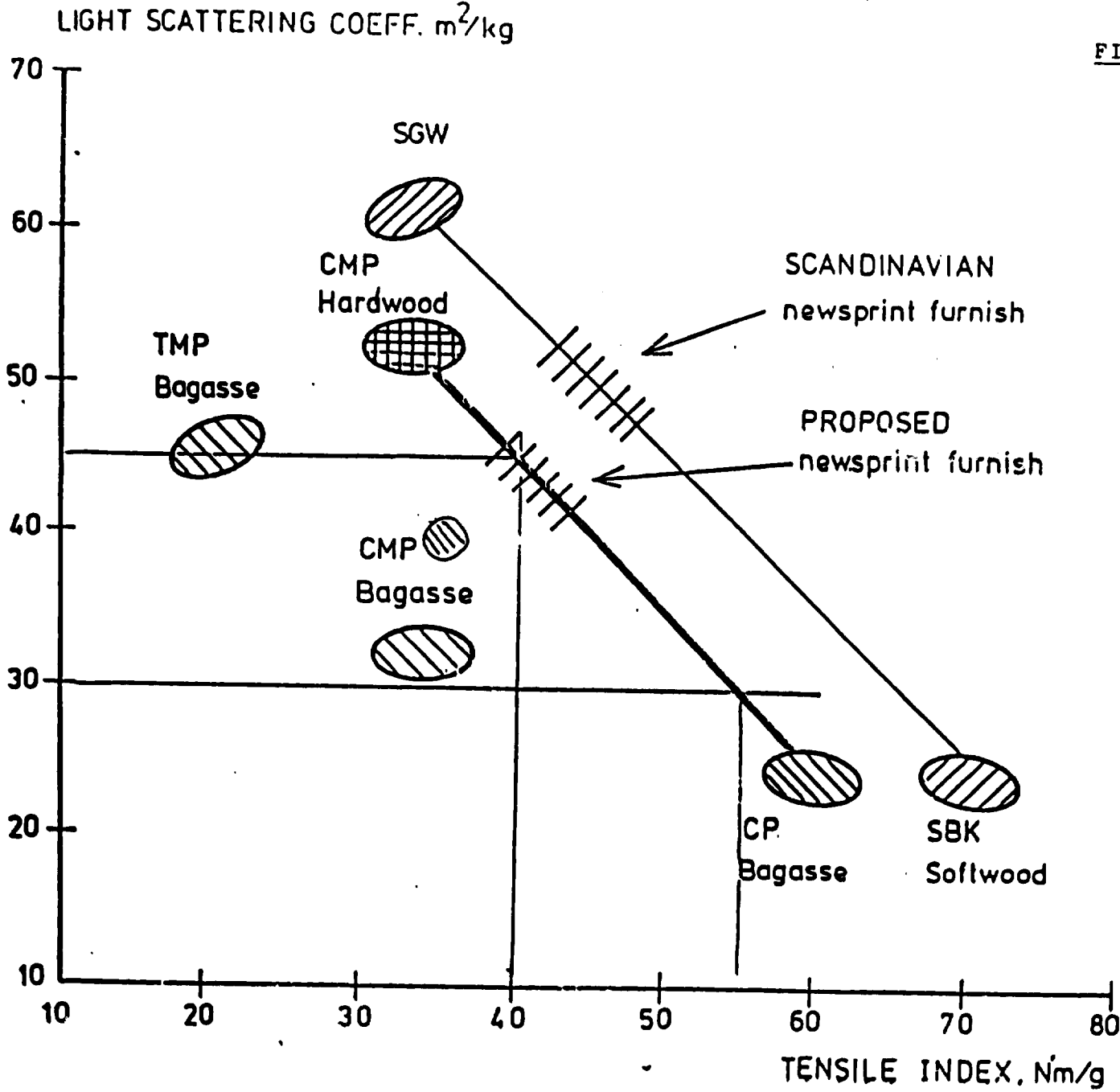
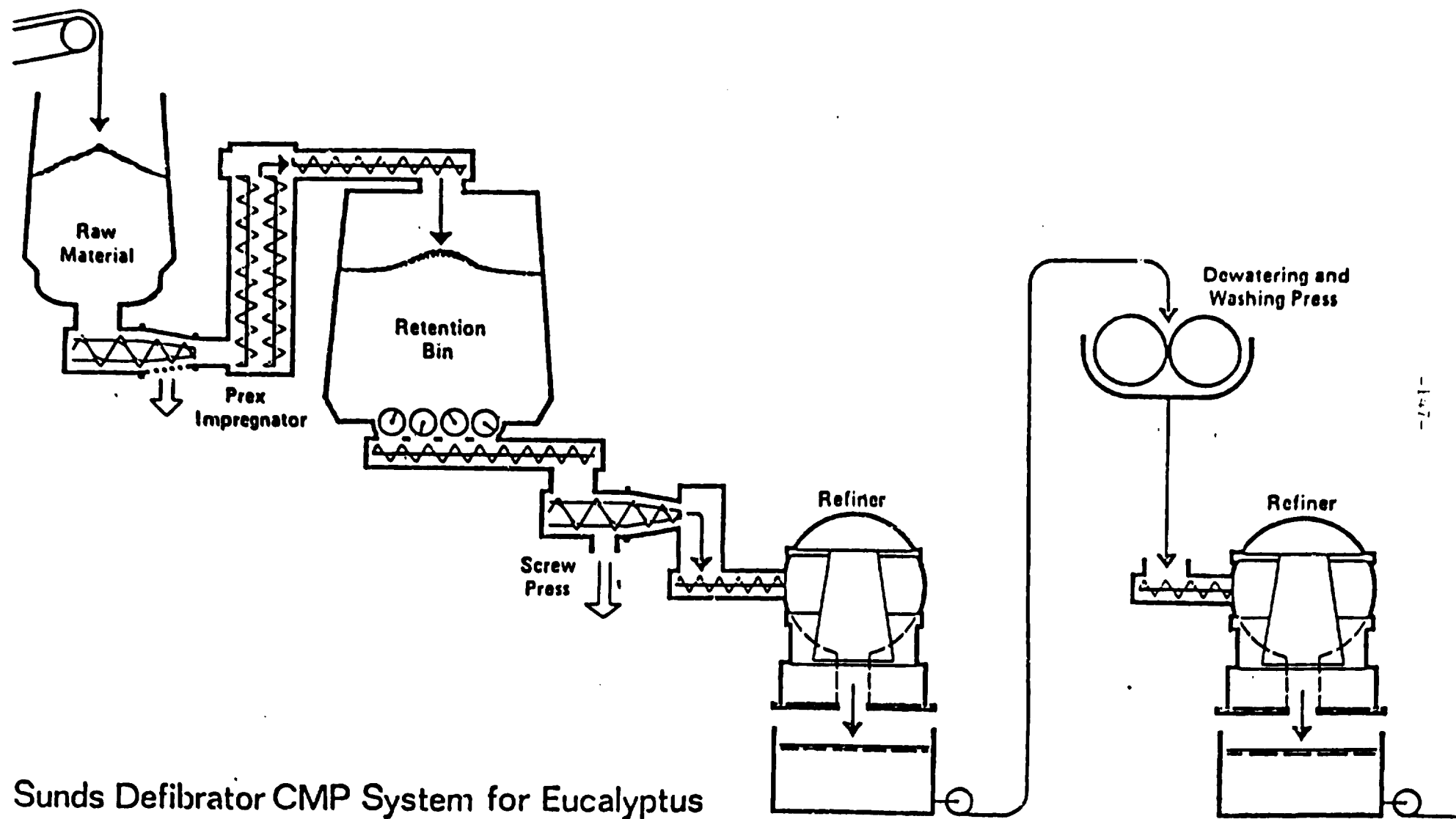


FIGURE 5





Sunds Defibrator CMP System for Eucalyptus

FIGURE 6

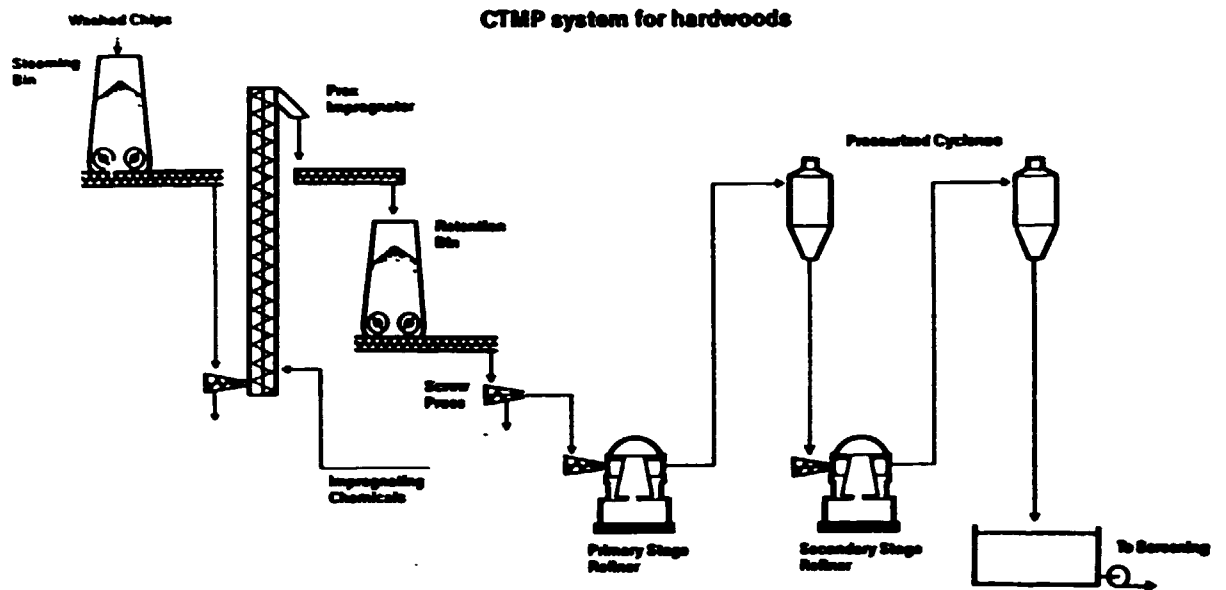


FIGURE 7

Quality characteristics of CTMP from different hardwood species. (Freeness 100 ml CSF.)  
CCA/SCAN testing. Pilot plant pulps and mill SGW.

Raw Material	Chemical charge		Pulp yield	Wet web strength	Density	Tensile index	Tear index	Light scattering coeff.	Brightness unbleached
	NaOH	Na <sub>2</sub> SO <sub>3</sub>							
	%	%	%	N/m	kg/m <sup>3</sup>	Nm/g	mN.m <sup>2</sup> /g	m <sup>2</sup> /kg	ISO %
Eucalyptus globulus	2.5	0	94.1	-	340	33.5	4.6	58.5	-
	3.5	0	93.8	-	365	39.5	5.2	54	-
	4.7	0	92.1	-	435	44.5	5.3	52.5	-
	6.7	0	90.5	-	495	51.5	5.8	47.5	-
Gmelina arborea	2.6	4.1	87.0	47	460	40	3.9	56.5	57.5
	3.4	4.3	86.5	49	535	47.5	4.5	51	53
	4.3	4.5	85.6	51	545	49.5	4.5	49	51.5
Populus euramericana (Poplar)	1.0	1.9	94.5	35	410	27.5	3.4	56.5	59
	2.2	3.0	93	54	450	35	4.4	51	54
	3.7	3.3	91	63	590	53.5	5.3	39	49
Leucaena lucosefala (Lead tree)	2.0	0	93.2	55	425	27.5	3.5	50	39.5
	4.1	0	91.1	57	475	30	4.9	44	34
Scandinavian Spruce									
TMP	-	-	96.5	93	430	50	10.5	46.5	58.5
SGW	-	-	97	50	425	32	4.0	61.5	60

FIGURE 8

Physical properties of BCTMP from different hardwood species. (Freeness 120 ml CSF.)  
 Bench bleaching tests on pilot plant pulps. CCA/SCAN testing.

Raw material	Chemical charge				Pulp yield		Pulp properties			
	Impregnation NaOH %	Na <sub>2</sub> SO <sub>3</sub> %	Bleaching H <sub>2</sub> O <sub>2</sub> %	NaOH %	Un-bleached %	Bleached %	Bright-ness ISO %	Density kg/m <sup>3</sup>	Tensile index Nm/g	Tear index mN.m <sup>2</sup> /g
Populus tremuloides (Trembling aspen)	1.0	3.0	1.0	0.8	92.6	91.3	73	490	41.5	5.5
	1.0	3.0	3.0	1.8	92.6	90.3	78	495	43	5.5
Fagus silvatica (Beech)	3.1	3.6	3.2	2.0	91.5	89.0	78	425	26	3.5
Gmelina arborea	2.7	0	1.0	1.5	87.3	85.2	71	410	28.5	3.0
			1.5	2.0	87.3	85.0	74.5	420	30	3.2
Eucalyptus globulus	5.4	0	4.0	1.8	90.7	89.2	75.5	560	49	5.0
	4.5	0	4.0	2.5	91.4	88.9	78.5	450	43	4.7

FIGURE 9

Figure 10 Hardwood CTMP. Influence of alkali charge on tensile index (Freeness 100 ml CSF.)

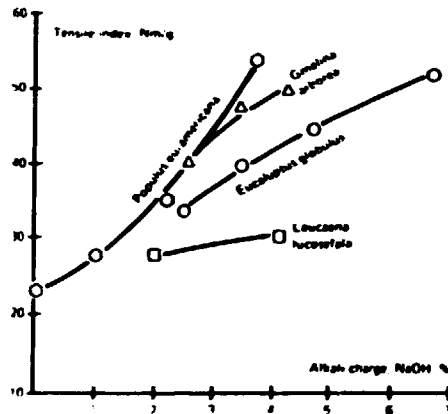
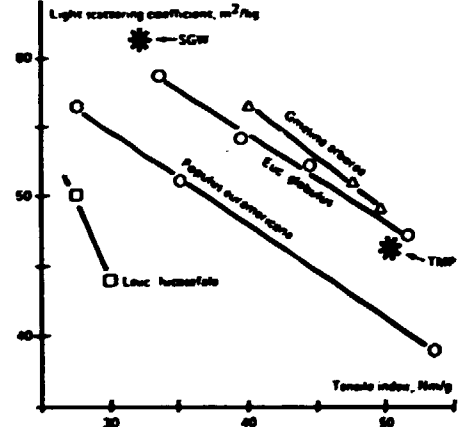


Figure 11. Hardwood CTMP. Relationship light scattering coefficient - tensile index (Freeness 100 ml CSF.)



## INVESTIGATION OF KENAF OXYGEN PULPING

by

Anchalee Kamolratanakul, Naiyana Niyomwan, Sirikalaya Suvachittanont

and

Suchart Tribumrungsuk

### ABSTRACT

This report presents a preliminary study on the oxygen pulping of Thai kenaf.

The single stage soda-oxygen pulping of Thai kenaf was investigated at constant alkali charge, temperature ranging from 120 to 150°C and oxygen pressure ranging from 0 to 140 psi. The results show that bright pulp could be obtained with moderate strength properties at oxygen pressure 140 psi and temperature levels of 130 to 140°C.

### INTRODUCTION

Industrial interest in oxygen pulping has been motivated by an achievement of a study on oxygen bleaching (Chang et al. 1976). The research work in this field was so successful that it has developed into industry. Since 1970 the oxygen bleaching industry has produced several types of paper (Rolandson 1970). But as for the study on oxygen pulping, it has not yet been accomplished to reach an industrial status, for reasons to be further stated. However, this has been developed to a pilot-scale level.

By oxygen pulping or bleaching, it always means alkaline oxygen pulping and bleaching. It has been known for a long time that lignin can degrade and dissolve when reacting to oxygen in alkaline condition (Chang and Kleppe 1973). However, there has been no clear study result about chemical reaction to oxygen pulping (Eckert et al. 1973). A research work by Kratzl et al. (referred to by Eckert et al. 1973) has shown two reactions by

(a) oxidative coupling of phenolic nuclei creating ortho-ortho linked diphenols when side chain being saturated alkyl group, and by (b) replacement of side chain in phenols model, comprising benzyl alcohol or carbonyl junctional groups. These two reactions have caused degradation of lignin.

Most of the research work on oxygen pulping usually has focussed on the use of wood, both soft and hard, as raw material. With regard to the quality of oxygen pulp in comparison with sulphate pulp, it has been found that the former could react to the beating better than the latter. So a good point is that less energy is consumed in the beating. However, at the same time oxygen pulp gives higher GSR Values than sulphate pulp, while its tearing strength is lower than that of sulphate pulp (Abson and Stockman 1979; Chang et al. 1974).

A concerning problem which has caused unsatisfactory effect on oxygen pulping is that carbohydrate degradation and penetration of oxygen into wood chips are not completely absorbent if they are not made small and thin enough as oxygen has low solubility. This problem has reflected in low quality of oxygen pulp which requires a long cooking time, and chances to get ununiform pulp, mostly uncooked part (Mekeluy et al. 1978; De Choudens and Monzie 1977). Thus, in order to solve this problem in wood oxygen pulping, wood chips must be prepared small and thin enough for perfect reaction. Normally a chip should have up to 20 - millimetre thickness (De Choudens 1977) and 6 x 25 millimetre by width and length (Jamieson et al. 1975), which is smaller than the conventional size for chemical pulping. To prevent carbohydrate degradation, magnesium salts in the form of MgO, MgCO<sub>3</sub> or others must be added for controlling oxygen pulp quality for industrial use (Chang et al. 1974).

At first the study on oxygen pulping was conducted on single stage pulping, which was later developed to two-stage pulping by first pre-cooking of chips with alkali, followed by oxygen pulping, with or without fiberizing in between. Presently there have been experiments on oxygen pulping by using thermomechanical fibres produced from softwoods, such as spruce and pine, as well as some hardwoods instead of wood chips. The result has proved more satisfactory (El-Ashmawy et al. 1977).

On the other hand, some non-wood raw materials, such as rice straw and bagasse, have less density than wood, thus facilitating the penetration of chemicals and oxygen (El-Ashmawy et al. 1977). So this kind of raw materials can react well to oxygen pulping by single stage process. In 1977 El-Ashmawy and his experimental team conducted an experiment on this single stage oxygen pulping by applying rice straw and bagasse of the same size as used in soda pulping. The result has shown that the oxygen pulping from rice straw and bagasse could replace other conventional pulping processes. The oxygen pulp rendered higher yield but lower lignin than soda pulp. In 1976 Watanabe applied for a patent for his accomplishment in oxygen pulping from rice straw and other non-wood fibres, with the size of raw materials being the same as in the chemical pulping. The pulp obtained bore the same quality with that of wood pulp and had brightness value so high that its bleaching stage could be reduced (Watanabe 1976).

Since kenaf is a non-wood fibre crop similar to rice straw and bagasse but with stronger structure, it is likely to react to the oxygen pulping just the same. The study on oxygen pulping from kenaf in this report is purposely to preliminary study and evaluate pulp obtained from a single stage oxygen pulping with stress specifically on technical data, by applying equipment and devices available in the laboratory for the experiment.

## EXPERIMENTS AND RESULTS

### 1) Raw Material

Source Raw material used in the experiment is Thai kenaf, variety of Green Stem, age 5½ months, cultivated in the area of Ubolratana Dam, Khon Kaen by the Agricultural Experiments Station, North East Agricultural Research Centre. This raw material was sun-dried in the field for 4 months before putting on experiment. Analysis of chemical compositions is shown in Table 1.

TABLE 1.

CHEMICAL COMPOSITION OF THAI KENAF, GREEN STEM AGE 5½ MONTHS

Chemical compositions	Percentage
1. Holocellulose	73.55
2. Alpha cellulose	36.60
3. Lignin	18.09
4. Alcohol-benzene solubility	5.06
5. Hot water solubility	20.82
6. Pentosan	16.32
7. Ash	3.72

Chemical analysis by TAPPI Standard Method.

TABLE 2.

OXYGEN PULPING CONDITION

Raw material charged, oven dry	50 g
Chemical charged, on o.d. chips	
- NaOH	26 %
- MgO	0.6 %
Liquor to chip ratio	6:1
Oxygen pressure	0-140 psi
Maximum temperature	120-150°C
Time to max. temp.	1 hr
Time at max. temp.	3 hr

Preparation Chipping and selecting of kenaf samples for uniform size were made before pulping in order to get well impregnation of the chemicals. Kenaf chips of 1 inch long were slightly crushed by Hammer mill just for their breaking. Then the samples were screened through 3 sizes of wire gauze at  $\frac{3}{4} \times \frac{3}{4}$  sq. in.,  $\frac{1}{4} \times \frac{1}{4}$  sq.in., and  $\frac{1}{8} \times \frac{1}{8}$  sq.in. Kenaf chips that passed the  $\frac{3}{4} \times \frac{3}{4}$  sq.in. wire but could not pass the  $\frac{1}{4} \times \frac{1}{4}$  sq.in. wire would be classified as "large fraction". The chips that passed through the  $\frac{1}{4} \times \frac{1}{4}$  sq.in. wire but left on the  $\frac{1}{8} \times \frac{1}{8}$  sq.in. wire, were called "small fraction". These two groups of kenaf chips would serve as the pulping samples.

As we broke down the chips by Hammer mill the raw materials consisted of kenaf ribbons and kenaf woody cores. The weight ratio of ribbon to core in large fraction and small fraction is 0.76:1 and 0.27:1 respectively.

## 2) Oxygen Pulping

Experiments were carried out on both sizes of the raw material samples. Cooking was conducted in an electrically heated pulping unit consisting of six stainless steel autoclaves, each having a capacity of 2.5 litres rotating in a heated liquid paraffin bath. The upper valve of the stainless steel cylinder was connected to the oxygen gas by copper tube which has oxygen pressure regulator for controlling the oxygen gas pressure in between.

Soda cooking process was experimented at 170°C conventional condition for 2 hours, to the screened samples for optimization of chemicals before running the oxygen pulping trials. The expected cooking yield was 40 - 50 % at the obtained pulp Kappa number of 30-40. The result gave the amount of NaOH 26 % on dry basis sample chips. This was rather high compared with the work of Chu which used only 21 % NaOH (Chu et al. 1971). However, this investigation would follow the 26 % NaOH.



The kenaf charging for each autoclave was 50 g oven dry weight. Cooking liquor to wood ratio of 6:1 consisted of 26 % NaOH and 0.6 % MgO. Magnesium oxide was used as carbohydrate protector in oxygen pulping. Oxygen pressure in cooking cylinder was adjusted from 0-140 psi. Cooking temperature was 120 - 150°C. Cooking time was 3 hours. Preheating time to the required temperature was within 1 hour. Cooking condition is shown in Table 2.

Properties of oxygen pulp were compared with those of kenaf soda pulp, at 170°C and at the same chemical amount and cooking condition.

### 3) Evaluation of Pulp Properties

Cooked pulp was washed until free of cooking solution and refined by Sprout Waldron 12" laboratory single disc refiner at 0.75 millimetre disc clearance. The pulp was then dewatered by Heine universal centrifuge and refined by Hobart mixer to determine its moisture and yield.

Kappa number was determined by Std. TAPPI. Testing for  $\text{SR}^{\circ}$  was carried out. Physical pulp property was tested through round sheet sample of 20 cm dia. produced from unbeaten pulp by the Sheet Machine of Karl Frank of the Federal Republic of Germany.

Results of pulping experiments and properties are shown in Tables 3, 4 and 5.

## DISCUSSION

### 1) Oxygen Pressure Effect on Pulp Quality

In pulping, the more the oxygen pressure, the brighter the pulp, and the less the Kappa number, this means higher physical quality but less yield. For example, at 120°C for the small kenaf fraction, when the gas pressure was increased from 0 to 140 psi, the pulp brightness rose to 14 - 23 units while its yield reduced by 3 - 8 % thus lowering Kappa number by 33 - 40 % when compared to the non-oxygen pulping under the same cooking conditions (Tables 3 and 4).

Oxygen pressure has much effect for the increase of pulp property particularly at the pressure of 140 psi. It has been found that every pulp sample has brightness over 50 which is considerably high in comparison with that of the pulp cooked under the same condition but without oxygen.

2) Temperature Effect on Pulp Quality

When the cooking temperature was increased from 120° to 150°C, the pulp brightness was reducing at the same time with the yield, while Kappa number much lowering. It can be seen from Tables 3 and 4 that Kappa numbers of the pulp samples cooked without oxygen at temperature between 120° and 140°C show not much difference, but increasing considerably when cooked with added oxygen. °SR of the pulp is also higher when heating temperature is increased.

Chip size	Temp. (°C)	O <sub>2</sub> Pressure (psi)	Yield	Kappa number	Brightness	O <sub>2</sub> SR	Breaking length (km)	Elmendorf tear factor	Burst factor	ph of waste liquor
Large Fraction	120	0	59.66	136.8	29	21	3.42	63.7	15.2	13.1
		80	53.45	95.8	38	23	3.99	44.7	14.2	10.8
		100	51.52	83.0	42.5	25	3.72	43.6	18.4	10.7
		120	49.23	80.6	45	28.5	4.73	43.1	21.4	10.7
		140	48.51	72.4	51	37	4.37	75.0	23.8	9.85
	130	0	58.40	127.6	27.5	-	4.33	62.3	19.2	13
		80	42.72	70.0	36	28	4.57	56.7	25.2	10
		100	47.24	69.3	40	29	4.65	46.3	21.1	10
		120	47.10	68.2	40	32	5.25	50.1	23.4	9.8
		140	44.48	43.8	52.5	43	5.68	83.8	29.8	9.25
	140	0	52.44	-	24	26	-	-	14.7	11.9
		80	46.70	56.7	33	-	4.27	68.2	19.5	9.7
		100	46.50	55.8	35	29.5	4.38	56.8	21.0	9.7
		120	46.93	52.3	38	-	4.31	61.8	19.8	9.7
		140	43.51	27.5	53.5	47.5	5.47	84.8	31.9	9.25
	150	0	48.69	73.7	24	26.5	4.25	100.9	24.1	12.0
		80	46.52	39.6	31.5	28	5.21	57.7	24.6	10
		100	46.23	37.7	32	32	4.70	69.5	21.8	9.6
		120	44.23	31.5	38	32	4.58	53.4	21.5	9.6
		140	37.95	14.3	53.5	49	4.80	91.4	28.7	9.25

PROPERTIES OF KENAF OXYGEN PULP (LARGE FRACTION)  
AT OXYGEN PRESSURE FROM 0 - 140 PSI

Chip size	Temp. (°C)	O <sub>2</sub> Pressure (psi)	Yield (%)	Kappa number	Brightness	°SR	Breaking length (km)	Elmendorf tear factor	Burst factor	ph of waste liquor
Small Fraction	120	0	56.19	136.5	29	21	3.29	64.3	12.3	13.0
		80	54.30	90.9	43	22	4.43	44.1	18.6	10.7
		100	53.56	87.6	44.5	24	4.33	40.4	20.5	10.65
		120	51.93	82.9	46	25	4.75	44.4	19.2	10.65
		140	51.80	81.4	52	40	3.90	59.2	19.6	9.85
	130	0	52.50	124.5	29	-	4.19	50.2	18.8	12.9
		80	49.55	73.4	35	23	4.29	41.7	22.1	9.6
		100	-	66.3	39	24.5	4.34	38.9	18.2	9.6
		120	49.45	61.5	41	34	4.88	43.2	18.3	9.5
		140	48.87	44.1	52.5	43.5	3.84	57.8	21.0	9.3
	140	0	52.35	124.2	26.5	25	-	-	11.5	12.1
		80	49.14	61.8	35	33.5	4.85	-	22.3	9.6
		100	47.99	52.1	39	-	5.23	46.5	23.7	9.6
		120	47.50	47.1	41	35	4.93	43.4	25.3	9.6
		140	46.45	34.0	55	48.5	5.75	53.6	29.1	9.3
	150	0	47.29	75.7	26	25	4.39	71.5	21.7	12.0
		80	47.89	34.4	33	37	5.71	43.8	25.3	10.0
		100	43.01	29.7	36	45	5.42	47.4	26.9	9.4
		120	42.42	20.7	41.5	47.5	4.50	43.6	26.8	9.4
		140	41.60	15.9	53.5	47.5	5.93	60.3	30.7	9.3

PHYSICAL PROPERTIES OF KENAF OXYGEN PULP  
AT OXYGEN PRESSURE FROM 0 - 140 PSI.

TABLE 5.

COMPARATIVE OF PHYSICAL PROPERTIES OF KENAF SODA PULP AND OXYGEN PULP

Physical Properties	Large Fraction		Small Fraction	
	Soda Pulp <sup>1/</sup>	Oxygen Pulp <sup>2/</sup>	Soda Pulp <sup>1/</sup>	Oxygen Pulp <sup>3/</sup>
Kappa number	31.2	31.5	37.1	34.4
Yield, %	45.22	44.23	46.24	47.89
°SR	23.5	32.0	27.0	37.0
Breaking length, km	6.66	4.58	5.06	5.71
Elmendorf tear factor	108.5	53.4	93.8	43.8
Burst Factor	41.5	21.5	27.1	25.3
Brightness	26.5	38.0	28.5	33.0
pH of waste liquor	11.2	9.6	11.2	10.0

1/ Soda pulp, 170°C, 26 7 ... a, 3 hrs.

2/ Results from Table 3, Oxygen pressure at 120 psi, 150°C.

3/ Results from Table 4, Oxygen pressure at 80 psi, 150°C.

At 120°C cooking temperature, some uncooked pulp was found in both sizes of the raw material. At 130°C and over, no uncooked pulp was noticed, but there were some unrefined fibres which could be taken as cooked, because these fibres were sufficiently soft.

### 3) Raw Material Size Effect on Pulp Quality

The pulping result of the raw material of both sizes has shown that under the same cooking condition the oxygen pulps obtained from both sizes had uniform Kappa number as well as similar quality. With an exception of the tearing factor, that of the oxygen pulp from the large sample was a little higher than from the small one, depending on the composition of the kenaf ribbon and core. As mentioned in paragraph 2.1, the ratio by weight of ribbon to core in "large fraction" and "small fraction" is 0.76:1 and 0.27:1 respectively. Usually, the fibre of kenaf ribbon is longer than that of the core, with the length of the former being about 2.2-3.00 millimetres while that of the latter being around 0.5-0.7 millimetres (Phoenix Pulp and Paper Co. Ltd. 1975; Chu et al. 1973). Thus, the large fraction whose ratio of ribbon to core is higher than the small fraction has better chance to produce higher tensile strength.

This has attested that the same pulp quality has been obtained by a thorough impregnation of chemical solution and oxygen as well as complete reaction in pulping of the raw material of both sizes. It is also seen that some non-wood raw materials, whose sizes are to be reduced for conventional chemical pulping, are not necessary to be made as small as woody chips, thus helping decrease the energy consumption in the processing.

### 4) Quality of Oxygen Pulp

This experiment was conducted by single stage oxygen pulping, the result of which shows that though kenaf has better chemical impregnation than wood its pulp quality has not proved very satisfactory. By property comparison of oxygen pulp from kenaf as in Tables 3 and 4

	Rice Straw <sup>1/</sup>	Bagasse <sup>1/</sup>	Reeds <sup>2/</sup>
<u>Cooking Conditions</u>			
Cooking Stage	Single	Single	<sup>*/</sup> Pre-impregnation before cooking
NaOH, % on dry basis of raw material	12	15	Sodium hydroxide solution concen- tration of 4 %
Oxygen pressure, psi	73.5	73.5	73.5
Temp. °C	100	135	120
Time to max. temp, min	90	90	60
Cooking time, min	30	30	120
Cooking yield, %	64.0	67.0	46.2
<u>Physical Properties</u>			
Breaking Length, km	3.95	7.10	6.07
Tearing Factor	80.0	67.0	66.7
Bursting Factor	32.5	32.0	36.2

<sup>1/</sup> El-Ashmawy et al. 1977

<sup>2/</sup> Results from T1STR

<sup>\*/</sup> Preimpregnation with NaOH solution 4 % concentration, soaking for 1½ hours, squeeze until solution was 28 % concentration disintegrating treated chips before cooking.

PHYSICAL PROPERTIES OF OXYGEN PULP FROM RICE STRAW, BAGASSE AND REED

TABLE 6.

to that from rice straw, bagasse and reeds as in Table 6 (all of which are non-wood), it can be seen that kenaf reacts to the oxygen pulping in the least among these 4 non-wood raw materials. Generally, for a conventional chemical pulping, kenaf should yield the highest quality pulp because it has longest fibre. The normal length of rice straw, bagasse and reeds is 1.45, 1.70 and 1.0 millimetre respectively (Kamolratanakul et al. 1979).

For quality test on all oxygen pulp samples, the experimental sheets have been made from unbeaten pulps to evaluate their physical qualities. Table 5 shows physical properties of unbleached pulp from both groups of the raw material, by soda cooking at 170°C conventional condition, for 3 hours, compared with those of oxygen pulp, cooked by the same chemical amount, but at lower cooking temperature of 140-150°C, and at same Kappa number between 30 and 40. The comparison result shows that oxygen pulp has more brightness than soda pulp while the breaking length and the burst factor of oxygen pulp are on the same level with soda pulp. The tearing factor of oxygen pulp is lower than that of soda pulp by almost one hundred percent. This indicates that the oxygen pulping reaction has greatly enfeebled the kenaf fiber strength, while °SR of oxygen pulp is higher than that of soda pulp, which is considered another short coming of oxygen pulp.

Regarding the qualities of kenaf oxygen pulp at different oxygen pressures (Tables 3 and 4), it is found that the pressure has a great impact on both physical properties and brightness of the pulp. At oxygen pressure 80 - 120 psi at same cooking temperature, the physical properties of oxygen pulp are not much different, while the brightness is increasing with mounting pressure.

When oxygen pressure being increased to 140 psi, the oxygen pulp properties have clearly proved to be higher than when cooked at 80 - 120 psi, both for physical property and brightness. However, the increasing °SR is its drawback.

At over 130°C the pulp cooked at oxygen pressure 140 psi would have low Kappa number that could be produced as bleached pulp, while the yield of which should not much reduce. Except at 150°C temperature, the large fraction would produce yield under 40 %. The oxygen pulp



cooked at pressure 140 psi, though without beating, has been placed on the medium-high quality, particularly for its tearing factor which is higher than that cooked at under 140 psi by almost one hundred per cent. The physical properties of the pulp are expected to rise up to high standard if passing the beating.

#### 5) Black Liquor

The pH of black liquor from oxygen pulping values around 7 which is lower than that from non-oxygen pulping under the same cooking condition (Tables 3 and 4). This indicates that it is easier for treatment of waste water from oxygen pulping than from soda pulping.

#### CONCLUSION

The experiment results can be concluded as follows:

1. Kenaf oxygen pulp produced by single stage oxygen pulping has light colour which is considered an advantage. The pulp quality ranges from medium to high while its yield accounts for 43.51-48.87 %.

Oxygen pressure bears a great effect on oxygen pulp quality. Under a pulping condition at oxygen pressure 140 psi and 130 - 140°C, the oxygen pulp would have high quality both in physical properties and brightness, that can be produced into high grade pulp. Physical properties and brightness of the said oxygen pulp are shown in Table 7.

2. When pulped to the same Kappa number, the yield of oxygen pulp will be the same as or a little higher than that of soda pulp, while the brightness of the former is more and its energy consumption is less than the latter. However, °SR of the oxygen pulp is higher than that of the soda pulp. This means that for the same production capacity of paper the oxygen pulp would require a larger paper machine than the soda pulp.

3. Though the medium-high quality pulp could be obtained from single stage oxygen pulping, the pulp has not been perfectly uniform. The pulp should be more uniform by two-stage pulping or by applying pre-impregnation.

TABLE 7.

PHYSICAL PROPERTIES OF KENAF OXYGEN PULP, COOKING AT 130 - 140°C  
OXYGEN PRESSURE 140 PSI

Physical Properties	Oxygen Pulp from large Fraction Sample		Oxygen Pulp from small Fraction Sample	
	130°C	140°C	130°C	140°C
Kappa number	43.8	27.5	44.1	34.0
Yield, %	44.48	43.51	48.87	46.45
°SR	43.0	47.5	43.5	48.5
Breaking length, km	5.68	5.47	3.84	5.75
Elmendorf tear factor	83.8	84.8	57.8	53.6
Burst factor	29.8	31.9	21.0	29.1
Brightness	52.5	53.5	52.5	55.0

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THE NACO PROCESS  
- A SELECTIVE PULPING PROCESS FOR ANNUAL FIBRE RAW MATERIAL  
by  
T. Franzén

THE NACO PROCESS FOR ANNUAL FIBRE RAW MATERIAL

Summary

This report shall be seen as an intermediate report for a project in Foggia, Italy, where the first Naco process is involved. Today the new digesting plant based on the Naco concept has been in operation for some eight months. The new digesting plant is designed for a production capacity of 100 ADMT/24 h. The production capacity of today is by means of a too small paper mill limited to around 80 ADMT/24 h. The pulp properties from the chemical pulping of wheat straw are well comparable with the corresponding pulp properties from sulphate digesting of Birch or Eucalyptus, why we today dare to say that there are new possibilities to produce excellent pulp from annual fibres raw material.

Later the new recovery system will be started and the total Naco process will be tested. The recovery system is delivered from Lurgi, West Germany. The recovery system consists of an evaporation plant and a recovery boiler, where the liquor from the new Naco pulp washing plant will be first evaporated and then burnt in the recovery boiler and  $\text{Na}_2\text{CO}_3$  will be recirculated to the digesting plant.

Later a new bleach plant will be built based on the Ozone bleaching technique. In Foggia a new concept for Ozone bleaching has been tested in a pilot plant, which now is ready to be evaluated in a new production plant in Foggia. The new Naco pulping technique means a process almost completely free from pollution problems. The environmental regulations in Italy have forced the new technique and it has for Sunds Defibrator been a big challenge to participate.

GOAL AND SCOPE - FOR THE DEVELOPMENT OF A NEW  
DIGESTING PROCESS

For many years Sunds Defibrator had been looking for a new process for chemical pulping of annual fibre raw material. In the beginning of the 1980's a co-operation agreement was signed to try to develop a new idea emanating from Mr. Franco Nardi and his technical group in Italy.

The following scope was formed to be the goal for the new chemical pulping process of different annual fibre raw materials:

- Produce a good chemical pulp from annual raw material
- Best chemical pulp and paper properties
- Small pollution load (no sulphur and chlorine involved)
- Simple process technology
- Usable for different types of raw material
- Low in investment costs
- Low operational costs

The new pulping technique was meant to be based on using of the new turbo-pulper designed by Mr. Franco Nardi.

Only a small amount of NaOH should be added to the turbo pulper together with the straw, while  $\text{Na}_2\text{CO}_3$  should be recovered and reused as alkali together with oxygen ( $\text{O}_2$ ). The need of NaOH should only replace the actual loss of digesting chemicals (from digesting, washing, evaporation and recovery boiler), while  $\text{Na}_2\text{CO}_3$  should be recycled from the recovery system separated from  $\text{SiO}_2$  and organic material.

The first step was to build a "Laboratory Turbo pulper" in order to measure all basic parameters needed for future calculations of the new pulping process. The first "Laboratory Turbo pulper" (see fig. 2) was built and placed at the IPZS pulp and paper mill in Foggia, Italy. The IPZS in Italy were also willing to finance some part of the project in order to define a new process, which later could replace the existing old system.

### TEST AND TRIALS

The first thing to study was the correlation between pressure and temperature by operation with NaOH and O<sub>2</sub> in combination, when the first trials had to be made batchwise. Fig 3 shows how the pressure develops as a function of temperature and time.

After that a number of tests with wheat straw was done in order to optimize the pulp properties against the need of digesting chemicals (from the beginning NaOH and oxygen) and digesting temperature.

Fig. 4 shows how the relation between Kappa number and charge of NaOH, when 23 - 25 % Na<sub>2</sub>CO<sub>3</sub> was mixed into the pulping solution. At a Kappa number of 15 - 18, the charge of caustic soda was found to be in the region of 6 - 8 %. This chemical balance point has later been found to be very sufficient.

In fig. 5 the relation between lignin content expressed as Kappa number and pulp brightness is shown. From the figure can be seen that straw pulp of a Kappa number of 16 - 18 gives a brightness of 40 - 50 % ISO. It is also noticeable that the Kappa number below 20 gives a high increase in brightness. As can be seen from the diagram in fig. 6, the pulp strength as tensile index and tear index, is not tremendously sensitive to the delignification degree (X- No). The level is acceptable also at Kappa numbers as low as 10.

### PILOT PLANT

Based on what was found in the Laboratory unit, a new continuously working pilot plant was built. The turbo pulper was given a diameter of 1.5 m and designed for the same temperature and pressure as the earlier one. The system (see fig. 7) was designed for a pulping production of around 5 ton/24 h and equipped with a small disk refiner of straw and a monopump as feeder of the straw, chemicals and dilution water to the turbo pulper. Chemicals were also foreseen to be charged directly to the turbo pulper. For rotation of the solution, the turbo pulper was equipped with a mixer in the bottom, forcing the pulp to circulate. The idea was to force the oxygen to

react very fast with the pulp in the turbo pulper in order to speed up the delignification work and oxidation of the liquor.

After the pulper the pulp is pumped over to a reactor, where a small final delignification will take place with  $O_2$  during slow rotation via a mixer in the bottom of the reactor. The Kappa will only be some 2 units lower than in the reactor. From the reactor the pulp will be blown over to a blow tank of standard type.

In fig. 8 is shown that the results from continuous operation are better than the corresponding ones from batch digesting. The only way to explain the higher total yield at the same  $X$  - No, better pulp properties, lower reject flow etc, is that something very special was developed.

The explanation was later expressed as 'a new selective digester'.

This selectivity means that all particles (see fig. 9) independent of size will be in the mixture of digesting chemicals and oxygen at a certain pressure and temperature, the necessary time, in order to be almost finally digested. As the time in the turbo pulper will not be 100 % right for every single fibre, the whole fibre flow will be pumped over to the static  $O_2$ -reactor, where the final delignification will take place in order to get an almost constant  $X$ - No. in the final pulp production.

This selectivity can be compared with the non-selective digesters, where all chips must have a uniform size to get good pulp properties at a certain time in the digester. This uniform particle size can never be reached with straw, and therefore the digester has to be selective.

Even other types of annual raw material have been tested in the turbo pulper as bagasse rice straw, saw dust and waste from Kraft and corrugated medium. In fig. 10 the results of a test with bagasse are listed. As should be noticed the bagasse raw material was unbeaten and even undepithed, which is the explanation for low drainage resistance ( $^{\circ}SR$  22).



Based on the received results from the trials with the Pilot Plant, it was decided to build a full scale production line for straw pulping at IPZS in Foggia, Italy.

#### RESULTS FROM OPERATION OF THE NEW PRODUCTION LINE IN FOGGIA

Since the beginning of 1985 the new Naco pulping line has been in operation on wheat straw in Foggia, Italy. From the very beginning the production capacity was 40 - 50 tBDP/24h and has since September been over 75 tBDP/24h. For the moment it is impossible to increase the production more, as the paper machines cannot take more. For the moment the only digesting chemicals used are NaOH and O<sub>2</sub>. After new year 85/86 the recovery system will be started and put into operation and the tests with Na<sub>2</sub>CO<sub>3</sub> will be started.

Produced pulp is today bleached in a 2-step NaOCl bleach plant before entering the paper machine system.

In fig. 11 the flow sheet of the new Naco digesting system in Foggia is shown. The pretreatment or depithing system is built as a wet system, where straw is mixed with water and some soda in an ordinary open pulper in order to remove wax etc. The straw is then separated from stones and sand in a cyclone separator. The straw is then fed to a washing and dewatering screw, where fresh water is showered over the straw. Finally, the straw is dewatered over a DKP-press. Washing efficiency is calculated to be around 50%, measured on the silica content.

Before entering the Naco pulping system the straw is passing a Sunds Defibrator Refiner machine, where knots are destroyed to a certain level. (Disc clearance 2 mm).

The straw will then be pumped into the pressurized turbo pulper and reactor system as the earlier described. The pressure in the system: 6 bar, and the temperature: 135°C.

In fig. 12 is shown the actual conditions measured from the Naco digesting plant in Foggia per September 30, 1985. The figures still correspond very well to the first tests, made in the laboratory test unit.

In fig. 13 the pulp properties of unbleached Naco digested pulp are shown, which correspond very well to what was received from the test runs in the Pilot plant.

The production system is today equipped with a heat recovery system installed for the blow steam, where all needed fresh water is heated to around 90°C. The pulp is then finally washed over a twin roll press, where the washing efficiency is above 90 % and hot water is used as washing water.

Some troubles with incrustations in the washing press have caused operational problems. The press has to be stopped and washed with acid and high pressure cleaning water. Today some small amounts of soda are added, which have decreased the problems.

Since the start-up of the pulping process in the beginning of the year, the stated pulp production has been kept within stated guarantee limits from the contract. Only small failures in the machinery have stopped the production at a few occasions, and therefore we have to say that the start-up of the new system has been very successful.

#### OZONE-BLEACHING

During the last three years, tests have even been made with different conditions of ozone-bleaching. From the literature could be found that ozone-bleaching should take place at low pH and high pulp consistency. These conditions are bad for the Naco system and annual fibre material, so other conditions had to be found.

The first test was done at high pulp consistency and at a pH of 3.5. Later some comparable test were made at a pH of 8.4. The straw was circulated in an atmosphere of ozone and oxygen in a circulating pipe system.

Bleaching results are shown in fig. 14 and tell us that low pH is not necessary to use. Other problems were the high dryness of the pulp which was setting the pulp on fire rather frequently. So another pilot for low consistency and high pH was put in operation (see fig. 15). The tests were done in the first turbo pulper built for laboratory trials which now was rebuilt and completed with a small ozonizer, for a production of  $O_3$  gas from  $O_2$ .

The ozone consistency in oxygen could be produced up to 6-7 % while max ozone consistency made from air could be up to 4 %. Electrical consumption when producing  $O_3$  from  $O_2$  was measured to 11 kWh/kg  $O_3$ .

In the new ozone bleaching turbo pulper tests have been carried out with high pH and low pulp consistency and at a pulp temperature of 20 - 45°C. The bleaching conditions and received pulp properties are shown in fig. 16.

#### NEW $O_3$ -BLEACH PLANT

Based on carried out trials, Sunds Defibrator will very soon be prepared to offer complete  $O_3$ -bleach plants. The design will be as shown in figure 17. First the pulp has to be cooled down from 55°C after the washing press to 30-40°C. In our described solution this is thought to be done by adding fresh water into the pulp after the dewatering press. As the dilution will go down to approx. 3.5 % the pulp is suggested to be further diluted to 1 - 1.5 % with circulating water. At these conditions the pulp will be screened over pressurized centrifugal screens. After screening the pulp will be dewatered to around 5-6 % pulp consistency. Dewatered pulp at 5-6 % pulp

consistency will then be fed by an ordinary centrifugal pump to the bleaching turbo pulpers. The pressure in the reactors will only be the static pressure of the pulp column. And therefore the pressure of the oxygen to the ozonizers only have to be some 1 bar over pressure.

The total retention time over the reactors will be some 25-30 minutes and the volume will be divided in two units in series and the pulp and ozone in counter-current.

Residual oxygen will be relieved from the turbo pulpers and then dewatered and compressed to 6-7 bar before being reused in the digesting turbo pulper and reactor as earlier described.

The bleached pulp will finally be dewatered over a washing filter before leaving for the paper mill or drying machine.

The final brightness after the  $O_3$  bleaching will not be higher than 75 % ISO, and therefore, if desired, the pulp has to be further bleached with  $H_2O_2$  or NaOC .

#### RECOVERY SYSTEM

The total Naco-system even involves a total chemical recovery system, where spent liquor from the pulp washing plant first will be separated from solid silicates and other solid chemicals. After the solids separation of the material, the liquor will be evaporated to around 48 % and then finally burned in new way in a recovery boiler without reaction bed.

From the recovery boiler green liquor will be recovered as  $Na_2CO_3$ , which will be reused in the digesting plant. Remaining silicates will be separated by mixing the black liquor with  $Ca(OH)_2$  which in the drainage tank after the boiler will be separated as sludge.

The total system is shown in enclosed block diagram. The system shows the entire system in balance. There will also be some flow of sludge from the recovery boiler, some effluent flow from evaporation plant and some flow of washing water from the pre-treatment and bleaching plant.

There will only be a limited pollution load compared with other straw pulping processes.

#### CONCLUSIONS

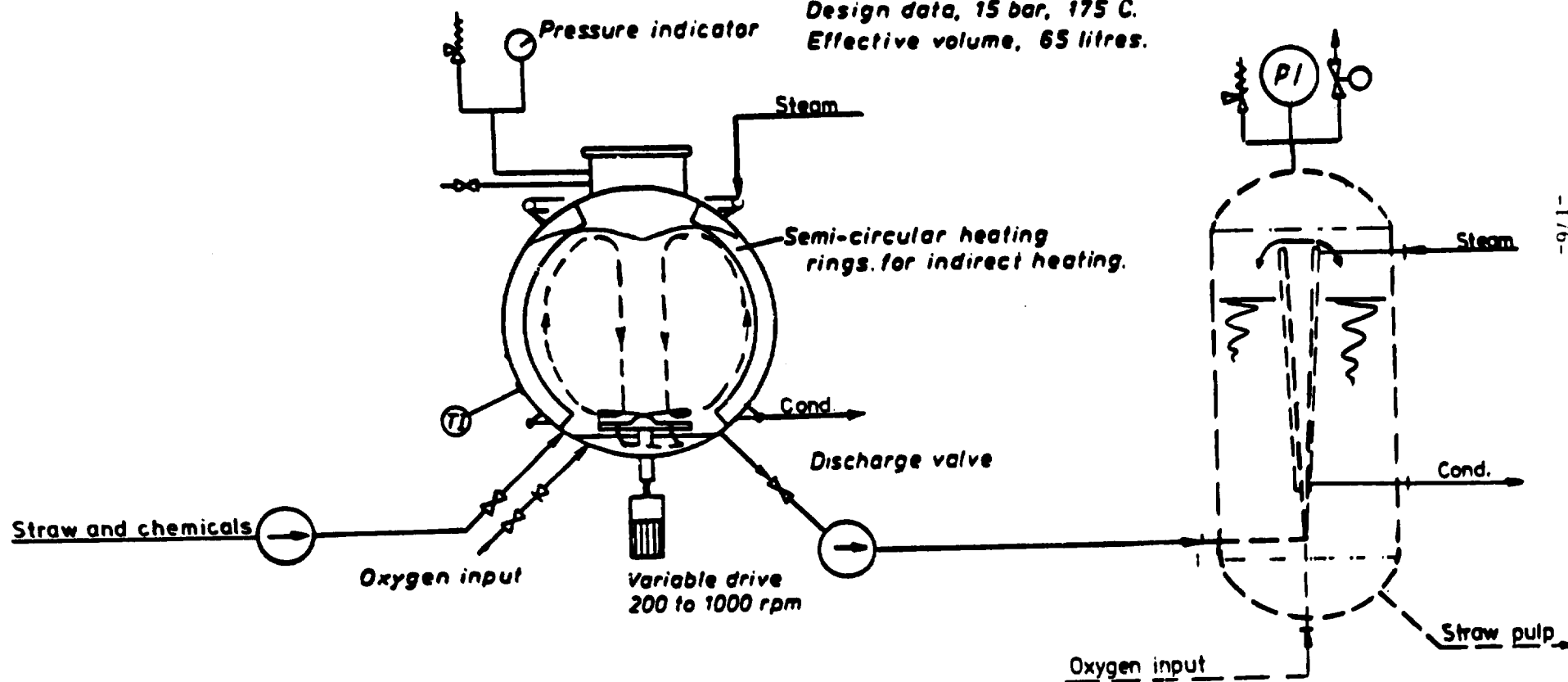
In the field where Sunds Defibrator AB is involved in the fibre line, results obtained up till today, confirm that the pulping process meets the demands of the pulp industry. Plants based on the presented pulping process can be built:

- with relatively small capacity and are not creating logistic problems in supplying non-wood fibre raw materials;
- with an acceptable capital investment level, including a full chemical recovery system;
- with a minimum of impact on the environment.

The Naco process can be used for treating a wide range of raw materials. It is obvious that we have now shown that the process will contribute to the economical production of pulp and paper from raw materials maintained in this report.

Fig.2. Laboratory Turbopulper:

Spherical recipient,  $\phi$  500 mm.  
Design data, 15 bar, 175 C.  
Effective volume, 65 litres.



**Figure 3. Straw digestion by batch operation using NaOH/O<sub>2</sub> in the Laboratory Turbo Pulper. Pressure development as a function of temperature and time.**

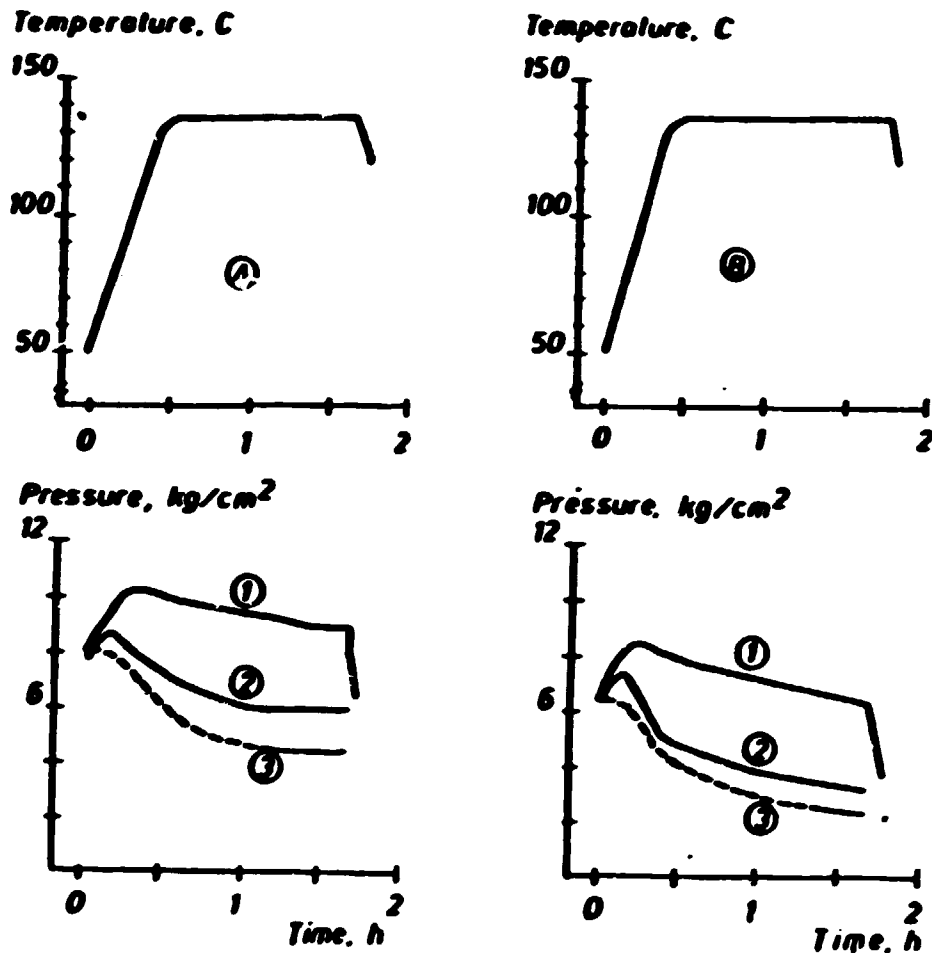


Figure (A) Initial pressure of O<sub>2</sub>; bar at 50°C

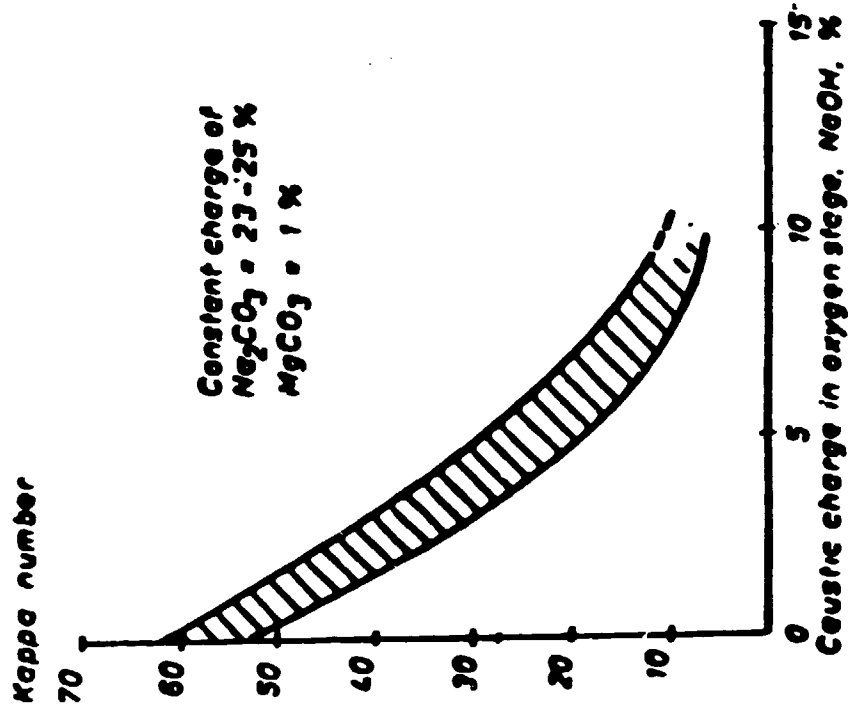
Figure (B) Initial pressure of O<sub>2</sub>; bar at 50°C

(1) Total pressure

(2) Partial pressure of O<sub>2</sub> and CO<sub>2</sub>

(3) Ditto corrected to 50°C

Figure 4.  
Wheat stem.  
Relationship  
between  
caustic charge  
and Kappa number





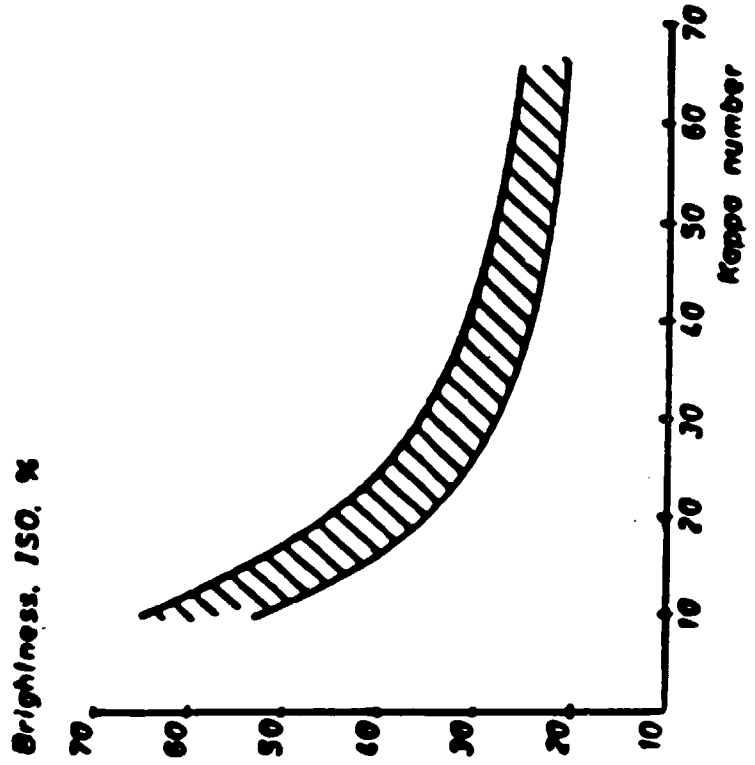
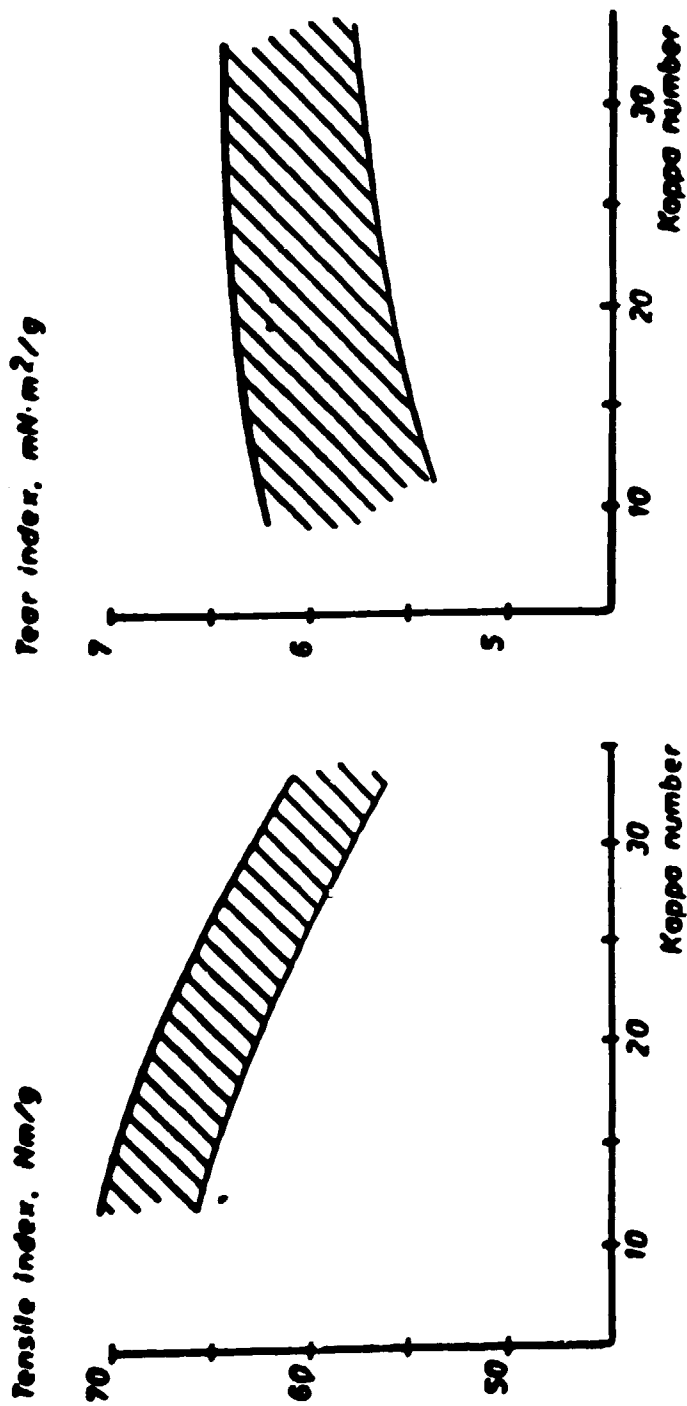


Figure 5.  
Wheat straw.  
Relationship between  
Kappa number and  
brightness, ISO.

Figure 6. Wheat stem. Tensile and Tear Index vs Kappa number



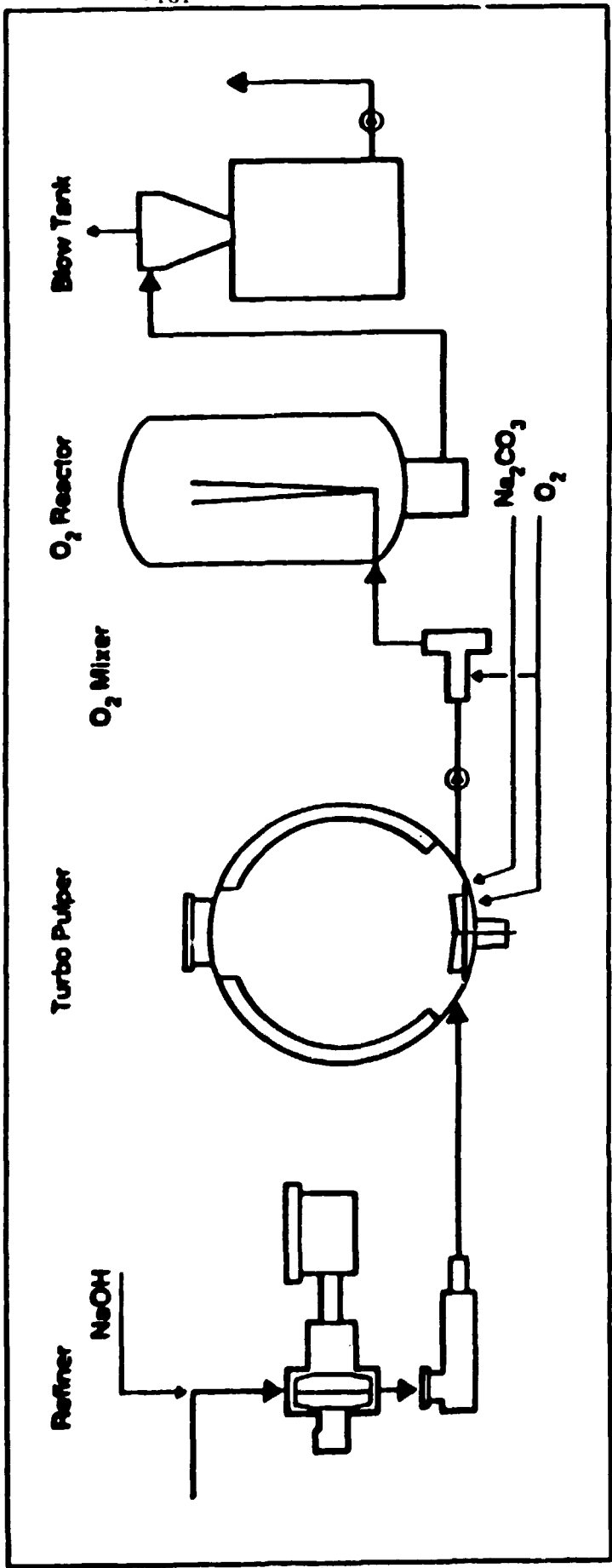
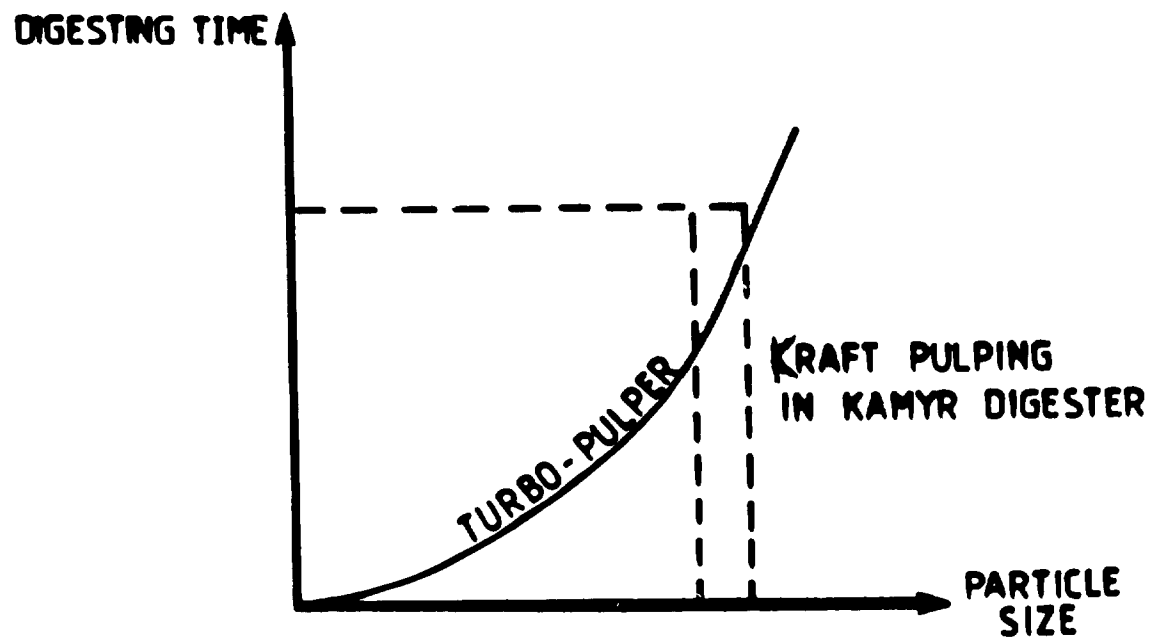


Figure 7. Flow diagram of the NACO pilot plant.

**Table 1 .**

*Continuous wheat straw pulping in the NACO pilot plant*

Reaction temperature	°C :	135	
Oxygen pressure	bar :	8	
Na <sub>2</sub> CO <sub>3</sub> (on b.d. straw)	% :	23.3	
NaOH (on b.d. straw)	% :	5	7
MgCO <sub>3</sub> (on b.d. straw)	% :	1	
Kappa number	No.:	22	11.5
Brightness (unbleached), ISO	% :	46	59
Drainage resistance	°SR :	27	26
Tensile index	Nm/g :	53	66
Tear index	mN·m <sup>2</sup> /g :	4.6	6.1
Burst index	kPa·m <sup>2</sup> /g :	2.9	3.5



**Fig. 2**  
 SELECTIVE GRADIENT OF TIME IN THE TURBO PULPER  
 DEPENDING OF PARTICLE SIZE OF THE FEEDED STRAW  
 COMPARED WITH A NORMAL CONTINUOUS DIGESTER

Table 10

Batch bagasse pulping in the NACO pilot plant

Reaction temperature	°C :	130
Oxygen pressure	bar :	7
NaOH (on b.d. bagasse)	% :	15
MgCO <sub>3</sub> (on b.d. bagasse)	% :	1
Kappa number	:	16
Brightness (unbleached), ISO	% :	49
Drainage resistance	°SR :	22
Tensile index	Nm/g :	47
Tear index	mN·m <sup>2</sup> /g :	4.2
Burst index	kPa·m <sup>2</sup> /g :	2.0

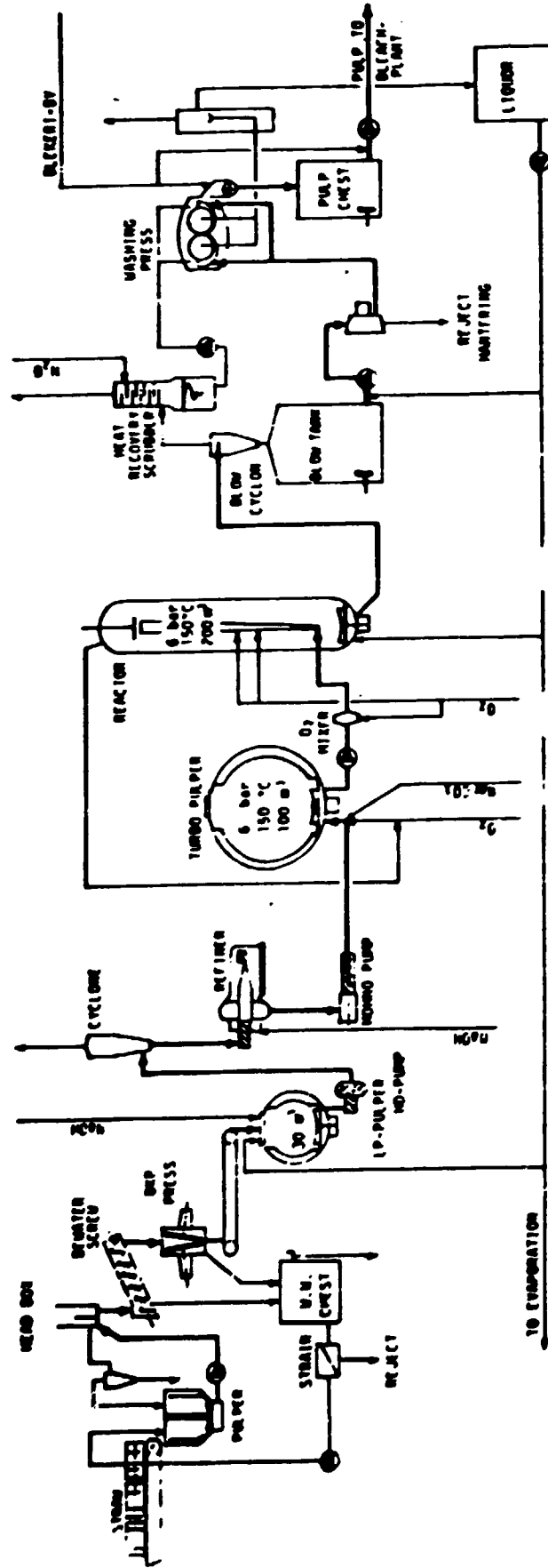


FIG. 11 FLOW SHEET THE NACO PULPING SYSTEM  
AT JPZS IN FOGGIA ITALY

Fig. 12

**Results from practical operation of the Maco Straw Digesting Plant at Polygrafico, Foggia, per September 30, 1985**

	<b>Range</b>	<b>Average</b>	
<b>Pulp production</b>	<b>50-85</b>	<b>75</b>	<b>ton BDP/d</b>
<b>Straw consumption</b>		<b>145</b>	<b>ton BDP/d</b>
<b>Yield</b>		<b>52</b>	<b>%</b>
<b>K-No</b>	<b>15-24</b>	<b>18<sub>2</sub></b>	
<b>Brightness</b>	<b>38-54</b>	<b>40-47</b>	<b>%ISO</b>
<b>NaOH-charge</b>	<b>220-290</b>	<b>265</b>	<b>kg (100% NaOH)/ton BDP</b>
<b>O<sub>2</sub>-charge</b>	<b>140-200</b>	<b>160</b>	<b>kg O<sub>2</sub>/ton BDP</b>
<b>Na<sub>2</sub>CO<sub>3</sub>-charge</b>	<b>not yet started</b>		
<b>Stear consumption</b>	<b>1.0-1.6</b>	<b>1.4</b>	<b>ton/ton BDP*</b>
<b>Water consumption</b>	<b>8-20</b>	<b>11</b>	<b>m<sup>3</sup>/ton BDP</b>



**FIG 13**

**PULPING WHEAT STRAW**

**NACO PROCESS**

**POLYGRAFICO FOGGIA ITALY**

<b>OPERATION CONDITIONS:</b>	<b>NAOH CHARGE KG/BD TON PULP</b>	<b>270</b>
	<b>O<sub>2</sub> "</b>	<b>165</b>
	<b>TEMPERATURE °C</b>	<b>132</b>
	<b>PRESSURE BAR</b>	<b>6</b>

<b>PULP PROPERTIES:</b>	<b>*SR UNSCREENED</b>	<b>42</b>
	<b>*SR SCREENED</b>	<b>32</b>
	<b>KAPPA NO</b>	<b>13.5</b>
	<b>INTRINSIC VISCOSITY CC/G</b>	<b>728</b>
	<b>BRIGHTNESS % ISO</b>	<b>55</b>
	<b>DENSITY G/CC</b>	<b>0.6</b>
	<b>BREAKING LENGTH KM</b>	<b>7.2</b>
	<b>DOUBLE FOLDING NO</b>	<b>110</b>

FIG 14

OZONE - BLEACHING TESTS  
DIFFERENT PH - HIGH CONSISTENCY

OPERATION COND:	O <sub>3</sub> CHARGE ON BDP	%	1	1
	TEMPERATURE	°C	30	30
	PH		8.4	3.2
	PULP CONSISTENCY	%	45	45
PULP PROPERTIES	°SR UNSCREENED		37	35
	°SR SCREENED		30	29
	KAPPA NO		4.5	4.0
	INTRINSIC VISC.	CC/G	500	550
	BRIGHTNESS	%	74	76
	YELLOWNESS	%	11.4	11.0
	DENSITY	G/CC	0.56	0.57
	BREAKING LENGTH	KM	5.4	5.2
	DOUBLE FOLDING	NO	27	26

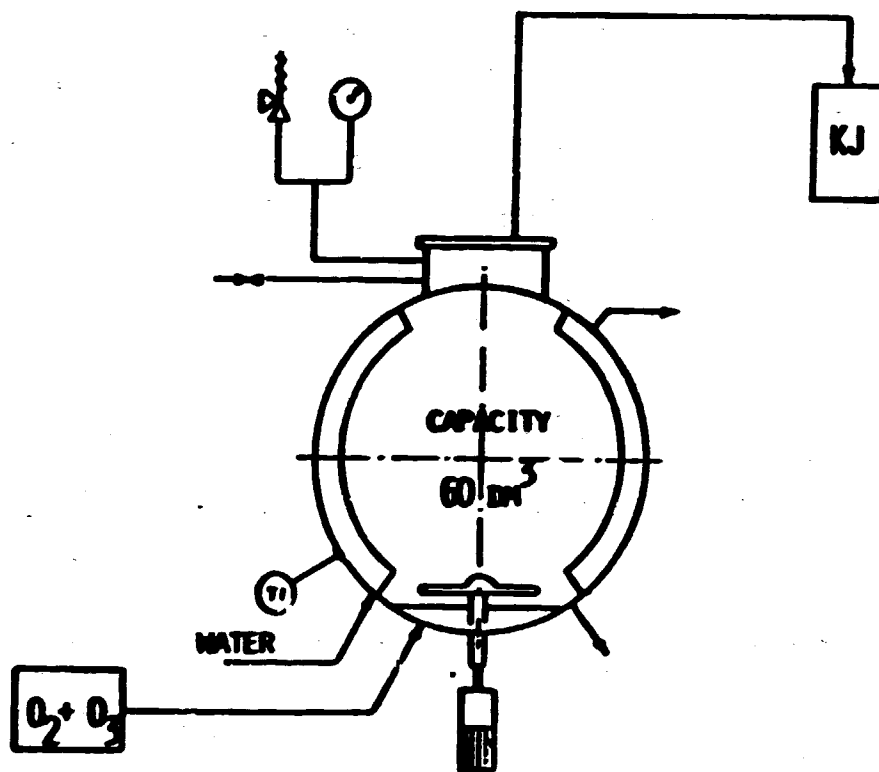


Fig. 15 LAB TURBOPULPER

**FIG 16**

**OZONE - BLEACHING TESTS  
HIGH PH - LOW PULP CONSISTENCY**

<b>OPERATION COND:</b>	<b>O<sub>3</sub> CHARGE ON BD PULP</b>	<b>%</b>	<b>2</b>	<b>2</b>
	<b>TEMPERATURE</b>	<b>°C</b>	<b>40</b>	<b>40</b>
	<b>PH</b>		<b>7</b>	<b>7</b>
	<b>PULP CONSISTENCY</b>	<b>%</b>	<b>5</b>	<b>2</b>
<b>PULP PROPERTIES:</b>	<b>*SR UNSCREENED</b>		<b>64</b>	<b>60</b>
	<b>*SR SCREENED</b>		<b>50</b>	<b>45</b>
	<b>KAPPA NO</b>		<b>6.1</b>	<b>4</b>
	<b>INTRINSIC VISCOSITY</b>	<b>CC/G</b>	<b>700</b>	<b>650</b>
	<b>BRIGHTNESS</b>	<b>%</b>	<b>74</b>	<b>75</b>
	<b>YELLOWNESS</b>	<b>%</b>	<b>10</b>	<b>9</b>
	<b>DENSITY</b>	<b>G/CC</b>	<b>0.57</b>	<b>0.62</b>
	<b>BREAKING LENGTH</b>	<b>KR</b>	<b>6.2</b>	<b>6.2</b>
	<b>DOUBLE FOLDING</b>	<b>NO</b>	<b>150</b>	<b>200</b>

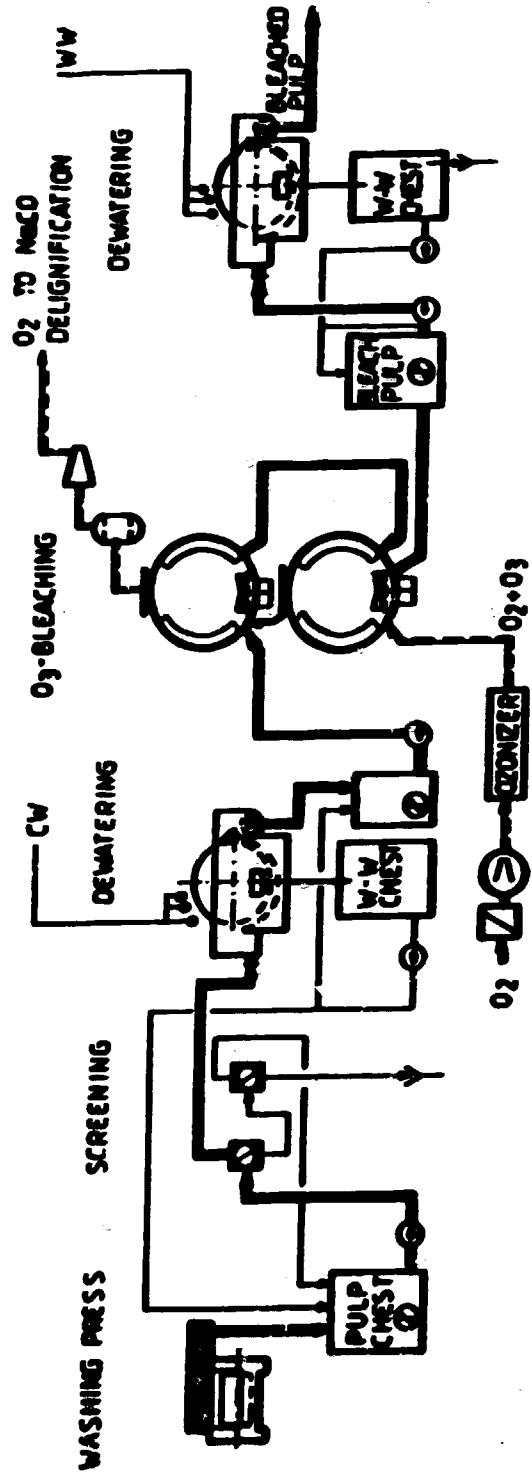


FIG. 17 NaClO SYSTEM FOR OZONE BLEACHING

DIRECT ALKALI RECOVERY SYSTEM (DARS)

by

Messrs. Matthys and Covey (BABCOCK & WILCOX)

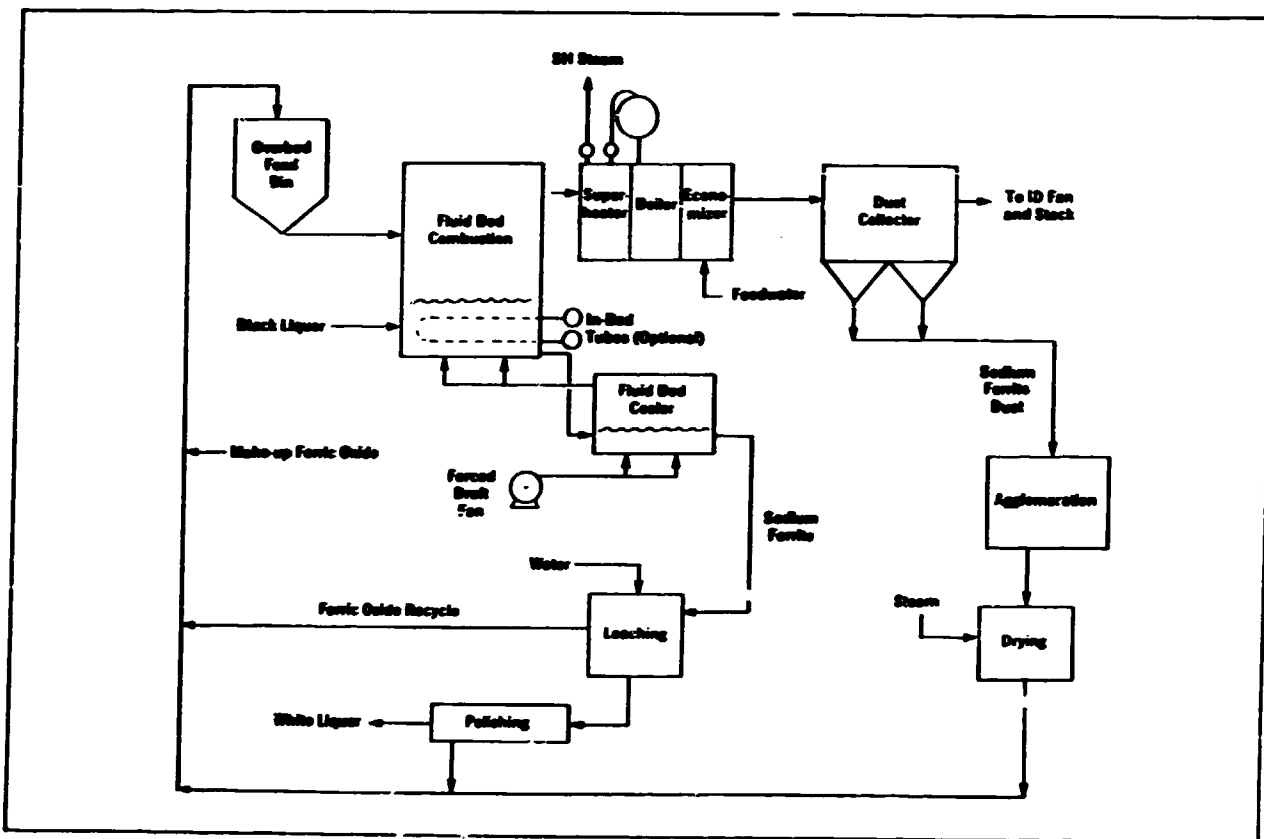
DIRECT ALKALI RECOVERY SYSTEM

The Direct Alkali Recovery System (DARS) is a new method of chemical and energy recovery for soda or soda-anthraquinone black liquor. Invented in 1976 by Toyo Pulp Company of Japan and tested in pilot operations for two years by Australian Paper Manufacturers, the process has now been licensed to Babcock & Wilcox (USA) for sale of commercial units. B&W has an agreement with the Sprout-Waldron Division of Koppers Company, Inc., for the supply of process equipment systems for DARS units.

The process, shown below, burns black liquor in a fluidized bed of ferric oxide ( $\text{Fe}_2\text{O}_3$ ) to combust the liquor organics and causticize the sodium directly by forming sodium ferrite ( $\text{Na}_2\text{Fe}_2\text{O}_4$ ), a high melting point solid. No molten smelt is formed. The solid bed product is cooled by contact with incoming combustion air and then leached with water to form high quality white liquor and to regenerate ferric oxide for recycle to the furnace. Dust collected from the boiler flue gas is almost entirely sodium ferrite fines, which are agglomerated and returned to the fluid bed to maximize sodium recovery.

Features

- Up to 99 % soda recovery
- White liquor causticities up to 94 %
- NaOH concentrations up to 300 grams/liter
- Low emissions
- Low corrosion
- No supplemental fuel except for start-ups
- No smelt for explosion hazard.



Closed Systems

There are essentially no uncontrollable losses from the system, except for a small stack loss, which can be minimized by proper selection of dust collection equipment. This results in a closed system with its benefits of low makeup chemical requirements, low process water usage, and low effluent treatment costs. However, non-process elements (NPEs) entering with the wood and make-up chemicals will have a tendency to build up, as would be the case in any closed system. Soluble impurities may be removed by a cold water leach (below the hydrolysis temperature) of the sodium ferrite bed product. Non-soluble impurities may be controlled by batch disposal of a small percentage of the recycled material.

### Energy Efficiency

Because the sodium ferrite formation reaction is endothermic (energy-absorbing), the net thermal efficiency of DARS combustion is one or two points lower than conventional recovery. However, this energy deficit is more than made up for elsewhere in the mill. First, there is no lime kiln auxiliary fuel consumption. Second, with continuous digestors, heating steam consumption is lower due to the higher white liquor concentrations. Third, evaporation steam is lower due to less water in the weak black liquor. Finally, no green liquor heating steam is required. These savings add up to an overall energy efficiency in favor of DARS recovery.

### Safety and Flexibility

The DARS combustor makes no smelt, so there is no risk of smelt-water reaction with its often disastrous consequences. Also, the fluidized bed operates under completely oxidizing conditions, which, coupled with the absence of sulfur from the system, minimizes corrosion problems. The absence of appreciable levels of sulfur also results in the ability to cool flue gases more than would be the case if acid dew point concerns existed. This means more high pressure steam energy from the flue gas is possible.

The fluid bed can burn black liquor from concentrations as low as 35 % solids. Higher calorific heating value and percent solids liquors are combusted by deployment of boiler or superheater tubes in the bed for excess heat removal. This method of heat absorption results in lower total boiler surface requirements due to the high heat transfer coefficients typical of in-bed tubes. And tube erosion can be controlled by application of pin studs, thus prolonging in-bed tube life.



DARS - FLUIDIZED BED RECOVERY AND CAUSTICIZING FOR SODA LIQUOR

Abstract

The Direct Alkali Recovery System (DARS) offers the user the benefits of simplicity, economy, and minimal environmental impact in recovery of energy and cooking chemicals from soda black liquor. White liquor of up to 94 % causticity and 300 grams per liter NaOH can be generated. The first step in the process is fluidized bed combustion of the liquor organics in the presence of ferric oxide, forming sodium ferrite. Soda recovery is completed by a leaching stage to generate white liquor from hydrolysis of the sodium ferrite. Capital and operating costs are lower than conventional soda recovery.

The Industry Dilemma

Since the early 1930's, when the advent of the modern water wall Kraft recovery boiler enabled efficient recovery of heat and chemicals from black liquor, Kraft pulping has rocketed to a position of overwhelming dominance among wood pulping processes in current use (Fig. 1). But today's economic, social, and political environments are causing the pulp and paper industry to look long and hard before committing valuable capital to new and replacement pulp production capacity. Matics (1) and Harton (2) report that softwood reserves are declining, and hardwoods, while plentiful, remain a relatively untouched resource. World-wide, non-wood raw materials such as bagasse, straw, bamboo, rice hulls and kenaf are in abundant supply. The pulp and paper industry of the 80's and beyond will continue to use processes that produce high yield pulps without sacrificing quality, but the successful realization of this objective will be hampered by concern over the high cost of pollution control, auxiliary fuels, labor and capital. Incremental additions to capacity, as well as replacements of relatively small production lines, will be the rule, and therefore a more economical process in these small sizes (50-600 TPD) will be required.

Kraft pulping, in the long term, will not provide an acceptable response to the problems facing the pulp and paper industry. Kraft mills are expensive, and must be built in very large capacities to be economic. Lime kiln auxiliary fuel consumption adds significantly to the overall production cost. Sulfur in the cooking liquor results in high costs for emission control and maintenance due to corrosion. High operating and maintenance costs are the direct result of a complex and relatively inflexible chemical recovery system. A recovery furnace explosion from water entering the smelt bed can put a boiler out of production for weeks. Finally, keeping the recovery boiler on line at rated capacity requires high sootblowing steam consumption and periodic outages for water washing, both of which add significantly to the cost of producing pulp.

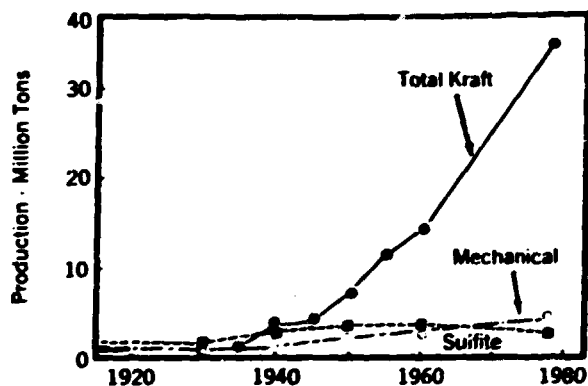


Fig. 1 US Pulp Production

#### Why Soda/Anthraquinone with DARS?

Soda/AQ pulping with Direct Alkali Recovery System (DARS) heat and chemical recovery is the first technically feasible, economic process to come along which overcomes most, if not all, of Kraft's problems (3,4,5). Compared to Kraft and soda with conventional recovery, soda/AQ with DARS offers the potential not only for smaller minimum economic size, but also for lower initial capital cost in most size ranges. Lack of significant levels of sulfur in the liquor results in lower emissions and negligible corrosion damage to recovery and causticizing equipment. Operating and maintenance costs are lower due to the inherent simplicity of the system and the fact that on-line operation requires no auxiliary fuel consumption. Higher white liquor causticities (94 % for DARS vs. 85 % for conventional recovery) and

higher active alkali concentrations (300 grams per liter as NaOH for DARS vs. 150 grams per liter for conventional recovery) results in lower inorganic dead load and lower evaporator steam consumption. The DARS also permits greater turndown ratios, greater stability and tolerance of upsets, and, best of all, no risk of smelt-water explosions in the black liquor combustor. Finally, soda/AQ with DARS recovery is well-suited for utilization of hardwoods and some non-wood species, as the pulp properties are very close to those achievable with Kraft.

What is Soda/AQ?

Anthraquinone (AQ) was first proposed as an additive for alkaline pulping in 1977 by Holton (6). While applicable to both sulfate and soda pulping, the greatest relative benefits are for the latter, as shown in Fig. 2 and Tables 1 and 2. These results are based on unpublished tests by Mead Corporation, which began using AQ in its Kingsport, Tennessee bleached printing paper mill in 1977 (7,8). Associated Pulp and Paper Mills, Ltd., Burnie, Tasmania, Australia, is also using AQ to improve rate and yield on eucalyptus pulping (9). Virkola (10) reports that AQ is attractive as an additive to circumvent some production bottlenecks situations, but that the current cost of AQ precludes its widespread use in alkaline pulping operations with conventional (high cost) recovery systems.

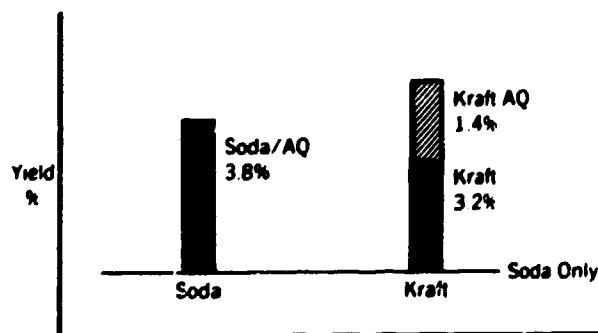


Fig. 2 Yield increase by AQ addition

The DARS Process

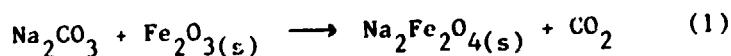
The DARS was invented and patented in 1976 by Toyo Pulp of Japan (11). Subsequent improvements to the process involving use of a fluidized bed for black liquor combustion and cold leaching for impurity removal were developed by Australian Paper Manufacturers (APM) of Melbourne, Victoria, and patented in 1980 (12). APM and Toyo have since licensed manufacturing rights for equipment utilized in the DARS process to Babcock & Wilcox.

	Soda	Soda/AQ	Kraft
% Active Alkali (as Na <sub>2</sub> O)	20	17	17
% AQ (dry wood basis)	-	0.1	-
% Suffidity (AA basis)	-	-	30
Top temperature (°C)	167	167	167
H factor	2400	1500	1100
Yield (%)	43.0	46.6	46.4
Permanganate No.	12.0	12.0	12.4

	Soda	Soda/AQ	Kraft
Tensile (m)	5750	6200	6150
Burst Factor	38	46	42
MIT Fold	110	170	180

\*300 CSF, Mixed Hardwood

In the process shown in Fig. 3, black liquor from soda pulp is burned with coarse (1-3mm) particles of hematite (Fe<sub>2</sub>O<sub>3</sub>) in a fluidized bed combustor. Acceptable liquor firing concentrations can be as low as 40 % solids, with higher levels requiring deployment of boiler or superheater tubes in the bed for excess heat removal. The organics combust, and the residual sodium carbonate reacts with ferric oxide to form sodium ferrite, thus:

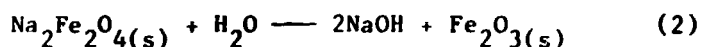


Flue gases pass through a waste heat boiler and gas clean up device (usually a baghouse or multi-clones and a wet scrubber), where entrained dust (predominantly Na<sub>2</sub>Fe<sub>2</sub>O<sub>4</sub>) is removed and agglomerated prior to reinjection into the fluid bed. With extremely low sulfur levels in the flue gas, cold end corrosion is not a problem even at very low exit gas temperatures. Consequently, more sensible heat can be extracted from the gases and higher efficiencies can be achieved.

The solid bed product, consisting mainly of sodium ferrite and excess (unreacted) ferric oxide, passes through a second fluidized bed which acts as a solids cooler/combustion air pre-heater.

In most cases the entire bed product passes to the leaching system, but occasionally there may be a need to remove non-process elements (NPE's) that have entered via the wood or make-up chemicals (note that sulfur buildup from burning fuel oil should not be a problem as the only oil used would be for startups). This is accomplished by further cooling a side stream of the bed product and washing same with relatively cold (approx. 30°C) water in order to dissolve soluble NPE's without causing hydrolysis of the sodium ferrite.

All the sodium ferrite is then hydrolyzed at 90°C - 100°C in a counter-current fashion to recover the sodium hydroxide for white liquor and to regenerate ferric oxide for recycle to the fluid bed:



Reaction (2) is exothermic, and therefore it is not usually necessary to provide additional heat to maintain the reaction at the desired temperature. Leaching at a lower temperature has no deleterious effect beyond reducing the leaching efficiency. The system is capable of producing white liquor of up to 94 % causticity and 300 grams per liter NaOH, which means lower inorganic dead load and less water to heat in the digester and evaporate from the black liquor. However, the system is flexible enough to produce higher or lower concentrations if preferred.

Most of the ferric oxide is recovered and recycled with essentially no change of particle size, but a small proportion forms fines which must be removed from the sodium hydroxide by centrifuging. Flocculation and sedimentation (or filtering) can be used if the NaOH concentration is kept below ca. 150 grams per liter.

APM conducted 2½ years of pilot scale tests starting in 1980. During this period the process was thoroughly examined and several variations of both central and auxiliary systems tested. Details of the pilot plant are reported by Covey (13).

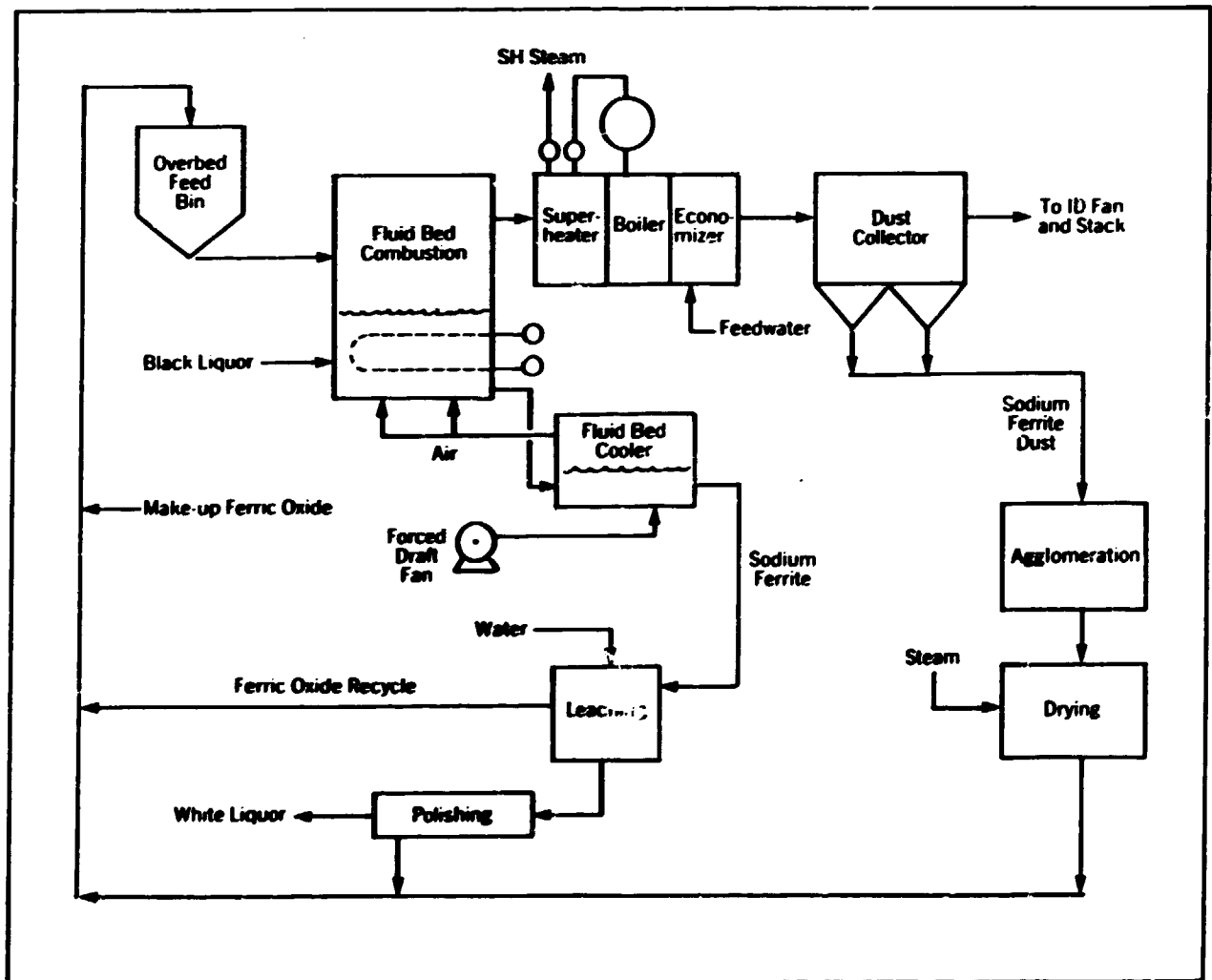


Fig. 3 Direct Alkali System Process Schematic

What about Cost?

In order to demonstrate the cost savings achievable with the DARS over conventional recovery, a comparison was made based on a 200 ODT/day (unbleached) pulp mill. Process schematics for the two systems are shown in Figs. 4 and 5. Table 3 gives an analysis of the steam and power balance which results from consideration of two alternatives for resolving the differences in steam and power production and consumption. Table 4 lists significant operating conditions and assumptions made for the conventional recovery and two DARS options. Data from Tables 3 and 4 are combined to yield the operating cost estimates given in Table 5. Note that savings in purchased items (auxiliary fuel and make-up chemicals) constitute about 80 % of the aggregate cost savings of roughly \$ 38.00/ODT estimated for each case relative to conventional recovery.

Available costing data for DAR Systems indicates a capital cost for a 200 TPD system to be in the range of \$ 10 - \$ 15 million, subject to site variables and scope of supply. Capital cost estimates obtained on conventional soda recovery systems were widely divergent, owing primarily to the lack of recent data for soda mills of this size range. However, the \$ 10 - \$ 15 million estimate for the DARS is in the lower range of conventional system estimates, and is roughly 20 % below the average of the estimates for the conventional systems. Westling and McKean (14) found that DARS capital costs would be roughly 30 % lower than a comparable Kraft pulp mill, based on estimates for a 1000 TPD installation, a conclusion that corroborates at least the direction and order of magnitude for expected capital cost savings of the DARS over conventional soda recovery.

**Table 3.**  
**Steam and Power Balance (Basis 1 00T\* Brown Stock)**

	Conventional Recovery	DARS			
		Case 1*	Δ	Case 2*	Δ
<b>Steam Generation (kg/ODT) (6030 kPa, 454C)</b>					
Recovery Boiler	4567	4422	145	4422	145
Power Boiler(s)	Base	Base	-0-	-687	-687
<b>Steam Consumption (6030 kPa, 454C)</b>					
Rec. Blr Sontblowers	454	-0-	-454	-0-	-454
<b>Net H.P. Steam to Turbine</b>	4113	4422	+309	3735	-378
<b>Extraction Steam (1035kPa)</b>					
B.L. Heaters	76	-0-	-76	-0-	-76
Steam Coil Air Heater	429	-0-	-429	-0-	-429
Digester	1711	1740	+29	1740	+29
Smelt shatter Jets	125	-0-	-125	-0-	-125
Process	Base	Base	-0-	Base	-0-
<b>Total</b>	2341	1740	-601	1740	-601
<b>Extraction Steam (275 kPa)</b>					
Evaporators	1662	1380	-282	1380	-282
Deaerator	320	309	-11	309	-11
G.L. Heaters	136	-0-	-136	-0-	-136
Ferric Oxide Dryer	-0-	204	+204	204	+204
Process	Base	Base	-0-	Base	-0-
<b>Total</b>	2118	1893	-225	1893	-225
<b>Steam to Condenser</b>	-345	789	+1134	102	+447
<b>Electricity Generation (kwh/ODT)</b>					
1035 kPa Extraction	Base	-	-56	-	-56
275 kPa Extraction	Base	-	-31	-	-31
Condensing	Base	-	+272	-	+107
<b>Total</b>	Base	-	+185	-	+20

\*Case 1: Constant power boiler steam generation  
 Case 2: Constant net electricity generation

\*Oven-dry ton (2000 lb) = .907 metric ton

What Does the Future Promise?

In a 1981 Tappi editorial, J.D. Kramer of St. Regis concluded, "Clearly the leaders of our industry are committed to extend the dominance of Kraft pulping, at least through 1985". (15). Industry planners in 1985 have indicated little propensity to deviate from this strategy.

However, the economic, social and political realities facing the industry in 1985 cannot be ignored. Increased pressure to reduce capital and operating costs, adopt environmentally acceptable processes, and assure long-term resource and energy availability, is forcing a re-evaluation in the pulp and paper industry. Increased usage of the various mechanical pulps (CMP,CTMP,TMP) is an indication of the industry's



effort to squeeze more paper out of a ton of wood without sacrificing quality. Soda/AQ and DARS recovery, with its advantages of reduced costs, reduced emissions, and increased operating flexibility, will take its place among the various solutions to Kraft's problems selected by the pulp and paper industry over the next decade.

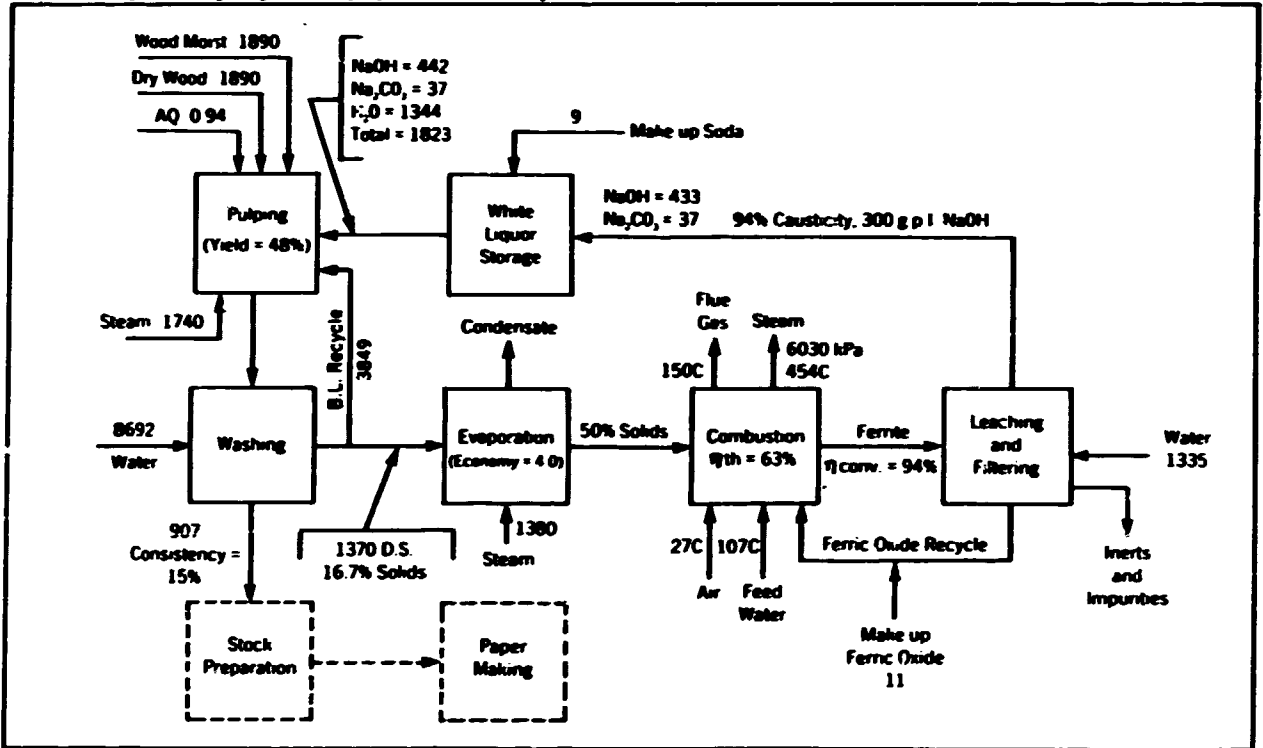


Fig. 4 Soda/AQ with DARS Recovery (Basis 1 ODT\* Brown Stock) All values in kg/ODT\* unless stated otherwise

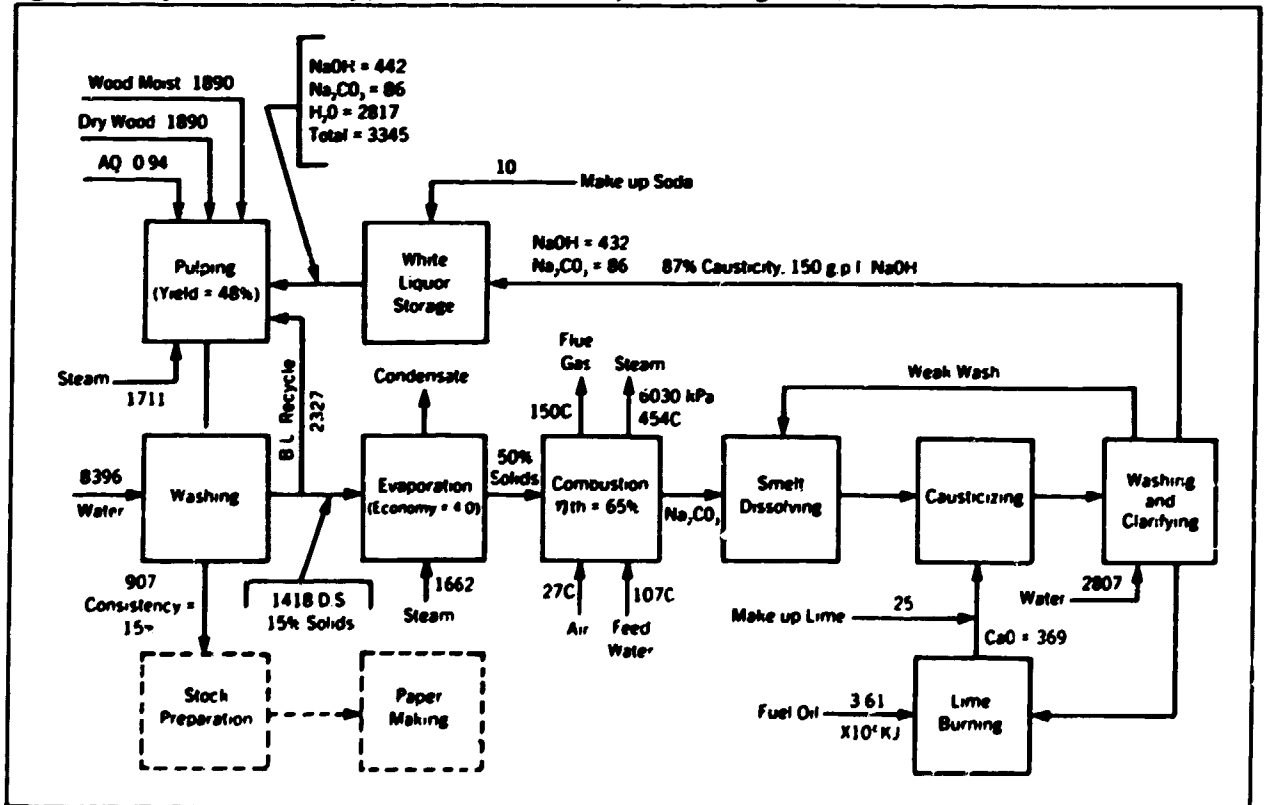


Fig. 5 Soda/AQ with Conventional Recovery (Basis 1 ODT\* Brown Stock) All values in kg/ODT\* unless states otherwise  
 \*Oven dry ton (2000 lb) = 907 metric ton

Table 4.  
Operating Conditions

Item	Units	Conventional Recovery	DARS	
			Case 1	Case 2
Pulp Output	ODT <sup>a</sup> /day AD <sup>b</sup> /year	200 69,800	200 69,800	200 69,800
Wood Species		Mixed HW	Mixed HW	Mixed HW
Yield	%	48	48	48
W.L. Causticity	%	87	94	94
W.L. Concentration	gpl NaOH	150	300	300
Aux Steam (1035kPa)	kg/ODT	2341	1740	1740
Aux Steam (275kPa)	kg/ODT	2118	1893	1893
Condenser Steam	kg/ODT	-345	789	102
Steam To Turbine	kg/ODT	Base	+309	-378
Power Generated	kwh/ODT	Base	+185	+20
Power Consumed	kwh/ODT	Base	+20	+20
Net Export Power	kwh/ODT	Base	+165	-0
Aux Fuel (Lime Kiln)	kJ/ODT	3.61x10 <sup>6</sup>	-0	-0
Process Water	L/ODT	13,500	12,000	12,000
Make-up Caustic	kg/ODT	10	9	9
Make-up Ferric Oxide	kg/ODT	-0	11	11
Make-up Lime	kg/ODT	25	-0	-0
O&M Labor	mh/ODT	.72	.48	.48

<sup>a</sup>Oven-dry tons (2000 lb) @ 0% moisture

<sup>b</sup>Air-dry metric tons (1000 kg) @ 10% moisture

Table 5.  
DARS Cost Summary (\$/ODT<sup>a</sup>)

Item	Cost Base	Case 1	Case 2
Auxiliary Fuel	\$7.60/10 <sup>3</sup> J	-29.27	-29.27
Generated Power	\$.024/kwh	-3.95	-0
Generated Steam	\$4.41/1000kg	0	-3.03
O&M Manpower	\$15/mh	-3.60	-3.60
Make-up Chemicals			
Caustic	\$154/1000kg	-13	-13
Lime	\$83/1000kg	-2.10	-2.10
Fe <sub>2</sub> O <sub>3</sub>	\$83/1000kg	+94	+94
Process Water	\$40/10 <sup>3</sup> L	-06	-06
Total Savings		\$38.17	\$37.25

<sup>a</sup>Oven dry ton (2000 lb) = .907 metric ton

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DESILICATION

by

Mr. P.F. Bleier

SILICA IN PLANTS

Most types of wood - all species useful for fibre-making - contain only very small amounts of silica - less than 0.1 %. Grasses, however, even those with a high degree of lignification like all types of bamboo, take considerable quantities of silica from the soil, - usually a few percent of their dry weight with a maximum in rice straw that can contain over 11 % depending somewhat on variety and on soil.

Very primitive plants like lichen are known to be able to attack rocks by dissolving silica - possibly to obtain dissolved minerals for their nutrition and for improving their foot-hold. To the knowledge of the author no physiological function of silica in higher plants has been described. Improved physical strength of stalks and leaves might possibly have played a role in selection resulting in high silica content.

Different plant organs contain varying amounts of silica. Straw leaves contain more silica than stalks and should be removed before pulping. Rice straw husks are very rich in silica. Bamboo nodes are richer in silica than internodal material; the internodal cavity may contain excreted pure silica.

No biochemistry of silica is available. Some silico-organic compounds have been isolated in plant tissue, particularly of the group of poly-hydroxy aromats, i.e. of tannic compounds. The inorganic silica cannot travel through the plant cell membranes not being soluble, as ion, at ordinary acidity of the plant juices. Deposits in plant tissue of the opal type of hydrated silica, i.e. material of rather low degree of order (crystallinity) has been described.

Extraneous silica from the soil, particularly in agricultural crops may further aggravate silica problems and can be removed by washing. Beyond separation of adventitious soil washing is reported to remove some annual plant silica - possibly by dissolving some low crystalline order material - as evidenced by increased desilication in case of alkaline washing.

#### SILICA IN PULPING

Acid sulfite pulping which could leave the bulk of silica undissolved in the fibre has not been of interest for many years, also because with straw, yellowish unbleachable aggregates remain that are difficult to remove.

In alkaline pulping processes plant silica dissolves more or less completely depending on the excess of active alkali used. Increased temperature enhances silica solubility. It has been proved that, in highly alkaline spent liquor, all silica is present as monomeric silicate. When most of the pulping alkali is used up during pulping i.e. is neutralized by the organic acids resulting mainly from carbohydrate decomposition, some of the dissolved silica redeposits on the fibre which has been reported in turn to weaken the fibre/fibre bond in papermaking. In this case the silica fraction remaining with the spent liquor is likely to contain polymeric silica and silica aggregates (i.e. "colloidal silica"). The silica dissolved in neutral semichemical processes should be of a similar nature.

#### SILICA IN CHEMICAL RECOVERY

Silica in spent pulping liquors - in whatever form it may be present - interferes at all stages with the established course of recovery of chemicals, a technology that has been developed to deal only with silica free wood black liquors.

##### 1) Brown Stock Washing

Colloidal silica may partly be responsible for the brown stock washing difficulties because of plugging of the screens of washing cylinders by "suspended solids".

2) Evaporation

On evaporation and concentration the unstable solution of silica in alkali decomposes under scaling at the hot evaporator surfaces. Siliceous scales (the bulk of the scales might consist of lignins and of Calcium Carbonate) do not respond to "boil out" or to chemical treatment and must be removed mechanically causing stand-still and shortened evaporator tube working life.

3) Combustion

In the recovery boiler high viscosity silicate glass is formed that causes "honeycombs" sticking to the boiler walls, plugging of tubes and difficulties in combustion, leading to increased frequency of boiler shutdown for overhaul.

4) Caustification

The silicates dissolved in green liquor are precipitated by lime as calcium silicate; this material interferes with the settling of lime mud so that less white liquor can be decanted; with filtration and washing becoming more difficult, soda losses are increased.

5) Lime Burning

When reburning of lime is attempted in presence of silica, glassy silicates are formed that form sticky rings in the rotary kiln and reduce the efficiency in lime decarbonization. In fact, difficulties and low yield result in omission of lime recycling by most pulpers of siliceous fiber sources. In case lime is expensive, due to long distance haulage, partial lime recycling is practiced.

Not recycled lime needs to be deposited as wet lime mud; rest alkali seems to prevent its utilization for soil improvement - even in lime deficient tropical countries.

### DESILICATION

Unless silica is removed in the recovery cycle, it will accumulate in all closed cycle operations. This is even true for low silica kraft wood pulping, where some material is continuously "bled out" to prevent silica accumulation and interference with efficient white liquor preparation. The optimal point for silica removal obviously is at the begin of chemical recovery which is immediately after fibre separation from black liquor. In order to prevent scaling of evaporators weak liquor should be treated. However, in order to reduce the volumes to be treated and possibly also to improve the degree of desilication, treatment could also be postponed after the first stage of evaporation. The large amount of organic material, with complex and pretty unknown chemical properties present in black liquor complicates desilication. Therefore desilication during combustion or at the green liquor stage also is under consideration - with the disadvantage mentioned.

#### 1) Desilication by burned lime

This probably is the most extensively investigated method of silica removal for chemical recovery. Lime being a cheap chemical and the known low solubility of calcium silicate render this approach most tempting. However, so far, not industrially useful process has emerged.

Lime desilication of black liquor suffers by the fact that about 6 times of the stoichiometrically necessary quantity of lime are necessary in practice to completely precipitate insoluble calcium silicate. Instead of about 1 kg of burnt lime required in theory to remove 1 kg of silica, actually about 6 kg are needed! In the case of rice straw, 1 ton of pulp would require more than 1 ton of burnt lime changing into at least 3 times the amount of wet lime mud to be filtered and to be deposited. Filtration properties of lime mud are difficult and washing to prevent large losses of black liquor chemicals, causes considerable dilution, requiring additional energy for reconcentration.

Some of the polyphenols in black liquor also form soluble calcium compounds, which again leads to additional calcium scaling of evaporator tubes.

Even careful countercurrent multistage calcium treatment of black liquor cannot overcome the handicaps mentioned.

Many of the above complications can be avoided by green liquor treatment with lime, i.e. by fractional caustification. There is however no indication that green liquor desilication has become industrially viable, also because it would leave the silica problems of evaporators and of the recovery boiler untouched.

## 2) Desilication by Alumina (and by Ferric Oxid)

Alumina has not proved really useful for precipitation of silica dissolved in black liquor. However, when added to the smelt in the recovery furnace, the aluminium silicate formed remains insoluble with the grit, to be removed from green liquor.

One South African pulp mill claims to industrially desilicate in the manner described.

The reports of the fate of silica in the ferrite (DARS) process are somewhat confusing.

Temperatures in DARS Fluid bed combustion are lower and dwell time is shorter than in the standard recovery boiler; also ferric oxide is less basic than aluminium oxide. If - under DARS combustion conditions - silica is insolubilized, desilication would actually take place. Silica or iron silicate would accumulate in the ferric oxide so that one of the advantages of the DARS process, i.e. the recycling of the causticizing agent ferric oxide would become incomplete. Technical and economic aspects of this version should be studied because DARS desilication could be an attractive proposition. The conditions under which DARS desilication does take place are to be defined at the first instance.

Desilication before DARS combustion is required in case silica remains soluble during combustion (as claimed in an early DARS patent) to prevent accumulation in the system.



### 3) Desilication by Carbonation

For silica precipitation in black liquor by partial acidification, Carbon Dioxide is the only justifiable reagent, because after silica removal and before concentration, black liquor has to be realkalized to regain lignin solution stability. With Carbon Dioxide this can be effected, at least partially, by hot vacuum decarbonation of carbonated black liquor. Using sulfuric acid or acetic acid, two reagents that were regarded worth of consideration, re-alkalisation has to be effected by either lime which complicates matters as partly discussed under 1) or by caustic soda which, unfortunately, is not realistic because more soda is required than the amount needed to compensate soda losses of the pulping process.

Silica precipitation from black liquor by acidification is a useful procedure because it is possible to unsolubilize silica without precipitating alkali lignins whose solubility in water also depends on pH. It is obvious, that acidification must be carried out carefully, avoiding local overacidification at the point of acid addition and establishing for each individual black liquor to be treated the critical lower pH limit to which alkalinity can be reduced for silica precipitation without lignin coprecipitation. Experiments have shown, that - independently of the acid used - the initial point of silica precipitation and the initial point of lignin coprecipitation are reproducible and characteristic for a black liquor.

Utilizing CO<sub>2</sub> gas as an acidifying reagent it is of course important to control concentration, partial pressure, size of gas bubble and velocity of flow, for control of material transfer across the gas/liquid interface which is the determining step for the reaction velocity. Neutralization of alkali and of sodium silicate with the formation of sodium bicarbonate and of silica are likely to be fast reactions.

Black liquor is a complicated buffered system in which pH changes with temperature (measured with temperature compensated glass electrodes) and with concentration. In fact pH drops with temperature increase. Therefore all silica precipitation pH data published in literature without temperature indication are meaningless.

In our own work we have standardized pH measurement temperature with 30°C for protection of glass electrodes. At this temperature and at a pH of about 10.2 - corresponding to about pH 9.9 at 70°C - silica precipitates almost completely without lignin coprecipitation.

For reasons of simplicity and of economy in industrial practice, carbonation of desilication of black liquor is carried out at elevated temperature. This permits conserving the heat contained in black liquor after digestion and after brown stock washing. Unfortunately, silica solubility increases with temperature at reduced pH; temperature lowers the degree of desilication.

For industrial practicability it is of utmost importance to obtain silica precipitated by pH reduction in a well filterable, i.e. in a well flocculated form. Due to its chemical affinity to water, silica precipitated from an aqueous medium always will be highly hydrated, amorphous or micro-crystalline. Literature states, that the primary particle of precipitated silica only has a magnitude of a few millionth of a millimeter. Hence the likelihood to obtain gelatinous nonfiltering material. In order to obtain filterable material it is necessary to conduct precipitation in such a way, that agglomeration to large secondary particles can take place; the particles must be larger than the pores of the filter medium and form a coarse and stable sediment, that permits free drainage of spent liquor and of wash solution.

#### THE UNIDO DESILICATION PROJECT

Desilication of spent pulping liquors for the recovery of chemicals is a requirement mainly of non-wood pulping and, in particular, of pulping of agricultural wastes. As such it has been bypassed by suppliers and research institutions centered on wood pulping. The difficulties faced by earlier investigators of desilication also was discouraging to new attempts in this field.

To fill this gap, SIDA (Swedish International Development Authority) and UNIDO (United Nations Industrial Development Organization) decided to dedicate funds and energy for desilication. It was decided to accept the offer of cooperation of a bamboo kraft pulp mill in India.

At a very early stage of experimental carbonation by recovery boiler flue gas of kraft bamboo weak black liquor the possibility of colourless silica precipitation was established. Such precipitates could be obtained in a flocculated condition, that sedimented and filtered easily.

This early encouragement lead to speedy erection of a first pilot plant. Carbonation was effected by countercurrent treatment of weak black liquor by recovery boiler flue gas in a filled column. The original packing of the 4 meter column in form of 100 mm bamboo sections was soon replaced by polyethylene pall rings. With this column, that could be operated in a continuous fashion over some hours, the limiting pH for differential silica precipitation could be determined as well as hot solubility of silica at the limiting pH. Varying pulping condition as changed pulping sulfidity, changes in residual free alkali and the pulping of different bamboo species in either "green" or "brown" condition did not affect pilot plant desilication beyond somewhat higher foaming tendency of freshly cut bamboo.

At a later stage of the investigations it was established that the process could be operated with resulting granular silica flocks also with bamboo black liquor from a different part of India, with bagasse black liquor, with mixed spent liquor from bamboo/Indian mixed hardwoods as well as with European wheat straw spent liquors and soft wood black liquor with added silicate.

After transferring the trials to another mill, operating a 8 m packed column (1 m diameter) but transporting the flue gas by suction instead of pressure foam problems became troublesome with ensuing flooding of the column. Therefore an all glass pilot plant was designed of standardized modular units operating in one or more stages with empty columns filled only with CO<sub>2</sub> - containing gas bubbles, the bubbles being large enough to prevent inconvenient foaming.

This carbonation unit can be dismantled for easy transport and for re-erection at varying pulp mills.

The new bubble-reactor permitted good control. It was operated in lengthy runs over many months with fresh mill weak black liquor to prove that the process developed to be tolerant to the variations of normal industrial operation.

Hot pilot plant operation permits careful carbonation avoiding irreversible lignin coprecipitation. The voluminous but granular precipitate sediments quickly and can be filtered in a filter press. On exhaustive washing a greyish filtercake is obtained that contains in an air dry condition over 70 % silica. Starting with weak black liquor containing 6 gpl silica a 90 % desilication can be reached.

The repeated and reproducible pilot plant trials have established a level of confidence in bubble reactor carbonation for desilication of weak black liquor to justify the decision of scaling up the operation and ordering a fully industrial sized demonstration unit for carbonation and filtration. This equipment has been manufactured and is at present about to be delivered. It is planned to start large scale carbonation utilizing recovery boiler flue gas containing about 12 % CO<sub>2</sub>; after recommissioning the lime kiln that has not been in use for many years because of silica problems, lime kiln flue gas with about 30 % Carbon Dioxide will be passed through the reactor.

The team of technologists connected with the desilication project feels that they have good reasons to hope, that after sufficient data will be collected operating the full size demonstration unit, an industrially viable desilication method will have been established.

NOTES ON THE VISIT TO PHOENIX PULP AND PAPER CO LTD,  
THAILAND, DECEMBER 5, 1985

Prepared by  
Thampoe Jeyasingam  
UNIDO Expert

INTRODUCTION

The Phoenix Pulp and Paper Mill Co Ltd. is located at Khon Kaen in the North West part of Thailand. A visit to this mill was part of the seminar on Comparative Pulping Processes including the Monopulp Process, organized by UNIDO, SIDA, FAO and TISTR. The participants of the seminar were interested in the visit to the Phoenix Mill as this is the first kenaf market pulp mill in the world. The designed capacity of the mills is 70.000 MTPY of kenaf pulp.

KENAF SUPPLY TO MILLS

Kenaf belongs to the MALVACEA family and consists of two main species known as HIBISCUS CANNABINUS and HIBISCUS SABDARIFFA also known as ROSELLA. The kenaf used at Phoenix mill is Hibiscus Sabdariffa which is mostly cultivated in Thailand. This species of kenaf is reputed to be resistant to drought and pest attack. Morphologically, kenaf is made up of two parts, a woody inner core surrounded by the bast fibre ribbon. The bast ribbon produces the long fibre of about 2.5 mm fibre length and averages 30 - 40 % of the whole kenaf stem. The rest of the weight is mainly from the woody core with an average fibre length of 0.7 mm.

Kenaf is grown by the Thai farmers mainly to produce the fibre needed for the production of burlap which is used for the manufacture of shipping bags. Kenaf therefore competes in the international market with jute which is largely produced in Bangladesh and India for the production of burlap.

Before the Phoenix mill was built the Thai farmers traditionally grew kenaf to supply the bast ribbon as a raw material for the burlap industry. It is estimated that the Phoenix mill requires about 15 % of the total cultivated kenaf to produce 70.000 MPTY of kenaf pulp. Since 85 % of the demand is from the burlap industry, the market price of the raw material and its availability for the paper industry is dictated by the supply and demand of the burlap industry in Thailand. The external factors that influence the supply and demand of this raw material are kenaf's effectiveness to compete with the jute industry in Bangladesh and India as well as its ability to withstand the encroachment of Polypropylene as a raw material for shipping bags.

The Phoenix mill was therefore currently (during the time of this visit) having some problems in getting sufficient quantity of kenaf to maintain the mill's designed output. The mill was at this time operating with bamboo in place of kenaf. To overcome these problems, the mills management has plans to get adequate supply of kenaf to maintain the production at the designed level by entering into long-term contracts with the Thai farmers.

#### KENAF STORAGE

Kenaf is received by the mills in bundles of approximately 200 to 250 mm diameter and of length 2500 mm to 3000 mm. These bundles are stacked in raised earthen platforms to obtain a stack size of 50 x 17 x 6 to 8 meters. It is estimated that each stack would contain about 600 to 800 tons of AD kenaf. The stacks are covered with corrugated iron sheets for weather protection during storage. This is needed to combat the following problems.

- Wet kenaf results in microbial degradation, fungus growth and causes problems in bleaching due to discoloration.
- Weather exposed kenaf results in poor yield.
- Wet kenaf causes bast fibre strand separation from the woody core and this results in problems on the chipper and screens.
- Separation of bast fibre from the woody core also results in heterogenous pulp quality.

The Phoenix mill also found the need to use pesticides such as CHLORODANE and HEPTACHLOR to prevent termites and beetle attack during storage.

#### PREPARATION OF KENAF

The preparation of kenaf prior to cooking is conducted using chippers to reduce the kenaf stem to chips which is then followed by screening on pentagonal rotary screens.

The Phoenix mill is provided with five chipper lines and the kenaf bundles are loaded to the rubber conveyor belts that feed the drum chipper. During the chipping process, 'fines' are produced and they are subsequently removed using the rotary screens referred to above. It is estimated that about 8 % of fines and seed pods get removed by the screens while 2 % get carried over to the digester along with the chips.

The kenaf chips get metered into the Kamyrdigester using a 'live bottom' bin that has a rotating travelling metering screw. The live bottom bin has a 20 minute volumetric capacity. Some problems are experienced with the live bottom bin due to the separation of bast fibre strands from the core resulting in non-uniform delivery to the digester.

#### COOKING OF KENAF

The cooking of kenaf at the Phoenix mill is done by the kraft process using a Kamyrdigester incorporating an 'Asthma' type of valve. The digester system provides for the cooking of the kenaf both under vapor and liquid phase.

The chips from the live bottom bin are fed into a hopper where a part of the cooking liquor is added for pretreatment. The chips are then admitted to a steaming vessel through the L.P. feeder where it is cooked for 2 minutes at a low pressure of 1 to 1 ½ Bars. The balance cooking liquor needed for cooking

is also admitted into the steaming vessel. The steam needed for cooking at low pressures is made up of steam from the following:

- Relief operation of the digester steam.
- Steam leakage past the H.P. feeder.
- Make up live steam.

The pretreated chips from the steaming vessel is now admitted to the main digester vessel through the H.P. rotary feeder valve. Cooking is now done under H.P. steam.

The cooking conditions employed are as follows:

- Active Alkali - 17-18 % as NA<sub>2</sub>O on OD chips
- Sulphidity - 22 %
- Temperature - 160 to 170 C
- Yield - 45-47 %

The digester level for chips and liquor are carefully controlled. The difference between the chip level and the liquor level in the digester determines the time taken for vapor phase cooking.

Provision is made for the injection of dilute black liquor at the bottom of the digester. This arrangement provides for a cold blow, thereby protecting the pulp strength properties.

#### BROWN STOCK WASHING

Brown stock washing is done in 3 stages using counter current washers. The washers are of 125 m<sup>2</sup> surface area each. Residual soda losses are estimated to be within 15 kg/ton of pulp as NA<sub>2</sub>SO<sub>4</sub> at a dilution factor of 3.5. The Phoenix mill does not experience foaming problems which were experienced by other kenaf pulp mills based on the soda process. The black liquor from B.S. washing is filtered using a rotary filter and then pumped to the C. Recovery plant. The fibre content of the filtered black liquor is around 20 p.p.m.



SCREENING AND CLEANING

The washed pulp is screened using a 2 stage pressure screen system operating at an inlet consistency of 1 %. The rejects from the pressure screens are handled on a flat open screen. The sewer losses from the reject screen amounts to about 0.5 %. The final stage of brown stock cleaning is done on a 3 stage C.C. System.

BLEACHING

The Phoenix is provided with a 4 stage bleaching system consisting of CD E H D Stages. The inter stage washers are of surface area 100 m<sup>2</sup> each.

Chlorination/Dioxide.

This is done using an up flow chlorination tower under the following conditions:

Chlorine	- 4.5 to 5.5 %
Consistency	- 3 %
Retention	- 45 to 50 mins
Temperature	- 40 C
pH	- 2.5 to 3.5

ClO<sub>2</sub> substitution is done during chlorination to the extent of 10 to 15 % of the Cl<sub>2</sub> demand. This treatment is claimed to preserve the strength and the viscosity of the pulp.

Extraction.

This is done using a down flow tower under the following conditions:

NAOH	- 2 to 2.5 %
Consistency	- 10 %
Retention	- 120 mins
Temperature	- 60 C
pH	- 11 to 11.5

The Kappa number of the extracted pulp is in the range of 4 to 6.

Hypochlorite.

This is done using a down flow tower under the following conditions:

Active Cl <sub>2</sub>	- 2.5 to 3.5 %
Consistency	- 10 %
Retention	- 180-210 mins
Temperature	- 40 C
pH	- 8 to 8.2
Brightness	- 74 to 76 G.E.

Dioxide.

ClO<sub>2</sub> is produced by the Mathieson process for use both during the chlorination stage as well as for the final dioxide stage. The ClO<sub>2</sub> treatment for the final stage is done in an up flow tower.

ClO <sub>2</sub>	- 0.6 to 0.8 %
Consistency	- 10 %
Retention	- 240 mins
Temperature	- 70 C
pH	- 4.5 to 5.5

Acidification.

The ClO<sub>2</sub> treated pulp is acidified using SO<sub>2</sub> water resulting in a final brightness of 86 to 87 G.E.

Cleaning.

The bleached pulp is cleaned using a 3 stage Bauer C.C. System.

PULP MACHINE

To produce the market pulp the Phoenix mill is using a Voith pulp machine. The wire part is made up of a fourdrinier section with a wire length of 33.9 meters and a trimmed width of 2.4 meters.

The press section is made up of 2 double felted presses.

The dryer section is made up of conventional steam drying cylinders followed by Flakt dryer.

Phoenix experienced limitations in the drying capacity at the start of the mill. It was found that kenaf pulp would give only about 65 % dryness compared with the drying capacity needed for long fibre wood pulp. The drying section, therefore, was redesigned to accommodate a Flakt dryer to obtain the needed 35 % capacity. The pulp is now dried to 90 % dryness and then finished to pulp sheets on an 'On Line Sheeter' and subsequently packed on automatic baling equipment to standard size 200 kg bales.

#### C.R. SYSTEM

The Phoenix mill does not experience scaling problems due to silica, unlike most annual plant mills. This is on account of the low silica content of 1 % silica in the black liquor.

The filtered black liquor at 15 % T.S. is concentrated to 50 % T.S. using quintuple effect evaporators. The liquor is further concentrated to 65 % using direct contact cascade evaporators. The incineration is done on a recovery furnace designed to use auxiliary liquid fuel. The calorific value of kenaf black liquor is 3,400 k.cal/k.g. The recovery furnace is capable of incinerating 400 tons of dry solids per day. The steam generating capacity is 58 TPH at 43 Bar and 440 C.

Recausticizing is done on a Dorr-Oliver system. The recovery efficiency of the system is about 94 %.

#### STEAM AND POWER GENERATION

The steam requirements are met through the recovery boiler and auxiliary oil fired boiler. Steam generated at 43 Bar and 440 C is used for power generation on a back pressure turbine of 8.800 KW capacity. Extraction steam from the turbine is used for process. Mill generates 70 % of the power requirements and the balance is purchased from the public grid.

#### WATER SUPPLY

The water supply is from Nam Phong River which is treated using a clarifloculator and rapid gravity sand filters.

#### EFFLUENT HANDLING

The effluent plant handles about 30,000 M3.P.O. The plant consists of one primary clarifier, an aeration pond fitted with 12 aerators, followed by a secondary clarifier and a rotary belt filter. The rotary filter handles the sludge from both the primary and secondary clarifiers and the dewatered sludge is used as landfill.

#### QUALITY AND FUTURE TRENDS

Phoenix is able to produce high quality market paper from kenaf. Thailand is short of indigenous pulp production and therefore most of the pulp mills depend largely on the use of imported secondary fiber and imported pulp from overseas. By producing kenaf pulp Phoenix is able to conserve foreign exchange for Thailand.

Currently, the Phoenix mill is having some problems in competing with imported wood pulp on prices due to the international market slump on account of the over-production of wood pulp. The Phoenix mill, however, has developed an overseas market where their pulp could be used for the manufacture of cigarette tissues. Traditionally, cigarette tissues are made using expensive hemp pulp. In order to keep prices down the cigarette tissue mills are trying to blend hemp pulp with less expensive wood pulp. For quality reasons the cigarette tissue manufacturers now prefer to use kenaf pulp in place of wood pulp. This trend is helping the Phoenix mills to some extent.

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- Mr. P.K. Paul, Director, Phoenix Mill

COUNTRY PAPER  
T U R K E Y

REPORT ON PAPER INDUSTRY IN TURKEY AND  
SEKA AFYON BLEACHED STRAW-REED PULP MILL

prepared by

Kemal Cankaya  
SEKA Akdeniz M~~u~~essesesi  
Icel/Turkey

## PAPER INDUSTRY IN TURKEY

Paper production in Turkey started in 1936 in Izmit, a town approximately 50 miles to the east of Istanbul. The production was about 4000 tons/year.

This industry was totally owned by the government and the Management was a branch in a large state company. In 1955 it became an independent General Directorate owned by the Government with the "TURKISH PULP & PAPER MILLS GENERAL DIRECTORATE" SEKA.

By the 1960's with new lines added at the same mill site the production capacity of the establishment had increased to 120.000 tons/year. Many grades of paper and boards including cigarette paper are produced in this establishment but some special grades are imported.

This mill includes the following installations:

- Ten paper/board machines;
- One sulfite pulp mill;
- One small size bleached straw pulp mill;
- One groundwood pulp mill;
- One rag-hemp pulp mill;
- One chlorine & alkali mill.

### THE PULP AND PAPER MILLS STARTED IN THE 1970'S

- CAYCUMA Mill: On the West Black Sea coast; started production April 1970 and has the following capacities:

60.000 tons/year kraft pulp  
75.000 tons/year kraft paper  
30.000 tons/year NSSC

- AKSU Mill: On the East Black Sea coast; started production October 1970 and has the following capacities:  
66.000 tons/year groundwood  
82.500 tons/year newsprint
  
- DALAMAN Mill: In South West Anatolia; started production in October 1971 and has the following capacities:  
70.000 tons/year bleached sulfate pulp  
15.000 tons/year viscose pulp  
35.000 tons/year writing and printing paper  
40.000 tons/year board  
  
It also has chlorine-alkaline and coating facilities.
  
- AFYON Mill: In Central Anatolia; started production in May 1979 and it has a capacity of 50.000 tons/year bleached straw-reed pulp and it is the biggest short fibre pulp mill in Turkey. This is the mill that this report will present detailed information about.

With the establishment of the above mills SEKA's paper-board production capacity has exceeded 300.000 tons/year.

On the other hand the following mills had been completed in the 1980's:

- BALIKESIR Mill: In North-West Anatolia; started production January 1981 and has the following capacities:  
100.000 tons/year newsprint  
105.000 m<sup>3</sup> / year lumber  
80.000 tons/year TMP

- AKDENIZ Mill: On the Mediterranean Sea; started production in August 1983 and has the following capacities:
- 155.000 tons/year kraft liner  
or  
90.000 tons/year cement bag paper  
and  
170.000 m<sup>3</sup> / year lumber
- KASTAMONU Mill: In the Western Black Sea region; started production September 1984 and has the following capacities:
- 5.000 tons/year cigarette paper  
22.000 m<sup>3</sup> /year pressboard

With the above mills included SEKA's paper and board production capacity has exceeded 600.000 tons/year and actual production in 1984 was 488.000 tons and was 85 % of available capacity.

While SEKA was the only paper-board producing organization in Turkey for many years, in the 1960's and 1970's the private sector has started many small paper mills and reached 250.000 tons/year capacity in 1983 and they are expected to expand to 387.000 tons/year in 1987.

The paper-board consumption per capita in Turkey is 12.5 kg/year.

In addition to the totally owned mills explained above SEKA has the following shares:

1 - Mannesman Sumerbank Steel Pipe Industry Corp.	3,57 %
2 - Industrial Transport Corp.	10 %
3 - Dostel Aluminium Sulphate Corp.	39 %
4 - Pakistan Security Papers Ltd.	10 %
5 - YIBITAS (Cement Sack Paper Mills)	10 %



SEKA's paper-board, lumber and viscose pulp export in 1984 was 25 million dollars.

SEKA is not only establishing new mills but a lot of work is going on with modification, modernizing and adding new effluent disposal systems to old mills in Turkey.

SEKA has been the pioneer company in environmental protection in the industry and in starting tug and barges system for marine transport of wood and finished products.

#### SEKA AFYON - BLEACHED STRAW - REED PULP MILL

##### INTRODUCTION

The mill was established with 50.000 tons/year capacity to utilize straw of central Anatolia which is one of the wheat producing areas in Turkey and to use reed which is cultivated from the lakes in the same area and to supply the country's requirement of bleached short fibre pulp.

The feasibility study for the mill had been carried out in 1969, and in 1970 the decision was made to build the mill. In 1973 a contract was signed with KHD, AEG-Telefunken, BELOIT Italy and POMILIO Italy Consortium for the supply of import equipment.

The main responsibilities of the Consortium were:

- Manufacture and ship all import equipment;
- Preparation of specifications for all local and import equipment;
- Supervision of all import/local equipment installation work;
- Preparation of all layout plants;
- Supply of technical information for civil design related to equipment;
- Overall guarantee of all local-import equipment performance (exception in this respect is for deviation from specifications),
- Assistance in mill start-up and personnel training.

According to this Contract the mill was to be completed in 41 months including all preparatory work, manufacturing, shipping, erection, tests and trial run. The mill was to start commercial production in 1976. But the trial production started in May 1979 due to import problems, contractors not being able to complete their work in time and difficulties of local supplied equipment. Production of the same year was only 680 tons.

Mill water is supplied from 12 artesian well at 25 km distance and pumped to the mill. The effluent water is distributed into a lake nearby using 5.5 km pipe and 4 diffusers.

SPECIFICATIONS

Daily Operation : 24 hours, three shifts  
 Annual Operation : 300 days  
 Capacity : 50.000 tons/year bleached straw/reed pulp on 100 % dry basis.  
 Daily Production: : Min. 167 tons on 100 % dry basis

	<u>Unit</u>	<u>Reed</u>	<u>Straw</u>
Tensile Strength	mt.	5500	4500
Brightness	GE	80	80
Dirt Count	Number/m <sup>2</sup>	50	50
Raw material (100 % dry into the digester)	Ton/Ton	2,44	2,7
Limestone	kg/ton		658
Sodium Sulphate	"		145
NaOH	"		40
Liquid Chlorine	"		120
Sulphur	"		3,2
Alum	"		9,32
Steam	ton/ton		12
Water	m <sup>3</sup> /ton		300
Power	kWh/Ton		1200
Fuel Oil	ton/ton		1.1

PRODUCTION

1979	680 tons
1980	6.926 tons
1981	9.157 tons
1982	18.542 tons
1983	20.261 tons
1984	22.649 tons
1985 (9 month)	12.234 tons

A review of the above figures shows that the production is increasing yearly but has not reached the desired level. As it will be explained in the following paragraphs elimination of design errors and bottlenecks has increased the production. The low production figures in 1984 and 1985 are mainly because of the recovery boiler which has had a long shut-down due to a major problem.

PRODUCTION COST

Low production obviously causes high production cost but substitution of high value wood which has a long life of rotation with annual crops is an important economic move. This mill has proved, had no design problems existed, the mill would have run at good production rates and the pulp with good quality would have been a lot better an asset for the Turkish company.

BOTTLENECKS AND DESIGN ERRORS

- MAIN DEPARTMENTS:
- 1) Raw Material cutting and cleaning
  - 2) Cooking, washing and tertiary preparation
  - 3) Bleaching
  - 4) Dewatering, drying and baling

The problems encountered to date in reaching capacity and the modifications made in the different departments are listed below in flow order:

1) Raw Material Cutting and Cleaning

- a) Blockage by raw material in suction pipes
- the suction fans are under design capacity and the flow rate in the pipes is also below design.
  - suction fans and dust screens are designed for 15 % moisture of raw material but the raw material moisture goes up to 30 - 40 % in winter.
- b) The electromagnetic separators were supplied under design and the arrangement was not suitable.
- c) Foreign materials like wire, rock and sand get into the straw bales and the department has no equipment to separate them.
- These materials cause blockage in feed lines and rotating equipment not only in this department but also in the cooking and washing department.
- d) The following modifications have been carried out to overcome the bottlenecks:
- The hole sizes in the dust screens have been enlarged;
  - To increase the suction fans' flow the speeds of the fans have been increased.

These modifications made it possible to use raw material with moistures up to 25 %.

To eliminate all problems the following modifications will be carried out.

- To separate wires and other metals bigger electromagnet will be installed.
- A design is developed to separate and eliminate rock and sand from raw materials and soon will be applied.
- An automatic screen cleaning device will be added to eliminate blockage of dust screens when high moisture raw material is used.

2) Cooking, Washing and Screening and Tertiary Preparation

- a) The feed lines get blocked especially in winter time due to high moisture of raw materials.
- b) As it was explained above the equipment has been modified to increase capacity but the best solution is to revert from pneumatic feed to belt conveyor feed.

3) Bleaching

- a) The DC motor cooling in this department was not sufficient and was causing failure of equipment. New cooling unit has been added.
- b) The high density stock pumps did not have sufficient capacity and they have been modified.  
These changes have enabled this department to run at full capacity.

4) Dewatering, Drying and Baling

This department includes the following sections:

- Fourdrinier machine
- First Press
- Second Press
- Air Dryer
- Third Press

- a) At the start in 1979 it was not possible to pass the pulp sheet through the first press because the sheet was too wet and the fourdrinier was not taking enough water out.
- b) A felt has been added to the top section of the first press and only light sheet of straw pulp started going through.
- c) In the early 1980 up to  $684 \text{ gr/m}^2$  pulp sheet of reed pulp was produced with less problems than those of a lot lighter sheet of straw pulp.
- d) After many trials with straw pulp in 1981 the following modifications were found necessary:

- Top felts were added to the second and third press;
- Vacuum pumps were added for top felts;
- A screen was added to the lower part of the air dryers;
- 2 vacuum boxes were added to the fourdrinier.

With these changes it became possible to produce reed pulp at full capacity but straw pulp at 100 - 110 tons/day.

To reduce straw pulp at design capacity additional measures are necessary to increase drainage at the fourdrinier.

#### RAW MATERIAL PROBLEMS

##### 1) Straw

The area has a lot more straw than required, but it stretches too wide, causing collection, baling and shipping costs to be major problems. The supply is dependent on price and when high prices are paid to supply the needed quantities it upsets the mill economy.

##### 2) Lake Reed

Not all the lakes around the mill are allocated to SEKA. In the ones that are allocated to SEKA harvesting is done by hand and it requires thousands of people. At the present time the lakes cannot be entered in all directions. The price paid by the mill is not high enough to make long distance shipments possible. In summary, cutting, access and transportation are the ongoing problems.

COUNTRY PAPER  
P H I L I P P I N E S

PULPING OF BAGASSE USING A MIXTURE OF SODIUM  
HYDROXIDE AND SODIUM CARBONATE AS COOKING LIQUOR

prepared by

Alan R. Dimzon  
United Pulp and Paper Company, Inc.  
Republic of the Philippines

## INTRODUCTION

The possibility of using sodium carbonate as part of the cooking liquor for bagasse pulping on a mill scale is being continuously studied. Cooks using different proportions of sodium carbonate and sodium hydroxide were first done on a laboratory scale in search for an alternative or supplementary cooking chemical. With encouraging results in the laboratory, UPPC decided to use a mixture of sodium carbonate and sodium hydroxide for its pulping process.

## GENERAL PROCESS DESCRIPTION

UPPC receives its bagasse fibres from the Pampanga Sugar Development Corporation (PASUDECO) which is about 18 kilometres from the mill. Bagasse is moist depithed at the sugar mill using SPM depithers.

The moist depithed bagasse from the sugar mill is stored wet and compacted by means of bulldozers at the mill site. This stored bagasse is reclaimed from the piles using payloaders on a first in-first out basis. The bagasse is fed into a hydrapulper via a belt conveyor, and mixed with recycled water from the pulp mill to form a slurry with a consistency of about 2.5 % to 3.0 %. It is then pumped through a distribution box to two drum drainers in order to improve the consistency while partially removing the soluble materials and some pith prior to wet depithing.

Washed bagasse is fed into Horkel depithers equipped with beating and traveling hammers. Wet depithed bagasse is discharged into a storage bin with a pin feeder that controls bagasse flow into a long inclined belt conveyor to the pulp mill.

At the pulp mill, bagasse is conveyed and fed to the digester by a screw feeder where steam and the cooking liquor at the desired flow, chemical proportion, and concentration are added.



Cooking of the bagasse is achieved in a continuous twin-tube horizontal American Defibrator continuous digester. The cooking temperature is controlled at 170°C and the retention time is about 20 - 25 minutes.

Cooked bagasse is washed in a 3-stage counter-current washing system. The washed bagasse pulp passes 2-stages of Cowan Screen and a 3-stage centri-cleaner systems. The accepts are thickened at about 12 % consistency and stored in a high density tower.

#### MILL TRIALS

Mill scale tests were carried in August of this year (1985) in cooking bagasse for use in the production of corrugating medium.

Sodium carbonate is dissolved in a tank prior to mixing with sodium hydroxide. The cooking chemical is diluted with some amounts of black liquor.

The trials started using 100 % sodium hydroxide and subsequently, introduced sodium carbonate in the cooking liquor. The cooking liquor mixtures of sodium carbonate and sodium hydroxide tested were:

- a) 70 % sodium hydroxide and 30 % sodium carbonate;
- b) 60 % sodium hydroxide and 40 % sodium carbonate;
- c) 30 % sodium hydroxide and 70 % sodium carbonate.

The other mill trials were on the production of bagasse pulp for sack kraft paper. These trials using a mixture of sodium carbonate and sodium hydroxide in cooking bagasse for the company's production of sack kraft paper are still going on. They are being done to establish the chemical proportion best suited for the mill process in terms of costs, runnability, pulp quality and yield.

DISCUSSION OF RESULTS

The pulp quality during the mill trial on bagasse for corrugating medium was comparable with that obtained with the caustic soda cook. The results are shown in Table 1. Pulp for the various trials was cooked to an average permanganate number (60 ml) of 40.4. Pulp evaluation was done on a Valley Beater according to TAPPI standards.

Table 1  
COMPARATIVE PULP PHYSICAL PROPERTIES

<u>Cooking Mixtures</u>	<u>CSF*</u> (ml)	<u>B.I.</u> (KPa/g/m <sup>2</sup> )	<u>B.L.*</u> (Km)	<u>T.S.<sup>2</sup></u> (mN/g/m <sup>2</sup> )
100 % NaOH	579	1.5	4.4	480
	500	2.0	5.0	432
	400	2.5	6.4	382
	300	2.5	5.8	353
70 % NaOH	575	1.8	4.6	402
30 % Na <sub>2</sub> CO <sub>3</sub>	500	2.2	5.2	372
	400	2.5	5.7	353
	300	2.7	5.9	333
60 % NaOH	516	1.8	4.2	441
40 % Na <sub>2</sub> CO <sub>3</sub>	500	1.9	4.3	432
	400	2.6	5.6	363
	300	2.7	5.8	343
30 % NaOH	567	2.0	5.0	441
70 % Na <sub>2</sub> CO <sub>3</sub>	500	2.5	5.7	412
	400	3.0	6.2	382
	300	3.2	6.3	363

\* CSF - Canadian Standard Freeness

\* BI - Burst Index

\* BL - Breaking Length

\* TS - Tear Strength

The properties of the bagasse cooked with different ratios of sodium carbonate and sodium hydroxide in the cooking liquor are not at all substantially different with bagasse cooked using 100 % sodium hydroxide at an average permanganate number (60 ml) of 40.4.

It is anticipated that scaling problems particularly in the washers may evolve but the mill trials are not yet showing this effect. However, inhibitors are prepared to be used when cooking bagasse for a long and continuous period of time.

When the mill shifted production to sack kraft paper, sodium carbonate was again mixed (at a lower proportion) with sodium hydroxide to be used as the cooking liquor. The results are in Table II. Pulp for the trial was cooked to an average permanganate number (40 ml) of 18. The pulp was evaluated in a Valley Beater according to TAPPI standards.

Table II

<u>Cooking Mixture</u>	<u>CSF (ml)</u>	<u>B.L.<sub>2</sub> (KPa/g/m<sup>2</sup>)</u>	<u>B.L. (Km)</u>	<u>TS (mN/g/m<sup>2</sup>)</u>
100 % NaOH	500	3.5	6.1	432
	400	3.9	6.3	412
	300	4.3	6.8	392
	200	4.5	7.5	373
80 % NaOH	523	2.8	5.8	402
20 % Na <sub>2</sub> CO <sub>3</sub>	500	2.9	6.0	392
	400	3.1	6.7	382
	300	3.2	7.1	353

Again, the pulp properties of bagasse pulp cooked with 100 % sodium hydroxide and a mixture of sodium carbonate and sodium hydroxide as the cooking liquor are practically comparative. Even the physical properties of the finished paper (sack kraft), at practically the same operating conditions are very comparative. The mill is still undergoing some trials to determine the optimum mixture of sodium carbonate and sodium hydroxide as the cooking liquor for bagasse in terms of costs, runnability, pulp quality and yield.

SOME CONCLUSIONS

It was proven during the mill trials that bagasse can be successfully pulped using a mixture of sodium carbonate and sodium hydroxide as the cooking liquor.

As indicated by the results in the mill trials, the chemical cost can be reduced by using sodium carbonate in the process. During the mill trials, some modest chemical cost reduction was achieved depending on the proportion of sodium carbonate and sodium hydroxide and on the grade of paper being produced.

It is the intention of the company to continue with the mill trials to determine the optimum amount of sodium carbonate in the cooking liquor in its pulping process.

COUNTRY PAPER  
B A N G L A D E S H

EXISTING PULPING PROCESS IN BANGLADESH

prepared by  
MD. Anwarul Haque  
KHULNA NEWSPRINT MILLS TLD.  
Khulna, Bangladesh

EXISTING PULPING PROCESS IN BANGLADESH

Bangladesh is situated at latitude 20°34' - 26°36N and longitude 88°7' - 90°E having common boundary with India in the north and west and Burma in the east. The Bay of Bengal lies in the south. Southern part of the country has a big natural mangrove forest spread over an area of about 2316 sq miles. The forest consists of:

- Sundri (Heritiera fomes) - 73 %
- Gewa (Excoecaria agallocha) - 16 %
- Others - 11 %

The country has four large pulp and paper mills, 2 hard board mills, a few medium size board mills and many small hard board mills. Khulna Newsprint Mill (KNM) is the only newsprint mill of the country using Gewa tropical hardwood species as groundwood pulp for making of newsprint and mechanical printing. The fibre length of Gewa groundwood pulp is between 0.5 - 0.6 mm. Making of newsprint or other grades of paper with the usual SGW Gewa pulp alone was not technically feasible. So about 40 % of the total furnish was chemi-groundwood pulp which has a fibre length between 0.9 - 1.2 mm, produced from Gewa log after mild chemical treatment with neutral sodium sulphite in autoclaves.

The mill observed many advantages of Gewa chemi-groundwood pulp over normal groundwood, specially the power saving (33 - 50 %) in grinding the logs to pulp and greater physical strength properties of pulp resulting in production of good strength paper. So the wood treatment plant of the mill was expanded to double of its size with addition of 5 autoclaves in the year 1981.

Process: (KNM) - Capacity: 48,000 M.T/yr. Newsprint & Mech. Printing etc.

Manufacture of chemi-groundwood pulp from Gewa in Khulna Newsprint mill consists of liquor preparation, wood treatment and grinding.

#### LIQUOR PREPARATION

Neutral Sodium Sulphite liquor is prepared by burning sulphur into sulphur di-oxide which is absorbed in soda ash solution to obtain a mixture of sodium sulphite and sodium bi-carbonate.

SO<sub>2</sub> gas produced in the burner cooled down to 150 - 180°F by passing it through coolers where the gas is sprayed with process water. Then it enters the Absorption Tower packed with saddles at the bottom. Soda ash solution is sprayed at the top of tower and kept circulated till it is converted to sodium sulphite (Na<sub>2</sub>SO<sub>3</sub>) and sodium bi-carbonate in batches. The usual ratio of bi-carbonate and sulphite in the cooking liquor after cook is maintained at 1:6 (both expressed as Na<sub>2</sub>CO<sub>3</sub>). However, the ratio in the make-up is maintained at 1:4 with at least double the strength than that of spent liquor.

#### WOOD TREATMENT

Debarked Gawa logs, 4' ft. in length having varied diameter from 2½" to 18" are loaded on wagon in six bundles of about 288 cft wood and charged in horizontal autoclaves of inner dia 7.5 ft. and 28 ft. long between heads. The vessel is closed and sealed and then subjected to an vacuum of 20 - 25' Hg for about 30 minutes. This is done to partially extract moisture out of logs in order to have good penetration of cooking liquor. About 7500 US gal. of cooking liquor of 0.85 - 1.0 lbs/gal (8.5 to 10 %) concentration is charged in the loaded autoclave. Then the liquor is circulated through a heat exchanger to raise the temperature to 290°F at 150 - 155 psig followed by a cooking period of 4 hours. The approximate heating time is 45 - 60' mins. During entire period of heating and cooking care is taken to maintain the temperature and pressure as above.

At the end of cooking period the spent liquor is transferred to another autoclave which is ready for operation with load and vacuum. After transfer of liquor the autoclave is pressurized to 150 - 155 psig with make-up liquor of higher concentration and at the same time heating cycle starts, followed by subsequent operations in succession.

After transfer of spent liquor at the end of cooking cycle pressure of the autoclave is realized in the nearby water flumes (condenser cooling water of turbo generator). Discharge in the water eliminates air pollution of the surrounding. When the pressure inside the autoclave falls down to atmospheric pressure the door is opened and the wagon with cooked log bundles pulled out and off - loaded.

Liquor ratio between bi-carbonate and sulphite as followed in NSS process is 1:6. After expansion of autoclaves from 5 to 10 it is not possible to keep the ratio usual due to limitation of the existing liquor preparation plant. The present ratio is 1:1. Owing to increased carbonate in cooking liquor the brightness of chemi pulp falls down further.

Quick rise of temperature before liquor penetration burns the fibre. But past practice in KNM was to raise the temperature of liquor as quickly as possible without allowing any time for penetration as suggested in Page 309, article 78. Penetration, chapter 4 of Pulp and Paper Manufacture - Volume 1 by J. Newell Stephenson, Editor-in-Chief, published in 1950 by McGraw-Hill Book Company, Inc. In order to overcome the brightness problem, at present, 30 mins. for penetration is allowed before cooking cycle and observed encouraging results in respect of brightness.

However, more experiments are being carried out in respect of cooking time to suit the mills requirements.



GRINDING

Bundles of cooked logs are washed and transported to grinders on trucks. Logs are ground in Great Northern Type Grinders. The pulpstones are burred with 9 x 1½" and 12 x 1½" spiral cut burrs.

Following grinding conditions are maintained:

Pit temperature - 150 - 170°F

Pit consistency - 2.5 - 3.5 %

Pit freeness (CSF) - 250 - 320 ml

Deckered Pulp

Freeness (CSF) - 200 - 250 ml

PULP QUALITY

SGW pulp made from Gewa wood shows very poor strength properties. But chemically treated logs produces improved quality SWG pulp with less energy consumption for grinding. Brightness of chemi-pulp is lower compared to that of GWD. The following table gives a comparative statement of strength properties and power consumption of usual groundwood, chemi-groundwood produced from Gewa with those of usual SWG pulp and soft-wood.

Table

Strength Property	Tropical Hardwood - GEWA		Soft-wood
	Usual Groundwood	Chemi Groundwood	Usual Groundwood
Tear Factor	22 - 25	35 - 40	45 - 55
Burst Factor	4 - 5	18 - 22	22 - 26
Breaking Length (M)	1000 - 1500	2000 - 4500	3500
Brightness ISO	50 - 52	42 - 45	54 - 58
Power Consumption Kwh/ton	1700 - 1900	900 - 1000	1200 - 1400

In order to increase brightness sodium hydro-sulphite is used. Usually sodium hydro-sulphite treatment of pulp as carried out in KNM is about 0.2 - 0.5 % on bone dry basis. Brightness of pulp is practically increased by 2 to 3 degrees against 7 - 8 in the Lab.

#### PULPING IN OTHER MILLS IN THE COUNTRY

All other pulp mills in Bangladesh manufacture chemical pulp in usual sulphate process. The mills have evaporators, recovery boiler, and causticizer with required accessories in each plants.

a) Karnaphuli Paper Mills (KPM)

Capacity: 30,000 M.T./yr. Writing, printing, wrapper, etc.

The mill is mainly designed to manufacture pulp from bamboo. Due to the scarcity of bamboo, now-a-days, the mill also uses local hardwood for making pulp. It has stationary vertical digesters for producing pulp.

b) North Bengal Paper Mill (NBPM)

Capacity: 20,000 M.T./yr. Pulp

The basic FRM is bagasse. It is not adequately available to meet the entire demand of the mill. So, wheat straw is used as make-up for pulp demand. The mill makes pulp in continuous digester.

c) Sylhet Pulp & Paper Mill (SPPM)

Capacity: 20,000 M.T./yr. Pulp

The mill based on reeds and bamboo faces shortage of supply. Presently, local wood, rejects of match factory, i.e. rejected veneers, jute cutting etc., are used to make pulp as a supplement. The mill uses rotary digester for manufacturing pulp.

d) Khulna Hardboard Mill (KHM)

Capacity: 2.79 million metre<sup>2</sup>/yr. Hardboard of thickness 3.22 mm

The mill uses Sundri (*Heritiera fomes*) - Tropical hardwood extracted from Sundarban, the only mangrove forest of the country. Pulp is made by TMP process. One continuous digester with 2 disc refiners and a chipper make the pulping process of the mill.

COUNTRY PAPER  
I N D O N E S I A

REPORT ON PULP AND PAPER INDUSTRY IN INDONESIA

Prepared by

Nursyamsu Bahar

and

Wickie Pratiwi

As a tropical country with sufficient rainfall, Indonesia has a significant potential of renewable resources, i.e. its plantation and its forest. With these vast resources, the Government has established several research institutions to back up the development of the plantations as well as its forest based industries. One of these institutions is the Institute for Research and Development of Cellulose Industries.

This report informs on some research activities done by the Institute, in which case it tries to utilize all the cellulosic fibrous resources for raw materials for the pulp, paper and rayon industries.

The fibrous resources studied come from various sectors, like the agriculture sector (mainly non-wood) and also from the forestry sector (softwood as well as hardwood). Some of the wood resources have been utilized as raw materials for the pulp and paper industry, special attention on wood resources is given during the studies.

Indonesian forests mainly consist of tropical hardwood with about several hundred different species. Non-wood resources from the agriculture section which are being utilized as raw material for the pulp and paper industry are mostly agricultural residues, such as rice straw and bagasse.

Recently, the number of paper mills has increased from 6 mills - all of them Government - owned, to 35 mills. Most of the paper mills are located at Java, the most developed island, and only 3 are located outside Java. The mills produce mostly writing and printing papers, corrugated medium. Later on, some mills started producing newsprint, tissue and cigarette paper. Besides that, Indonesian people make also straw board and wrapping papers in small scale industries.

In the short planning, sack kraft paper and bleached kraft pulp mills will be built.

For backing up all of the pulp, paper and rayon industries, our institute makes the following activities:

- 1) Conduct applied studies on the utilization of Indonesian fibrous resources for the cellulose industry. We conduct the experiment of pulping in laboratory or pilot scale, such as:
  - the experiment in pulping of *Glirisia maculata* at laboratory and pilot scale.
  - the experiment in pulping of *Pinus merkusii* and *Pinus oocarpa*.
  - the experiment is integrated pulping of agricultural residue, i.e.: the use of rice straw as a fibrous raw material combined with the use of rice husk as an energy resource in the pulping process.
  - etc.
- 2) Conduct training programmes for technical staff of the cellulose industry.
- 3) Conduct studies on pollution abatement caused by cellulose industry.
- 4) Promote cellulose technology by cooperating with other agencies, either national or international in research studies and other scientific activities.

COUNTRY PAPER  
I N D I A

PULP AND PAPER INDUSTRY IN INDIA

prepared by

S.S.S. Verma  
(NEPA Paper Mills, Nebanagar, India)

and

P.V. Mehta  
(Min. of Industry, New Delhi, India)

and

S.C. Bajaj  
(Min. of Industry, New Delhi, India)

It gives us great pleasure that UNIDO is holding this conference in the developing region of the world. The topic of comparative pulping processes and monopulp process has been much talked of by the technocrats of the world. But for us the main thing is to decide what process is appropriate and what technology is suitable in the developing countries which have different geophysical and socio-economic conditions.

We all know that paper is made out of fibre available from vegetation, may it be natural forest or agricultural produce. It may be wood or grass in the natural forest or bagasse, straw grass etc. in cultivated land. Consumption pattern of wood as shown in Annexure 1 indicates that in 1980 soft wood consumption all over the world was 365 million M<sup>3</sup> against that of 123.4 M<sup>3</sup> of hardwood. This may be due to the fact that the advanced countries in the northern part of the world are endowed with soft wood forests mainly conifers which have long fibres conveniently processed. Hardwoods, on the other hand are situated in tropical countries or the southern hemisphere. Hardwoods are shortfibred, difficult to pulp and bleach. Naturally the age old traditional technology that was developed for softwoods needs a change or modification to suit the hardwoods.

There is one more factor to be considered seriously. Population density is higher in the hardwood growing regions as compared to softwood regions. Man's basic needs of food, clothes and shelter have to depend on nature either forest or agriculture. Naturally the pressure on land and forest to meet the basic needs is greater in tropical countries or southern parts of the world. In other words, land/forest areas available per capita in Europe, America, Canada etc. is very high compared to that in the developing countries. In India yet another use of wood is predominant in the form of fuel and we have only 37 % of wood available for pulping (Annexure 2).



The strength characteristics of soft wood pulp are far better than those of hardwood ones.(Annexure - 3). The countries in tropical region or southern part of the world now cannot survive on the technology developed over years in U.S.A, Canada or other European countries which have a different culture and different environment from that of ours. We have to develop our own technology, equipment, pulping and bleaching processes to suit our raw material.

Softwoods have a great advantage of shorter life-cycle, i.e. 5-10 years for wood species and 4-10 months for agricultural products. Availability of wood can be increased per hectare by adopting high density plantation for some fast growing species like subabul, *Sisbania grandiflora*, *Eucalyptus* etc. By adopting these species in social forestry pressure on forest land for fuel can be reduced considerably as fuel and fodder will be grown on their land. Captive plantation for paper industry can yield wood to the tune of 50 MT/Ha/year. *Eucalyptus* plantation in 30000 Ha is sufficient for a 300 T.P.D. mill in perpetuality. *Subabul* plantation in 5,000 Ha can meet the demand of 200 T.P.D. mill like Nepamills.

Over and above these methods of producing more wood in the limited area of land available for allowing greater quantity of wood going for pulp and paper industry, we have to look to processes which yield more fibre and less pollution. Recently some high yield processes have been developed like 90:90.

- i) Semi chemical
- ii) Mechanical
- iii) Cold Soda Pulping
- iv) Refiner mechanical
- v) Thermo mechanical
- iv) Chemi thermomechanical

In all these processes attempt has been made to reduce the costly chemical consumption and to substitute these chemicals by some form of direct energy. A balance is to be struck between the various factors of energy consumption, steam, water, chemicals requirement and pollution effects as well as the yield and strength

properties of various available raw material (Annexure 4 &5) to arrive at the optimum processes. Some species like subabul, Eucalyptus have shown good results by cold soda/CMP/CSRMT process giving 80 % yield and 75 - 80 % I.S. brightness as well as acceptable strength properties for newsprint grade.

Nepa Paper Mills and Mysore Paper Mills are making newsprint paper by adopting cold soda process and whereas H.P.C. is following thermo-mechanical pulp process. Stone ground wood process is also used in Nepa Mills for making pulp from hardwood.

Recently Tamil Nadu Paper and Newsprint Ltd. have set up a writing printing newsprint project having capacity of 300 tons/day, based on unconventional raw material using more than 75 % bagasse pulp.

The brief process adopted in Nepa paper mills developed over a year is given below.

Bamboo of 10 - 20 % moisture is chipped in Papco chipper to produce chips (of size 15 - 20 mm x 10 - 15 mm x 3-8 mm). The chips are cooked with 14 - 15 % active alkali to produce pulp (50 % yield) of 23  $\text{KMnO}_4$ . This pulp after washing and screening is bleached in conventional bleaching system of CEH sequence.

Initially cold soda pulp was being made from Salai but due to very short fibre (.8 mm fibre length) the pulp produced was of very inferior quality, BF-4-5, TF-20-25, BL-1200-1400.

Bamboo was tried in cold soda plant and the results were quite encouraging. Bamboo chips from chipper are soaked in caustic (26 gpl at 70°C) for about two hours. The impregnated chips are refined in two stages to produce pulp of 400 - 450 CSF freeness. This pulp is screened and bleached with 10 % to 12 % Calcium Hypochlorite. This is again refined to get a pulp at 200 CSP freeness having BF-12-TF-65-70, and BL-2500-2800 M, of course of 30 % ISO Brightness. (Block diagram attached, Annexure 6).

Stone Ground wood process is used for making pulp from hard wood. Debarked logs 4' x 4" to 12" Ø are ground on Great Northern stones to get a pulp of 100 CSF, BF-2-3, TF-18-20, BL-500-600. Purchased fibre TMP, CTMP/STMP/Paper Cutting are also used in the newsprint furnish to produce newsprint of Basis Wt. 52±2 BF-10, TF-50, BL-2200-2600.

Number of hard woods were tried at Nepamills. All the three processes were adopted for pulping. Wood suitability for particular process is given in (Annexure 7). Out of all the 3 processes available at Nepa, Cold Soda Process has proved to be the best for hard wood. The yield is about 75 to 80 % brightness of these pulps 60-70 % and the strength properties of the pulp are also acceptable.

Nepa has tried comparatively new species subabul (*Leucaena leucocephala*) on plant scale. The results are quite favourable. At 200 CSF/CSP pulp is having BF-18, TF-65, BL-3000-3400 Brightness achieved is 50-55 % ISO with only 10 % Hypo.

#### NON WOOD FIBRES

More than 200 units are using non-conventional raw materials such as cereal straw, kenaf, bagasse and waste paper.

The Government is at present encouraging setting up of newsprint project based on deinking technology and have approved substantial capacity in this regard.

Paper industry in India has been well established. In 1950 - 51 there were seventeen paper mills, which increased to 75 units in 1975 with installed capacity of 23.5 lakhs tons. The production statistics which reflects the growth of Paper Industry is at (Annexure 8.)

A significant feature of the present structure of paper industry is the growth of Small Paper Mills. Since 1979-80 number of new small industry having capacity of less than 10,000 tons/annum have been installed in view of the liberal policy of the Govt. in announcing various relaxation from time to time to help the industry such as

- (1) Importation of second-hand paper machine up to a capacity of 30 tons/day. This facility is however not available now.
- (2) Exemption from excise duty on the paper made of more than 75 % bagasse pulp.
- (3) Relaxation in excise duty to small paper mills.

During the current year the increase in installed capacity was entirely due to small units, which now represent nearly 50 % of the total capacity and are based on utilizing unconventional raw materials like cereal straw, bagasse, waste paper etc.

Demand of paper and paper board and newsprint has been assessed as under:

Year	Paper & Paper Board (lakhs tonnes)	Newsprint (lakhs tonnes)
1985-86	14.30	3.90
1986-87	15.01	4.13
1987-88	15.76	4.39
1988-89	16.55	4.65
1989-90	17.38	4.94

The entire requirement of the country of paper and paper board is being met through indigenous production except for speciality paper which is being imported. We are making about 42 varieties of paper which generally classified under broad heading as under:

- (1) Printing Paper
- (2) Writing Paper
- (3) Packing and wrapping paper
- (4) Other varieties of paper
- (5) Paper board

The production of pattern of these varieties during 1984 was:

(1) Printing Paper	23.08 %
(2) Writing Paper	22.45 %
(3) Packing and wrapping paper	37.24 %
(4) Other varieties	2.68 %
(5) Paper board	13.18 %

The production has also increased from 14.200 tonnes during 1958 to 199,000 tonnes during 1984.

To day therefore the basic need is how to make/economize the cost of good quality paper, particularly when the sustained availability of raw materials to meet the long-term requirement of the paper industry has been causing concern both from the point of view of meeting future requirements of paper, as well as the imperative need to arrest the decline of our natural forests. There is a need to strengthen research activities for:

- (1) Utilization of non-wood raw materials and their pulp mix.
- (2) To save energy inputs, high yield pulping and effluents control.
- (3) Optimization methods for saving in raw material costs.

In order to make the paper cheap, so that it should reach to everybody within their needs at comparative cost.

In nutshell, it is concluded that, the process and quality control are the only tools to optimize an efficiency and to produce goods of exacting standards at minimum costs.

ANNEXURE NO. 1

WORLD OUTLOOK FOR WOOD CONSUMPTION IN PAPER  
PRODUCTION, (1960-2000) MILLION CUBIC METRES)

	<u>1960</u>	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>
Softwood	177.7	299.2	365.0	462.4	615.1
Hard wood	<u>32.6</u>	<u>80.7</u>	<u>123.4</u>	<u>197.0</u>	<u>255.3</u>
TOTAL	210.3	379.9	488.4	641.4	870.4
Hard wood %	16	21	25	28	29

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SOURCE IPPTA CONVENTION ISSUE 1983.

ANNEXURE NO. 2

USE OF WOOD IN INDIA, 1975-76

<u>Item</u>	<u>Million M<sup>3</sup></u>	<u>Percent</u>
Industrial wood	9.9	37
Fuel wood	<u>16.6</u>	<u>63</u>
	<u>25.5</u>	<u>100</u>

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SOURCE IPPTA CONVENTION ISSUE, 1983.

## ANNEXURE NO. 3

## STRENGTH PROPERTIES OF CHEMICAL PULP DIFFERENT HARDWOOD/BAMBOO/SPRUCE

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Brightness PV	82	70	75	81	81	71	73	70	79	80	83	80	78/80	78/80	91
Burst Factor	40.3	55.2	44.1	42.3	47.3	26	47.7	45.3	39.6	42	47	42	30	30	100
Tear Factor	75.2	54.5	67.8	64.2	89.7	57	57	50	59.1	67.3	47	59	88	93	100
Breaking length Metres	5874	9642	5418	5998	6854	4221	6709	6393	6951	6972	7710	7525	5200	4700	11,600

- |                                   |  |                            |
|-----------------------------------|--|----------------------------|
| 1. <u>Acacia planifrons</u>       | 2. <u>Sesbania grandiflora</u>             | 3. <u>Acacia decurrens</u> |
| 4. <u>Casium fistula</u>          | 5. <u>Eugenia tumbolana</u>                | 6. <u>Albizzia</u>         |
| 7. <u>Protium caulatum</u>        | 8. <u>Rhombadia frenalia</u>               | 9. <u>Pinus patula</u>     |
| 10. <u>Melia indica</u> (Murgosa) | 11. <u>Pithecolobium saman</u> (Rain Tree) | 12. <u>Casuarina</u>       |
| 13. Bamboo                        | 14. Eucalyptus                             | 15. Spruce                 |

SOURCE: - IPPTA July, Aug., Sept., 72 Vol., IX No. 3.

/RS/

SOME IMPORTANT PROPERTIES OF PULP OBTAINED FROM  
DIFFERENT PROCESSES (RAW MATERIAL - HARDWOOD)

	KRAFT	CSMC	COLD SODA	GROUND WOOD
1. Yield	45	55.85	85-90	90
2. Brightness	85	75	75	70
3. Opacity	75	80	88	94
4. Tear	90	75	65	10
5. Burst	60	25	20	5

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SOURCE IPPTA CONVENTION TISSUE, 1983.



STRENGTH PROPERTIES OF DIFFERENT GRADES OF PULP FROM BRUCE

Properties	Kraft	S.G.M.	R.M.P.	T.M.P.
Tear Index $\text{mN.m}^2/\text{g}$ .	10	3.2	1	5-6
Tensile Index $\text{Nm/g}$ .	112	25	32	40
Burst Index $\text{Kpa. m}^2/\text{g}$ .	10	1.7	1.9	2
Brightness %	90	85	64	62

TABLE 1

THE NATIONAL NEWSPRINT & PAPER MILLS LTD. NIPANAGAR NE  
SUMMARY OF LABORATORY TRIALS ON DIFFERENT WOOD SPECIES

Completed in Nov.

S.NO.	PULPING PROCESS	SPECIES YIELDING PULP STRONGER THAN SALAI NO BLEACHING NEEDED	SPECIES YIELDING PULP AS GOOD AS SALAI NO BLEACHING REQUIRED	SPECIES YIELDING PULP STRONGER THAN SALAI BUT NEED BLEACHING	SPECIES YIELDING PULP AS GOOD AS SALAI BUT NEED BLEACHING
1.	MECHANICAL PULPING STONE GROUND WOOD	1. ALLANTHUS EXCELSA (MAHARUKH)	1. ANTHOCEPHAL NUS CADAMBA (KADAMB)	1. DIOSPYRES ME LOOXYLON (TEJDU)	1. EUCALYPTUS PINE FROM HIMA- CHAL PRADESH (NILGIRI) GAVE GOOD PULP BUT FREQUENTLY CLOSED THE STO- ME. ITS USE IS THEREFORE NOT RECOMMENDED FOR STONE GROUND WOOD.
		2. ALBIZIA PROCERA (SAFED SIRIS)	2. BUTEA FRONDOSA (PALAS)	2. MELIA AZIDE RACH (SARKAN)	2. PTEROCARPUS MERSUPIUM (BIJA)
		3. BROUSSONETIA PAPYRIEERA (PAPER MULBERRY)	3. DALBERGIA PANNICULATA (FANSI)	3. EUCALYPTUS GRANDIS (MYSAN)	
		4. CRYPTOMERIA JAPONICA	4. ERYTHRENA SUBEROSA (GADALA)	4. TERMINALIA TO MENTOSA (SAR)	
		5. EUCALYPTUS GRANDIS (NILGIRI)	5. FICUS RELIGIOSA (PIPAL)	5. XYLIA XYLO CARPA	
		6. FIR (INDIAN)	6. GERUCA PINNATA (KAKAD KHARPAT)		
		7. PITHECOLOBIUM SAMAN (RAIN TREE)	7. HYMENODICTYON EXCELSUM (DHONRSAL)		
		8. POINCIANA REGIA (GULMOHAR)	8. LAGERSTRONEMIA PARVIFLORA (LENDIA)		
		9. RICINUS COMMUNIS (CASTER OIL PLANT)	9. MORINGA PTERY GOSPERMA (MUNGA)		

TABLE 1 CONT.

		10. SPRUCE (INDIAN)			
		11. TERMINALIA ARJUNA (ARJUN)			
2.	COLD CAUSTIC SODA PULPING	1. ALBIZZIA PROCERA (SAFED SARIS)	1. CASSIA SIAMIA	1. EUCALYPTUS GRANDIS (NILGIRI)	1. ACACIA PINE FROM HIMA MURCULI CHAL PRADESH FORMIS GAVE GOOD PULP BUT THE REFINED DISCS BY STICKING. USE NOT RECOMMENDED FOR COLD SODA PULPING.
		2. HIBISCUS CANNI BINUS (MESTA AMBADI)	2. DIOSPYROS MELONOXYLON (TENDU)	2. CEIBA PENTENDRA (KOPAK)	2. EUCALYPTUS HYBRID (NILGIRI)
		3. OPOMOEIA CARNEA (DESHAM GHAPAN)	3. LAGERSTROEMIA PARVIFLORA (LENDIA)	3. MELIA AZEDA RACH (BAKATN)	
		4. PITHECOLOBIUM SAMAN (RAIN TREE)	4. PTEROCARPUS NERSUPIUM (BINA)	4. TERMINALIA TOMENTOSA (SANT)	
		5. POINCIANA REGIA (GULMOHAR)	5. TECTONA GRANDIS (SAGON-ONLY LOPS & TOPS)	5. XYLIA SYLOCARPA	
		6. SESBANIA GRANDIFLORA (AGATHI)			
		7. TERMINALIA ARJUNA (ARJUN)			

SD- R.P. GOUR  
CHIEF CHEMIST.  
24.11.1980

Annexure 8

Year	Installed capacity (laks tonnes)	Production (Lakhs tonnes)	No. of units
1970	8.59	7.58	
1971	8.66	7.80	
1972	9.53	8.03	
1973	9.62	7.96	
1974	10.09	8.37	
1975	10.63	8.29	75
1976	10.68	8.80	75
1977	11.37	9.36	75
1978	12.65	10.06	86
1979	13.80	10.47	106
1980	15.38	11.12	121
1981	16.56	12.35	136
1982	18.16	12.36	157
1983	19.15	11.97	175
1984	21.65	13.71	220
1985	23.5	14.5	249

COUNTRY PAPER  
P A K I S T A N

PULP AND PAPER INDUSTRY IN PAKISTAN  
USING CHEMICAL PULPING PROCESSES

prepared by

Mohammad YOUSUF  
(Pakistan Paper Corp., Charsada, Pakistan)

and

Saiful MALOOK  
(Century Paper-Board Mills Ltd., Lahore, Pakistan)

and

Syed Amjad ALI  
(Century Paper-Board Mills Ltd., Lahore, Pakistan)

PULP AND PAPER INDUSTRY IN PAKISTAN

Prospects of growth in the field of pulp and paper in Pakistan are bright - as a number of new mills are coming up. Until recently, the local production of paper/board has been largely provided with contributions by the following mills:

Pakistan Paper Corporation:(Commissioned in 1971)

100 tons per day writing/printing paper,  
based on bagasse - integrated with chemical  
recovery and a caustic chlorine plant.

Adamjee Paper/Board Mills: (Commissioned in 1963)

25 tons/day writing/printing paper,  
and 50 tons/day board.

Packages Ltd:

(Commissioned in 1968)

20 t/day writing paper  
50 t/day corrugated media & liner boards  
5 t/day tissue & poster paper  
45 t/day box board & food boards.

In recent years, there is a growing trend among the local entrepreneurs of installing small waste paper based, second hand units purchased from Europe. About 5 such paper mills have already come into partial production or are in the stage of commissioning. Production capacity of individual mill is 20 - 40 tons per day writing/printing grades.

In addition few other mills are in the stage of construction or planning, which are based on chemical pulping processes are as under:

- Kamalia Paper Project : 200 tons per day writing/printing paper  
to be based on bagasse by public sector.

- Century Paper/Board: 120 tons per day  
Based on neutral sulphite pulping of wheat straw and Kahi grass with product range from tissue, poster offset paper to box boards & food board.
- Another mill with 100 tons per day writing/printing to be based on bagasse based for production of extendable cement sack paper in private sector.

By and large, the major raw material for pulp production is bagasse or wheat straw and Kahi employing soda or sulphite processes.

Availability of bagasse for pulp making has diminished, as the sugar mills supply bagasse are forced to use it as fuel due to country-wide curtailment of natural gas during the peak season. This situation is likely to persist for some time. So the wheat straw has become single major source for pulp production and is available in abundance.

One particular paper mill, which at present is the largest in the country, was based on bagasse only, and with a chemical recovery process. Bagasse is supplied to the four paper mills located in 30 - 50 km radius. With bagasse in short supply, this mill has been forced to change over to wheat straw, partially or fully. Unfortunately, however, the major sources of supply of wheat straw are 300 - 400 km away. The mill is facing a major problem of producing local pulp at economical cost—one major reason being the raw material - costing around US\$ 50 for each ton of wheat straw.

#### Chemical Recovery at Pakistan Paper Corporation

There is a recovery boiler with a direct contact venturizer/scrubber evaporator following a multiple effect evaporation plant. The system has an inherent design problem. Ever since the mill was commissioned in 1970, the recovery boiler never operated on its designed capacity, due to problems of handling the black liquor viscosity encountered beyond 52 % concentration. So the system is not capable of sustained operation and rendered uneconomical.

### Pulp Mills

#### Pakistan Paper Corporation.

The pulp mill, after bagasse depithing (SPM) and wet cleaning operations consists of a horizontal tube continuous digester followed by a three stage brown stock washing, a centrifugal screen, centricleaner plant and finally a three stage bleaching chlorine - alkali - hypo. Use of wheat straw in the existing system is found to be retarding factor for pulp mill. A reduction of 10 - 15 % in capacity is experienced as compared to the bagasse.

Recently, improvement has been achieved in the operation of pulp mill as a result of which, the mill is now depending more and more on the locally produced pulp. At present about 60 % of bleached local pulp is being used in the paper furnish. The problem with the recovery system remains, in fact, it will be aggravated with more capacity utilization in further. The mill's management is very anxious to operate the recovery system at optimum level and to balance the same with the pulp mill.

Good Bagasse storage, aging and handling systems are the key factor for successful operation of a bagasse pulp mill. Ideally, the bagasse must be depithed as soon it is delivered from the sugar mill. Compacted pile storage system is found to be a convenient method of storage, but elaborate arrangements are required for distributed stocking and reclaiming of the material. For this purpose mobile stackers are suitable.

It is experienced that 3 - 6 weeks aging of depithed bagasse produces better results in pulping, in respect of, pith removal in wet depithing stage, yield, washing efficiency and black liquor quality. Bagasse yield from the green bagasse to be depithed obtained about 32 %.



COUNTRY PAPER  
V I E T N A M

THE DEVELOPMENT OF VIET NAM'S PAPER INDUSTRY

prepared by

Vo Quoc Lam  
Union of Paper No. 1

ASSESSMENT OF VIET NAM'S PRESENT PAPER INDUSTRY

1. Position of Paper Industry in National Economy

Education is an urgent demand in the social life. The Vietnamese are fond of studies, three among ten are studying. The development of paper industry therefore will respond not only to the need of the development of other branches of the national economy but also to the demand as necessary as for clothing and food of the population.

Paper making existed in Viet Nam for a long time, but the method was still rudimentary and the total output was rather low in this century. Before 1945 there was only one factory for the whole country. The total output of paper in Viet Nam in 1939 was nearly 6,000 tons.

Viet Nam's paper industry had started to develop since 1960, but it was later heavily destroyed by the war.

After the country was reunified, its paper industry resumed development with the output of 85,000 tons of paper/year - and the output of pulp was only 44,000 tons/year. Since 1978 the production of pulp had increased in southern Viet Nam. Before 1975, the amount of pulp produced at home was only 5 % of the need, but in 1978, the pulp output increased, making 45 % of the need.

In 1981, the Vinh Phu paper mill began to produce. But due to the sharp decrease of the amount of imported pulp and the lack of other materials at home, the 1984 output was around 71,000 tons (the record paper output was 90,900 tons in 1976).

The output value of the paper industry keeps a modest position in the national economy: from about 1 - 3 percent of the industrial total value.

The actual paper output per capita is very low, about 1 - 1.5 kg per year.

A number of high-quality paper must be imported; some of the paper for culture is not whitened enough thus badly effecting the quality of publications.

## 2. Capacity of Production

The total pulp production capacity at present is 116.500 tons/year. But it increases to 156.500 tons/year when the expansion project of the Man Mai paper mill is completed.

The present total paper production capacity is 154.000 tons/year, but it can rise to 184.000 tons/year when the new TMP plant of the Tan Mai mill will be completed. Even that time the country will be short of 15 % of pulp to produce paper.

## 3. Level of Technique

The existing paper mills have different technical levels. They can be classified into 5 categories:

- High automatic technique, good equipment: The Vinh Phu mill (48.000 tons of pulp and 55.000 tons of paper a year).
- Medium level technique with relatively good equipment: The Tan Mai and Dong Nai mills (17.500 tons of pulp and 40.000 tons of paper per year).
- Rather old technique with old and easily out-of-order equipment: State-run mills in northern Viet Nam (25.000 tons of pulp and 32.160 tons of paper per year).
- From medium to low technique, equipment of bad quality: State-run mills in southern Viet Nam (15.300 tons of pulp and 20.000 tons of paper per year).
- Low technique, home-made equipment small mills with total of 8.000 tons of pulp and 6.500 tons of paper per year.

#### 4. Process and Equipment

The process of producing sulphate pulp remains monotonous and therefore the effect of using its products and material is limited.

Except the Vinh Phu mill with chemical recovery equipment, all other mills have no such equipment thus causing pollution to the environment.

The common cooking digesters are the batch digesters with a small capacity of 8 - 25 cubic metres.

The screening systems are below technical requirement thus reducing the quality of products.

### POSSIBILITIES OF DEVELOPMENT OF PAPER INDUSTRY IN VIET NAM

#### 1. Possibility of Development

Over the past few years, the development of paper producing branch in Viet Nam had to face many difficulties. The real possibilities, however, have shown many respects for the development of this branch.

#### Raw Material

Bamboos and wood: there are about 7.3 million hectares of forest in Viet Nam, and 2.2 million hectares among them remain unexploited. Besides, there are 10.7 million hectares of uncovered land capable for planting forest. Thus, the total areas of planting forest account to 60 per cent of the total planted forest. The material supply for paper producing branch in Viet Nam remains a great problem at present. But it will be of no concern if the present bases are duely invested and if forest is planted in the areas of uncovered hills.

### Soda and other Chemicals

At present there are 3 soda-producing mills in Viet Nam: The Vinh Phu paper mill, the Viet Tri chemical producing factory and the Dong Nai soda producing workshop. These mills are producing soda supplied for paper branch in our country. As for the Vinh Phu paper producing mill, if operated at the output as designed, it can produce not only enough soda for self-supply but also produce 2.000 tons of more soda for sale. The designed output of the Dong Nai soda-producing workshop is 3.000 tons per year and that of the Viet Tri chemical producing factory is 4.700 tons per year. The ever-increasing development of paper producing branch may face difficulties but the possibility to solve this problem is easily achieved by collecting the soda remaining from the two big producing soda bases in Viet Tri and Dong Nai provinces.

### Kaolin

Kaolin is considered as the best material for both purposes: to improve the whiteness and smoothness of paper and to be the best filler for paper producing industry. There are many kaolin mines in Viet Nam, but it's a pity that this kind of material has been rarely used in most of the paper-producing enterprises in this country so far.

## 2. Present bases and level of technique

### Present Bases

As it is mentioned above that most of equipments are old and out-of-order but it still constitutes favourably for the development of paper industry in Viet Nam. The total output of 100.000 tons per year, the present structure of organization, buildings and labour forces and so on constitute favourable sources for the investment and development of this branch.

Level of Technical Profession

At present there are 30.000 cadres and workers - who are working in this branch. Most of them are very good at their work. 1.000 among them have been working in paper industry for 3 years running, 400 others have been trained at the universities either at home or from socialist countries.

The output of paper producing branch should be increased so as to meet the requirement of the development of industry and national income in the following years:

	1986	1990	1995
Requirement	105.000 tons	135.000 tons	176.000 tons

The main requirement of paper is the paper to be used for printing newspaper and text books.

ORIENTATION OF THE DEVELOPMENT OF VIET NAM'S PAPER INDUSTRY

1) Objectives

By gradual preparation of raw materials, chemicals and other material and technical basis to develop the production of paper, chiefly from the internal supply of materials, in order to meet the requirement of the national economy in paper, first of all, the paper for culture, then the cardboard and wrapping papers, and to reduce the import of these materials and gradually get self-sufficient most of the home consumption.

The immediate objective is to cut down the quantity of imported paper pulp.

Further objective is to get a proportion in the import and export of paper.

2) Investment

Building some more large-scale and modernly equipped paper pulp factories which have a close cycle system of production, find a solution to the impropotion in the production of paper and pulp, to the pollution of the environment, raise the economic efficiency: the first phase with a target of output of 20,000 - 30,000 tons per year, then to 50,000 tons per year.

Making full use of available establishments which have favourable sources of materials and energy, and are able to avoid the pollution, so as to make intensive investment (The Viet Tri Paper mill produces wrapping papers, the Van Diem Paper Mill produces cardboard, the Dong Nai paper mill produces duplex carton, the Tan Mai mill produces paper for printing and pulp).

Pushing ahead the investment in building small-sized mill each with a capacity ranging from 300 to 1,000 tons per year to produce paper for local requirement in remote areas.

3) Raw Materials

Making best use of the favourable tropical monsoon and the differences of the land surface which are suitable to the favourable for the growth of both long-term and short-term groups of vegetation in order to set up, as soon as possible, special areas capable of supplying sufficient material for large-scale production.

Expanding the cultivation of crops of multiusage for various branches of production such as sugarcane, jute, straw.

4) Process and Equipment

Raising the quality of pulp produced at the pulp-producing mills by applying the method of sulphate, concentrating the manufacture on the mills with output of more than 10,000 tons/year so as to meet the requirements of producing items of public needs (printing

paper, wrapping paper), at the same time supply pulp for nearby small-sized mills to avoid the pollution, to make use surplus energy, to raise the efficiency of materials, reduce the cost of production.

Applying the methods of producing mechanical pulp (MP), temperature mechanical pulp (TMP) or chemi-thermo-mechanical pulp (CTMP) to the manufacture of printing paper cardboard and paying more attention to the use of non-wood raw materials.

Applying new production method such as coating the surface with glue, plating a thin membrane on papers so as to create new characters for paper and carton, and enriching the resources of paper articles, all to meet the needs in industrial production and daily life.

Supplying spare parts and supplement equipment for the repair of a number of principle appliances at factories which have been put into operation and they are now still possible to promote their effect.

#### 5) Economization of Materials, Energy and Chemicals

The construction of large-scale, close-cycle system of production enterprises permits the paper industry to become self-proportionate with regard to chemicals and energy, and reducing the cost of production.

Reducing the grams per square metre of the paper being put into use.

Increasing the use of kaolin in replacement of parts of the vegetation fibre.

Using more waste paper (only 13 per cent of which is now used).