INTERACTION MEET

ON

USE OF RECYCLED FIBRE IN PAPER & NEWSPRINT

12th April, 2001

Total Recycle Concept & Practice

Organised by

CENTRAL PULP & PAPER RESEARCH INSTITUTE
SAHARANPUR

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SAHARANPUR – 247 001 (U. P.) INDIA

केन्द्रीय लुग्दी एवं कागज अनुसंधान संस्थान
Central Pulp & Paper Research Institute
An autonomous organisation registered under societies Act Under the administrative control of the Ministry of Industry (Govt. of India)
POST BOX NO. 174, PAPER MILLS ROAD, HIMMAT NAGAR, SAHARANPUR - 247 001 (U.P.) INDIA
Tel. EPABX (0132) 725317, 722756, Direct 727227, 726834, 726794
Cable : CEPPRI, Saharanpur Fax (0132) 727387, 721367 website:www.cppri.org. e.mail director @ cppri.org.

PREFACE

CPPRI is organizing the 4th Interaction Meet on **"USE OF RECYCLED FIBRE IN PAPER AND NEWSPRINT"**, with an objective to disseminate the findings of the research work and also for improved interaction with the Indian paper industry. Recycled fibre is one of the important sources of fibre for paper industry. In developed countries, the use of recycled fibre is practiced primarily to conserve the natural resources and also to have the products which are environmentally compatible.

CPPRI has been working on this important area of research since last three years under various research projects sponsored by different agencies like; IPMA, AISPMA & Govt. of India. The objective of these projects is to study in details, the quality of waste paper available in the country and various products those can be produced through furnish optimisation using recycled fibres. These research projects also cover the other aspects of recycled fibre such as; gradation, quality upgradation and deinking etc. This interaction meet will provide an opportunity to have one-to-one discussion on the various issues related to use of recycled fibre, the trends in developed countries and perspectives in the context of Indian paper industry.

I hope, this interaction meet will facilitate in evolving the strategies for increased utilization of recycled fibre in our country.

I wish the interaction meet a success.

(A. G. Kulkarni)
DIRECTOR

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UTILISATION OF RECYCLED FIBRE – AN OVERVIEW

Dr. A.G. Kulkarni
CPPRI, Saharanpur

INTRODUCTION

The Indian paper industry has made a steady progress in the last few decades from a total installed capacity of merely 1.37 million tons with a production of 1.16 million tons from 17 mills in 1951 to an installed capacity of 5.1 million tons with a production of 4.7 million tons from 411 mills by the year 2000. The industry has seen many ups and downs and at times found itself at cross roads. During the recession industry has always exhibited its preparedness to buildup an edge in quality and cost parameters through technology upgradation to ably face the challenges. However inadequacy and high cost of raw material always remained the single most inhibiting factor for the growth and development of the industry.

India is a fibre deficient country. The prospects of long term fibre availability appears so bleak that unless industrial plantation are undertaken on a war footing, India will have to depend on large scale imports of pulp or perhaps as trend shows, paper itself. Unfortunately National Forest Policy (NFP) in its present form is neither conducive to sustainable development of forest based raw materials nor supportive of the dependent pulp and paper industry. The policy completely negates the role of forests for economic development through integrated development of forest based industries. Under such a situation, the industry can neither grow nor globally strategise without an access to a strong domestic base. It is estimated that due to restricted availability of raw materials, the shortage in paper is likely to be of the order of around 3.64 million tons by 2010, which would require import of paper as well as waste paper and pulp for domestic conversion in to paper.

Presently the industry utilizes mixture of raw materials viz, bamboo hardwood, bagasse, straw indigenous /imported waste paper and imported pulp. Bamboo was the traditional fibre resource and was in use since early 20's and continued to be the main raw material for paper making till end of the 60's. Only in early 70's due to change in Govt. policy a number of small mills were established with installed capacity ranging from 2t/d to 30t/d based on agricultural residues and waste paper to meet the domestic demand of paper.

The availability of agricultural residues is surplus, however due to limitations in handling and transportation and lack of adequate technology to process these raw materials at this stage, it might be difficult to go for mills with larger capacities. Among agricultural residues, however bagasse is regarded as most suitable raw material for papermaking.

The future of the Indian Paper Industry appears to be bright considering the expansion of installed capacity, increased demand for paper, industrialization and changing economic reforms, however the raw material situation for future capacity expansion programmes appears to be a major constraint and industry will find themselves having to "share" with various fibre resources in the coming years, including recycled fibres/waste paper.

In the recent years, the environmental concerns of our society have overtaken the industry all over the world and the concept of eco-paper is gradually holding its roots. The public has become more demanding about the environmental aspects and are ready to sacrifice the quality of products to save the environment. World over the pulp and paper industry in looking for alternatives for its existence and among few alternatives available, waste paper recycling was found to be more suitable over the other alternatives like utilization of agricultural residues having some limitations with respect to availability and usage.

In India also there is a need to evolve a long-term strategy to ensure the supply of the raw materials from sources other than forests. The non-wood fibres particularly bagasse and recycled fibre occupies a pivotal position in bridging the gap between demand and supply of raw materials. However, due to fluctuations in the price of market pulp and waste paper prices, there is a need to control waste paper prices as its utilization is considered as one of the important way to conserve the cellulosic fibre at a time when natural resources are depleting.

RECYCLED FIBRE - A FIBRE SOURCE FOR THE INDUSTRY

In the recent years worldwide, the use of waste paper in pulp and paper making process has gained a momentum. In our country, only during the last two decades, recycling of paper has been identified as one of the survival routes against dwindling forest resources.

While the pros and cons of various suggestions are under active consideration by the industry, large scale organized collection of indigenous waste paper to be supplemented by import may be recommended as an immediate measure, to partly bridge the widening gap between the demand and supply of raw materials, otherwise the country might confront a paper famine situation more severe than it had witnessed in early 70's. Further the paper industry today is far more customer driven than it has ever been earlier. It is felt that a customer movement may grow very soon, which might insist on utilizing paper made from recycled fibres. The pressure of public opinion may even force appropriate legislation measures for its compulsory use in the years ahead.

There is an urgent need for concerted efforts to develop a plan to use more waste paper in our paper industry. The enhanced recycling would provide low cost material for industry, reduce energy and water consumption, and diminish pollution besides conserving forest wealth. Use of waste paper should not only be viewed as an economic development but also as part of industrial policy. There is a tremendous scope for increasing the use of waste paper through the adoption of more rational and scientific method of waste paper collection and grading. However, for the effective utilisation of wastepaper in India there are number of constraints, technical problems and economic issues that need to be addressed.

RECOVERY AND REUSE OF RECYCLED FIBRE – GLOBAL SCENARIO

In the recent years, world wide the use of waste paper in pulp and paper production has made a tremendous growth. **Fig.-1.** shows the trend of virgin versus recycled fibre consumption between 1971 – 2001 for paper & board production worldwide which clearly indicates that from 1991 onwards the share of recycled fibre has sharply increased.

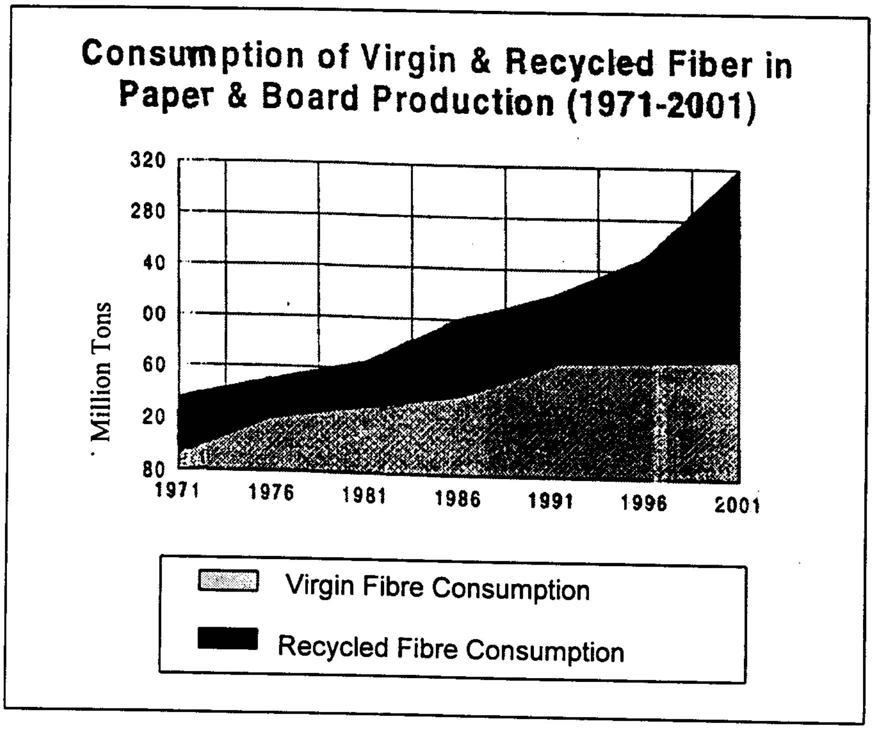


FIG. 1

World waste paper consumption has increased from about 50 million tons in 1982 to about 100 million tons in 1994 and is expected to grow to almost 200 million tones by the year 2010. Since 1990 the consumption of waste paper in Asian countries has increased from 15 million tons to 22 million tons. **Table-1** illustrates how waste paper use has increased over the period from 1986-2000.

TABLE –1

GLOBAL RECOVERED PAPER USE

Year	Pulp & Paper production (in million tons)	Waste paper Consumption (in million tons)	Apparent Utilisation rate (%)
1986	202	63	31
1990	237	85	36
1991	239	91	38
1992	246	96	39
2000	307	138	45

In many parts of the world, realizing the importance of recycling, efforts have been made to get back as much recycled fiber as possible. Even countries rich in wood supply like US, Finland and Sweden have evolved means by which recovery rates can be improved.

Fig-2. shows the bubble diagram of waste paper consumption and recovery rates in different countries.

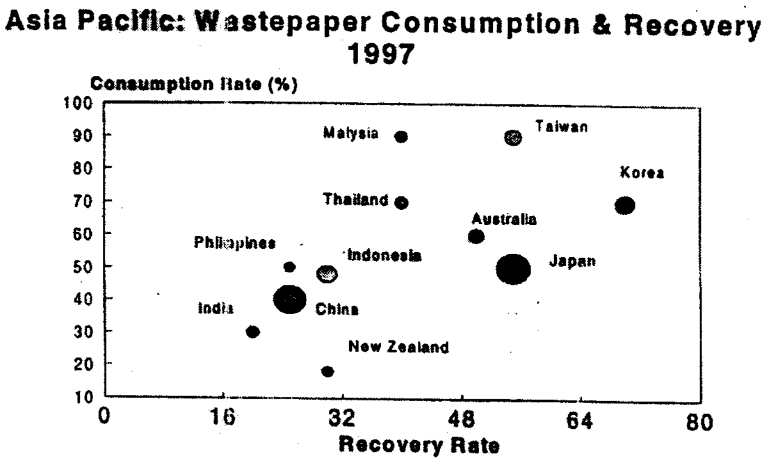


FIG. 2

The world average for waste paper recovery is about 35% with Japan having highest recycling rate (about 56%). The potential use of waste paper is evident from the fact that mills in South Korea and Taiwan are dependent on waste paper as a raw material to the extent of about 90%. Around 14% of the world's waste paper consumption is traded internationally of which 50% in provided by US.

Waste paper-grading system

The purpose of waste paper grading system is to provide a frame work for sorting, so that grades which are defined within the system represent acceptable levels of non-homogeneity of fibre types, as well as contaminant types and proportions. This allows recycling to be accomplished, even in products in which specific properties are desirable. Waste paper consists of several grades. The international classification is becoming more uniform even if many national variations still exist. FAO has developed a classification dividing wastepaper into four main groups, as given in **Table- 2,** which is found very useful for international comparisons.

TABLE –2

INTERNATIONAL CLASSIFICATION OF WASTEPAPER

Grading	Types of wastepaper	End use
Grade I	Old newspapers Magazines	Deinked pulp for newsprint
Grade II	OCC Brown kraft waste	Main grade, accounting more than 41% of world's consumption for producing corrugating raw material.
Grade III	Wood free waste Pulp substitutes	Tissue, writing / printing papers
Grade IV	Mixed waste	Low quality packaging grades

There are many different wastepaper grading system in use usually restricted to specific geographic regions such as:

(i) **CEPAC System** (Confederation of the European Industries)

This consists of four groups including 49 varieties. No emphasis is given to the fibre type to separate wood free and wood containing papers. The groups are:

Group A – Ordinary qualities, includes eleven (11) varieties
Group B – Medium qualities, includes thirteen (13) varieties
Group C – Higher qualities, includes nineteen (19) varieties
Group D – Kraft qualities, includes six (06) varieties

This system was developed to provide a common waste paper grading system in Europe but has not been widely adopted.

(ii) U.K. System

This consists of eleven groups, which includes 68 varieties. Considerable emphasis is given in this system to the fibre types in the paper, so that separation of wood free and wood containing paper grades is encouraged.

Group 1 – White woodfree unprinted paper, includes seven (07) varieties
Group 2 - White woodfree printed paper, includes ten (10) varieties
Group 3 - White and lightly printed mechanical paper, includes six (06) varieties
Group 4 - Colored woodfree paper, includes ten (10) varieties
Group 5 - Heavily printed mechanical paper, includes eight (08) varieties
Group 6 - Colored kraft and manilas, includes seven (07) varieties
Group 7 - New KLS, includes two (02) varieties
Group 8 - Container waste, includes one (01) variety
Group 9 - Mixed papers, includes one (01) variety
Group 10 - Colored cards, includes one (01) variety
Group 11 - Contaminated grades, include fifteen (15) varieties

(iii) German System

This consists of four groups including 40 varieties. No emphasis is given to the fibre type to separate wood free and wood containing papers. The groups are:

Group I - Lower grades, includes eleven (11) varieties
Group II - Medium grades, includes seven (07) varieties
Group III - Upper grades, includes sixteen (16) varieties
Group IV - Strength retaining grades, includes six (06) varieties

(iv) Paper stock of America

This system is applicable for United States and Canada. It includes 51 varieties as regular grades with detailed specification for each variety inclusive of prohibitive materials and total outthrows. There are some varieties which are not included in regular grades of paper stock due to presence of contaminants and are listed as specialty grade which includes 32 varieties.

(v) Japanese System

In this system there are nine (09) groups, which includes 26 varieties of paper.

Group 1 - Hard white shaving, white cards, includes four (04) varieties
Group 2 - White woody shavings, white manilas, inlcudes three (030 varieties
Group 3 - Fine printed paper, includes four (04) varieties
Group 4 - Quires, woody paper, printed, includes four (04) varieties
Group 5 - Old news, includes one (01) variety
Group 6 - Old magazines, includes one (01) variety

Group 7 - Kraft browns, includes four (04) varieties
Group 8 - Old corrugated containers, includes one (01) variety
Group 9 - Box board cuttings, includes four (04) varieties

Recovery of waste paper

Different systems have been evolved to recover waste papers which are continually changing. All the recovery systems have not concentrated on supplying wastepaper in grades for eg. in U.K. with the grading system the recovery systems concentrate on the production of homogenous grade of waste paper whereas in Germany emphasis is on volume recovery and than "in-grade" recovery. Hence some of the differences between the two grading systems. In most industrialised countries the recovery of waste paper from converters and printers is well developed which do not normally exceed 5 – 15% of the paper or board converted or printed. This necessitates to develop collection by other recovery systems.
Some of the key issues affecting the collection of recovered papers are presented in **Fig. 3**.

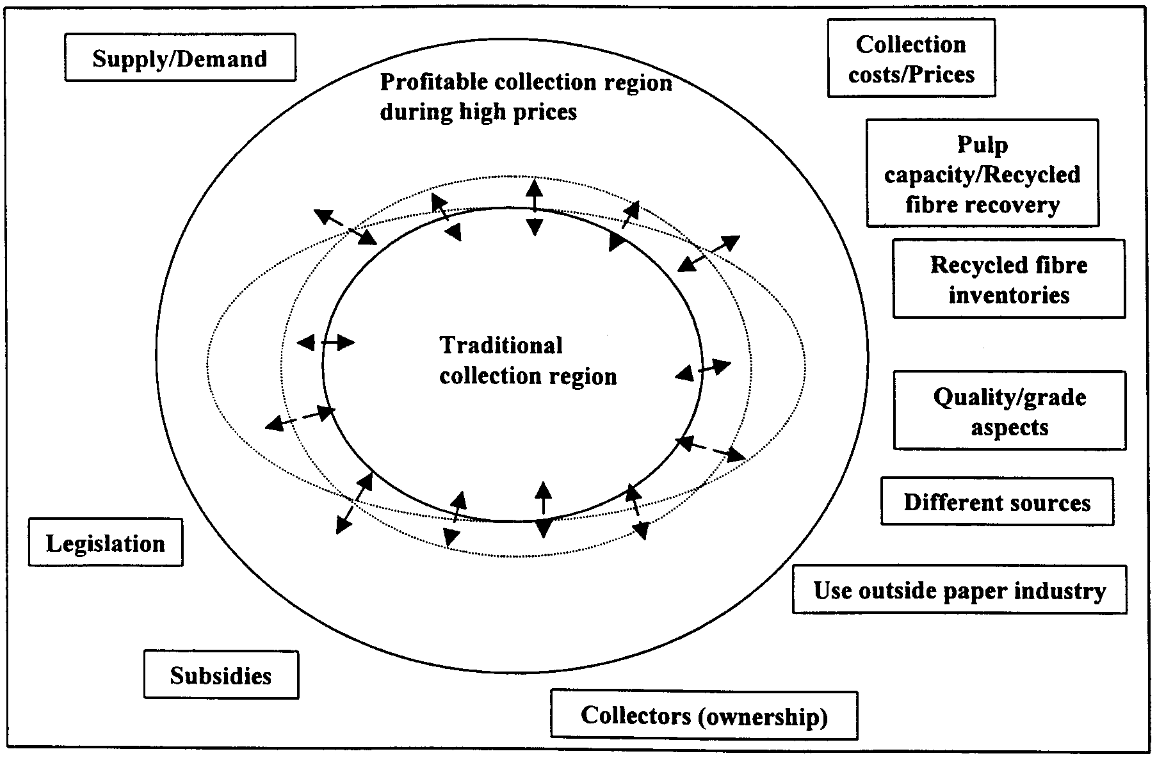


FIG.3 RECOVERY REGION – INFLUENCING FACTORS

Although there is an upward trend both in consumption and collection of recovered paper through out the world there will be some regional and occasional imbalances. In a period of decreasing demand it is most important to find other means of leveling supply than by collapse of a collecting company.

TECHNOLOGICAL TRENDS

In recent years a technological revolution has emerged in recycling technology particularly in the area of contaminant removal systems and deinking technology. The improved technologies are adequate to allow for successful cost effective processing of recycled fibre into usable paper making fibre.

Deinking technology has advanced combining chemical and mechanical treatment of recycled fibre. This will allow for processing and higher value reuse of the current deinking grades, mixed office waste as well as more contaminated sources, however utilization ratio in different grades of end uses shows big variations from country to country. In many countries there are great difficulties to recover waste paper and import of waste paper has increased rapidly.

DEVELOPMENT IN DEINKING TECHNOLOGY

The objective of wastepaper processing is to remove non fibrous materials or contraries / contaminants from the paper stock to make it homogenous for paper/board making. Designing and operating a deinking system involves two major challenges

- To remove ink and brighten the pulp to a specified level.
- To remove the contaminant from recycled fibre.

Both are accomplished within same system by installing equipment with flexibility to accommodate both goals. Key elements in de inking system design include

- Type and quality of waste paper
- .Final product specification
- .Equipment selection and system configuration i.e. process synthesis .
- Water system design (including effluent treatment)
- .System operation and maintenance.

Several new technological developments have taken place in the deinking plant. Mechanical advances such as high consistency pulping, mechanical dispersion of large print specks and improvements in flotation cell design have become well accepted. Changes in process sequence including second stage flotation after dispersion and upgrading of basic water system are gaining acceptance. **Fig. 4** shows a typical deinking system and is the basis of many European deinking systems which is characterised by use of high consistency pulping, flotation deinking and dispersion after flotation. Different technologies had evolved in North America and Japan, however the European technology and modifications of it are adopted more widely.

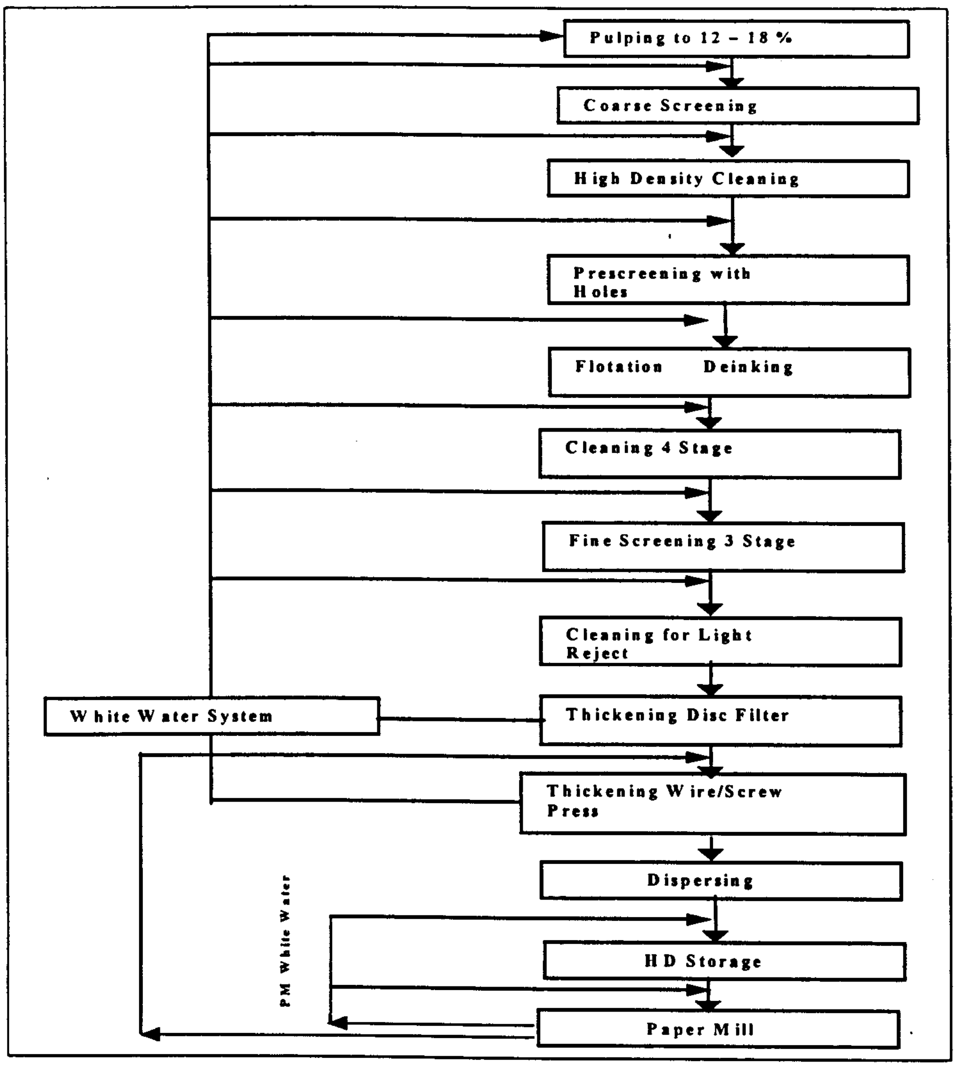


FIG-4 TYPICAL DEINKING SYSTEM

STATE OF ART DEINKING TECHNOLOGIES

Traditionally all the deinking systems were single loop system. Later two loop deinking systems were introduced containing more contaminants removal modules added in the second loop with an objective to -

- Improve the quality of the final Deinked product.
- Improve the paper runnability of the final Deinked product
- Utilize a lower quality waste paper.
- Increase the addition level of Deinked product to the papermaking furnishes. The last few years have seen introduction of three loop system to further enhance the performance of deinking systems.

(i) Deinking technology for production of newsprint from ONP / OMG furnish

Two loop combination deinking system incorporating post flotation stage is the most recent stae of art system to produce high quality deinked pulp from combination of ONP & OMG. This system is designed based on the premise that any residual ink that was not removed in the first loop is broken down by the dispersion stage into many small particles and is removed by post flotation loop. The major benefits are :

- Improved brightnessas the ink particles that are disposed across the dispersion module can be removed in the post flotation loop.
- Better machine runnability.
- Stickies and residual chemicals are also removed in the second loop which often run with no flotation chemical.

The schematic of the system is shown in **Fig. 5**

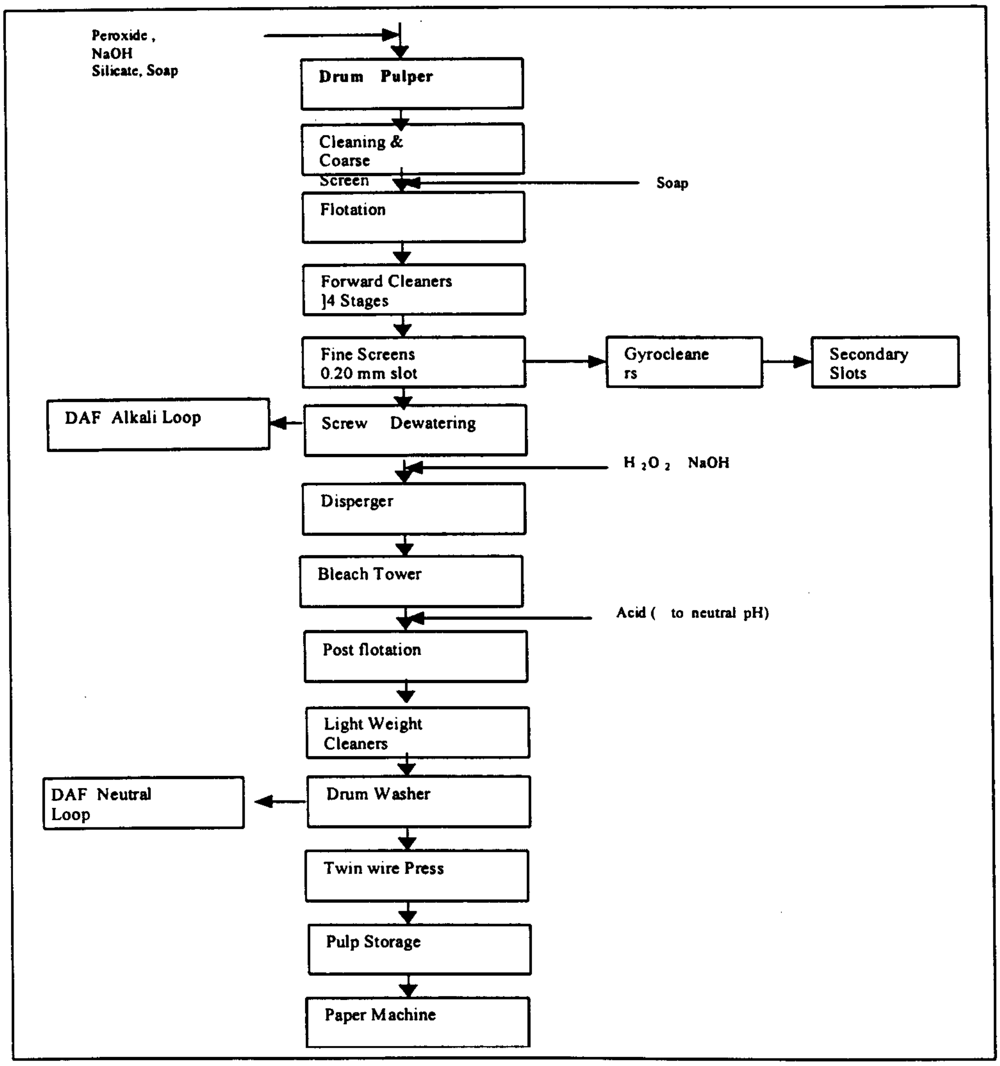


FIG-5 TWO LOOP COMBINATION SYSTEM

(ii) Deinking technology for production of wr/pr grades from MOW

Three loop combination system with double dispersion is the most recent state of art system to produce very high quality DIP from mixed office waste (MOW). The novel feature is the introduction of second stage of dispersion. The major module in the first loops are pulping, screening, pressing and dispersion. In second loop the major module are very fine screening flotation cleaning, washing, pressing and second stage dispersion. Bleaching is carried out in the dispersion unit. The third loop contain a second stage of flotation (post flotation) washing and second stage of bleaching.

In the deinking system for MOW, slow operating kneader type dispersion have been found more suitable when placed before pre flotation stage for the better ink removal efficiency. A typical example of this system is American Fiber Resources (AFR) located in Fair mount, West Virginia using MOW as fiber source to produce very high quality deinked market pulp with pulp brightness 84 %ISO and stickies 5.0 ppm (Pulmac (0.006"). The schematic is shown in **fig. 6**

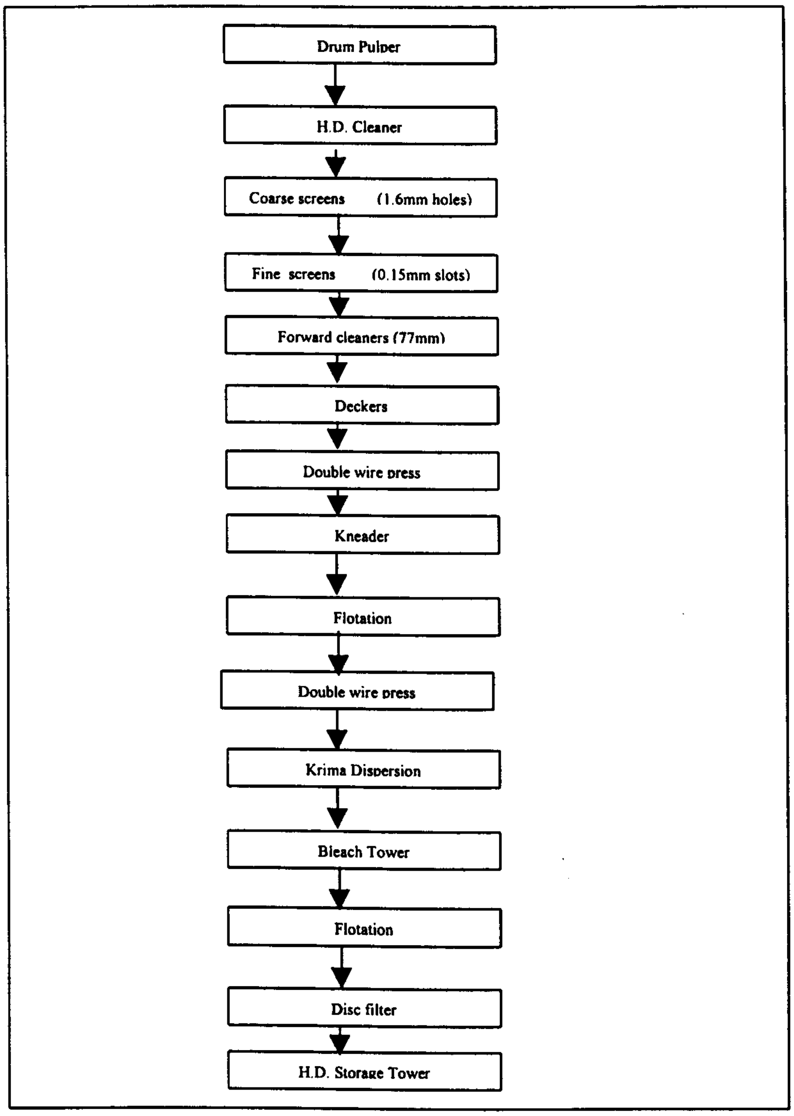


FIG. 6 THREE LOOP COMBINATION SYSTEM

STATUS OF RECYCLED FIBRE USE IN INDIA

The recycled fibre / waste paper has long been in use as one of the important raw material for paper making in India by all segments of the industry. The industry has made steady growth in recycled fibre utilization reaching a target of 40% by the year 1999. However this target has been achieved with more than 50% of import substitutes as no appreciable rise in recovery rate was achieved. Presently the generation of recovered paper in India is of the tune of 0.75 million tons at recovery rate of 18.7% as shown in **Table – 2.**

TABLE – 2

SCENARIO OF WASTE PAPER CONSUMPTION AND RECOVERY IN INDIA

	1995	1996	1997	1998	1999
Total P & B Production, Million tons/yr.	3.11	3.17	3.30	3.14	3.79
Waste paper consumption of total production (%)	25.0	27.4	32.0	33.4	39.5
Percentage of indigenous recovered paper	63.6	62.0	61.9	52.3	47.0
Percentage of imported waste paper	36.3	38.0	38.0	47.6	53.0
Total recovery rate (%)	14.7	15.4	16.5	14.0	18.6

About 68% of the mills (241nos.) are using recovered paper in their raw materials furnish including small, medium and large mills. The mills which are exclusively based on recovered paper, the capacity ranges from 4t/d –260t/d with majority of mills falling in the capacity range of 4t/d-80t/d. Broadly the mills are utilizing a wide variety of both indigenous and imported waste paper and the segment as whole is heavily dependent on imported waste paper to a large extent.

Due to acute shortage of woody raw material one large mills viz. NEPA Ltd. has also switched over to recycled fibre use as a substitute for their mechanical furnish in newsprint production, Hindustan Newsprint Ltd. has plans to use ONP to partly substitute its mechanical furnish in near future.

Presently there is no organised collection system prevailing in the country due to lack of grading system, however compared to north zone, in the west and south zone the waste paper is collected by contractors and supplied to the mills to some extent on a segregated to a practicable limit. The imported varieties of recovered paper are available in grades as per the International Standards but at higher costs. Due to absence of any grading system the indigenous waste paper particularly the post consumer waste is available in mixed form due to which there is lot of inconsistency in the quality of in coming raw material due to presence of contaminants which is sorted at mill site with additional cost input. **Table – 3** shows the type of contaminant present in recovered paper.

TABLE-3

CONTAMINANTS IN RECOVERED PAPERS

External	Internal		
	Soluble	Insoluble	
		Nonstickies	Stickies
Sand	Starch	Plastic	Hot melts
Glass	Alum	Fillers	Wax
Wires	Soluble glue	Wet strength	PSA
Golf balls	Sizing agent	Ink	Latex
Sneakers	Notes: 1. PSA= Pressure- sensitive adhesives 2. Wax may or may not be sticky, depending on temperature. 3.Certain components of inks may be water soluble components may be sticky or nonstickies.		
Wooden boards			
Watches			
Engine blocks			
Kitchen sinks			
Styrofoam			
Cans			

Major end products

Both bleached and unbleached grades of paper / boards are being produced, however majority of the mills are confined to the production of industrial varieties including a wide range of products. The bleachable grades includes mainly poster paper, newsprint and cream/white wove.

Status of technology

By and large the system components unit operations incorporated in the recycled fibre based mills are inadequate to attain acceptable cleanliness level in the resulting pulp.

In most of the cases the system configuration in the mills is inappropriate for efficient contaminant removal. The waste paper process need initial size separation for bigger contaminates/plastics trash followed by a combination of coarse density separation and size separation before the smaller contaminants like ink and coatings can be treated. The energy requirement for such sophisticated cleaning system is the major consideration for smaller units to adopt the right process. The lack of support from the indigenous equipment manufactures to develop energy efficient design of cleaning equipments to cater to the small and medium sector is also a reason for Indian units to limit their process to most primitive and inefficient systems which results to low product yields, high rejects leading to excessive fibre loss and poor quality of the end product.

Waste paper shushing and pulp cleaning systems are available, however systems for removing inks or dispersing it to invisible entity are not well developed and practiced in India. The end product is the deciding feature in identifying what should be the right process adopted. When the waste paper pulp is required to give very clean and bright pulp, deinking is better option. In most of the product of packaging quality, the speckey appearance of ink agglomerate is not well accepted, but the brightness not being of consideration, dispersion of ink is sufficient to make acceptable product. **Fig. 7 & 8** show the system configuration being employed by waste paper mills for producing industrial as well as cultural varieties.

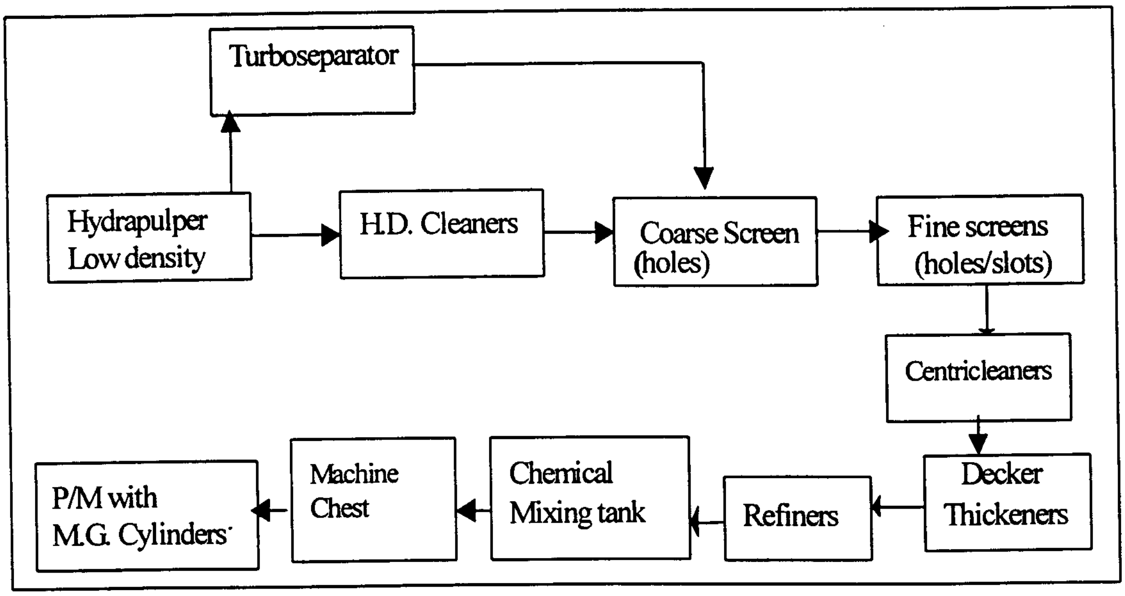


FIG-7 SCHEMATIC OF PROCESS FLOW FOR PACKAGING GRADES

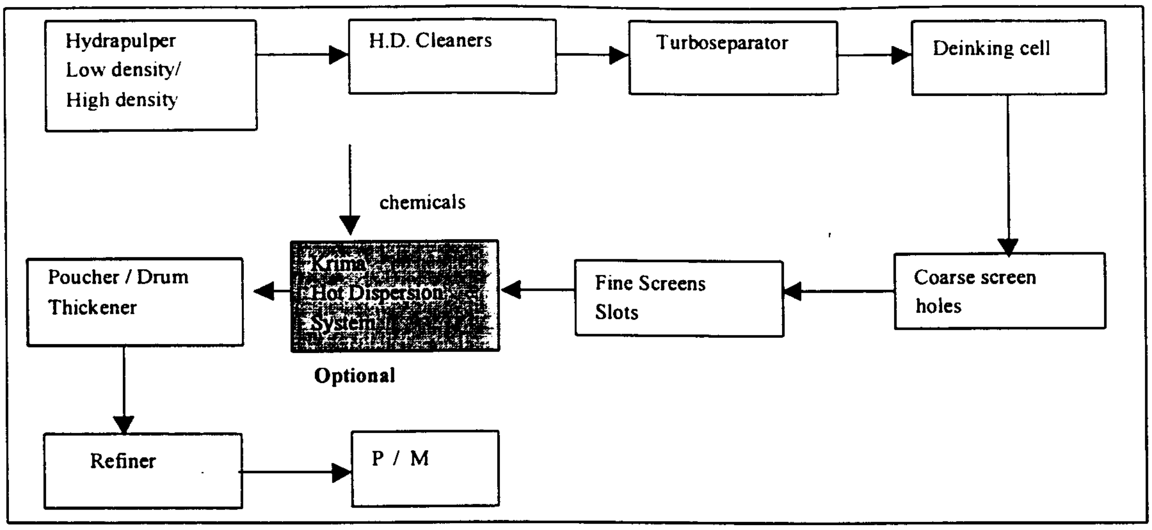


FIG-8 SCHEMATIC OF PROCESS FLOW FOR BLEACHED GRADES

CONSTRAINTS IN UTILISATION OF RECYCLED FIBRE

Some of the major constraints in recycled fibre utilization are:

1. **Poor accessibility of good and consistent quality of recovered paper:**
   The quality of the recovered paper is largely influenced by the quality and type of virgin fibre present in paper, sizing chemicals added during paper making, mode of consumption of the end product and aging of the end product. Since these factors are difficult to control, obviously the quality of recovered paper can not be consistent.

2. **Poor drainage due to increased formation of fines:**
   The recycled fibre are once dried since it has undergone the entire paper making process due to which the fibre gets hornified i.e. it looses the swelling properties and becomes less flexible. When this fibre is subjected to refining the fines generation is high.

3. **Problem in sheet transfer due to low wet web strength:**
   The recycled fibre are characterized by short average fibre length which further reduces during refining. In absence of any long fibre being added, the paper produced using 100% recycled fibre may cause runnability problems.

4. **High alum consumption during sizing due to presence of $CaCO_3$ filler :**
   The recovered paper stock contains good amount of coated varieties from imported source. It is observed that due to improper washing the fillers are retained with the pulp and causes problems during acid sizing. It is

recommended that neutral sizing is preferable when using coated paper as raw materials.

5. Recycling of highly contaminated grades of recovered paper

Currently around 53% of waste paper is being imported from countries like U.S. which has been continuously raising with increasing demand. Among the different varieties wet strength paper used for liquid packaging, unlike other grades of waste paper, posses problems during shlushing due to presence of wet strength resins resulting into high rejects contents, low yields and high electrical consumption. It is otherwise an excellent source of long fibre substitute and is available in bulk quantities.

Based on extensive studies conducted at CPPRI a system module has been proposed for the future installation for the mills which are using wet strength paper to produce packaging varieties. The schematic of proposed system is shown in **fig. 9**

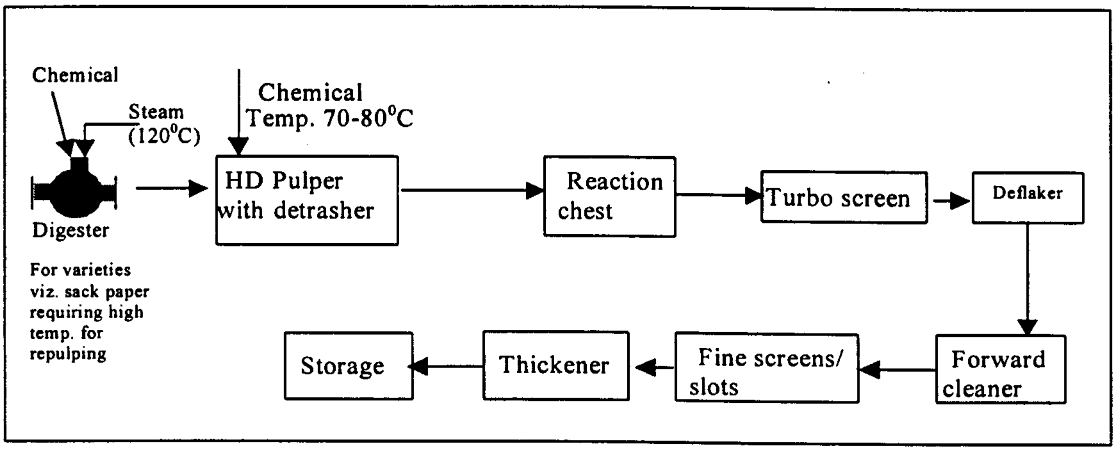


FIG.9 PROPOSED SYSTEM FOR WET STRENGTH PAPERS

Other constraint includes:

- Increased fluff on machine due to rigidity of recycled fibre.
- Locking and crushing of paper due to uneven moisture content.
- Increased heat requirement on dryers due to frequent fallings.
- Adverse effects on structural and optical properties due to raiging fibres.

MAJOR ISSUES TO BE ADDRESSED

Despite of the fact that a major segment of the industry is utilising the recovered paper for papermaking, the industry is facing serious problems in processing of imported and indigenous waste paper primarily due to poor quality of indigenous waste paper and presence of contaminants in imported waste paper. There are number of constraints, technical problems and economic issues that need to be addressed for effective utilisation of recycled fibre. Some of the important issues are:

1. **Unorganised collection and distribution of domestic waste paper-** The collection and distribution system in the country is very much unorganized and unscientific. Due to lack of Indian grading system most of the paper is recovered in the mixed form and could not be utilized effectively

2. **Lack of appropriate grading and sorting system at source-** Presently at source grading /sorting is not practiced and it is done manually at the mill site incurring additional cost to the mill. This eventually leads to inconsistency in the incoming raw material causing technical problems due to presence of contaminants in the paper.

3. **Inconsistent quality of indigenously recovered paper-** This aspect particularly infers to the quality of indigenously recovered paper. The present recovery rate in the system, the quality of the recovered paper deteriorates significantly. At times ^{0}SR is reported as high as 60 ^{0}SR for the incoming varieties which is considered to be a bad stock.

4. **Presence of high level of contaminants in imported waste paper-** The presence of contaminants reduce the recovered paper value, but it is very difficult to produce contaminant free paper since the paper and paper products undergo several converting and finishing steps before reaching to the consumers. The level of contaminants in waste paper grades to be used has a major effect on the complexity of a processing line and hence its capital costs. In most of the cases the system configuration in the mills is inappropriate to handle the contaminants particularly the stickies and non-stickies type of contaminants.

5. **High prices of waste paper -** While the availability of waste paper has dwindled substantially, the prices have also been going up steadily for almost all grades and varieties of waste paper. In some of the categories the price rise is to the extent of 40-50% and in such scenario sustainability of the mills is in question which are dependent on 100% recycled fibre to manufacture paper. Prices of waste paper grades vary depending on availability, quality and end use possibilities eg. White envelope cuttings have been most valued and mixed grades have remained at the other end of the scale.

6. **Appropriate technology for production of quality papers** – Due to lack of proper technical know how particularly for the production of DIP from ONP / OMG and stock containing MOW and other grades of coated paper, the mills are confined only to produce industrial varieties and low quality grades of paper.

7. **High percentage of prohibitive material and out throws in indigenously recovered paper due to improper collection system** – Materials like iron, pins, plastics and clothes & thread etc. increases the level of outthrows and adversely affect quality of recovered paper.

CONCLUSIONS

In reference to India, the necessity for increasing the utilisation of recycled fibre requires to re-look at our present status of collection as well as the processing technology. Some collection systems are adopted in big cities, which are also mostly limited to printers or industrial houses. Baling and transportation is not well organized. The cost of waste paper is relatively more due to manpower intensive sorting systems. General awareness of fibre quality and segregation of waste paper accordingly before disposal, does not exist. There is a need of guideline to classify the waste paper quality on the basis of fibre quality type and extent of contaminates and prohibitive materials.

RECOVERY & REUSE OF WASTE PAPER IN INDIAN PAPER INDUSTRY

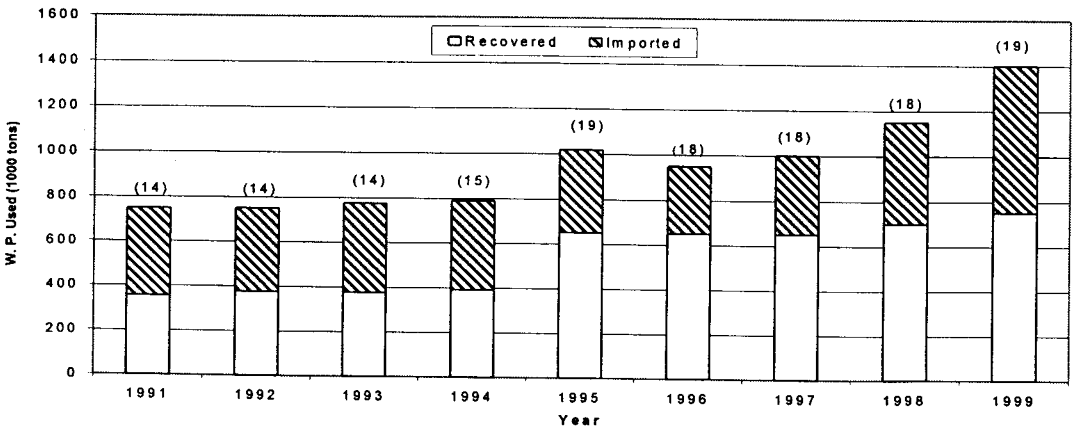
Rita Tandon, R. M. Mathur, Manju Prajapati & A. G. Kulkarni
CPPRI, Saharanpur

INTRODUCTION

The waste paper recovery rate in individual countries is dependent on its fibre resources and structure of the paper industry as well as the per capita paper and paperboard consumption. In 1991, the world average waste paper recovery rate was 37% but the recovery rate was below 30% in many cases where the per capita consumption was lower than 20Kg.

The Indian paper industry started using waste paper as a fibrous raw material for paper making in early 70's only, when the Govt. took a conscious decision to increase the domestic capacity to compensate the sudden spurt in domestic demand. With the Govt. encouragement a number of small paper mills based on waste paper and other non-conventional raw material were installed.

In the informative years, this segment of the industry was not very much organized and the capacity of the mills ranged from 4t/d-30t/d mainly producing low quality grades of paper. Only after 1990's the actual growth of this segment could be observed. **Fig-1** shows the statistics for waste paper recovery, utilisation and imports trends in India during 1991-1999. It clearly indicates that during the last decade though the waste paper consumption has gradually increased from 0.749 million tons in 1991 to 1.5 million tons in 1999, there has been a very marginal increase in waste paper recovery i.e. from 0.355 million tons in 1991 to 0.750 million tons in 1999, which has led to increased imports of waste paper to meet the short fall in domestic demand of paper.



* Figures in parentheses indicate percentage recovery rate

Fig.1 : Waste Paper Used, 1989-1999

Till recently, in our country, the waste paper was used as an alternate to woody raw materials in addition to non-wood fibre resources to meet the short fall in total paper and board demand. Due to its inferior quality of fibre, the production was confined only to low quality-packaging grades of paper, termed as down cycling. However, in the last few years with the advent of new technological innovations in recycling technology, the shift is towards production of high quality writing/printing grades and newsprint rather than packaging grades. Off late, realising the trend, the Indian paper industry has also started using recycled fibre for the production of newsprint and low quality writing/ printing grades of paper. However the technology inputs are not on par with world trend and as a consequence the quality of products still remains inferior particularly in bleachable grades resulting with high specks and low brightness paper.

The perspective of the recycled fibre (RCF) use in Indian industry to a large extent will depend on the cost of waste paper available for the paper industry and indigenous sources of RCF will be an ultimate choice. For effective processing of the indigenously recovered paper the main issues to be addressed are:

- Segregation and classification
- Contraries removal
- Cleaning
- Deinking
- Fibre up-gradation
- Sludge disposal

Most of these issues are related to inferior quality of indigenously recovered / recycled papers and inconsistency in incoming raw material due to improper collection system prevailing in the country and also due to inappropriate system configuration being adopted by mills for contaminant removal. Most of the mills need to have adequate waste paper processing facilities.

Although RCF processing technology has undergone a lot of changes and is well developed, there is a need for R&D efforts in adoption and absorption of these technologies for our scale of operation and type of waste paper available.

RECOVERY OF WASTE PAPER

In the current scenario the driving force for increased utilisation of waste paper is presumably due to –

- Cost competitiveness of recycled fibre over virgin fibre
- Legislation
- Customer preference for eco-paper

The rate of consumption of waste paper by a country is dependent on its rate of waste paper recovery and import of waste. The major factors influencing the recovery rate are:

- Per capita consumption of paper
- Efficient collection system to recover papers to maximum practical limit.

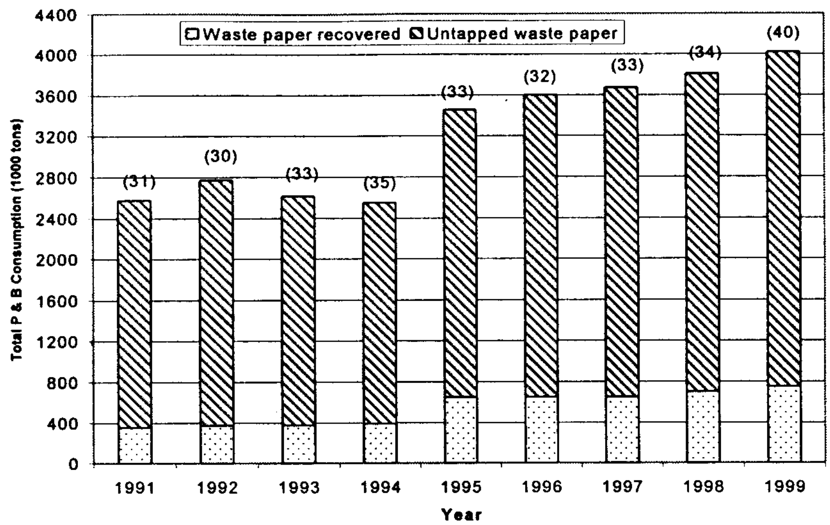
To a large extent, the structure of the industry also determines the utilisation rate. When a high proportion of products in an individual country is board, the recycling rate achieved can be very high as in Denmark, The Netherlands and U.K., when a high proportion of production is high quality papers, then the utilisation rate tend to be lower, since the waste paper utilisation in high quality printing is low.

It is clear from the statistics shown in **Table -1**, showing a profile of major recyclers in the world, with respect to utilisation rate, recovery rate and per capita consumption that the per capita consumption of paper in India is low at a level of 4.0 Kg, due to which the generation of waste paper is much less compared to other countries. Under such conditions use of imported waste paper becomes essential to increase the utilisation rate.

TABLE-1
MAJOR RECYCLERS IN THE WORLD (1999)

Country	**Per Capita Consumption**	**P&B Production M.T.**	**W.P. Recovery %**	**W.P. Utilisation %**
USA	354	88.0	45.3	38.3
Germany	215	16.7	73.3	61.5
Sweden	257	10.0	62.6	18.0
U.K.	215	6.5	40.6	72.4
Nether land	224	3.26	78.3	73.7
Japan	239	30.6	55.7	55.1
Taiwan	232	4.35	55.2	40.2
Korea	143.2	8.8	70.5	79.0
Malaysia	105	1.0	33.4	83.9
China	28.0	29.6	31.2	46.2
India	4.0	3.79	18.6	39.5

It is not possible to collect all the discarded paper, hence the waste paper collection is attractive when it is available in sufficiently large quantities. Fig. -2 shows the potential of untapped source of available papers for the industry.



* Figures in parentheses indicate percentage utilisation rate

Fig. 2 : Untapped Waste Paper

The probable waste paper sources are :

(i)	Domestic refuse	:	Newspaper, magazines, board cartons
(ii)	Industrial refuse	:	Corrugated boards, duplex & other packaging board, paper sacks etc.
(iii)	Office refuse	:	Ledger files and papers from Govt. offices, Universities & large business organisations
(iv)	Trade refuse	:	Boards trimmings from converters & packaging manufactures, paper savings from printers
(v)	Road Sweeping	:	Waste collected by rag pickers

Of all these above sources of 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.

Fig. 3 shows the trend of production of major grades of paper in India during 1991-1999. There has been a considerable rise in the production of packaging paper and board since 1994 whereas the production of wr/pr paper has relatively gone down. There has been a marginal rise in domestic newsprint production.

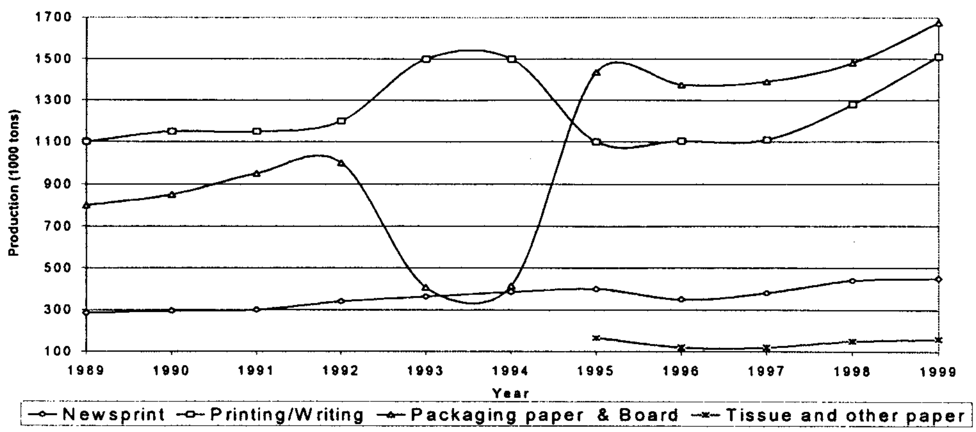


Fig.3 : Yearwise production of various paper grades in India

It clearly indicates that the potential domestic available sources of waste paper are wr/pr and packaging grades of paper. The recovery of packaging grades of paper to some extent is organised whereas the writing / printing grades of waste paper which includes a large number of varieties including office papers are not collected in an organised manner. In view of this it is almost important to have a scientifically organised collection system established for recovery of these sources.

UTILISATION OF WASTE PAPER

Production of clean stock from waste paper involves a number of process steps including pulping, cleaning, screening, flotation deinking, washing etc. Using recycled newsprint fibres in linerboard is known as **"down cycling"** which poses no special problems. Also using recycled newsprint fibres to produce more newsprint known as **"straight recycling"** pose no surmountable difficulties. The greatest challenge occurs when mills go to **"up cycling "** ie. using recycled fibres for higher grades of papers such as newsprint to a wood free paper where there is a limitation of ground wood content in the final product. This would require more complex system configuration with mutiliplicity of cleaning equipments to produce a clean stock with low specks.

In India, the utilization pattern of recycled fibre is more of **"down cycling"** nature which is attributed mainly to inferior quality of indigenously recovered paper. Besides unorganised collection system, poor quality of virgin fibre is one reason for quality deterioration of waste paper. In absence of grading and quality characterization of recycled fibre it is very difficult to ascertain whether the recovered paper is suitable for **"up cycling"**.

In view of this a project was sponsored by IPMA sponsored to CPPRI on **"Availability & utilisation of waste paper"** under which extensive studies were carried out on quality characterization of different indigenously available grades of waste paper. Based on the findings these varieties were graded under different groups for their effective utilisation for various end products. The major outputs of the project are discussed here.

SUMMARY OF THE PROJECT STUDY ON AVAILABILITY AND UTILISATION OF WASTE PAPER

Objective

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 products 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.

STUDIES CONDUCTED BY CPPRI

- Collected information through questionnaires and mill visits on utilisation pattern of different varieties of indigenous and imported waste paper for various end uses.
- Evaluated waste paper samples collected from mills for quality characterization including fibre furnish, freeness, ash content, contaminants, initial brightness, speck/dirt count and Bauer Mcnett fibre classification for further grading of waste paper.
- Based on literature review and studies conducted at CPPRI identified / developed appropriate technology for the production of different end products utilising available grades of paper including indigenous and imported varieties.

OUTPUTS OF THE PROJECT

Reviewing the current scenario, the mills are using wide varieties of indigenous and imported waste paper for the production of paper and board, as summarized in **Table 2.**

Among these available varieties the level of contaminants are relatively low in trade refuse compared to domestic refuse. The imported varieties are graded as per the international standard and are available to the user mill as per the specifications required but at higher cost. However due to absence of any grading system in our country the indigenous waste paper is available more or less in a mixed form due to which there is lot of inconsistency in the quality of incoming raw material.

TABLE-2
VARIETIES OF WASTE PAPER BEING USED IN INDIAN MILLS

Indigenous	Imported
Text Books	Duplex cuttings
Old Directories	Coated book stock trimmings
Note Books	Shredded office waste
Duplex cuttings	Fly leaf shavings
Old Newsprint	Old newspaper
No. II Cutting (mechanical)	Super mix trimmings
White records/Office records	Shredded magazines
Colored cuttings/Colored records	Woody book pages
Road sweeping	Over issue magazine waste
No. I Cuttings	Printer trimmings
Old magazines / over issues	Envelope cuttings
Mixed waste paper	Imported pure white cuttings
New double lined kraft corrugated cutting/NCC	Imported mix waste
Hard white shavings	Currency cuttings
Over issue newsprint	Map stock
Old corrugated boxes	
Kraft multiwall bag waste	
Lottery tickets	
Mixed kraft cuttings	
Sack kraft waste / cuttings	
Currency cuttings	

QUALITY CHARACTERIZATION OF INDIGENOUSLY RECOVERED PAPER

The collected samples were subjected to fibre quality characterization and following parameters were studied.

- Moisture content
- Ash content
- Quantitative fibre furnish composition
- Bauer Mc nett classification
- Canadian Standard Freeness
- CED Viscosity
- Brightness
- Yellowness
- Speck count
- Physical strength properties

GRADING / CLASSIFICATION OF INDIGENOUSLY RECOVERED PAPER

Based on extensive literature review carried out on gradation system, prevailing in industrialised 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.

Looking into the trend and gradation system available in industrialised countries and the type/quality of waste papers available in India for recycling, it is felt that the combination of UK system and Japanese system would be more appropriate to adopt under Indian conditions. These two systems broadly categorise the different groups on the basis of fibre quality/furnish type, which is easy to define and hence more applicable under Indian conditions.

While arriving at new grading system the limitations for moisture content, out throws and prohibitive materials have also been taken into account. Grade specifications are based on the physical appearance of the waste paper variety as received from mills.

In primary classification the grades were classified into :

- White / brown / mixed grades
- Heavily printed, light printed and unprinted grades

The details of each variety are summarised in **Table-3**.

TABLE -3
BASIS FOR PRIMARY CLASSIFICATION

Name of the variety	Type of Grade	Print density
Text book	White	Medium
Old directories	White	Heavy
Note books	White	Very light
Duplex cutting	White	Unprinted/Light
Old newsprint/over issue	White	Heavy
No II cuttings	White	Unprinted
White records/ office records	White	Mix of heavy & unprinted
Colored cuttings /colored records	Mixed	Heavy
Road sweeping	Mixed	Heavy
No. I cuttings	White	Unprinted
Old Magazines/over issues	White	Heavy
Mixed waste paper	Mix	Heavy
NDLKC	Brown	Light
Hard white shavings	White	Unprinted
Old corrugated box	Brown	Medium
Kraft multi wall bag waste	Brown	Light
Lottery tickets	Mix	High
Mixed craft cuttings	Brown	Light
Sack kraft waste/cutting	Brown (wet strength)	-
Currency cuttings	White (wet strength)	Light

Secondary classification was made based on fibre quality characterisation which included :

- Fibre furnish composition to differentiate between wood containing and wood free grades.
- Brightness and Yellowness to segregate between high quality and low quality grades.
- Visual speck count for qualitative quantification of ink particle density.
- Presence of contaminants

The details of each variety are summarised in **Table – 4.**

TABLE- 4
BASIS FOR SECONDARY CLASSIFICATION

Name of the variety	Fibre furnish C:M *	Brightness %ISO	Yellowness %	Visual specks	Initial freeness CSF, ml	Ash, %
Text book	8:2	42-56	10-25	High	380-510	9-13
Old directories	9:1	42-43	15-16	High	400-500	0.6-3
Note books	10:0	53-67	1-3	Speck free	400-500	9-16
Duplex cuttings	9:1	45-46	14.0	Low	350	8-14
Old newsprint	6:4	39-40	13-16	Medium – low	200-350	2-7
No.II cuttings	8:2	45-52	15-21	Speckfree	300-350	2-7
White /office records	10:0	60-67	4-12	Low	480	12-14
Colored records/cuttings	10:0	37.0	21.0	Medium	360	11.4
Road sweeping	9:1	34.0	26.4	High	450	12.5
No. I cuttings	10:0	68-80	0.6-6	Speck free	400-450	8-16
Magazines	9:1	48-55	8-13	High	400	17-25
Mixed waste paper	9:1	34.0	43.0	Medium	550	16
Hard white shavings	10:0	62.0	7.6	Speck free	300-450	14-22

* C-Chemical M-Mechanical

Based on the findings and reviewing the trends adopted in industrialised countries, CPPRI has made an attempt to classify all the standard qualities of indigenously available grades and accordingly following grading system has been proposed. In this system all the twenty (20) varieties of indigenous waste paper have been classified in to nine (09) groups which are summarised in **Table –5.**

TABLE –5
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 woodfree*	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.

Contd.....

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

Based on these studies a detailed document have been prepared fulfilling the objectives of the project.

CONCLUSION

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 fibres, as well as provide guidelines for suppliers so that there is a high value realisation from this important source. Appropriate modification will also be needed in this system as and when new varieties of paper are made available to the consumers.

AN EFFECTIVE WAY TO HANDLE THE SIZING PROBLEM DURING RECYCLING OF WASTE PAPER CONTAINING CALCIUM CARBONATE

Kapoor S. K., Sood Y. V., Tyagi S., Manoth M., Bharti

ABSTRACT

Paper mills in India use different types of waste paper in the production of various paper grades ranging from cultural to packaging. The waste papers of foreign origin are generally neutral sized containing substantial amount of Calcium carbonate as filler. Recycling of such type of papers give problem in sizing with rosin soap and alum under acidic conditions. The present studies indicated that such paper can be suitably sized by using dispersed fortified rosin at pH 6.2. The pH can be controlled by using either alum or Poly Aluminium Chloride(PAC) or by the mixture of both. PAC did not show advantage over alum up to pH 6.2 however it was more effective at higher pH levels. Premixing of dispersed rosin size with alum prior to addition to the stock gave better sizing than separate addition. Addition of cationic starch gave improvement in the sizing with dispersed rosin where as not much effect was observed for rosin soap size. The rosin-alum system may not match the performance of common neutral sizes under all conditions, however, it gives a viable alternative to raise the wet end pH close to neutral level. Plackett Burman statistical evaluation of different process variables on sizing indicated that more effective variables were Sizing dose > Stock temperature > filler amount > cationic starch.

INTRODUCTION

All over the world, the trend of using recycled fibers for papermaking is increasing. Recycled fiber has become an important element in pulp and paper business. The key driving force for the utilization of recycled fibers has traditionally been economics. In India, paper industry is rapidly shifting towards paper making from raw materials other than wood. The agricultural residues and wastepaper have emerged as two main alternatives to the forest based raw materials. Today about 63% of paper mills in India are using waste paper as raw material and it accounts for 31% of total paper production. The supplies of waste paper in India are from eastern countries, Middle East and USA. One of the major problems with the imported papers is that these are generally alkaline/neutral sized containing substantial amount of $CaCO_3$ as filler. Recycling of waste paper containing $CaCO_3$ therefore tends to give problems in acid process owing to the decomposition of $CaCO_3$. This decomposition results in accumulation of sparingly soluble gypsum(calcium sulphate) and calcium hardness in the white water, with the liberation of carbon dioxide.

The $CaCO_3$ filled papers when repulped and sized with Rosin soap/alum under acidic pH condition give problems like severe pH swings, excessive alum and size consumption, loss of filler, high deposit problem, foaming, etc in the system. To overcome these problems it is advisable to size such paper at neutral or close to neutral pH. The reactive sizes available are alkyl ketene dimmers(AKD) and alkenyl succinic anhydrides (ASA). However, it is well-known that sizing with synthetic sizes becomes more difficult and uneconomical when the proportion of "trash" and detrimental substances are sufficient in paper pulp[1]. It is generally considered that the concentration of trash material increases with pH. In an acid system, alum act as a remedy to bind or cogulate un wanted components while, in alkaline systems containing $CaCO_3$, pH depression to the "alum level" would not be acceptable. Keeping all these in view the development of close to neutral pH with rosin is being preferred now a days.

In the present investigations different ways of sizing the waste paper containing $CaCO_3$ have been studied with the objective of making properly sized paper. Different process variables like amount of dispersed rosin size, Alum PAC ratio, amount of cationic starch, filler amount, residual hypo, stock temperature and mode of mixing which affect the paper sizing have also been studied using Plackett Burman statistical model.

RESULTS AND DISCUSSION

Sizing with fortified rosin soap size and dispersed fortified rosin size were tried for waste paper containing $CaCO_3$ and without $CaCO_3$. The sizing response of these is shown in Fig.1 There is a marked difference in sizing response between wastepaper containing no $CaCO_3$ and waste paper containing $CaCO_3$ with rosin soap size/alum at 4.5 pH. At this pH, with Rosin soap size, wastepaper containing no $CaCO_3$ develops a good sizing while waste paper containing $CaCO_3$ shows poor sizing. At the same pH, when sizing was carried out with Dispersed rosin size, sizing response for both types of pulps improved in comparison to Rosin soap sizing and the difference in sizing response between wastepaper containing no $CaCO_3$ and waste paper containing $CaCO_3$ also narrows down. However the decomposition of filler to the extent of 40% was observed at this pH. When pH was increased to 6.2, Dispersed rosin size shows effective sizing with both wastepapers. Also the loss of $CaCO_3$ was relatively lessened(6%) at this pH.

Dispersed rosin showed relatively more improvement in sizing than rosin soap with the increment in size dosage (Fig.2). Fig.3 illustrates the effect of stock pH on the degree of sizing on waste paper containing $CaCO_3$, with rosin soap / alum and dispersed rosin / alum systems. At the pH range 4 to 6.2 dispersed rosin acid /alum system shows effective sizing. However rosin soap/alum system fails to give effective sizing above pH value of 5.0. The effective sizing at 4.2 to 5.0 pH, is probably due to the highest charge density of alum at this pH[2].

Fig.1 Sizing of waste paper with rosin soap and dispersed rosin at different pH level

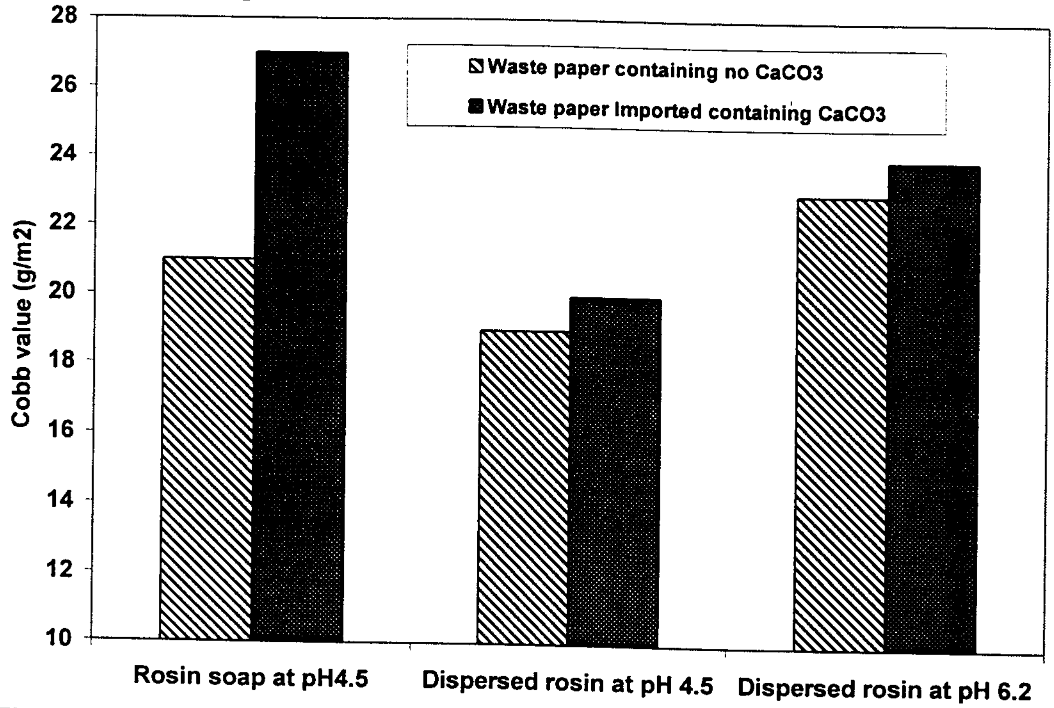


Fig.2 Effect of size dosage on sizing on cobb value at different pH level

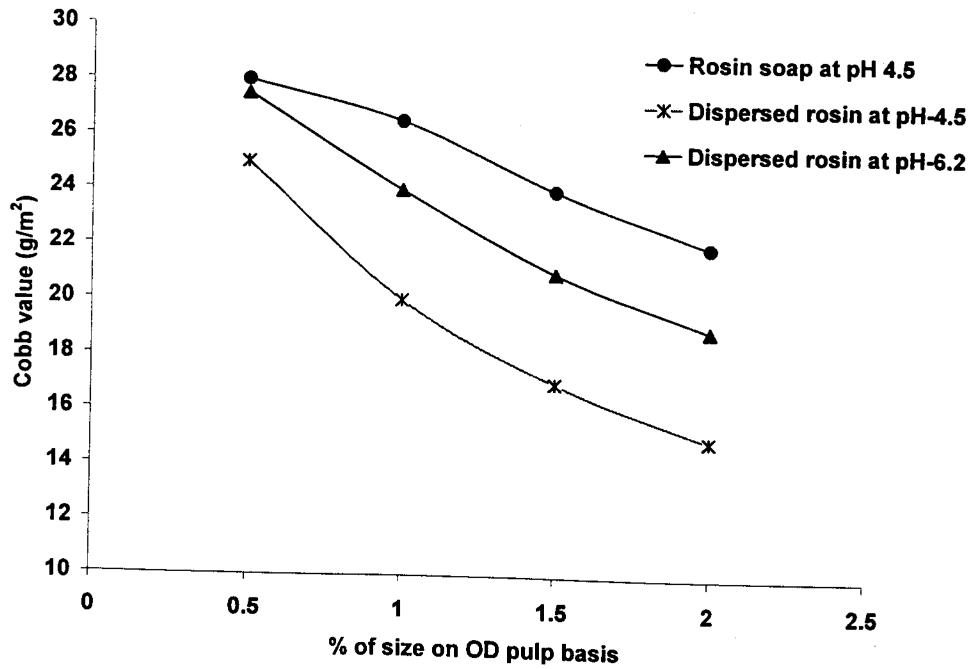
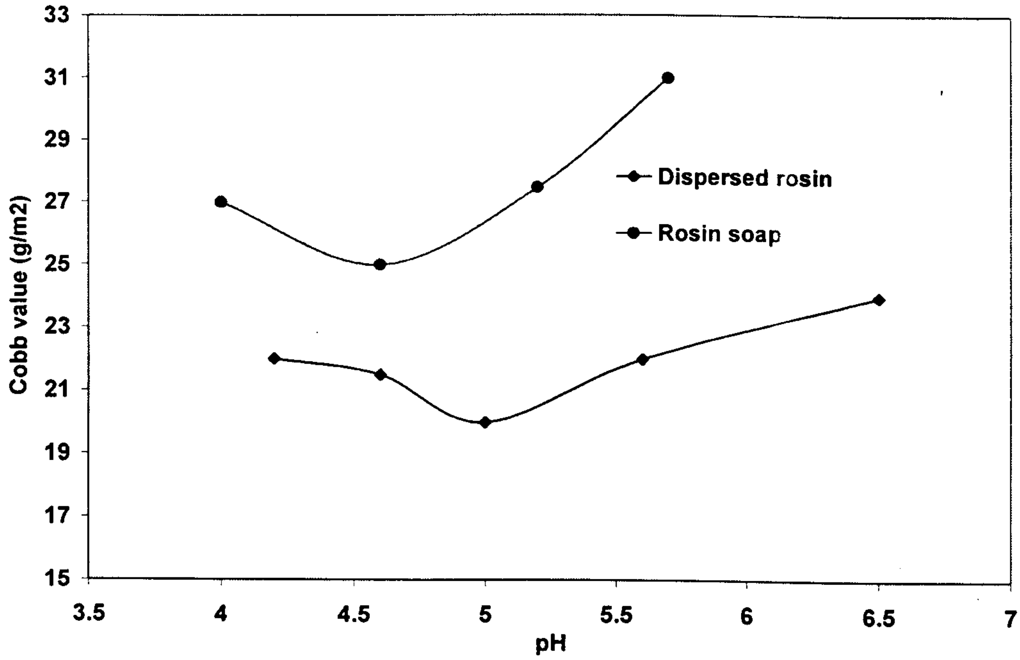


Fig.3 Effect of pH on sizing with rosin soap and dispersed rosin



Mechanism of sizing

These observations can be explained on the basis of sizing mechanism of Dispersed rosin and Rosin soap. Soap size reacts with alum as soon as it is added to the paper stock. Both electro static bonding and co-ordinate bonding participate in this reaction, which obviously results in a strong bond complex as illustrated in Fig.4. Since alum is able to form ionic and co-ordinate bonds with rosin only at acidic pH, sizing with soap size has to be developed in the low pH region[2].

On the other hand, dispersed rosin size consists of rosin acid droplets, which have considerable surface areas. Therefore, its retention is a consequence of colloid and surface chemistry. Dispersed rosin does not react readily with alum to form an aluminium resinate. The alum acts as a bridge between the negatively charged fibre and the negatively charged rosin micelle Fig.5.

The most significant property of the dispersed size is its reduced reactivity to form resinate as it enters the paper machine water system. Soap sizes cannot be used in $CaCO_3$ systems as they quickly exchange their sodium ions to form resinate and Ca++ ion, which in turn interferes with size. The presence of Ca++ ion would compete with alum and form calcium soap which is reported to reduce sizing[3].

Many researchers have described the strong reactivity of alum with cellulosic fibre at higher pH. Alum hydrolyses as pH increases to form colloidal aluminium aggregates[4] which can help to retain the size due to their strong surface activity. As pH increases, aluminium species have higher adsorption on fibres[5-8], which is no doubt beneficial to sizing.

In a rosin -alum system, rosin in either its free acid or soap form will react with alum to give the aluminium ester products which create hydrophobicity. In the case of soap rosin size under acidic conditions, most of the rosin reacts rapidly with alum in solution to give the aluminium ester. In case of dispersed rosin size the reaction of rosin acid and alum does not proceed in solution, but occurs on the fibre surfaces in the drier section. The dispersed rosin size particles are relatively free to migrate during the drying process, throughout the paper web. However, as the paper temperature increases on its movement over the drying cylinders, the heat creates a sintering process where the rosin particles melt and distribute uniformly over the surface area of the fibres to form the aluminium resinate[9].

Fig. 4 Mechanism of sizing with rosin soap/alum

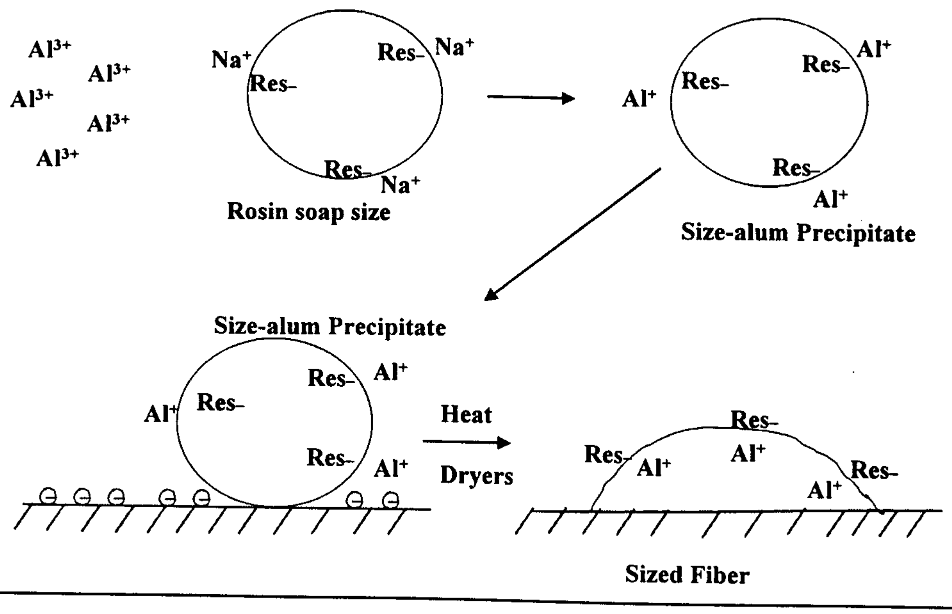
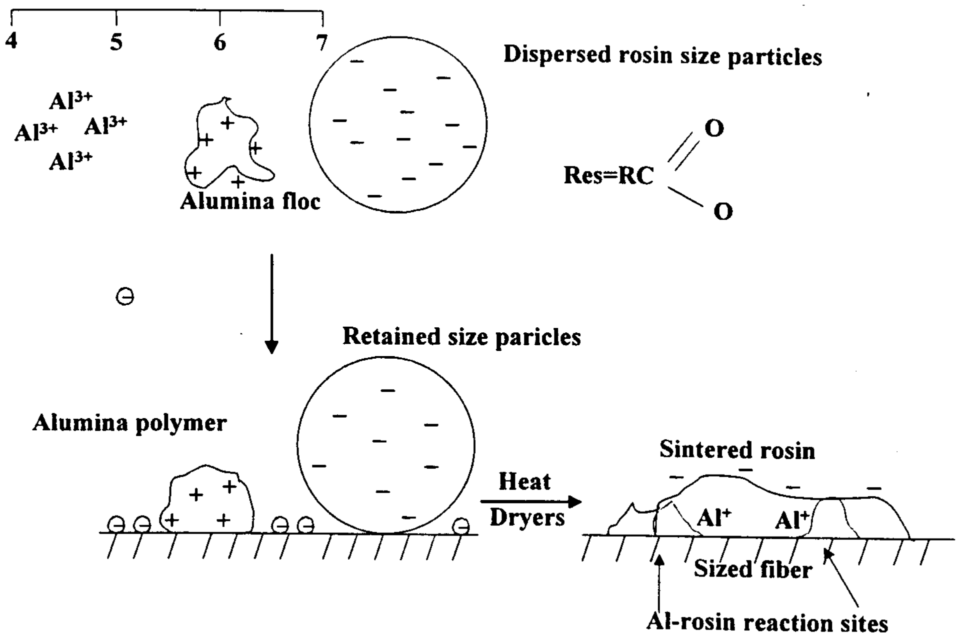


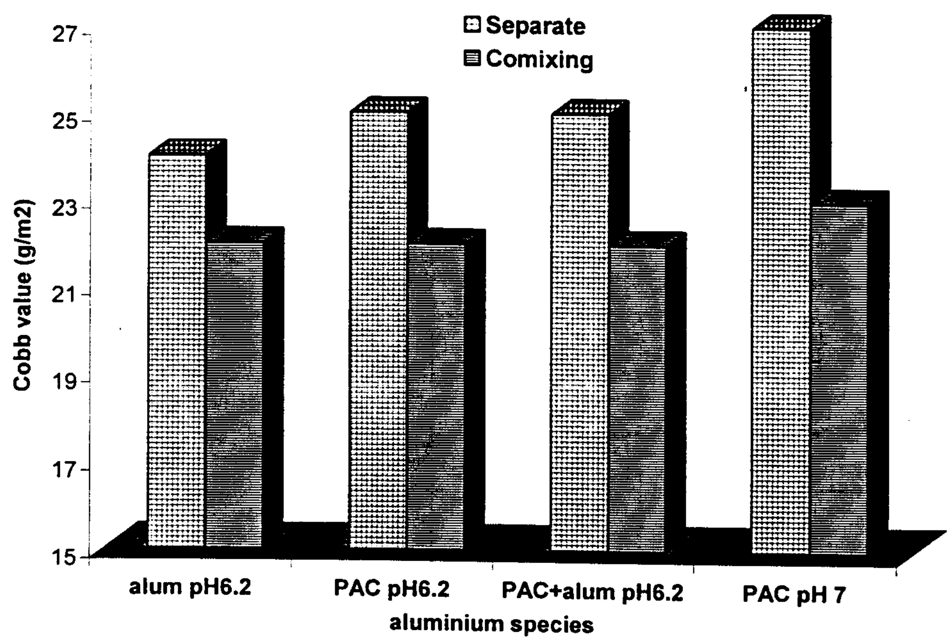
Fig. 5 Mechanism of sizing with dispersed rosin/alum



Addition of PAC

Addition of PAC in place of alum did not show much difference in sizing improvement upto pH value of 6.2. At pH higher than 6.2 PAC showed better effect indicating that addition of PAC will be required at higher pH (Fig.6). Different modes of addition of alum and PAC play an important role on the sizing efficiency especially at neutral pH. Two modes of mixing were tried. One separate i.e. rosin size followed by alum/PAC, another pre-mixing in which alum/PAC was mixed with rosin size and then the mixture of these two was mixed to the thick stock. An improvement in the cobb value of hand sheets was observed when rosin size and alum/PAC were pre-mixed as shown in Fig.6. Pre-mixing allows interaction in an environment where the cationic charge of alum/PAC is higher than it would be in the elevated pH stock. Hence, a higher degree of reactivity is achieved with available rosin leading to increased retention and sizing. Premixing of Dispersed rosin and alum/PAC and addition to thick stock allows the formation of the discrete aluminium/size particles immediately in the presence of the fibre. This minimizes any opportunity for polyanions or cations to interfere in the case of waste paper containing $CaCO_3$.

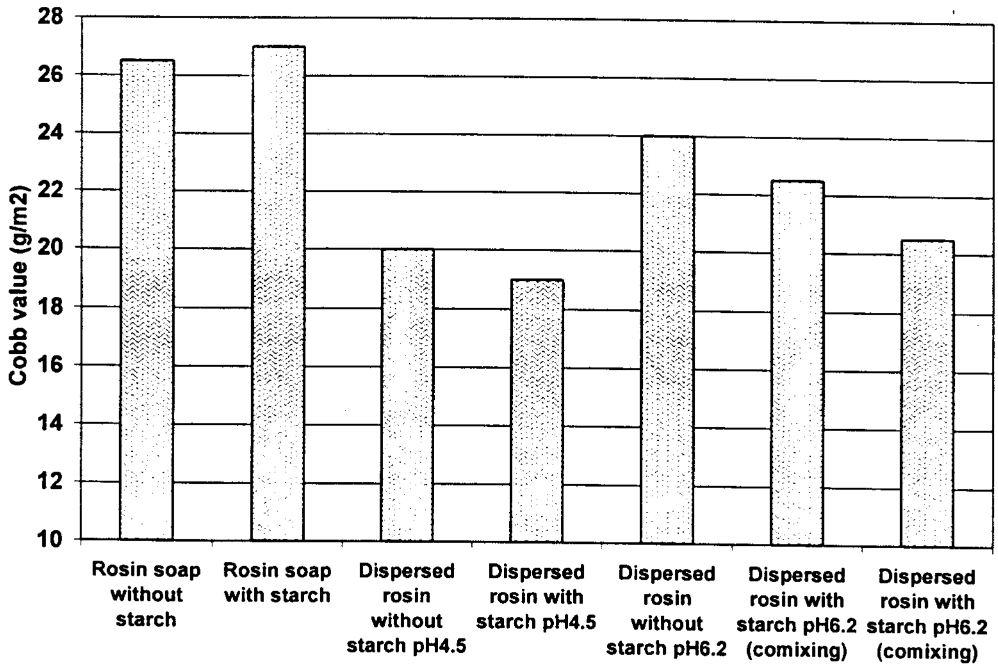
Fig.6 Effect of mode of addition on cobb value



Addition of Cationic starch in sizing

The addition of cationic starch in the stock further improves the sizing response in case of dispersed rosin. Since dispersed rosin sizes, are the dispersion of free rosin acids which have considerable surface areas. Therefore, its retention is a consequence of colloid and surface chemistry and is facilitated by conventional retention aids like cationic starch, which can bridge between surfaces. Cationic starch being a high molecular weight polyelectrolyte, creates electrostatically assisted multiple bond that helps to anchor the dispersed size particle. This also assures good attachment under high shear. Fig.7 shows the effect of cationic starch on sizing efficiency of two types of rosin sizes. With the addition of 0.5% of cationic starch, the cobb value decreases in case of dispersed rosin size. The decrease in the cobb value is more at 6.2 pH than at 4.5 pH for dispersed rosin size. By adding cationic starch and premixing of alum & dispersed rosin sizing can be improved further. Rosin soap sizes on other hand did not show such improvement in sizing on the addition of cationic starch. This suggests that cationic starch is more suitable for sizing with dispersed rosin sizes for neutral application. An added feature of cationic starch is that it also functions as the retention aid for fines and filler, improving first pass retention.

Fig.7 Effect of addition of cationic starch on cobb value



EFFECT OF DIFFERENT PROCESS VARIABLES ON SIZING

Since paper making stock is the complex mixture of fibers, fiber fines, fillers, sizing chemicals, retention aids, slimicides etc. it was decided to check the effect of selected seven process variables on sizing of waste paper. The relative effect of seven process variables on imported waste paper pulp (with $CaCO_3$) has been studied using a Plackett-Burman statistical design.

Plackett-Burman design:

In this type of experimental design[10], two levels of each variable were selected as given in Table I.

Table I

S.No.	Process Variables	Process Variable Conditions Low level (-)	High level(+)
A	Dispersed rosin size (%)	1%	2%
B	Alum/ PAC ratio	1:0	1 : 1
C	Cationic starch (%)	0.2%	1%
D	Filler amount (%)	10%	30%
E	Residual Hypo (%)	0%	0.5%
F	Stock Temperature (°C)	20 °C	50 °C
G	Mode of Mixing	Seperately mixed	Pre-mixed

The high (+) and low (-) levels are chosen far enough apart to expect a significant response in sizing properties, but not so remote from normal stock preparation conditions which are usually practiced in mill. The assumption made was that with in the restricted range of each variable, the response is essentially linear.

Table II shows the combination of sizing conditions for waste paper pulp containing $CaCO_3$, used in the experimental setup.

Table II Sizing conditions used in accordance to Plackett- Burman design

Experiment No.	A	B	C	D	E	F	G
1	+	+	+	-	+	-	-
2	-	+	+	+	-	+	-
3	-	-	+	+	+	-	+
4	+	-	-	+	+	+	-
5	-	+	-	-	+	+	+
6	+	-	+	-	-	+	+
7	+	+	-	+	-	-	+
8	-	-	-	-	-	-	-

The sizing degree of hand sheets, evaluated by Cobb and contact angle are given in Table III. The relative ranking as process variable was evaluated and the results were recorded in Table IV.

Table III Cobb & Contact angle values for different experiments

Experiment no.	1	2	3	4	5	6	7	8
Cobb Value (g/m^2)	19	52	42	47.4	48.7	21.4	23.5	41.4
Contact Angle °	109°	53°	72°	68°	61°	101°	95°	76°

Table IV Main effect of Process variables on sizing and their relative ranking

S. No.	Process Variables	Cobb value	Contact angle
A.	Amount of dispersed rosin size	-18.2 (1)	+27.75(1)
B.	Alum/ PAC ratio	-2.25(7)	+0.25(7)
C.	Amount of cationic starch	-6.65(4)	+8.75(4)
D.	Amount of filler	+8.6(3)	-14.75(3)
E.	Residual Hypo	+4.7(6)	-3.75(6)
F.	Stock Temperature	+10.9(2)	-17.25(2)
G.	Mode of mixing	-6.05(5)	+5.75(5)

* Figures in parenthesis are the rank number.

The results indicated that the variables mainly affecting the cobb value and contact angle of handsheets are the amount of dispersed rosin size, stock temperature and the amount of filler added. The main effect of -18.2 means that when the amount of size increased from low level (1%) to high level (2%), there is a decrease in cobb value (as indicated by -ve sign) which implies that sizing improves with addition of dispersed rosin size. This is in accordance to our earlier findings in studying the effect of rosin size dosage on sizing performance. Similarly, the value of 10.9 for process variable, stock temperature indicates that when stock temperature increases from its low level (20°C) to higher level (50°C), the cobb value increases (as indicated by +ve sign), which implies that sizing falls drastically with the rise in stock temperature. Same is the case with other variables. The relative rank of effectiveness of different process variables remains same when sizing of paper was checked by contact angle method, although the sign got reversed. The sign reversal is due to the fact that increase in contact angle values indicates sizing improvement.

Relative effect of major process variables

Table V shows the major influential process variables and their effect on sizing property of waste paper. The effect here has been expressed as a percentage of the mean values of cobb values. This immediately demonstrates that when sizing was checked by cobb value, amount of dispersed rosin size and stock temperature were particularly sensitive. Similarly amount of filler is more sensitive than amount of cationic starch.

Table V Most Influential Process Variables for Sizing of waste paper

Property	Process variables	Main effect as % of mean
Cobb value (g/m2)	1. Amount of dispersed rosin size	-49.32%
	2. Stock Temperature	+29.54%
	3. Amount of filler	+23.3%
	4. Cationic starch	-18.02%
Contact angle (°)	1. Amount of dispersed rosin size	+34.96%
	2. Stock Temperature	-21.73%
	3. Amount of filler	-18.58%
	4. Cationic starch	+11.02%

EXPERIMENTAL

The waste paper pulp used for the above experiments was procured from a mill based on waste paper as raw material. The pulp contained 20% $CaCO_3$ filler. The pulp was sized with Rosin soap/Dispersed rosin. The dispersed rosin used was white emulsion, fortified anionic in nature having pH 6. Rosin soap used was fortified, anionic in nature having pH value of 8.5. Handsheets were made on Rapid Kothen sheet former according to the ISO standard method TO6/ 565N706. The hand sheets were conditioned at temperature 27± 1° C and 65 ± 2 % relative humidity prior to testing. Cobb value was tested as per standard Tappi Method 441om-90 and contact angle measured as per standard Scan method P18: 66

CONCLUSIONS

- Dispersed fortified rosin and alum can be used as a sizing system for making paper from waste paper containing $CaCO_3$. This system has significant advantages over common acid sizing system using rosin soap and alum & is operable over a wide range of pH.

- Sizing of waste paper containing $CaCO_3$ can be done more effectively using dispersed fortified rosin rather than rosin soap.

- Dispersed rosin works effectively at pH range 4.5 to 6.2. At 4.5 pH the decomposition of $CaCO_3$ to the level of 40% was observed where as it was only 6% at pH levels of 6.2.
- PAC in place of alum did not show much advantage up to pH level of 6.2, however going to higher pH 7.0 addition of PAC was found to be useful.

- Premixing of dispersed rosin with alum/PAC showed better sizing than normal practice of separate addition.

- Addition of cationic starch produced better effect in sizing with dispersed rosin at 6.2 pH than acidic sizing.

- The process variables which affect sizing in descending order were found to be Sizing dose > Stock temperature > filler amount > cationic starch

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POTENTIAL OF BIOMETHANATION PROCESS IN RECYCLED FIBER BASED PAPER MILLS

M.K.Gupta, S.Mishra, N.Endlay, A.Pandey, S.Panwar & V.Bisht
CPPRI, Saharanpur

ABSTRACT

The Indian paper industry is faced with multifold challenges to sustain itself such as forest based raw material shortage, high energy costs and ever increasing environmental pressures. The paper industry is trying to resolve these issues by increased use of recycled fiber and the present trend shows that in coming years recycled fiber will be a major raw material for pulp and papermaking. In recent times, treatment of mill effluents by biomethanation process has gained popularity due to its low operating cost involved along with the added advantage of cogeneration of bioenergy in form of methane rich biogas, which can be used as fuel in boiler or for generation of power. Though the pollution load in recycled fiber based mill is low compared to mill producing chemical pulp yet the application of biomethanation technology to treat the effluent generated in recycled fiber based mill particularly for combined effluent of a group of mills located in close proximity offers a viable opportunity to reduce their energy demands to a certain extent. The present paper highlights the application of biomethanation technology in treatment of effluents from recycled fiber based paper mills abroad as well as the potential and advantages of application of biomethanation technology in treatment of effluents in Indian recycled fiber based mills .

INTRODUCTION

Owing to the present scenario of fibrous raw material shortage, increasing environmental pressures, stringent discharge norms and high cost of inputs for treatment of effluent, it has become imperative for the Indian paper industry to increase the use of waste paper / recycled fiber for the production of paper so as to sustain the growth of paper industry .The major advantages which calls for increasing use of recycled fiber by the paper industry are:

- Sustained availability & eco -friendly.
- Low cost compared to virgin fibers.
- Higher fiber yield compared to woody raw material.
- Less capital investment required for processing compared to woody raw materials.
- Lower water, energy and chemical consumption compared to mills based on woody raw materials.

STATUS OF RECYCLED FIBER BASED MILLS IN INDIA AND ABROAD

The increase in recycled fiber consumption worldwide has been significant and the growth pattern forecast the use of recycled fiber as a major raw material by the paper industry in the new millennium. Countries like Netherlands, Singapore and Taiwan have achieved recovered paper utilisation rates more than 85%. It is reported that secondary fiber is the second largest source of fiber in USA. Indian subcontinent, which comprises of India, Bangladesh and Pakistan has also made a steady progress in incorporating recycled fibers for paper making. A comparative analysis of the furnish structure in global, china and Indian subcontinent's paper industry is depicted in **Fig - 1.** Trends in fiber furnish in paper industry globally from 1990 to 2000 and forecast till 2010 is depicted in **Fig – 2.** The data on recycled fiber recovery and consumption in different countries is given in **Table –1.** In India more than 250 mills manufacture various grades of paper using recycled fiber fully or along with chemical pulp from agricultural residues to an extent of 25-40% and these category of paper mills are contributing around 40% of total paper and paperboard production of the country. These recycle fiber based mills are largely dependent on imported waste paper. The major exporters of recovered paper to India are USA (60-65%) and Middle East (25 -30%) while some quantity is also imported from Singapore and Europe.

TABLE-1
RECYCLED FIBER RECOVERY & CONSUMPTION IN PAPER AND BOARD INDUSTRY OF DIFFERENT COUNTRIES

Country	Apparent P & B Consumption X1000 Tons	Recycled fiber recovery X1000 Tons	Recycled Fiber Use %
China	32,701	8,760	37.8
Japan	31,569	16,546	53.5
Korea	6,842	4,531	72.8
Taiwan	5,074	2,789	90.8
Indonesia	3,694	1,163	46.6
Thailand	2,215	943	68.9
Malaysia	1,721	698	90.5
Philippines	810	211	50.4
TOTAL ASEAN	**4,578**	**3,509**	**57.2**
India	3,934	650	31.8
Australia	3,137	1,458	59.8
New Zealand	701	210	17.0

STATUS OF POLLUTION LOAD IN INDIAN RECYCLED FIBER BASED MILLS

The recycled fiber based paper mills in India have a wide spectrum in terms of production capacity ranging from 5 ton per day to 350 ton per day. The mills are characterised by simplicity in process as compared to wood or agricultural residues based paper mills producing chemical pulp since the complicated pulping and exhaustive bleaching process which contribute maximum pollution load are not practiced in these recycled fiber based mills.

The main steps involved in processing of waste paper includes removal of ink, glue, grits and debris. Most of the non-fibrous raw material is dissolved or separated by use of water. To minimise the water consumption most of these mills practice recycling of water. Still the water consumption varies between 40-100 m^3/ton of product (depending on the extent of recycling) which is quite high as compared to waste paper based mills in Europe **(Table -2).**

TABLE-2

SPECIFIC WATER CONSUMPTION IN RECYCLED FIBER BASED MILLS IN EUROPEAN COUNTRIES

Type of Mill	**Water Consumption m^3/ ton of product**
Packaging Board	6-8
Newsprint & Tissue	12-15
Writing & Printing	20

The major factors for high water consumption in Indian mills based on recycled fiber are low capacity, obsolete machinery and equipments multiple number of machines etc. Recently Central Pollution Control Board has prescribed the discharge standards for Indian Paper Mills **(Table-3)** which will make imperative for these mills to reduce their water consumption.

TABLE-3
STANDARDS FOR WATER DISCHARGE IN INDIAN PAPER MILLS

MILLS	**m^3 /ton of paper**
Large Mills:	
Writing & Printing	200 (100)*
Rayon Grade & News Print	150
Small Mills:	
Based on Agricultural Residues	200(150)
Based on Waste Paper	75 (50)

*** Figures in ( ) are for new mills set up after 1992**

PRESENT PRACTICE OF EFFLUENT TREATMENT IN RECYCLED FIBER BASED MILLS

The major pollutants in the effluent of recycled fiber based mill include fiber, fines, fillers, ink particles, colloidal organic and inorganic substances like adhesives, coating binders etc. Some mills practice mild bleaching of the pulp stock by hydrogen peroxide, which results in dissolution of natural resin and fatty acids in the effluent.

Some mills have installed **Krofta Dissolved Air Floatation System** where the suspended and dissolved matter in the process back water (generated during pulping) are removed in form of sludge and the clarified back water is reused in pulping, pulp cleaning and washing process. However the maximum percentage of pollution load is generated in the deinking plant.

The general characteristics of the waste water generated in these mills is given in **Table-4.**

TABLE-4
CHARACTERISTICS OF WASTE WATER DISCHARGED IN RECYCLED FIBER BASED PAPER MILLS

S.No	Particulars	Value
1.	Waste Water Generation m^3 /ton of paper	40-100
2.	pH	6-8
3.	Total Dissolved Solids, mg/l	1000-2500
4.	Total Suspended Solids, mg/l	750-1800
5.	COD, mg/l	400-1500
6.	BOD, mg/l	150-600
7.	Chlorides, mg/l	300-750
8.	Colour, Pt Co unit	200-500

The major pollutant in the recycled fiber based mill effluent are suspended solids removal of which is carried out either by simple sedimentation and polishing ponds (in areas of easy availability of water) while in mills with high production capacity and also restricted availability of water, the conventional effluent treatment system is practiced which include primary clarifier, aeration tank/aerobic lagoon and secondary clarifier. In these mills more than 50% of treated waste water is recycled in the internal process and the remaining is utilized for irrigation of crops or discharged .

BIOMETHANATION PROCESS AS AN ALTERNATIVE TO CONVENTIONAL TREATMENT PROCESS

Biomethantion process has gained popularity for treatment of industrial effluents including pulp and paper industry. A number of full-scale biomethantion plant are operating in paper industry worldwide and most of these installation are working in recycled fibre based mills. Biomethanation process offers a dual advantage of treatment of effluents along with cogeneration of energy in form of methane rich biogas, which can be used as a fuel. The anaerobic treatment has several advantages over aerobic treatment process, which are summarised in **Table–5.**

TABLE –5

COMPARISION OF AEROBIC & ANAEROBIC PROCESS

Particulars	**AEROBIC**	**ANAEROBIC**
Bacterial Growth	Fast	Slow
Carbon Balance	50% CO_2 50% Biomass	95% CH_4+CO_2 5%Biomass
Energy Balance	60% Retained as O_2 40% Heat Production	90% Retained as CH_4 5% as Biomass
Energy Input for Aeration	Yes	No
KWH/Ton COD Reduction	1100	15

In addition to this the other areas where anaerobic process scores over aerobic process are

- Anaerobic processes can be operated at 10-15 times higher organic loading rate compared to aerobic process. Consequently less space required for establishing biomethanation plant
- Less capital investment is required in anaerobic process, since the capacity of the reactor is 10-15 times less in comparison to the capacity required for the aerobic system.
- Less generation of biosludge takes place in anaerobic process which is 4-5 times less due to slow growth rate of anaerobic bacteria.

- Cost of disposal of biosludge in anaerobic process is low, since biosolids generated during anaerobic treatment are relatively stable and have high densities (8-13%) while aerobic sludge has low densities (0.5 – 2%)

- Nutrient demand in anaerobic process is low compared to aerobic process. As the growth rate of anaerobic bacteria is slow, so the demand of nutrient required for multiplication of bacteria is less.

The biomethanation technology has been well accepted in developed countries for cogeneration of energy from mechanical, semi-chemical, prehydrolysis liquor, evaporator condensates etc. and a number of full scale biomethanation plants are working in pulp and paper mills worldwide. In India a full scale biomethanation plant has been successfully commissioned by CPPRI in collaboration with MNES at Satia Paper Mills Ltd, Muktsar, Punjab which is probably the first plant in the world treating the complex substrate like black liquor. The plant is running successfully for last four years with an average COD reduction around 45-50% along with biogas generation of around 10,000 m^3/day, which is fired in the boiler. The mill has been able to achieve a saving of Rs.4.5 lacs/ month in terms of fuel (rice husk) after taking operating costs into consideration. This excludes the savings in chemical and electrical energy in subsequent effluent treatment by conventional activated sludge process.

FACTORS INFLUENCING BIOMETHANATION PROCESS

Biomethanation Process is influenced by a number of factors some of which are discussed below :

- Treatment process kinetics (i.e., substrate removal, production of excess biomass).

- Temperature.

- pH and alkalinity.

- Nutrients.

- Production rate and composition of the biogass produced.

- Inhibitiory and toxic compounds.

KIENETICS

The rate of organic removal and bio solids production in anaerobic (and aerobic) system depends on the quantity of active biomass in the system and on kinetic constant such as the substrate removal rate constant , biological synthesis yield and decay coefficients. The values for the synthesis coefficients depends on the waste composition while the value of the rate constants for substrate removal and decay coefficients depends on both the waste composition and system temperature.

Values of the substrate removal rate constant for anaerobic treatment of pulp and paper mill wastes are significantly lower than the values for aerobic treatment. The anaerobic values range from about 2 to 5 kg BOD_5 removal / kg VSS / day while the aerobic values range from about 7 to 17. Thus, anaerobic system can require three to four times the active biomass to achieve treatment efficiencies similar to those obtained in aerobic system in the pulp and paper industry. Therefore the anaerobic system is used as a pretreatment step for biological treatment system .

Anaerobic bio solids synthesis yield and decay coefficient for pulp and paper mill effluents are about one – third of the corresponding values for aerobic treatment. It implies that for similar sludge ages, the sludge production is also about a third of aerobic treatment sludge production. The smaller decay coefficient allows anaerobic system to remain dormant for long periods of time (months) with little or no loss in treatment capacity upon startup.

TEMPERATURE

The metabolic rate of all biological system is affected by temperature. Biochemical reactions proceed more rapidly with increasing temperature. The treatment efficiency of anaerobic process compared with aerobic process is particularly sensitive to operation below optimum temperature because of the significantly lower substrate removal rate constants as mentioned above. Anaerobic treatment system can be operated in the thermophilic temperature range (55 to 60 $^{\circ}$ C) or in the mesophilic range (30 to 35 $^{\circ}$ C). Using the relationship between temperature and rate constant, decrease in the temperature of about 10° C would reduce the substrate removal rate constant about 60 percent.

pH AND ALKALINITY

The optimum pH range for maximum methane production is generally between 7.0 – 7.5,. Below a pH of 6.5 to 6.8, methane gas production will begin to drop as a result of methane bacteria growth inhibition. Below pH 6.0 and above 8.5 to 9.0, methane gas production may cease altogether.

Bicarbonate alkalinity is the primary buffer for maintaining pH because carbon dioxide is released as an end product of anaerobic degradation. Bicarbonate alkalinity in the range of 1,000 to 1,500 mg/l ($CaCO_3$) normally is adequate to neutralize volatile acids and maintain a near neutral pH. The necessity for supplement alkalinity will depend on the specific process streams treated and the volatile acid concentrations maintained in the anaerobic digester.

NUTRIENT

Inorganic nitrogen and phosphorous are required as macronutrients for biomass synthesis . The nitrogen requirement is approximately 11 % of the net cell weight, based on an empirical cell composition of $C_5H_9NO_3$ where phosphorous is approximately 2 % of the biomass. In addition to nitrogen and phosphorous, several other inorganic constituents are required in trace quantities for optimum functioning of anaerobic process. These micronutrients include iron and nickel (1 to 5 ppm), cobalt, molybdenum, and selenium (approximately 0.05 ppm).

BIOGAS PRODUCTION AND COMPOSITION

Biogas produced from the anaerobic decomposition and metabolism of organic compounds is primarily a mixture of methane and carbon dioxide. At standard conditions of temperature (273°K), and pressure (1atm.), 0.35 m^3 of methane will be produced for every kg of COD removed. If sulfate and sulfite are present in the waste water, typical of many pulp and paper mill effluents, these sulfur compounds reduced to sulfide. This, in turn, results in the presence of hydrogen sulfide in the biogas. Hydrogen sulfide can be toxic and can cause corrosion of process equipment.

In addition to forming sulfide, the reduction of sulfate and sulfite present in pulp mill waste water can significantly affect the overall process economics by reducing methane gas generation. This is because energey kinetics favours reduction of sulfate and sulfite over the production of methane, causing reduced methane production per unit of substrate (COD) removal. 2.0 kg COD are required to reduce 1.0 kg of sulfate or sulfite (as sulfur) as a result methane yield is reduced by 0.70 m^3 for every kg of sulfur reduced.

However the recent development by way of biological scrubbing of H_2S from biogas is a revolutionary invention for purification of biogas containing H_2S. The process has been developed at Wagneningen Agricultural University, Netherlands and commercialised by Paques BV at Industrie Water, Eerbeek, B.V., Netherlands.

The **ThioPaq Scrubber Process**, as it is popularly known is based on the biological oxidation of sulfide into elementary sulfur.The distinguishing feature of the process is that the sulfur is not formed in the scrubber itself but outside the scrubber. The removal efficiency of H_2S in thio paq scrubbing process is more than 99% and has high operational safety as there is no risk of blockage . The schematic diagram of Thiopaq Scrubber is given in **Fig-3**

INHIBITORY AND TOXIC COMPOUNDS

Anaerobic process have been identified to be more sensitive than aerobic to conditions or chemical constituents which are inhibitory or toxic . As mentioned above presence of sulfate /sulfite in the effluent can adversely affect the process efficiency. In addition, chlorinated organics (AOX), heavy metals, resins, tannins also have inhibitory and toxic affect on the anerobic biomass. Deosition of recalcitrants like lignin/silica in the reactor biomass during the course of continuous operation of biomethanation plant may lead to decline in the performance of the biomethanation plant.

CASE STUDY: BIOMETHANATION PLANT AT INDUSTRIE WATER EERBEEK B.V., NETHERLANDS

Industriewater Eerbeek B.V. is a company that treat the waste water of three shareholders. These shareholders are three different paper mills located in the town of Eerbeek in the Netherlands, namely:

- **Reedpack, de Hoop** with a production of 750 tons /day of corrugated medium and testliner from waste paper. This mill is the major source of BOD load to the treatment plant.
- **Mayr Melnhof Eerbeek,** producing 250 tons /day of folding box board from pressurized ground wood (40%) and deinked waste paper (60%)
- **Coldenhove Paper Mill,** with a production of 60 tons /day of envelop and special cover paper from Virgin pulp (50%) and waste paper (50%).

The schematic diagram of the biomethanation treatment plant is given in **Fig-4.** The three different wastewater streams, discharged by the mills , flow by gravity through an independent sewage system to the treatment plant, where the combined waste water is received in the collection sump.

Two screw pumps lift the waste water to create a gravity flow to the primary clarifier after first passing through a rotating screen to remove large solids and through a pre-aeration to remove odorous components. The pre-aeration tank is covered with a compost filter to prevent air containing H_2S from entering the atmosphere. The clarified waste water is then pumped into a BIOPAQ Upflow Anaerobic Sludge Blanket reactor (UASB reactor). Incoming flow above a certain level are directed to an equalization tank. The volume of a UASB reactor is 2200 m^3. In the reactor , the dissolved organics are converted mainly into biogas (approx. 80% methane, 19% carbon dioxide and 1 % H_2S) and into granular biological sludge.

The biogas produced by the system passes through a 70 m^3 gas buffer. After that, a part of the biogas is scrubbed for H_2S removal and utilise in a gas engine to generate 155 kw of electric power. All excess biogas is burned by a flare. Excess anaerobic sludge is removed periodically from the reactor and stored before it is deliverd to other sites for start up of new reactors.

The anaerobically treated waste water is post treated by an extended aeration system, consisting of two aeration tanks, each one with a volume of 4,000 m^3, and two final clarifiers. The return aerobic sludge is pumped back to a sludge thickner and mixed with the primary sludge. The sludge mixture is dewatered on two belt presses and discharged for land fill. The final effluent ,with BOD concentrations of 5-15 ppm, is discharged to a river.

The Pollution load from the respective mill and the salient features of the biomethanation plant is indicated in **Table- 6 & 7**.

TABLE-6
POLLUTION LOAD FROM THE MILLS

Name of the Mill	Flow m^3/day	Soluble COD Kg/day	Soluble BOD Kg/day	Settlable Solids Kg/day
Reedpack de Hoop	5000	14000	8000	2000
Mayr Melnhof Eerbeek	5900	5000	2000	14000
Coldenhove Paper Mill	1400	200	100	1000
TOTAL	12300	19200	10100	17000

TABLE-7
SALIENT FEATURES OF THE BIOMETHANATION PLANT

PARTICULARS	
Reactor Type	UASB
Reactor Capacity,m^3	2200
Organic Loading Rate, kg COD/m^3/day	10-12
Waste WaterFlow,m^3/hr	600-650
COD Reduction %	60-70
BOD reduction %	70-75
Specific Biogas Production ,m^3/kg COD removed	0.35-0.45

PROSPECTS OF BIOMETHANATION PROCESS IN RECYCLED FIBER BASED MILLS IN INDIAN SCENARIO

The installation of biomethanation plant an individual recycled fiber based mill (even in a 100 tpd mill) may not be technically and economically feasible owing to low pollution load as indicated in **Table- 8**

TABLE-8
POLLUTION LOAD IN A 100 TPD RECYCLED FIBER MILL

S.No	Particular	Value
1.	Waste Water Generation m^3 /day	5000-7500
2.	Suspended Solids, ton/day	4.0-5.0
3.	Dissolved Solids, ton/day	6.0-7.5
4.	COD, ton/day	5.0-7.5
5.	BOD ton/day	2.0-3,.0

However the concept of **cooperative biomethanation plants** (as that of Industrie Water Eerbeek B.V.Netherlands) where the effluents from three or four recycled fiber based mills located in a close vicinity is collectively treated together and the bio gas generated is utilisied together among the mills not only make application of biomethanation feasible but also economically viable specially in Indian scenario..The potential and technoloeconomic viability of biomethanation system evaluated for a cluster of mills are given in **Table 9&10.**

TABLE – 9
POTENTIAL OF BIOENERGY GENERATION IN A COOPERATIVE BIOMETHANATION SYSTEM OF 3-4 RECYCLED FIBER BASED MILLS.

S.No	PARTICULARS	VALUE
1.	COD Load ,ton/day	15-18
2.	BOD Load, ton/day	6.0-7.5
3.	COD Reduction %	60- 65
4.	BOD Reduction%	80- 85
5.	Biogas Generation m^3/day	4000-4500
6.	Calorific Value,kcal/m^3	6200-6500
7.	Coal Equivalent, ton/day	5-6
8.	Fuel Oil Equivalent, ton/day	2.5-3.0

TABLE-10
ECONOMICS OF THE PROPOSED BIOMETHANATION PLANT

PARTICULARS	VALUE
Installation Cost, Rs (Lacs)	150
Operation & Maintenance Cost including Electrical Power, Chemicals (Nutrients) & Manpower, Rs(Lacs)/Annum	20
Total Savings per Annum (Rs Lacs)	40
Net Savings after considering operating costs.,Rs.(Lacs)	20
Pay Back Period, Years	6-7

CONCLUSION

The increased trend in recycling of waste paper world wide indicates that the recycled fiber will be a major raw material in coming years to reduce the dependency of the paper industry on the natural resources and also promote better environmental mangement. In India around 40% of the total paper production comes from recycled fiber. The effluent generated during the processing of waste paper contain easily biodegradable organic matter. The full scale biomethanation plant have been already working successfully for treatment of effluent generated in recycled fiber based mill abroad. The biomethanation technology has been demonstrated successfully for treatment of black liquor in agro based paper mills. In view of increased cost of energy and also high operating cost of conventional aerobic treatment process, the biomethanation process has a good potential in recycled fiber based mills specially where number of mills are operating in close proximity.This will not only help in meeting the discharge norms but also reduce the mill's dependence on purchased power to a certain extent.

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FIG.1 Furnish Structure in Global, China & Indian Subcontinent Paper Industry

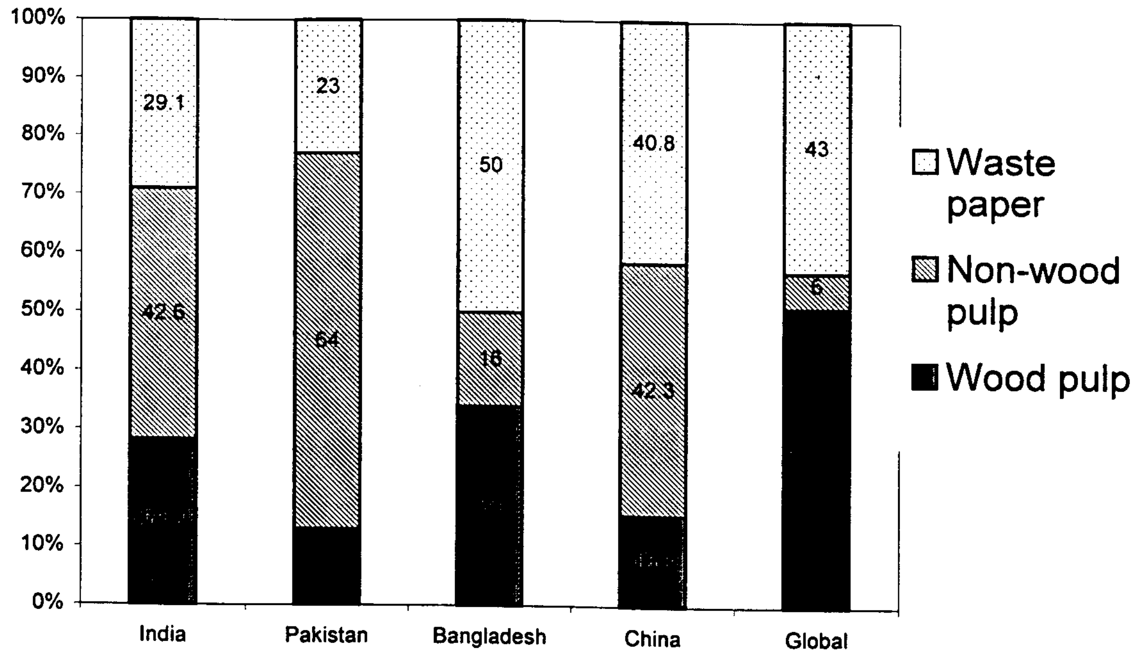
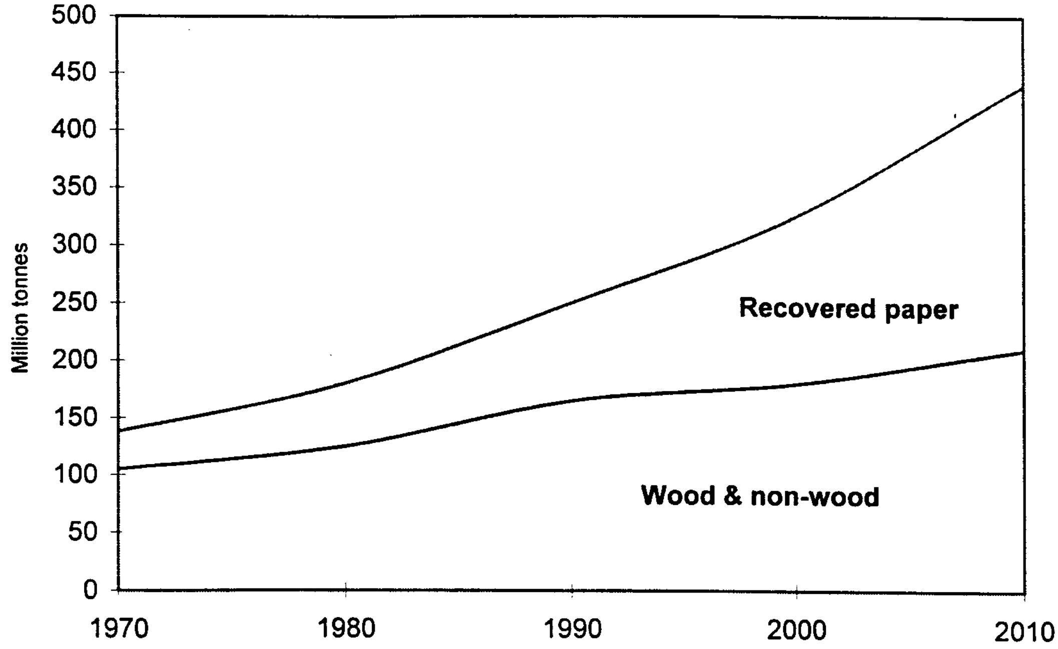


FIG.2 Trends in Fiber Furnish in Paper Industry



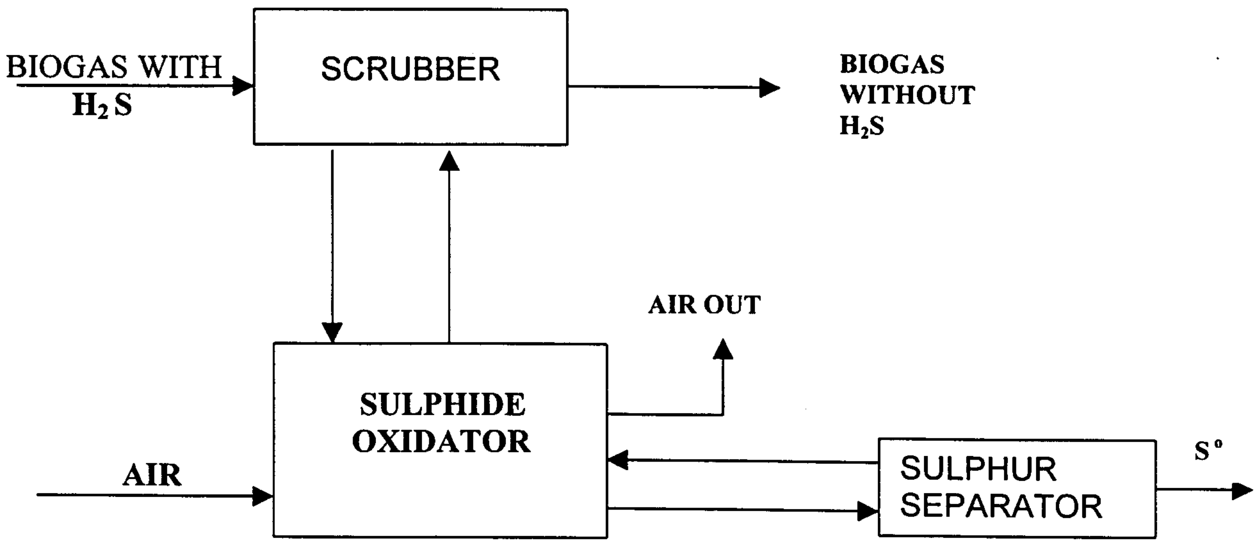
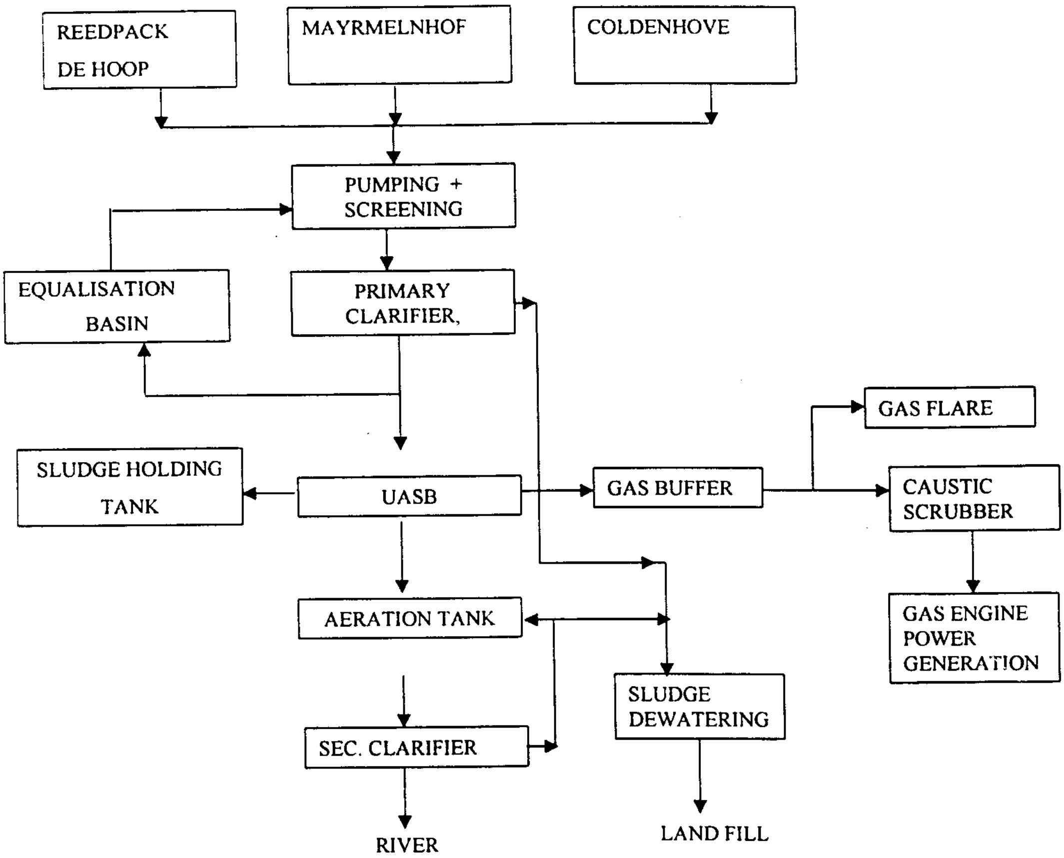


FIG.3 THIOPAQ SCRUBBER

FIG.4 FLOW DIAGRAM OF BIOMETHANATION PLANT AT INDUSTRIE WATER EERBEEK, NETHERLANDS



ENZYMATIC DEINKING OF NON-IMPACT PRINTED TONERS - A REVIEW

Dr. R.K.Jain, Dr. R.M.Mathur & Dr. A.G.Kulkarni
CPPRI, Saharanpur

ABSTRACT

Mixed office waste present technical and economic challenge to the recycler and of the wide variety of fibre and contaminants present in the paper stock, toner and other non contact polymer ink from laser printing process, is one of the most difficult to deal with. Toner and laser printing ink are synthetic polymers with embedded carbon blocks, they don't disperse readily during conventional repulping processes. Moreover, these are not readily recovered during floatation or washing. Because of these problems recycled papers contaminated with toner have a relatively low value. Most of the deinking chemicals and high-energy dispersion steps employed in current deinking technology are tedious, cost prohibitive and some times leads to loss in pulp yield. The enzymatic deinking process employing suitable enzymes cocktail effective in deinking of laser and xerographic waste paper and show promise in Indian paper industry. The present article discuss an overview of enzymatic deinking technology and how effectively can it be employed in Indian paper industry.

INTRODUCTION

Forest based pulps has continuously lost its share of the total pulp and paper furnish in the global paper industry. This is likely to continue but at significantly reduced pace. As per estimate the share of wood pulp out of the world furnish mix will be 44% by 2014 as against 52% in 1998 and 70% in year 19980. Recycling of fibre is a rapidly growing segment of the paper industry and will continue to gain share of the fibre furnish world wide. The major driving force for increased use of the recycled fibre has been the environmental concern form the pollution control authorities as well as the customers preference for the environmentally benign products which demand highest quality of DIP because of the high brightness level of the final product.

The main quality issues of paper products using recycled fibres have been runability and printability that have been limiting the use of these furnish. These are normally related to the instability and cleanliness of the raw materials and strength properties, filler contents and average fibre length of the furnishes. The recovered furnish is actually a mixture in which the different material contents can vary uncontrolled based on the type and quality of collected and mixed paper and boards. These running and printing problems have been solved by developing better deinking processes, machinery, screening and sorting technology, than can help in achieving better quality of DIP and will also allow to use more low quality of recycled paper and even unsorted materials in near future.

Though the recycled source of fiber, non-coated printed papers which includes xerographic and laser printed papers are the fast growing sources due to the increased usage of office photocopier and computer print outs. However due to the difficulties in deinking of these waste paper by conventional deinking methods, the volume of recycling for this high quality fibre is in less use. In order to effectively utilise larger volume of recovered non-contact printed laser papers there is a need to introduce an effective and efficient technology that will deink non contact ink to an acceptable residual ink count in an economically and environmentally acceptable manner. New deinking mills establish in response to these projected needs are already competing for the cleanest and most homogeneous post consumer paper sources e.g. sorted white ledger and soon will have to dip deeper in to the post consumer stream of unsorted mixed office waste (MOW) to remain competitive.

Current deinking technology is being stretched to accommodate both the hard to remove toner ink. Stickies and the coloured dyes and unbleached fibre present in unsorted MOW. Additional chemicals, multiple floatation steps and dispersion alleviate some of the limitation of the heterogeneous paper stocks. While pulp cleanliness resulting from this sequence is good enough, however the process is capital and energy intensive and sometime loss in pulp yield also occur. Moreover they are not readily removed during floatation or washing. Because of these problems, recycled paper contaminated toners have a relatively low value.

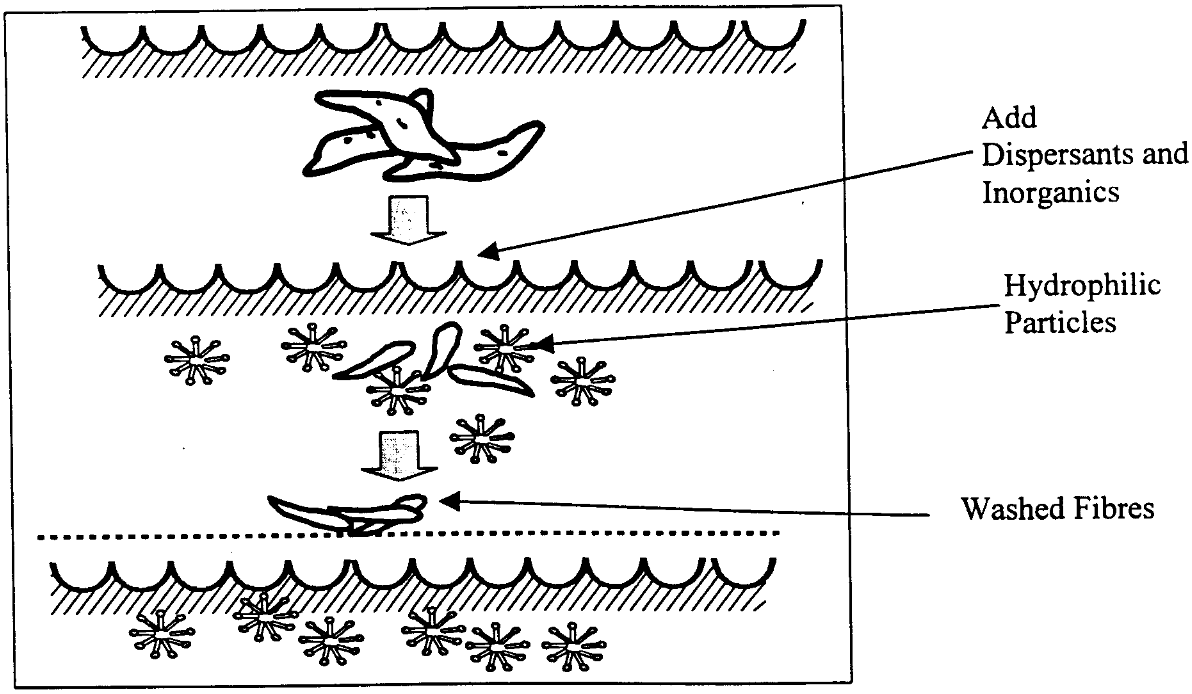
Enzyme enhanced deinking shows promise as a process for improving toner removal from laser and xerographic waste paper so that lower quality office post consumer paper with high laser content can be up-graded. The present paper discusses an overview of enzymatic deinking technology particularly for deinking of xerographic and laser office waste highlighting the mechanism and the factors influencing the enzyme deinking.

DISCUSSIONS

Deinking principles and Current deinking practices

The common technique used for ink removal from laser and Xerox printing waste are washing and floatation. These kind of paper use thermoplastic toner that fuse on to the fibre surfaces during high temperature non-contact printing. These non-dispersing inks require special chemicals, thermal and mechanical actions to detach the inks from the fibre so that the ink can be removed by floatation and washings. **Floatation** is a step in deinking process that separates hydrophobic particles from the hydrophilic fibres as shown in fig.-1. Floatation removes particles that are too small to be removed by screens and cleaners and yet are too big to remove by washing.

FIG. 1. FLOATATION STEP



Washing is most efficient at removing the smallest particles of the ink. The objectives in washings are to keep the ink particles finally disperse and agglomerations. Washing requires the ink particles to be rendered hydrophilic so that they remain in the aqueous phase as shown fig.-2. Both of the process normally operates at high pH(10-11) with the use of conventional alkaline deinking agents such as sodium hydroxide, sodium carbonate, sodium silicate and hydrogen peroxide. In this environment the paper structure collapses rapidly and release the ink particles in to the suspension. A dispersant is added to stabilize the colloidal suspensions of ink particles in washing processes.

The dispersion is replaced with a collector soap in floatation deinking. The optimum size range for the different unit operation are shown in fig.-3.

FIG. 2. WASHING STEP

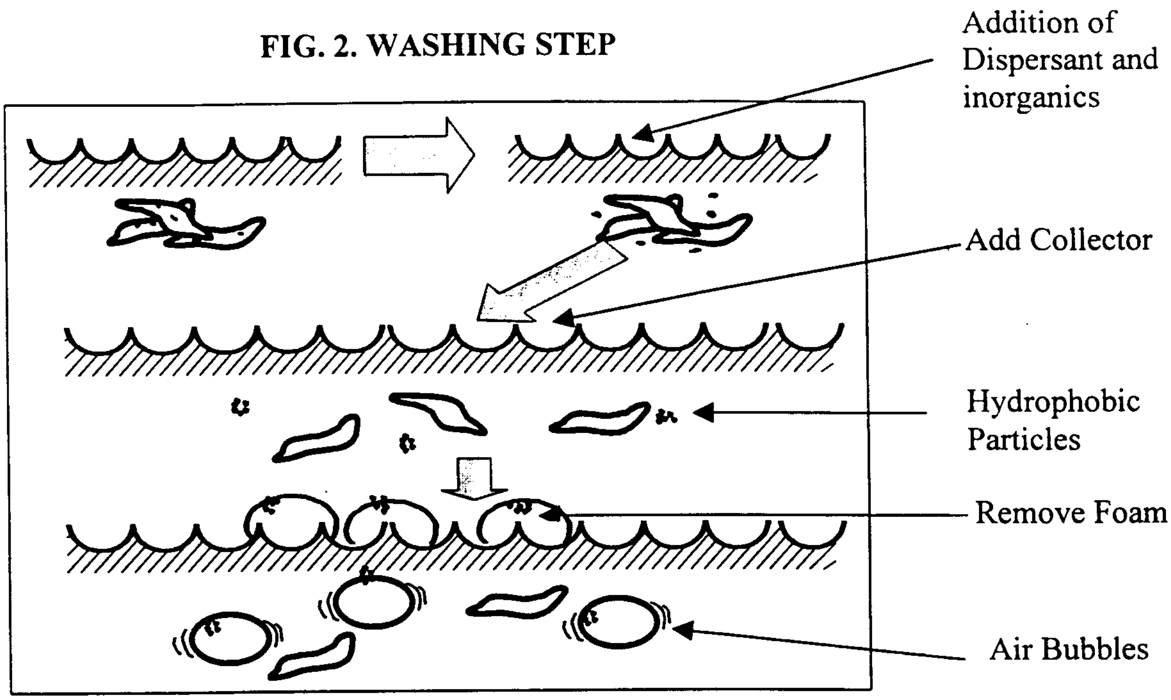
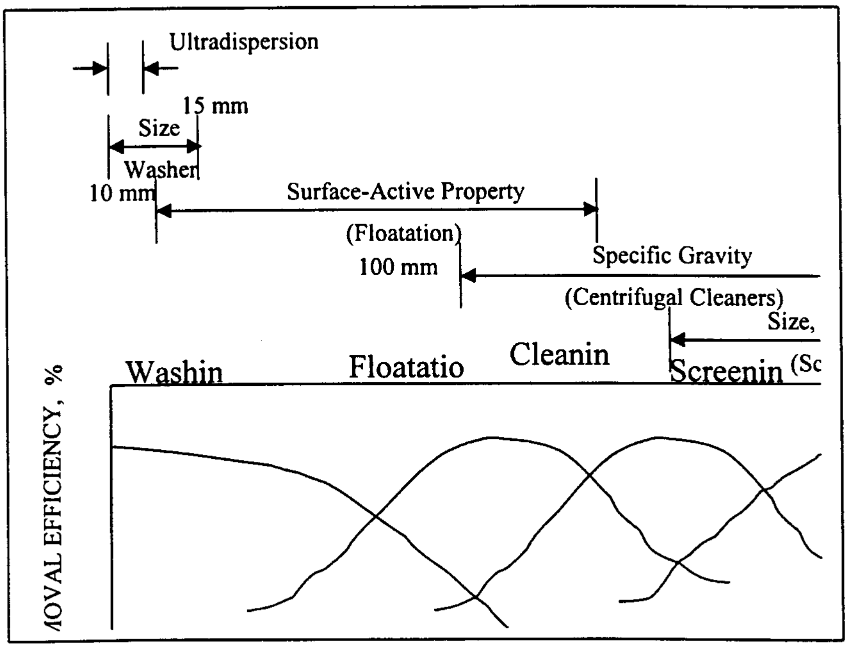


FIG.-3. OPTIMUM PARTICLE SIZE RANGES FROM VARIOUS UNIT OPERATIONS IN DEINKING



LIMITATIONS AND PROBLEMS IN CURRENT DEINKING TECHNOLOGY

As discussed laser and xerographic inks are thermoplastic which are copolymer of styrene and acrylate designed to be non tacky at room temperature but it melt at temperature of 70-120^{0}C. During the fusion stage of the copolymer process at high temperature (100^{0}C). These thermoplastic resin binder set to form the printed film by cross linking.

These hard cross linked strongly bond system will only be fragmented to minimum size by strong mechanical forces, which in term leads to fibre degradation. Conventional chemical treatment is not effective in reducing particle size further and particles are visible as dirt in the finished product.

Due to this special treatment of laser and xerographic inks some modified deinking processes have been tried, among which washing/ floatation, two stage floatation and agglomeration and disintegration with subsequent removal of screening and cleaning are prominent are to mention. These requires some chemicals and the equipments but the process are capital and energy intensive too.

ENZYMATIC DEINKING

Predominant enzymes used for deinking of waste paper is mainly the cellulases and hemicellulases. Cellulases could work in several ways to enhance deinking. These reduce the hydrodynamic drag to increase the filtration and floatation rate. As cellulases are known to enhance drainage rates they can enhance any separation process such as filtration or floatation. Deinking with enzymes involves dislodging ink particles from fibre surfaces and then separating the disposed ink from the fibre suspension by washing and/ or floatation.

Mechanisms of enzymatic deinking

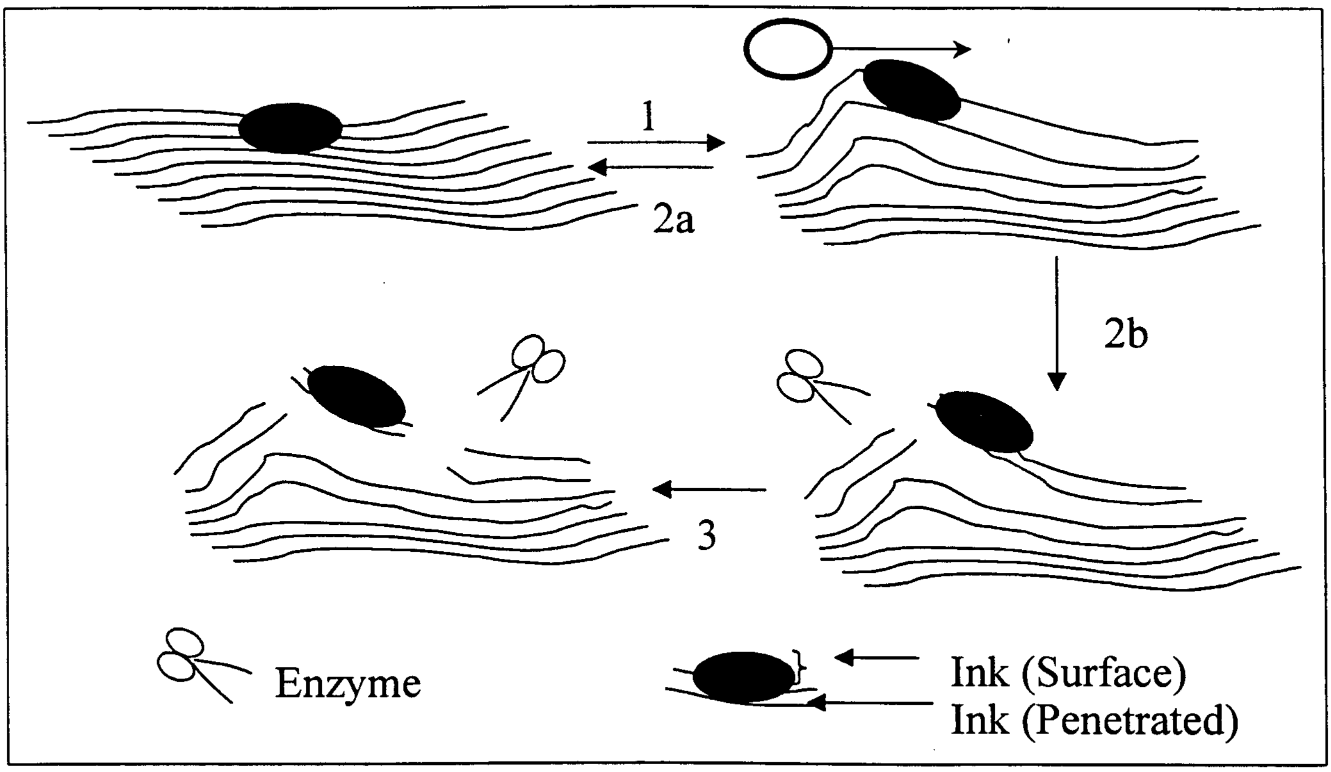
Deinking can be divided in to five different operations occur in partly consecutively and partly overlapping stages. These stages are:

Disintegration, precleaning, chemical or enzyme treatment, floatation and/ or washing and finally bleaching.
During enzymatic treatment, the process is preceded by disintegration and followed by a cleaning operation, which makes it very difficult to determine the exact role of the enzyme. Cellulases action may also increase the specific surface area of the fibres and they reduce interaction with contaminants. That is to say that there might be microfibrils on the surface of these very frazzled, recycled fibres which could be trapping the ink particles, and by giving the fibre a haircut then reduce their adhesion. A model of enzymatic deinking is shown in Fig. -4.

FIG. 4. A MODEL OF ENZYMATIC DEINKING:

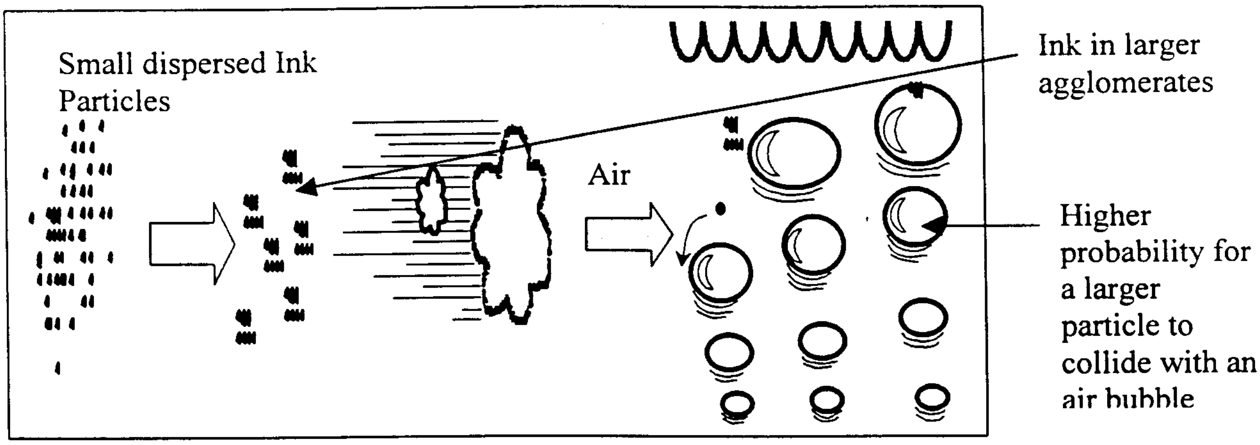
1- Friction open the fibre, 2a- Relaxation,

2b - Enzyme cutting, 3-Ink removed



However the studies have shown that the most important fraction with respect to toner removal is the increased floatation efficiency imparted by cellulase enzyme activities and the increased removal of toner has been observed during floatation stage. During floatation air bubbles rise to the surface of the floatation tank through a relatively dilute pulp stock, approximately a 1% consistency. The surface of air bubbles being relatively hydrophobic, they carry the toner particle to the loop where they are removed by a skimming action. The operating principle of floatation deinking is shown in fig.5.

FIG. 5- OPERATING PRINCIPLE OF FLOATATION DEINKING



PROCESS CONDITIONS DURING ENZYMATIC DEINKING

Deinking Enzymes and the order of its addition

The preferable enzymes used for deinking wastepaper are commonly a mixture of cellulase and hemicellulase. The order for addition of material is to first added the proper amount of waste and waster in order to achieve desired consistency followed by the diluted solution of enzyme.

Access of cellulase enzyme to cellulase fibre is essential for achieving maximum activity of enzyme. Proper mixing of the enzyme at consistency 11-16% helps in dislodging toner particles from fibre and presence of surfactants help the enzyme penetrate through the paper additives. The increased cellulase available for cellulose attachment. Smoothing of fibre increase pulp freeness, which prevents toner particles from becoming trapped in the repulped fibre network.

Enzyme dosing point has been of great significant to achieve maximum enzyme efficiency. Enzyme activity being site specific, distribution of enzyme throughout the pulp is essential to achieve maximum enzyme efficiency. Addition of the enzyme after proper dilution at pulper near the beginning of the repulping process has been desirable. This allows the enzyme to react with waste furnish at higher consistency while under getting optimum mechanical agitation.

Pulp Consistency

Results shown in the figure-5 clearly indicate that pulping at medium consistency, 12% is advantageous for recovering toner through the combined effect of enzyme and mechanical action. However from the results shown in table-1 clearly indicate that increasing the consistency to as high as 16% increase deinking efficiency. However at higher deinking pulping consistencies and extended pulping time the effect of mechanical action predominant with only little additional benefit from the enzyme.

Table -1 Effect of pulping consistency in ink removal[a]

Particulars	Residual ink at various levels of consistencies (PPM)	
	12%	16%
Control pulp	681	343
Enzyme treated pulp	329	220

a : Residual ink on hand sheets counted in 10-2000 μ range

Surfactants

Addition of surfactants during enzymatic deinking process plays an important role for separation of ink from pulp fibre during floatation. Surfactants make the cellulose more accessible to cellulase enzymes and facilitate enzyme dispersion, thus making the enzyme available to attach to cellulose sites. Under appropriate conditions, surfactants increase cellulose effectiveness. The use of non-ionic surfactants to the paper prior to addition of enzymes has been preferred to achieve better deinking efficiency as indicated from the results shown in Table-II.

Table-II . Effect of adding surfactant via floatation cell or pulper.

Specimen	Residual ink (PPM)	
	Floatation cell	Pulper
Control	326	231
Enzyme treated	278	168

Certain anionic surfactants containing sulphates or sulphonated functionally can reduce the efficiency of the enzyme to hydrolyze cellulase and in tern reduce the deinking efficiency of the enzyme.

Moreover there should always be synergy of enzyme with a particular surfactant, which leads to be evaluated for an ideal enzyme preparation. Results of effectiveness of two of the identified enzymes and their synergy with the available surfactants are shown in table-III.

Table-III. Enzyme/ surfactant synergy

Variables	Residual ink (PPM)
Control	368
Enzyme A, Surfactant A	242
Enzyme A, Surfactant B	303
Enzyme B Surfactant A	278
Enzyme B, Surfactant B	214

pH

The commercial cellulase enzyme preparation selected for deinking most active nearly to neutral pH range and around 6.5 to 7.5. increasing the waste paper stream containing alkali additional place some office waste paper repulped waste at the upper end of pH range of approximately 8.5 - 8.9, however better deinking efficiency have been obtained by adjusting the pH to 7.0 -. Results of the effect of pH on ink removal are shown in table- IV

Table -IV Effect of pH on Ink Removal

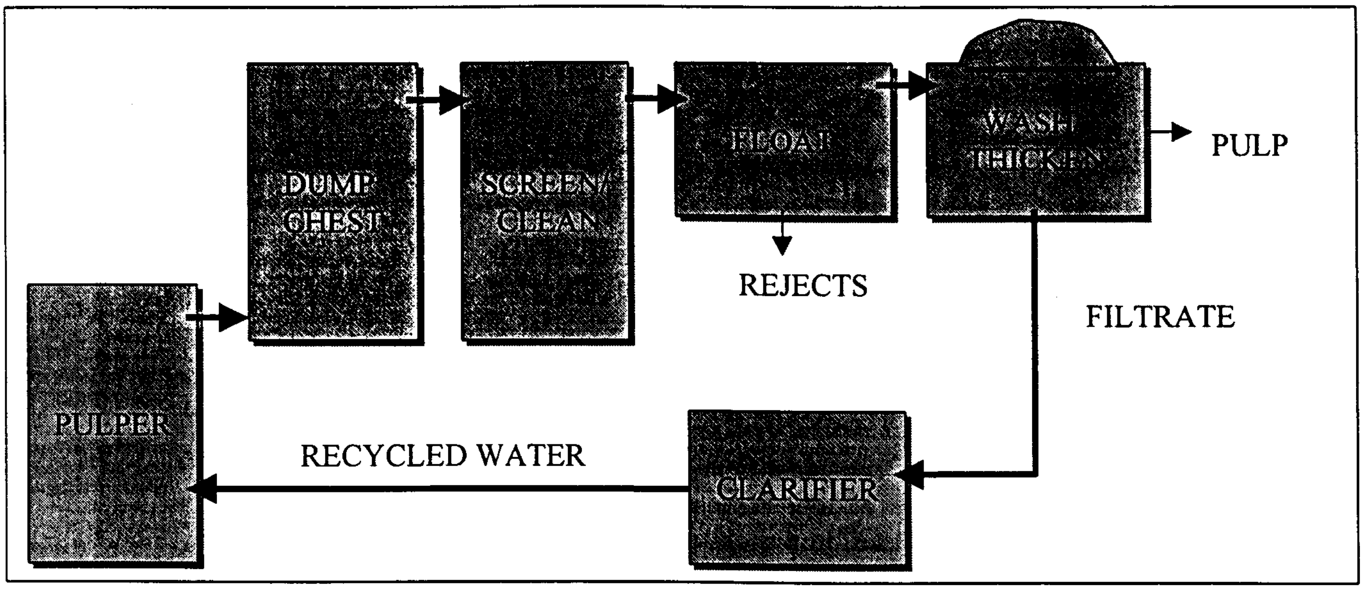
Particulars	pH	Residual Ink (PPM)
Control pulp	---	139
Enzyme treated pulp	8.6	64
Enzyme treated pulp	7.0	47

Depending on the mill performance sulphuric or phosphoric acids can be used to maintained proper pH. Relative enzyme activity at various pH levels is shown in fig.

Temperature

The optimum temperature range for a conventional cellulase based enzyme has been 45 - 55^{0}C. Having realized that the toner-based inks might began to fuse and reattach at higher temperature, the temperature below 65^{0}C is always preferable. The schematic of the proposed process flow sheet of the enzymatic deinking is shown in fig.- 6

FIG. - 6. PROPOSED PROCESS FLOW SHEET FOR ENZYMATIC DEINKING



CONCLUSIONS

1. Enzymatic deinking of laser and xerographic waste paper appears to be promising technology for deinking of hard to remove toner inks.
2. Medium consistency pulping conditions of 11-13% appeared to be more effective than low consistency pulping conditions for toner removal.
3. Higher consistency and washing remove laser and xerographic toner from mixed office waste more effectively with a suitable blend of cellulase and xylanase.
4. Selection of an enzyme with optimum activity in the range of the pulped paper stock would minimize pH adjustment in the pulper and therefore simplifies the process and lowers the process cost.
5. Efforts are required to develop and evaluate enzymes preparation suitable for the kind of waste paper utilized by the Indian paper industry to make the technology techno-economically viable.

ACKNOWLEDGEMENT

Authors are thankful to M.Manthan for his assistance in preparation of the manuscript of the paper.

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ENERGY AUDIT AND PROCESS OPTIMISATION IN WASTE PAPER BASED MILLS FOR COST EFFECTIVE PRODUCTION- A CASE STUDY

R.M.Mathur, B.P.Thapliyal, A.G.Kulkarni
CPPRI, Saharanpur

INTRODUCTION

In India more than 250 mills manufacture various grades of paper using recycled fibre partially or fully in their furnish. This figure is increasing day by day, clearly indicating the growth of this sector with time. Majority of waste paper based mills in India fall under the category of small paper mills and do not have resources to opt for the the latest technologies. With the prevalent processes & technologies, most of the small mills are not in a position to produce quality products in a cost effective way.

Energy is one of the major cost component in production of paper. To make the product cost competitive, it is essential to take all the measures for the reduction of energy consumption during manufacturing process. Process controls in these mills are inadequate and therefore major process operations are un-optimized. This results in wastage of energy and un-accounted fibre losses and in most of the cases mills are not able to contemplate the extent of resource drainage. Central Pulp & paper Research Institute has conducted several studies in waste paper based mills to indicate the quantum of wastage which can be reduced by simple process optimization exercises in the mill. In present paper results of a case study conducted in one of the small paper mill based on waste paper are highlighted to present the potential of savings in these mills.

ENERGY AUDIT & PROCESS OPTIMISATION STUDIES

The Mill

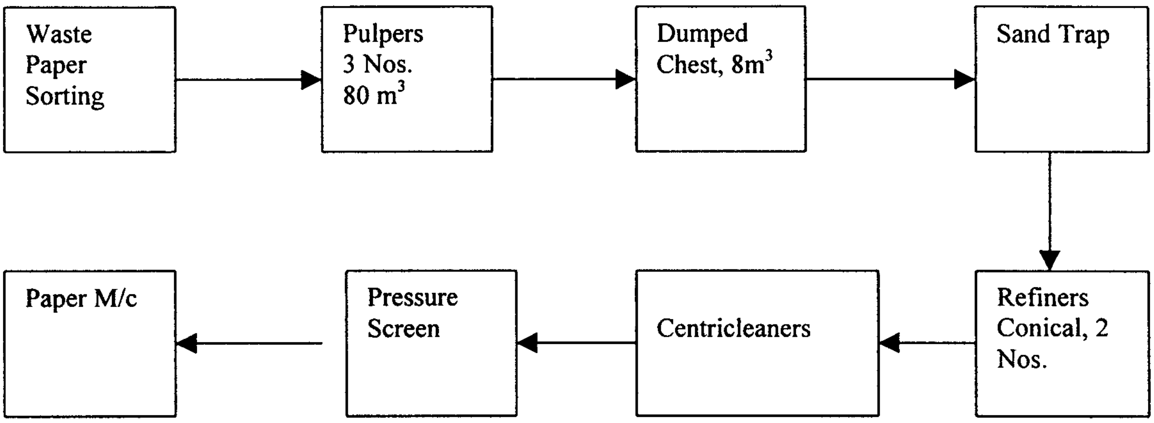
CPPRI team conducted exercises in a mill based on waste paper, producing Newsprint with an installed capacity of 10,000 tpa to find out energy consumption pattern in various sections, to locate the area / processes consuming high energy & trace energy wastages, if any, and to conduct process optimization studies in the mill.

Energy Consumption Pattern in the mill before the energy audit exercises is shown below;

Electrical consumption, KWh/t	-	700-800
Steam consumption t/t paper	-	2.75
Water consumption m^3/t paper	-	45.50

A schematic flow diagram of the mill is shown in Fig.1. Details of the major sections are given below;

Fig. 1 Schematic Diagram of the mill.



Mill uses waste paper, Old Newsprint (ONP), mixed waste paper (MWP) and Imported waste paper for production of Newsprint. The waste paper (ONP & mixed waste paper) is procured locally through the suppliers and agents. The waste paper is cleaned normally by sorting and fed to pulpers as such without shredding.

Mill is equipped with 3 pulpers, of 89 m^3 capacity. Pulper No.2 & 3 are used for waste paper defibration (30 minutes per batch)whereas the pulper No.1 is used for broke defibration. Most of water for pulping is recycled from Decker/thickener, krofta and machine back water. Small amount of fresh water is also used occasionally during pulping. Pulping is done at ambient temperature and the consistency during pulping is 5%.

The mill is not practicing any chemical addition in the pulper and the ink particles are carried over to refiners. The objective of the refining may be to reduce the size of the specks so that they will not appear as spots. The stock is refined giving multipasses to bring the ^{o}SR from 28 to 42. The total time of refining is around one hour. The mill is having two conical refiners (capacity 20 t/d each) and only one refiner is used at a time. The mill has only sand trap and vibratory screen as coarse screening system which does not fulfill the required features for contaminant removal. Mill uses centricleaners for cleaning paper machine stock. There are 3 stages of the centricleaners. Ist stage has 3 tubes, IInd and IIIrd stages one each. The amount of rejects from IIIrd stage is app.200 kg/day, which is drained out .

Mill has one M.F. Fourdrinier paper machine with following details :

Deckle of machine	-	288 cm at pope real
Speed of machine	-	150 m/min
gsm range	-	45-100
Capacity	-	30 t/day
Electrical Consumption	-	474 kwh/t
Steam Consumption	-	2.75 t/t

The paper web after two plain presses goes to 18 dryer cylinders in 4 groups using live steam in all the dryer cylinders.

Mill has one Loco boiler fired on lignite. Details of boiler are given below :

Capacity	4.0 t/hr
Steam production	2.75-3.0 t/hr at 6.0 Kg cm^2
Calorific value	3300 Kcal/Kg
Flue Gas temperature	180^0C- 190 ^{0}C
Oxygen %	11-14 %
Ash temperature	285-290 ^{0}C
Radiation losses	3 %
Heat losses (% of gross heat input)	12.5

Total connected load of the mill is 563 KW. The electrical requirement is met by power generated from 2 DG sets of 380 and 500 KVA respectively. Electric power generated per day is 11500 KWh from both DG sets. Mill also has a 3rd DG set of 75 KVA which is used only for running the tubewell pump.

OBSERVATIONS & RECOMMENDATIONS

CPPRI team carried some instruments such as Minolta non-contact pyrometer, fuel efficiency monitor and tongue tester etc. to study the steam generation & distribution to various processes and energy consumption in processes including both steam and electrical energy consumption. An energy audit approach consisting of collection of data from different sections of the mill, compiling the information, analysis & reporting was conducted. CPPRI Energy team formulated reporting formats and energy management planning for the mill.

The suggested optimization measures for different sections and processes in the mill are given below;

Pulpers, chests and sand trap

- Utilization of condensate tank flash steam to raise the temperature (upto 40 °C) in pulpers results in reduction of defibration time and a saving of 15 minutes leads to saving of app. 10 kWh per batch.
- Use of 0.3- 0.5 % alkali and hypochlorite was suggested during pulping at higher temperature (e.g. 40°C) to remove ink particles from stock and for producing better quality product.
- Mill utilized all chests of same size and dimension. It was suggested to use the chests capacities according to their application and agitators and pumps installed according to the chest requirement.
- A study of the sand trap in the mill revealed that it is undersized for the machine capacity of 30 t/d. Mill is constructing one more sand trap considering following objectives;

  * Consistency of pulp be 0.55-0.6% in the sand trap.
  * Easily approachable to remove the sand from baffles to a trolley for disposal.
  * Design requirements
    slope — 2 % in the direction of flow
    width — 2821 mm (940 mm for each trough for 3 channels)
    Height of the stock above baffle = 80mm.

Refiners

- The refining for a period of one hour generates high amount of fines which is upto 30 % in this case. These fines drain slowly on recycled pulp compared with virgin fibres and affect the sheet strength properties also. Refining the stock upto 45 min along with use of small amount of caustic (0.3-0.5%) in the pulper resulted in saving of 17 KWh/t during refining with improved drainage properties and sheet strength.
- On the recommendations CPPRI, Mill is optimizing its refining operation by finding out the most suitable sheet properties and drainage characteristics after different time intervals, i.e. 15, 45 and 60 min.

Centricleaners

- On the recommendations, mill installed pressure gauges at the inlet and outlet of the centricleaners in stage I, II and III. The pressure is now maintained in the range of 275—340 kN/m^2 for achieving the best operating results.

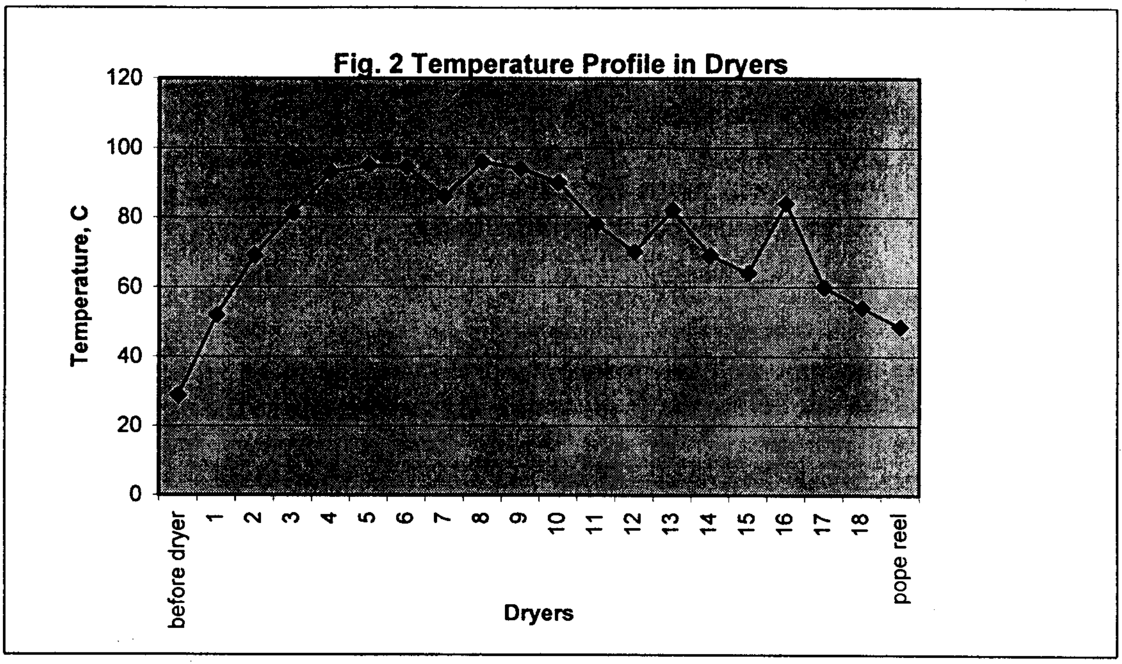
- Mill uses consistency of 0.8 % in the centricleaners which result in the less degree of cleanliness of the stock. As per the advice of CPPRI, mill reduced the consistency to 0.6 % in the centricleaners. However, this resulted in marginally higher energy consumption due to pumping requirement but considerably improved the stock cleanliness.
- Earlier mill used stock upto 40 °SR and at this freeness, the amount of short fibres going with the reject was more. By reducing the refining time and producing pulp with lower °SR, mill could reduce its fibre losses.

Paper Machine

- In the paper machine mill can reduce the drying energy from 5-10 % by utilizing flash steam shower before the II press nip. This will improve the dryness after the II press by minimum 2 % and thereby lead to savings in dryer energy requirements.
- The percent moisture profile at various stages was recorded and is shown below at machine speed 115 m/min.

	% Moisture at		
	Front side	Middle side	Back side
After couch	80.2	—	84.6
(Couch vacuum 210 mm Hg)			
(Flat box vacuum 100 mm Hg)			
After Ist press	67.2	68.0	64.7
After IInd press	64.0	62.8	59.2
At pope real	5.5	6.9	6.7
Calander load- 1.5 kg/cm^2			
Quality- Newsprint at 48 gsm.			

- The temperature profile in the dryer groups was studied to find out the drying efficiency and condensate removal from dryers. Fig.2 shows the temperature profile for various cylinders. In the dryer part live steam is used and the temperature is controlled by manual control of opening the valves. The temperature profile shows variation in the dryers cylinder and it may be mainly due to improper condensate removal. The siphon clearance is 1- 1/2 " and mill is consulting paper machine suppliers in this regard.



Boiler House

- The studies conducted in the mill revealed that the temperature and oxygen percentage in the flue gas was very high which shows an inefficient boiler operation carrying large amount of useful heat with excess air. By running the boiler under optimized conditions, the temperature of flue gases could be reduced to 150 °C from 180 °C and by controlling the ID fan speed percentage oxygen reduced to 8 % from 11.4 %. This results in boiler

  - efficiency improvement from 79 to 86 %, leading to savings in lignite consumption upto Rs.40,000/-per month.
  - Mill has no measuring system for the combustion air and flue gases. Only temperature of flue gas can be measured and mill was recommended to install a continuous CO_2/O_2 analyzer to check the optimum operating conditions.

Electrical Systems

In order to stop the losses due to oversized motors, it was suggested to replace these motors with optimum size energy efficient motors. Mill has potential of Saving approximately 1600 KWH/day by using the proper sized motors and has started replacement of various motors.

CONCLUSIONS

The study shows that there exists a large potential for reduction of energy consumption in waste paper based mills by optimizing the existing processes, without much capital investments. The results of the case study show that by using correct size motors & pumps and optimization of process variables during defibration and refining mill can save electrical energy to the tune of 10%. Similarly a few optimization measures in presses, dryers and boiler house can reduce 3-5% of the steam requirement. A process optimization study is therefore an effective way to produce quality products in a cost effective way.

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1. **Mill materials for the new millennium**
Leslie Webb
Pulp & Paper International, January 2000 / p. 49

Abstract : The paper highlights the issues related to wet end chemistry while using recycled fibre as a papermaking raw material.

2. **Environmental research for the newspaper industry**
Peter Tucker, Irene Taylor, Andrew Durrant
Paper Technology, December 1999 / p. 51

Abstract : This paper summarises research into environmental issues associated with newspaper recycling. The role of the individual consumer is addressed in terms of how much of their available paper waste they recycle and the environmental burdens they might generate from this activity.

The heavy metal contents of printed and unprinted papers were measured and correlated with the increasing use of colour printing in the newspaper industry. The environmental pathways of the heavy metals are followed through the deinking and waste water treatment plants of a recycling mill back into the environment through the land application of sludge.

The paper provides evidence that the heavy metals present in today's newspapers pose very low environmental risks.

The research has provided new data upon which improved newspaper lifecycle analyses might be developed.

3. **Upgrading equipment a more economical choice in dewatering**
Dan Backstrom & Eivind Willoch
Paper Asia, March 1999 / p. 21

Abstract : More and more closed white water loops force pulp and paper makers to pay more attention to the filtrate quality produced by their mill's dewatering equipment. In many stock preparation system, the dewatering equipment is a bottle-neck when it comes to production increase. Due to their physical dimensions, the replacement of these machines by a larger unit is not easy and it is relatively expensive to relocate them due to their ties to the white water circuit.

Besides increasing customer's benefits, further development has resulted in highly attractive upgrade 'packages' which allow a remarkable increase in production capabilities of existing unit.

4. **A novel flotation deinking chemistry to remove flexo inks: 30 tons/day pilot-plant results**
Oliver U.Heise, Kenneth E. Schriver & Arbit J. Horng
Tappi Journal, Vol. 82: No. 3, March 1999 / p. 131

Abstract : Current recycling processes typically incorporate aggressive washing stages to successfully remove flexographic or fexo inks. The yield losses associated with such washing stages are often economically unacceptable. A goal for many old newsprint (ONP) deinking mills is to be able to efficiently deink ONP containing varying, moderate levels of flexo inks in the flotation deinking stage. Deinking systems utilising only flotation cannot handle more than 3 - 5% flexo ONP content.

This paper discusses two flexo flotation deinking trials utilising a novel organoclay chemistry in a 30 tons/day continuos process pilot plant. Flexo ONP content was 25% and 30% in each of the two trial runs. The trials were performed with closed thickner filterate loops without process water clarification. Brightness exceeded 60 points at the end of the process that involved predispersion flotation, conventional dispersion peroxide bleaching, post flotation, and thickening.

5. **How to simplify RCF – Process ?**
Mr. H. Nerg, Mr. J. Pousi, Mr. I. Hourula, Mr. V. Juutinen & Mr. J. Meimonen
Inpaper International, Apr.-June, 1999 / p. 30

Abstract : A recycled fibre (rcf) line is composed of several process steps that can be called "value added" sub process. Such active process steps for eg. pulping, screening, fractionating, flotation and washing stages has been discussed.

6. **Deinking into the Millennium: Synthesis and design of optimum deinking systems**
Marco Pescantin
Paper Technology, Feb. 1999 / p. 35

Abstract : Process experience, good pilot plant test facilities, innovative de-inking equipment and system simulation capability are required to deliver an optimum deinking system. This paper presents performance data for a new pulping rotor design as well as a new 5-stage air flotation cell for ink removal. High consistency (3.5-4.0%) screening data are also presented.

Process simulation is demonstrated as a computer aided design tool. Spread sheet input/output and a new graphical user interface are applied to an actual deinking line design.

7. **Impact of pulp chemical composition on recycling**
Bangji Cao, Ulrike Tschirner and Shri Ramaswamy
Tappi Journal, Vol. 81, No. 12, 1998 / p. 119

Abstract : The effects of hemicellulose and lignin on recycled pulp quality were studied using hemlock pulps. The amount of pentosans in the pulps played a crucial role in their recycling potential, with pulp recyclability improving with higher pentosan content. This effect was observed in both low-yield chemical pulps and ultra high yield chemimechanical pulps. For five pulp properties (apparent density, tensile strength, burst strength, tear resistance, and light-scattering coefficient), the magnitude of changes induced by recycling can be statistically explained by the variation of pentosan content alone. Lignin content did not significantly affect the recycling potential of these pulps. A mechanism is proposed to explain how xylan molecules could influence the pulp recyclability.

8. **ONP / OMG recycled pulp washing**
Daniel Tse, Sylvie Dessureault and Michael C. Barbe
1998 Tappi Recycling Symposium / p. 133

Abstract : The paper highlights that the optimum washing sub-system depends on the importance given to either end product quality or production cost. When considering the end product quality only the two washing sub-systems composed of a screw press and a slusher or a decker gives the best performance. When considering factors related to pulp production costs such as minimum fresh water consumption and maximum process yield, the washing sub-system composed of a disc filter and a twin wire press gives the best performance. The approach used in the present study allows to assess the impact of various alternatives on the end product quality and production cost, bearing in mind environmental issues. The study can therefore offer guidelines for the design of future deinking plants or in modifications to existing installations.

9. **Pilot plant studies of office paper deinking. Part 2. Chemical aspects of process design**
John K. Borchardt, Ruth J. Blanco
1998 Tappi Recycling Symposium / p. 13

Abstract : This paper highlights the results of deinking tests that were performed using following sequence of unit operations: pulping, screening, thickening, kneading and flotation. It was found that for a mixed office furnish containing substantial amounts of toner-printed paper, the optimum addition point of a proprietary surfactant was to the kneader. While the process conditions were not optimised for the surfactant used, overall ink removal efficiency was as great as 94%. The highest overall brightness gain was obtained in the experiment in which the same total amount of surfactant, 0.2%, was added in equal portions to the pulper and the kneader. Excessive amounts of surfactant addition resulted in less efficient ink removal. Surfactant dosage had little effect on ash removal or Canadian Standard Freeness values.

10. **System development for the recycling of polycoated and wet strength containing food packaging materials**
Michael X. Meng
1998 Tappi Recycling Symposium / p. 241

Abstract : Recycling of the high quality fibers used in food packaging materials remains a major challenge due to their polymer laminations and wet strength nature. In the present study, a system based on high consistency pulping was first tested in a laboratory, and then evaluated in a pilot plant scale study. The effects of major variables, that is, pH, temperature and pulping time, on the defibered fiber yield in the repulping stage were examined in a laboratory through a 2^3 statistical experimental design. It showed that temperature and pulping time had a significant impact but pH was not important. A comparison between the polycoated and uncoated paperboard indicated that peeling of the polymer film from paperboard was crucial. In the pilot study, the results indicate that the complete recycling system with high consistency pulping was very effective in defibration. At the repulping stage effective defibration could be achieved at 110°F in 45 minutes and at 12% consistency. Removal of plastics with the detrash plate in the pulper, the pressure screens and cleaners was essentially completed. Pulps recycled from the base paperboard and cartons were similar and both were superior to normal OCC and MOW pulps.

11. **Deinking at Papelera Peninsular and the philosphy of deinking system design**
Jose Miguel Zabala and Michael A. McCool
Tappi Journal, August 1998 / p. 62

Abstract : This new system deinks a furnish of 100% waste newsprint by flotation deinking. The design is based on measuring the ink particle size distribution by image analysis.

12. **Advanced systems and tools for processing Asian ONP and OMG for newsprint, SC papers**
Erwin Hertl & Harald Selder
Papermaker, April 1998 / p. 39

Abstract : Advanced systems for processing old newspapers & magazines for newsprint and SC papers have been discussed.

13. **A better insight could help flotation technology take off**
Roland Mckinney
Pulp & paper international, June 1998 / p. 45

Abstract : The paper deals with technological innovations that has taken place in flotation technology.

14. **Producing deinked pulp for newsprints**
Dr. W H Matzke & Dr. E Linck
Paper Asia, Feb. 1997 / p. 13

Abstract : Modern concepts of deinking systems are presented for the production of lower-grade, standard and up-graded newsprint DIP. Significant modules in the various deinking systems are also summarised.

15. **Sticky issue – evaluation where no standard exists**
Peter Schweiss
Pulp & Paper Europe, June 1997 / p. 24

Abstract : There is no such thing as a standard system for stickies removal but there are plenty of broadly applicable essentials. In all plants, efficient hole prescreening is required for slot screening to function in either the low consistency or medium consistency range and this is essential for efficient stickies removal. Holed or slotted screens are always fitted in the approach flow system. But discussion focuses more and more on simple system for board and packaging grades in which the screening only takes place in the approach flow using fine slots.

16. **Improved deinked pulp for newsprint**
Tom Fulton
1997 Tappi Pulping Conference / p. 535

Abstract : Many newsprint mills have trouble running flotation deinked pulp when its proportion gets up to 30%. At that level, paper machine efficiencies tend to suffer due to various contaminants, such as stickies, or perhaps dissolved solids in the paper machine white water. It is believed that most contaminants stem from old magazine papers which flotation deink mills are forced to use to achieve optimum ink removal.

Mill data is presented to illustrate the effect of coated magazine paper on the ONP deinking system and how we have learned to cope with higher OMG addition rates. This industry, including chemical vendors and scientists are challenged to find ways to improve ONP flotation efficiency without reverting to OMG addition.

17. **Effects of recycling on papermaking properties of mechanical and high yield pulps. Part 1: Hardwood pulps**
Kwei N. Law, Jacques L. Valade and Jinying Quan
Tappi Journal, Vol. 79: No. 3, March 1996 / p. 167

Abstract : Recycling characteristics of aspen mechanical and high yield pulps, and a spruce thermomechanical pulp have been studied using laboratory procedures. The results indicate that the most obvious change in fibre properties occur during the first drying cycle. The changes are irreversible. Subsequent

rewetting-drying induces relatively little effect. Losses in water retention value and fibre bonding capacity are particularly evident. Aspen TMP seems to behave differently from that made from spruce. Aspen commercial pulps have their own unique properties. Repeated drying-wetting of lignocellulosic fibres is a complex phenomenon and needs to be further examined.

18. **Selection and configuration of washing systems for secondary fibres**
Dipl-Ing (FH) Joachim Kleuser and Dr-Ing T.H. Egenes
Paper Technology, June 1996 / p. 42

Abstract : Washing technology needs to be re-evaluated in the light of changing conditions: increased ash content in wastepaper; increased recycling rates; and rising demand for RCF in LWC and office papers.

Since the efficiency of dispersion and bleaching is improved by the removal of ash and fines, the state-of-the-art sequence in a rcf system is: washing -dispersion – bleaching . This paper describes the impact of different types of washing equipment, plus a new process which focuses on:

- Improved ash removal;
- Outlet consistency above 30%;
- Feed consistency below 1%
- Controlled ash content in the accepts;
- Improved retention of long fibres

19. **Comparison of deinking processes for high quality newsprint production**
S. Dessureault, M.C. Barbe, S. Tremblay and A. Thom
1995 Tappi Recycling Symposium / p. 291

Abstract : The findings of the paper are particularly important in view of the potential benefits of increasing recycled pulp content in the furnish and of the shift in the marketplace towards the production of high quality newsprint and specialty grades. Furthermore, the higher quality achieved at lower fresh water consumption levels is of importance in view of the capital expenditures which are made on effluent treatment plants required to meet the more stringent environmental regulations.

20. **Making newsprint from 100% deinked pulp**
J. Frenzel
Paper Technology, Oct. 1995 / p. 40

Abstract : Increasingly, recycled fibre is being used in value added grades such as printings and writings paper, and in greater quantities in traditional newsprint grades where a 100% deinked pulp is not uncommon.

To meet these new demands, deinking technology has improved continuously and the extended system described in this paper can produce a deinked pulp with better mechanical strength properties and higher brightness than groundwood pulp.

21. **High consistency screening proves itself in recycling mills – efficient and economic**
Borje Fredriksson
Paper Technology, May 1995 / p. 35

Abstract : The new high consistency barrier screen has been evaluated in recycling mills using DIP, OCC and mixed office waste, (MOW).

The HC screen is more efficient than conventional screens in reducing stickies, and only the disperser can rival it for speck removal. The disperser is much more energy intensive using 75 kWh per ton to the 5 to 10kWh of the HC screen installed on a line using MOW for the top layer of linerboard, cleanliness improved so much that the disperser could be closed down.

Since the HC screen can be operated at low reject rates, a two stage HC system can replace a three-stage LC System. HC means smaller pipes and valves for the same capacity and operational costs are less.

22. **System modules for wastepaper stock preparation**
Dr-ing. Wolfgang H. Siewert
Paper Asia, Nov. 95 / p. 13

Abstract : Stock preparation from recycled materials requires numerous system modules. These are selected, arranged and balanced to make up customised stock preparation systems for specific raw materials and products. The technology involved in stock preparation using Voith Sulzer machines promises vast possibilities for wider product range to meet specific needs. Screening and separation system in pulping, heavies cleaning system, screening system for removing components of irregular shape and dirt speck and ink removal has been discussed.

23. **Upgrading recycled board into value – added product with hydrogen peroxide bleaching**
P.Y. Dionne, M. Hoyos
Paper Technology, Oct. 1995 / p. 72

Abstract : Approximately 45% of the paper manufactured in Western Europe is recycled, and grades like cartonboards and fluting / liners have very high percentage of recycled fibres up to 100%. With increasing demand on recycled paper the availability of high quality waste will decrease, and the industry will be forced to use low quality waste and up-cycle i.e. bleach to higher brightnesses.

Studies indicate that hydrogen peroxide bleaching can be an effective chemical treatment for recycled paperboard. By increasing the final brightness of recycled board, mills can integrate bleached recycled fibres into value-added products like folding box, plasterboard, etc or develop new products without investing in new wastepaper processing equipment. This could also enable board-mills to produce multilayer board grades using only one type of waste furnish.

On the other hand, bleaching the middle or the backing ply can allow mills to reduce the amount of high quality white top for a similar product and to produce multilayer board grades at a lower cost.

24. The deinkability of office and business waste papers
Dr-Ing R. Klein and Dr-Ing H. Grossmann
Paper Technology, Oct. 1995 / p. 61

Abstract : Can deinking processes, which are designed to deal with traditionally printed materials, deal effectively with modern office papers which are largely printed electronically? Since such office papers account for 8% of Germany's paper consumption, and are therefore a significant source of secondary fibre, this question was addressed in a research project conducted by the International Deinking Research Association in Munich.

The findings, presented in this paper, show that washing is better than flotation, but both processes are unsatisfactory for toner printed papers, ie laser and copier. Several basic options are suggested to improve system performance.

In addition to the deinkability factor, optical inhomogeneities should be measured. In this context, office papers made from unbleached chemical pulp should be excluded; but coloured papers which can be bleached in a reduction process are not problematic.

25. Recycled fiber -its use and effect in fine papermaking
Philip A. Ford
1995 Tappi Recycling Symposium / p. 355

Abstract : Many fine paper mills are becoming environmentally conscious and have either built, are building, or are planning to build a recycled/deinked fiber plant. These mills are planning to substitute 20-25% of virgin fiber with recycled deinked office waste paper (OWP). Great care has to be taken to ensure there is the minimum of carryover of silicate and/or deinking surfactants onto the paper machine.

Experience has shown that a well run deinking plant can produce a very suitable paper making fiber. Poorly washed pulps, or overdosed chemicals can play havoc with the wet end chemistry balance. Deposits of silica, variable retention of fibre and filler and adverse effects on sizing are potential pit fall for the unwary papermaker.

Carefully monitoring the chemistry of the deinking system and the wet end system of the paper machine or machines will give the stock preparation and paper machine management the data to maintain control.

Retention is one of the most important parameters effected by poor control of deinking systems. The retention aid supplier can evaluate the effect of the deinked / recycled fiber on the fine paper machine wet end chemistry and recommend the most suitable system. Single component, dual polymer, dual component, or maybe even a three component system are all available for maintaining a clean problem-free running paper machine wet end.

26. **Recycled fibre – the research needs**
John Clewley and Professor Nicholas Wiseman
Paper Technology, Oct. 1995 / p. 51

Abstract : This paper describes the empirical advances that have eliminated the 'technological limit of 60% RCF content in newsprint; But, current technology has in-built limitations, i.e. its multi-stage complexity and its high capital and operating costs.

The industry needs a new generation of equipment that is effective within three parameters – capital cost, operating cost and quality. The development of this technology requires a better understanding of what is happening during the recycling process, an understanding of fibre degradation, deinking chemistry and recyclability.

27. **Recycled pulp washing. Part I. Comparison of washing equipment and sub systems**
S. Lafreniere, S. Dessureault & M.C. Barbe
Pulp & Paper Canada, 96:2 (1995) / p. 35

Abstract : The findings of the paper shows that the removal efficiency of contaminants is affected by the washing equipment design. In addition to the mechanism of slurry dewatering, which can be filtration, settling or pressing, several other parameters must be considered in the design and optimisation of the washing system.

28. **Process variables that affect deinking operations and final deinked pulp (DIP) quality**
Lowell F. Lott and Christopher D. Perry
1995 Tappi Engineering Conference / p. 309

Abstract : Standard and ideal processes are illustrated that are essential for the production of quality or market acceptable deinked pulp. Cleaning, screening, ink flotation, ink washing, brightening, and process water clarification variables are listed and discussed. The impact that furnish consistency has on final deinked pulp is illustrated for three defined secondary fiber types. Finally, problems that result from poor process control and a misunderstanding of water quality and secondary fiber quality prior to the deinking process are tabulated and reviewed so that a process trouble shooting checklist can be constructed.

29. **The effects of recycling on the strength properties of paper**
Jonathan Phipps
Paper Technology, July/August 1994 / p. 34

Abstract : The paper addresses the issue of multiple recycling and fibre degradation. It explains the different reactions of chemical and mechanical fibres and the role of fines from chemical, mechanical and recycled fibre on strength properties. The author describes computer techniques used to

assess the age distribution of fibres in a papermaking furnish. It concludes that strength loss through fibre degradation is unlikely to inhibit maximum recycling. The inhibiting factors are: de-inking efficiency, residual filler material and the availability of suitable sources of waste paper.

30. Fundamentals of strength loss in recycled paper
Mousa M. Nazhad and Laszlo Paszner
Tappi Journal, Vol. 77, No. 9, 1994 / p. 171

Abstract : The paper states that most challenging aspects of recycling is understanding the cause of loss in potential fibre bonding when fibres are dried. Since mechanical pulps do not seem to suffer from the same problems as chemical (low yield) pulps, difficulties in paper recycling seem to be related to the structure of the lignin-free cell wall. The damage usually manifests itself in hornification and surface inactivation of the fibres. Various ideas proposed on the cause of hornification & surface inactivation in predried cellulosic materials are reviewed, and the importance of the hornification is pointed out. Areas of necessary further research on cellulose (fibre) are outlined.

31. The effects of recycling on the chemical properties of pulps
J. Bouchard and M. Douek
Journal of Pulp and Paper Science, Vol.20, No.5, May 1994 / J 131

Abstract : Changes in the physical properties of pulp during recycling are sometimes reported to be caused by changes in chemical properties of fibres. In order to determine the relationship, if any, between physical and chemical properties, a chemical charaterisation was carried out for several recycled pulps. Measurements of carbohydrates, lignin, crystallinity index, and DP of cellulose were carried out as well as FTIR spectra. The results showed no direct relationship between the removal of hemicelluloses or lignin and the loss or gain of strength properties during recycling. Slight cellulose depolymerisation occurred during recycling of kraft pulps. However, it was largely inhibited in the presence of deinking chemicals. Also, there were no increases in cellulose crystallinity index after recycling.

32. Effect of particle size and density in flotation deinking of electrostatic papers
Bret A. Snyder and John C. Berg
Tappi Journal, Vol. 77, No. 7, 1994 / p. 157

Abstract : The particular type of electrostatic printing machine affects the flotation deinking behavior of pulps from this source. Slower-printing machines produce larger toner particles which contain attached fibers after pulping. These fibers greatly retard effective flotation. Producing the smallest toner particles provides the greatest separation of toner and fiber. This is the primary step for optimization of repulping to provide the best separation of toner and fiber.

33. **Process design optimisation for deinking plants**
Albert W. Griffin
Tappi Journal, Vol. 77, No. 5, 1994 /p. 103

Abstract : A simulation program of a deinking plant was used to find optimum filtrate recycle rates. The program calculated how changing the recycle rates would affect the yield, ink, ash and fines concentration, fresh water makeup, and effluent flow.

34. **Effect of pulping conditions on stickies behaviour in office waste deinking systems**
Tien Feng Ling, Frank J. Sutman, Sandra K. Richmann, and Mary Beth K.Letscher
Tappi Journal, Vol. 77, No. 7, 1994 /p. 143

Abstract : Office recovered paper (ORP) as a fibre source for printing and writing grades can be limited by its high content of non-impact or "laser print" inks. Chemical aggregation and densification of non-impact inks are one option for deinking ORP. ORP containing stickie contaminants was deinked under "mild" and "harsh" pulping conditions. Contaminants were removed using cleaning and screening. The same furnish was also deinked using the chemistry and harsh pulping conditions, required for aggregation and densification of non-impact inks. The effects on the size of stickies, efficiency of stickies removal by cleaning and screening, and the nature of the finished stock were investigated. Under the pulping chemistry and conditions required for aggregation and densification of non-impact inks, most stickies are associated with the ink in the pulper. The combined particles were separable from the fibre by mechanical systems, particularly by forward cleaning. These contaminants were less prone to deposition than stickies formed without chemical treatment. The deposition potential of the chemically treated contaminants was no greater than stickies formed under mild pulping conditions without chemical treatment.

35. **ONP Re-use without deinking: short sequence recycling**
T. Blain, J. Grant
Pulp & Paper Canada, 95:5 (1994) /p. T 186

Abstract : For newsprint mills without deinking facilities, or with insufficient recycle fibre availability, short sequence recycling of old newsprint (ONP) offers a route to additional recycle content with zero or minimal capital investment. The simple addition of appropriately formulated chemistry to the pulper before the addition of the ONP leads to the following advantages over pulping this furnish without chemical: fibres of 51 to 55% ISO brightness (a 6 to 15 point gain); a relatively clear filtrate; and a paper making fibre slurry with a reduced tendency for ink deposition of the paper making machine hardware.

36. **Flotation deinking – basic principle and system integration.**
Herbert Britz
Paper Asia, November 1993 / p. 32

Abstract : This paper introduces the new compact flotation cell and discusses the physical laws on which flotation deinking is based.

37. **De-inking of wastepaper containing water-based flexo-printed newsprint**
G. Galland and Y. Vernac
Pulp & Paper Canada, 94:6 (1993) / p. T 181

Abstract : With conventional flotation deinking, low brightness pulps are obtained from waste papers containing waterbased flexoprinted newspapers. There are difficulties which are discussed. They are mainly due to the small size of the ink particles and redeposition phenomena. Improvement to conventional alkaline deinking process appear to be insufficient to produce high brightness deinked pulp. Good deinking can be achieved with a mixture of waste paper including various amounts of waterbased flexoprinted newspapers by using a new process that is proposed. Waterbased inks are removed in a first stage in non alkaline conditions and conventional inks in second alkaline stage including peroxide bleaching.

38. **Laboratory de-inking practices**
L.D. Ferguson
Pulp & Paper Canada, 94:4 (1993) / p. T 86

Abstract : The paper presents laboratory deinking methods currently used as ICI Canada's Sheridan Park Research Centre for flotation deinking using bench top and semi pilot scale equipment. The techniques were assembled from many diverse sources, then adopted for North American requirements. Experimental results from a pulper chemistry evaluation are used for illustration.

39. **The Basic Effects of Recycling on Pulp Properties**
R. C. Howard and W. Bichard
Journal of Pulp and Paper Science, Vol. 18 No. 4, July 1992 / J 151

Abstract : Using standard laboratory procedures, it was found that different pulp types showed very different recycling effects. Mechanical pulp fibres became flatter and more flexible giving a denser and stronger sheet. Beaten chemical pulp fibres "hornified", resulting in a bulkier, weaker sheet. Unbeaten chemical pulp fibres were initially curly; recycling removed the curl. A mechanical/chemical pulp blend revealed that these effects occur at different rates. In no case was there any evidence of fibre strength loss, or of fibre embrittlement. In these laboratory experiments, fines loss during sheetmaking affected the magnitude of the sheet properties, but not the trends.

40. Novel techniques for enhancing the strength of secondary fibre
Ganapati R. Bhat, John A. Heitmann and Thomas W. Joyce
Tappi Journal, September 1991 / p. 151

Abstract : One impediment to the wider use of recycled fibres is the loss of strength that occurs when these materials are repulped. This report examines the effects of several techniques for enhancing the strength of secondary fibre. Repulping under alkaline conditions and refining are the most commonly used methods to improve the strength of secondary fibres. High shear field (HSF) treatment produces an effect similar to refining while producing less fines. The best results were obtained using a combination method of alkali treatment followed by HSF treatment. Strength properties were higher than refining and were comparable with virgin pulp in some cases. The report also shows that enzymes can be used to increase the freeness of secondary fibre without affecting its mechanical properties.

41. Deinking plant optimisation using image analysis
G. Lowe, B.H. Licht & G. Leighton
Tappi Journal, January 1991 / p. 125

Abstract : Results showed that ink removal could be improved and the effect of residual ink on paper quality minimised by maintaining a narrow range of particle sizes in the pulper.

42. The role of the pulper chemistry in deinking
Loreen D. Ferguson
Tappi Pulping Conference, 1991 / p. 793

Abstract : In Europe, considerable work has been done on deinking processes and chemistry. It has also been reported that North American inks respond differently from European inks to the deinking process. This paper looks at the role played individually and in combination, by the principal chemicals used in the pulper on North American furnish. Pulper chemistry multistage and short sequence (pulper) deinking is discussed.

The wood containing furnish used in this study was a 70/30 blend to letterpress and offset printed news and magazines. The paper are produced and printed in North America. The function of a chelant, sodium silicate, hydrogen peroxide, sodium hydroxide, surfactant and collector chemicals were examined. The effect on downstream flotation was examined when appropriate.

43. The use of recycled paper in the manufacture of newsprint
Harry E. Crawford , William G. Garrett, Jr. and Craig A. Szmania
1991 Advanced Topics in Wet End Chemistrry Short Course / p. 25

Abstract : The Augusta Newsprint mill in Augusta, GA, a joint venture of Abitibi-Price and Thomson Newspapers, produces in excess of 1000 metric tons per day of newsprint. The mill uses a blend of thermomechanical pulp (TMP),

purchased bleached kraft pulp and secondary fiber from an on-site deinking operation that started up in August of 1990. Concurrent with the start-up of the deinking plant, the stone groundwood mill was shutdown.

The construction of the deinking operation was driven by the high electric power consumption of the groundwood mill and cost of the purchased kraft. This paper will discuss the effects this change in furnish along with the corresponding change in chemical additives has had upon paper machine operation.

44. **The effects of recycling on paper quality**
R. C. Howard
Journal of Pulp and Paper Science, Vol. 16 No. 5 September 1990 / J 143

Abstract : The paper highlights the effect of recycling on the properties of fibres and on the paper made from those fibres. Lost papermaking potential in a recycled pulp can be recovered to some extent by refining, by chemical additives, by furnish blending, and by separate treatment and recombination of pulp fractions. Each of these possibilities are reviewed. Overall, it is shown that our knowledge of the causes of recycling effects is still incomplete.

45. **Effective secondary fiber treatment process for high quality deinked pulp**
G. Rangamannar and Luigi Silveri
Tappi Journal, July 1990 / p. 188

Abstract : Secondary fiber is being used more in fine papermaking and the demand is growing for strong, high-brightness, speck-free pulps made from recycled fiber. Modern printing employs chemically nondispersible inks that are difficult to remove by the conventional deinking process.

The Beloit Diskpersion process is an effective treatment to improve the product quality of raw secondary material containing non-conventional inks. The process combines high-consistency refining and dispersion. The plate pattern, consistency, and specific energy influence the quality of the pulp. The best system configuration entails flotation, dispersion, and flotation.

46. **Secondary fibre for newsprint**
P.(Pete)L. Morel
Tappi Pulping Conference, 1989 / p. 367

Abstract : Increased public concern about the environment and government legislation will result in ever increasing recovery rates of waste fibres. North America's recovery and utilization rate of waste fibre in the production of newsprint has been historically low. Operating and capital costs are lower for the deinking plant than for a traditional pulp mill of equivalent capacity, offering the pulp and paper industry a significant opportunity for the future. Although the economics are good, there are a number of factors that affect plant process and engineering design. A number of support systems are required for the deinking plant each of which requires careful consideration both from a process and design point of view.

47. **Flotation deinking and waste paper recycling systems**
Lothar Pfalzer, J.M. Voith
Tappi Pulping Conference 1989 / p. 43

Abstract : Flotation deinking and the recycling process for the waste paper has been discussed . The various deinking systems for the normal quality requirements and specific grades has been discussed.

48. **Xerography deinking – a fundamental approach**
T. H. Quick and K. T. Hodgson
Tappi Journal, March 1986 / p. 102

Abstract : Xerography waste is an important and growing contaminant in ledger. In pilot trials, it was found that conventional deinking processes were not satisfactory to produce pulp clean enough for blending in writing paper furnish. Several alternative processes were tried which were satisfactory, including two - stage conventional (washing/ flotation and two stage flotation) and a new adsorption process.

49. **Physiochemical aspects of waste paper deinking by washing**
Jean De Ceuster, Georges Papageorges
Appita, Vol. 35, No. 2, 1981/p. 145

Abstract : The Influence of the addition of chemical to the pulper on the efficiency of the deinking of waste newspaper by washing was studied on a laboratory scale. The importance of some physical parameters and working conditions was also assessed. A hand washing technique was used to simulate the deinking process. A special procedure avoiding any extra washing during handsheet preparation, was set up to measure correctly the brightness of the pulp after the different washing stages.

When caustic soda, dispersants or surfactants are used in the absence of bleaching agent the brightness gain brought by the chemicals is usually limited to about 10 units. When hydrogen peroxide is used combined with caustic soda and stabiliser dispersants like silicate, phosphonate or polylactonate an improvement of about 20 units in brightness can be obtained.

Compared with fresh water, counter-current washing decreases the efficiency of the deinking by about 2 brightness units.

Compared with soft water the use of hard water can decrease the brightness of deinked pulp by about 4 units as the ink pigments are retained on the fibres and cannot be washed out easily.

50. **Recycling of waste paper**
Jaya Krishnagopalan, Sandhya Bapna and A. Y. Kulkarni
Ippta, Vol. XVIII, No. 4, December 1981/ P. 84

Abstract : Recycling of waste paper, waste paper sources, important technologies and systems developed for waste paper recycling are discussed with reference to the Indian waste paper recycling industry. A case study is also discussed.

51. **The Siropulper – a new concept in wastepaper recovery**
H. Mamers
Appita, Vol. 32, No. 2, Sept. 1978 / p. 124

Abstract : The Siropulper system is a new, gas pressurised wastepaper recycling method suitable for the recovery of papermaking quality fibres from almost any type of recycled paper or board. In its various forms, the Siropulper can recover fibre from garbage, high wet strength papers, cast coated boards, metal and plastic laminates and bituminized furnishes. The same equipment can also be used for deinking and the segregation of various paper and board components from mixed feed stocks. The Siropulper works at a high stock concentration, has a low chemicals and energy demand and is simple and reliable in construction and operation.

52. **Recent innovations in paper recycling**
Peter Seifert
Recycling: A Tappi Press Anthology of Published Papers / p. 368

Abstract : In this paper two paper recycling systems have been selected for discussion, namely washing deinking and flotation deinking. Recent innovations are reviewed, in the context of the basic mechanisms responsible for the functioning of these machines. An update is also given for their application in the processing of used office papers.

53. **Comparison of enzyme – enhanced with conventional deinking of xerographic and laser – printed paper**
Thomas W. Jeffries, John H, Klungness, Marguerite S. Sykes, and Kathie R. Rutledge – Cropsey
Tappi Journal, Vol. 77, No. 4 / p.173

Abstract : This study examines seven commercial enzymes with cellulase activity, xylanase activity, or a combination of both applied to paper stock in the pulper at optimum conditions for each enzyme. Results of deinking efficiency showed that most enzyme preparations performed better than the conventional chemical method. Pilot results agreed with laboratory experiments for two enzymes. Dewatering and dispersion steps and subsequent reflotation and washing may therefore not be essential. Their elimination could save capital costs and reduce electrical energy consumption.

54. Design of a modern waste paper deinking process
David Thurley & Ross Francis
Appita, Vol. 48, No. 2 / p. 125

Abstract : In 1989 Australian Newsprint Mills Ltd. Began to consider the introduction of secondary fibre into the furnish used for the manufacture of newsprint. The issues of waste minimisation, resource and energy conservation and the escalating concerns about the difficulty of finding adequate landfill sites were important motivating factors. The likely product quality changes as a result of using secondary fibre were also important.

The principal aims of the project team were to design a process which would produce high quality deinked pulp and so minimise the impact of the new furnish on paper machine and printing press operations, to operate the new plant without increasing the mill's water consumption and to have minimal environmental impact as a result of the plant's operations.

The problems of specks, 'stickies' and chemical consumption are addressed in this paper and rationale behind the process design and layout is discussed. Some commentary is given on the types of the process equipment available and the selection of particular units is discussed in detail where the plant is considered to be innovative in its approach.

SELECTED PUBLISHED LITERATURE

Studies On Dispersion Of Wet Strength Papers During Recycling

KULKARNI A.G.*, MATHUR R.M.*, NAITHANI S.* PANT R.*

ABSTRACT

Secondary fiber is going to be one of the major fiber resources for the paper industry in coming years. Our paper industry is utilizing substantial amounts of waste paper imported from different countries. Wet strength paper, used for packaging of agricultural and cement products, is one of the varieties among imported waste paper. Conventional hydrapulpers, used for processing of broke, are commonly emplyed for slushing of the waste paper. It was observed that unlike other grades of waste papors (eg : computer print out), wet strength paper poses problems in slushing operation due to presence of wet stregth resins. Present paper discusses the results of the studies conducted for optimizing the process conditions during repulping of wet strength papers. Studies reveal that efficent dispersion of fibers could be achieved by slushing at temperature above 70 C in the pH range of 3-4. The strength properties of pulp, with efficient fiber separation, were better than the pulps dispersed under normal temperature and pH conditions

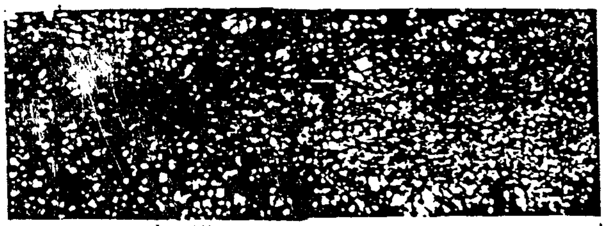
To augment the raw material situation and to achieve sustained production of paper and paper products, there will be an increasing thrust on the usage of waste paper. It is estimated that about 85% of the paper and board consumed in our country could be theoretically recovered[1]. However creation of market and demand will be important aspects to make waste paper collection more attractive. Important constraints, currently faced in the recycling of domestic waste paper are (i) Lack of method for efficient removal of contraries, (ii) reduction in strengsh properties during recycling and (iii) possible health hazards and aesthetic factors. Due to these constraints the domestic waste paper is not attracting the consumers. Small mills are using substantial proportion of the waste paper for production of cheaper varieties of paper and paper products. Better methods of collection and cleaning of waste paper should facilitate the increased use of this secondary fiber source in writing, printing and other fine papers. When the raw material became the major constraint faced by the industry, GOI liberalized its policy of import and permitted the import of waste paper. It has been experienced that the imported kraft grade waste paper is a better source of long fiber than indigenous bamboo virgin pulp. Imported waste paper generally is comprised of computer print outs (CPO), kraft paper and wet strength papers. While processing wet strength papers, some of the mills have experienced that unlike other grades of paper it is difficult to disperse the fibers during slushing of wet strength papers. Waste paper from corrugated board, solid case boards and wet strength paper often contains wet strength additives, like urea formaldehyde and malemine formaldehyde resins[1]. These resins become water insoluble components when the web comes out of the dryer section which makes the wet strength papers resistant to dispersion under the normal pH and temperature conditions. In the literature[2] higher temperature and lower pH conditions are recommended. The present study was taken up to optimize the process conditions like temperatures, consistency and pH during repulping operations. The sample of wet strength paper, studied was imported multiwalled sack used for packaging of cement and agricultural products. The advantages of efficient dispersion with respect to strength development was also studied.

RESULTS AND DISCUSSIONS :

In fiber dispersion experiments two variables were chosen-one was elevated temperature (around 80° C) and the other variable was pH range, In all cases the dispersion was not favourable with the stock consistency below 5%.

Dispersion under normal pH and temperature conditions :

Preliminary dispersion experiments were carried at 25-30° C with 5% consistency. Before dispersion this sample was allowed to soak in water for 10 minutes. Dispersion was carried out in a laboratory blender. After dispersion the stock was diluted to 0.25% consistency for visual observation and freeness measurement. Stock obtained after dispersion had a pH around 6.2 Fibers were not dispersed efficiently and stock contained undispersed fiber bundles. The freeness value was 720 ml, CSF. These experiments clearly showed that it was difficult to disperse the fibers under normal temperature and pH conditions. (Photomicrograph—1)



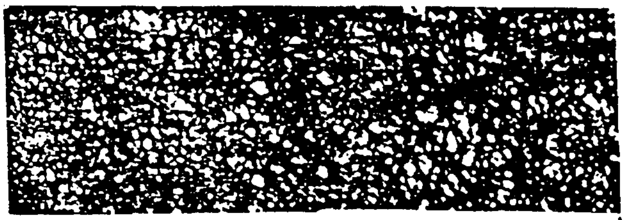
PHOTOMICROGRAPH - 1

Dispersion at elevvted temperature : Except the temperature, in this case. the dispersion was carried out under the conditions similar to these maintained in cold dispersion. The temperature during dispersion was kept 80° C. .Stock obtained in hot dispersion also had the freeness value around 720 ml, CSF with distinct fiber bund'es, showing poor separation of fibers, It was concluded that only increasing the temperature will not facilitate efficient dispersion of fibers.

Dispersion at 3–4 pH in cold conditions : Here the pH of dilution water was reduced to around 3-4 by addition of sulfuric acid and the paper sample was then dispersed under.the similar conditions. With reduced pH of the stock there was a marginal improvement in fiber separation and the freeness value of 695 ml, CSF was obtained. However visual observation of diluted stock showed that the fiber separation was not satisfactory and fiber bundles continued to exist.

Dispersion at elevated temperature with 3–4 pH range :

In this case dispersion was carried out at a temperature around 80° C with lower pH range (3-4). After disintegration the pH of the stock was around 6–7. It was observed that in this case, there was an efficient separation of fibers which was supported by the fact that the freeness value reduced to 500 ml, from 695 ml. The diluted stock was completely devoid of any fiber bundles. Thus lowering of pH followed by hot disintegration was highly effective in eliminating the adverse effect of wet strength resins. The quantity of the acid required, to bring down the pH range to 3–4, would be about 17 kg of 90% pure sulfuric acid per tonne of O. D pulp in the stock at 5% consistency. (Photomicrograph—2).



PHOTOMICROGRAPH - 2

Strength properties : Strength properties of pulps with wall dispersed fibers (low pH and temperature around 80° C) and poorly dispersed fibers (normal pH and temperature) given in Table 1, clearly indicate that extent of fiber separation during repulping is an important factor which influences the strength development. Pulp (A) with poorly dispersed fibers even upon beating showed lower strength properties as compared to the strength properties of pulp with well dispersed fiber (B). It can be observed that pulp B had better strength properties even before beating, as compared to unbeaten pulp (A). Thus the efficient operation of fibers, during slushing and repulping operation, will facilitate in having the pulps with improved strength properties.

CONCLUSION :

1. Studies indicate that pH value during dispersion has more influence than temperature on fiber separation.
2. The effect of pH is more pronounced at elevated temperature.
3. pH values between 3-4 and temperature preferab! above 70° C are the optimum conditions fc efficient" separation of fibers during repulpir operation.
4. Higher consistencies would be preferable.

TABLE—1

STRENGTH PROPERTIES OF RECYCLED WET STRENGTH PAPER

Pulp No.	PFI (rev)	Freeness ml, CSF	Drainage time (s)	Apparent density (g/cm³)	Burst index (kPa.m²/g)	Tensile index (N.m/g)	Strech (%)	Fold (Kohler Molin) log.	Tear index (mN.m²/g)	Air resistance Gurley (s/100ml)
A	0	720	3.85	0.58	1.25	25.0	1.6	1.71	14.3	3.6
	6000	355	6.30	0.74	4.35	63.5	3.0	2 96	9.60	150
B	0	585	4.05	0.65	2.90	43.5	2 6	1.95	14.5	12 3
	6000	235	7.00	0.76	6.70	83.0	3.7	3.10	8.70	290

A. Disintegrated at ambient temperature with no pH adjustment.

B. Disintegrated in hot (70-90°C) with pH of stock adjsted to 3.0

EXPERIMENTAL :

Imported waste paper samples were collected from a mill. Samples consisted mainly of bleached and unbleached multiwalled sack paper (wet strength paper) used primarily for packaging of cement and agricultural products. It was presumed that waste paper may be containing urea formaldehyde and/or melamine formaldehyde resins which are usually added as wet strength resins. The paper was first cut into small pieces of size 1 cm x 1 cm The moisture content was determined after uniform mixing. For small scale trials 5 gms of O. D. samples were used. After optimizing the conditions on small scale the results were confirmed by dispersion 100 g of samples. Cut sample were soaked in water for 10 minutes before it was subjected to disintegration. Consistency of 5% was maintained in all the cases and the dispersion was effected in a laboratory blender with a timer. The dispersion time was kept constant (3 minutes) in all experiments. Stock was diluted to 0.25% consistency for visual observation.

For hot disintegration sample was heated to 80-90° C with water at pH 3-4 with 5% consistency, for about 60 minutes and then dispersed in blender. Strength properties were evaluated, after beating in PFI mill, as per the methods mentioned in the manual of laboratory research methods[3].

ACKNOWLEDGEMENT :

Services of Shri K. S. Moorthy and Shri Y. V. Sood in evaluation of pulp properties are gratefully acknowledged.

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Recycling of Wet Strength Paper

Tandon* Rita, Mathur* R.M., Kulkarni** A.G.

ABSTRACT

Secondary fiber is going to be one of the major fiber resources for the paper industry in the years to come. It is estimated that waste paper will meet 50 percent of the increased demand for raw materials by year 2000 and it has already become an internationally traded commodity. In India, majority of the paper mills are utilizing waste paper as raw material and a substantial amount of waste paper is being imported from different countries. Wet strength paper used for packaging of liquids and cement products is one of the several varieties of imported paper which unlike other grades of waste paper poses problems in slushing operations in the conventional hydrapulpers, due to presence of wet strength resins. Studies conducted at CPPRI have revealed that chemistry plays a vital role in imparting wet strength to the paper due to which specific repulping conditions are required to achieve higher yield with low energy consumption. An appropriate combination of chemical and mechanical treatment facilitates the repulping operation keeping the energy demand low and maximizing the yield. The paper highlights the various aspects influencing the repulping efficiency of wet strength papers and the role of chemical additives on resin depolymerization. Although the findings are at laboratory scale but are expected to be translated successfully at mill scale.

INTRODUCTION

The growing demand for paper, paperboard & newsprint in our country through the next millennium and the need for massive capacity expansion to the tune of 8.0 million tons, require a strong and sustainable raw material base. With the limitations of forest produce and also the size constraints with agro based mills, the use of recycled fiber (RCF) perhaps will be acceptable to the industry by virtue of well developed processing techniques.

Today majority of paper mills (63.4%) are using waste paper as raw material and account for 31% of total paper production in the country. Around 35% of recovered paper is being imported from countries like U.S. which has been continuously rising with the increasing demand. The apparent reason for high imports is low recovery rate, which is around 17% at present and the deteriorating quality of indigenously recovered paper. This situation is hardly going to improve unless an organized domestic collection system is adopted in the country. Under the circumstances the use of imported paper is inevitable to keep the product quality.

In our country, most of the production from waste paper is confined to packaging grades, and long fibered imported waste paper is used as top liner or bottom liner in the production of duplex board for quality reasons. The quality of RCF from imported waste is superior than our virgin fiber but lot of problem are faced during processing due to the presence of contaminants. Among the different varieties of imported waste paper, wet strength paper used for liquid packaging and for cement products is one, which unlike other grades of waste paper poses problems during slushing due to presence of wet strength resins resulting in high reject content, low yields and high electrical energy consumption.

The wet strength paper keeps its integrity because of its chemistry. This chemistry also defends it in the pulper unless it is attacked with the right combinations of chemical and mechanical energy. The wet strength resin in paper forms a cross-linked insoluble, covalently bond net work of organic polymer and hemicelluloses, between and/or around the fiber contact. Depending on the chemistry of resin, the network may become insolublised by resin-resin crosslinking and or by crosslinking of cellulose or hemicellulose through resin molecule (1).

Urea formaldehyde (UF) and polyaminoamide epichlorohydrin (PAE) are the two most commonly used wet strength resins. Urea formaldehyde has been declining over the past several years since it requires acidic pH during curing and PAE is the predominant resin used today (83%) as it requires neutral/alkaline pH during curing, preferable for neutral/alkaline sizing.

Detailed studies conducted on repulping of wet strength paper has revealed that paper containing permanent resin usually requires drastic conditions for repulping and a combination of chemical and mechanical treatment is more effective than mechanical treatment alone with little cost added due to chemical, however the added benefits are low power consumption, increased productivity, efficient contaminant removal,

TABLE -1

CLASSIFICATION OF WET STRENGTH RESIN

Resin Class	Wet Strength	Typical pH During Papermaking	Type Of Curing	Percent Usage (Global)	Repulping Condition
Urea Formaldehyde (Aminoplast)	Permanent Low Cost	3.8-4.5	Acidic	1.0	Acidic
Melamine-Formaldehyde (Aminoplast)	Permanent Low Cost	4.0-5.5	Acidic	1.0	Acidic
Aminopolyamide - epichlorohydrin (PAE)	Permanent	5.0-9.0	Neutral/ Alkaline	83.0	Strong Alkaline Oxidative
Polyamine-epichlorohydrin	Permanent	5.0-9.0	Neutral/ Alkaline	8.0	Strong Alkaline Oxidative
Aldehyde Polymer					
-Polyacrylamide glyoxal	Temporary	4.5-7.5 (Neutral)	Neutral	5.0	Mild Alkaline
-Dialdehyde starch	Temporary	4.5-6.5 (Acidic)	Acidic		Acidic

TABLE -2

PHYSICO-CHEMICAL CHARACTERSTICS OF DIFFERENT WET STRENGTH PAPER/BOARD (IMPORTED PRE-CONSUMER WASTE)

Sample	Extract pH	Ash % w/w	Alcohol/ Benzene Extract w/w	Dry Strength NM/gm.	% Wet Strength Wet/Dry 100	Possible Resin Type	Proposed Repulping Conditions
KCB - I (Unbleached)	6.9	6 - 8	2.76	*ND	Poor wetting	Permanent	Highly alkaline
Sack kraft (Unbleached)	6.5	0.87	3.08	77.5	23.0 (After16hrs.)	Permanent	Highly alkaline
Bleached-I	7.2	14.0	1.4	*ND	Poor wetting	Permanent	Oxidant With alkali
Bleached-II	7.5	4 - 19		59.4	15.0 (After 2hrs.)	Temporary	Mild alkali

• N.D. not determined due to improper sample size.

low rejects, improved quality of fibers and improved strength properties. The present paper discusses the various aspects of efective repulping of wet strength paper, with respect to optimum process conditions, effect of process variables and impact of pulper configuration on repulping efficiency.

RESULT AND DISCUSSION

Behaviorally, wet strength resins can be classified as

- Temporary resin - 70 - 80% wet strength is lost after 2hrs soaking.
- Permanent resin - >20% wet strength is lost after 2hrs soaking.

But chemically, resins can be classified into three board classes as given in Table -1 The different resin type has typical pH range for best working and this pH range on the finished paper gives an idea of probable resin type.

IDENTIFICATION OF RESIN TYPE

Following tests have been found very effective in identifying the resin type on the paper, which subsequently facilitated in formulating the treatment method for repulping

Test-I

Determination of wet Strength as percentage Of dry strength (Tappi Method T 456-OS-68) - Differentiates temporary and permanent resin

Test - II

Extract pH - Differentiates acid curing and neutral/alkaline curing resin

Test-III

Solvent extraction (Alch/Benz.) - Quantifies resin content

The above tests were performed for four varieties of imported wet strength paper containing both bleached and unbleached varieties and based on the test results, the samples were subjected to specific treatment methods. The result are depicted in Table -2.

Three varieties - Sack Kraft, KCB and

Bleached-I belonged to permanent resin class and bleached - II contained temporary resin. Extract pH clearly shows that all the varieties contained neutral/alkaline curing resin and hence the possible resin type is PAE which is the most predominant type. Based on the findings the samples were subjected to alkaline repulping conditions using NaOH as chemical, however in case of bleached variety oxidants were used in combination of NaOH to prevent yellowing caused by NaOH alone.

OPTIMIZATION OF REPULPING CONDITIONS

To arrive at optimum repulping condition for different varieties, the samples were treated at specified temperature and pH with reagents in a closed vessel with gentle mixing to augment the performance of the reagents used in the process. After treatment the paper mixture was subjected to high shear rate in a laboratory disintegrator for 6 minutes and accept yield after passing the stock through a vibratory slotted

TABLE -3

OPTIMIZATION OF PROCESS CONDITION FOR DIFFERENT VARIETIES OF WASTE PAPER

Variety	Chemical Used	Chemical Concentration g/l	Pulping Time hrs.	pH	Temperature °C	Shearing Time in min. at 3000 rpm	Accept Yield %
Sack Kraft	-	-	0.0	7-7.5	70	6	4.0
	-	-	0.0	7-7.5	70	20	46.0
	-	-	3.0	7-7.5	120	6	48.2
	NaOH	0.6	0.25	9.5	70	6	22.5
	NaOH	0.6	0.25	9.5	70	20	84.3
	NaOH	1.2	2.0	>11.0	120	6	60.3
	NaOH	2.5	1.5	>11.0	120	6	71.0
	NaOH	5.0	1.5	>11.0	120	6	83.0
	NaOH	5.0	0.5	>11.0	120	10	88.6
	NaOH	7.5	1.0	>11.0	120	6	87.0
	NaOH	7.5	1.0	>11.0	120	10	94.0
*K.C.B							
Sample-1	-	-	-	-	70	6	42.6
	NaOH	1.0	1.0	>11.0	70	6	85.2
	NaOH	1.6	0.5	>11.0	120	6	87.0
	NaOH	2.0	1.0	>11.0	70	6	88.4
	NaOH	2.0	0.5	>11.0	120	6	87.5
Sample-2	NaOH	0.4	1.0	9.5	70	6	75.0
	NaOH	0.6	1.0	10.5	70	6	84.0
	NaOH	1.2	1.0	11.0	120	6	75.6
*Bld. -1.	-	-	-	-	70	6	53.0
	$Ca(OCl)_2$	0.6	1.0	8-9	70	6	75.0
	$Ca(Ocl)_2$	0.6	1.0	6-7.5	70	6	80.2
	H_2O_2	0.1	1.0	7/11	70	6	65.0
	H_2O_2	0.2	1.0	7/11	70	6	78.0

a - Kraft Corrugated Board
b - Bleached Variety of Paper
c - Theoretical Yield on ash basis
Sack Kraft = 93%
KCB - 93%
Bld. - 86%

d- Accept yield % - Defibered stock obtained after passing the pulper stock through Serle Vibratory screen with 0.2 mm slots opening screen with 0.2 mm opening was taken as a measure for repulping efficiency. Sodium hydroxide was used as a repulping aid for unbleached variety. Although traditionally hypochlorite is being used to break down PAE resins during pulping (1), however being environmentally unfriendly the shift is towards use of chlorine free chemicals. Potassium Monopersulphate has been found to be the most effective chemical for repulping of wet strength paper (2) but it is economically unviable under Indian conditions being an imported chemical. For our studies $H^2 O^2$ has been used as an alternate to hypo for bleached variety.

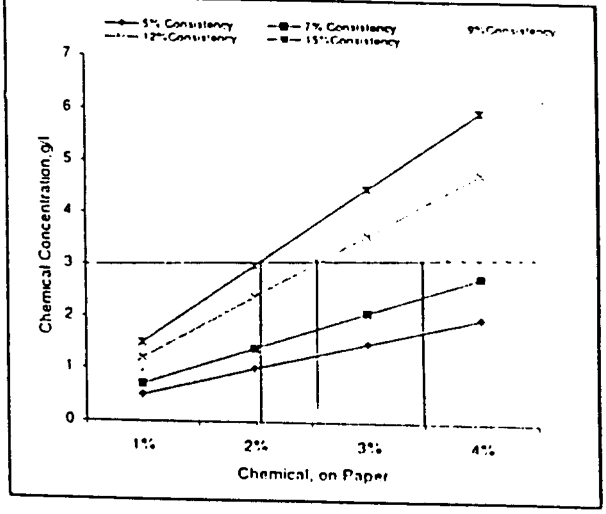
Table-3 summarises the optimum repulping conditions for all the three varities of wet strength paper. since bleached -II variety contained temporary resin, a mild alkaline condtions using 0.1% $Na_2 CO_2$ during slushing was suficient to get an yield close to theoretical value. The results at a glance clearly indicates that sack kraft requires more drastic conditions for repulping. The yield is best at high pH, high temperature and high shear rate, presumably due to high amount of resin in it. To achieve an yield close to theoretical vale i.e. 98% an optimum chemical concentration of 5-6 g/l, a pH level>11.0 and pressurized cooking at 120 °C for 30 minutes followed by disintegration in hydrapulper is required. However for the mills which do not have digester facilities, slushing in the hydrapulper at 80-90 °C using Na OH can be done, but a minimum slushing time of 60 minutes will be required. It was observed that mechanical treatment alone is not sufficient to defibrise the sack paper and requires specific process conditions for repulping. For KCB variety, however an optimum chemical concentration in the range of 1.0-1.5 g/l at 70 °C during slushing with minimum pulping time of 30 minutes will be sufficient to get an yield of 88% as against 42.6% under same repulping conditions but without chemical aid. For the bleached - I variety a selective two pH range i.e. 7/11 at 70 °C has been found to be the most suitable condition using $H_2 O_2$ as an oxidant. A minimum of 1 hour rection time is required which includes 30 minutes for $H_2 O_2$ to react under neutral conditions followed by NaOH under alkaline conditions. In all these experiments, it is observed addition of chemical aid accelerates the rewetting phenomena in these varieties, eventually facilitating the fiber to fiber friction during slushing operation.

FACTORS INFLUENCING REPULPING EFFICIENCY

i) Pulper Cofiguration:

To repulp wet strength paper, the right chemistry combined with mechanical energy are required for optimal results. Mills with repulping equipments that has both high agitation and shear are best suited for increased efficiency. Mills equipped with high-density pulper are more benefitted due to low energy and chemical consumption. Further with batch operations, control of process variables is easier. Additionally it is beneficial to have repulpers linked to steam lines since desired temperature will increase the efficiency. Mills having low consistency pulper will require a secondary pulper or defibrator for achieving best results.

Fig.-1 Effect of Consistency on Actual Chemical Requirement



ii) Process variables

The important process variables affecting the repulping efficiency are pH, Temperature, Consistency, time and Shear rate. Besides high shear rate., pH emperature and consistency have been found to have profound influence on repulping efficiency. Highly alkaline pH is more effective for unbleached grades containing PAE type resin while for bleached variety repulping at selective two -pH range is more favorable. Moderate to high temperature positively influences the efficiency. Repulping at high consistency would reduce the pulping time, chemical requirement as well energy requirement. Effect of consistency on actual chemical requirement is shown in Fig 1. At same level of chemical charge in percent on paper, the concentration will be low at lower consistency and hence for desired chemical concentration an additional dose will be required thus increasing the cost. By reducing the consistency from 15% to 5% the cost will increase by 3.0 times.

Fig. - 2 (a) Effect of Process Variables on Repulping Efficiency of sack Kraft Paper

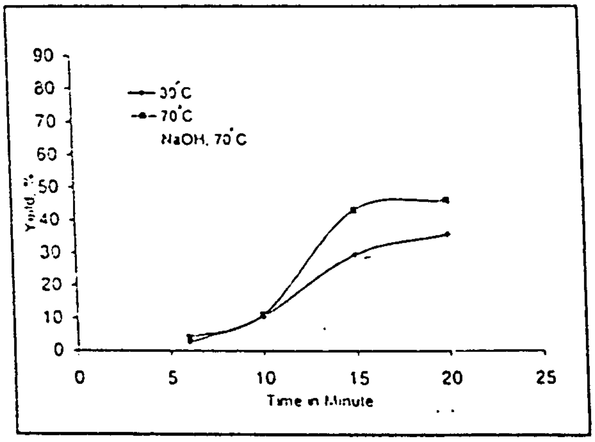
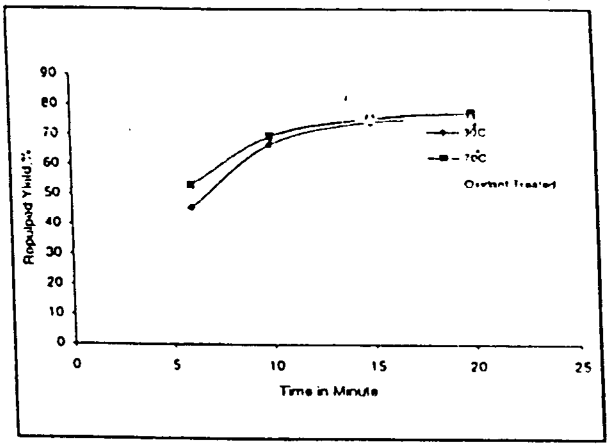


Fig. - 2 (b) Effect of Process Variables on Repulping of Bleached Variety of Waste Paper



The influence of different process variables on repulping efficiency are depicted in Fig. 2 (a-c). pH has a very distinct role on repulping efficiency. Acid curing resin would require acidic pH for repulping while neutral/alkaline curing resin would require neutral to alkaline pH for repulping depending upon the amount of resin on the paper.

A higher temperature more than 60 °C is required for repulping of wet strength paper as the high temperature facilitates the penetration of chemical into the paper. A minimum retention time of 30 minutes is essential for reaction to take place between resin and chemical aids.

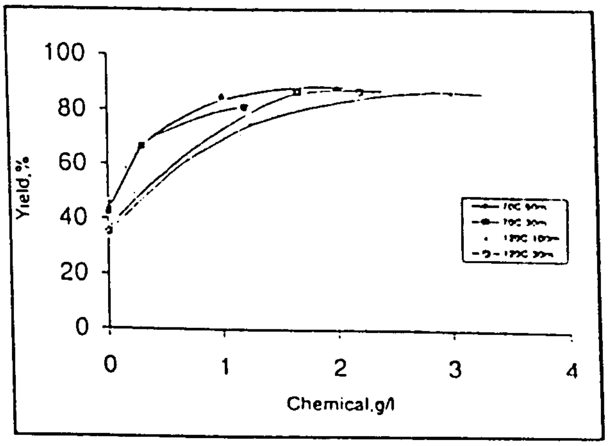


Fig. - 2 (c) Effect of Process Variables on Repulping Efficiency on K.C.B. Variety

ROLE OF REPULPING AIDS ON RESIN DEPOLYMERISATION

Each chemical added has a specific role on repulping chemistry.

Sodium Hydroxide: In unbleached grades treatment with strong alkali (pH above 11) at 70 °C may work by saponifying the ester cross links between resin and hemicelluloses and is more effective in the range of 60-80 °C.

Calcium Hypochlorite: At pH 6-7 the HOCl attacks the cross-link itself or the polymer chain at the cross link site to form secondary amine and an aldehyde. At higher pH the predominant free amine groups are attacked by OCl anion (1)

Hydrogen Peroxide: The secondary amine and tertiary amines are susceptible to oxidation, which predominates at low pH when strong oxidant is used. With the use of strong oxidant two pH process is more preferable to single pH process (3).

FIBER CLASSIFICATION AND PHYSICAL STRENGTH PROPERTIES

The fiber classification clearly reveals that the quality of fiber is much better than Indian virgin fiber as shown in Table -4. The + 20 fraction is as much as 80% in sack kraft and is close to soft wood pulp. The unbleached fiber can be further upgraded with bleaching to be used in the production of fine grades, while the bleached variety can be used directly for writing printing grades.

There has been a drastic improvement in physical strength properties with chemical addition. The burst factor is improved by 40% and breaking length by 28% with NaOH in unbleached grades.

TABLE - 4

FIBER CLASSIFICATION OF RECYCLED PULP STOCK USING BAUER MCNETT CLASSIFIER AND COMPARED WITH BLEACHED PULPS FROM OTHER FIBROUS RAW MATERIAL

Type of Pulp	Retained on			Passing Through
	20 mesh	50 mesh	100 mesh	100 mesh
	values in (%)			
Sack Kraft	80.4	9.2	5.8	4.6
KCB	68.0	17.0	4.0	11.0
Bleached Variety	48.9	24.7	9.7	16.7
Rice Straw[4]	2.7	18	25.3	54.0
Bamboo[4]	43.8	3.6	16.5	36.1
Hard Wood[4]	0.9	27.1	52.2	19.8
Soft wood[4]	82.5	6.5	5.0	6.0

CONCLUSIONS

- Wet strength paper known to be hard to-slush variety can be successfully repulped by proper understanding of chemistry of wet strength resins. An appropriate combination of chemical and mechanical treatment is necessary to obtain high fiber yield with low energy requirements.

- Pulper configuration plays a vital role in slushing the wet strength papers. High consistency facilitates improved fiber to fiber friction maintaining high chemical concentration, both of which are necessary for high repulping efficiency.

- Other process variables of vital importance are pH, temperature and shear rate maintained in the pulpers. Proper control of these process variables is essential for improved efficiency.

- The fiber classification indicates that the fiber quality of sack kraft is close to softwood pulp, which can be used for production of cultural variety by further upgradation through bleaching. Pulps obtained from bleached variety of wet strength paper can be used directly for production of writing/printing grade paper.

EXPERIMENTAL

Single pH-Process

Commercial paper was cut into 1" x 1" pieces and diluted to a weight ratio of 2% before heating to desired reaction temperature. Chemicals are added while gently stirring the paper. In case of using oxidants pH was maintained using NaOH. The paper was mixed for minimum 60 minutes reaction temperture and then transferred to lab disintegrator (Tappi Test Method T 205 om -88) and sheared for 6 minutes at 3000 rpm. Yield was determined by passing the defibred stock through a vibratory slotted screen having 0.2 mm opening and the rejects were dried at 105 °C.

Two pH-Process

In two -pH process the oxidant was added and mixing continued for 30 minutes at reaction temperature. The pH was adjusted to about 11 with aqueous Na OH and mixed for another 30 minutes at reaction temperature. The mixture is then transferred to disintegrator and sheared as mentioned above.

The pulp obtained were subjected to Bauer Mc Nett classification and evaluated for physical strength properties.

ACKNOWLEDGEMENT

We sincerely acknowledge the services of Mrs. A.V. Janbade and H.C. Joshi in conducting the laboratory experiments during the course of study.

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Printing Characteristics of Recycled Papers and Ways to Improve Their Print Quality

Kapoor S.K., Sood Y.V., Pande P.C. and Mohta D.C.

ABSTRACT:- Substitution of recycled fibres for virgin fibres in the manufacture of a wide range of writing and printing grade papers has become more essential now a days due to ever increasing concern for environmental protection and the necessity to conserve forest resources. The papers containing recycled fibres have not always been welcomed by the printers as their performance is markedly different from the papers made from virgin pulp. In the present investigations paper made from the virgin pulp and the recycled one made from the printed paper after deinking on the same paper machine were compared for the characteristics which mainly govern printability.

Brightness and whiteness of the paper containing recycled fibres (rcf) was lower than virgin paper but the Sp. scatt. co-eff. was higher. The virgin paper was smoother and more rigid than recycled paper. The print penetration was higher and surface strength was lower in the case of paper containing rcf. Higher print density at a particular ink layer was obtained for virgin paper as compared to recycled paper.

No doubt there are some deficiencies in the papers containing recycled fibres but keeping in view the increased emphasis on recycling it is necessary that some changes in the printing practices are adopted to get the best possible print.

Excellent work can be produced on recycled papers for which specific properties must be understood and changes made at every stage of production. Clients and designers however need to adjust the expectations in the light of print contrast limitations and other constraints.

INTRODUCTION

The waste paper recycling is being encouraged worldwide due to ever increasing concern for Environmental protection and to conserve forest resources. Some countries like U.S.A. and Sweden have even obligated legally the blending of a substantial proportion of wastepaper pulp in paper manufacture. The waste paper utilization rate which is a measure of secondary fibre utilization in different countries is given in Table I. The main advantages of using recycled fibres are saving of forests and energy as comparatively lesser energy is required in processing of recycled fibres than virgin pulp. In India also the use of waste paper is being encouraged. The category wise installed capacity of the mills provided by the ICICI report on the Indian paper industry is given in Table II. The data shows 27% of the total installed capacity share based on waste paper. Recycled fibres are used in a wide variety of paper and board ranging from low quality packaging material to the superior qualities intended to be used for printing. proportion of recycled fibres varies anything from 1% to 100% and source of fibres are mill broke. unprinted white paper or inked post consumer wastes.

Table-1.

Waste paper utilization rate (Waste Paper consumption/ Paper Production) in different countries.

Countries	Utilization rate
Japan	50.4
W. Germany	42.9
U.K.	44.5
Italy	44.7
Korea	75.1
U.S.A.	25.5
Canada	10.9
Sweden	10.5
Finland	4.1

Source: Japan Pulp & Paper Vol. 29. No.-4. 31 (1991)

Table-2.

Installed capacity (in hundred thousand tons) of paper and paper board mills in India.

Mill Type	No of mills	Total installed capacity	No of closed mills	Closed capacity	Effective capacity	%share
Wood	28	14.44	9	4.00	10.44	41
Agro	87	9.42	12	1.29	8.13	32
Wastepaper	210	9.18	69	2.56	6.62	27
Total:	325	33.04	90	7.85	25.19	100

Source- Paper Asia. 14 (October 1993)

The effect of recycling on strength properties had been discussed in detail by different workers (1-17). Generally it has been emphasized that the effect af recycling on the paper strength depends mainly upon the degree of papermaking potential utilized from the fibres in the previous cycle of papermaking. High yield mechanical pulps which usually undergo relatively lesser processing compared to chemical pulps i.e. had lesser papermaking potential utilized in first cycle. suffer lesser drop in strength properties on recycling In contrast, a refined chemical pulp which had the maximum amount of papermaking potential generated/utilized in first cycle looses much more severely on recycling. Phipps (18) has explained this in terms of the basic structure of fibres. The removal of lignin and hemicelluloses in a chemical pulp leaves porous and flexible fibres, which swell, fibrillate and bond very effectively. These fibres undergo irreversible collapse when they are dried and thus their bonding ability decreases with recycling, paper made from mechanical fibres have much porous structures and the fibres are less able to swell and bond.The fibres donot collapse on drying. and thus their bonding potential is not greatly affected by recycling.

The papers containing recycled fibres (rcf) generally have not always been welcomed by printers as their performance is markedly different from papers made from virgin fibres. In the present investigations papers made from either only virgin pulp or 100% recycled fibres after deinking on the same paper machine were studied for characteristics which mainly affect printability.

RESULTS AND DISCUSSION

Optical properties

The brightness and whiteness of the paper containing recycled fibres was lower than that of the paper made from virgin pulp (Table III). This was due to the presence of contaminants including ink particles which are always difficult to remove completely during deinking of printed waste paper furnish. Sp. Scatt. co-eff was higher for rcf. This may be due to lower apparent density (0.72) as compared to paper made from virgin pulp (0.89). As the rcf become more brittle and break like match sticks when beaten (19) the sheet formed is of lower density.

Roughness and Rigidity (Stiffness)

The roughness of rcf containing Paper was higher almost double than that of the paper containing virgin pulps. The rigidity was about half. These are probably due to increase in bulk (l/apparent density) and poor cohesiveness between fibres on recycling. The higher roughness in case of rcf containing papers can make them inferior for gravure printing which require smoother surface .

Absorbency

The absorbency of rcf paper was relatively higher than that of virgin pulp paper as apparent from the higher print penetration value for the former. The reason may be its relatively lower moisture content and lower density which are general features of most recycled stocks. 'the low moisture content makes such papers more prone to absorption of moisture from the surrounding air and also low density gives a large volume of air spaces which exert capillary suction on moisture and ink vehicle resulting in the observed high print penetration and loss in print gloss.

Surface strength

Surface strength of rcf containing paper was lower than virgin pulp paper as indicated by lower picking velocity value in the case of former. One reason for lower surface strength may be due to poor cohesiveness between fibres due to recycling. As a result such papers are prone to linting and picking.

Dimensional Stability

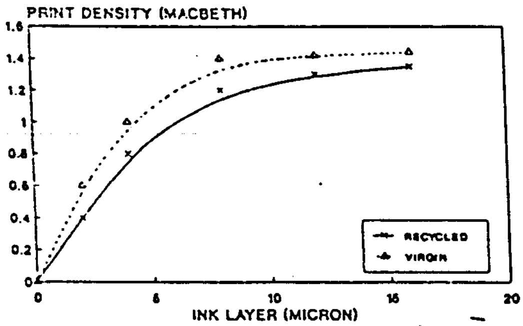
Rcf containing paper was less hygrostable than virgin paper. The expansion observed in the case of recycled paper for humidity change from 44% to 94% was 0.89% as compared to 0.55% for virgin paper in CD direction. Similar trend was observed for MD direction.

Table-3.

Characteristics of papers containing either virgin pulp or recycled pulp only.

Property	Values obtained for paper	
	Virgin	Recycled
Apparent density (g/cm^3)	0.89	0.72
Breaking length (m)		
CD	3220	1570
MD	6290	4280
Stiffness (Rigidity), mN		
CD	88	46
MD	174	72
Bendtsen roughness (ml/min)		
TOP	250	570
Wire	300	610
Moisture content (%)	7.2	5.0
Ash Content (%)	12.8	13.0
Print penetration (1000/Stain length mm)	27	33
Picking velocity, cm/s medium viscosity oil		
CD	381	195
MD	409	290
Dimensional hygroinstability (%) for R.H. change		
44% to 75%		
CD	0.20	0.36
MD	0.10	0.20
75% to 94%		
CD	0.35	0.53
MD	0.17	0.30
Brightness (%)	90.9	79.6
Whiteness, Hunter (%)	95.4	83.1
Sp. Scatt. Co-eff. (m^2/kg)	49.6	52.1

FIG.1- PRINT DENSITY CURVES FOR VIRGIN PAPER AND RECYCLED PAPER.



Print Density and Print Appearance

Print density curve for both rcf containing paper and virgin paper are shown in Fig.1. The print density obtained for recycled paper at a particular ink layer was lower than that obtained for virgin paper. The reason may be its lower brightness and higher absorbency.

Visual examination of solid print obtained on IGT printability tester indicated that print had uneven appearance in the case of recycled paper. The print was relatively dull with reduced gloss than that obtained for virgin paper. The loss in print gloss in case of rcf paper was due to its high absorbency. This high absorbency caused ink vehicle to penetrate quickly into sheet thus affecting the gloss of the print.

GETTING THE BEST POSSIBLE PRINT FROM RECYCLED PAPERS

No doubt there are some deficiencies in recycled papers as indicated above but keeping in view the increased emphasis on recycling it is necessary that some changes in printing practices are followed to get best possible print. Measures to obtain the best possible reproduction quality on recycled paper have been extensively studied (20). Few of the important measures are

Reproduction

Printer should establish the tonal reproduction curve and ensure that appropriate dot gain allowances are built into halftones, tint and colour separation. Scanner gray balance for critical colour work should be adjusted on off white papers and GCR (Gray colour removel) separations should be used where possible.

Printing

Printer should increase ink weight and printing pressure to obtain the best possible ink layer. This must not be done in isolation from making adjustments to the dot gain allowance at reproduction since it will have the effect of increasing dot gain.

Ink

Low tack inks should be used with slightly higher viscosity and opacity than normal. Good results can be obtained from inks with high pigment strength and good hold out.

By careful adjustment of such parameters in printing process and selection of compatible inks it will be possible to achieve results that will be acceptable for most purposes. No doubt there will still be constraints regarding print quality in respect of print contrast, sharpness, colour gamut and gloss. Keeping in view the benefits of being environmental friendly such constraints on image quality at least to some extent may be ignored.

EXPERIMENTAL

Prior to testing the paper samples were conditioned at temperature 27 ± 1°C and 65 ± 5% relative humidity. The printing tests were carried out using IGT printability tester.

Print penetration (Absorbency)

Print penetration was tested according to the method described in IGT information leaflet W24. A drop of fixed amount of standard oil was printed over the paper and the length of stain was measured. The print penetration was calculated using the formula

Print penetration = 1000/ stain length in mm

Print density and ink requirement

Paper strips of 35 mm width and 250 mm length in machine direction were taken. Prints were made on the wire side of paper using different ink layer thicknesses of IGT density ink on the printing forme. The printing conditions used were

Speed	:	Constant, 20 cm/s
Printing pressure	:	686 N
Printing disc	:	2 cm wide (aluminium)
Blanket	:	IGT paper blanket

The prints were allowed to dry overnight and the optical density of the printed area in reference to optical density of blank paper was measured using Macbeth densitometer RD 514. Graphs between print density and ink layer were plotted.

Dimensional Hygroinstability

Dimensional hygroinstability of paper was measured using PIRA paper expansion measuring apparatus. Paper specimen of length 200 mm was fastened between two clamps, preloaded and the measuring device was set to zero. The specimen was then subjected to atmosphere of different relative humidity values for sufficient time so that there was no further expansion or contraction occurring and the strips had stabilized in lenght. The amount of expansion was measured by dial micrometer gauges provided in the instrument. The percentage expansion was calculated and reported as hygroinstability.

Other Tests:

Thickness	:	ISO R 534
Tesnile Strength	:	ISO 1924
Stiffness	:	BIS : 11087/1986
Bendtsen roughness	:	ISO 2494
Moisture content	:	ISO 287
Ash content	:	ISO 2144
Picking velocity	:	ISO DIS 3783
Sp. scatt co eff.	:	SCAN C 27 : 69

CONCLUSIONS

* Brightness and whiteness of rcf containing paper was lower than virgin paper but the sp Scatt. co-eff. was higher
* The virgin paper was smoother and more rigid than recycled paper.
* The print penetration (absorbency) was higher and surface strength was lower in case of rcf containing paper.
* Print density at a particular ink layer was higher for virgin paper as compared to the recycled paper.
* With recycled paper a careful adjustment of printing process and compatible inks are required to achieve good print results.
* Low tack ink with slightly higher viscosity and opacity than normal should be used
* Ink should have high pigment strength and good hold out.
* Relatively higher amount of ink and printing pressure should be used keeping in view proper dot reproduction to get best possible print from recycled papers.

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Newsprint From Waste Paper, Its Quality and Requirements of The BIS 11688/1986 Standard

Kapoor S.K., Sood Y.V., Pande P.C. and Mohta D.C.

ABSTRACT:- Recycling of waste paper for the manufacture of not only boards but various grades of paper is increasing rapidly. Few paper mills in India are manufacturing newsprint from waste papers and many others are planning. The quality of these newsprints varies depending upon the type of waste paper & process employed. There has been instances when the printer was satisfied with the newsprint quality, however that did not meet completely the standard specifications (BIS 11688/1986). Thickness, smoothness, porosity, tearing strength & speckiness were generally found to be short of the specifications. In few cases thickness requirement of 80 ± 3.2 micron was not met even by the imported newsprints and those manufactured by big Indian mills. Whereas the quality of newsprint manufactured from waste papers need quality upgradation through proper deinking and other measures, some flexibility in the standard specification also needs consideration.

INTRODUCTION

India has been a traditional importer of newsprint. The domestic production of newsprint started during the end of 1955 when the first mill was started in the public sector. Due to several constraints (main being scarcity of suitable fibrous raw material) indigenous newsprint production has remained at the level around 60 percent of the total demand, the shortfall being met by imports.

With the latest world wide trend of maximizing the recycling of waste paper for the production of not only boards but various grades of paper as well, few paper mills in India have already started manufacturing newsprint from mainly waste paper & others are planning.

The quality of such papers obviously can not match exactly with those made from virgin pulps & specially the imported newsprints. The BIS 11688/1986 standard (1) specifies certain quality parameters for newsprints. In the recent past there has been certain occasions when the printer was overall satisfied with the quality of newsprint manufactured mainly from waste paper though that did not completely meet the specifications of the BIS 11688/1986 standard. When the paper industry is faced with acute shortage of conventional fibrous raw materials, rising costs of imported pulp & even the judiciary taking very serious view of environmental considerations the importance of recycling waste paper to the maximum extent can not be undervalued. The modern printing technology has advanced enormously. On our hand it requires rigid uniformity in the quality of paper for top quality prints at very high speed at the same time it has become more versatile & accommodating in certain aspects

In view of all this there is a need to harmonize the end users' requirements, the quality of indigenous newsprints & the standard specifications. This paper is an attempt in this direction based on the results of the laboratory studies carried out on a variety of indigenous & imported newsprints.

DEFINITIONS OF NEWSPRINT

As per BIS 4661/1986, ISO/R-135-1959 & British Standard BS 3203 the term Newsprint means "Paper intended for the printing of newspaper". "The Dictionary of Paper" by the American Paper Institute, INC (1980) (2) defines the newsprint as - "A generic term used to describe paper of the type generally used in the publication of newspapers. The furnish is largely mechanical wood pulp with some chemical wood pulp. The paper is machine finished and slack sized and it has little or no mineral loading. It is made in basis weights varying from 28.5 to 35 pounds (24 x 36- 500). (as calculated this is equivalent to 46 to 56 gsm) the greatest preponderance being 38 pounds (48 gsm). The term includes standards newsprint and also paper generally similar to it and used for the same purpose but which may exceed to slight degrees the limitations of weight, finish, sizing and ash applicable to standard newsprint. It does not include printing papers of types generally used for purposes other than newspapers such as groundwood printing papers for catalog, directories etc.

THE END USERS' REQUIREMENTS

For the production of any quality of paper one should consider thoroughly the requirements that should be built into the product to meet the end users' requirements. The end users in case of newsprint are

- the printer
- the advertiser
- the reader
- the recycler.

Some of the important requirements of each of them are

PRINTER'S REQUIREMENTS

Uniform sheet

Printer requires uniform sheet for printing. The printing presses are either reel or sheet fed. The running cost of the former being cheaper as it involves less handling in printing however its capital cost is relatively higher. The printer always desires reels with break free operation. Breaks of one or two per hundred reel are acceptable for reel fed presses. Reels of uniform hardness from core to the periphery and in perfectly round conditions are preferred.

Printing speed

Printer desire high printing speed (more than 60000 copies per hour) for the printing of newspapers as all matters in newspapers are to be printed in a short duration. The sheet therefore should be strong enough to run at high printing speed and it must have sufficient absorbent characteristics to take up the ink quickly without smudging.

Free of Lint & Dust

The surface of paper should be free from dust and lint and should be strong enough to hold fibres in place so that they donot get lifted out of the web during printing and get struck to the printing plates/ blanket. Excessive presence of such material causes deposition on the printing plates compelling printers for frequent wash ups. Two washups per 8 hours are considered reasonably satisfactory but target should be of one wash up after 800,000 copies.

Thickness or Bulk

The printing method used by the printer dictates the requirement of thickness of paper. Non impact printing can use a thin, dense paper. Heavy impact printing like letterpress can tolerate a low caliper dense paper whereas high speed offset printers prefer a thicker sheet. Low caliper results in more meters of paper in a reel and for printer it is an advantage as more copies are possible to print per reel change. Each reel change means lost quality, lost production time or both due to shut.

The paper should not have uneven thickness across the web i.e. not fluctuating more than ± 3 micron. This will improve runnability.

Stiffness

The printer prefers stiff paper as it feeds well in the printing press and does not get corrugated after printing.

ADVERTISER'S REQUIREMENTS

Brightness

The advertiser wants that his display should look good in the finished work. One sure way to get that is to have its printing on a brighter sheet. Preference of brighter newsprint is gaining more attention now a days. The brightness level of newsprint in Australia increased from 49 to 62% from 1950 to 1989. During the same period in west coast U.S.A. it changed from 52 to 59%.

Opacity

The advertiser wants his display to stand out and does not like the print from page three showing through his display on page one. So higher opacity is preferred.

Colour

The advertiser expects the paper to be able to accept good coloured printing.

READER'S REQUIREMENT

Reader expects different qualities in different products and does not expect the newspaper to look like a prestigious magazine. The printed material should be clear and easy to read. He desires good rigidity and resistance to creasing, a paper with a matt finish to make text easily readable, but which would give four colour pictures an attractive print gloss and whose surface should be scratch and smudge resistant as possible.

RECYCLER'S DEMAND

Now a days an increasing amount of paper is being recycled. As some printing processes, paper sizing and coating make this more difficult and a balance may be necessary between the use and final disposal. The paper should not contain any material which is hazardous to health as some of the waste newsprint may be recycled in the manufacture of food packaging grade papers. To avoid this paper should not contain any substance which could end up being a problem in the food chain

RESULTS AND DISCUSSION

Quality of indigenous newsprints manufactured from waste paper and imported varieties:

Strength, optical & printing characteristics of various newsprints i.e.

- Newsprints produced mainly from waste paper by medium/ small paper mills (India)
- Newsprints manufactures by big mills (India)
- Imported varieties of newsprints

are given tables I to IV.

Table-I

Strength and optical characteristics of newsprints from waste paper manufactured by few medium/ small size paper mills (Indian).

Property	IS : 11688/1986 specifications	Values obtained for the newsprint of S.M paper mills 1	2	3	4	5
Grammage (g/m²)	48 to 52 ± 4%	48.2	52.0	49.4	49.5	50.1
Thickness (micron)	80 ± 4%	94	88	75	93	97
Brightness (%)	49.0 min.	61.7	52.4	57.8	49.0	52.1
Opacity (%)	90.0 min.	94.8	97.0	95.5	93.7	91.6
Bendtsen roughness (ml/min)						
Top	--	580	340	370	590	780
Wire	--	1040	490	450	1170	910
Avg.	300 max.	810	415	410	1080	860
Bendtsen porosity (ml/min)	800 max.	1280	2060	980	840	2120
Breaking length (m)						
CD	1500 min.	2490	1850	2120	2730	1980
MD	3000 min.	3390	3400	3760	3770	3180
Tear factor Elmendorf, CD	45 min.	39	39	41	30	37
In plane tear CD (N)	--	1.5	1.5	1.5	1.5	1.5
Oil absorbency (s)	60 max.	33	10	28	16	18
Specks	--	----------------	----------------	Specks	----------------	----------------
Stiffness MD (mN)	--	16	17	17	16	15
Gloss, 75° (%)	--	4.5	5.9	5.8	6.1	1.0

Table-II

Printing characteristics of newsprints from waste paper manufactured by few medium/small size paper mills (Indian).

Property	Values obtained for the newsprint of mills 1	2	3	4	5
Print through (Macbeth density)	0.58	0.56	0.55	0.63	0.70
Pinholes intensity (% Elrepho)	5.9	6.5	8.2	5.8	6.8
Print set off after (s)					
0.1	0.45	0.39	0.40	0.45	0.32
1.0	0.37	0.33	0.33	0.33	0.31
5.0	0.28	0.26	0.26	0.31	0.26
15.0	0.24	0.24	0.20	0.28	0.22
60.0	0.18	0.19	0.17	0.22	0.18
Speckle at print density 0.90 (IGT Std. scale)	6-7	6-7	6-7	6-7	6-7
Ink requirement to get print density of 0.90 (micron)	8.8	8.0	8.0	8.8	8.8

Table-III

Strength and optical characteristics of newsprints of big mills (Indian) and foreign newsprint samples.

Property	IS : 11688 1986 specifications	Indigenous Mill 1	Mill 2	Mill 3	Mill 4	Foreign Canadian	Norwegian	Finish	Swedish
Grammage (g/m²)	48 to 52	49	49	50	49	49.5	49.6	49.5	48.1
Thickness (micron)	80 ± 4%	72	75	80	73	82	75	75	71
Brightness (%)	49.0 min	55.4	52.8	54.1	57.0	58.1	60.5	62.1	59.5
Opacity (%)	90.0 min.	99.6	93.9	94.3	91.8	94.3	94.1	94.4	93.6
Bendtsen roughness (ml/min)									
Top	--	--	--	--	--	150	120	110	130
Wire	--	--	--	--	--	170	170	140	150
Avg.	300 max.	180	140	225	150	160	145	125	140
Bendtsen porosity (ml/min)	800 max.	330	475	500	270	320	240	210	180
Breaking length (m)									
CD	1500 min.	2180	1870	2370	1820	2310	2010	1840	1760
MD	3000 min.	5560	5990	4080	5750	4750	4720	5130	6210
Tear Factor CD	45 min.	53	58	45	57	54	49	57	66
In plane tear (N) CD	--	2.0	1.5	1.5	1.5	1.5	1.5	2.0	2.0
Stiffness (mN) MD	--	29	23	27	24	27	26	34	27
Gloss, 75° (%)	--	8.0	8.1	9.3	8.0	10.7	10.5	12.2	10.1

Note: Some data for indigenous papers had been taken from Reference-15

Table-IV

Printing characteristics of newsprints of big mills (Indian) and foreign newsprint samples.

Property	Indigenous Mill 1	Indigenous Mill 2	Indigenous Mill 3	Indigenous Mill 4	Foreign Canadian	Foreign Norwegian	Foreign Finnish	Foreign Swedish
Print through (Macbeth density)	0.32	0.53	0.42	0.47	0.19	0.23	0.21	0.17
Pinholes intensity (% Elrepho)	4.3	5.3	4.7	5.2	0.8	0.8	0.7	0.6
Print set off after (s)								
0.1	0.19	0.18	0.24	0.30	0.18	0.19	0.20	0.19
1.0	0.11	0.10	0.20	0.26	0.15	0.16	0.18	0.16
5.0	0.07	0.06	0.13	0.24	0.11	0.11	0.13	0.12
15.0	0.04	0.04	0.06	0.22	0.08	0.09	0.08	0.09
60.0	0.02	0.03	0.03	0.12	0.03	0.04	0.03	0.03
Speckle at print density 0.90 (IGT Std scale)	5-6	4-5	4-5	4-5	3-4	3-4	3-4	3-4
Ink requirement to get print density of 0.90 (micron)	6.2	5.6	5.6	5.1	4.8	4.8	4.0	4.8

STRENGTH & OPTICAL CHARACTERISTICS

The properties of newsprint manufactured by small paper mills using waste paper as the main furnish component are given in Tables I & II. When compared with BIS requirements these papers meet all other requirements except thickness, smoothness, porosity and tearing strength. All these papers were highly specky mainly due to the ink particles left due to insufficient deinking.

Tensile Strength:

Good runnability is a fundamental property of newsprint ensuring that the newspapers can be printed without delay caused by web breaks or reduced printing speed in order to keep proper register. Tensile strength is one of the main parameters which affects press runnability. The tensile strength values of these newsprints are sufficient and should not pose press runnability problem as web tension in web newsprint printing is quite less than other printing presses (Fig.). The total web tension in newsprint printing press is generally 150 N/m (3) which corresponds to about ten percent of the tensile strength of newsprint.

Tearing Strength:

Elmendorf tearing strength of these newsprints (tear factor in CD 39 to 41) is lower than BIS requirement (tear factor CD 45 minimum). But this type of tearing test is not that important for newsprint as most of the newsprint is printed on web fed presses. More precisely it is the in-plane tearing

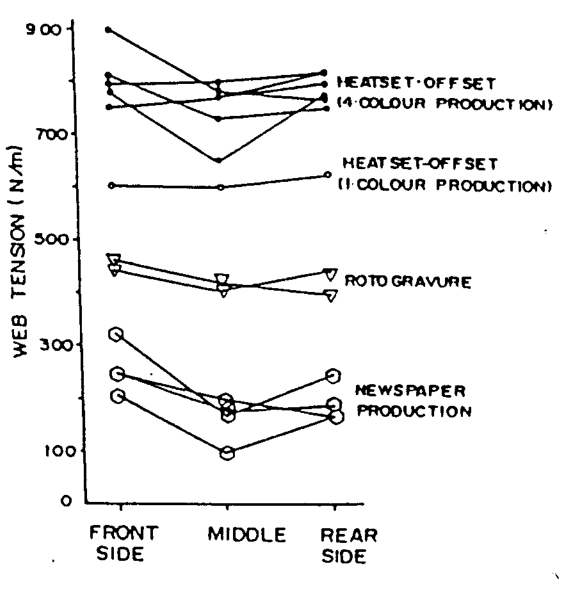

FIG. , WEB TENSION PROFILES IN DIFFERENT PRESS LINES. (Ref. 3) strength and the tensile strength of newsprint which are indicators of the potential runnability of newsprint webs in a printing press (4.5). The in-plane tearing strength of these papers (1.5 N) is comparable to newsprints of big Indian newsprint mills and foreign newsprint samples tested, whose values are in the range 1.5-2.0 N (tables III, IV).

Further, more carefully made cores and good wrapping of reels ensure still better runnability.

Thickness:

The limit specified for thickness in BIS standard 80 ± 4% micron needs careful review as bulkier sheet is preferred for offset printing and dense sheet for letter press as explained earlier. Some of the newsprints manufactured even by Indian big newsprint mills and foreign newsprints (Table III) had failed to meet BIS specifications for thickness.

Porosity, Roughness & Stiffness:

The newsprints produced using waste paper are quite porous, have rougher surface and about half stiffness values than that of virgin papers. The high roughness and porosity values will give poor print quality. Presently all over the world the demand is for smoother newsprint.

Brightness, Opacity & Gloss:

The brightness values 49.0 to 61.7% obtained for the newsprints manufactured by medium/ small mills from waste paper comfortably meet BIS requirement of 49% minimum and are comparable to newsprints of four big Indian newsprint mills (52.8 to 57%) though slightly lower than foreign papers (58.1 to 62.1%). The opacity is more than 90% and comparable for all samples. One of the general features being the papers manufactured from waste paper are highly specky. The gloss of these samples (4.0 to 6.1%) is about half the value observed for other newsprints (8.0 to 12.2%).

Printing Characteristics:

For newsprint grade paper the most important are the printing characteristics. In BIS standard the only parameters specified which affect printability are smoothness and porosity which are hardly enough to define completely the printability of paper. The best way to evaluate printing quality of paper would be to conduct actual printing tests under controlled printing conditions and evaluate them

Ink Demand & Print Set Off:

One of the most important printability evaluation parameter is ink requirement as it determines ink consumption for printing of the paper. Printing tests carried out using IGT printability tester which simulates the press conditions to a reasonable degree (6-11) indicated that the ink demand to attain 0.90 print density was found to be higher (range 8.0 to 8.8 micron) in the case of newsprints from waste paper as compared to indigenous newsprints of big Indian newsprint mills (5.1 to 6.2 micron) & foreign newsprint (4.0 to 4.8 micron). This is probably due to higher roughness and porosity which always affect the uniform transfer of ink. The print set off values were comparatively higher for newsprints manufactured from waste papers. This is probably due to high ink demand for these papers and reduced absorption capacity of recycled fibres.

Print Through:

Print through (0.55 to 0.70) was very high for newsprints from waste paper as compared to newsprints of big Indian newsprint mills (0.32 to 0.53) and foreign newsprints (0.17 to 0.23). As the print through is affected by the penetration of pigment on impression and is mainly a function of movement of the oil vehicle into pores with in the paper web would otherwise scatter light (12, 13). the higher print through is probably due to bigger pores in the surface of paper as paper having finer pores generally exhibit lower print through due to confinement of oil migration to the surface layer by higher capillary suction forces. The other factor responsible is higher roughness which increases ink requirement

Speckle Tendency:

Speckle tendency which is indicative of the extent of white spots left unprinted in solid print at same print density. This value is quite high (range 6 to 7) in case of newsrprints from waste papers as compared with big newsprint mills (4 to 6) and imported ones (3 to 4). This indicates that print uniformity will be relatively poor. The probable cause may be high roughness. Another factor responsible for this is uneven ink absorption due to comparatively poor formation. Madsen and Aneliunas had observed that light and heavy basis weight spots in newsprint webs had different printing characteristics after calendering (14)

To improve the quality of newsprint from waste paper produced mainly by the medium/small paper mills the efforts should be to improve smoothness, reduce porosity, improve stiffness and to reduce the extent of specks. This can be achieved to a large extent by proper refining and blending with virgin stiff fibred pulps. To reduce the extent of specks optimization of deinking operation is necessary which in turn will also help to reduce ink demand, improve readability and the printing quality.

EXPERIMENTAL

Newsprint of five medium/small paper mills, four Indian big newsprint mills and imported from Canada, Norway, Finland and Sweden were evaluated. Before testing, all the samples were conditioned at 27 ± 1°C and 65 ± 5% relative humidity. All printing tests were carried out using IGT printability tester according to procedures as under.

Print density & ink requirement:

Paper strips of 35 mm width and 250 mm length in machine direction were taken. Prints were made on the wire side of paper using different ink layer thicknesses of IGT striking in ink on the printing forme. The printing conditions used were

Speed	-	Constant, 350 cm/s
Printing pressure	-	196 N
Printing disc	-	2 cm wide (aluminium)
Blanket	-	IGT paper blanket.

The prints were allowed to dry over night and the optical density of printed area in reference to optical density of the blank paper was measured using Macbeth densitometer RD 514. Graphs between print density and ink layer for various papers were plotted and ink layer thickness required to get print density of 0.90 was determined for individual paper sample.

Print through and pinholes intensity:

The strips were printed using 16 micron thick layer of IGT striking in ink. The printing conditions used were

Type of ink	-	IGT striking in ink
Amount of ink	-	2 cm^3 on the inking rollers
Blanket	-	IGT paper blanket
Speed	-	Constant, 20 cm/S.
Pressure	-	686 N
Disc	-	2 cm wide (aluminium).

For print through values, the density of the print visible on the reverse unprinted side was measured after allowing the printed sheets to dry overnight. For pinholes intensity determination during printing, another strip of smooth blank paper was kept beneath the printing strip to get the ink impression caused by the seepage through pinholes present in the paper. The brightness values of the pinholes impression and blank paper was measured. The difference between the two values was reported as a number directly proportional to the amount of pinholes present in the test specimen.

Speckle:

The prints were made on the wire side of paper using the amount of ink sufficient to get print density equivalent to 0.90. The extent of unprinted area in solid print was compared with IGT speckle scale for newsprint printing. The scale has been numbered from 1 to 7 and the higher values indicate more unprinted spots in solid print thus poor print quality. The printing conditions used were same as those for print density tests.

Set Off:

The prints were made on the top side of the paper strip using the ink quantity required to get print density of 0.90. The printed strip was run through the second nip after time interval of 0.1S, 1S, 5S, 15S & 60S, so that a part of ink gets transferred to a clean strip. The set off print density on the latter strip was measured using Macbeth densitometer. The printing conditions used for set off tests were:

Speed	-Constant, 70 cm/S.
Pressure	-686 N
Disc	-2 cm wide (aluminium)
Blanket	-IGT paper blanket

Other Tests:

Grammage	-ISO 536
Thickness	-ISO R 534
Brightness	-ISO 2470
Opacity	-ISO 2471
Breaking length	-ISO 1924
Tear factor	-ISI 1974
In plane tear Strength	-Tested using MBR in plane tear tester
Bendtsen roughness	-Measured using Bendtsen tester
Stiffness	-BIS 11087/1986
Gloss	-Tappi 480 os-72

CONCLUSIONS

- Newsprint manufactured from waste paper by medium/small paper mills studied generally were short of BIS 11688/1986 specifications in parameters such as thickness, smoothness, porosity and tearing strength.
- The web tension in newsprint printing press is quite low as compared to other printing presses. All the above newsprints had sufficient tensile strength to have smooth runnability on the printing press.
- The Elmendorf tearing strength though lower than BIS requirement yet not likely to cause press runnability problem as their in-plane tearing strength was found to be comparable to the newsprints of big Indian newsprint mills and foreign newsprint samples studied.
- The thickness limit specified in BIS standard should not be rigidly desirable as bulkier sheets are preferred for offset printing and dense sheet for letterpress. Even some newsprints manufactured by Indian big newsprint mills and foreign newsprints failed to meet this specification. It may therefore be desirable to review the standard specifications suitably.
- Newsprint from waste paper was quite porous with rougher surface and had about half stiffness value than those of other newsprints.
- The optical characteristics viz brightness and opacity were satisfactory but the papers were highly specky. The gloss was about half the value observed for other samples.
- Laboratory printing tests indicated that these papers had higher ink demand, higher print through and higher speckle tendency as compared to newsprints of big Indian newsprint mills and foreign samples.
- Proper deinking of the waste paper, suitable refining/mixing of the pulp to improve formation & blending of appropriate amount of virgin pulp may improve the over all quality of newsprint produced from recycled waste papers.

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Incineration-An Option for Sludge Disposal in Recycled Fiber (RCF) Mills

Tandon Rita*, A.V. Janbade, Mathur R. M., Kulkarni A.G.

ABSTRACT

Handling of waste sludge is a major concern for all pulp and paper mills. It is especially important for recycled fiber mills (RCF) which produces more sludge compared to virgin mills and is even more for deinked mills where it contains ink along with fibre, fillers & coating materials. Currently the waste sludge from these mills are being disposed off as landfill or sold off to board manufactures. The studies conducted at CPPRI has revealed that there is a potential of energy recovery from waste sludge as the heating value is close to that of black liquor, however it requires to be dewatered to a minimum solid concentration of 40%, as high moisture content has a negative influence on combustion temperature. Fluidized, Bed Combustion technology (FBC) is the most viable technology for waste sludge incineration to recover energy using sludge as a mian fuel or after blending with coal. World wide a number of installations have come up on FBC technology utilizing waste sludge for steam generation. In the present Paper, an assessement has been made on fuel characteristics of, waste sludge from RCF mills with respect to its potentialities and limitations for steam generation.

INTRODUCTION

Deinking of waste paper & the use of recycled fibre (RCF) may have numerous environmental and operating benefits like forest resource preservation, decrease in chemical & energy use, decrease in odour emissions etc, but the handling & disposal of waste sludge is still a matter of great concern. Recyclers are known to produce much more sludge as compared to virgin mills, which is partly attributed to the fillers in the paper, and which for the most part, are not recovered. Sludge generation for Deinked (D.I) mills is even more pronounced as the sludge contains ink along with fibre, large amounts of fillers & coating material.

The characteristics & volume of sludge generated however depends on many factors such as size of the mill, waste paper furnish, number of contaminant removal modules in the system and final product development. The amount of waste sludge can be essentially negligible or as much as 40% of the production depending on the raw material, process and product quality consideration. The amount of sludge for different grades of paper usually is in order of Brown grades < Newsprint > Writing/printing < Tissue.

Worldwide several methods are in use to dispose off the waste sludge, however local, ecological, economical and regulatory conditions generally dictate which is the most cost effective. The major options are

- Landfilling
- Land spreading
- Incineration
- Land filling ash

Of all these, landfilling is the most commonly used disposal method and landfilling dewatered sludge is often the least expensive disposal method in terms of capital cost although large land areas are required particularly in case of deinked sludge. Another problem with landfilling is the leakage of hazardous components from deinked (DI) sludges particularly heavy metals. It is now becoming a less viable option as environmental problems and restrictive legislation are making landfills a buried liability.

Landspreading technique is rather appealing since it represents a natural reuse & recycling of the material. Landspreading of deinked (DI) sludge may be beneficial to crop or forestland particularly due to its ability to improve soil properties e.g. the water retention of sandy soils. Field study conducted else where (1) have shown that germination and root development rate in sludge amended soils is equal to or greater than the control. However the only concern for landspreading of paper mill sludge is its potential for temporary nitrogen immobilization, which usually begins about one month after plowing of the organic matter when the sludge beings to decompose and therefore a waiting period between sludge application and planting or addition of supplementary nitrogen ferlizer is essential to enhance microbial activitien soil (2).

Sludge incineration is an attractive option of disposal as it allows to recover heat from waste simultaneously reducing the landfill volume. The heat recovered by burning sludge at 40% to 50% solids may reach up to 10,000 KJ/Kg depending on its organic content. The landfill volume required for ash disposal is 70-80 % less than that required for sludge.

Energy recovery covers a wide range of technologies from simple travelling grate process and fluidized bed combustion to more advanced methods such as destructive distillation & wet air oxidation. However the ash must be characterized to determine the leachability of the heavy metals in the ash if it is being disposed to landfills or it can be used in cement, concrete or brick manufacturing

SLUDGE DISPOSAL PRACTICES IN INDIAN MILLS:

The sludge quantity produced by recycled mills in India ranges from 0.5 t/day to 12 t/ day based on the information collected by CPPRI and largely depends upon the quality of incoming waste paper, process steps involved in processing and type of the end product produced.

Most of these mills are producing packaging variety while others are producing writing/printing grade particularly newsprint. Both indigenous and imported varieties are being used and sometimes ash content is very high in imported varieties. Most of the mills dispose off their sludge by selling it to board manufacturers while few mills have adopted landfilling. However with mounting environmental pressure landfilling is no longer a viable option for country like India where the land is scarce. In view of this studies were conducted at CPPRI to assess the suitability of waste sludge from RCF mills as a fuel for steam generation.

RESULT AND DISCUSSION

Sludge samples collected from different mills producing packaging grades and newsprint were characterized for physico-chemical and thermal properties to evaluate the sludge quality with respect to fuel characteristics. The result of sludge characterization is summarized in Table-I

Characterization of sludge is a prerequisite to evaluate the suitability of waste sludge for combustion and steam generation. In general the sludge samples are characterized by high moisture content, high ash content and modest heating values and can be categorized as "difficult to burn fuels." The studies conducted at CPPRI also revealed the same trend. The results clearly indicate that the quantity of waste sludge produced by deinked mill is more compared to other mills due to more number of unit operations employed by deinking mill. The moisture content ranged from 87.5 to 96.7% as none of the mills was equipped with dewatering equipment.

The ash content is low for clarifier sludge and is in the range of 32-36% compared to deinked sludge with 60% ash content. The reason is attributed to

TABLE - 1
CHARACTERISATON OF WASTE SLUDGE SAMPLES

Particulars	Indian Mills			
	Mill-I	Mill-II	Mill-III	
	Clarifier sludge	Clarifier sludge	Deinked Sludge	Clarifier Sludge
Production, t/d	70	80	54	-
End product	Liner Boards	Duplex Board	Newsprint	-
Type of waste paper	Pre-Consumer	Post Consumer	Post Consumer	-
Sludge production, t/d	3.6	5.0 - 6.0	5.0	-
Ash content, % w/w in incoming raw material	0.35 - 11.4	0.14 - 24.5	1.0 - 17.0	-
Dewatering equipment	Not present	Not present	-	Not present
Moisture, % w/w	89.0	96.7	-	89.2
Volatiles,% w/w	63.1	66.0	50.7	47.0
Ash, % w/w	32.0	31.8	60.0	64.2
Calorific value MJ/Kg (on dry basis)	13.4	11.4	7.5	6.6

the quality of incoming waste paper and the system configuration for contaminant removal, which is different for both the end varieties.

The reason for high ash content in deinked sludge is attributed to the quality of wastepaper being processed; number of cleaning stages and the grade of paper being manufactured. The mill is producing newsprint, a low ash content product, by processing office waste (sorted ledger cutting) which has high initial ash content of 17%. Further, the mill has installed a number of cleaning stages (including deinking) compared to other two mills, to obtain a clean stock with relatively low ash content.

The heating value or calorific value of the sludge depends largely on ash content. Higher the ash content, lower will be its heating value. From the Table it is clear that the clarifier sludge have high calorific values than deinked sludge due to marked difference in their ash contents. The heating values of clarifier sludge is in the range of 11.4 - 13.4 MJ/ KG compared to 6.6-7.5 MJ/kg in deinked sludge.

CONSIDERING SLUDGE AS A FUEL

The key parameters governing the incineration of sludge are the composition, the calorific value and the physical and chemical properties of the sludge.

High moisture and high ash content and usually modest heating values makes the sludges difficult to burn fuels. Large amounts of water makes as-fed heating value of sludge low. It is therefore necessary to mechanically dewater these sludges to a solid content of atleast 40% before considering them as fuel.

Sludges with an ash content higher than 33.5% can not support self sustaining combustion (3) since ash values for clarifier sludge is close to this value, they can be considered as acceptable fuels. However for the D.I. sludges, the high ash value makes it unsuitable for incineration/combustion, as it will require high supplementary fuel and handling of large quantities of ash.

The heating values for the clarifier sludge is although comparable to that of black liquor but lower than the threshold value of 14 MJ/kg required for self sustained combustion (3). The clarifier sludges can be considered as a fuel but will require some auxiliary fuel for sustained combustion if burnt alone or can be burnt with high grade fuels like coal, rice husk bagasse pith etc. The deinked (DI) sludges on the other hand with heating value only half that of threshold value can not be considered as a fuel for steam generation and if burnt along with high-grade fuels will reduce the thermal efficiency. The deinked sludge should be treated separately & should not be mixed with clarifier sludge, if latter is to be used for steam generation.

These observations are further confirmed by the volatile contents, which are known to facilitate the combustibility of the fuel. The clarifier sludge has more volatile content (63-68%) than deinked sludge (47-50%)

SLUDGE DEWATERING

It is an essential step as high moisture content has negative impact on sludge incineration/combustion Wet sludge produces low combustion temperature which further decreases the evaporation rate of moisture and volatiles resulting in reduced boiler efficiency and increased emission. Auto thermal combustion of sludge pre supposes a dry solid content of 35-45%(4).

Today the dewatering equipment's available are capable of attaining as high as 50 to 55 % total solids. Equipment selection is now based on suitability for end use. Individual sludge evaluation is must with respect to disposal method as well as attainable verses economically practical cake dryness. The dryness content is higher with high ash content and low content of biological sludge. Table-2 gives a comparis on of different dewatering equipment available (5)

Maximizing final cake dryness is of prime importance to ensure maximum heat value out of sludge. Recently screw presses is the predominant choice, since they can achieve the high cake dryness usually over 45% with relatively low secondary sludge content. For high ash, low heat value sludges, high pressure belt presses are more practial to yield sludge dryness in the range of 35-40%.

APPROPRIATE COMBUSTION TECHNOLOGIES FOR INCINERATION OF WASTE SLUDGE

Although a number of technologies are available today but based on the fuel characteristics of sludge, the most common type of combustion system for steam generation from waste sludge include the grate furnaces, the bubbling and circulating fluidized bed furnaces. Though the grate furnaces are still in use but it has limitation with co-firing the waste sludge with high grade fuel beyond certain limits of sludge content. The fluidized bed combustion is the most common combustion technology utilized for the incineration of the sludge. The preferred type of

TABLE - 2
VARIOUS DEWATERING EQUIPMENT AVAILABLE FOR SLUDGE DEWATERING

Type of Dewatering Equipment	Inlet Consistency, %	Outlet Consistency, %	Applicability w.r.t Sludge Incineration
Rotary Vacuum	2-4	18-25	Not Applicable
Centrifuge	0.5-2.0	10-30	Not Applicable
V. Belt Press	15-20	22-40	Not Applicable
Belt Filter Press	2-3	30-50	Applicable
Screw press	4-5	33-50	Applicable

fluidized bed combustion is the bubbling bed. Small amount of sludge generation due to smaller scale of operation for recycled fibre based mills, makes the use of circulating fluidized bed combustion uneconomical.

A comparison of both these technologies with respect to sludge Incineration (6) is summarized in Table -3

TRAVELLING GRATE COMBUSTION TECHNOLOGY

It is a common method for burning sludge co-fired with coal using existing power boiler, however blending sludge quanitics upto 20% by weight is the limit as beyond this the heating values of solid fuel mix is reduced, drastically. Besides, incineration of sludge with high moisture and ash content increases the amount of boiler clinker & scales and decreases of production of steam significantly (6).

FLUIDIZED BED COMBUSTION TECHNOLOGY

High moisture & ash content do not cause problems in the modern FB boilers & circulating FB boilers. Potential temperature variations, caused by variation in waste fuel or water content are smoothened by the thermal fly wheel effect of the inert bed material. FB boilers are most favorable for the recovery of heat energy for both waste as a main fuel or after blending with coal. However when it is necessary to burn sludge with high quantities of high calorie fuel

TABLE - 3
COMPARISION OF COMBUSTION TECHNOLOGIES W.R.T SLUDGE INCINERATION (6)

Travelling Grate Combustion Technology	Fluidised Bed Combustion Technology
• Sludge can be co-fired with coal/bark using an existing power boiler. • Combustion of sludge suitable only for the production of low pressure steam. • Requires high combustion zone Temperature for good combustion and change in fuel moisture negatively influences combustion temperature. • Heat transfer takes place through radiation which is a direct function of combustion temperature and is dropped with decreased combustion temperature. • Sludge burning requires more air than coal to release same amount of heat due to low oxygen. • Sludge quantities as much as 20% by weight can be co-fired. • A 10 °C increase in air temperature is required to compensate one moisture point.	• Sludge can be used as a main fuel as well as co-fired with high HHV fuel. • High pressure steam can also be generated. • Allows successful burning at significantly lower combustion temperature. Temperature is between 760 - 900 °C. • Heat transfer is by conduction and the heat transfer remains high as long as the bed temperature is maintained. • Generally a dewatered sludge content of atleast 35-40% is required for self combustion of sludge. • The boiler can run with 100% sludge with some support fuel eg. coal or oil. Sludge can be burned alone if dewatered to a point where no in bed heat transfer surface is required (Approx. 58-62% MC levels) • Sand bed offers enormous area for heat exchange with close to ideal mixing. Maintenance is low because of its design and operation.

TABLE - 4
FLUDIZED BED TECHNOLOGY FOR FUEL OF VARIOUS HEATING VALUES

Bed Configuration	Typical Fuel heating Values MJ/Kg
Fluidized	Less than 7.0
Bubbling	7.0 - 10.5
Circulating	More than 10.5

CFB are more suitable:

Typically bubbling beds operate with excess air in bed, however operating bubbling bed as a gasifier in which a portion of the required combustion air to bed is applied to release a portion of the fuels chemical heat, the bed temperature is controlled even with high HHV fuel. The required heating value to sustain combustion without auxiliary fuel is generally lower in bubbling FB combustion than in other combustion methods. Table-4 Summarize the FB technologies in relation to the heating values of the fuel (7).

It is from the Table that the clarifier sludge with heating values between 11-13 MJ/Kg and DI sludge with HHV value of 6-7 MJ/Kg can be effectively burnt in BFB boilers. Also with BFB combustion technology a wide boiler capacity range is achievable. Bubbling FB technology is an efficient, flexible & cost effective method of burning sludge & related low-grade high moisture fuels.

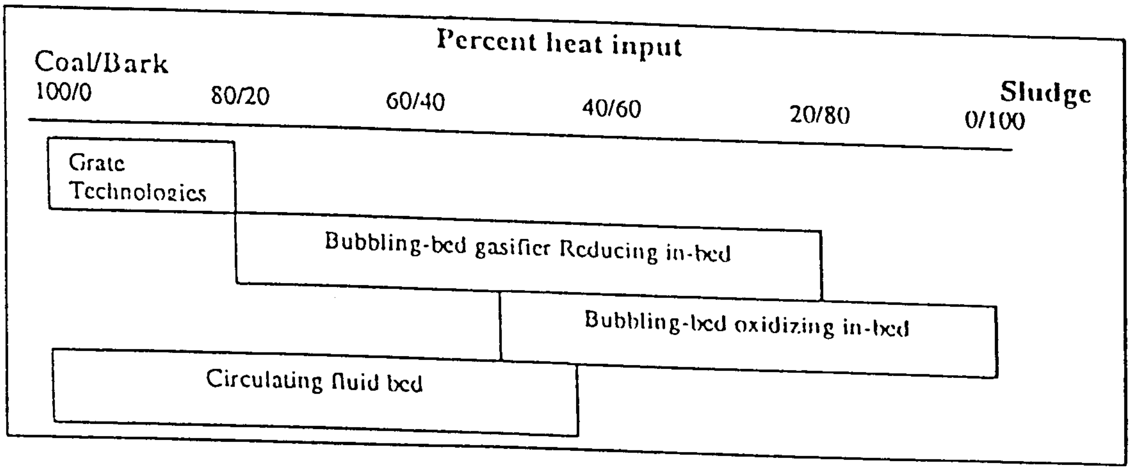
The presence of chlorides in the ash can sometimes be a problem. A value greater than 1% of chloride in the ash can cause lowering of the ash melting temperature & lead to agglomeration & defludization of bed material (8). Though the chloride levels will be low for mills using H_2O_2 bleaching but for mills using calcium hypochlorite, the levels of chloride will be a matter of concern.

Figure-1 summarizes different combustion technology choice for varying bark or coal/sludge combination.

COMMERCIAL STATUS

Over 20 installation are now running in Europe

FIGURE - 1
COMBUSTION TECHNOLOGY CHOICES WITH VARYING BARK OR COAL/SLUDGE COMBINATIONS



and United States, several of these are conversion of traditional travelling, or sloping grate successfully converted to FB type.

* In Japan the CFB boiler commissioned at Nippon Paper Industries in 1995 is said to have the biggest capacity in the world with steam generation at 260 t/h at 140 Kg/cm² pressure at 550 °C temperature. The distinguished feature of this boiler are:

- Wide adaptability for various kind of coal
- Applicability to incineration of paper sludge
- Low air pollution

The Norske Shog BFB boiler in Golbey, France, commissioned in 1998, utilizes de-inking sludge, bark & natural gas as its main fuel. the boiler provides saturated steam without super heating with a capacity of 144 t/h, 25 bar, 224 °C. The boiler is designed to burn deinking sludge at the rate of 400 tons dry solids per day (42% ash & 45% moisture).

HANDLING OF SLUDGE ASH

If a mill is planning to burn its sludge and dispose of the ash by landfilling, the boiler ash must be characterized to determine its toxicity. The main concern is the leachability of the heavy metals in the ash.

Ash from various sludge samples were characterized at CPPRI for their heavy metal content. Table - V summarizes the values of major components of the ash samples.

FIGURE - 5
ELEMENTAL COMPOSITION OF SLUDGE ASH SAMPLES

Values in, %

Particulars	Mill-I	Mill-II	Mill-III	
	Clarifier Sludge	Clarifier Sludge	Deinked Sludge	Clarifier Sludge
Calcium	0.16	0.14	14.67	15.60
Magnesium	0.33	0.36	0.53	0.68
Chlorides as cl	Not found	2.38	0.18	0.23
Silica as SiO_2	13.75	9.6	12.2	16.3
Mixed Oxides (R_2O_3)	N. D	9.55	11.7	12.0
Chromium	-	-	0.005	0.005
Mangnease	-	-	0.013	0.011
Nickel	-	-	0.004	0.004
Copper	-	-	0.012	0.012
Lead,	-	-	0.005	0.004

N.D.-NOT DETERMINED

The ash consists mainly of calcium silica & aluminium and iron oxide i.e. (R_2 O_3) and small amounts of magnesium. These compounds are derived from fillers & coating materials such as clay & calcium carbonate and also from the use of alum for acid sizing.

Chromium, managenese, Nickel copper & lead are the minor components and are of interest due to their potential environmental impact. Since these elements are present in very low concentration, hence will not have any toxic effect on soil. Further lead criginating from clay and other heavy metals are likely to be in the form of oxides that are bound within the clay structure and are thus unleachable. Thus, they should not be a concern from an ash disposal point of view. The other option for ash disposal is its utilization in cement, concrete or brick manufacturing.

CONCLUSION

- The waste (both clarifier and DI sludge) are characterized as poor and difficult to burn fuels due to high initial moisture content. Mechanical dewatering to atleast 40% dryness is must, if sludge is to be considered as an acceptable fuel.
- With HHV and ash values close to the threshold value for self sustained combustion i.e. 14MJ/Kg and 33.5%, clarifier sludge is suitable as a fuel.
- Waste sludge from DI mill will require high amount of supporting fuel i.e. coal rice husk oil etc.
- At low percentage of fuel inputs, sludge can be burnt in the existing grate boilers but sludge quantities more than 20% by weight will however result to reduced boiler efficiency.
- The bubbling fluidized bed technology is the most suitable method for burning high mositure, low -grade fuels like sludge owing to its low heating value requirement for sustained auxiliary fuel free combustion & fuel flexibility.
- Recovery of medium and low grade steam not only depends upon the heating value of the sludge but also upon the type of combustion. Fluidized bed type is suitable for generating higher pressure steam compared to the grate process.
- With the average production of sludge in Indian mills in the range of 0.5 -12 tpd, it can be burned together with coal or other secondary fuels in FBC boiler for steam generation.
- in the exiting stoker fired boilers although burning of sludge may not contribute to additional steam generation due to high moisture content, it may help in solid waste management

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