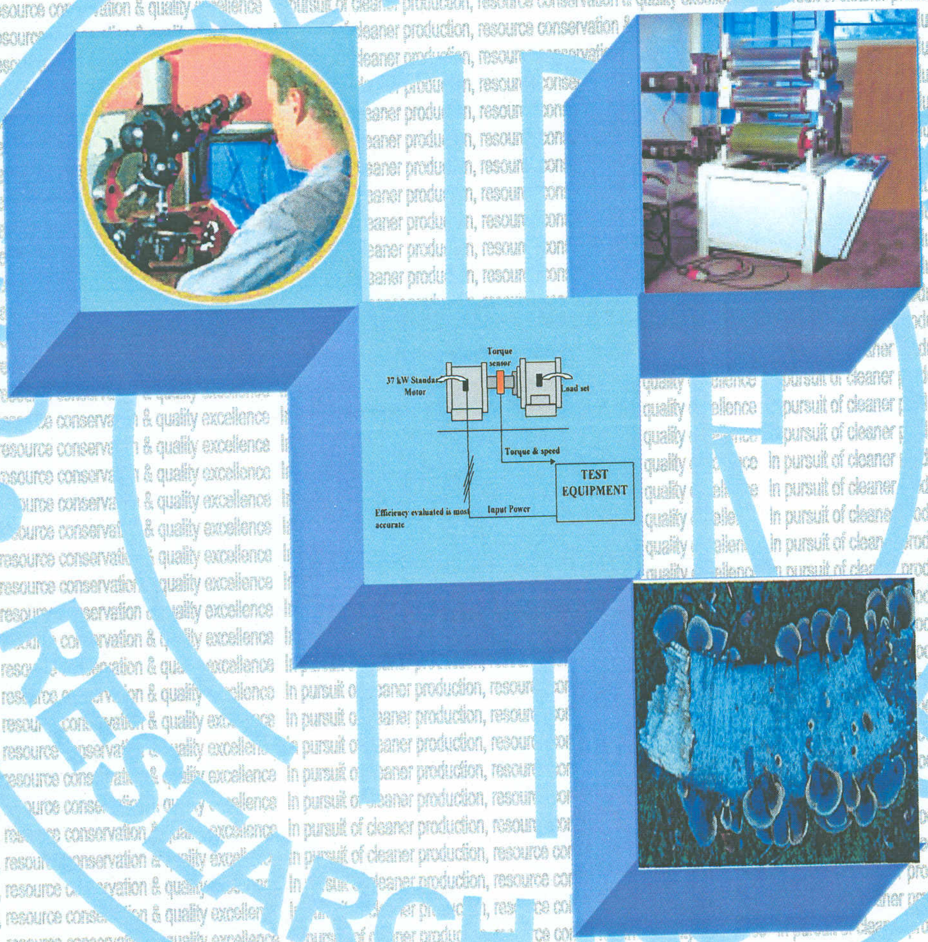
WORKSHOP
ON
FRONTIER TECHNOLOGIES ADDRESSED
UNDER
CESS FUNDED PROJECTS

In pursuit of cleaner production, resource conservation & quality excellence



CENTRAL PULP & PAPER RESEARCH INSTITUTE

SAHARANPUR - 247 001, U.P., INDIA

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SAHARANPUR - 247 001, U. P., INDIA

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(औद्योगिक नीति और संवर्धन विभाग)
उद्योग भवन, नई दिल्ली–११००११
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FOREWORD

The paper industry is one of the important sectors and there is a need for ensuring sustainable growth and improving competitiveness of this sector. Although the industry has made steady progress in the last 50 years but the industry today is faced with a number of challenges, particularly in the area of raw material, environmental management and quality aspects. In order to understand the problems faced by different segments of this sector and to resolve these problems appropriately, the allocation of Cess funds for Research & Development was initiated in the year 1996. During the last six years, number of Cess funded projects were taken up to address the important issues before the paper industry. The Cess funded projects essentially are intended to understand the immediate requirements of the paper industry and to make possible efforts to resolve them. As many as 26 projects were initiated during the last six years covering raw material, process research, energy & water conservation, quality improvement, forestry, biotechnology, etc. Efforts were made by the Cess committee to periodically review the projects thoroughly, keeping in view of the requirements of the industry. Global competitiveness of Indian paper industry was one of such projects, the study of which was conducted by JPC, Finland. The study has enabled us to understand how to address various issues having impact on global competitiveness of paper industry.

It was felt in one of the Cess Committee meetings that the dissemination of data collected in these Cess funded projects undertaken by different agencies, was considered important and it was decided that CPPRI should organize a "Two-day Workshop" to disseminate and discuss the findings of the Cess funded projects, which have been completed, on-going & new schemes. In this direction, this workshop, which is first of its kind and I am sure this will facilitate thorough dissemination of information.

I am confident that the industry will take benefit by utilization of the research data. I compliment CPPRI for bringing out a comprehensive Souvenir covering the highlights of various Cess funded projects. I am sure that the deliberations and outcome of the workshop should be useful to the participants from different pulp & paper units, scientists & engineers.

I wish the workshop a success.

(S. Jagadeesan)

Dr. A. G. KULKARNI
Director

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PREFACE

Central Pulp & Paper Research Institute (CPPRI) is devoting considerable amount of time in Cess funded research projects, as most of these projects address the short term requirements of the paper industry. As many as 15 projects were assigned to CPPRI and it has successfully completed nearly 8 projects in the area of technology, global competitiveness, environmental management, recycled fiber utilization and application of biotechnology in paper industry. The Institute has brought out a comprehensive report on the completed projects and I am sure the contents of the reports should be useful to the paper industry. The implementation of research findings is a key step for transfer of R&D results to the industry and in the process of implementation, the dissemination of information becomes important. Keeping in view of this, CPPRI, as per the advice from the Cess Committee, decided to organize this "Two-day workshop", which will cover large number of areas and the discussion between scientists and pulp & paper mill technical personnel should become a prelude for effective transfer of the research findings to the paper industry.

I am sure this comprehensive souvenir covering the highlights of various Cess funded projects by CPPRI and other organizations will be a useful reference material for pulp & paper technical personnel.

(A.G. Kulkarni)

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CONTENTS

S.No	PARTICULARS	P. No.
	COMPLETED PROJECTS	
1.	AVAILABILITY & UTILIZATION OF WASTE PAPER	1
2.	ENZYMATIC IMPROVEMENT IN DRAINABILITY OF THE WIRE PARTS IN PAPER MACHINE	17
3.	IMPROVING FILLER LOADING IN THE PAPERS MANUFACTURED FROM INDIGENOUS FIBROUS RAW MATERIAL	24
4.	UTILIZATION OF ENZYMES DURING PULP & PAPER MAKING FOR REDUCTION OF COOKING & BLEACHING CHEMICALS, ENERGY DURING PULPING, REFINING AND MANAGEMENT OF INDUSTRIAL WASTE MINIMISATION	28
5.	FEASIBILITY STUDIES ON COLOR REMOVAL FROM MECHANICAL PULPING EFFLUENTS	39
	ONGOING PROJECTS	
6.	MONOGRAPH ON INDIAN PAPERMAKING FIBERS	50
7.	DEMONSTRATION OF ENZYMATIC PREBLEACHING IN A PULP & PAPER MILL	59
8.	STUDIES ON BENCH MARKING / INPUT NORMS IN INDIAN PULP & PAPER INDUSTRY	74
9.	ENERGY PERFORMANCE EVALUATION & OPTIMIZATION IN PULP & PAPER INDUSTRY	85
10.	CALIBRATION & INTRALABORATORY QUALITY ASSESSMENT SERVICE FOR PULP PAPER AND ALLIED INDUSTRIES (CESS/IPMA PROJECT)	91
11.	DETOXIFICATION OF BLEACH PLANT EFFLUENT FOR RECYCLING & REUSE	93
12.	WATER CONSERVATION IN PULP AND PAPER INDUSTRY	108
13.	CONTINUING EDUCATION FOR TECHNICAL PERSONNEL OF PULP & PAPER INDUSTRY	113
	BISR PROJECT	
14.	BIOBLEACHING : ENZYMATIC COLOUR REMOVAL FROM PULP	128

COMPLETED PROJECTS

AVAILABILITY & UTILIZATION OF WASTE PAPER

Mrs. Rita Tandon
Scientist E - I

About The Author

Presently working as a senior scientist in CPPRI, the author has a Master's Degree in Chemistry with specialization in Organic Chemistry. The author with a brilliant academic record has dedicated almost 19 years of service to the Institute working in the area: Paper testing, Papermaking, Black liquor characterization, Chemical Recovery, Secondary fibre processing, Energy & Environmental Management.

She has a wide experience in the area of chemical recovery and secondary fibre processing. Has completed two projects on waste paper namely **"Technological Treatment Of Waste Paper"**, sponsored by AISPMA and **"Availability And Utilization Of Waste Paper"** sponsored by IPMA under which **an indigenous gradation system has been evolved** and proposed for implementation. Currently working on project **"Identification, Characterization & Removal Of Contaminants From Recycled Fibre"** under a plan scheme.

She was associated with development of Desilication technology also and currently working on development of color removal technology for liquid effluents.

She has undergone two months extensive training on **"Energy Management in Pulp & Paper Industry" in Cia Suzano Mill in Brazil under UNIDO fellowship training programme**. She has around 30 publications to her credit and author/co-author of number of R&D reports, training & course manual.

AVAILABILITY & UTILIZATION OF WASTE PAPER

A. G. Kulkarni, R. M. Mathur, Rita Tandon, Satya Dev Negi,

1.0 BACKGROUND & OBJECTIVE OF THE PROJECT

The project on "Availability & Utilisation of Waste Paper" was sponsored by Indian Paper Manufacturers Association (IPMA). The project commenced in January 1999 and was completed in June 2001. Later on in one of cess committee meeting the project was extended upto September 2001 to carry out the deinking studies exclusively for Nepa Mills Ltd. The project team comprised of following scientists:

The objective of the project is to suggest an indigenous gradation system based on the quality and characteristics of indigenously recovered paper which eventually will help in formulating a mechanism for an organised collection system and distribution system in the country and also to identify an appropriate processing system with proper selection of equipment so that different varieties of indigenous and imported waste paper can be effectively utilised by the mills.

The study involves preparation of status report on "Availability & Utilisation of Waste Paper" containing meaningful recommendations for implementation to improve the present collection and distribution system in the country and also the appropriate processing technology and system configuration for producing different types of product using different varieties of waste paper. This would not only enhance the utilisation rate but also facilitate the production of quality papers from waste paper.

The outputs of the project will immensely benefit the Indian Paper Industry as it is facing an acute shortage of fibre resources. The new national Forest policy (NFP) in 1989 of GOI and the guidelines provided by NFP have clearly indicated that no forest wood supply would be forthcoming for paper industry in near future and therefore raw material requirement cannot be sustained from forest produce and paper industry shall have to generate their own woody raw material source or have to increase the use of agricultural residues or waste paper.

Though there is surplus availability of agricultural residues, however due to limitations in handling transportation, lack of adequate technology to process these raw materials and also in absence of a technology for recovery of chemicals, it is difficult to go for mills with larger capacities based on agro residues.

Under such conditions, there is a need to evolve long term strategies to ensure the supply of raw materials from sources other than forests, and waste paper occupies a pivotal position in bridging the widening gap between demand and supply of raw materials.

Increased use of waste paper can ensure the sustained supply of raw materials to a large extent provided an organised sector is evolved for supply of waste paper. Presently in India, in absence of grading system, there is no systematic/organised collection and distribution system existing, due to which large volume of waste paper remains unrecovered.

The paper industry in India has long been utilising waste paper in its product -furnishes, but a major portion is being utilised for the production of packaging grades or low quality writing/printing grades of paper due to poor quality of indigenously recovered paper.

As the waste paper is recovered in mixed form, the out throws and prohibitive percentage is high due to presence of contaminants and contraries in the recovered stock. The inconsistent quality of indigenously recovered paper, presence of contaminants/contraries in imported waste and improper selection of equipment and technology prevailing in the mills, limit the effective utilisation of waste paper for producing good quality paper.

In view of the above problem, it was felt that there is an urgent need to evolve an indigenous gradation system, and formulate a mechanism for an effective system of waste paper collection and distribution in India, so that consistent quality of waste paper grades could be made available to the mills for subsequent utilisation in various end uses in an effective manner and to fulfill these objectives the above project was envisaged.

2.0 METHODOLOGY ADOPTED

2.1 To fulfill the objectives, extensive literature have been reviewed to collect information on gradation system being adopted by developed nations as well as in other countries where the recovery rates have steadily increased over the years due to improved collection system.

2.2 Information has been collected through questionnaires on utilisation pattern of different available varieties of imported and indigenous waste paper for the production of different end products in India.

2.3 Mill visits have been undertaken to conduct on the spot study and collect information on raw material supply, collection & sorting system being adopted by mill.

2.4 During mill visits waste paper samples were collected for subsequent evaluation at CPPRI for their quality characterisation and fibre furnish composition.

2.5 For effective utilisation of waste paper, extensive studies have been conducted on contaminant removal particularly wet strength resin which is commonly found in most of the imported varieties.

3.0 OUTPUTS OF THE PROJECT

3.1 Extensive literature review was carried out on gradation systems, collection/recovery systems and technological trends prevailing in industrialized countries, considered to be major recyclers in the world for effective collection and utilisation of waste paper.

3.2 To assess the current status of the industry with respect to waste paper collection and its subsequent utilisation, technology inputs & state of equipments and the major issues, questionnaires were sent to nearly 150 mills to collect information. Information has been received from following mills.

1. Servalakshmi Paper & Boards, Tamil Nadu
2. Chandpur Enterprises Ltd., Chandpur
3. Gambhir Paper Mills, Saharanpur
4. Vijay Laxmi Paper Mills, Tamil Nadu
5. Saurashtra Paper & Board Mills Ltd., Rajkot
6. Daman Ganga Paper Ltd., Vapi
7. Rama Newsprint & Papers Ltd., Surat
8. Pudumjee Pulp & Paper Mills Ltd., Pune
9. Ponmudi Paper Mills Ltd., Tiruvananthapuram.
10. B.G. Shirke Construction Technology Ltd., Pune
11. Laxmi Board & Paper Mills, Kalyan
12. Progressive Paper Mills Pvt. Ltd., Calcutta
13. Sri Venkatesa Paper & Boards Ltd., Coimbtore
14. Jaipur Paper & Board Mills Sanganer (Jaipur)
15. Orient Paper Mills, Orissa
16. Shri Swami Harigiri Paper Mills Ltd., Gujrat
17. Ashi Dipi Paper (P) Ltd., Ujjain
18. Surya Chandra Paper (P) Ltd., A.P.
19. Kasat Paper & Pulp Ltd., Pune
20. Danalaxmi Paper Mills Ltd., Tamil Nadu
21. Khatema Fibres, Khatema

3.3 Following mills were visited to conduct on the spot study and collect information on waste paper supply, collection & sorting system being adopted by mill and its subsequent utilisation for various products.

- Khatema Fibres Ltd., Khatema, (U.P.)
- Rollatainers Ltd., Sonepat, (Haryana.)
- Madhya Desh Paper Ltd., Nagpur
- Gambhir Paper Mills, Saharanpur
- Shree Acids Ltd., Ahmedabad
- Chandpur Eneterprises, Chandpur
- Rama Paper Mills, Bijnor, (U.P.)
- Shri Swami Harigiri Papers Mills, Gujarat

- Rama Newsprint and Paper Ltd., Surat
- Servalakshmi Paper & boards, Tamil Nadu
- Vijayalakshmi Paper mills, Tamil Nadu

3.4 Despite of making efforts the response of most of the mills was very lukewarm and in many cases the mills were hesitant in giving the required information.

3.5.1 Quite a large number of waste paper samples including imported as well as indigenously recovered paper were collected during the mill visits which were evaluated at CPPRI for their quality characterisation. The following parameters were studied for fibre quality characterisation.

- Pulp yield
- Ash content
- Quantitative fibre furnish composition
- Bauer Mcnett classification
- Canadian standard freeness
- CED viscosity
- Brightness
- Yellowness
- Visible speck
- Physical strength properties

3.6 Based on extensive literature review carried out on gradation system prevailing in industrialized countries and the studies conducted at CPPRI, an attempt was made to grade the indigenously recovered paper in different groups based on their fibre quality and fibre furnish.

3.7 To disseminate the findings of the project, an Interaction Meet was organised on 12th April, 2001 at CPPRI on 'Use of Recycled Fibre in Paper and Newsprint' which was well attended by representatives from Industry Associations, Paper Mills, Chemical Manufacturers, Waste Paper Suppliers and Senior Officials from Ministry of Industry.

3.8 As one of the case study, deinking studies were undertaken for Nepa mills Ltd to improve the brightness of deinked pulp through flotation deinking. A separate report has been prepared and is included in Volume - IV.

4.0 CONTENTS OF THE REPORT

The contents of the report are presented in four volumes which have been compiled based on the information collected from literature review, questionnaires, mill visits, studies undertaken at CPPRI and through discussions with mill personnels and experts in the field. The volumes broadly cover the following areas:

Volume I: Background & Status of the Industry

Volume II: Availability of Waste Paper

Chapter I – Availability of waste paper in India
Chapter II – Recovery & utilisation of waste paper - A global scenario
Chapter III – Gradation of indigenously recovered paper – Studies conducted by CPPRI

Volume III: Utilisation of Waste Paper

Chapter I – Waste paper processing and contaminant removal techniques
Chapter II – System Modules for processing of waste paper
Chapter III – Environmental Impact of waste paper recycling

Volume IV: Analysis of Data Collected from Mills

A brief account of each volume is given below.

Volume – I: Background & Status Of The Industry

It gives an overview of the Indian paper industry elaborating the major issues of the Indian paper industry. One such issue is the sustained availability of fibrous resources, which has been dealt in detail with specific reference to recycled fibre (RCF) use in the country.

The prime focus is on the status of paper recycling in India, technical constraints in increased utilisation and domestic collection of waste paper in the country and a detailed review of waste paper based mills in the country with respect to system configuration, process equipment and quality of products produced. Attempt has been made to discuss the major issues in detail. The review is based on the collected information through questionnaire and studies undertaken during the mill visits.

Volume – II: Availability Of Waste Paper

This volume mainly focuses on 'Availability of waste paper in India'. A retrospect of waste paper recovery rate and utilisation rate over the years is presented showing a very slow rising trend in recovery of waste paper in India during last one decade. The volume also highlights about the unorganized domestic collection of waste paper, which is mainly due to lack of grading/classification of waste paper varieties. An overview of global scenario with respect to waste paper grading and collection system adopted in industrialized countries, which are considered to be major recyclers in world, has been presented.

The volume also covers in detail the studies conducted at CPPRI on fibre furnish composition and quality characterisation to evaluate the type and quality of indigenous and imported varieties of waste paper being utilized by Indian Paper Industry. Based on these findings CPPRI has proposed a system for gradation of indigenously recovered paper, which needs to be discussed and appropriately modified to benefit the large number of pulp & paper mills based on recycled fibre, as well as provide guidelines for suppliers so that there is a higher value realization from this important source.

The volume also covers recommendation for effective collection system that can be implemented under Indian conditions.

Volume – III: Utilisation Of Waste Paper

This volume focuses on unit operations and equipment for contaminant removal, the integral process steps in the waste paper processing line. The volume also covers in detail the various type of contaminants present in waste paper and the role of process chemistry in performing various deinking mechanisms/functions which facilitate the removal of stickies and non-stickies contaminants like hot melts, waxes, adhesives, wet strength resin, ink, filler etc and decolorisation of pigments and dyes.

Removal of stickies, processing of wet strength papers, deinking aspects of mixed furnish of ONP/OMG for production of newsprint and mixed office waste (MOW) for the production of writing, printing grades of paper has been discussed in detail and appropriate system modules have been proposed based on extensive literature review on available technologies and mill visits.

Lastly, the environmental impact of RCF mill has been discussed in detail particularly in reference of biomethanation of liquid effluents and utilisation/disposal of deinked sludge and solid waste generated in these mills.

Volume – IV: Data Collected From Mills

This volume comprises of case studies and the information collected through questionnaires, which have been presented in the form of Technical Data Sheets.

4.1 Recommendations

4.1.1 Availability Of Waste Paper

Sustained availability of fibrous raw material for paper manufacturing is one of the key issues of Indian Paper Industry. Globally recycling of paper has been identified as one of the survival routes against dwindling forest resources and a great concern amongst the people for greener environment. in India also, large scale organised collection of indigenously recovered paper, supplemented by imports may be recommended as an immediate measure to partly bridge the winding gap between the demand and supply of raw materials.

The use of recycled fibre in paper and board production can be considered as the mainstay of raw material sourcing provided an efficient collection system is adopted to collect waste paper varieties in grade.

To establish an efficient collection system in India on par with countries like Germany, China, USA, Japan etc., it is imperative that the available waste paper is segregated at source before collection and which requires classification/ grading of different varieties, based on their type and quality.

In view of this, CPPRI has made an attempt to classify/grade all the standard verities of waste paper available indigenously by adopting a scientific approach, which have categorised the different varieties, based on its sources, quality and fibre furnish. In this system all the twenty (20) varieties of indigenous waste paper have been classified into nine (09) groups as summarized in **Table-1.**

TABLE-1

CLASSIFICATION OF INDIAN STANDARD VARIETIES OF WASTE PAPER

Statistical group	**Grades**	**Contents**
Group – I White woodfree Unprinted	No. I cuttings	Printers cuttings from high quality white printing paper uncoated or coated but without any printing. (Contains ruled or unruled cuttings)
	Hard white shavings	Shavings or sheets of untreated high grade, high brightness bond ledger papers. Free from printing and ground wood.
Group –II White woodfree printed	Note books	School notebooks, bleached variety with less ink. Sometimes slight yellowing observed.
	White records/office records	Mixed waste paper as collected from office refuse. Contains mixed office records including various grades of writing, printing, xerox, typing paper, CPO, envelops with some staple/pins/cellophane and carbon paper (contains both heavily printed and unprinted matter).
Group –III White & lightly printed mechanical	No-II cutting	Printer cuttings from average quality printing papers made of recycled or high yield pulps, unwanted or coated but without printing.

	White duplex cuttings	New cuttings of uncoated/coated duplex boards with very little printing/lamination received from folding box board cartons converters
Group-IV Colored wood free	Colored cuttings /colored records	Colored cuttings received from printers of books, magazines, posters or advertisements. Contains newspapers, lottery tickets, text books, brown boards etc.
Group-V Heavily printed mechanical	Text book	Old text books without plastic laminated or straw board covers, contains bleached printed sheets, yellowness observed due to ageing.
	Old directory	Clean telephone directories bleached & heavily printed. Severe yellowness observed due to ageing. Includes both old as well as over issues from publisher house.
	Old newspaper/ over issues	Old newspapers collected from consumer or from newspaper vendors. Newspaper, printed but unused as available from newsprint presses or agencies.
	Old magazines/ over issues	Old or over issue magazines printed on good quality printing paper from chemical or recycled pulp, uncoated or coated paper.
Group-VI Brown Kraft	Kraft multiwall bag waste	New kraft multiwall bag waste and sheets with little printing but without staples or stitching.
	Mixed kraft cuttings	Cuttings of kraft paper received from converters with very little printing and no staples/pins or cellophane.
	New double lined kraft corrugated	Corrugated cuttings received from industrial packaging, corrugated box manufacturers with very little printing & staples/paste/cellophane.
Group-VII Old corrugated containers	Old corrugated boxes	Mixture of corrugated box with kraft/white top liner /printed/ unprinted. Stapled/pasted/spliced with cellophane, having one or few piles of corrugation.
Group-VIII Mixed papers	Mixed waste paper	Mixture of all varieties of paper including white or colored paper, bleached & unbleached, coated & uncoated, printed & unprinted, with & without mechanical pulp papers not limited to fibre content/quality and contaminants from converting units.

	Road sweepings	Mixture of various grades of waste paper as received from municipal dust bin not limited to fibre content or quality.
	Lottery tickets	Printed lottery tickets, unused over used received from agencies/vendors.
Group-IX Contaminated grades	Sack Kraft waste/ cuttings Cuttings from the converters making industrial sack Kraft, having high stretch, wet strength and burst made from chemical Kraft pulp.	
	Currency cuttings Printers trimmings of currency paper	

This proposed classification/grading system is a preliminary attempt, which needs to be discussed and appropriately modified to benefit the large number of pulp and paper mills based on recycled fibers as well as provide guidelines for suppliers so that there is a high value realization from this important source.

To improve the efficiency of existing collection there is an urgent need that the proposed grading system (duly amended, if required) may be implemented immediately and mill owners should demand the suppliers to supply waste paper "in grades".

Waste paper collection of office refuse has not been to its fullest extent due to lack of any viable collection systems at these sources. There lies a huge potential of recovery from this source provided a scientific method of collection is introduced in offices and other business establishments.

In a market, which is moving towards the production of higher quality paper products, specific grades such as mixed office waste (MOW) must be pre sorted and collected at source.

To increase the over all recovery rate, there is a need to induct legislation like in USA, UK, Germany etc. In USA the legislation is grouped into following five categories.

- Collection and separation legislation
- Minimum secondary fibre content legislation
- Legislation prohibiting government agencies from purchasing products with no recyclable content.
- Incentives for recycled products
- Surcharges for virgin paper products

In India, such legislation can be enforced based on these guidelines in phase wise manner, which will eventually force the paper merchants and municipal government to set up schemes to collect and sort reusable waste.

There is an urgent need to make the use of recycled fibre mandatory for some of the paper grades like newsprint, few packaging varieties, tissue papers and specialty papers.

Some of the recommended measures to improve existing collection system in India are.

- Enforcement of collection & recycling legislation by Government, as enacted in Germany
- Adopting "pick up" collection system network involving Paper Industry Association, and other associations related to publishing, packaging, printing, traders & wholesalers

To establish such a system in India, there is a need to make a visit to some of these countries and study the implementation mechanism for inducting such programmes for countrywide collection of wastepaper in India.

In view of this it is recommended that a visit should be made by a team of executive to Japan, USA, United Kingdom and Germany to study collection sorting and distribution system prevailing in these countries and mechanism of implementing various collection programmes at state levels and National levels for increased recovery, so that an indigenous system could be formulated and implemented for wider collection of domestic waste paper in the country.

4.1.2 Utilisation Of Waste Paper

- There is a need to have a system configuration of appropriate technology/ technologies for processing different varieties of waste paper to produce good quality kraft paper, writing/printing paper, newsprint and boards etc.
- The use of RCF in packaging varieties is well established in Indian industry. Looking into the future prospects of RCF utilisation more & more RCF should be used in newsprint & tissue production.
- The use of recycled waste paper is bound to grow because of environmental awareness but high quality writing & printing paper cannot be made out of waste paper, which has its own limitation.
- Based on the studies conducted by CPPRI on quality characterisation of different varieties of imported and indigenous waste paper, these varieties should be utilized for specific end uses as summarized in **Table-2.**

TABLE-2

UTILISATION OF WASTE PAPER GRADES FOR VARIOUS END USES

Waste Paper Grades	Utilisation
No. I cuttings, Hard white shavings	Writing/ printing paper along with pulp substitutes For standard newsprint (high brightness) Top layer for liner boards
Note books, white records/office records	do-
No.II cutting, white duplex cuttings	Ordinary newsprint for improved brightness
Colored cuttings/ records	As fillers in Liner boards
ONP/ over issues, OMG/ over issues, Text Books, Old Directory	Ordinary Newsprint Low quality printing and as filler for Liner board
Kraft multiwall bag waste, mixed kraft cuttings, new double lined kraft corrugated	All varieties of packaging
Old corrugated boxes,	Superior kraft
Mixed waste paper, Road sweepings, Lottery tickets	As fillers in Liner boards
Sack Kraft waste/ cuttings, Currency cuttings	Superior kraft For writing / printing papers

The unbleached imported varieties of waste paper viz. NDLKC, OCC, KCB, and similar grades which has fiber quality comparable to virgin fiber (Non-woods) should be utilized for the production of bleachable grades employing conventional pulping and bleaching process

The studies conducted on quality characterisation have revealed that the fibre length of RCF ranges from 0.7 – 1.2 mm which is considered to be short fibre. In view of this it is suggested that long fibre based waste paper and long fibre pulp should be imported and short fibre demand should be met through domestic collection of waste paper which means the recovery rate has to improve to at least 40% or otherwise the country would be a net importer of short fibre based waste paper as well.

Among the imported varieties a lot of contaminated grades are received. Removal of contaminants is essentially required to overcome the runnability problems on the paper machine. Identification and characterisation of contaminants is essential for selection of appropriate processing system.

Adoption of the appropriate technology/combination of technologies (chemical & mechanical treatments) must be coordinated into a comprehensive stickies control treatment programme specifically designed to solve each individual mills waste paper stickies problem and which requires a strong R & D back up.

Based on the studies conducted by CPPRI, mills using wide range of wet strength paper should have following system configuration. The inclusion of digester in system design is essential to keep optimum thermal condition for breaking of covalent bond of wet strength resin (PAE type) in paper.

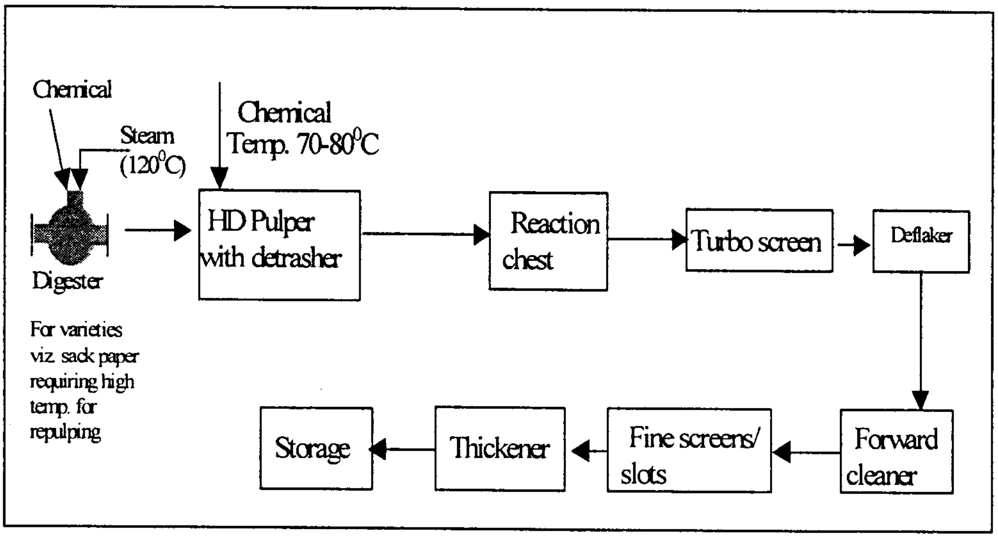

FIG.1 - PROPOSED SYSTEM FOR PRODUCING UN-BLEACHED PULP FROM WET STRENGTH PAPER

The state of art technology for production of newsprint and writing/printing paper from ONP/OMG furnish and MOW is either two loop or three loop system to achieve the required brightness specification and dirt count. In such system, the contaminant removal stages are being repeated to achieve the required cleanliness and are capital intensive. Under Indian conditions a universal system is proposed which can handle various grades of waste paper available. The schematic of the system is shown below.

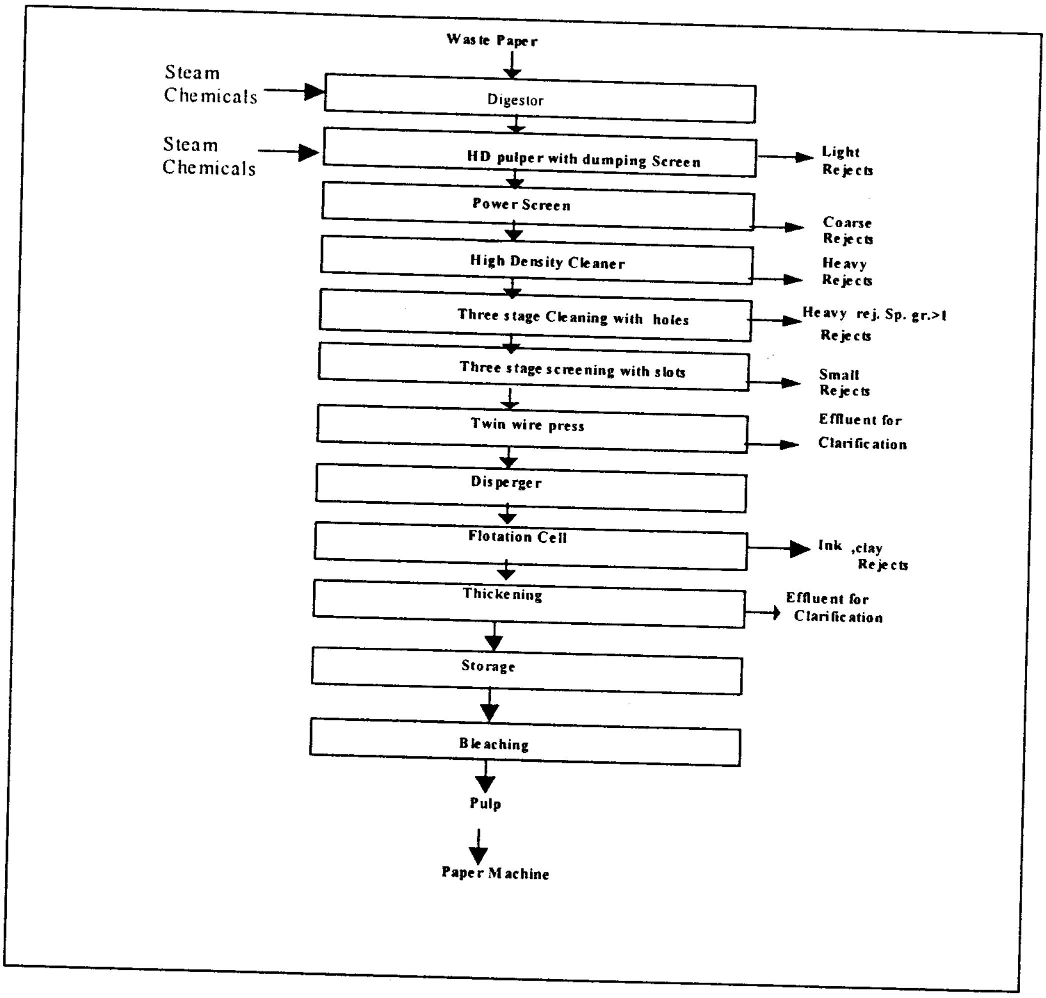

FIG.2- UNIVERSAL SYSTEM FOR PROCESSING OF WASTE PAPER

The waste paper based mills produce large amount of waste sludge (Clarifier and Deinked sludge) due to number of cleaning step during processing. As a part of waste management, incineration of sludge (clarifier sludge) in FBC boiler along with coal/ rice husk (HHV fuels) is proposed for implementation as a disposal alternative. Since the calorific value of sludge is close to black liquor, it can partially substitute the conventional fuels.

The sludge generated during deinking operation has high ash content and low calorific value, and when burned with conventional fuels will reduce the thermal efficiency of the boiler and auxiliary fuels requirement will be high. Other option of deinked sludge disposal is land spreading for loamy soil, which may be considered as an alternative.

Sludge dewatering is a necessary step to increase the dryness content of waste sludge to 40-45%. Belt press can be employed for sludge dewatering.

Other options for waste sludge utilisation can be adopting biological routes for energy generation such as biomethanation, ethanol production by fermentation etc. however feasibility studies need to be undertaken.

Closing of water loop with efficient water clarification system (Dissolved Air Flotation) is essentially required since recycling of back water without removal of contaminants (inks, stickies, fillers etc.) will create problem in maintaining the quality of product with respect to brightness and will also enhance the accumulation of stickies causing runnability problems on paper machines.

The installation of biomethanation plant in an individual RCF mill (even in 100 tpd mill) may not be technoeconomically viable, however, the concept of cooperative biomethanation plants where the effluent from three or four recycled fibre based mills located in a close vicinity is collectively treated together will not only help in meeting the discharge norms but also reduce the mills dependence on purchased power to a certain extent.

The data collected through questionnaire clearly reveals that there is a need for modernization in these mills and mills producing white grades should essentially have deinking system for more flexibility in utilising different varieties of waste paper.

4.1.3 Fiscal Lncentives And Government Policies

- In order to reduce investment burden and upgrade machinery and technology, import duty should be reduced from capital goods not manufactured in country like waste paper processing/ treatment plants and related equipments and technology.
- All such technologies and equipments, which will help in improving the quality of domestic waste paper, should be allowed to import without duty.
- 100% depreciation should be allowed on such capital goods since these equipments will facilitate reduced pollution and energy saving.
- Waste paper recycling right from its Collections to its processing stage should be seen as a separate industry so that a centralised system may be developed to maintain the quality and supply on sustained basis.
- A high level committee with representatives from Industry, policy making authorities and R&D sectors should formulate action plan for creating such centralised waste collection units (waste salvage stations) in different regions of the country.
- Financial institutions should give priority to waste paper recycling projects with the favorable debt equity ratio.
- The international cooperation like USAID/SIDA/JIACA may also be sought in promoting the deinking technology.

4.1.4 There is an urgent need for concerted efforts in research and development activities aimed at improving the process without additional machinery or higher processing cost. The R&D activities should be aimed at

- Economic means of contaminant removal
- Screening and cleaning methods
- Post treatment of pulps stock like refining beating, bleaching etc.

A premier institution like Central Pulp & Paper Research Institute is already working on projects on up gradation of waste paper for higher quality grades utilizing simple and economic technologies and equipments.

ENZYMATIC IMPROVEMENT IN DRAINABILITY OF THE WIRE PARTS IN PAPER MACHINE

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He has visited China and Sweden under UNIDO fellowship training programme in the areas of Chemical recovery and Environment management.
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ENZYMATIC IMPROVEMENT IN DRAINABILITY OF THE WIRE PARTS IN PAPER MACHINE

A.G. Kulkarni, R. M. Mathur, R. K. Jain, Abha Gupta, Vasanta Vadde Thakur

1.0 BACKGROUND OF THE PROJECT

The tendency in modern pulp and paper mills is both to close the circulation of process waters and to get closer to neutral pH. Both trends favor the growth of micro-organisms, especially bacteria. In some mills, the use of recycled fibres at moderate temperatures adds further to the presence and activity of micro-organisms.

Most micro-organisms in the process waters are harmless, but some cause problems as they colonise surfaces, so-called biofouling, leading to the growth of biofilm. The activities of micro-organisms in the pulp and paper mills lead to frequent cleaning and maintenance costs, lower quality of the paper or board due to holes and spots, and breaks during production.

Conventionally, the papermaker has used biocides to control growth of micro-organisms. However, increased public consciousness regarding environmental issues has led to strict regulation on the use of biocides (including slimicides) in western countries. This has led to a limited number of biocides being available for the papermaker to use. Actually it is an almost twenty-year-old concept, which is today well proven and effective when the right product is used. It is for this reason that selection of ecofriendly slimicides or enzymatic slimicides appears to be an attractive part of the present and future.

In view of above Indian Agro Paper Mills association now renamed as All India Agro & Recycled Paper Mills Association sponsored a CESS funded project to Central Pulp and Paper Research Institute (CPPRI) entitled " **Enzymatic Treatment to Improve the Drainability of the Wire Parts in Paper Machine** " i.e. control of slime in small agro based paper mills using ecologically compatible preferably enzyme based slimicides.

Initially the project activities were basically aimed at using enzyme based slimicides (enzyme technology is being environmentally friendly) technology. CPPRI after extensive interaction with leading enzyme manufacturers and chemical companies could observe that enzyme based slimicides could not make a headway in any part of the world for control of slime in paper machine. Interaction with the companies and extensive literature survey revealed that although some of the companies try to develop enzyme based slimicides but the effectivity could not come to the expected levels. CPPRI also formulated an enzyme-based slimicide and studied its activities along with other Eco-friendly slimicides.

2.0 OBJECTIVE

Basic objective of the project is to identify and evaluate the globally available environmental friendly and ecologically compatible slimicides to promote them in Indian Paper Industry after evaluating their efficacy under the conditions prevailing in Indian Paper Industry.

3.0 WORK PLAN

Before implementing an effective slime control programme in a mill will be essential to make a systematic study in context to identification of the sources and extend of microbial contamination in paper machine white water loops.

- Study on the extent of build up of slime collected on slime collection unit and from various parts of the paper machine loop and various other samples of white water from trey, back water tank, silo and stock from premachine chest and head box etc.
- Detailed Physico-chemical, biochemical and microbiological characterisation of the samples of slime.
- Procurement of samples ecologically compatible slimicides companies of national and international repute
- Evaluation of slimicides against predominat microbes responsible for slime formation
    - Relative population density test against dominating microbes responsible for slime development
    - Efficacy test against sample of white water and pulp stock.
- Development of a slime control programme for agro based mills.

4.0 EXPERIMENTS

4.1 Slime Control Programme In An Agro Based Paper Mill

Before an effective slime control programme could be implemented in a paper mill, it is essential to know the source, extent of the contamination and the nature of the slime. Other factors such as the correct dosage and frequency of the biocide, temperature and the pH of the system are also important to the success of any biocide treatment programme. This requires detailed study in respect of physico-chemical, biochemical and microbiological characterisation of slime and white water.

4.1.1 Study Of Slime Build Up & Collection Of Slime

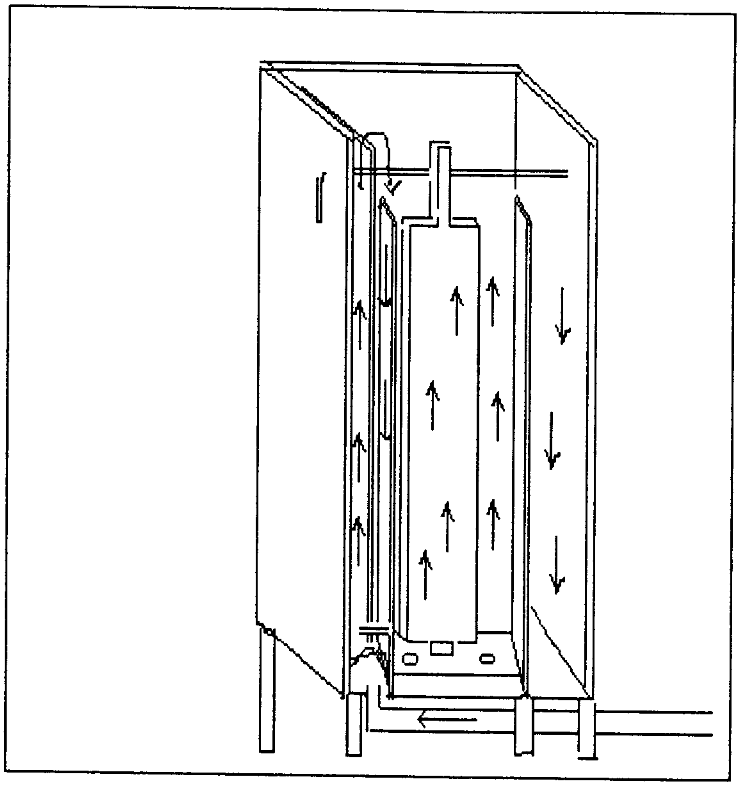
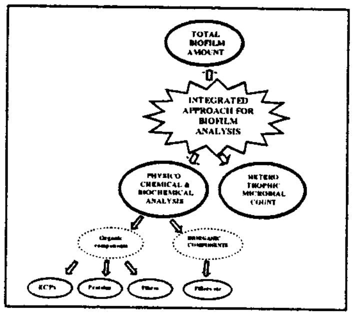


FIG.1- SLIME COLLECTION UNIT

4.1.2 Physico- Chemical, Biochemical & Microbiological Characterisation Of Slime

An integrated approach adopted for characterisation of the biofilm samples collected on slime collection unit and from various points in paper machine.



Physico- Chemical, Biochemical Analysis

- Total Biofilm amount analysis
- Biofilm Components
- Estimation of total inorganic and organic contents
- Extraction of extracellular polysaccharide (ECPs) and protein
- Estimation of Extracellular polysaccharides (ECPs)
- Estimation of Total Proteins

Microbiological Characterisation Of Slime And White Water Samples

Filamentous bacteria responsible for slime formation

Bacterial Colonies Isolated From Slime Sample Collected From the Wooden Panel

4.1.3 Evaluation Of Slimicides Against Predominant Microbes Responsible For Slime Formation

- Relative Population Density Test

4.1.4 Drainability Test Of The Wire Part Of Paper Machine To Prove Effectivity Of The Slimicides

5.0 INTERACTION WITH THE INDUSTRY

The Institute has done extensive interaction with various industries in the identified areas, during the project period.

Slime Control Studies On Paper Machine		
1.	Shiva paper Mills Ltd, Rampur	To collect slime samples from various sampling sites i.e. white water reservoir, krofta, Couch pit, paper machine wall, etc.
2.	Sikka Paper Mills Ltd , Shamli	- do -
3.	Bindlas Duplex Ltd., Muzaffarnagar	- do -
4.	M/S Shreyans Paper Mills, Punjab	To study the prevailing conditions for implentation of the slime control programme.

6.0 SLIME CONTROL ON PAPER MACHINE

- Collection of slime samples from different mills using slime collection unit
- Procurement of commercially available slimicides and dispersants.

Slimicide	Trade Name	Active Ingredient
1.	Nalcon 7334	Glutaraldehyde
2.	Nalcon 7649	2, 2, dibromo3 nitrilo-propionamide
3.	Nalcon 7647	5 chloro-2 methyl- 4 isothiozolin-3-one +2, methyl,4, isothiazolin-3-one
4.	Excel solid	2, bromo-2 nitropropane-1,3 diol
5.	Precexcel-3013	THPS
6.	Finor-CWT 302	Methy bis thiocyanate (MBT)
7.	Antimucine p-95-08 Liq	MBT
8.	Antimucine TBT Liq	THPS + MBT
9.	Bussan 888	
10.	Precexcel-3013	
11.	Treline	Methay iso thiozoline

- Selection of slimicides for ecologically compatibility on the basis of their approval from authorities like, EPA, FDA etc.
- Physico-chemical, biochemical and microbiological evaluation of slime samples
- Isolation and characterisation of predominant microbes present in the slime samples.
- Efficacy test of the selected slimicides against the predominant microbes for selection of efficient slimicide.
- Relative population density test for optimisation of slimicide doses.
- Treatment of wire parts with selected slimicides to analyse the effectivity of slimicide to improve drainability.

7.0 SELECTION OF SLIMCIDE

- Should decrease the production of EPS ("slime"), thereby preventing growth of biofilm.
- Should delay the growth of bacteria and decreases the formation of spores, thereby preventing bacteria in ready-made paper or carton

- pH-stable
- Temperature stable
- Environmentally friendly.
- Does not endanger the health of the staff.
- Is proven to be a satisfactory or even better alternative to other biocides.
- Should be cost effective.

8.0 RESULTS & DISCUSSION

8.1 Slime Control In Paper Machine

- Eight slimicides were identified as environmental compatible slimicides.
- *Bacillus subtilis* is found to be predominant in slime formation in agro based paper mills.
- From the results , slimicide - 5 is found to be highly effective and reduces 99% of the microbial count within 15 minutes whereas slimicide-9, slimicide-2 and slimicide-3 can reduce 90-99%.
- Use of slimicide in combination with biodispersants could be used to achieve optimal slime control programme in terms of efficiency & cost. The programme is being continued at the Institute for promotion of the ecologically compatible slimicides in Indian Paper Industry, which will prove to be more environmental friendly.
- The project activities resulted in a slime control programme, which includes complete analysis of microbial slime, white water, stock, their characteristics and effective slimicide(s) required to control as well as eliminate the microbial growth in the paper machine.The requisite slimicide and dosages are determined after a comprehensive experiment of efficacy test, which determines the slimicide where as relative population density test determines the required dosage of the slimicide.

9.0 OUT PUTS DELIVERED / ACHIEVEMENTS

CPPRI has developed a slime control programme using ecologically compatible slimicides after a thorough integrated approach of slime characterisation. This programme includes slime characterisation, isolation of predominant microbes, and selection of suitable slimicide and requisite dosages of selected slimicide against the predominant microbe.

10.0 INDUSTRIAL IMPORTANCE OF THE PROJECT

- Use of ecologically compatible slimicides in Indian paper mills will help in curtaining the downtime, quality improvement in finished products vis-à-vis with better environment.

11.0 REPORT

A detailed report of the project activities has been submitted to Indian /agro & Recycled Paper Mills Association

IMPROVING FILLER LOADING IN THE PAPERS MANUFACTURED FROM INDIGENOUS FIBROUS RAW MATERIAL

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IMPROVING FILLER LOADING IN THE PAPERS MANUFACTURED FROM INDIGENOUS FIBROUS RAW MATERIAL

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SUMMARY

Cost of paper can be reduced appreciably by improving and optimizing the filler retention. Increasing the filler content in paper within certain limits may yield the benefits such as reduced raw material cost, lower steam consumption in drying, improved optical properties and better print quality.

Laboratory scale studies with different types of fibrous raw materials viz. Bagasse, bamboo, wheat straw, eucalypt and softwood pulps indicated that in the absence of any retention aid, the amount of filler retained was highest for wheat straw pulp and lowest for softwood pulp. Eucalypt and bagasse pulps both had comparable filler retention capability but higher than that of softwood pulp. The retention of filler in bamboo pulp was lower than wheat straw, bagasse and eucalypt pulps but higher than softwood pulp. The specific surface area and swollen volume measured by permeability method was higher for wheat straw and bagasse pulps than other pulps.

The filler retention capability is not improved by changing the bleaching sequence as observed in case of CEHH and D/CEHD bleached eucalypt pulps.

With the increase in filler content, softwood, bamboo and eucalypt pulps showed continuous increase in the apparent density. Whereas in the case of bagasse and wheat straw pulps after an increase upto certain filler level a slight drop was observed. Tensile and tearing strength dropped with the increase in filler content. At 15% filler level in the sheet the percent drop in tensile strength observed for softwood, bamboo, eucalypt, and bagasse and wheat straw pulps was 30, 18, 18, 21 and 22 percent respectively. The relative drop in the tearing strength with increase in filler content was lowest in the case of softwood pulp. The improvement in the Sp. Scatt. Co- eff. with increased filler content was highest in the case of bagasse and least for eucalypt pulp. The effect on the improvement of Sp. Scatt. Co-eff. for softwood pulp, bamboo and wheat straw pulps was somewhere between bagasse and eucalypt pulps.

Coarser particles of talc are retained better than finer ones. The larger particle size (> 5μm) has lesser disruption effect on the tensile strength than finer particles. The porosity is relatively more improved with coarser particles, whereas reverse had been observed for the specific scattering coefficient for eucalypt pulp.

The filler retention in pulps studied improved by addition of cationic starch, hydrocol (a dual type retention aid), pre flocculation of filler and using described adsorbed additive

technique on the filler surface. Hydrocol gave better effect than starch on the filler retention and maintained higher paper strength at increased filler level. Pre flocculation technique gave better results than starch alone but these were slightly lower than hydrocol especially on Sp. Scattering Coefficient improvement. The best results were obtained using pre adsorbed additive method on filler surface. The retention was better (about 0.3 to 3%) than other methods. The effect on the strength was comparable to that for hydrocol system.

Addition of filler caused drop in the wet web TEA index values. Talc caused higher drop than china clay and calcium carbonate. Using pre adsorbed additive on filler surface technique (Polarity treated filler) caused lesser drop in the wet web tensile energy absorption than the other methods.

The filler retention is also improved by adopting refining which improves fibrillation of fibres as indicated by studying the eucalypt pulp devoid of primary fines.

Fibre surface charge determinations using a particle charge detector indicated that amongst the different fillers studied, TiO_2 (Anatase) had the highest negative charge followed by china clay, TiO_2 (Rutile), talc and barytes. GCC has slightly positive charge.

Indigenous mill pulps, which are mostly hypochlorite bleached, had 2 to 3 times higher negative charge than imported wood pulps. Bagasse pulp had highest negative charge followed by rice straw, wheat straw, bamboo and softwood. The higher negative charge in indigenous pulps than imported wood pulps will result in their different behaviours towards retention aids, strengthening agents and sizing chemicals. Some of such chemicals, which had been found to be suitable abroad for the imported pulps, may not function satisfactorily for indigenous pulps. Also Indian chemical manufacturers need special care especially from charge point of view to manufacture such chemicals effective for Indian Paper Mills.

With the addition of filler in the blend of bamboo and eucalypt pulp in the ratio 20:80 the printing characteristics like contact factor got improved from 0.42 to 0.53 and saturation density got increased from 1.23 to 1.51. Soft nip calendaring of filled sheets gave better improvement than hard nip calendaring on these parameters. The print through tendency got reduced with the addition of filler. The value of print through of 0.75 for blank got reduced by about 33% at filler level of 26.2%. The total fiber rising area (TRA), another important printing property measured using fibre rising tester (FRT) got increased with addition of filler. Upto filler addition level from 7.9 to 26.2% the increase in TRA was not steep (of level of about 9%). But further addition gave abnormally high rising area (to the extent of about 30%). This indicated that probably filler addition level beyond 26 % for blend of bamboo and hard wood pulps in the ratio 20:80 may lead to serious linting problem in offset printing. Addition of cationic starch gave reduction in TRA value. The polarity treated method of filler addition also gave better effect.

Evaluation of paper samples from 25 different Indian Pulp and Paper mills revealed that there is wide variation in formation index values. Deterioration in formation also caused drop in sizing degree, retention of filler. The bonding properties (tensile index, burst index) are also adversely affected with deterioration in formation. The extent of difference observed in tensile index ranged from 7.8 to 36.1%. Similarly for bursting strength and tearing strength it ranged from 9.4 to 34.8% and 6.7 to 42% respectively. Final report submitted.

UTILIZATION OF ENZYMES DURING PULP & PAPER MAKING FOR REDUCTION OF COOKING & BLEACHING CHEMICALS, ENERGY DURING PULPING, REFINING AND MANAGEMENT OF INDUSTRIAL WASTE MINIMISATION

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Dr. R.M. Mathur, is presently working as Scientist E-II and Head, Chemical Recovery, Energy Management, Environmental Management and Biotechnology Division.

After completing his D. Phil in Pulp Chemistry, joined CPPRI, in 1978. He has more than 100 publications to his credit. Area of specialization includes Black liquor properties, Lignin byproducts, Energy Conservation in Paper Industry and Biotechnological applications.

He has widely traveled abroad as UNIDO fellow to Canada, France, Germany, Australia & Japan and been to Turkey & Thailand for Demonstration of Desilication Technology developed by CPPRI. He has four patents to his credit

UTILIZATION OF ENZYMES DURING PULP & PAPER MAKING FOR REDUCTION OF COOKING & BLEACHING CHEMICALS, ENERGY DURING PULPING, REFINING AND MANAGEMENT OF INDUSTRIAL WASTE MINIMISATION

A.G. Kulkarni, R. M. Mathur, R. K. Jain, Abha Gupta, Vasanta Vadde Thakur,

1.0 BACKGROUND OF THE PROJECT

The pulp and paper industry is facing increasing pressure from environmental regulations. To simultaneously keep up with the increasing demand for pulp and paper and to meet increasingly stringent environmental regulations, the industry has been constantly looking towards technological improvements. Over the past 20 years, research efforts in laboratories around the world have sought to apply biotechnology in industrial wood processing. Different biotechnological applications of microbes and their enzymes in the pulp and paper industry which have been commercialised or are under development also offer a perspective on future developments.

Modern biotechnology attempts to achieve the same goals – new or better products – but more efficiently. The incentives to develop the new biotechnological alternatives in pulp and paper industry are :

- environmental legislation
- consumer pressure for more environmentally-friendly products
- the cost of cleaning up waste
- opportunities for products with improved properties

Several applications of biotechnology in pulp and paper processing have been commercialised and others are under development. Basic discoveries are being made all the time and it seems likely that some of the directions being pursued today will lead to major new applications. Today's enzymes will be replaced by natural ones that are more robust in industrial processes, and these in turn will be replaced by enzymes designed for specific applications. Use of whole micro organisms in wood and pulp processing is likely to become increasingly attractive; biopulping, for example, has been shown to have great potential even without strain improvements.

Although studies have been carried out using various enzymes and xylanase enzyme for pulping & prebleaching of kraft pulps from soft wood and hard wood in the developed countries but very little work has been done on enzymatic prebleaching of pulps produced from hardwoods , non -wood fibers like bamboo , grasses employed by Indian paper industry. The work on enzymatic prebleaching of pulps from various raw materials especially being employed by Indian paper industry -bamboo, hardwoods and other non woody raw materials is primarily aimed to assess the suitability of bleaching enzymes produced indigenously and the imported ones in terms of their suitability with pulps produced from various raw materials in Indian paper industry in respect of improvement in pulp quality and improved environmental situation particularly the reduction in requirement of Cl_2-based chemicals and reduction in toxicity in the final discharged effluents without loss in pulp quality.

In view of wider potential and urgent need of Biotechnological applications in Pulp & Paper Industry , Indian Paper Manufacturer's association (IPMA) sponsored a CESS funded project to central Pulp & Paper Research Institute (CPPRI) entitled " **Utilization of Enzymes during Pulp & Paper Making For Reduction of Cooking & Bleaching chemicals, Energy during pulping, Refining and Management of Industrial Waste Minimisation ".**

2.0 OBJECTIVE OF THE STUDIES

Studies on fungal treatment of fibrous raw material were done with an objective to screen some of the identified strains of white rot fungi for selective delignificatin of the fibrous raw materials like eucalyptus chips and bagasse being commonly used by Indian Paper Industry. The present work is done with aim of

- Selection of suitable strains of white rot fungi for pretreatment of fibrous raw materials
- Optimisation of the biopulping process with selective strains
- Chemical pulping of fungal treated raw materials in order to find out savings in chemicals , if any.

Studies on enzymatic prebleaching were done with an objective to evaluate commercially available xylanase enzymes as prebleaching agents on both hard wood & non wood kraft pulps procured from Indian paper mills for their response towards

- Potential of savings in elemental chlorine & chlorine based chemicals
- Reduction in AOX levels in bleach plant effluents
- Gain in final pulp brightness.

3.0 WORK PLAN

- **Screening & Selection Of Suitable Strains Of White Rot Fungi For Pretreatment Of Fibrous Raw Materials**
  - Procurement of ligninolytic strains from culture banks / Institutes
  - Isolation of new ligninolytic strains
  - Fungal treatment of the raw materials
- **Determination Of The Delignification Efficiency Of The Fungi**

  - Characterisation of fungal treated raw materials for various parameters likeweight loss, loss/modification of lignin, Holocellulose, α - cellulose, pentosans etc.

- **Pulping Studies**
  - Characterisation of untreated and fungal treated unbleached pulps
  - Analysis of black liquor

- Procurement of commercially available prebleaching enzymes i.e. xylanase from company's manufacturing enzymes both indigenous and imported and other Institutes for evaluation in context to enzymatic prebleaching of pulps.

- Studies on enzymatic prebleaching on mill procured pulps from forest based and nonwood based raw materials i.e. wood, wheat straw and /or bagassae under speciific conditions of temp., pH, time and consistency.

- Subsequent bleaching of enzymatic prebleaching pulps by conventional bleaching sequences adopted in the Indian Mills like CEH or CEHH etc and also elemental chlorine free sequence, i.e. CEDED to targeted brightness level of 78- 80% ISO.

- Analysis of the resultant effluents (CEH) for pollutional loads, COD & toxicity to find out impact of enzymatic prebleaching on pollutional load reduction.

- Charactreisation of untreated & enzymatically bleached pulps for its optical & strength properties.

- Up scaling of the laboratory scale studies to semipilot scale test trials in a mill to generate data for commercial scale application.

4.0 RESEARCH ACTIVITIES UNDER THE PROJECT

The Institute has been identified as a nodal centre to take up biotechnology related projects for Institutions, Pulp & Paper Industry Associations, Government organizations, Enzyme manufacturers and other reputed laboratories. Based on the facilities created, the institute could come to a firm standing of working in the following areas. Some of the potential areas of research, where the activities are carried out are Fungal Degradation of Fibrous Raw Materials (Biopulping) , Enzymatic Prebleaching of Pulps (Biobleaching)

4.1 Creation Of Infrastructural Facilities At CPPRI

CPPRI having created its vast infrastructure facilities in the area of biotechnology is actively engaged in promotion of biotechnological application in Pulp & Paper industry. Looking in to the work requirements, discussions were held with experts of reputed laboratories and Institutions engaged in biotechnological research of India & abroad and to take up the activities in the areas of biopulping, biobleaching, the following equipments were identified, purchased & installed.

LIST OF EQUIPMENTS INSTALLED IN BIOTECHNOLOGY LABORATORY AT CPPRI	
Equipment procured	**Utility**
Imported Equipment	
Laboratory Fermentor, Biostat- G (B - Braun ,Germany)	Production of enzyme, biosurfactants and growth of microorganism in liquid culture for its application in biopulping, biobleaching and enzymatic deinking studies. Production of various enzymes i.e. cellulases, xylanases from bacterial cells on laboratory scale in submerged fermentation.
UV-Visible Spectrophotometer (Safas Monaco), France	Colorimetric analysis and determination of enzyme activity, substrates, chromophore and lignin during enzymatic prebleaching and biopulping studies. Kinetic studies of enzymes like xylanase, cellulase and lignolytic enzymes for its applications in pulp & paper industry.
Nikon Research Japan Microscope with software for particle size analysis, studies on microflora etc.	Microscopic studies of morphology of microorganisms, fibre, analysis of slime spots on paper, microbial count, study of microbial dimensions, motility, degree of delignification on fungal treated raw materials
Indigenous Equipment	
Autoclave	Sterilisation of solid and liquid media, & fermenter vessel, etc for microbiological and biotechnological applications.
Laminar air flow	Inoculation and transferring of microbes, enzymes, etc in an aseptic condition for biotechnological studies.
Colony counter	Counting viable microbial colonies grown on solid media.
Remi high speed centrifuge (20,000 rpm)	Solid liquid separation studies for enzymes, microbial separation from growth media.
Homogeniser	Fragmentation of fungal mycelia for its application in biopulping studies.
Cyclo mixture	Mixing of enzymes, substrate and other materials like slime samples in minute quantity.
Environmental/ Humidity chamber	Facilitate growth conditions for microbes particularly for fungi for biopulping studies.
Orbital shaking incubator	Shake flask culture in particular for bacterial as well as fungal multiplication studies.
pH meters	Measurement of pH.

Remi magnetic stirrers	Mixing of liquid substances.
Analytical balance	Weighing chemicals, substrates, enzymes and other special chemicals.
Microwave oven	Dissolving agar media for microbiological studies.
Computer with Software, & Printer	Documentation of progress reports, data management, web surfing, internet communication.
Refrigerator	For maintaining of cultures, pulp samples, enzymes & slimicides at low temperatures.

4.2 Interactions With Other Agencies Engaged In The Biotechnological Research Related To Pulp & Paper Industry

Some of the reputed institutions and laboratories have been visited and interacted engaged in the area of biotechnological research in Pulp & Paper.

Interaction with Institutions / R & D laboratories		
1	Indian Institute of Technology, New Delhi	To collect the enzyme samples, to discuss the project activities and to attend review meetings
2	Institute of Microbial Technology, Chandigarh	For collection of microbial strains for enzymes production.
3	Thapar Corporate Research & Development centre	To visit the laboratory and to discuss the biotechnological applications in pulp & paper
4	National chemical laboratory , Pune	To visit the laboratory and to discuss the microbial activities

4.3 Areas Identified By CPPRI For Biotechnological Applications In Pulp & Paper Making

Initially, thrust has been laid upon few of the biotechnological applications like enzymatic prebleaching of pulp, control of slime and waste paper deinking and up-gradation of waste paper quality, etc.

- Fungal degradation of wood and non wood based fibrous raw materials (Biopulping)
- Enzymatic Prebleaching of Pulps (Biobleaching)

4.3.1 Fungal Degradation Of Fibrous Raw Materials (Biopulping)

Biopulping is the treatment of raw materials with white rot fungi prior to chemical or mechanical pulping. It is the fungal treatment of wood chips designed as a solid -state fermentation process for production of mechanical

- Enzymatic Prebleaching of Pulps (Biobleaching)

4.3.1 Fungal Degradation Of Fibrous Raw Materials (Biopulping)

Biopulping is the treatment of raw materials with white rot fungi prior to chemical or mechanical pulping. It is the fungal treatment of wood chips designed as a solid -state fermentation process for production of mechanical or chemical pulps. The concept of biopulping is based on the ability of some white rot fungi to colonise and degrade selectively the lignin in wood, thereby leaving the cellulose relatively intact. For chemical pulping, biopulping should help to reduce the charge of cooking chemicals, to increase the cooking capacity or to enable extended delignification resulting in reduced consumption of bleaching chemicals. Biopulping also helps to further reduce the negative environmental impact of pulp & paper production if applied before mechanical or chemical pulping.

4.3.2 Enzymatic Prebleaching Of Pulps (Biobleaching)

Traditionally, chlorine has been used as a primary bleach chemical , but because of consumer resistance and environmental regulations on chlorine bleaching, pulp makers are turning to other bleaching chemicals (chlorine dioxide, oxygen, ozone and peroxide, to extended pulping times (there by lowering the pulp lignin content and decreasing bleaching chemical requirements) and to other process modifications. However, disadvantages associated with some of these methods are higher cost and/or greater danger of loss of pulp yield and strength as compared with chlorination. The essence of the process is said to be the same as the conventional chlorine – intensive method. The drawbacks of conventional enzymes have been to overcome to make a step change in the competitiveness of the biotechnology – based process. The use of enzymes offers alternative approaches to reduce the demand for bleaching chemicals or to achieve higher brightness ceilings.

Although many different types of enzymes exist, nearly all of the commercially available and implemented in the pulp and paper industries will be those that have applications in other industries ,such as the textile, food or detergent sectors. To be successfully applied in pulp & Paper manufacture, enzymes must find niches within a complex process where they are able to enhance or compete with existing physico-chemical processes. Although the technology is being adopted commercially in other countries , it is still in nascent stage as far as Indian Paper Industry is concerned.

5.0 WORK CARRIED OUT

5.1 Biological Delignification Of Fibrous Raw Materials - (Biopulping)

Studies were carried out to select the fast growing lignin specific strains (less or no cellulose degradation) which is most important factor for the efficiency of biopulping process. Also, for biopulping process extended treatment time is another bottleneck so the optimisation studies were carried out to select

5.1.1 Evaluation Of New Strains For Their Biopulping Efficiency

Exploration of the natural habitat i.e. soil of various sites of the pulp & paper industry, infected raw materials, degraded pulps, effluent scum for the possibilities of occurrence of new microbial organisms with desired enzyme activities like ligninases.

5.1.2 Screening Of Lignin Specific Strains Of White Rot Fungi

To select efficient biopulping agent for raw materials employed in Indian paper industry i.e eucalyptus, bagasse & wheat straw. Screening studies were carried out on these raw materials using the standard strains and also the new strains, *Ceriporiopsis subvermispora,* (the efficient strain for biopulping known at present was procured from Forest Products Laboratory, Madison, USA & the two new isolated strains viz. CPPRI-1 & CPPRI-2.

5.1.3 Fungal Degradation Of Fibrous Raw Material

Bagasse & Eucalyptus wood chips were treated with the five selected fungi (3 standard & 2 new) for different time periods (14 & 21) days. The treated & untreated raw materials were harvested, air-dried and are being analysed for weight loss vs lignin loss to find out the preferential lignin degradation and depolymerisation. Estimation of cellulose and other components of interest are being carried out.

6.0 RESULTS & DISCUSSION

6.1 Evaluation of New Strains For their Biopulping Efficiency S_2 & S_4 Strains Developed At CPPRI

6.2 Growth & Laccase Activity of the Fungal Strains

6.3 Optimisation of the Biopulping Process With Selective Strains

Case – 1 Fungal Degradation of Bagasse

Case – 2 Fungal degradation of Wood chips

- **Pulping studies of the fungal treated & untreated Rawmaterials**

The results of the pulping studies are not encouraging. One of the main observation of the pulping studies is the increase of kappa number of the treated raw material pulps when compared to untreated raw material pulps.

The results indicate that in comparison to the original sample, the material obtained after microbial treatment has undergone condensation reactions of lignin. Proposed theory was further confirmed with the water extracts of the sample, where it was seen that the fungal treated raw material, when treated with distilled water showed a pH value of 4.3 in comparison to a pH level of 5.6 observed in case of original raw material. Further , the reactions of the lignin are responsible for higher kappa number value of the microbially treated raw materials after chemical pulping. Thus, under these acidic conditions, the cellulose degradation and lignin condensation reactions undergo simultaneously.

- **Observations : Biopulping**

The two new fungal strains, CPPRI-1 (S2) &CPPRI-2 (S4)

- Two unidentified ligninolytic strains were isolated from the soils of the Indian Paper Industry using selective media for the Basidiomycetes. On the basis of cultural characteristics and biochemical / enzyme characters, the fungi were categorised as white rot fungi, (Ligninolytic fungi group) and were assigned the name as CPPRI-I (S2) & CPPRI-2 (S4).

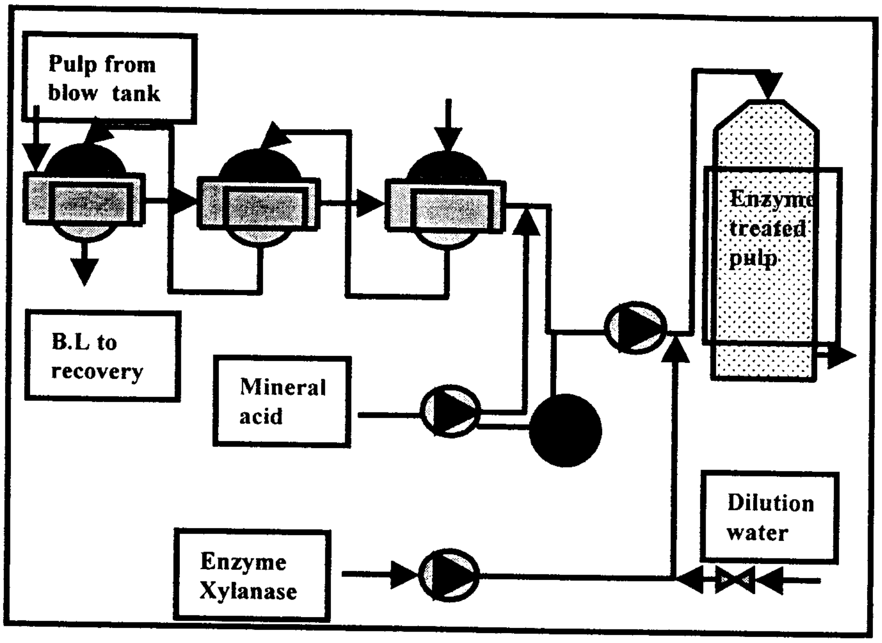
- Among these identified strains, CPPRI isolated fungal strain have found to be a better delignifying strain compared with *C. subvermispora* on both eucalyptus and bagasse. Results showed that CPPRI-1 strain has showed better delignification efficiency i.e. lignin loss varying from 4 to 6% in eucalyptus and up to 6% in bagasse has been reported with corresponding weight loss without loosing much of α – cellulose.

- **Comparative Account Of Results Of Xylanase Enzymatic Prebleaching Technology Using Identified Xylanases On Various Kinds Of Pulps**

Enzyme	% Reduction in Cl2 demand	% Brightness gain	% Reduction in AOX
XYL - A	15	2.3	30
XYL - B	13	3.2	20
XYL - C	9.3	3.0	18-20
XYL - D	12	2.6	ND
XYL - E	12	4.0	17 - 20
XYL - F	14	2.2	20-25
XYL - G	15	3.0	20-30
XYL - H	15	1.9	ND
XYL - I	15	1.9	ND

- **Proposed Plan For Enzymatic Prebleaching Of Pulp In A Mill**

The proposed diagrammatic flow sheet for implementation of enzymatic pre-treatment in a mill is shown here.



7.0 HIGHLIGHTS OF THE PROJECT

- Changes in public policies , customer preference for environmentally benign products & new market demand have increased the interest in developing eco friendly biotechnological applications to the pulp & paper industry. The exercises has been done Studies at the mill had shown satisfactory results wherein it has been possible to save neatly 15% of elemental chlorine with reduction of atleast 20% AOX , further brightness gain of more than two units can be obtained.

- Data generation on enzyme prebleaching in terms of brightness gain, AOX reduction, chlorine savings etc for different pulps.

- The Institute has extensively evaluated various enzymes on various kinds of pulps like hardwood pulp, Bagasse, Bamboo and mixed pulps and got very encouraging results in terms of brightness gain 2-3%, 15-20% reduction in chlorine demand, 20-25% AOX reduction.

- The information on an ideal xylanase enzyme for pulp & paper industry by CPPRI in some mills which could help the mills in conducting commercial trial on Enzyme prebleaching.

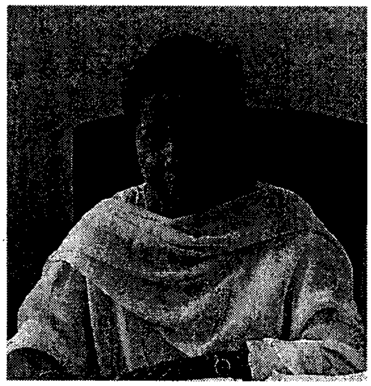
- Having successfully completed laboratory studies with the three of the enzyme preparations have been identified to be satisfactory for their response on indigenous pulps and these three enzyme preparations have been tried at eucalyptus & bamboo based mills.

- The enzyme bleaching technology has successfully resulted in the use of less of chlorine during bleaching which correspondingly reduces the AOX level in the bleach effluents with out compromising the pulp quality Studies on enzyme pre-bleaching were taken up on the samples procured from large integrated paper mills employing eucalyptus, bamboo and bagasse as raw materials.

- Various xylanase preparations both indigenous & the imported have been evaluated for their response on the pulps from the above said raw materials

- Standardisation of enzyme pretreatment conditions for bleaching of various pulps i.e. Wood kraft pulps and bagasse pulps and higher brightness level.

FEASIBILITY STUDIES ON COLOR REMOVAL FROM MECHANICAL PULPING EFFLUENTS



Mrs. Rita Tandon
Scientist E – I

About The Author

Presently working as a senior scientist in CPPRI, the author has a Master's Degree in Chemistry with specialization in Organic Chemistry. The author with a brilliant academic record has dedicated almost 19 years of service to the Institute working in the area: Paper testing, Papermaking, Black liquor characterization, Chemical Recovery, Secondary fibre processing, Energy & Environmental Management.

She has a wide experience in the area of chemical recovery and secondary fibre processing. Has completed two projects on waste paper namely **"Technological Treatment Of Waste Paper"**, sponsored by AISPMA and **"Availability And Utilization Of Waste Paper"** sponsored by IPMA under which **an indigenous gradation system has been evolved** and proposed for implementation. Currently working on project **"Identification, Characterization And Removal Of Contaminants From Recycled Fibre"** under a plan scheme.

She was associated with development of Desilication technology also and currently working on development of color removal technology for liquid effluents.

She has undergone two months extensive training on **"Energy Management in Pulp & Paper Industry" in Cia Suzano Mill in Brazil under UNIDO fellowship training programme**. She has around 30 publications to her credit and author/co-author of number of R&D reports, training & course manual.

FEASIBILITY STUDIES ON COLOR REMOVAL FROM MECHANICAL PULPING EFFLUENTS

A. G. Kulkarni, R. M. Mathur, Rita Tandon, Satya Dev Negi, Subodh K. Singh

1.0 BACKGROUND & OBJECTIVE OF THE PROJECT

The project on "**Color removal of liquid effluents from Mechanical Pulping**" was sponsored by Indian Newsprint Manufacturer's Association (INMA). **The objective of the project is to prepare a feasibility report on color removal from mechanical pulping effluents after evaluating various state-of-art technologies commercially available for color removal and propose a techno economic viable process for treating the mechanical pulping effluents.**

The removal of color from industrial waste has received an increasing amount of attention in recent years. This interest has been prompted by public demand for a cleaner environment as well as by efforts to comply with federal regulations regarding the color discharge which are expected to come into effect in the years to come. In India also the public perception and restrictive environmental discharge limits imposed by some of the state pollution control authorities have made the color removal a prominent issue for pulp & paper industry. Though the effluent color load varies from mill to mill depending upon the raw material used, process employed, type of end products and extent of closure of the system, however the problem of effluent color is more pronounced in newsprint mills than other mills producing cultural grades of paper.

The effluent color load in newsprint mills is mainly due to presence of extractives in woods. The newsprint mills in India which are using hardwood for mechanical pulp production employing CMP or CSRMP process are generating highly colored effluent as the extractives having strong chromophoric groups and present in high proportion are leached out during pre steaming and refining operation. The color in mechanical pulping liquors exist mainly in macromolecular colloidal and dissolved form and more than 50% color in mechanical pulping effluent is in dissolved form making it difficult to remove with conventional chemical precipitation method. The intensity of color in CMP effluent from hardwood is 3-4 times higher than color intensities in the normal lignin bearing compounds at the same concentrations. The average effluent color load in these mills is around 300-400 kg/t and requires heavy dosage of coagulant to remove the suspended color.

Keeping in view the problem of effluent color in newsprint mills, a need was felt that a systematic study should be carried out on various combinations of color removal techniques to achieve maximum color reduction. However prior to taking up the systematic study it was decided to carry out feasibility studies on various color reduction technologies which are available or emerging as promising technologies.

1.1 Methodology Followed

- To fulfill the objectives, extensive literature review was undertaken to assess the commercially available state–of–art technologies for color reduction of mechanical pulping effluents.
- Information has been collected through questionnaires on prevailing practices of color reduction technologies in Indian newsprint mills employing mechanical pulping process.
- Mill visits were undertaken to newsprint mills employing mechanical pulping process for collection of data and colored effluent samples to assess the magnitude and intensity of color load generated during various unit operations of mechanical pulping process.
- Based on the reviews and assessment of newsprint mills with respect to magnitude of color loads and the practices being adopted by the mill for color reduction, preparation of feasibility report of commercially available technologies.

1.2 Contents Of The Report

The report is presented in a comprehensive form consisting of three parts.

PART I - General Introduction

It gives an overview of different sources and magnitude of effluent color in pulp & paper industry and the continued R&D efforts in development of different color reduction technologies till date. It also covers update of commercially available technology and new emerging technologies, which have a potential to be employed for pulp & paper industry.

PART II - This broadly covers a detailed assessment of current status of Indian newsprint mills with respect to magnitude of color loads in mechanical pulping effluent generated and prevailing practices for its control/reduction/removal. The status is based on first hand information collected during mill visit and also includes data on characterization of raw material and mill effluent carried out at CPPRI.

PART III- Feasibility Studies

Based on collected information and technical data on effluent characteristics evaluated at CPPRI, studies were conducted at CPPRI to evaluate the techno-economic viability of commercially available technologies for treating mechanical pulping effluents.

2.0 SUMMARY & CONCLUSIONS

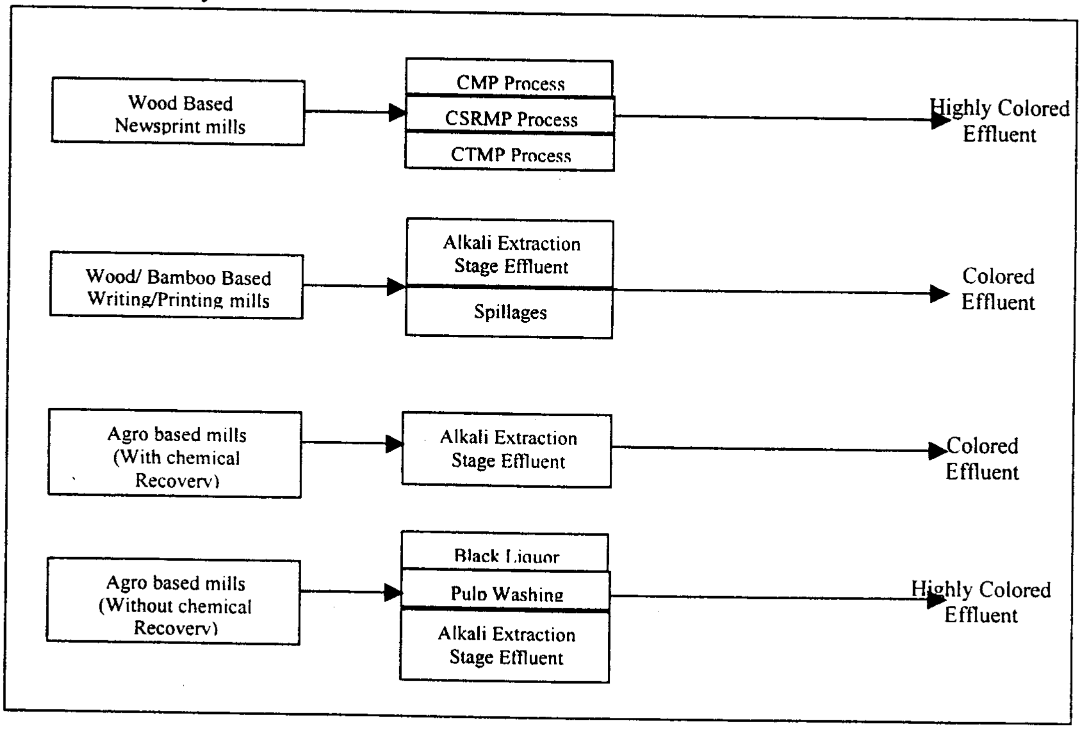
2.1 Indian Scenario

The Indian paper industry uses on an average 100 to 250 m^3 of fresh water/ton of paper and nearly 75% of which is discharged as effluent. In addition to high proportion of inorganics and organic pollutant the effluent from paper industry contains significant color loads. Although there is no stringent legislation for the discharge of color by Central Pollution Control Board (CPCB), some states however have imposed tolerance limits for discharge of color i.e. 100 PCU + color of the receiving stream, which is too low and difficult to achieve target for the mills generating effluents with high color loads.

In general color can broadly be categorized into two groups

- Color due to colloidal particles
- Color due to relatively large colloidal macromolecules i.e. suspended color.

It is easy to remove the color due to larger colloidal macromolecules, but the dissolved color is very difficult to remove and is sensitive to ionic strength, electrical charges etc. Various sources generating colored effluent in pulp & paper industry are :



It is estimated that the quantity of lignin going through spent liquors varies from 300- 400 Kg / ton of pulp, generating a color load of about 1400-1500 Kg PCU (platinum-Cobalt Unit) per ton of pulp. It is estimated that 90% of the color is due to lignin.

In alkali extraction stage only about 50-60 Kg of lignin per ton of paper is going into effluents and the combined efl1uent will have color load of about 1500 PCU.

In newsprint mills where eucalyptus constitutes the main raw material for production of mechanical pulp component, very high color loads are noticed in the effluents. Eucalyptus contains about 3-6% extractives, mostly tannins that are leached out during presteaming and refilling stages. The washings of CMP pulp are highly colored and the color intensity is several times higher when compared to color due to lignin compounds.

The mills which are based on waste paper do not have effluent color problem, however on the contrary in wood based mills the effluent color problem has become a major environmental issue. The problem is further aggravated for the mills, which have mechanical pulping street for the production of newsprint based on Eucalyptus. **In mechanical pulping effluent the effluent color is mainly contributed by presence of extractives, which is the specific organic component present in hard woods known to be the compounds with chromophoric groups.** The mills, which are based on non-woody raw material particularly bamboo, problem of effluent color is relatively less and the major sources of colored effluent is from bleaching operation. The mills, which are based on agricultural residues, in absence of available chemical recovery system, are discharging the spent liquor directly to receiving stream and the color load of which is high due to presence of higher molecular weight lignin components.

2.2 Global Scenario

No official color standards is promulgated by EPA in USA for pulp and paper industry. Some states in USA such as Florida do not have color requirements but have transparency requirements. Other States in USA are now becoming more concerned about color issue. Some existing facilities have attempted the use of end-of-pipe technologies on wastewater treatment facilities to remove color.

In developed countries the concern for effluent color is mainly for bleach effluents and most mills have been able to demonstrate the color removal technologies as an unviable option due to higher cost of treatment. The industry is now inclined towards process changes like using extended delignification, ClO_2 substitution and more sophisticated spill collection and recovery systems.

2.3 Overview Of Effluent Color Reduction Technologies

Following approaches can be adopted to reduce the problem of effluent color

2.3.1 Inplant control measures

2.3.2 Process modification/technology innovation to control the generation of highly colored compounds.

2.3.3 End-of-Pipe treatment methods.

Extensive literature review has revealed that whatsoever R&D efforts have been done to control/reduce the effluent color loads were confined to chemical pulping street and bleach plants only. Not much attention was given to contain effluent color loads from mechanical pulping process. The reason is attributed mainly to worldwide trend of producing mechanical pulps using TMP process. In developed countries TMP being predominant pulping process and use of softwood species as raw material for mechanical pulp production, the effluent color is not a major issue. On the contrary, in India, out of three newsprint mills having mechanical pulping street, only one is based on TMP process based on bagasse and other two mills using E.hybrid are based on CMP process. The effluent generated from these mills has very high color loads. For these mills, adoption of APMP (Alkaline Peroxide Mechanical Pulping) is one alternative to contain effluent color loads, however economic feasibility needs to be worked out.

Various EOP treatment options which have been tried, are confined to bleach effluents only. These methods include physico-chemical treatment method physical separation method, UV Irradiation methods, biological methods etc. An overview showing the status of these technologies is summarized in **Table-1**.

TABLE-1

STATUS OF VARIOUS EOP TREATMENT TECHNOLOGIES

TREATMENT TECHNOLOGY	STATUS
Chemical Precipitation Alum Lime Polymer addition followed by air flotation	**Full Scale application** On mill effluent On bleach & mill effluent On unbleached kraft mill effluent
Membrane Filtration	Mill scale application in E-stage effluent
Ozonation	Bench scale application with bleach effluents
UV Irradiation	Bench scale trials on bleach effluents
Electro-flocculation	Lab scale trials on bleach effluents
Biological Process Mycor Process Lacasse Treatment	 Bench Scale Development trial stage

From the above table it is clear that till date only chemical precipitation and ultra-filtration techniques have been demonstrated on mill scale for reducing color from bleach effluents. In the current study both these techniques have been tried using mechanical pulping effluents. Other emerging technologies, which have been identified and can be studied using mechanical pulping effluent are

- Ozonation
- Photo-oxidation/UV Irradiation
- Electro-flocculation Process.

2.4 Current Status Of Newsprint Mill In India

Among 62 newsprint mills in India, only three mills viz. M/s Hindustan Newsprint Ltd. (HNL), Kerala, M/s Mysore Paper Mills (MPM), Bhadravati and Tamil Nadu Newsprint Ltd. (TNPL), Tamil Nadu are producing mechanical pulp from wood/non wood employing mechanical pulping process for Newsprint production.

Mill I

The mill is presently using E. hybrid, E. grandis and Acacia as raw material for mechanical pulp production employing chemi-mechanical process.

Presently the ratio is 60% E. grandis and 40% E. hybrid, which may gradually change towards more use of E. hybrid and Acacia as E. grandis, which is available through state Govt. may cease after 2004. Due to increase in the ratio of E. hybrid the mill is facing acute effluent color problem. In the colored stream, color variation ranges between 6000 to 8000 PCU and sometimes even more due to plant upsets. The mill has adopted cross recovery of CMP and CP liquor for partial control of color in effluent and also using alum as a coagulant for EOP treatment. The mill has separate treatment facility for colored effluent. Due to high effluent color the alum requirement is very high and the mill is incurring Rs. 1.4 crores annually on EOP treatment. Besides, due to poor settleability of alum flocs there is a carry over of sludge with clarifier overflow. The discharge color remains between 600-800 PCU after treatment.

Mill II

The mill is presently using Acacia as raw material employing cold soda refiner mechanical pulping process. The mill has made some internal modifications which has helped in controlling the effluent color to some extent. Since the mill is based on Acacia which is a light colored wood and due to which the color load in effluent is 50% lower than the mill based on E. hybrid. In the ETP, combined effluent is treated and no separate treatment is followed for colored stream. The discharge color in the final effluent is around 811 PCU.

Mill III

The mill is using Bagasse as a raw material employing TMP process. The effluent color load is significantly low compared to other two mills. The mill is using 1.2 g/l alum presently to treat the colored effluent (bagasse washing) and the final discharge color obtained is 200 PCU.

3.0 FEASIBILITY STUDIES UNDERTAKEN AT CPPRI

Studies conducted at CPPRI on impact of raw material species on effluent color generation has clearly revealed that the amount of alcohol soluble extractives, which represents a group of color bearing compounds like phlobanes, tannins and stilbens is higher for E. hybrid and Acacia compared to bagasse and E. grandis. The color intensity under alkaline conditions is also of the same order.

Extensive literature review has revealed that only alum precipitation and ultrafiltration techniques have been commercialized and have been practiced by mills in USA and Europe to treat bleach effluents. Studies conducted on mechanical pulping effluents using these two technologies have clearly indicated that both theses technologies when used alone are not ideally suited for mechanical pulping effluent having higher color loads. However a combination of both these technologies will be a more suitable option, by incorporating alum treatment to remove suspended color followed by ultrafiltration to remove true color. However this option will have higher economics.

For the effluents having low color loads ultrafiltration is suitable, though the technology is an expensive one.

Among emerging technologies, three technologies have been identified which have been tried for treating bleach colored effluents only. The same techniques can be studied in detail with mechanical pulping effluents. The technologies are:

3.1 UV/Photo Irradiation Process

Irradiation of effluents in the presence of oxygen/or hydrogen peroxide has also been found promising for significant reduction in effluent color and total organically bound chlorine (TOCl) in bleach plant effluents.

The efficacy of enhanced photo-oxidation of bleached kraft mill effluent for color reduction has been demonstrated on bench scale. The effectiveness and versatility of photo oxidation method has given rise to the development of various process alternatives employing $UV/O_2/H_2O_2/O_3$ + H_2O_2/fentons reagents and various combination of these. Preliminary experimental results have demonstrated the potential of photo-assisted catalytic oxidation of organic contaminants and have shown promise of being developed into a viable process for commercial application.

3.2 Ozonation

Use of ozone for removal of color in liquid effluents have been found to be very effective. Ozone has been increasingly used for waste water treatment and tried on lab scale for treating paper mill effluent. The high cost of ozone generation and operation limits the commercial installation. However, this technology can be used as a combination technology for tertiary treatment only, and need to be studied in for generating data base for its application on mechanical pulping effluent.

3.3 Electroflocculation Process

This is the technology of new millennium. Extensively tried on small industrial plants for treating waste waters, the process is very promising in reducing the effluent color. Only lab studies have been conducted on bleach effluents. Some preliminary studies on lab scale have been conducted at CPPRI using mechanical pulping effluents and the findings are very encouraging. A detailed study would be required to establish the economic feasibility of the process.

4.0 RECOMMENDATIONS

4.1 With the growing public concern over the discharge of colored effluents to the river, the problem of effluent color has become a prominent issue for the Pulp

& Paper Industry. The problem is more serious for newsprint mills based on wood. For newsprint mills effluent color reduction can be achieved either by a proper selection of the raw material or by adopting a suitable pretreatment process in order to extract out the extractives from the wood. A systematic study would be required.

4.2 In the existing system when the mills do not have an option to change its raw material, the mills should look into the possibility of adopting new pulping technology i.e. Alkaline Peroxide Mechanical Pulping Process (APMP) for mechanical pulp production to reduce effluent color load.

4.3 For EOP treatment technology it is essential that mill should have a separate street for treating the colored effluents and then combine it with other effluents for conventional treatment.

4.4 The EOP treatment facility should essentially have an equalization tank prior to treatment to absorb the shock loads due to variations in color loads. This will improve the overall performance of the treatment plant.

4.5 Feasibility studies conducted at CPPRI on Chemical precipitation method using alum have clearly indicated the alum precipitation is not a viable option for treating mechanical pulping effluents due to the following reasons:

- Highly colored effluents require high alum dosage leading to higher costs.
- Formation of very light flocs of precipitate having poor settleability, which leads to carryover of precipitated color with supernatant.
- The addition of acid to bring down Alum consumption may further increase the treatment cost, however some improvement in sludge settleability is obtained.
- The addition of polymers in combination of Alum to improve settleability will substantially increase the treatment cost.

4.6 Studies conducted employing ultra-filtration technology clearly indicates that the technique is viable only for effluents having low color loads. For high color load effluents, a combination of alum precipitation followed by ultrafiltration is more suitable option for higher efficiency, however the cost of treatment will be substantial.

4.7 From the literature review three emerging technologies have been identified which are

- UV Irradiation Process
- Ozonation
- Electro-flocculation

Of these three technologies, preliminary studies on lab scale have been conducted on electro-flocculation process using mechanical pulping effluents. A color reduction efficiency of 97% with 50% reduction in COD and 70% reduction in organic components is achieved. The process is technically feasible and needs to be studied on pilot scale to establish the economic viability of the process.

4.8 Also there is need to take up detailed R&D activities to study ozonation and irradiation process for treating mechanical pulping effluent.

4.9 In view of this, CPPRI has already taken up a project as one of the plan schemes in which identified technologies will be studied on lab scale and pilot scale to evaluate the techno economic viability of the process for treating mechanical pulping effluents.

ONGOING PROJECTS

MONOGRAPH ON INDIAN PAPERMAKING FIBERS

Dr. S.V. Subrahmanyam
Scientist E - I

About The Author

Dr. Subrahmanyam has a Masters degree in Botany with specialization in Wood Science and obtained his Doctoral degree in Botany from Sardar Patel University, Gujarat.

He joined Hindustan Paper Corporation in 1981 in their R & D group in the Kerala unit and worked in the area of biotechnological application in Pulp & Paper industry and evaluation of various fibrous raw materials for their suitability in Paper industry.

Subsequently in 1990, he joined Central Pulp & Paper Research Institute, Saharanpur as a Scientist. He has worked in the areas of refining of wood and non-wood fibers. He has obtained training in the area of fiber morphology and quality control from PAPRO, New Zealand. He is currently working in area of Pulping & Bleaching.

MONOGRAPH ON INDIAN PAPERMAKING FIBERS

S.V.Subrahmanyam, R.D.Godiyal, A.K.Sharma & A.G.Kulkarni

1.0 INTRODUCTION

The first paper has seen the light in this world in about A.D. 150 and the inventor was Ts'ai Lun of China. He has claimed to use macerated vegetable fibers from rags, waste hemp fishing nets, young shoots of bamboo and the inner bark of mulberry to form truly felted sheet in a flat porous mould. Japanese acquired this art about five hundred years later. Arabs in A.D.751 set up a mill in Samarkand with the help of captive papermakers from China. Arabs spread it later to Baghdad in A.D. 793, Damascus and Egypt between 10^{th} and 12^{th} centuries, Morocco in A.D.1125 and Spain in A.D. 1156. The art of papermaking spread to France in A.D. 1189, England in A.D.1484 and Scotland in A.D. 1590. It is further spread to Mexico in A.D. 1580 and North America in A.D.1590.

2.0 DEVELOPMENTS IN PROCESS CHEMISTRY AND MACHINERY

The papermaking remained the same until the end of 18^{th} century. Nicholas Louis Robert invented the first Fourdriner machine in principle in A.D.1799. Henry and Sealy successfully introduced the Fourdriner machine in 1804. The important sour ce of fiber was cotton and linen rag along with some straw. The demand for paper continuously increased and the short supply of these fiber sources had often created serious problems for papermakers. After considerable efforts by the chemists, the wood fiber could be extracted using soda process in second half of 19^{th} century. In the mean time, the mechanical wood pulp production was also introduced in 1856.

Current Global pulp and paper scenario shows that most paper is made from wood fibers. Of the total pulp and paper production, wood pulp accounts for about 90% and the rest is derived from vegetable fibers such as seed hairs, bast fibers, grasses and even animal and mineral fibers. Many specialty paper production demands the fibers other than wood. In areas where the wood supply is constraint, the pulp and paper mills use locally available raw materials such as straw, bamboo, bagasse, kenaf, jute etc. Consequently, determination of what fiber has been used in any particular paper, it is important to have means of identifying very specifically a wide variety of different fibers.

3.0 CLASSIFICATION OF FIBROUS RAW MATERIALS

The vegetable fiber sources are classified as wood fibers and nonwood fibers. The wood fibers are further classified as softwood fibers those are derived from gymnosperm trees and hardwood fibers, which are derived from angiosperm trees. The non-wood plant (shrubs and grasses) fibers can be grouped into four based on the botanical part used in making the paper pulp.

1. Stalk or culms fiber: Cereal straws, Grasses, Reeds, Bamboo, Sugarcane(Bagasse).
2. Bast fibers: Flax, Jute, Kenaf, Hemp
3. Leaf fibers: Sisal, Abaca
4. Seed hull fibers: Cotton

4.0 PAPERMAKING FIBERS USED IN INDIAN INDUSTRY

Indian pulp and paper scenario shows that it uses 39% of forest based fiber, 31% agro residue based fiber and 30% fiber is derived from waste paper. The fibrous raw materials used by Indian paper industry for the production of different varieties of paper comes from different sources like wood, bast, leaf of trees, shrubs, and grasses. Fundamental properties of any pulp fiber are length, diameter/width, and cell wall thickness lumen diameter/width.

4.1 Fibers used in Indian paper industry

1.	Rice straw	2.	Kenaf
3.	Wheat straw	4.	Jute
5.	Bagasse	6.	Eucalyptus
7.	Sarkanda	8.	Casuarina
9.	Sabai grass	10.	Mango
11.	Kans grass	12.	Subabul
13.	Bamboo	14.	Popular
15.	Reed grass	16.	Imported softwood pulp

4.2 Morphology of Papermaking Cells

The fibrous raw materials have different tissue composition based on the botanical source. The cells normally found in the paper pulps are fiber tracheids (normally present in softwoods) or fibers (found in all other fibrous raw materials), parenchyma, vessels (found in raw materials other than softwoods and bast fibers) and epidermal cells (mostly found in agro residues). The composition and structure of these different cells determines the papermaking quality of and acceptability of the fiber source.

4.2.1 Fibers

Fibers are the most useful cellulose material in the pulp. These are normally long, flexible and form the basic network (web) in the paper. Fibers contribute to the basic strength of the paper. Fiber is long narrow cell with tapering ends and a central canal known as lumen. The fibers depending upon origin differ significantly. The average fiber length varies from 3.5 mm in softwoods, 0.8-1.2mm in hardwoods, 2-5mm in bast and leafy fibers and 1.0mm to 2.5mm in straws, bagasse and bamboo. Weight proportion of fibers in pulp varies from 95% in softwoods, 65-75% hardwoods and 55-65% in agricultural residues. Detailed examination of fiber structure by electron microscopy shows the fiber wall exists as four layers surrounding the central canal.

4.2.2 Fiber Length

The papermaking pulps have fiber population with varying lengths. The heterogeneity of the fiber population influences the papermaking and the knowledge and understanding of the fiber length distribution is highly essential in predicting the behaviour of a raw material in the papermaking process. Generally, the fiber length is averaged for a source, which is a relatively easy expression and gives a broad idea for comparison purpose. The average fiber length varies from 3.5 mm in softwoods, 0.8-1.2 mm in hardwoods, 2-5 mm in bast and leafy fibers and 1.0 mm to 2.5mm in straws, bagasse and bamboo.

4.2.3 Fiber Width

The terms width and diameter of the fibers are normally used for all the practical purposes for the same dimension. In a two-dimensional view of the light microscope, it is not possible to distinguish between width and diameter. The unrefined fibers are normally tubular structures, which become flattened on refining. In the paper web when the fibers cross over randomly, the area of fiber cross over (area of bonding) is influenced by fiber width. If the fibers are wide, then the area per cross over increases where the fibers are held together that contributes to the strength of paper web. For a given fiber length, the fibers with higher fiber width gives higher paper strength due to increased cross over area per fiber. The length to width ratio is known as slenderness of the fiber.

4.2.4 Fiber Lumen

The central cavity in the fiber is known is fiber lumen, which is void. Depending on the extent of void space, the fiber may flatten (collapsibility) to different extents, as the fiber is refined. Higher the extent of collapsibility then higher is the bonded (contact) area. The fiber lumen is different for different species. The fibers in the same source have different fiber lumen due to seasonal variations in the wood formation. For example the late (winter) wood fibers are have narrower fiber lumen compared to the early (spring) wood fibers. Rind fibers have thicker wall compared to the fibers in vascular bundles as in bagasse and straws.

4.2.5 Fiber wall thickness

Fiber wall is specific to a given fiber source. Depending on the fiber wall thickness the fibers' response to refining varies. Fibers with thin cell walls collapse readily. Increase in fiber wall thickness leads to increase in mass per unit length (coarseness) of the fiber. Fibers with higher coarseness are called coarser fibers and with lower coarseness as finer fibers. Fibers of higher coarseness are stiff and difficult to collapse which leads to poor bonding due to less bonding area and lower strength. This will result in increased porosity and surface roughness of the paper.

4.2.6 Parenchyma

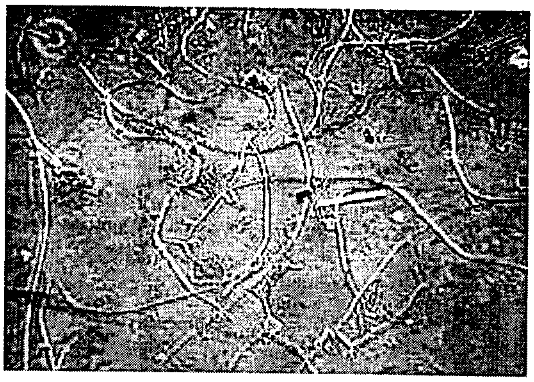
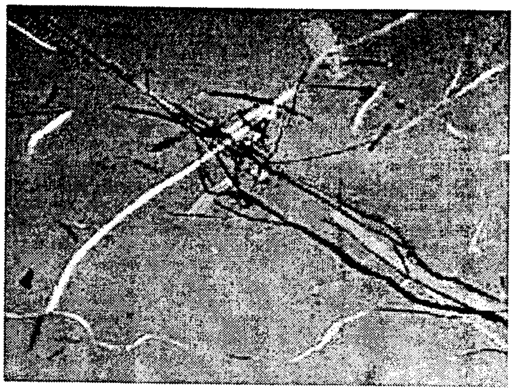
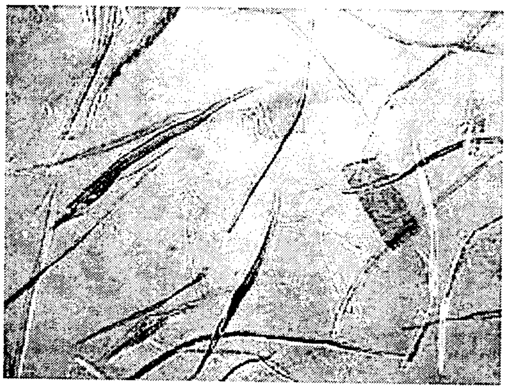
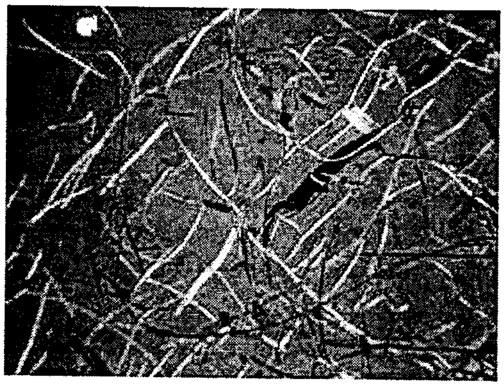
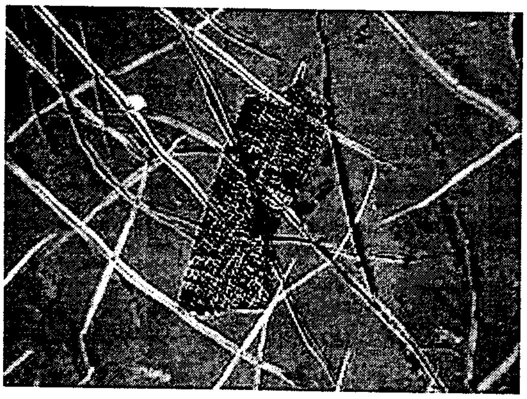
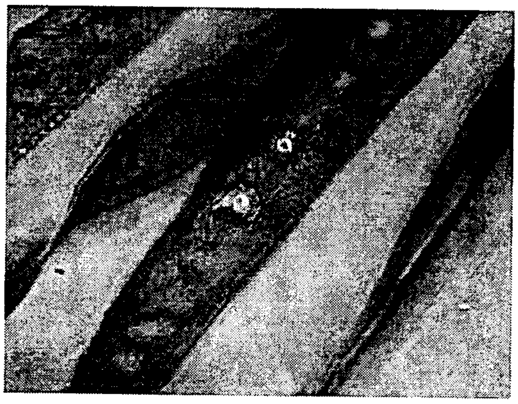
It is also called as nonfibrous tissue, pith tissue or ground tissue. The parenchyma cells are cellulosic. The dimensions of parenchyma vary with source raw material. They do not contribute to the strength of the paper and often create serious drainage problems affecting the productivity especially in the agricultural residues. The weight percent of parenchyma (nonfibrous) cells is about 5% in softwoods, 25-35% in hardwoods and 30 to 45% agriculture residue pulps. The parenchyma is the source of primary fines in virgin chemical pulp.

4.2.7 Vessels

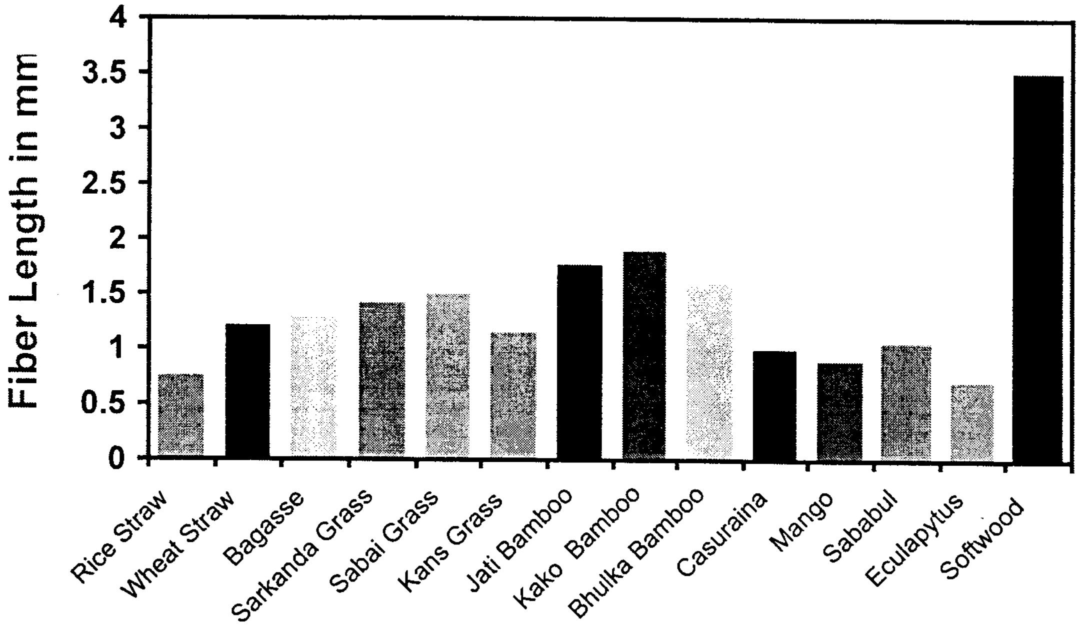
The vessel elements are the single units of the vessels. They are spiral shaped in straws, long, narrow and cylindrical in bagasse and bamboo, short, wide and cylindrical with short tail in the hardwoods. They are absent in the softwoods. Wherever they are present they help in the mobility of pulping liquor (penetration) in longitudinal direction of chips. When they are short and wide, they create the vessel pick problem in papers.

4.2.8 Epidermal cells

The epidermal cells are significantly small cells with serrated margins. They appear either in groups or as singles. Their presence is noticeable in straws and bagasse.

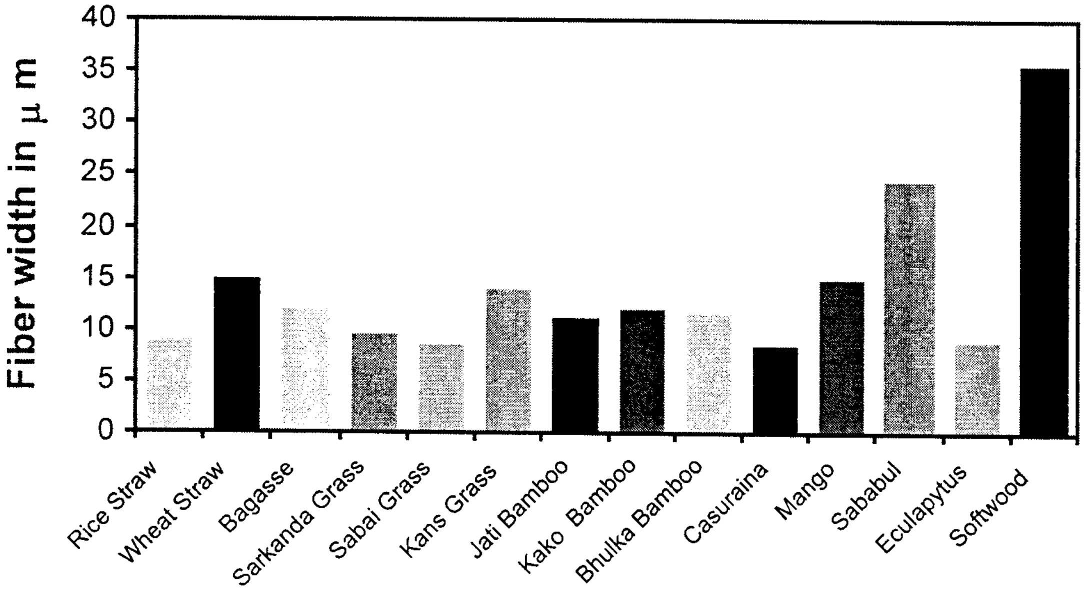
	
Rice straw pulp	Wheat straw pulp
	
Bagasse pulp	Sarkanda grass pulp
	
Hardwood pulp	Softwood fiber tracheids

FIBER LENGTH OF DIFFERENT FIBEROUS RAW MATERIALS



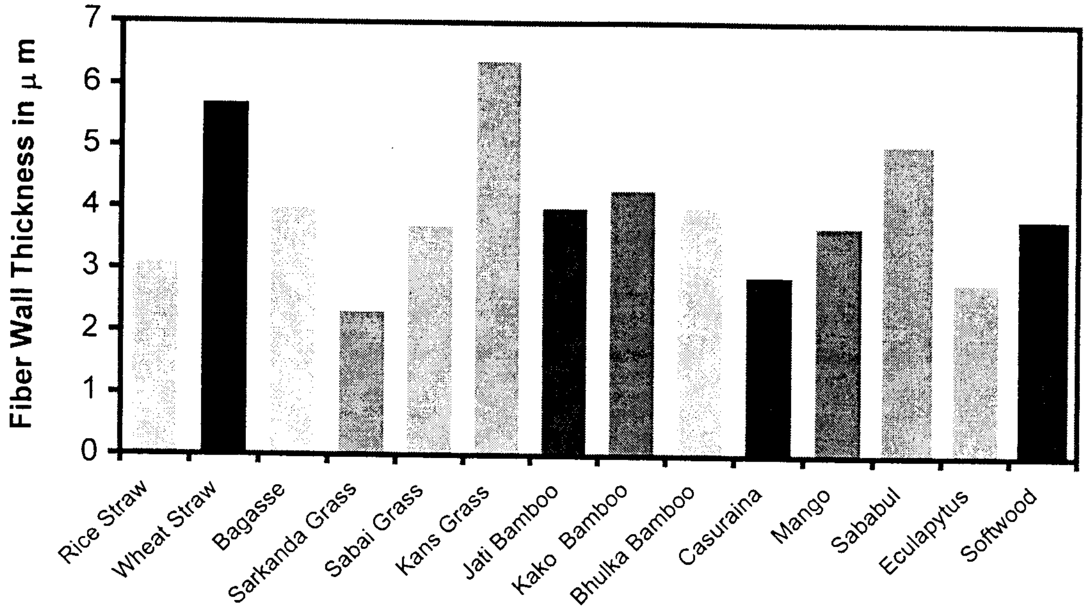
Fiber length is one of the major factors that influence the paper strength. It is one single major factor influencing the Wet web tensile strength that contributes to the runnability. In a paper web the number of fiber crossings per fiber proportionally increases with fiber length, thereby increases the tearing strength of the paper.

FIG.-2 FIBER WIDTH OF DIFFERENT FIBEROUS RAW MATERIALS



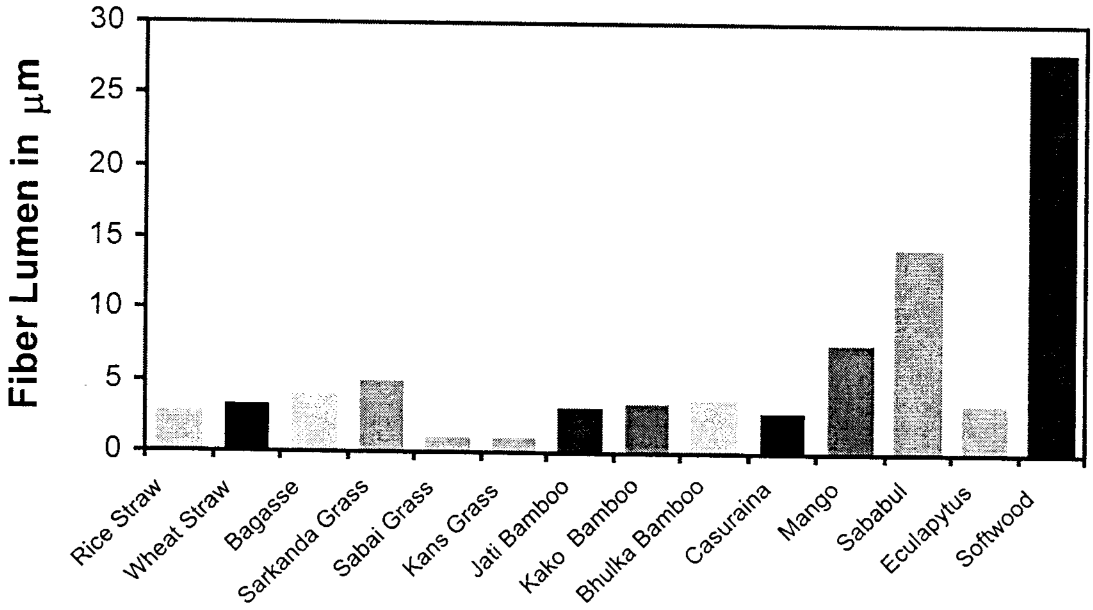
Fiber width influences the area of bonding. At a given fiber length, increase in fiber width increases the fiber bonding area which has direct impact on tensile, tear and bursting strength of paper.

FIG.3- FIBER WALL THICKNESS OF DIFFERENT FIBEROUS RAW MATERIALS



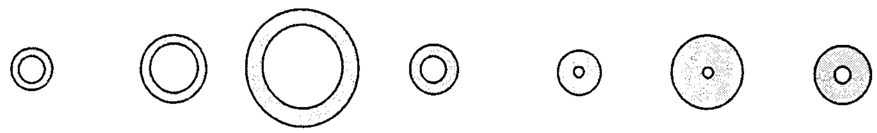
Fiber wall thickness indicates the mass of the wall material per unit length of the fiber. As the wall thickness increases, the fibers are difficult to collapse in the refining treatment. The paper strength was found to improve with increasing fiber length and decreasing wall fraction (only to certain extent) (Rydholm).

FIG.4- FIBER LUMEN OF DIFFERENT FIBEROUS RAW MATERIALS

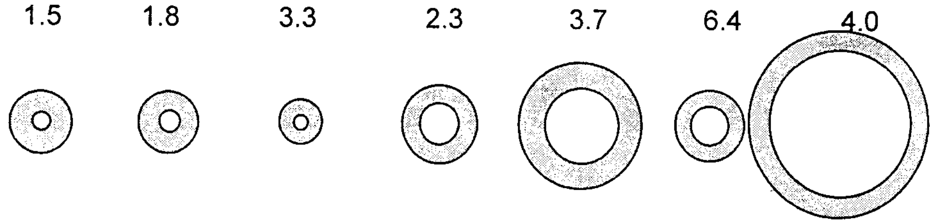


Fiber lumen influences the collapsibility and conformability of the fibers. Collapsibility of the fibers improves the area of fiber bonding as the contact area increases.

FIG.-5COMPARITIVE CROSS SECTIONAL DIMENSIONS OF DIFFERENT FIBERS



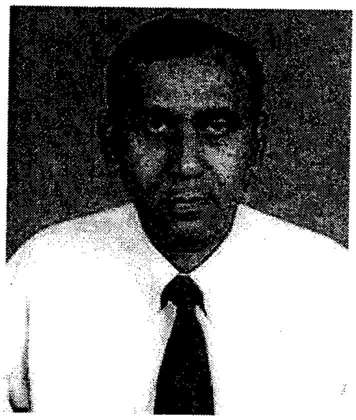
	Rice Straw	Wheat Straw	Bagasse	Sarkanda Grass	Sabai Grass	Kans Grass	Jati Bamboo
Fiber diameter, µm	8.1	12.9	22.5	9.6	8.5	13.9	11.2
Fiber Lumen, µm	5.1	9.3	15.9	5.0	1.1	1.1	3.2
Wall Thickness, µm	1.5	1.8	3.3	2.3	3.7	6.4	4.0



	Kako Bamboo	Bhulka Bamboo	Casuraina	Mango	Subabul	E.Hybrid	Softwood
Fiber diameter, µm	12.0	11.7	8.5	15.0	24.2	13.5	35.45
Fiber Lumen, µm	3.4	3.7	2.8	7.7	14.3	7.3	27.9
Wall Thickness, µm	4.3	4.0	2.9	3.7	5.0	3.1	3.8

The coarseness was found to influence the bulk with an exponent of –0.3, burst with – 1.0, tensile strength with – 0.6, and tearing strength with – 0.3 (Rydholm)

DEMONSTRATION OF ENZYMATIC PREBLEACHING IN A PULP & PAPER MILL



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Dr. R.M. Mathur, is presently working as Scientist E-II and Head, Chemical Recovery, Energy Management, Environmental Management and Biotechnology Division.

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He has widely traveled abroad as UNIDO fellow to Canada, France, Germany, Australia & Japan and been to Turkey & Thailand for Demonstration of Desilication Technology developed by CPPRI. He has four patents to his credit.

DEMONSTRATION OF ENZYMATIC PREBLEACHING IN A PULP & PAPER MILL

A.G. Kulkarni, R. M. Mathur, R. K. Jain, Abha Gupta, Vasanta Vadde Thakur, Sonal Agarwal

1.0 BACKGROUND

As the global trend & Customers preference are switching towards cleaner and greener products, pulp and paper industry in India is required to modify its technology for elemental chlorine free (ECF) bleaching so as to reduce to adopt technologies which are eco friendly & there is a reduced generation of AOX in bleaching operation. Although the enzymatic prebleaching technology is widely adopted in developed countries, it is in very primitive stage as far as Indian Paper Industry is concerned.

CPPRI has been engaged in the area of enzymatic prebleaching of pulps using the globally available enzymes wherein several commercial xylanase preparations have been evaluated for their response on different kinds of pulps. Xylanase enzymes have been developed and are available in the market but these enzyme preparations are highly sensitive to pH and temperature which varies considerably from mill to mill depending upon the fibrous raw materials and also the process conditions.

In view of wider potential and urgent need of adoption of enzymatic prebleaching technology in Indian Paper Mills, CESS Grant Authority sponsored project to CPPRI entitled " **Demonstration of enzymatic Prebleaching in a Pulp & Paper Mill** " Demonstration of the process on mill scale should help in creating the confidence among the paper mills.

2.0 VISIT TO MILL & DATA COLLECTION

CPPRI selected Seshasayee Paper & Boards Ltd. as the first mill for the mill scale trial of enzymatic prebleaching. Two scientists of CPPRI visited the mill to see the existing mill processes, type of raw materials used, pulping, washing & bleaching conditions and also to discuss the other mill facilities for application of enzymatic prebleaching . The process conditions were evaluated specially for the enzyme dosing point and enzyme mixing equipment which are very important for the efficiency of the process.

2.1 Selection Of The Dosing Point Of The Enzyme

From the process lay out of the mill , two points were taken in to consideration for the enzyme addition.

1. HD Chest after brown stock 4^{th} Washing : Unscreened Pulp
2. After screening : Screened pulp

Pulp Characteristics

Unscreened pulp		Screened pulp	
Consistency	: 6%	Consistency	: 6%
Temperature	: 50° C	Temperature	: 30 – 35 ° C
Retention time	: 60 - 90 min.	Retention time	: 45- 60 min.
pH	**: 10 -11**	**pH**	**: 8.0-9.0**
COD Carry over	: 15-20 kg/tp	COD Carry over	: 7-10 kg/tp
Kappa number	: 21- 25	Kappa number	: 21- 25

For Unscreened Pulp

1. Because of unscreened nature of pulp enzyme demand will be high which increases the cost .
2. There should be pH adjustment with acid to 8.0-9.0 which is the optimum pH range for most of the commercial xylanases , which may lead to corrosion of pipes and also adds to the cost.

Screened Pulp

1. Enzyme demand will be low which decreases the cost .
2. No pH adjustment. Hot water washing is required to raise up the temperature.

On the basis of above characters, Decker was selected for the enzyme addition and for retention is Screened chest.

2.2 Enzyme Dosing

Dosing pump for enzyme will be supplied by the mill

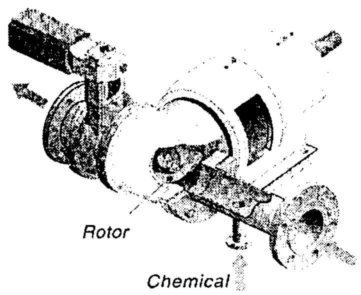
2.3 Mixing Of The Enzyme With The Pulp

The main bottleneck for the application of this technology is mixing of the enzyme with the pulp. For proper mixing of enzyme with the pulp a mixing device should be provided after the enzyme addition. An efficient & cost effective device has to be selected suggested equipment are as follows.

2.3.1 AHLMIX Chemical Mixer (App.16 Lacs)

1. AHLMIX is a medium consistency chemical mixer designed for mixing both gaseous and liquid bleaching chemicals in to paper stock.

2. Variously used for oxygen , peroxide , chlorine dioxide & chlorine mixing.



2.3.2 Peg Mixer

Mixing in medium consistency pulp suspensions has conventionally been achieved by peg mixers. These are tubular vessels having one or two shafts with pegs that rotate between stationary elements attached to the mixer casing. As pulp is conveyed through the mixer, the rotating bars shear the suspension against the stationary elements.

Used to mix bleaching chemicals in to high consistency pulp.

2.3.3 Conventional Pin Screw Conveyor

Details will be furnished after obtaining the required information.

3.0 MATERIAL & METHODS

3.1 Pulp Samples

Unbleached screened pulp samples of mixed hardwood (Casuriana + Eucalyptus hybrid) pulp from the Decker washer and OD thickner were collected and mixed in a ratio of 70: 30 to make a Composite samples which were used for enzymatic prebleaching studies conducted both at R & D lab at SPB and at CPPRI.

3.2 Enzyme Source

Two of the identified **x**ylanase enzymes, xylanase-1 & xylanase-2 procured from reputed enzyme manufacturing companies has been used for these studies.

Enzyme	Enzyme Activity , IU/ ml
Xylanase -1	5,000 IU/g
Xylanase –2	7,000 IU/ml

3.3 Enzyme Pretreatment Of Pulps

Xylanase pretreatment of pulp was carried out. Enzymes were added to the pulp after sufficient dilution & mixed properly by kneading mechanism. The conditions for enzyme treatment of pulp are shown in corresponding Tables. Control was run paralally with maintaining all the conditions except the enzyme.

3.3.1 Process Conditions Used During Bleaching Of Pulps

Both enzyme treated and untreated pulps were followed by conventional bleaching without washing the pulps after enzyme treatment stage. Process conditions employed for bleaching of Pulps CE(P)HH sequence both with & with out enzyme preparations according to the present mill conditions is shown in table-1.

TABLE-1

PROCESS CONDITIONS USED DURING BLEACHING OF PULPS

Particulars	C- stage	Alkali Extraction Stage (p)	Hypo stage - 1	Hypo stage - 2
Temperature, ^{0}C	Ambient	70	2.0	2.0
Pulp Consistency, %	3.0	10.0	10.0	10.0
Retention Time, min	45	60	120	120
Final pH	1.8-2.0	>10.5	>9.0	>9.0

4.0 EXPERIMENTS

4.1 Bench Scale Enzymatic Pre Bleaching Studies At R & D Lab At Mill

Lab scale enzymatic prebleaching studies were conducted at R & D laboratory of the mill to evaluate the response of enzymes on the pulp produced by the mill and also using the mill prevalent conditions.

Evaluation of the enzyme response on the pulp as prebleaching agent in order to

- Explore potential of savings of elemental / total chlorine so that possibility of reduction of AOX could be explored.
- Assessing gain in brightness of the pulp after final bleach stage without loosing strength properties

TABLE – 2

CHARACTERISTICS OF THE UNBLEACHED SCREENED PULP

Particulars	Decker	OD Thickner
pH of the pulp	8.8	8.9
Consistency of the Pulp	7.34	6.84
Brightness , % ISO	22.0	21.0
Soda loss, %	13.4	13.4
Kappa number	19.5	19.5
Both pulps mixed in a ratio of 70: 30		

TABLE- 3

ENZYME PRETREATMENT CONDITIONS

Particulars	Control	Enzyme treated pulp	
		Xylanase-1	Xylanase-2
Enzyme dose, % (OD pulp)	0	0.04	0.06
Treatment time , (hrs)	1.0	1.0	1.0
Temperature ,° C	50	50	50
Consistency of the pulp , %	7.0	7.0	7.0
pH	8.7	8.7	8.7

5.0 RESULTS & DISCUSSION

5.1 Effect Of Enzyme Treatment On Pulp

5.1.1 Kappa number

From the results shown in Table - 4, it is clearly evident that there is reduction in kappa no. of unbleached Kraft wood pulp after enzyme treatment which has been decreased by 1.0 point with gain in pulp brightness of 1.0 point i.e. from 22.0 to 23% ISO.

TABLE- 4

EFFECT OF ENZYME TREATMENT ON UNBLEACHED PULP

Particulars	Control	Enzyme treated pulp	
		Xylanase-1	Xylanase-2
Brightness, % ISO	22.0	23.0	21.0
Kappa number	19.3	18.3	18.5

5.1.2 Effect Of Enzyme On Brightness Of The Pulp

Results of the enzymatic prebleaching followed by CEHH bleaching are shown in the table –5. The enzyme treated pulps could be bleached to higher brightness with a gain in brightness level of 1.5-2.0 % ISO in both sets while using similar chlorine dosages as in case of control pulp sample.

5.1.3 Effect Of Xylanase Treatment On Bleach Chemical Requirement

Xylanase treated pulps differ in response to bleach chemical when compared to untreated pulps. Bleaching of the control and enzyme treated pulps using conventional CEHH bleach sequence showed remarkable reduction in the requirement of total chlorine 16.5% i.e from 8.5 % to 7.1% whereas elemental chlorine which is reduced from 4.5 (45.00 kg/tp) to 3.8% (38.0 kg/tp) and hypo demand is reduced from 4.0% to 3.3% in case of enzyme treated pulps while maintaining the targeted brightness of 83.

TABLE - 5

EFFECT OF ENZYME TREATMENT ON HARD WOOD PULPS BLEACHED WITH CEHH SEQUENCE

Particulars	**Control**	**Xylanase-1 ET1**	**Xylanase-2 ET2**	**ET1**	**ET2**
Chlorination stage					
Applied chlorine, %	**4.5**	**4.5**	**3.8**	**4.5**	**3.8**
Cl_2 Consumption , %	**98.9**	**98.9**	**99.2**	**98.5**	**98.9**
Savings in chlorine , %	--	--	**15.5**	-	**15.5**
Permanganate number	**6.0**	**5.6**	**5.8**	**5.5**	**5.7**
Alkali Extraction stage					
Applied NaOH, %	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**
Peroxide , %	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
CE brightness, %	**53.0**	**56.0**	**52.0**	**57.0**	**54.0**
Permanganate number	**3.5**	**3.2**	**3.8**	**3.6**	**3.8**
Hypo stage – H1					
Applied Hypo, %	**2.0**	**2.0**	**1.5**	**2.0**	**1.5**
Consumption , %	**96.1**	**95.4**	**96.7**	**95.4**	**97.6**
Brightness of the pulp, % ISO	**77.0**	**78.0**	**75.0**	**77.0**	**75.0**
Hypo stage – H1I					
Applied Hypo, %	**2.0**	**2.0**	**1.8**	**2.0**	**1.8**
Final brightness of the pulp, % ISO					
Evaluated at SPB	**83.0**	**84.5**	**83.5**	**84.0**	**83.0**
Evaluated at CPPRI	**82.0**	**83.31**	**81.0**	**85.33**	**82.60**
CED Viscosity , Cm^3/g	**402**	**342**	**450**	**302**	**441**

ET1 : Enzyme treated pulps bleached with same Cl_2 dose as of control
ET2 : Enzyme treated pulps bleached with less Cl_2 dose as of control

6.0 OBSERVATIONS

Studies on evaluation of the identified xylanases at R & D lab on wood kraft pulp of SPB has been found to be encouraging in terms of

- Reducing the requirement of Cl_2 to the tune of 15-18% in wood kraft & kraft bagasse pulps
- Brightness gain of the bleached pulp is estimated to more than 2% ISO

7.0 BENCH SCALE ENZYMATIC PRE BLEACHING STUDIES CONDUCTED AT CPPRI

Unbleached pulp from the mill was brought to CPPRI to confirm the results of enzymatic prebleaching studies conducted at R & D lab and also for detailed characterization of the enzyme treated pulps.

TABLE – 6

CHARACTERISTICS OF THE UNBLEACHED SCREENED PULP

Particulars	Pulp collected from Decker & OD Thickner
pH of the pulp	8.0
Consistency of the Pulp	9.67
Brightness , % ISO	22.00
Soda loss, Kg/tp	14. 25
COD Carryover of the Pulp , kg/tp	43.26
Kappa number (unwashed) (Washed)	24.73 19.56

7.1 Determination Of The Kappa No. Of Pulp

Kappa no. of the pulp procured from the mills, control pulp & enzyme treated pulp i.e just after xylanase treatment , after chlorination & extraction stage (CE) were determined following standard TAPPI procedure T-236-0S-76.

7.2 Evaluation Of Bleached Pulp Characteristics

7.2.1 Determination Of Pulp Brightness

Brightness of the pulp samples were measured on a pulp by following the procedure given in ISO DIS 3688.

7.2.2 Determination Of Strength Properties

Strength properties of both enzyme treated & untreated pulp samples were determined by beating the pulp in PFI mill to various degree of freeness under standard conditions as per ISO DP 5264 i.e :

Beating pressure -- 17.7 N/Cm.
Relative speed -- 6.0 m/s
Beating consistency – 10% on weight basis.
CSF measurement -- ISO DP 5267.

The temperature of the stock is recorded before and immediately after beating. Handsheets are made as per ISO DP 5269 & dried on plates in stack under the standard conditions for tropical countries (27°C , 65% RH).Physical testing of the handsheets are made according to the following standards:

Tensile Index -- ISO 1924
Tear index -- ISO 1974
Burst Index -- ISO 2758

7.2.3 Determination Of Intrinsic Viscosity

Viscosity of the pulp was measured as per standard procedure SCAN C – 15:62

7.3 Characterisation Of The Unbleached Pulp

Unbleached pulp samples both control & enzyme treated were characterised for Kappa No., Brightness % ISO & Viscosity and other parameters of interest.

TABLE- 7

ENZYME PRETREATMENT CONDITIONS

Particulars	Control	Enzyme treated pulp	
		Xylanase-1	Xylanase-2
Enzyme dose, % (OD pulp)	0	0.04	0.06
Treatment Time , (hrs)	1.0	1.0	1.0
Temperature ,° C	50	50	50
Consistency of the pulp , %	8.0	8.0	8.0
pH	8.0	8.0	8.0

8.0 RESULTS & DISCUSSION

TABLE- 8

EFFECT OF ENZYME TREATMENT ON UNBLEACHED PULP

Particulars	Control	Enzyme treated pulp	
		Xylanase-1	Xylanase-2
Brightness, % ISO	23.0	23.64	23.58
Kappa number	19.94	19.57	19.16

8.1 Effect Of Enzyme On Brightness Of The Pulp

The results of the enzymatic prebleaching studies with SPB pulp conducted at CPPRI are similar to the results of the enzymatic studies conducted at R & D lab of SPB.

Data shown in the table-9 indicated that the enzyme treated pulps could be bleached to higher brightness with a gain in brightness level of 1.5-2.0 % ISO in both sets while using similar chlorine dosages as in case of control pulp sample.

8.2 Effect Of Xylanase Treatment On Bleach Chemical Requirement

Xylanase treated pulps differ in response to bleach chemical when compared to untreated pulps. Bleaching of the control and enzyme treated pulps using conventional CEHH bleach sequence showed remarkable reduction 16.5% in the requirement of total chlorine i.e from 7.3 % to 6.1% whereas elemental chlorine which is reduced from 4.8 (48.00 kg/tp) to 4.1% (41.0 kg/tp) and hypo demand is reduced from 2.5% to 2.0 % (20%) in case of enzyme treated pulps while maintaining the targeted brightness level of 83.5. Results are shown in the table – 9. Overall impact of enzymatic bleaching is shown in table-10. There was considerable decrease in yellowness of enzyme treated pulps compared to the untreated pulp.

TABLE – 9

EFFECT OF ENZYME TREATMENT ON HARD WOOD PULPS BLEACHED WITH CEH SEQUENCE

Particulars	Control	Xylanase-1		Xylanase-2	
		ET1	ET2	ET1	ET2
Chlorination stage					
Applied chlorine, %	4.8	4.8	4.1	4.8	4.1
Consumption , %	96.3	90.4	97.5	94.4	96.1
Savings in chlorine , %	--	--	**14.6**	--	**14.6**
Kappa number	6.4	6.1	6.4	6.5	6.5
Brightness, %	36.0	36.7	36.7	37.07	36.5
Alkali Extraction stage					
Applied NaOH, %	1.8	1.8	1.8	1.8	1.8
Peroxide , %	0.5	0.5	0.5	0.5	0.5
Alkali Consumption, %	84.4	84.8	83.6	86.39	88.39
CE brightness, %	51.44	50.81	50.89	52.55	52.53
CE kappa number	2.87	2.87	2.87	3.08	2.87
Hypo stage					
Applied Hypo, %	2.5	2.5	2.0	2.5	2.0
Savings in Hypo , %	--	--	**20**	--	**20**
Consumption , %	99.5	99.7	99.4	98.5	98.7
Final brightness of the pulp, % ISO	**83.7**	**84.7**	**83.6**	**85.4**	**84.7**
Post Colour Number	2.75	1.17	1.66	2.01	1.16
Yellowness , %	**8.41**	**8.08**	**8.4**	**7.40**	**7.50**

TABLE – 10
OVERALL IMPACT OF ENZYMATIC PREBLEACHING ON HARD WOOD PULPS

Parameters	Xylanase-1	Xylanase-2
Total Cl_2 reduction , %	**16.5**	**16.5**
Elemental Cl_2 reduction , %	14.6	14.6
Hypo Reduction, %	20	20
Final Brightness improvement , % ISO (with same 16.5 % less Cl_2 dose of control)	--	**1.0**
Final Brightness improvement , % ISO (with same Cl_2 dose as of control)	**1.0**	**1.8**

8.3 Effect Of Xylanase Treatment On Strength & Optical Properties Of The Pulp

Strength properties of both enzyme treated pulps showed improvement when compared with the untreated pulps. Results are shown in table – 11.Determination of the strength properties of both enzyme treated pulps bleached with same Cl_2 dose , showed that burst, tensile , and tear index could be slightly improved which were found to be 3.0 and 3.1 Kpa .m2/g against 3.2 Kpa .m2/g of control and 52.0 and 56.5 N.m/g against 52.5 N.m/g and 3.7 & 3.6 $mN.m^2/g$ against 3.6 $mN.m^2/g$ of control in case of enzyme treated pulps respectively with Xyl – 1 and Xyl – 2 respectively.

There is a significant improvement in strength properties could be noticed in enzyme treated pulp bleached with less Cl_2 dose. The burst index was increased from 3.2 Kpa .m2/g of control to 3.6 & 3.5 Kpa .m2/g of both the enzyme treated pulps. Tensile & tear indexes of the enzyme treated pulps were improved considerably when compared to the control. i.e from 52.5 N.m/g to 60.0 & 58.0 N.m/g and 3.6 $mN.m^2/g$ to 4.2 & 4.1 $mN.m^2/g$.

TABLE - 11

STRENGTH & OPTICAL PROPERTIES OF WOOD PULP BEFORE & AFTER ENZYME TREATMENT

Particulars	Control	Xylanase -1		Xylanase –2	
		ET1	ET2	ET1	ET2
		Strength Properties			
Revolution , PFI	2000	2000	2000	2000	2000
Freeness, CSF	205	185	225	200	225
Apparent density, g/m^3	0.88	0.88	0.87	0.91	0.84
Burst Index, $Kpa.m^2/g$	3.20	3.00	3.60	3.10	3.50
Tensile Index , Nm/g	52.5	52.0	60.0	56.5	58.0
Tear Index , Mnm^2/g	3.60	3.70	4.20	3.60	4.10
		Optical properties			
Opacity, %	79.6	78.2	80.1	77.9	78.9

8.4 Environmental Effect Of Enzyme Treatment

Reduction in total chlorine demand of around 16% during CE(P)HH bleach sequence resulted in lowering the toxicity of the bleach plant effluent in enzyme treated pulps remarkably. From the results shown in table-12 it is evident that the AOX level in the bleach effluent generated from enzyme treated pulps was reduced to 20%. i.e from 2.88 to 2.27 Kg/tp.

TABLE – 12

CHARACTERIZATION OF BLEACH EFFLUENT (C+E +H STAGE) BEFORE & AFTER ENZYME TREATMENT OF PULP

Particulars	Control Pulp	Xylanase -1		Xylanase-2	
		ET1	ET2	ET1	ET2
AOX , Kg / tp	2.88	2.80	2.33	2.89	2.27
AOX Reduction , %	--	--	**19.1**	--	**21.18**
COD , Kg / tp	52.5	55.5	58.82	57.34	56.75
BOD, Kg / tp	25.18	28.32	28.74	29.17	29.1
COD: BOD Ratio	1:2.1	1:1.96	1: 2.05	1: 1.97	1:1.95

8.5 Optimisation Of Enzyme Doses

To see the effect of low doses of the enzyme on SPB hardwood pulp , experiments were conducted with the enzyme which showed better results , Xyl-2. The process conditions and results are shown in the tables – 13 to 15. Results indicated that there was no brightness improvement in enzyme treated pulps with 0.02 & 0.04% doses when compared to the control but there was total chlorine reduction of 14.5 % in enzyme treated pulps maintaining the untreated pulp brightness level.

TABLE - 13

ENZYME (XYLANASE –2)PRETREATMENT CONDITIONS

Particulars	Control	Enzyme treated pulp	
Enzyme dose, % (OD pulp)	**0**	**Enzyme dose 0.02 %**	**Enzyme dose 0.04 %**
Treatment Time , (hrs)	1.0	1.0	1.0
Temperature ,° C	50	50	50
Consistency of the pulp , %	8.0	8.0	8.0
pH	8.0	8.0	8.0

TABLE – 14

EFFECT OF ENZYME (XYLANASE -2)TREATMENT ON UNBLEACHED PULP

Particulars	Control	Enzyme treated pulp	
		Enzyme dose 0.02 %	Enzyme dose 0.04 %
Brightness, % ISO	22.93	23.02	22.96
Kappa number	20.79	20.2	20.12

TABLE- 15

EFFECT OF ENZYME (XYLANASE –2) TREATMENT ON HARD WOOD WITH CEHH SEQUENCE

Particulars	Control	Enzyme dose 0.02 %		Enzyme dose 0.04 %	
		ET1	ET2	ET1	ET2
Chlorination stage					
Applied chlorine, %	4.8	4.8	4.1	4.8	4.1
Consumption , %	98.09	97.13	98.88	98.09	98.32
Savings in chlorine , %	--	--	14.6	--	14.6
Alkali Extraction stage					
Applied NaOH, %	2.5	2.5	2.5	2.5	2.5
Peroxide , %	0.5	0.5	0.5	0.5	0.5
Alkali Consumption, %	92.52	87.3	85.3	86.76	85.04
Hypo stage -1					
Applied Hypo, %	2.5	2.5	2.0	2.5	2.0
Savings in Hypo , %	--	--	20	--	20
Consumption , %	94.64	93.88	94.55	94.36	96.49
Final brightness of the pulp, % ISO	76.51	79.47	78.36	78.87	74.27

Hypo stage -2					
Applied Hypo, %	1.0	1.0	1.0	1.0	1.0
Consumption , %	89.8	80.2	80.8	85.9	80.8
Final brightness of the pulp, % ISO	82.7	82.6	82.5	83.6	82.4

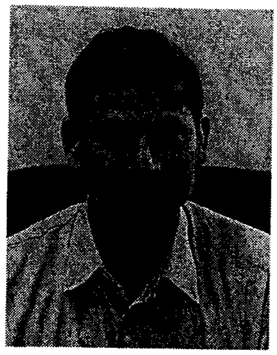
9.0 OBSERVATIONS

- Bench scale experiments on enzymatic prebleaching were conducted with two Identified xylanase enzymes to see the response of the pulp produced at Seshasayee Paper & Boards Ltd., Tamilnadu .
- The results are encouraging .The final pulp brightness improvement is up to1.52. in enzyme treated pulps with same chlorine dose as that of control pulps .
- The Savings in total Cl_2 demand is 16.5% & in elemental chlorine is 16% while targeting the brightness 83.0 % ISO.
- Discussions are made with mill officials regarding the process conditions Selection of equipment for the mixing of enzyme at HD tower will be selected after the techno economical evaluation by CPPRI Scientists & mill technocrats.
- Mill personnel suggested for one month trial for the assessment of techno economical viability of the process in mill scale.

10.0 FURTHER ACTION PLAN

- CPPRI needs large amount of commercial enzyme for one month's trial & and to tie up with suppliers for the supply of enzymes and finalise the terms & conditions etc.
- CPPRI published a advertisement in Hindu Newspaper for a wide publicity among nationwide enzyme suppliers for the selection of a supplier on the basis of quality & cost of the enzyme.
- CPPRI received good response from the leading manufacturers & suppliers in India and a suitable vendor will be selected after the final discussions

STUDIES ON BENCH MARKING / INPUT NORMS IN INDIAN PULP & PAPER INDUSTRY



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Subsequently in December 1990, he joined Central Pulp & Paper Research Institute, Saharanpur as a Scientist. Prior to joining this Institute, he has 3 years of experience in Teaching and Research.

His areas of expertise are Chemical Recovery, Energy Management, Computer Simulation, Energy Audit, Benchmarking, Pinch Technology, Lignin utilization & Byproduct. He has obtained training in the area of Computer Simulation from Czechoslovakia and visited mills in Hungary and Austria. He is credited with 40 research publications in National and International Journals and 20 Technical reports in various fields of pulp & paper.

STUDIES ON BENCH MARKING / INPUT NORMS IN INDIAN PULP & PAPER INDUSTRY

1.0 OBJECTIVE AND BACKGROUND OF THE PROJECT

Fibre, energy, water and chemicals are the important inputs in the manufacture of pulp and paper. In the post liberalization era, with competition in the open market, it has become necessary to achieve the cost effective production while maintaining the quality standard of paper and paper products. Both from the quality aspect and also from the cost of production point of view, it is very important to have some norms of the basic inputs, so that the cost of production is maintained at minimum level without sacrificing the quality of production. Indian paper industry uses wide range of fibers like; cereal, straw, bagasse and forest based raw materials and there is a wide variation in the basic inputs therefore cost of the production is more than what it actually should have been. For instance; for production of 1 tonne of paper, mills are using raw materials from 2 to 3 tonnes and energy used varies from 1000 to 2000 KWhr/t, water consumption from 125M^3 to 400M^3 t/paper, and labour/manpower from 5 to 30. Considering all these basic inputs it is impossible for Indian paper industry to achieve the cost effective production and to survive in the open market with availability of better products at lower prices.

Further, at National level, considering the need for resource conservation particularly chemical, water, and energy, it is very important that industry must adhere to and strive to arrive at some input norms, which are fixed-up considering their cost of production, raw material mix, existing processes, technological status, level of automation & control, impact on environment etc. Industry needs to have certain norms for basic inputs in a documented form. So far for paper sector comprising of large , medium and small industry based on different types of raw materials, no benchmarking/ input norm study has been carried out except some brief studies conducted on energy norms for paper industry. It was also recommended in the Research Advisory Committee (RAC) meeting of CPPRI as well the Cess committee for pulp, paper board and allied products that the Institute must prepare the input norms for basic inputs for paper industry in the form of a document.

2.0 ACTIVITIES AND TECHNICAL PROGRAMME OF THE PROJECT

The Line of Investigation for the project activities involved various steps starting from the selection of mills on the basis of size, raw material used, processes, products etc., mill visits, analysis of data and setting up the norms for the industry.

A set of questionnaire was prepared as data collection sheets to have uniformity in information collection from various mills producing different types of products from varying input materials. The questionnaires were submitted to almost all mills in India for sending information to study the pattern of consumption in different types of industries. Despite repeated reminders to the industry with promise for confidentiality of the data and commitment for no sharing of information with other mills, a very mild response was obtained from the industry for acquiescence of data. Only 35 mills out of 250 mills selected for the study submitted information about their consumption levels. Based on the low feed back from the industry, it was decided that visits should be undertaken to selected mills for collection of information.

In case of mills where no information about inputs was available, systematic collection of data on consumption of raw materials, water, energy, labour etc. per unit of production was taken-up using modern analytical / monitoring tools by manpower available in the institute. This led to collection and compilation of basic input data of different mills and their comparison with best achievable national and international norms. A systematic study was conducted for arriving at the rational baseline data using statistical analysis methods and techniques for different types of mills. Finally a detailed report covering the project studies conducted alongwith benchmarks and input norms for industry is being prepared.

Standard Testing Procedures as a manual for industry have also been prepared which will serve as uniform testing procedures as a prerequisite for the industry to monitor their basic inputs and to study data on the various inputs like; raw materials, energy, water, chemicals etc. The Standard Testing Procedures have been published and are available for the industry.

3.0 BENCHMARKING

Benchmarking is defined as a **"systematic and logical method of improving performance by continuously identifying, understanding and adopting outstanding practices and processes found both inside and outside any organization"**. Therefore, benchmarking is;

- **A measure of best in class performance that has been achieved in reality.**
- **A powerful tool to spot weaknesses and establish improvement goals.**

Benchmarking is a popular management tool used by several European & Non-European Nations to spread good practice across Public & Private sector.

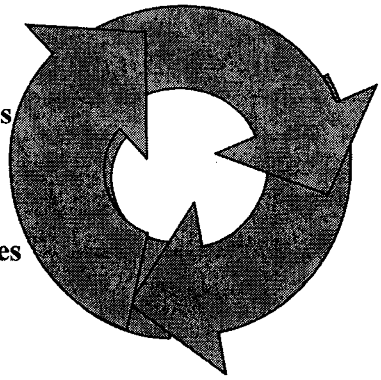


FIG.1- BENCHMARKING - A CONTINUOUS IMPROVEMENT TOOL FOR MANUFACTURING PROCESSES

In private sector benchmarking has traditionally been used to gain competitive advantage through organizational learning and keeping pace with technological advances. Benchmarking helps to

- Identify best achievable practice
- Measure true productivity / cost effectiveness.
- Establish targets and goals,
- Increase performance that is comparable to the best in Industry.

4.0 BENCHMARKING/ INPUT NORM STUDIES FOR INDIAN PULP AND PAPER INDUSTRY

The Indian Paper Industry is characterised by large variations in inputs levels indicating a huge potential to reduce input cost and achieve cost effective production while maintaining product quality. There is a growing need to conserve scarce resources and address environmental issues for sustaining long-term productions. Benchmarking has been successfully applied in the pulp & paper industry in developed nations and resulted in finding-out important factors for the growth and sustainability of the industry, such as;

- Benchmarking the financial performance.
- Cost competitiveness.
- Resource utilisation & energy consumption
- Discharge requirements.
- Strength & weakness of an industry

The project on benchmarking and input norms in Indian pulp and paper industry was taken-up to bring out input norms for different sectors of the industry with main objective to reduce and conserve the scarce resources like; fibre, water, energy and chemicals, so that the industry based on the input norms as a guide line can monitor their level of consumption against some fixed norms. The studies to identify the consumption of basic inputs such as fibre, energy, water and chemicals in Indian pulp & paper industry, would help the industry to identify their process efficiency and ultimately to optimize the inputs and achieve cost competitive production. During project studies, preparation of Standard Testing Procedures as a manual for industry was also taken up as the uniform testing procedures are a prerequisite for the industry to monitor their basic inputs.

CPPRI, during last few years, conducted exercises on resource recovery & conservation in Pulp & Paper industry. The studies on raw material, energy , water conservation and optimisation of chemicals input to the processes have produced excellent results. However, an integrated study on bench marking / input norms for the pulp & paper industry has been carried out in this project.

The data collected from different categories of mills has been analysed and presented with sector specific Input norms and benchmarks. The input norms and benchmarks are compared with the best practice in industry

4.1 Input Norms

The input norms for various pulp and paper industries are shown below;

Proposed Input Norms for Indian Pulp & Paper Industry (Sector wise)

S.No.	Input Norms	Units	WOOD	AGRO	WASTE PAPER
1	Power	kWh/t	1200	1000	700
2	Steam	t/t	9.0	5.8	2.0
3	Water	m^3/t	125	100	15
4	Coal	t/t	2.15	1.25	0.5
5	Chemicals				
	Caustic	kg/t	375	250	-
	Chlorine	kg/t	100	120	-
6	Effluent				
	COD	mg/l	100	230	150
	BOD	mg/l	15	40	35
	SS	mg/l	35	80	50

5.0 BENCHMARKING AND BEST PRACTICE

The data collected from various mills has been analysed and compared with the best practice in pulp and paper sector.

The sector wise details of input norms and their benchmarks are given in tables below.

5.1 For Integrated Pulp & Paper Mills

Basis:
Brightness, ISO % 82
Ash Content, % 10

S. No.	Input Norms	Units	Input Norms	Mill 1	Mill 2	Mill 3
1	Water	m3/t	125	142	110	182
2	Steam	T/t	9	8.42	8.8	9.0
3	Power	KWh/t	1200	1168	1564	1634
4	Coal	T/t	2.15	2.28	2.0	2.25
5	**Chemicals**					
	Caustic	kg/t	260	260	262	500
	Chlorine	kg/t	100	100	100	110
	Lime	kg/t	350	481	533	391
6	**Effluent:**					

	Input Norms	Units	Norms	Best Practices	Mill 1	Mill 2	Mill 3
	BOD	mg/l	30	15	5-15	25-28	24-28
	COD	mg/l	250	175	175-225	230-285	180-220
	SS	mg/l	100	35	30-90	35-45	40-60

5.2 For Packaging Grade paper

Basis:
Burst Factor, 18-26
Tear Factor, 50-80

S.No.	Input Norms	Units	Benchmarks	Mill 4	Mill 5
1	Water	m3/t	100	63	150
2	Steam	T/t	4.3	4.5	4.3
3	Power	KWh/t	600	730	595
4	Coal	T/t	1.5	1.75	1.5
5	**Chemicals**				
	Caustic	kg/t	120	120	149
6	**Effluent:**				

	Input Norms	Units	Norms	Best Practices	Mill 4	Mill 5
	BOD	mg/l	100	76	76	60-150
	COD	mg/l	-	240	240	350-600
	SS	mg/l	100	80	80	110-350

5.3 For Newsprint Grade Paper

Basis:
Brightness, ISO% 65

S.No.	Input Norms	Units		Benchmarks	Mill 7	Mill 8
1	Water	m3/t		90	112	92
2	Steam	T/t		4.5	5.7	4.5
3	Power	KWh/t		1800	2138	1720
4	Coal	T/t		1.25	1.27	1.25
5	**Chemicals**					
	Caustic	kg/t		200	257	160
	Chlorine	kg/t		50	41	60
	Lime	kg/t		150	79	198
6	**Effluent:**					
	Input Norms	**Units**	**Norms**	**Best Practices**	**Mill 7**	**Mill 8**
	BOD	mg/l	30	30	27.4	30
	COD	mg/l	250	180	242	180
	SS	mg/l	100	48	91	48

5.4 For Rayon Grade Pulp

Basis:
Brightness, ISO% 91-95
Ash, ppm 550

S.No.	Input Norms	Units		Benchmarks	Mill 10		Mill 11
1	Water	m3/t		110	145		118
2	Steam	T/t		6	4		11
3	Power	KWh/t		650	650		990
4	Coal	T/t		1.0	1.00		.85
5	**Chemicals**						
	Caustic	kg/t		100	80		236
	Chlorine	kg/t		40	40		51
	Lime	kg/t		300	145		350
6	**Effluent:**						
	Input Norms	**Units**	**Norms**	**Best Practices**	**Mill 10**		**Mill 11**
					Non Color	**Color**	
	BOD	mg/l	30	20	<20	<50	22
	COD	mg/l	250	50	<50	<300	275
	SS	mg/l	100	25	20-30	30-50	44

6.0 PROCESS BENCHMARKS

The process variables which significantly control the product quality and cost competitiveness have also been benchmarked for the various sectors of pulp and paper industry. These benchmarks would help as guideline to follow the consumption pattern in industry.

The benchmarks are specific to the industry using various raw materials in their furnish and processes employed in pulp and paper manufacturing. The benchmarks can differ from industry to industry, however, some general figures are arrived at to address the importance of variables for the industry to benchmark their processes and process variables.

PULPING		Benchmark		
Process		Hardwood for Wr/Pr Kraft	Agro for Wr/Pr Soda/AQ	Agro for Packaging Soda
Steam consumption	t/t	1.6	2.0	2.0
Electrical consumption	kWh/t	40	55	27
Bath ratio		01:02.5	01:03	01:03
Maximum temperature	deg C	165	165-170	165
Cooking cycle	hrs	5.5	4.0	3.0
White Liquor charge as Na_2O	%	18	14	10
Sulphidity	%	16-18	- -	-
Pulp Kappa Number		18-20	12-14	16-17
Screened yield	%	48	46-48	52

BLEACHING		Benchmark	
		Hardwood for Wr/Pr	Agro for Wr/Pr
Sequence		CEpH	CEpH
Steam consumption	t/t	0.55	1.1
Electrical consumption	kWh/t	125	120
Bleached pulp yield	%	43-45	38-40
Final brightness	% ISO	82-84	80
Chlorination			
Chlorine	%	6	5.5
pH		2-2.2	2-2.5
Temperature	Deg C	Amb	Amb
Retention time	hrs	0.75	0.75

Consistency	%	3	3
Alkali Extraction			
Alkali	%	3-3.5	3.0
H_2O_2	%	0.5	0.4-0.5
pH		10-11	10-11
Temperature	Deg C	65-70	60-65
Retention time	hrs	1.5	60-65
Consistency	%	10	9
Hypo		**H1**	
Hypo	%	3.5	4.0
pH		9-9.5	9.5
Temperature	Deg C	40-42	40-45
Retention time	hrs	2.0	2.0
Consistency	%	10	9

STOCK PREPARATION		Benchmark		
		Hardwood for Wr/Pr	Agro for Wr/Pr	Agro for Packaging
Refiner	Unit	DDR	DDR	DDR
Initial Freeness	°SR	18-21	16-18	20-24
Consistency	%	4.5	4.0	3.5-4
Refining power	kWh/t paper	65	75	60
Power consumption	kWh/°SR	8-10	10-11	6-8
Final freeness	°SR	30-35	30-35	30

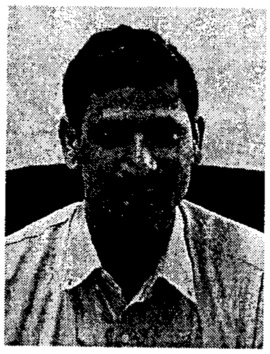
PAPER MACHINE		Benchmark		
		Hardwood for Wr/Pr	Agro for Wr/Pr	Agro for Packagin g
Type		MG/MF	MG/MF	MG/MF
Capacity utilisation	%	95	95	85-90
Condensate recovery	%	97	85-90	85-90
Dryness after couch roll	%	20-22	20-22	20
Dryness after press	%	38-43	38-40	37-40
Dryness before size press/Final Dryness*	%	96	94*	93*
Steam consumption	t/t	3.5	4.0	3.5
Electrical consumption	kWh/t	400	400	400

CHEMICAL RECOVERY		Benchmark	
		Hardwood for Wr/Pr	Agro for Wr/Pr
Weak black liquor			
Solids	%	17-18	14-16
RAA	gpl	5.5-6.0	4.5
Calorific value	kcal/kg ds	3100-3300	3200-3500
Evaporator (LTV / FF)			
No. of effects	Number	5+1	5+1
Steam economy		50-5.5	4.8-5.0
Recovery boiler			
Firing solids	%	70	65
Reduction efficiency	%	92-94	92-94
Steam generation	t/t of B.L.solids	3.5	3.5
Causticization			15-20
Green Liquor concentration	gpl	105	105
Lime cons. at 100% purity	kg/t pulp	62-65	60-65
Causticization efficiency	%	88	88
Weak liquor concentration			
Lime Kiln			
Furnace oil	lt/t	110	-
Lime production	t/t of paper	2.5-3.0	-
Lime sludge dryness		64-65	-

7.0 CONCLUSION

Paper industry which is facing intense competition from global pulp and paper market has to face the challenges varying from resource utilization, cost competitiveness, and product quality comparable with manufacturers from other countries. The mills therefore need to achieve world-class performance with reduced cost of production and increased customer satisfaction. This is possible by a focused and competitive assessment of their resources and their best utilization. Many mills in India have taken up many developmental projects through expansion and modernization and are striving hard to improve. However, very few mills are aware of the need and action to be initiated with a careful understanding of the best practices being followed in the country and the world over. Benchmarking exercise conducted in this sector would help the industry to achieve improved performance, particularly in the areas of efficiency, operation and quality improvement and thus competitive advantages. The studies would be helpful for mills to identify good practices and opportunities for improving performance and achieve excellence.

ENERGY PERFORMANCE EVALUATION & OPTIMIZATION IN PULP & PAPER INDUSTRY



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Subsequently in December 1990, he joined Central Pulp & Paper Research Institute, Saharanpur as a Scientist. Prior to joining this Institute, he has 3 years of experience in Teaching and Research.

His areas of expertise are Chemical Recovery, Energy Management, Computer Simulation, Energy Audit, Benchmarking, Pinch Technology, Lignin utilization & Byproduct. He has obtained training in the area of Computer Simulation from Czechoslovakia and visited mills in Hungary and Austria. He is credited with 40 research publications in National and International Journals and 20 Technical reports in various fields of pulp & paper.

ENERGY PERFORMANCE EVALUATION & OPTIMIZATION IN PULP & PAPER INDUSTRY

1.0 BACKGROUND

Paper Industry is one of the highly energy intensive industry. Consumption of energy is considerably high in Indian paper industry as compared to developed countries. On an average, energy inputs contribute more than 30% towards cost of production. The energy cost component is today dictating the cost of production and the Indian paper industry is facing tough challenges of competition in the "Global Market".

The high energy consumption in Indian mills is due to various factors such as mill integration, its design, processes & equipments in addition to the raw materials and product mix, capacity utilization & size of the plant. The absence of modernisation has also resulted in poor energy efficiency of the Indian mills. Besides, the lack of energy efficient process technologies, lack of energy monitoring & reporting is also one of the reason for high-energy inefficiency. In many mills un-optimised process operations without energy accounting result in large amount of energy wastage, which can be tapped by following simple measures thereby saving considerable energy.

Studies conducted by CPPRI during last decade have revealed that there is potential to save upto 15% energy in Indian pulp & paper mills by following simple energy management practice. Adopting energy management practices in a paper mill is a well planned programme with actions aimed at reducing the organisation's energy bills & minimizing the detrimental environment input.

2.0 OBJECTIVE

The energy management programme under the project has two central energy management strategies.

1. Conservation: Avoiding the wasteful energy use and reduction in demand for energy consuming process.
2. Efficiency: Improvement of energy efficiency in paper manufacturing by optimization and introduction of more efficient equipment and systems. Thereby reducing operating energy cost, while maintaining consistent product quality.

As a successful energy management exercise, energy audits were conducted in various mills for collecting energy data, report their energy performance and enable the organizations to have an overview of energy use and its related cost, as well as facilitating the identification of savings that might otherwise not be detected. These studies under the project resulted in :

- Demonstration of savings, which could otherwise be difficult to identify.
- Benchmark energy performance of process and identify anomalies, specially poor performance processes for priority attention.
- Track and trend consumption and demand to monitor process performance and
- Provide decision support to various levels of management to facilitate the managerial activities pertaining to planning, organizing, directing and controlling energy management functions.
- Creation of general awareness of various levels of management.

3.0 SUMMARY OF THE PROJECT

The project study on Energy performance evaluation & optimisation in pulp & paper industry has been initiated with the intention of studying the energy performance of paper industry.

The consumption of energy in Indian mills varies depending on the mill integration, its design of processes and equipment, raw material, product, size of the plant etc. The energy consumption figures are much higher in Indian mills than the norms. The high cost of excessive energy used by most of the Indian mills makes the economic evaluation of conservation measures reasonably straight forward for cost effective production.

Implementation of energy management programmes in mills of different categories with different sizes, different raw materials, products, mill layout, design of processes & equipment etc makes it quite difficult. A uniform methodology can not be applied in all the mills for energy management activities.

The study was taken-up to follow and implement the improved energy management practices in some selected mills from different categories for; energy performance evaluation in their major processes, to identify main areas of energy wastages in various sections, to suggest measures for minimising the energy losses and improving energy efficiency.

4.0 WORK CARRIED-OUT

4.1 Energy Audit

Detailed diagnostic energy audit of representative plants from different categories of mills was conducted. The Audit was based on collection of energy & material data beginning from raw material to the finished product, fuel & power utilization defining the energy flows within different processes & generating energy balances in different sections. Since the structure of the industry is complex & the energy audit structure developed for one mill could not be applied to another mill, ample scope was provided during the study for unit operations as per the mill lay-out.

4.2 Performance Evaluation

Collected data was analysed for the over all efficiency of the mill as well as for the particular process over a period of time and these were compared with the standard norms.

This brought into consideration various operating procedures, maintenance procedures and system modification requirements.

4.3 Recommendations

Based on evaluation of energy audit data, recommendations were made by some simple, short and medium and long term measures for energy conservation to minimize energy use and maximizing recovery of energy & material utilisation.

4.4 Implementation

Various recommended energy conservation proposals have been implemented in various mills after getting approval from the mill management.

4.5 Follow-up

Monitoring and follow-up will start after the implementation activities are completed. Technical data will be collected again and compared with the targets.

5.0 OUTPUTS OF THE PROJECT

For project activities, more than fifty paper mills were contacted and Energy Audit proposals were submitted. Response was received from the following mills and energy audits were conducted in these mills.

- Seshasayee Paper and Boards Ltd. , Erode ,T. N.
- TNPL, Karur Distt, Tamil Nadu
- Shreyans Industries Ltd., Ahmedgarh, Punjab
- Kalptaru Papers, Ahmedabad
- Well Pack Industries, Ahmedabad
- Rainbow Papers Ltd, Ahmedabad
- Kailash Paper Mills Ltd, U.P.
- Karan Paper Mills Ltd., Ahmedabad
- Shelavi paper Mills Ltd., Ahmedabad
- BILT, Ballarshah

Subsequent to mill visits, a detailed report covering following items has been prepared and submitted to the mills:

- Energy generation, distribution & consumption pattern within the mill based on a detailed energy audit exercise.
- Energy data & technical data analysis (section wise/process wise).
- Recommendations on energy conservation options & their overall implications on the energy pattern of the mill

Energy audits will be taken-up in following mills in the month of May and June, 2003.

- Sirpur Paper Mills Ltd
- Madhya Bharat Paper Mills Ltd.
- Emami Papers Ltd
- Yash Paper Mills Ltd
- Simplex Paper Mills Ltd.
- Navrang Paper Mills, Pune
- Shreyash Paper Mill, Dandeli

The recommendations have been submitted with following saving potentials. Many mills are implementing the suggestions and a follow up study will be taken up finally when we have finished studies in all selected mills.

Mills	Savings
Seshasayee Paper and Boards Ltd.,Erode, T.N.	Rs. 12 Crores per annum
Tamil Nadu Newsprint and Papers Ltd.,Karur, T.N.	14 Energy Saving Recommendations submitted
Shreyans Industries Ltd., Ahmedgarh ,Punjab	Rs. 2 Crores per annum
Kalptaru Papers Ltd., Ahmedabad Gujrat	Rs. 4.3 Crores per annum
Rainbow Papers Ltd, Ahmedabad, Gujrat	Rs. 0.49 Crores per annum
Well Pack Papers & Containers Ltd., Ahmedabad ,Gujrat	Rs. 0.90 Crores per annum
Kailash Papers,Unit Kailash Industries Ltd., Aghwanpur, U.P.	Rs. 0.66 Crores per annum

6.0 PRACTICAL IMPORTANCE OF RESULTS OF STUDIES UNDERTAKEN

The high energy consumption in Indian mills is due to various factors such as mill integration, its design, processes & equipments in addition to the raw materials and product mix, capacity utilization & size of the plant. The absence of modernization has also resulted in poor energy efficiency of the Indian mills. Besides, the lack of energy efficient process technologies, lack of energy monitoring & reporting is also one of the reasons for high-energy inefficiency. In many mills un-optimized process operations without energy accounting results in large amount of energy wastage, which can be tapped by following simple measures thereby saving considerable energy. This has been indicated in the studies conducted under the project activities that mills can save substantial amount of energy by following very simple energy management practices and optimization of processes can result in improvement of product quality with significant energy savings. The exercises conducted would set an example for paper industry to achieve energy efficiency.

CALIBRATION & INTRALABORATORY QUALITY ASSESSMENT SERVICE FOR PULP PAPER AND ALLIED INDUSTRIES (CESS/IPMA PROJECT)

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CALIBRATION & INTRALABORATORY QUALITY ASSESSMENT SERVICE FOR PULP PAPER AND ALLIED INDUSTRIES (CESS/IPMA PROJECT)

Y. V. Sood, P. C. Pande, Suhail Akhtar Rao, Nisha, Arti Pandey

SUMMARY

Quality of any end product has become one of the most important factor in global trading. Evaluation of quality is closely linked with the proper calibration of the testing machines. Finish Pulp & Paper Research Institute, Helsinky & PIRA in UK etc. have been providing calibration service to the pulp and paper mills in their countries for quit long time. This helps the mills to ensure correct evaluation of pulp, paper & chemicals etc. It generates a confidence among the users. In India many of the pulp & paper mills have very old & obsolete testing machines. Many of their machines need to be repaired. For ensuring the accurate performance these machines need regular calibration & performance check.

Under the present project, calibration services similar to PIRA UK will be provided to the mills. As a first step, the Institute has procured, installed and commissioned instruments like Digital tear tester, programmable thickness tester having Statistical evaluation facilities. To improve the performance of existing instruments an Auto work station is also being procured. The institute has also got rechecked all of the paper instruments by M/s Elof Hansson (Sweden) for their satisfactory functioning. Seven mills have been requested to send the paper samples for evaluation and to be used for preparing the calibration check samples. These samples will be evaluated to check the standard deviation within lab to evaluate the warning limit and action limit ranges. Work is in progress.

DETOXIFICATION OF BLEACH PLANT EFFLUENT FOR RECYCLING & REUSE

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About The Author

Dr .S. Panwar is a senior scientist working in Environmental Management Div of CPPRI for the last twenty years. He has Masters Degree in Chemistry and has Doctoral degree in Pulp & Paper Chemistry.

He has a rich and wide experience in the area of pulping & bleaching, environmental management including bioenergy recovery from wastes, performance evaluation and trouble shooting of effluent treatment plants, environmental auditing etc. He has been responsible for commissioning of full-scale biomethanation plant for recovery of bioenergy from black liquor. He has been actively associated with the projects completed on behalf of CPCB like "Development of Standards of AOX for Large and Small Scale Pulp & Paper Mills" & "Standardization of Methods for Determination of AOX in Environmental Samples".

He has undergone an advanced training at Finland and Sweden on microbial aspects and application of biomethanation technology in pulp and paper industry. He has also been actively associated with prestigious projects sponsored by UNDP, MNES, and mill associations like IARPMA, IPMA etc. He has represented CPPRI at various national & International Conferences and Seminars. He has around 30 publications to his credit and has been author/ co-author of a number of R& D reports, training and course manuals.

DETOXIFICATION OF BLEACH PLANT EFFLUENT FOR RECYCLING & REUSE

1.0 BACKGROUND

The bleaching of pulp with molecular chlorine has become a major environmental concern since it produces a various chlorinated phenolics, dioxins and furans which are highly toxic, and have tendency to accumulate and persist in environment for a long time. The reduction of these chlorinated phenolic compounds at source involves the adoption of new environmental friendly technologies like extended and oxygen delignification, ECF& TCF bleaching etc. The pulp mills abroad have adopted these new technologies to reduce the levels of chlorinated phenolic compounds below toxicity level . However, Indian Pulp & Paper Industry continue to use conventional pulping and bleaching technologies and use high dosages of elemental chlorine resulting in the generation of high level of chlorinated phenolic compounds as the low scale of operation, use of mixed raw materials and high capital restricts the Indian mills to adopt these new technologies.

In the changed scenario of open market economy , increasing environmental awareness & imposition of stringent discharge standards, the Indian pulp and paper mills are at the cross roads .The immediate alternatives / options available are to explore the feasibility of end of pipe treatment methods for treatment of bleach plant effluents to reduce the toxicity to make them suitable for recycling as well as for discharge to the recipient body. The advantages of detoxification of bleach plant effluent are double fold i.e. on one hand it will reduce the pollution load and on the other hand it will help in increased recycling / reuse of bleach plant effluent within the process thus helping the industry in reducing water consumption.

2.0 OBJECTIVE

The present studies are aimed to evaluate technoeconomic feasibility of end of pipe treatment (EOP) methods i.e. physico-chemical methods for treatment of bleach plant effluent in order to reduce the pollution load and its toxicity so as to make it compatible for recycle/reuse in the process.

3.0 WORK PLAN

- Literature Survey
- Characterization of bleach plant effluent from individual bleaching stage and combined bleach plant effluents for various pollutional parameters.
- Optimization of treatment condition for various combination of chemicals for removal of toxic materials.
- Evaluation of toxicity level of treated and untreated bleach plant effluent to the aquatic organisms.
- Evaluation of efficiency and viability of chemical and physical methods for removal of toxic material from bleach plant effluent.

- Identification of chlorinated phenolic compounds present in bleach plant effluent.
- Evaluation of biological treatment methods for removal of toxic material from treated and untreated bleach plant effluent.
- Explore the possibility of recycling / reuse of treated bleach plant effluent to the process.

4.0 ACTIVITIES CARRIED OUT

4.1 Literature Survey

An exhaustive literature survey has been made on status of various technologies involving pulping and bleaching process, pulp washing ,recycling ,end of pipe treatment methods including chemical and physical methods at source reduction. etc. These end of pipe (EOP) treatment methods include use of different chemicals individually and in combination as well, ultrafiltration, reverse osmosi, desalination etc. However the applications of most of these EOP methods have been in the mills abroad which has resulted in considerable reduction in pollution load and toxicity which has led to significant reduction in water consumption . Literature reveals that due to techno-economic constrains of EOP methods ,most of the mill abroad have gone for new fibre line involving modern pulping and bleaching technologies to reduce pollution loads at source rather than at end of pipe treatment. Moreover, most of the studies conducted in developed countries have been related to ECF & TCF bleached effluents which are less toxic and easy to handle as compared to effluents generated in conventional bleaching process and thus promoted the closed water cycle concept in these mills. However no information is available on application of such technologies for treatment of bleach plant effluents in Indian context.

4.2 Characterisation Of Bleach Plant Effluents

Bleach plant effluents generated in laboratory and also collected from an agro based and a wood based mill using chlorine based conventional bleaching sequences were characterised for various pollutional parameters as indicated in **Table 1 & 2.**

4.3 Detoxification Of Bleach Plant Effluent

In accordance with the work plan the detoxification studies were carried out with a two way approach .i.e.

- Chemical treatment methods (Precipitation, Coagulation, Oxidation etc.) and
- Physical treatment methods (Electrofloculation, Membrane filtration & Adsorption techniques)

4.4 Chemical Treatment Studies

The studies were focused mainly to optimize the dosages, treatment conditions, combination of chemicals to reduce the level of toxic material in bleach plant effluent. The various chemicals generally used by industry were tried individually & in combination to evaluate their response in reducing the chlorinated phenolic compounds. The response of various chemicals used for treatment of bleach plant effluent are tabulated in **Table – 3 & 4.** The results indicate that chemical treatment is quite effective and the reduction in COD, AOX and colour achieved was 50-80%, 50- 81% and 83-97% respectively.

The **preliminary economics** of the chemical treatment indicates that the cost of treatment of C, E & combined bleach effluent of **wood based mill** is approximately Rs. 150-200 / t_{pulp}, Rs 250-350 / t_{pulp} & Rs 300-450 / t_{pulp} respectively while in case of **agro based mill** it is around Rs. 250- 400 / t_{pulp}, Rs 150-350 / t_{pulp} & Rs 400- 650 / t_{pulp} respectively.

However , the main **limitations** observed in chemical treatment are :

- Increase in TDS concentration of treated effluent
- Settleability of precipitated sludge
- Disposal of precipitated sludge

4.5 Physical Treatment Methods

The physical treatment methods involves the use of membrane filtration, electro-flocculation and adsorption techniques for treatment of waste water

4.6 Electro-flocculation

Electrofloculation studies were carried out in a lab fabricated electrolytic cell . The alkaline extraction stage bleach effluent was treated using Electrofloculation technique. The results obtained are indicated in **Table -5**

The results obtained in laboratory have been found encouraging and the reduction in COD, AOX & Colour achieved was 60%, 67% & 88% respectively. The main advantage of Electrofloculation technique is easy and effective separation of lignin at very lower input of electric current.

4.7 Membrane Filtration

The bleach plant effluents (C-stage, E-stage, H-stage & combined) were fractionated into various fraction through membrane filtration using different cut-off values of membranes like 1,000 , 3,000 , 10,000 , 30,000 and 100,000 D.The aim of the membrane filteration was to make the mass balance of various AOX fractions present in the bleach effluent. The permeate and concentrate obtained were analysed for various pollutional parameters including toxicity and AOX. The results of various molar fractions and reduction in colour, COD & AOX are depicted in **Fig. 1 - 4**. The mass balance of AOX in different bleach plant effluent is indicated in **Fig. 5 - 8.**

4.8 Carbon Adsorption

In the other study, the carbon adsorption technique was evaluated for treatment of the alkali extraction bleach filtrate (E-stage) collected from a wood based mill. The studies were aimed to evaluate the adsorption efficiency as well as the saturation point of activated carbon in order to achieve maximum removal of colour, COD and AOX.

A known amount of bleach effluent was passed through the carbon bed and elute were collected in batches. The treated sample of each batch was analyzed for COD, colour and AOX reduction. The results obtained are shown in **Fig. 9.**

The results indicate that the adsorption efficiency of activated carbon decreased with increased use of carbon bed and the reduction in AOX was decreased from 90% to 40% after fifth batch/cycle.

4.9 Toxicity Of Bleach Plant Effluent

4.9.1 Fish Toxicity

Toxicity of bleach plant effluents (C-stage, E-stage, H-stage & combined) collected from a wood based mill were determined by using LC_{50} bioassay technique in lab scale aquarium using fish. The results are indicated in **Fig.10**.

Further the toxicity studies were carried out of the E - stage bleach effluent after chemical treatment with alum and lime. The studies indicate that the mortality rate reduced from 100% (without treatment) to 0% after chemical treatment (i.e. fish survived even after 24 hrs of exposure)

4.9.2 Microtox Toxicity

Toxicity inhibition response of bleach plant effluents (C-stage, E-stage, H-stage & combined) on Luminescent bacteria was determined by using Microtox Toxicity Analyser. The results obtained are shown in **Fig. 11**. The bioassay techniques indicates the inhibition caused by toxic materials to the lower organisms.

4.9.3 Identification Of Chlorinated Phenolic Compounds

The procedures were standardized for identification of these chlorophenolic compounds in bleach plant effluents by gas chromatograph. The standard calibration curve for various reference-chlorinated compounds were also prepared in order to identify and quantify of various chlorinated phenolic compounds present in bleached plant effluents. Identification of chlorinated phenolic compounds in bleach plant effluent before and after chemical treatment and membrane filtration were carried out by Gas chromatographic techniques. Ten to twelve phenolic compound have been identified in bleach plant effluents.

4.9.4 Observation

- The bleach plant effluent is one of the main environmental concern in the mills particularly in large pulp and paper mills.
- The discharge of AOX in Indian mills is comparatively very high as most of these mills use high dosages of chlorine based bleaching chemicals to achieve the desired brightness.
- Adoption of modern technologies to reduce AOX and other pollutants are capital intensive and so most of the Indian mills need to expand their pulp mill capacity to make these technologies viable.
- The high level of AOX, COD, colour and inorganic salts restricts reuse of bleach plant effluent into the internal process.
- Combination of chemicals have been found effective in reduction of pollution load and reduction in COD, AOX and colour achieved was around 50-65%, 60-80% and 65-85% respectively. However, an increased level of TDS in treated effluent was observed.
- The chemically precipitated sludge contains around 90% organics which may be incinerated in boiler or lime kiln.
- Membrane filtration of bleach plant effluent indicates that around 40% of molar mass of chlorinated phenolics are below 3000 D and 43% of molar mass is having molecular weight more than 100,000 D.
- Electrofloculation technique used in laboratory for treatment of bleach plant effluent has been found more effective in removing of colour, COD and AOX at lower rate of electric consumption. However, the technique needs to be demonstrated on mill scale.
- The bleach plant effluent has been found toxic to test fish and bacteria used to measure the inhibition /toxicity .
- Chemical treatment of bleach plant effluent reduce the toxicity and no fish toxicity was observed after chemical treatment of bleach pant effluent.

5.0 QUANTIFIED DELIVERABLES OF THE PROJECT

- The project studies will generate data based information on techno-economic viability including limitations of physico- chemical methods to reduce the level of AOX in mill effluents.
- Studies will also help the pulp and paper mills to reduce the toxicity of bleach plant effluent in order to improve overall performance of their existing ETP to reduce the pollution loads.
- The mills will also be benefited by exploring the potential of recycling of treated bleach effluent to the process without having any adverse impact on process and quality of the product.

TABLE NO.- 1

CHARACTERIZATION OF BLEACHED PLANT EFFLUENT COLLECTED FROM WOOD BASED MILL

Parameters	C-stage	E-stage	H-stage	Combine bleach effluent
pH	2.5	7.0	6.6	5.0
T.S. , mg/l	3200	3460	6940	2970
T.D.S., mg/l	1470	3430	6820	2900
T.S.S., mg/l	1789	40	110	181
COD mg/l	490	1598	1020	1411
BOD mg/l	160	391	350	414
Chloride mg/l	759	766	2537	1089
Colour, PCU	305	3460	424	2750
Organic, %	46.0	42.7	42.7	44.3
Inorganic, %	54.0	57.3	57.3	55.7
Lignin, mg/l	96	595	158	390
AOX, mg/l	41.4	87.9	70.5	50.7

TABLE NO. 2

CHARACTERIZATION OF BLEACHED PLANT EFFLUENT COLLECTED FROM AGRO BASED MILLS

Parameters	C-stage	E-stage	H_1-stage	Combine bleach effluent
pH	2.5	10.2	7.1	7.8
COD mg/l	971.96	1488.96	1985.28	1158.08
BOD_3 mg/l	225	310	808	402
T.S. mg/l	1602	2320	4309	2162
T.S.S., mg/l	183	201	180	230
T.D.S., mg/l	1419	2119	4129	1932
Colour, PCU	136	3760	152	1310
AOX (mg/l)	70.39	75.95	47.70	54.97
Lignin, mg/l	97.11	505.3	72.0	232.6
Chloride,(mg/l)	749.77	339.89	1437.05	562.33
Organic, %	50.3	45.5	47.8	41.0
Inorganic, %	49.7	54.5	52.2	59.0

TABLE-3

CHEMICAL TREATMENT OF BLEACHED PLANT EFFLUENT (AGRO BASED MILL)

Parameters	C-stage effluent	E-stage effluent	Combined bleach plant effluent
(A) Effluent Characteristics			
pH	1.8	7.1	6.6
COD mg/l	3528	2307	2883
AOX mg/l	48.2	125.3	50.02
colour, PCU	3372	6778	3689
(B) Chemical Dosages			
Alum : COD	1:1	0.5:1	1:1
Lime : COD	1.5 : 1	0.5:1	1.5:1
PAA, ml/l (1% solution)	-	2.0	2.0
(C) Treated Effluent Characteristics			
pH	5.5	5.6	5.0
COD mg/l	1033	438	542
AOX mg/l	23.82	62.2	21.06
colour, PCU	145	246	156
(D) Removal Efficiency, %			
COD	71	81	81
AOX	51	50	57
Colour	95	96	96

TABLE-4

CHEMICAL TREATMENT OF BLEACHED PLANT EFFLUENT (WOOD BASED MILL)

Parameters	C-stage effluent	E-stage effluent	Combined bleach plant effluent
(A) Effluent Characteristics			
pH	2.0	9.0	6.4
COD mg/l	851	3048	612
AOX mg/l	46.16	134.0	37.8
colour, PCU	392	11320	1048
(B) Chemical Dosages			
Alum : COD	1:1	0.5:1	1:1
Lime : COD	0.75 : 1	0.5:1	1:1
PAA, ml/l (1% solution)	1.0	10.0	2.0
(C) Treated Effluent Characteristics			
pH	5.5	5.5	5.5
COD mg/l	240	596	306
AOX mg/l	18.14	25.43	13.23
colour, PCU	67.0	363	61.0
(D) Removal Efficiency, %			
COD	72	80	50
AOX	61	81	65
Colour	83	97	94

TABLE-5

TREATMENT OF BLEACH PLANT EFFLUENT THROUGH ELECTROFLOCULATION (WOOD BASED MILLS)

Particulars	Untreated Eop effluent	Treated Eop effluent 2 Lit. volume	% Reduction	Treated Eop effluent 5 Lit. volume	% Reduction
pH	11.7	9.3	-	8.5	-
COD, mg/l	1159	395	66	458	61
BOD, mg/l	178	69	61	105	41
AOX, mg/l	42.8	10.5	76	14	67
Colour, PCU	1133	60	95	135	88
Power consumption Watt h. / l	-	21	-	11.6	-

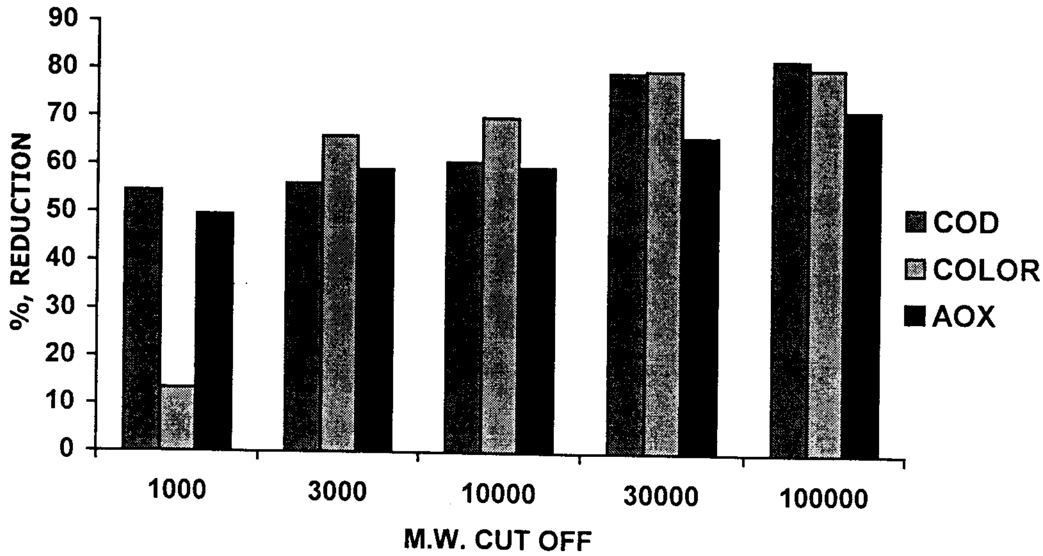


FIG. 1- MEMBRANE FILTRATION OF C STAGE FILTRATE (WOOD BASED MILL)

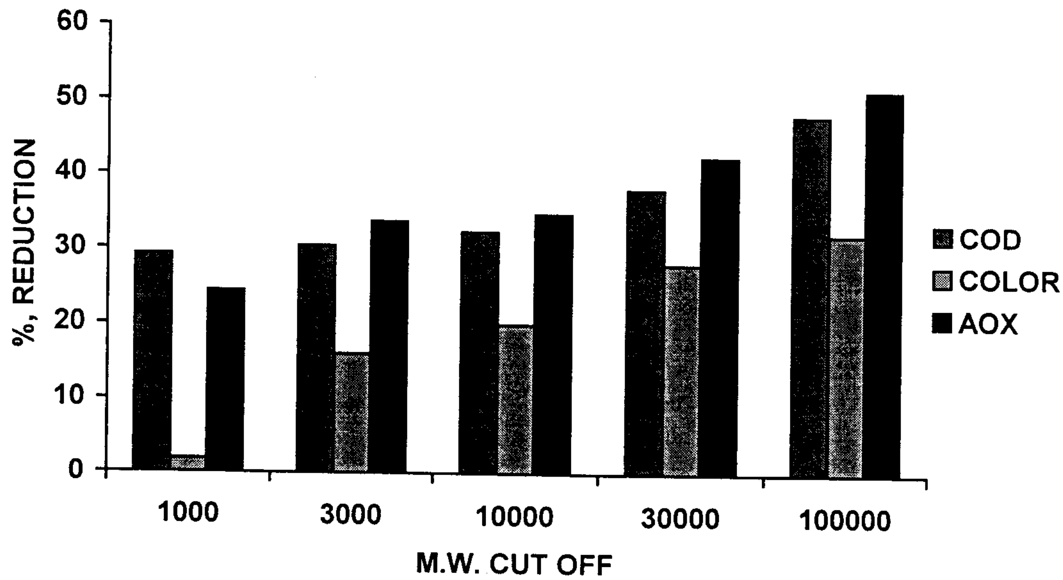


FIG.2- MEMBRANE FILTRATION OF E STAGE FILTRATE (WOOD BASED MILL)

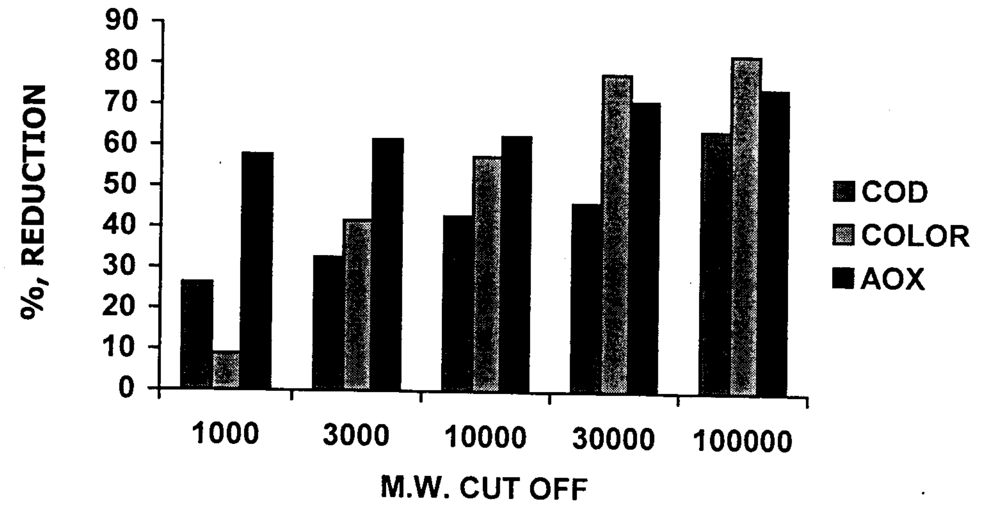


FIG. 3 - MEMBRANE FILTRATION OF H - STAGE FILTRATE (WOOD BASED MILL)

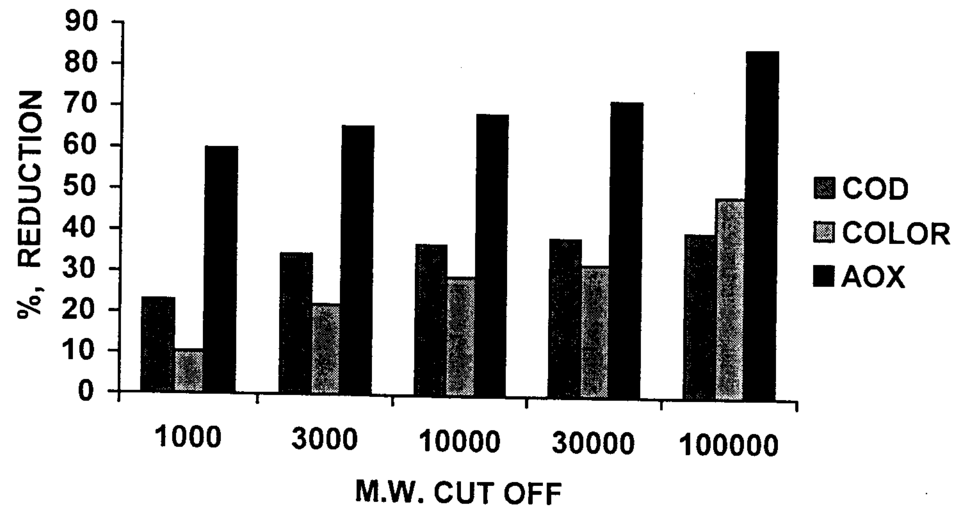


FIG. 4- MEMBRANE FILTRATION OF COMBINED BLEACH EFFLUENT (WOOD BASED MILL)

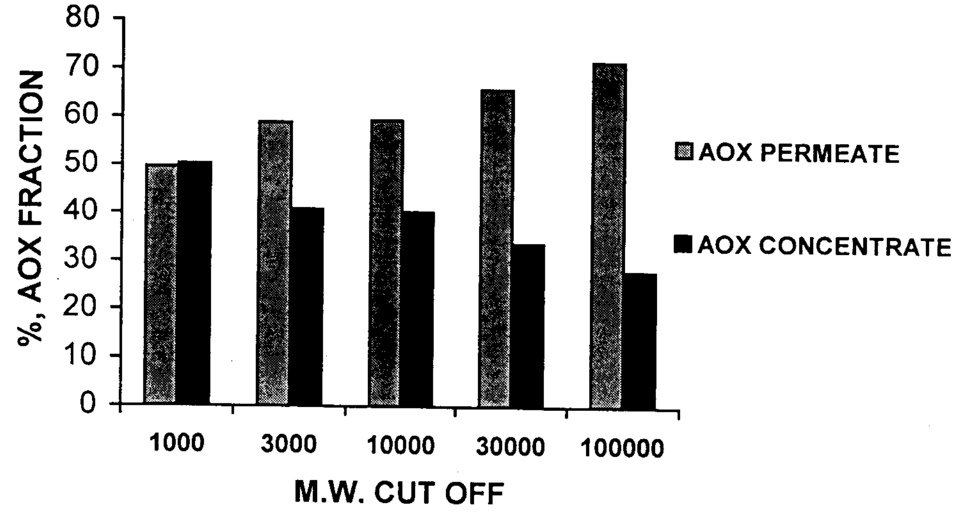


FIG. 5 - AOX BALANCE - C STAGE FILTRATE (WOOD BASED MILL)

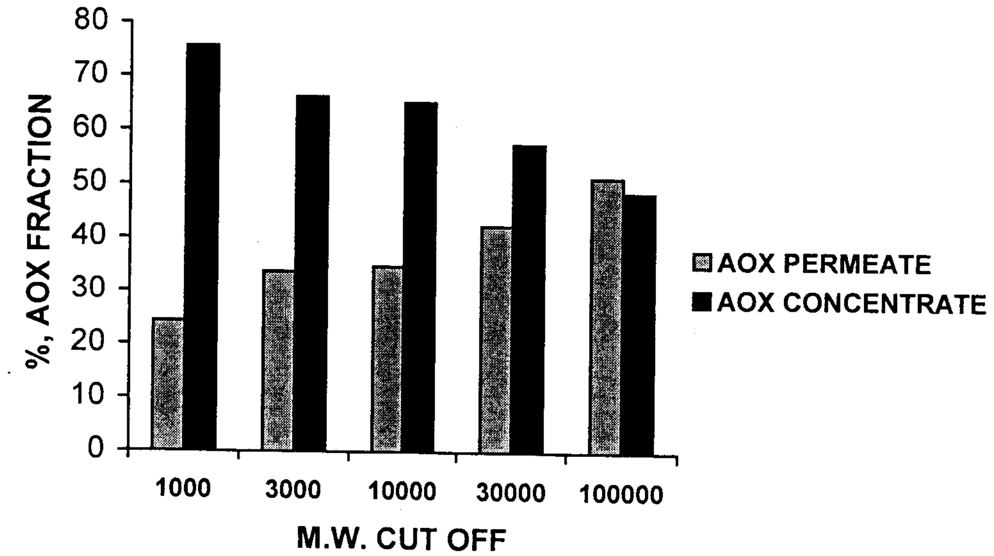
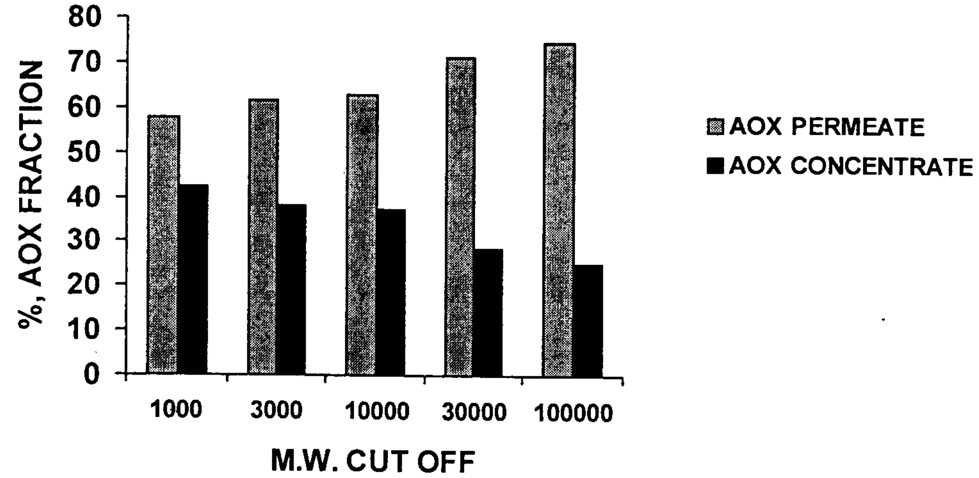


FIG. 6 - AOX BALANCE- E STAGE FILTRATE (WOOD BASED MILL)

Fig. 7- AOX BALANCE - H STAGE FILTRATE (WOOD BASED MILL)



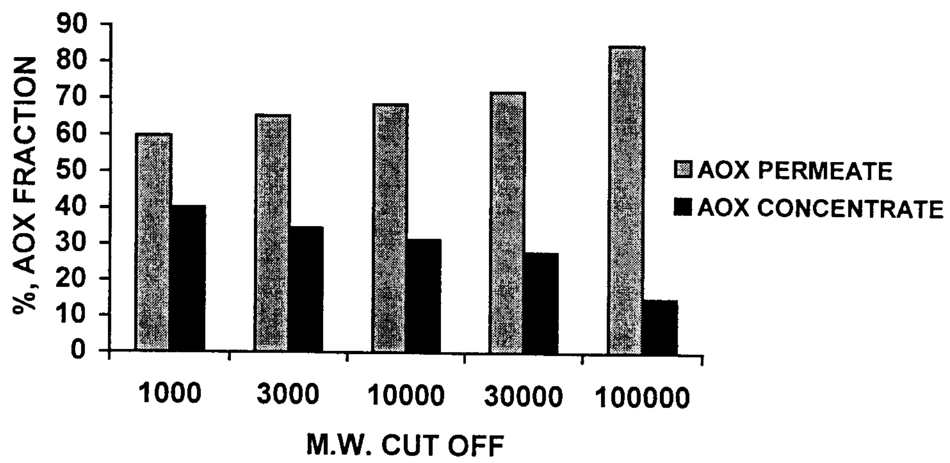


FIG. 8- AOX BALANCE - COMBINED BLEACH EFFLUENT (WOOD BASED MILL)

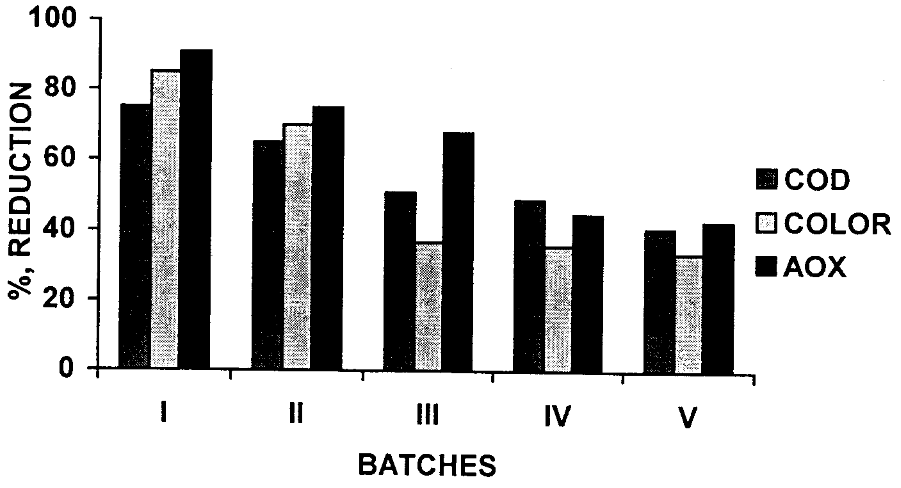
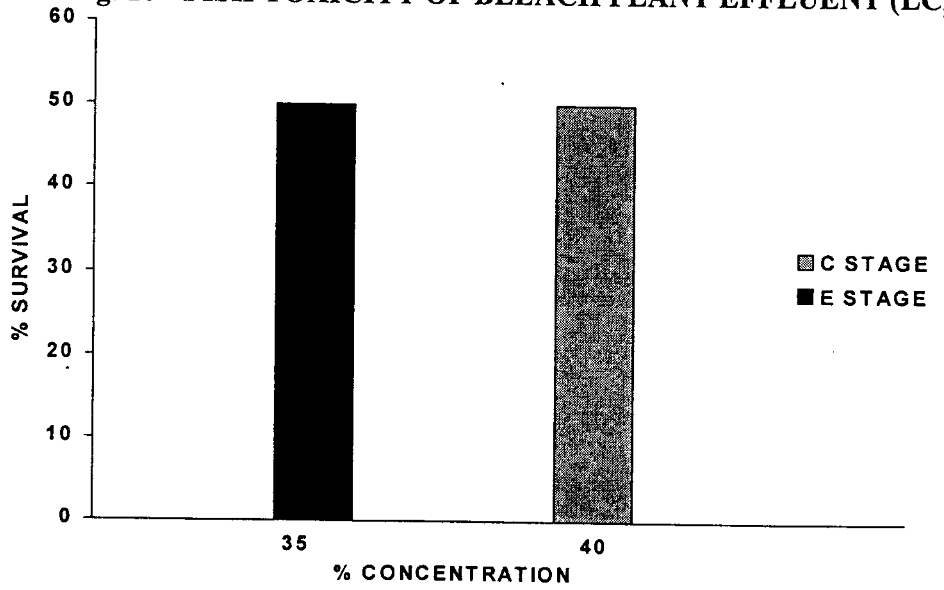


FIG. 9- RESPONSE OF ACTIVATED CARBON - E STAGE FILTRATE (WOOD BASED MILL)

Fig. 10 - FISH TOXICITY OF BLEACH PLANT EFFLUENT (LC_{50})



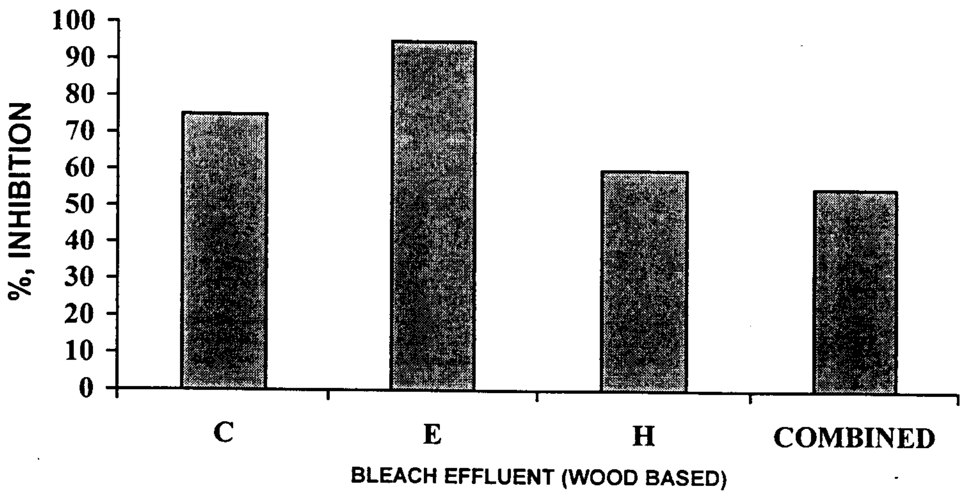


FIG. 11 - MICROTOX TOXICITY- LUMINESCENT BACTERIA

WATER CONSERVATION IN PULP AND PAPER INDUSTRY

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About The Author

Dr .S. Panwar is a senior scientist working in Environmental Management Div of CPPRI for the last twenty years. He has Masters Degree in Chemistry and has Doctoral degree in Pulp & Paper Chemistry.

He has a rich and wide experience in the area of pulping & bleaching, environmental management including bioenergy recovery from wastes, performance evaluation and trouble shooting of effluent treatment plants, environmental auditing etc. He has been responsible for commissioning of full-scale biomethanation plant for recovery of bioenergy from black liquor. He has been actively associated with the projects completed on behalf of CPCB like "Development of Standards of AOX for Large and Small Scale Pulp & Paper Mills" & "Standardization of Methods for Determination of AOX in Environmental Samples".

He has undergone an advanced training at Finland and Sweden on microbial aspects and application of biomethanation technology in pulp and paper industry. He has also been actively associated with prestigious projects sponsored by UNDP, MNES, and mill associations like IARPMA, IPMA etc. He has represented CPPRI at various national & International Conferences and Seminars. He has around 30 publications to his credit and has been author/ co-author of a number of R& D reports, training and course manuals.

WATER CONSERVATION IN PULP AND PAPER INDUSTRY

1.0 BACKGROUND

Most of the Indian pulp and paper mills (with few exceptions) are associated with generation of high pollution load . The high pollution load in term of liquid wastes is mainly due to high consumption of water during the process operations of pulping and paper making .The main reasons for high consumption of water are :

- Ease of availability
- Use of obsolete technology and equipments and multiple number of machines of small capacity
- Use of second hand imported machines which are not designed for Indian raw materials
- Use of mixed fibrous raw material
- Poor drainage characteristics of pulp especially from agro residues
- Frequent changes imnpaper quality on machines
- Poor washing efficiency of pulp washers

The high water consumption leads to high effluent treatment costs and also handling problems as a result ETP in most of the mills are over loaded leading to poor performance efficiency of treatment plants. The magnitude of pollution load generated in Indian paper mills is summarised as under

Particulars	W&P mills	NP mills	Agro based mills	RCF based mills
Raw material	Bamboo, Hard wood	Bamboo, Hardwood Bagasse	Straws, Bagasse, Sarkanda etc	Waste paper
Effluent m^3/t_{paper}	100-200	125-150	150-200	50-100
pH	6.0 –9.0	7.2-7.3	6.0 –8.5	6.0 –8.5
Pollution load , kg/ t_{paper}				
SS	100 –150	100	90-240	50-80
BOD_5	35-50	45	85-370	10-40
COD	150	135	500-1100	50-90
AOX	2.0-4.5	1.0-1.5	6.0- 8.0	-
Colour, kg PCU/t_{paper}	30 – 196	-	800-1350	-

With increasing public awareness and legal strictness about environmental issues it has become imperative for pulp and paper mills to take immediate measures to become environmental compatible . The Central Polution Control Board (CPCB) has laid down the following standards for quantity of effluent discharged and other pollutional parameters :

Parameters	Discharge Standards	
	Small Mills	**Large Mills**
Volume, m^3 / t_{paper}	Agro based : 200 (150) Waste Paper 75 (50)	Writing & Printing : 200 (100)* Rayon grade / Newsprint: 150
pH	5.5-9.0	7.0 –8.5
BOD_5 at 20 °C , mg/l	30 (if discharged into inland surface water) 100 (if discharged on land)	30
COD,mg/l	Not specified	350
SS, mg/l	100	50
TOCl, kg/ t_{paper}	Not specified	2.0
SAR	30	-

However , due to reasons mentioned above most of the mills particularly agro based mills are not able to meet the above discharge standards. Still CPCB is already considering of further reducing the discharge limit to 140 m^3 / t_{paper} in next 3 years and subsequently 100 m^3 / t_{paper} for mills producing virgin pulp.

In this perspective it is important that necessary steps should be taken timely in the area of water conservation / minimization of water consumption. Recycling / reuse of waste water is the first step and the most effective in reducing water consumption as well as the pollution load. The Indian pulp & paper mills have realised the importance and today the reduction in water consumption has become a top agenda before the pulp and paper mills.

Reuse / recycling of effluents back into the various process operation of pulp and paper making is increasingly gaining interest as an approach towards water conservation .The pulp & paper industries in developed countries are practicing the recycle concept with a greater degree of success, which has resulted in lower consumption of water to the tune of 50- 60m^3/t_{paper}. In Indian paper industry, though the efforts have been taken to bring down the water requirements, but still the water consumption figures are high ranging from 150-250 m^3/ ton of product. With the increased concern for improved and cost effective use of available natural resources coupled with greater emphasis on pollution control, more attention is required to be given to cut down the fresh water usage and increased recycling of paper mill waste water.

The major advantages of water recycling are :

- Less water requirement depending on degree of back water recycling
- Savings in energy
- Reduced waste water load on environment and

- Simultaneous reduction in effluent treatment cost due to lower effluent discharges.

Inspite of the above advantages , recycling and reuse of water has a few limitations which restrict the complete water recycling such as :

- Increasing operating problems of change in water quality because of the accumulation of various inorganic and organic components
- Odor and corrosion problem due to increased levels of calcium, chlorides, sulphates and suspended matter etc.
- Adverse effects on the product quality due to lower retention and drainage of the additives.
- Increased levels of microbial population with rise in temperature (in some cases) by water recycling which might affect the runnability of the paper machines.

2.0 OBJECTIVE OF THE PROJECT

The project has been planned with following multidimensional objectives so as to promote increased recycling of water in pulp and paper mills :

- To carry out systematic studies in individual sections of the paper industry to over come the problems / limitations associated with water recycling .
- Thorough study & treatment of streams resulting from bleach plant section, paper machine and chemical recovery.
- Evaluation of section wise fresh water usage, possible quantity of water recycling in each section and its impact on system performance will be looked into.
- Evaluation of impact of recycling on product quality, machine runnability, volume of effluent generated and its treatability .
- Adoption of Process Integration Approach for reuse of process water by using water pinch technology.

3.0 WORK PLAN

The following work plan has been worked out to achieve the above objectives :

- Organization of inception workshop to highlight the objective and targeted output of the project.
- Data collection and formulation of mass and energy balances on major water streams by means of a process simulator.
- Identification of the main contaminants (substance that restricts process water reuse) and their maximum allowable concentration in water streams, and other process constraints that have to be considered in water reuse strategies (water temperature, lay out constraints, etc.). Technical support from process specialists will be necessary at this stage.

- Application of water process integration technique to determine the minimum fresh water target and required modifications to be implemented to the existing water network configuration to achieve the target, given all constraints identified in above step.
- Selection of the more realistic water reuse scenarios and verify the impact on process condition by incorporating the changes in to the mill simulation.
- Conducting an economic analysis and select water reuse scenarios that are in line with the mill's acceptable payback period.
- Evaluation of existing technologies and optimization of process parameters leading to reduction in water consumption.
- Studies on reducing the fresh water consumption through reuse / recycling of water generated in different sections.
- Evaluation of reuse of contaminated condensates after steam stripping
- Closed screening system
- Segregation and treatment of various streams like bleach plant effluent, Spill collection system, Gland water recycling.
- Evaluation of chemical & physical methods for purification of the waste water such as :
    - Membrane filtration followed by incineration of concentrates and toxic compounds.
    - Evaporative crystallization

4.0 QUANTIFIED DELIVERABLES OF THE PROJECT

- The project studies are a step towards improving the environmental problems of the paper industry through increased recycling of the wastewater generated at different stages of paper making .
- Studies will help to generate the data based information on characterization of individual streams, water balance of the mill, technology level, process optimization, techno-economic viability of the emerging state of art technologies.
- Process integration applied to water network has been used in major waste water reduction projects in developed countries. Indian pulp & paper mills should also be able to benefit from it in their efforts to fulfill environmental compliance requirements and cut energy costs.

CONTINUING EDUCATION FOR TECHNICAL PERSONNEL OF PULP & PAPER INDUSTRY

Dr. Vimlesh Bist,
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Planning & Coordination and
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About The Author

Dr. Vimlesh Bist, Head, Planning & Coordination and Library & Documentation Division is with Central Pulp & Paper Research Institute, Saharanpur since January, 1983. She holds a Master's degree in chemistry & D.Phil in Chemical & Microbial degradation of Lignin. Has 25 years of R&D experience in the areas of raw material evaluation, pulping, bleaching, biotechnological applications in pulp & paper, environmental management, etc.

She has attended the International Course in the area of Pulp & Paper Technology" at Markaryd, Sweden & 'Anaerobic Treatment of Waste' at IHE, Delft & Agricultural University of Wageningen, The Netherlands. She was first Indian lady scientist to attend the International course on Pulp & paper technology in Sweden. Was awarded a national scholarship by CSIR, New Delhi for pursuing D.Phil in Chemistry and also selected for Ford Foundation Fellowship in 2002. She has more than 35 publications to her credit and author/co-author of number of R&D reports, training & course manual.

CONTINUING EDUCATION FOR TECHNICAL PERSONNEL OF PULP & PAPER INDUSTRY

1.0 BACKGROUND

Technical manpower in Indian paper mills do not receive any significant training during the service. In India there is no Institute that imparts technical training to the mill personnel on continued basis. Continuing education is essential to improve the technical capabilities of the mill personnel , as there is consistent increase in the use of new technologies in the paper industry to meet the market demands. It becomes very difficult to exploit the new technologies to the optimum level without proper technical understanding about the new processes.

2.0 OBJECTIVE

To train the technical manpower of the Indian Paper Industry and personnel involved in paper handling so as to equip with new technological developments taking place elsewhere.

3.0 REVIEW OF RESEARCH CONDUCTED /BEING CONDUCTED ON THE SUBJECT

Continuing education has been a routine in all the western countries as it contributes significantly to the improvement of individual skills to deal with the new challenges in shop floor. The premier Institutions like TAPPI , Canada, PAPRICAN, Canada organize regular training programs in various fields of pulp & paper. In India , we have regular academic programs in pulp & paper , but have no facility for continuing education for the mill personnel.

4.0 TECHNICAL PROGRAM (LINE OF INVESTIGATION)

- Preparation of syllabus in different areas
- Preparation of comprehensive training manuals
- Setting up of training centers in various regions of the country like Chandigarh , Ahmedabad, Kolkata, Hyderabad.
- Organising four training programs in each center

5.0 PROGRESS OF THE WORK

The activities of the project were initiated in July , 2002 and first training program for the middle level technical personnel of the paper industry was designed and organized at CPPRI in the area of "Pulping, Bleaching & Pulp Quality". An overwhelming response was received from the paper industry and 27 participants representing 16 paper mills from all the four regions of the country attended the training program. Eminent faculty from industry, academic institution shared their experiences with the participants of the training program.

Based on the success of this [program the following programs have been designed in the following areas.

S.No	Name Of The Location For The Conducted/Forthcoming Trg. Program	Area Of Proposed Training	Tentative Training Schedule	Status of the program
1.	CPPRI, Saharanpur	Pulping, Bleaching & Pulp Quality	2nd – 5th December , 2002	Organized 27 participants attended in the program
2.	Ahmedabad	Waste Paper Recycling & Energy Conservation	April First Week , 2003	Organised 41 participants attended the program
3.	Bangalore	Chemical Recovery & Environment	Sept . Second Week , 2003	Activities initiated
4.	Chandigarh	Non-Wood Fibres & Testing Procedures	February First Week , 2004	Proposed

Second training training program was successfully organized in Ahmedabad in the area of " Waste Paper Recycling & Energy Conservation" from 12th to 16th April, 2003 keeing in vioew the fact that Gujarat has clusters of waste paper based mills. 41 participants also representing all the four regions of the country attended the training program. Activities have been initiated fopr conducting the third training program at Bangalore in September, 2003. List of faculty with their lecture topics & list of participants of both the training programs organized so far have been given in Annexure I&II respectively.

6.0 QUANTIFIED DELIVERABLES OF THE PROJECT

- It will help in updating the scientific knowledge of technical manpower of the paper industry & in understanding the new horizons of technological developments in paper science.
- Improve the productivity of the mills and competitiveness.

ANNEXURE-I

LIST OF EXTERNAL FACULTY & THEIR LECTURE TOPICS

FIRST CESS TRG. PROGRAM ON "PULPING BLEACHING & PULP QUALITY"

VENUE :CPPRI , SAHARANPUR

DURATION : 2nd TO 5TH DECEMBER, 2002

RESOURCE PERSON	TOPIC OF LECTURE
Dr.B,L. Bihani G-18 , Road No. 24, Saket , NEW DELHI – 110 017	Appropriate Bleaching Technologies For Large & Small Paper Mills With Particular Reference To AOX Control
Prof. Dr. N.J.Rao Department of Paper Technology, IIT Roorkee Campus, Paper Mill Road, SAHARANPUR – 247 001	Environmental Impact & Bleach Plant Operations
Dr.S.P.Singh Reader, Department of Paper Technology, IIT Roorkee Capmus, Paper mill Road, SAHARANPUR – 247 001	Modern techniques of Pulp Screening & Its Relevance To Pulp Quality & Productivity
Dr.S.P.Singh Reader, Department of Paper Technology, IIT Roorkee Capmus, Paper mill Road, SAHARANPUR – 247 001	Washing Practices In Indian Mills
Prof.Dr.A.K.Ray, Deptt.Of Paper Technology,IIT Roorkee Campus,Saharanpur	Control Systems for Washing

LIST OF INTERNAL FACULTY & THEIR LECTURE TOPICS

FIRST CESS TRG. PROGRAM ON "PULPING BLEACHING & PULP QUALITY"

VENUE :CPPRI , SAHARANPUR

DURATION : 2nd TO 5TH DECEMBER, 2002

RESOURCE PERSON	TOPIC OF THE LECTURE
Dr.A.G.Kulkarni,Director	Chemical Aspects Of Pulping & Bleaching
Dr.A.G.Kulkarni ,Director	Pulping & Bleaching Practices In Indian Paper Industry
Shri V.K.Mohindru, Scientist –F & Head,E.E. & Pilot Plant	Efficient Brown Stock Washing Of Agro-Residues With Double Wire Belt Washer
Dr.S.K.Kapoor, Svcientist –F & Head SPPMC	Significance Of Optical Properties Of Pulp & Their Measurement
Dr.Y.V.Sood,Scientist E-II	Evaluation Of Pulps For Physical & Strength Properties
Dr. R.M.Mathur,Scientist E-II & Head CR,ET,EM & Biotech. Div.	Enzymatic Prebleaching Of Pulps In Indian Paper industry – Laboratory & Mill Experiences
Dr.Suresh Panwar, Scientist E-I	Environmental Impact Of Toxic Chlorinated Phenoloic Compounds Released In Pulp & Paper Industry & Its Control Measures
Dr. S.V.Subrahmanyam , Sc.E-I	Fibre Structure In Relation To Fibre Processing & Its Influence On Pulping & Bleaching

LIST OF EXTERNAL FACULTY & THEIR LECTURE TOPICS

SECOND CESS TRG. PROGRAM ON "WASTE PAPER RECYCLING & ENERGY CONSERVATION"

VENUE :AHMEDABAD ,GUJARAT

DURATION : 12TH TO 16TH APRIL, 2003

RESOURCE PERSON	TOPIC OF LECTURE
Dr. A. Panda IARPMA,709 Pragati Tower Rajendra Place DELHI – 110 008	Separation of Contraries/other undesirable components
Prof. Dr. M.C. Bansal Department of Paper Technology, IIT Roorkee Campus, Paper Mill Road, SAHARANPUR – 247 001	Sensitivity analysis of screening systems
Prof. Dr. A.K. Ray Department of Paper Technology, IIT Roorkee Campus, Paper mill Road, SAHARANPUR – 247 001	Explosion & other non-conventional deinking process
Shri R.Vardhan Vice President(Corporate R&D) BILT, First India Place,Tower C, Block-A ,Sushant Lok -Phase-I, Mehrauli Gurgaon Road GURGAON-122 002 HARYANA	Waste paper processing – BILT Experience

LIST OF INTERNAL FACULTY & THEIR LECTURE TOPICS

SECOND CESS TRG. PROGRAM ON "WASTE PAPER RECYCLING & ENERGY CONSERVATION"

VENUE :AHMEDABAD ,GUJARAT

DURATION : 12TH TO 16TH APRIL, 2003

RESOURCE PERSON	TOPIC OF LECTURE
Dr. A.G. Kulkarni, Director	Present Status of Paper Industry
Dr.A.G.Kulkarni, Director	Utilisation of recycled fibre –An overview
Dr.Y.V.Sood, Scientist E-II	An effective way to handle sizing problem during recycling of waste paper containing calcium carbonate
Dr.Y.V.Sood, Scientist E-II	Newsprint manufactured from secondary fibres
Dr. R.M.Mathur, Scientist E-II & Head CR,ET,EM & Biotech. Div.	Recovery & reuse of waste paper in Indian paper industry
Dr. R.K. Jain, Sc. E-I	Enzymatic deinking of non—impact printed toners –An overview
Mrs. Rita Tandon, Sc. E-I	Contaminants in recycled papers & their removal
Mrs. Rita Tandon, Sc. E-I	Grading of indigenously recovered papers – key to effective collection & utilization
Dr.Suresh Panwar, Scientist E-I	Potential of biomethanation process in recycled based paper mills
Dr. S.V.Subrahmanyam, Sc.E-I	Fibre structure in Relation to fibre processing & Its influence on waste paper processing
. B.P.Thapliyal, Sc. E-I	Enegy Audit & Process Optimistion in waste paper based mills for cost effective production – a case study

ANNEXURE-II

LIST OF PARTICIPANTS

FIRST CESS TRG. PROGRAM ON "PULPING BLEACHING & PULP QUALITY"

VENUE :CPPRI , SAHARANPUR

DURATION : 2nd TO 5TH DECEMBER, 2002

S. No.	Name	Designation	Mill Name & Address
1.	Mr. Anoop Kumar Agarwal	Director	J.B. Daruka Papers Ltd. Hardoi Road, P.O. & Distt. Sitapur – 261001 (U.P.)
2.	Mr. Sanjay Kumar	Assistant Scientist	Thapar Center For R&D, Thapar Technology Campus, P.B. No. 68, Patiala – 147004
3.	Mr. Shree Prakash Mishra	Assistant Scientist	Thapar Center For R&D, Thapar Technology Campus, P.B. No. 68, Patiala – 147004
4.	Mr. R. Madhava Reddy	Asst. Manager Production	Ballarpur Industries Ltd. AP Rayons, Kamalapuram – 506 172 (A.P.)
5.	Mr. S.V.V.S.R. Koteswara Rao	Executive Production	Ballarpur Industries Ltd. AP Rayons, Kamalapuram – 506 172 (A.P.)
6.	Mr. Ashish Agarwal	Asst. Engineer	Orient Paper Mills, P.O. Amlai Paper Mills, Pin – 484 117 Distt. Shahdol (M.P)
7.	Mr. Alok Khare	Research Officer	Orient Paper Mills, P.O. Amlai Paper Mills, Pin – 484 117 Distt. Shahdol (M.P)

8.	Mr. I. Jamaludeen Kunju	Supervisor (Pulp)	Hindustan Newsprint Ltd., P.O.: Newsprint Nagar, Distt. Kottayam – 686 616 (Kerala)
9.	Mr. F. Dileep	Senior Analyst	Hindustan Newsprint Ltd., P.O.: Newsprint Nagar, Distt. Kottayam – 686 616 (Kerala)
10.	Mr. S.K. Tarafdar	Sr. Supervisory Chemist	The Sirpur Paper Mills Ltd., Sirpur Kaghaznagar – 504 296 (A.P.)
11.	Mr. G. Jagan Mohan Roa	Asst. Manager Pulp	The Sirpur Paper Mills Ltd. Sirpur Kaghaznagar – 504 296 (A.P.)
12.	Mr. Chinmoy Das	I/c Mgr (Pulp) CPM	Hindustan Paper Corporation Ltd. Cachar Paper Mill, Panchgram, (Assam)
13.	Mr. C. Nandi	Asst. Rec.	Hindustan Paper Corporation Ltd. Cachar Paper Mill, Panchgram, (Assam)
14.	Mr. Rakesh Kumar	Dy. Manager	Shreyans Industries Ltd., Unit – Shree Rishabh Papers, Banan
15.	Mr. S. Chinmi	Junior Manager	Seshasyee Paper & Boards Ltd. Namakkal, Distt. Erode
16.	Mr. C. Thangavel	Officer	Seshasyee Paper & Boards Ltd. Namakkal, Distt. Erode
17.	Mr. Pradip Banerjee	Sr. Shift In charge	Supreme Paper Mills Ltd., 12, Darga Road, Kolkata – 700 017
18.	Mr. Bhushan Awte	Officer	BILT, Ballarshah
19.	Mr. Niranter Sharma	Executive	BILT, Ballarshah
20.	Mr. S.C. Agarwal	Sr. Shift In Charge (Pulp Mills)	Star Paper Mills Ltd., Saharanpur – 247 001 (U.P.)

21.	Mr. K.V.R.N. Sharma	Sr. Process In charge (Pulp Mills Process)	Andhra Pradesh Paper Mills Ltd., Rajanmundry – 533 105 East Godavari Distt., (A.P.)
22.	Mr. S.R. Vasan	Shift Engineer (Pulp)	Tamil Nadu Newsprint & Papers Ltd., Kagithapuram- 639136, Karur Distt. (Tamil Nadu)
23.	Mr. Sanjay Kumar Yadav		BILT, Yamunanagar
24.	Mr. D.K. Singh		BILT, Yamunanagar
25.	Mr. N.K. Tyagi		BILT, Yamunanagar
26.	Mr. R.K. Malhotra		BILT, Yamunanagar
27.	Mrs. Chhaya Sharma		Department of Paper Technology, (IIT Roorkee) Saharanpur –247 001 (U.P.)

LIST OF PARTICIPANTS

SECOND CESS TRG. PROGRAM ON "WASTE PAPER RECYCLING & ENERGY CONSERVATION"

VENUE :AHMEDABAD ,GUJARAT

DURATION : 12TH TO 16TH APRIL, 2003

S. No.	Name	Designation	Mill Name & Address
1.	Mr. D.K. Singhal	V.P. (Tech)	Chandpur Enterprises Ltd., Sargam Theatre, Chandpur, Bijnor – 246 725 (U.P)
2.	Mr. Lalit Maheshwari	Director	Maheshwari Papers Ltd. C/o Maheshwari Cloth Control, Station Road, Palampur
3.	Mr. Girish A. Deshpande	Dy. Manager (Stock Preparation)	Rohit Pulp & Paper Mills Ltd., P.O. Khadki, Udvada (R.S.) Dist. Valsad-396 185 (Gujarat)
4.	Mr. J. Chaudhary	Production Manager	Shri Rajeshwaranand Paper Mills Ltd., Vill. Goyak (Jagdm Road), Bharuch (Gujarat)
5.	Mr. U.D. Joshi	Sr. Electrical Engg.	Shri Rajeshwaranand Paper Mills Ltd., Vill. Goyak (Jagdm Road), Bharuch (Gujarat)
6.	Mr. Ingle Bharat Ranganath	Asst. Supervisor	M/s Bhikusa Papers Pvt. Ltd., 178, Hirawadi, Panchwati, Nasik – 3
7.	Mr. Pagar Jitendra Sahebrao	Asst. Supervisor	M/s Bhikusa Papers Pvt. Ltd. 178, Hirawadi, Panchwati, Nasik – 3
8.	Mr. Abhijeet Kshatriya	Technical Consultant	M/s Bhikusa Papers Pvt. Ltd. 178, Hirawadi, Panchwati, Nasik – 3

9.	Mr. Subhash	Director	Navrang Papers, Town Hall Road, Yavatmal – 445001
10.	Mr. R.S. Deshpande	Production Manager	Shreyas Papers Pvt. Ltd., Nayak Chambers, 51, Raj Nagar, Hubli – 580 032 (Karnataka)
11.	Mr. S.K. Sidrai	Stores In charge	Shreyas Papers Pvt. Ltd., Nayak Chambers, 51, Raj Nagar, Hubli – 580032 (Karnataka)
12.	Mr. KVS Shiva Kumar	Sr. Supervisor (Waste Paper Pulping Plant)	Coastal Papers (A div. Of APPM Ltd.), Near Kadiam, Rly. Station, M.R. Palem 533 126 E.G. Dist. (A.P)
13.	Ch. Satyanrayana Murhy	Sr. Supervisor (Operation of De-inking Plant)	Coastal Papers (A div. Of APPM Ltd.), Near Kadiam, Rly. Station, M.R. Palem 533 126 E.G. Dist. (A.P)
14.	Mr. A.V.S. Kameswara Rao	R&D Staff	Coastal Papers (A div. Of APPM Ltd.), Near Kadiam, Rly. Station, M.R. Palem 533 126 E.G. Dist. (A.P)
15.	Mr. A.K. Mehra	Asst. Gen. Manager (R&D)	Rohit Pulp & Paper Mills Ltd., P.O. Khadki, Udvada (R.S.) Dist. Valsad – 396 185 (Gujarat)
16.	Mr. R.R. Niranjan	Partner	M/s Associated Paper & Straw Boards, P. Box No. 30, Hunsur Road, K.R. Nagar – 571 602, Karnataka
17.	Mr. Rajashekar Achar	Works Manager	M/s Associated Paper & Straw Boards, P. Box No. 30, Hunsur Road, K.R. Nagar – 571 602, Karnataka

18.	Mr. Shri Gupta	Paper Maker	M/s Associated Paper & Straw Boards, P. Box No. 30, Hunsur Road, K.R. Nagar – 571 602, Karnataka
19.	Mr. J.V.N. Murty	Sr. Manager Pulp	M/s Indo Afrique Paper Mills (P) Ltd., Vill. Pande, P.O. Sarole, Tal. Bhor, Dist. Pune – 412 205
20.	Mr. A.C. Mittal	Vice President	Kalptaru Papers Ltd., Vill. Karoli, Khatraj Chokdi, Tal – Kalol, Dist. Gandhi Nagar (Gujarat)
21.	Mr. Sanjeev Srivastava	Chemtech	Kalptaru Papers Ltd., Vill. Karoli, Khatraj Chokdi, Tal – Kalol, Dist. Gandhi Nagar (Gujarat)
22.	Mr. Mritunjay Sinha	Shift In charge	Kalptaru Papers Ltd., Vill. Karoli, Khatraj Chokdi, Tal – Kalol, Dist. Gandhi Nagar (Gujarat)
23.	Mr. Ramesh Kumar	Shift Incharge	Kalptaru Papers Ltd., Vill. Karoli, Khatraj Chokdi, Tal – Kalol, Dist. Gandhi Nagar (Gujarat)
24.	Mr. C.M. Tiwari	Pulp Mill Incharge	Kalptaru Papers Ltd., Vill. Karoli, Khatraj Chokdi, Tal – Kalol, Dist. Gandhi Nagar (Gujarat)
25.	Mr. Palaniappa	Asst. Manager (Stock Preparation)	BIPCO - Coimbatore
26.	Mr. V.N. Chopra	Manager Commercial	Ballarpur Industries Ltd., F.I.P Tower –C Mehrauli, Gurgaon Road, Gurgaon (Haryana)

27.	Mr. P.S. Sarang	Dy. Manager (Stock)	Nepa Limited, Post Nepanagar - 450221 Distt. Khandwa (M.P.)
28.	Mr. A.N. Deshmukh	Dy. Manager (Technical)	Nepa Limited, Post Nepanagar - 450221 Distt. Khandwa (M.P.)
29.	Mr. S.S. Kothalkar	Dy. Manager (Machine)	Nepa Limited, Post Nepanagar - 450221 Distt. Khandwa (M.P.)
30..	Mr. Niazi R.A. Khan	Dy. Manager (R&D)	Nepa Limited Post Nepanagar - 450221 Distt. Khandwa (M.P.)
31..	Mr. Subhodh Kumar	J.R.A.	CPPRI, Post Box No. 174, Saharanpur –247 001 (U.P.)
32.	Mr. Vinod M. Patel	C.M.D.	Well Pack Papers & containers Ltd.,
33.	Mr. Deepak M. Soni		Rainbow Papers Ltd.,
34.	Mr. A.K. Sinha		Rainbow Papers Ltd.,
35.	Mr. M. G. Patel	C.M.D.	Sabarmati Papers Pvt. Ltd.,
36.	Mr. P.R. Upadhyay		Dhanvati Industries,
37.	Mr. Lalit Bhai C. Patel		Dautu Tegel Paper Mills Pvt. Ltd., Gujarat.
38.	Mr. Mihir Patel	CMD	Shelvi Pulp & Paper, Block No. 726, Chhatral, North (Gujarat)
39.	Mr.M.S. Sankara Babu		ITC, (Pulp & Paper Department) Unit Bhadrachalam
40.	Mr. P. Vasudeva Reddy		ITC, (Pulp & Paper Department) Unit Bhadrachalam
41..	Mr. B.V. Ogale		Karan Paper Mill, Block No. 1074/1078, Kadi – Kalol Road, Chhatral

BISR PROJECT

BIOBLEACHING : ENZYMATIC COLOUR REMOVAL FROM PULP

P. Ghosh, Bijan Choudhury, M. Krishna Mohan, Rahul Mantri, Vinod Kumar Nigam, Preetlka Aggarwal and Rajkumar Gothwal

Birla Institute of Scientific Research, Jaipur.

In the recent years, improvement of xylanase enzyme performance as a prebleaching agent has been an area of interest among biotechnologist and paper technologists. It needs special consideration with respect to thermostability and enzyme stability at alkaline conditions. In this project, an effort has been made to isolate thermophilic culture with the ability to produce xylanase enzyme and its application as prebleaching agent in pulp bleaching. Major objectives of this project were to use alkali and thermostable xylanase enzyme for pulp treatment. During implementation of the project, number of sources has been utilized for isolation of xylanase producing cultures. After number of attempts, two isolates (Culture 1 and culture 2) have been identified as suitable for biobleaching applications. Both these cultures have been used to produce xylanase enzyme and enzyme produced has been characterized. Some of the observations made for these cultures are as follows :

MAJOR OBSERVATIONS

- Enzymes produced from both the cultures show optimum activity at pH 7 but culture 2 enzyme is active over broad pH range (6-11).
- Culture 2 enzyme has optimum activity at much higher temperature of 70^0C, which is higher than the culture 1 enzyme.
- Stability of both enzymes has been studied at optimum temperature and pH. It has been observed that enzyme from isolate number 2 has higher thermal stability and pH stability . At 55^0C (usually the pulp treatment temp.), culture 1 enzyme lost 85% of its activity within 2 hrs. whereas enzyme from culture no. 2 retain 50% of its activity after 2 hrs.
- Optimization of enzyme production using culture no. 1 and 2 have been studied.
- Among the various carbon sources tested, wheat straw powder seems to be better for culture 1 and xylan isolated from wheat straw favors highest xylanase production.
- Maximum xylanase enzyme production of 166 IU/ml was observed with culure 1 using 2% wheat straw xyaln.
- Similarly, xylanase enzyme production with culture 2 has been studied and maximum activity of 52 IU/ml was achieved with 1% wheat straw xylan.
- In case of culture 1, time of harvesting is a critical factor as farmentation beyond 24 hrs. results in significant enzyme activity decrease.
- An attempt has been made to enhance storage stability by adding glycerol (20-25%) to the enzyme sample. Addition of glycerol has improved storage stability of enzyme in cold room whereas, at room temperature effect was not significant.

- Both the enzymes has been used to treat three different agro based pulps (jute straw, wheat straw and rice straw) at two different pH values (7 & 8.5). enzymes produced has also been evaluated in Central Pulp and Paper Research Institute, Saharanpur on hardwood pulp with conventional CEH sequences. Both the enzymes were found to have bleach boosting effects. Besides strength properties of pulp were also marginally improved after enzyme treatment with a corresponding increase in CED viscosity of enzyme treated pulp.

FUTURE ACTIVITY :

- The enzyme production traits would be scaled upto 100 L and above from 20L stage. The components of these enzyme systems would be purified and N-terminal sequences would be determined. The genes responsible for the enzymes would be cloned into a heterologous host and bioinformatic tools would be used to increase the thermal tolerance and catalytic activity.