EVALUATION & IMPROVEMENT OF SURFACE PROPERTIES OF NEWSPRINT MANUFACTURED FROM RECYCLED FIBERS

(CESS PROJECT)

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Based on the work of

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EXECUTIVE SUMMARY

Due to lack of suitable fibrous raw material, India for the last few decades has been importing about 50% ($\pm$10 %) of its requirement of newsprint. The scenario is slowly changing as the recycling of waste paper is gaining momentum and this substantially improve the production of indigenous newsprint and reduce the imports in near future. At present, a large number of small and medium paper mills based on waste paper are manufacturing newsprint. Only few of these mills are able to meet the minimum quality standard. One of the main drawbacks is the inferior surface property of the sheet such as Smoothness, Gloss, etc.

The detailed investigations were carried out to systematically evaluate the surface characteristics of the indigenously manufactured newsprint from recycled fibers. The process systems of the nine mills based on waste paper were studied in detail. Based on the detailed study, the following recommendations are made to improve the newsprint quality

- The quality of newsprint being manufactured from waste papers by medium scale paper mills can be improved by systematic optimization of different process unit operations like Deinking, Calendering and fines retention at wire part.
- Foreign printed newspapers are comparatively easy to deink as compared to Indian newspapers especially the papers printed in local languages. This is probably due to excessive amount of oil content in the printing inks in latter. The unaged newspapers are relatively easy to deink. As long as possible unnecessary aging of newspapers should be avoided.
- The deinking chemicals being used by the mills need proper evaluation and selection. The chemicals suitable for Indian papers should preferably have sodium soap of fatty acid and copolymers.
- To get proper bulk, opacity and smoothness in newsprint the waste paper selection should be in such a way that the final furnishes content contains at least 50 % mechanical pulp content.

- High consistency pulper (HC) should be preferred over low consistency pulper (LC) for newsprint manufacture as it gives better reduction in dirt specks area at particular specific energy input.
- The moisture content in newsprint should be kept in the range of 9 to 10 % instead of 5 to 6 % as observed. This will give better runnability on printing press. This will also give appreciable financial saving to the manufactures.
- The smoothness. gloss and printing characteristics of newsprint from waste papers can be improved by improving formation and soft nip calendering. Soft nip calendering will help to get better smoothness and linting control than hard nip calendering.
- Double disc refiners which are generally being employed in Indian mills for refining of waste paper pulp are sometimes not suitable in the development of proper fiber flexibility, which may cause higher linting. The conflow refiners are generally more suitable for such furnish.
- The retention of fines is extremely important in improving the surface characteristics of newsprint. Retention aid of polyethylene amine type is quite effective as compared to alum or poly aluminum chloride.
- The production trials (Case Study) at five mills had shown that it is possible to manufacture newsprint conforming to BIS: 11688/1999 specifications after alterations/optimization of manufacturing process. Each mill required different approach.

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EVALUATION & IMPROVEMENT OF SURFACE PROPERTIES OF NEWSPRINT MANUFACTURED FROM RECYCLED FIBRES

1. BACKGROUND

Due to lack of suitable fibrous raw material, India for the last few decades has been importing about 50% (+10 %) of its requirement of newsprint which entails the out go of considerable amount of foreign exchange. The scenario is slowly changing as the recycling of waste paper (newspapers magazines & other varieties) is gaining momentum and this substantially improve the production of indigenous newsprint and reduce the imports in near future. At present a large no. of small and medium paper mills based on waste paper are manufacturing newsprint. Only few of these mills are able to meet the minimum quality standard.

One of the main drawbacks is the inferior surface property of the sheet such as SMOOTHNESS, GLOSS, etc. This results in poor quality of print and excessive amount of fluff generation during offset printing. There is a need to systematically evaluate the surface characteristics of the indigenously manufactured newsprint from recycled fibres and find out the possible ways to improve them. The importance of the problem was recognized by the learned members of the meeting held on 7th Aug 2002 in Udyog Bhavan, New Delhi under the Chairmanship of the Joint Secretary (JS) to discuss BIS specifications for Newsprint manufactured out of Recycled waste paper for determining the eligibility of the concerned mills in Schedule-I to Newsprint Control order 1962. A Para from the minutes of the meeting is reproduced below

"AFTER DETAILED DISCUSSIONS IT WAS DECIDED THAT FOR THE PRESENT, CPPRI MAY TAKE UP A CESS FUNDED PROJECT JOINTLY WITH FOUR OR SIX PAPER MILLS FOR IMPROVING SMOOTHNESS FOR PAPER BASED ON RECYCLED WASTE PAPER. AFTER LOOKING INTO THE RESULTS FUTURE COURSE OF ACTION CAN BE DECIDED".

In pursuance of these recommendations the present project approved by Cess Grant Authority, Govt. of India was taken up.

In the present study the process data collected from nine mills was analyzed to study the possibilities of manufacturing better newsprint with improved smoothness. In five mills actual trials were taken to improve the smoothness of newsprint on the production scale.

2. MANUFACTURE OF NEWSPRINT USING RECYCLED FIBRES

Data collected from nine different mills (***Table* 1**) in India manufacturing newsprint from waste paper as raw material indicated that generally mixture of old newsprint (ONP), old magazines (OMG), sorted office waste (SOW), mixed colour cuttings (MCC), note books and other chemical pulp containing white papers etc. are used as furnish components. The proportion of each component generally depends on the availability and cost. The general trend is to use ONP in the range 26–30% and remaining is old magazine, office waste and notebooks etc.

Considering the different variety of waste paper in details ONP has a high percentage of mechanical fibre, groundwood or thermo mechanical pulp. In addition to the fibre components of the furnish, additives required for the production of newsprint are also present in ONP ranging from 3 to 12wt%. These include starch, inorganic fillers and dyes for colour control. Ink amount is about 1 to 2 wt% in the ONP furnish.

OMG is a highly variable raw material. The fibre component of the magazine can range from 100% Kraft pulp to 100% groundwood. A single magazine may include coated free sheet, coated groundwood, and uncoated mechanical fibre. Also the additives are also highly variable. Fillers such as clay, alum, precipitated calcium carbonate (PCC) are also present which had been added during the paper making process to improve the sheet characteristics. In magazine stock this inorganic portion of the furnish can range from 10wt% in the uncoated sheet to as high as 50wt% in a sheet that is coated on both sides. Adhesive associated with bindings, thermal plastics and hot melts can all contribute to stickies. Ultraviolet cured inks, common on magazine covers, are difficult to deink. Ink can range from 1 to 7wt% in magazine grade of waste paper.

Sorted office waste, mixed colour cuttings and notebooks contain mainly chemical pulp as pulp component. Chemical pulp component in indigenous waste contains mainly short fibred pulps like agricultural residues, bamboo and hardwood. Also indigenous papers are acidic sized whereas imported ones are alkaline or neutral sized.

Newspapers are often thought of as a mature form of media that involves little or no modern technology. However, as in the case of papermaking, much technological advancement are occurring at a faster pace than ever. The world-wide newsprint market remains a very large 40 million tones a year grade. There is rapid conversion from the direct plate to paper letterpress process to offset. This conversion of the industry from letterpress began in the late 1960s with many locations installing offset presses in the 1970s. One of the many advantages was the greatly improved print quality of offset vs. letterpress, especially for color graphics. Due to the contact between the press blankets and 100% of the paper surface, these offset presses made sheet linting a major papermaking concern. Today, a 250,000 copy production between press blanket washes is becoming an industry standard.

In the late 80's and into the early 90's, flexographic printing was introduced to newspapers moved to flexo printing. This trend has now mostly stopped, with offset again being the method chosen for new newspapers presses. Technology on offset presses allows much faster operation with actual operating speeds of 70,000 copies per hour.

New presses have greatly increased automation for production efficiency and product quality. These systems include automatic color setting, automatic camera-based registration and compensation setting systems. These high speeds increase the strength demands on the paper as well as lessening the tolerance for defects such as holes and shives in the sheet. High operating speeds has made 50 inches the new standard roll diameter on these presses requiring increased precision in roll winding control.

As well, these rolls must more than ever be received in good condition at customers including not being out of round to allow automatic roll changing at these high speeds. Many new installations feature automated roll handling systems such as high rack storage are using computerized retrieval cranes and robotic-guided vehicles. The demand on suppliers for perfect roll wrapping and scan able roll bar codes becomes a priority.

The major trend over the last 20 years has been the greatly increased use of colour in newspapers for both editorial and advertising. Most new press installation now consist of press lines where many, if not all units, allow two-sided, four colour production on stacked tower units. This increased use of colour has changed the demands on newsprint as well. The need for consistent colour between rolls and between mills to produce consistent printed colour has become a major publisher concern. The use of a large percentage of newsprint on four-colour leads, where the sheet is printed in up to eight separate units, increases the wetting of the sheet. This results in increased concerns about dimensional stability of the sheet that causes fan out during printing and sheet curl when the sheet redried.

In the last two years, presses that have the capacity to print a major daily only in straight runs were introduced and became a major part of the new press market. As most newspaper readers realize, page size has been shrinking in the last 15 year. This trend is based on both reader preferences for a smaller, easier-to read product, as well as the desire to reduce the paper usage for economic reasons. The current, most common, North American standard is 12.5 inches originally used in Canada at the Toronto Star. To further decrease paper usage, this size is being reduced slightly by many publishers. These new roll widths create challenges for mills to efficiently trim the paper machines designed for previous width standards.

3. NEWSPRINT CHARACTREISTICS GENERALLY SOUGHT BY NEWSPAPER PUBLISHERS

The functional requirements of newsprint are pressroom runnability, Printability, good appearance and low price.

Runnability: Ability to run the web through the presses without break.

Printability: Ability to accept and preserve the imprinted ink pattern with minimum rub off, set off, and show through.

Appearance: Brightness, whiteness, cleanliness, opacity.

4. STEPS INVOLVED IN MANUFACTURING PROCESS FROM WASTE PAPER AS RAW MATERIAL

The general steps involved are

- Slushing and deflaking
- Screening
- Cleaning
- Dispersion
- Deinking
- Bleaching
- Refining
- Papermaking

The block diagram of process operational steps for nine different mills is given in ***Fig. 1*** (***Figs. 1.1 to 1.9***). It can be seen that all the mills studied have basically similar machinery set up. In some mills kneaders are also being used.

The different waste paper treatment unit operations are described as below

4.1 Slushing and Deflaking

The first step involved in waste paper processing is to break down the raw material into individual fibres as much as possible to form suspension so that at least it can be pumped. Out of nine mills studied, two mills have low consistency (LC) pulper and remaining has high consistency pulper. The pulping consistency in LC is normally in the range. 5–6 %, mills having high consistency (HC) pulpers operate at 12–20 % stock consistency.

The general trend of fibre dispersion in LC and HC pulper is shown in ***Fig. 2.*** Clearly, HC pulper give steepest reduction in flake content and are preferred over LC. Old newspapers and magazines or coated grades are preferably slushed using HC pulpers. LC pulper is normally used in recovered paper processing, for the manufacture of packaging paper and board. During slushing/pulping all the mills studied are using sodium hydroxide in the range 0.8–1%, some mills are also using sodium silicate in the range 0.8–1.5%. and the temperature kept is 45–60^{0}c . Different types of deinking chemicals are also used. The chemical composition of deinking chemicals is not clear to mills.

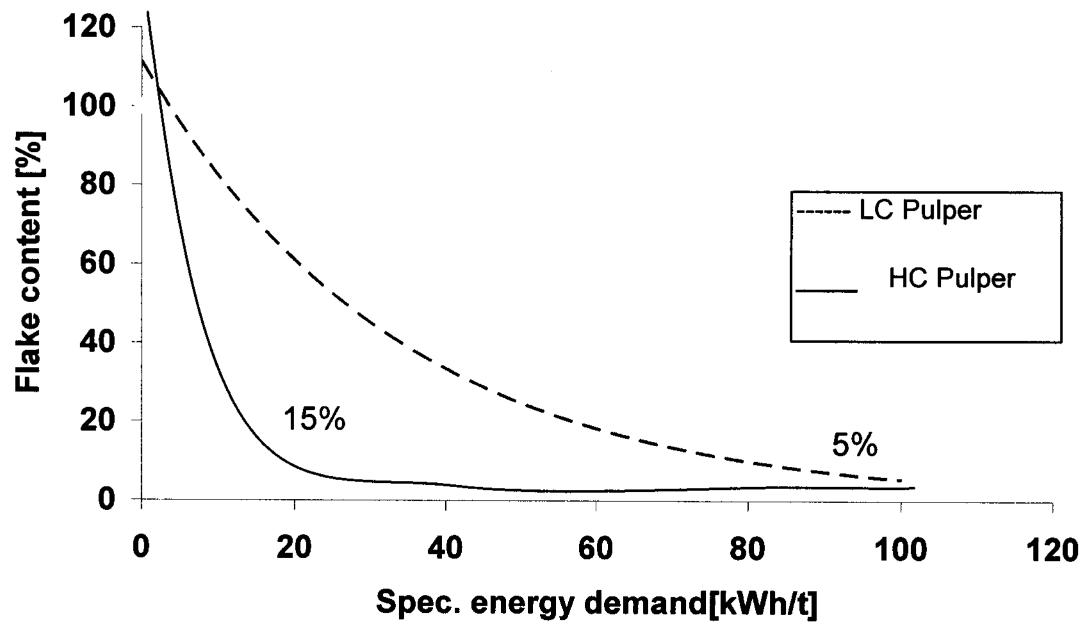


Fig.2: Deflaking characteristics of pulpers at different stock consistencies vs. sp. energy demand

4.2 Screening

Screening is to remove debris and contaminants from recycled fibre pulp. It is primary separation process in processing recovered paper where high debris content places special demand in the screening process. All the mills studied had hole type as well as slot type screening system.

4.3 Dispersion and Kneading

Four of the mills studied had hot dispersion or kneading systems. The primary task of dispersion is

- Reduce dirt specks below the visibility limit
- Break down stickies
- Break down coating and sizing particles
- Detach ink or toner from recycled fibre
- Mix in bleaching agents
- Treat fibre mechanically for retaining or improving their strength characteristics
- Treat fibres thermally to increase the bulk

Dispersion involves application of high shear forces to the fibres and the debris particles to disperse. Kneaders have a horizontal tubular housing with a stock feed chute at one end and outlet at the other. Inside the housing are two or three rotating shafts fitted with kneading elements that also act as impellers. ***Fig. 3*** shows that how specific energy demand influence dirt speck reduction. High specific energy gives improved results. Mechanical loading at excessively high consistency can cause fibre crinkling in kneading dispersers. One of the mills having kneader was operating it at 30–32 % consistency, which is quite high consistency.

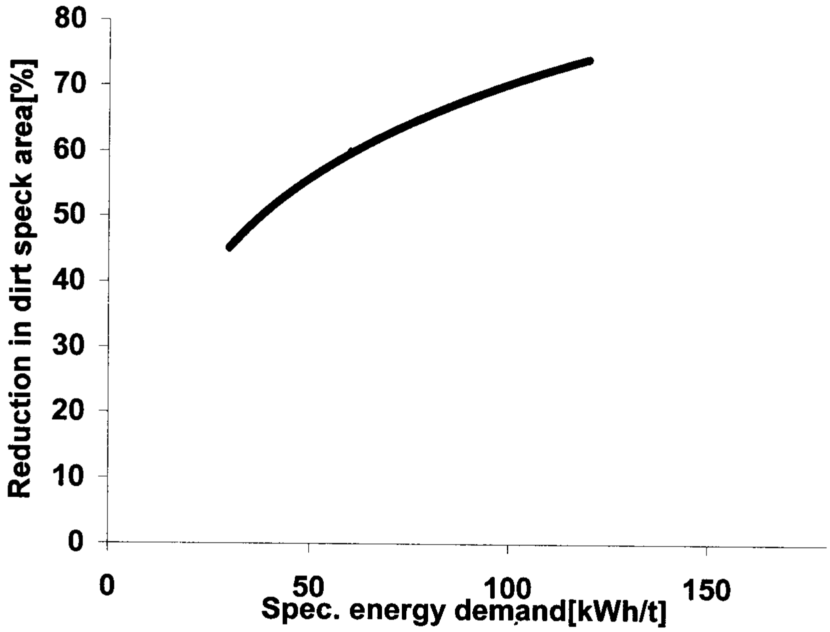


Fig. 3 Reduction of dirt speck area in a disk disperger vs. sp. energy demand

4.4 Deinking Floatation

In deinking floatation the principal of selective floatation is used in removing ink particles. The separation criterion is different surface wettability of the particles to be removed and the fibres to be retained. Particles, where surface is or has been hydrophobic i.e. watering repellent, can be floated within a certain size range. These particles included printing inks, stickies, fillers, coating pigments and binders. The mechanism involved in releasing ink particles is probably fibre swelling during slushing, mechanical forces due to friction and the chemical bond loosening. Fibre swelling break ink apart by crack formation. When flakes disintegrate, the ink particles also break down. Mechanical forces remove the ink through friction between fibres. The size range of the free ink particle in a suspension is very wide. Originally the basic size of ink particles (carbon black and pigment) was 0.02–1.0 micrometer. Water based flexographic printing ink agglomerates are 1–5 micrometer. Offset printing ink agglomerates can be up to 100 micrometer. The oxidized ink agglomerates which adhere so strongly to fibres reach size of 500 micrometer and more. For efficient floatation of the ink particles, their size range must be 10–250 micrometer. Smaller particles require agglomeration into larger ones. They can be accentuated by applying calcium soap.

Floatation system generally operates at stock consistency 0.8–1.5 % and temperature of 40°–70°C. The pH should be about 7 to 9. The relative air load is mostly about 300% and more expressed as total air volume flow to total suspension volume flow. Certain floatation system operates at air load of up to 1000%.

Some imported newspaper coming to India as wastepaper contains water based flexographic ink used during printing. Flexography is mainly used in Italy and to some extent in UK and United States. Saponifiable synthetic dispersion is binders. Because this dispersion is soluble in alkaline environment, the conditions of floatation deinking are insufficient to deink water based flexo printing ink. Flexographic ink is also very small which impaired floatation efficiency. In recent years, several studies have been tried to discover ways to improve the deinkability of water based flexographic ink. Floatation of conventional water based flexographic inks achieve higher level of brightness in slightly acid pH range of 5.5 to 7.0 than alkaline environment.

4.5 Bleaching

Peroxides are the oxidizing bleaching agents used for bleaching of wood containing DIP. All the mills studied are using H_2O_2 during deinking. The practice is sufficient to satisfy the optical demands for newsprint. This operation is not bleaching but a compensation for the avoidance of alkali yellowing.

4.6 Refining

The purpose of refining in recycled fibre processing is to improve the main properties of recycled fibres. In standard newsprint making, refining is partially required to improve strength and net energy demand is less than 50kwh/t. It is surprising to note that all the mills studied are using either double disc or triple disc refiner, which is generally used for virgin pulps.

4.7 Papermaking

The paper machine layout in all the mills studied is fourdrinier type having synthetic type wire. Wet pressing system is similar except in three mills those have press blind drill press and inverse press arrangement. All the mills have similar type of calendering system.

5. QUALITY OF THE NEWSPRINT BEING MANUFACTURED BY THESE MILLS

Nine mills based on the waste paper as raw material were studied. The paper samples were evaluated for different characteristics mentioned under BIS standard 11688/1999 specifications. It was observed that out of the nine mills studied, the newsprint manufactured by two mills met all the requirements of BIS 11688/1999 standard (***Table III***). Newsprint manufactured by the remaining mills meet all other BIS specifications except smoothness. The moisture content are in the range 5 to 6 percent. It is suggested that if newsprint is produced near moisture level 9 to 10 percent instead of 5 to 6, there will be appreciable financial saving .The customer will be quite satisfied to receive newsprint at higher moisture level because of improved runnability. In particular newsprint exhibits improved stretch at higher moisture levels, which enables the sheet to better absorb shock energy without breaking? The effect of moisture content on runnability is shown in ***Fig.5***. In pressroom runnability (number of breaks) is directly proportional to (tensile strength)*(Stretch)$^{1/2}$ of newsprint in the machine direction (36).

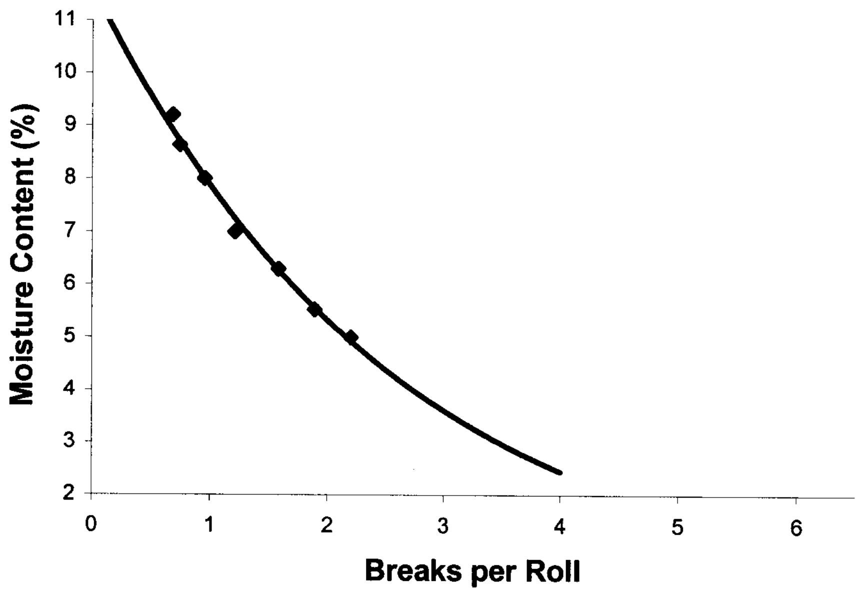


Fig 5 . Effect of Newsprint moisture content on "Relative Pressroom Runnability".

The machinery set up of all the nine mills described above is almost same with variation in operational process parameters. It is clear that the quality of the newsprint manufactured by the remaining seven mills can also be improved by carefully controlling the following unit operations

- Furnish optimization
- Optimization of deinking process
- Calendering

5.1 Furnish optimization

It can be seen from ***Table II*** that the newsprint samples which satisfied the smoothness requirement were having higher mechanical / chemimechanical pulp content than those samples which were having higher roughness. Laboratory studies carried out indicated that increasing the amount of mechanical pulp in the pulp sample collected from a mill making newsprint from furnish containing ONP, magazine, exercise notebook and office waste showed improvement in smoothness after calendering. The porosity is increased with the amount of mechanical pulp content (***Fig 4***). Reasonable porosity is a requirement of newsprint. In recycling mechanical fibres are not prone to hornification. To some extent, they even gain in flexibility probably due to internal fibrilation caused by repeated drying and calendering. Mathematical relationship shows how the apparent density and relative bonded area of a fibre network in sheet grow with a dimensional flexibility number F , that is affected by fibre character

$$F = (w_f/t_f)(C.w_f.W_{FF})^{1/4}$$

Where W_{FF} is fibre flexibility in the wet state

W_f the width of fibre

t_f the thickness of fibre

C a constant that depends on the fibre material

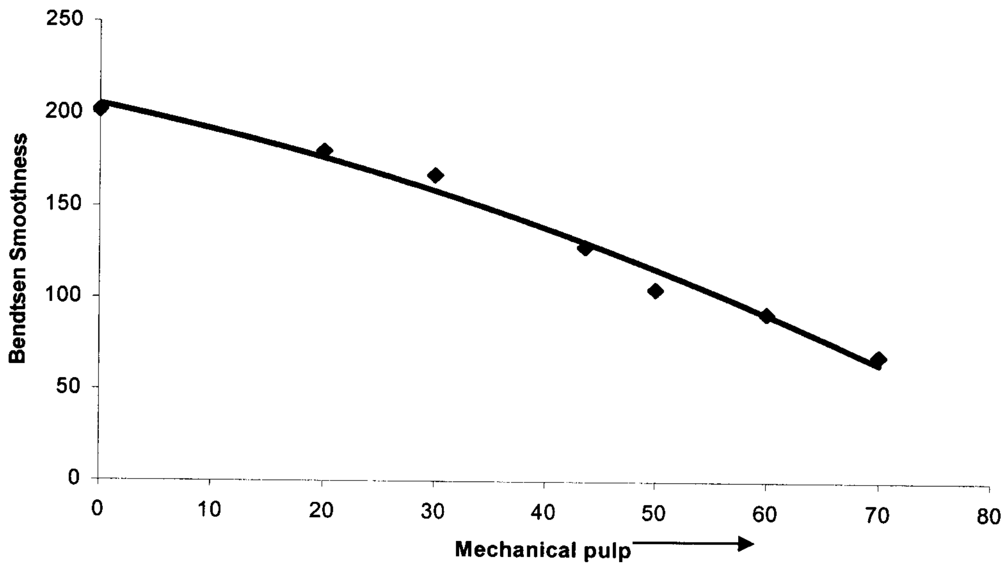
Although this formula ignores the importance of fines and fillers, it does show the effect on recycling. The apparent density and relative bonded area of a fibre network grow when the thickness of fibres decreases due to flattening. The increasing proportion of recycling chemical fibres affects the sheet density more strongly than any change in mechanical fibres because they are flat and their flexibility value in wet state is more. Despite hornification, the flexibility of chemical fibres will increase by outer damage (twisting and kinking). When DIP replaces mechanical pulp, the reduced thickness compared with the virgin fibre sheet will show declining rigidity as the stiffness is related to thickness as formula

$$S = E/t^3 12$$

Where E is the elasticity modulus

t the thickness of the sheet.

Newsprint is printing paper segment in which the use of DIP is particularly well established abroad. Newsprint with DIP content of 100% is almost standard in some regions. The progress in deinking and paper making technology has eliminated the disadvantages in runnability and appearance of the sheet.



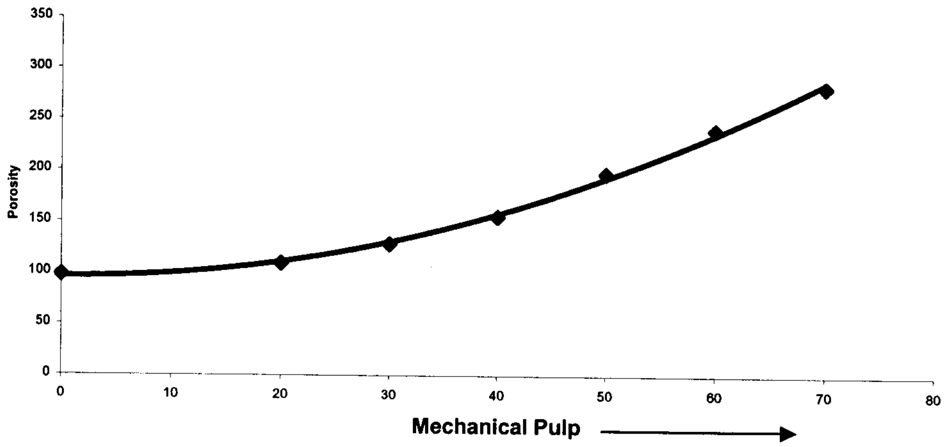


Fig. 4: Effect of increasing Mechanical pulp on Smoothness and Porosity of Newsprint.

The problem with the medium scale paper mills in India is the improper selection of the furnish components. It can be seen that notebook, office waste are the major component of waste paper in the manufacture of newsprint. These mainly consist of chemical pulp. Generally the excess amount of chemical pulp adversely affects the printing characteristics. Also in Indian waste papers, agricultural residues, bagasse and hardwood are the major components in papermaking. Such fibres are short fibres containing lot of fines like parenchyma cells and vessel elements. Such fibres on recycling give relatively more hornification than wood pulps. Such fibres on reuse may give paper of relatively poor smoothness. Also the proportion of chemical pulp in DIP based newsprint is more and also filler content is higher. The smoothness for such type of paper can better be controlled by lighter calendering, than virgin mechanical fibres. Generally the resistance against compression in a calender is small with chemical fibre and flat mechanical fibres.

6.0 STUDIES ON LABORATORY CALENDERING OF WASTE PAPER CONTAINING NEWSPRINT

Newsprint is calendered on the paper machine with an on line calender. Traditionally this is done with a 4 to 6 roll hard nip calender. Typically, newsprint paper machine with linear load 80–110 kN/m and thermo roll water temperature are 80 to 120 degree centigrade.

As the waste paper containing newsprint normally has higher ash content due to raw material, the steps to improve the surface characteristics should be chosen in such a way that strength of the paper be not adversely affected. Newsprint samples of three mills not confirming in smoothness were subjected to two types of calendering i.e. hard nip calendering (40 kN/m) and soft nip calendering (40 kN/m at 90°C). It was observed that soft nip calendering improve the paper surface relatively more than hard nip calendering. The adverse effect on thickness, tensile strength, specific scattering coefficient was relatively lower in soft nip calendering. The smoothness level was improved to BIS standard and also linting tendency got reduced as shown by lower value of LRC (***Table III***).

This is probably due to the reason that pressure applied to the sheet in soft nip calendering which may also helps in thermal bonding between the mechanical pulp fibres.

As most of the newsprint mill based on waste paper as raw material have slow speed machines, so it is possible that by installing soft calenders the product quality can further be improved. Also with the increased production of newsprint based on deinked fibres world over lot of improvements in the soft nip calender technology is going on.

The benefits of soft nip calendering of newsprint can be divided into two main categories

- Runnability
- Printability

A soft calendered DIP sheet will have a superior runnability in the printing press due to following reasons

- A DIP based sheet is less affected by changes in moisture compared to virgin fibre sheet as the fibres swell less
- The strength of the soft calendered sheet is higher at the same smoothness level than a machine calendered sheet
- The soft calendered sheet has less linting

Maintaining sufficient strength in web to ensure runnability in printing press is important if ash content of the DIP sheet is high due to raw material.

A soft calendered sheet has better printability than machine calendered sheet

- Sheet surface density as well as ink absorption is more uniform
- Print mottling is reduced
- Smooth sheet can be calendered at a high moisture level without blackening

In hard nip calendering process, the web is processed together between hard, unyielding rolls. Because of the unyielding rolls, the paper is calipered to an equal thickness. As a result the flocs are more heavily densified than the thinner area of the paper (***Fig. 6***).

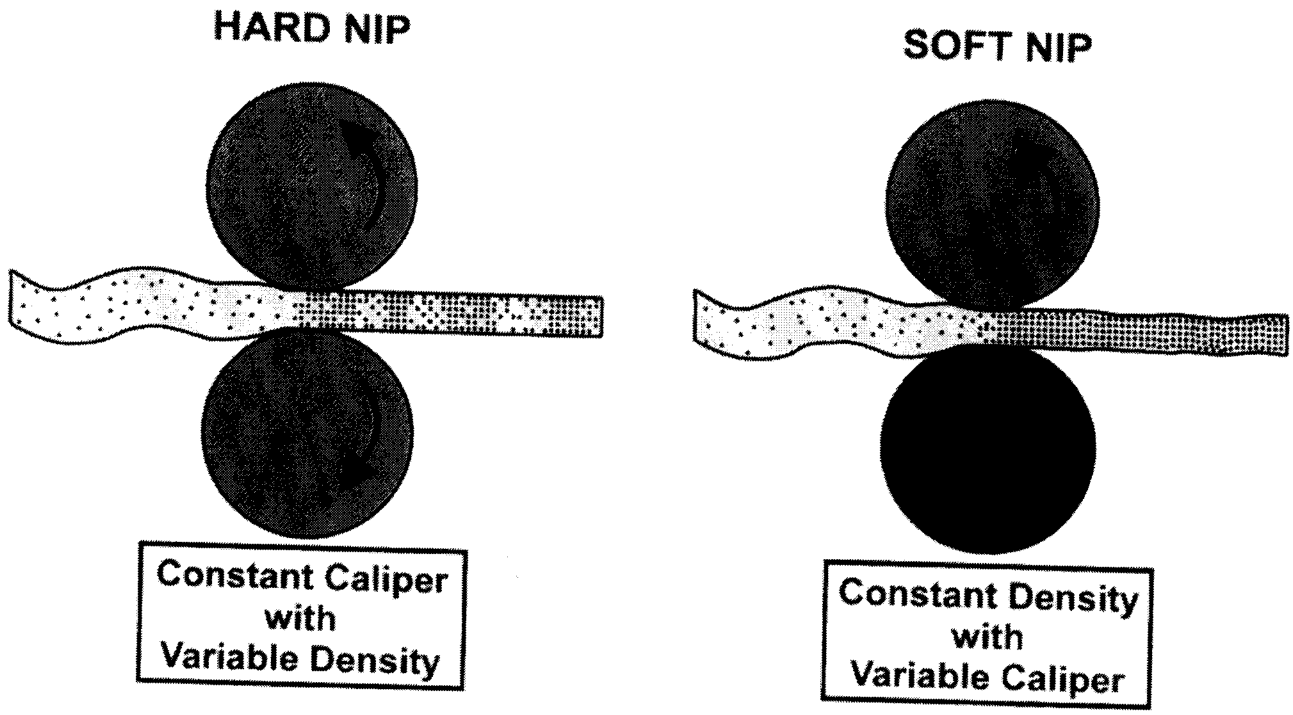


Fig. 3. Principle of machine calendering with a hard (left) and a soft (right) nip.

This induces local density variation which lead to the familiar problems of mottling, strength losses and in extreme cases, blackening. In a soft nip or multi nip calender the paper is calendered in the nips, which are formed by, chilled iron and a resilient roll. While assign through the nip, the paper undergoes more equal densification due to elasticity of the roll cover. This means that the soft cover distributes the compressive stress in the nip more equally over the thicker and thinner part of paper and mottling is distinctly reduced. The soft roll cover material has an effect on the uniformity of the compressive stress in the nip. The lower the roll dynamic elastic modulus (softer) of the roll is, the more uniform calendering result is achieved.

Today, technology for newsprint grade is progressively moving towards soft calendering. Typical running conditions for newsprint soft calender that use a DIP base are from 20 to 80 kN/m in two soft nip and a temperature of 80^0C–100^0C. In some cases, even one soft calender nip is enough depending on paper two sidedness. As presently the soft nip calendering arrangement is only available in one or two mills in India which are manufacturing good quality of printing papers from chemical pulp. The medium scale paper mills manufacturing newsprint from waste paper have hard nip calenders. So the possibilities of improving the surface characteristics of newsprint using hard nip calendering was also tried in the laboratory.

The parameters studied were

- Effect of loading pressure
- Effect of loading temperature
- Effect of moisture content

To increase the moisture content in paper a fine water spray on the paper just prior to calendering was done. The water spray was sufficient to increase 1.5 % moisture content in the paper whose initial moisture content was 7.0%. During this operation the roll was heated to 120°C temperature. The moisture content of the paper after calendering was kept same as initial. The results indicated that increasing the calendering pressure from 80 kN/m to 160 kN/m has shown improvement in smoothness however there is a reduction in tensile strength to the extent of 63%. On increasing the temperature from 60° to 80°C there was further improvement in smoothness however there was further reduction in tensile strength. But when the calendering was carried out after fine water spray at temperature close to 120°C, an appreciable improvement in smoothness with lesser reduction in tensile strength, specific scattering coefficient was observed. Also there was improvement in gloss (***Table IV***).

The print quality can further be expected to improve for newsprint manufactured by medium mills if attempts are made to improve the CD profile and formation. It can be seen that the newsprint is having wide variation in thickness (***Table III***). The sample with lesser deviation in the thickness has better smoothness. Also the formation is relatively better.

The mills studied have double disc refiners in their stock preparation section, which sometimes is not suitable, for wastepaper furnishes. The recycled fibre is more sensitive to errors in refining than virgin fibres. It has been weakened and undergoes irreversible change. If not refined in correct way the results can be disastrous. Undesired effects - increased drainage resistance and major reduction in fibre length and tearing strength can be avoided by selecting refining equipment and conditions correctly. The best way to develop bonding ability is by moderate low consistency refining which is also able to straighten curly and kinky fibres. The conflow refiner are generally more suitable for such treatment. The conflow refiner concept was developed to perform gentle and fibre saving refining. In other words to develop the bonding ability of fibre with a minimum decrease in fibre length. The other targets such as low energy consumption and easy maintenance are also met. The hornfication of chemical pulp component which is about 40–50% in waste paper newsprint their furnish may also lead to insufficient fibre bonding. The other cause may be that the newsprint is made of waste papers containing short fibred pulps like agricultural residues, bagasse and hardwood, which are major raw material for Indian mills. All these fibres have small diameter and thick cell walls. Due to this, the sheet tends to be more rigid and form weak, bulky paper on recycling. Recycled fibres have passed through the paper making process at least once, with intensive pressure and drying in pulp. Drying has created collapsed fibres and caused irreversible changes. Due to this, the swelling and bonding ability of recycled fibres is considerably reduced. The other reason may be due to improper pressing and drying during papermaking. Sometimes high intensity wet pressing creates density and moisture gradient in paper, which in turn results in fibre having very different moisture and stress histories, since some fibre had more of water removal by mechanical densification than by evaporation. Any subsequent treatment of the paper surface with water can result in out of plane disturbance in areas where fibres with different histories are adjacent.

7.0 EFFECT OF DIFFERENT PROCESS VARIABLES ON DEINKING OF NEWSPRINT FURNISH

Waste paper stock is a complex mixture of fibres, fibre fines, fillers, sizing chemicals, ink particles, retention aids and slimicides etc. Different process variable affects the deinking by interacting in different ways. The effect of seven selected process variables on deinking of waste paper was studied. The seven-process variable affecting the deinking expressed by residual ink, dirt count and brightness in decreasing order are

- Consistency
- Caustic dose
- Temperature
- Deinking chemical dose
- Sodium silicate dose
- Time
- Hydrogen peroxide dose

The relative effect of seven process variables on waste paper pulp has been studied using a Plackett-Burman statistical design.

In this type of experimental design, two levels (low and high) of each variable were selected as given in ***Table V***.

Table V: Process variables used in the experiments.

S. No.	Process variable	Process variable conditions	
		Low level	High level
A.	Caustic dose(%)	0.3	1.1
B.	Sodium silicate dose(%)	0.3	1.9
C.	Temperature (^{0}C)	40	70
D.	Consistency(%)	6	15
E.	Deinking chemical INDI(%)	0.05	0.3
F.	Hydrogen Peroxide (%)	1	3
G.	Time (minutes.)	10	20

The high (+) and low (–) levels are chosen far enough apart to expect a significant response in deinking properties, but not so remote from normal deinking conditions usually practice in mills. The assumption made was that within the restricted range of each variable, the response is entirely linear.

Table VI shows the combination of deinking conditions for waste paper used in experimental set up.

Table VI: Deinking conditions used in accordance to Plackett–Burman design.

Exp. No.	Process variable						
	A	B	C	D	E	F	G
1.	+	+	+	–	+	–	–
2.	–	+	+	+	–	+	–
3.	–	–	+	+	+	–	+
4.	+	–	–	+	+	+	–
5.	–	+	–	–	+	+	+
6.	+	–	+	–	–	+	+
7.	+	+	–	+	–	–	+
8.	–	–	–	–	–	–	–

The deinkability of pulp was evaluated by Brightness; residual ink and dirt count is given in ***Table VII***.

Table VII : Brightness, residual ink and dirt count values for different experiments.

Expt no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Brightness	51.8	50.8	49.9	48.8 1	51.3	50.8	46.9	50.8
Residual ink	251	324	332	360	289	281	542	350
Dirt count	134	22	26	28	150	199	17	1062

The main effect of process variable as properties - brightness, residual ink and dirt count was calculated and ranked accordingly (***Table VIII***).

Table VIII: Main effect of process variable on deinking

S.No.	**Process variable**	**Brightness**	**Residual ink**	**Dirt count**
A.	Caustic dose	–2.3 (3)	–10.2 (6)	–107.6 (4)
B.	Sod. Silicate dose	0.2 (7)	–6.3 (7)	–120.6 (2)
C.	Temperature	2.8 (2)	–25.8 (2)	–106.8 (6)
D.	Consistency	4.1 (1)	–28.4 (1)	–177.1 (1)
E.	Deinking chemical	1.8 (4)	–19.5 (3)	–117.3 (3)
F.	Hydrogen peroxide	1.2 (6)	–16.3(4)	–102.4 (7)
G.	Time	–1.6 (5)	11.7 (5)	–104.1 (5)

The results indicated that the variables mainly affecting the brightness are consistency, temperature, caustic dose and deinking chemical.

7.1 Relative effect of major process variables

Table IX shows the major influential process variables and then effect on deinking. The effect has been expressed as % of the mean value. The demonstrates deinking is mainly affected by consistency, temperature and deinking chemical. The higher consistency and higher temperature helps in better deinking.

Table IX: Most influential process variables for deinking

Property	Process variable	Main effect as % of mean
Brightness	Consistency	8.2
	Temperature	5.6
	Caustic Dose	–4.6
	Deinking chemical	3.6
Residual ink	Consistency	–2.5
	Temperature	–7.6
	Caustic Dose	–5.7
	Deinking chemical	–4.8
Dirt count	Consistency	–86.4
	Temperature	–58.8
	Caustic Dose	–57.2
	Deinking chemical	–52.5

The caustic dose gives negative effect on brightness and dirt count. This indicated that to get better deinking effect for the furnish of newsprint the following are required.

- High consistency
- High temperature
- Shorter treatment time
- Optimum deinking chemical

The optimum repulping conditions for the paper furnish containing ONP/OMG waste paper furnish in the ratio 2:1 is 1% sodium hydroxide, 1.6% sodium silicate,0.2 % INDI deinking chemical (or 0.9% Serfax) , stock consistency 15% at 50 degree centigrade temperature and pH 9–11 for 15 minutes.

The optimum conditions in floatation cell are Stock consistency 1 to 1.3 %, pH 9 to10 and hardness 12 to 20 DH. The hardness should be maintained in the floating cell by adding required amount of calcium chloride.

The optimum bleaching conditions are Sodium hydroxide 1% Sodium silicate 1.5%, hydrogen peroxide 1.5%, EDTA 0.05%, temperature 60 degree centigrade, pH 9 to 11 and time 60 minutes. The pulp after bleaching should be treated with sulphuric acid to adjust the pH to less than 7.

Table II: Characteristics of newsprint collected from different mills based on waste paper as raw material.

Property	IS:11688/1999 specifications	Values obtained for the mills								
		1	2	3	4	5	6	7	8	9
Grammage (g/m^2)	40 to 52± 4%	50.0	50.2	49.3	47.3	52.1	50.0	46.3	50.64	49.2
Thickness (micron)	56 to 90 ±4%	75	74	61	72	75	73	69	74	68
Range		56–78	61–79	57–65	68–77	64–79	66–74	60–72	69–79	65–74
Brightness (%)	52.0 min.	52.2	56.5	52.9	55.5	62.5	54.7	55.4	54.1	67.1
Opacity (%)	90.0 min.	96.7	95.1	90.8	95.5	95.0	93.8	96.1	96.1	92.4
Smoothness Bendtsen (ml/min)										
Top	250 max.	370	344	118	218	350	277	293	297	278
Wire	300 max.	490	485	138	236	400	413	413	400	380
Porosity Bendtsen (ml/min)	800max.	790	469	359	259	470	278	550	330	440

Tensile index (N.m/g)										
CD	15.0 min.	19.0	18.5	26.0	18.0	20.0	22.0	22.0	26.0	28.0
MD	35.0 min.	48.5	43.5	36.5	46.0	38.5	41.0	36.5	62.0	40.0
Tear index ($mN.m^2/g$) CD	4.50 min.	5.70	5.45	6.10	5.70	5.75	5.85	5.30	5.90	4.50
Paper appearance (Specky/ Notspecky)		specky	specky	Not specky	Not specky	Not specky	Specky	Not Specky	Specky	Specky
Formation Index (Paprican)		43	38	64	68	45	48	54	50	55
Furnish Composition										
Mechanical / chemimechanical (%)		40	41	59	61	43	50	65	48	46
Pulp Chemical pulp(%)		60	59	40	39	57	50	35	52	54

Table III: Effect of different types of calendering on surface characteristics Of newsprint made from waste paper

Property	Values obtained for		
	Uncalendered	Hardnip calendered	Softnip calendered
MILL 1			69
Thickness (micron)	75	57	
Smoothness,			
Bendtsen (ml/min)	370	210	180
Top	490	275	240
Wire			
Tensile index (N.m/g)			
CD	19.0	12.2	17.5
MD	48.5	29.5	41.5
Fibre rising test			
LRC	48	30	10
(mm/m)	14.1	9.0	6.0
SRA(mm^2/m)			
Sp.Scatt coeff (m^2/kg)	50.1	36.4	48.5
Brightness (%)	55.7	52.5	54.8
Print uniformity index	36	40	60
MILL 2			
Thickness (micron)	74	59	68
Smoothness,			
Bendtsen (ml/min)	344	220	200
Top	485	285	230
Wire			
Tensile index (N.m/g)			
CD	18.5	15.0	17.5
MD	43.5	35.5	40.5
Fibre rising test			
LRC (mm/m)	46	32	15
SRA(mm^2/m)	12.9	9.4	7.2
Sp.Scatt coeff (m^2/kg)	39.8	29.5	38.4
Brightness (%)	56.5	53.0	54.9
Print uniformity index	45	55	65

Cont.

MILL 3			
Thickness (micron)	73	58	70
Smoothness, Bendtsen (ml/min)			
Top	350	240	200
Wire	400	340	310
Tensile index (N.m/g)			
CD	20.0	17.5	19.0
MD	38.5	35.5	37.0
Fibre rising test			
LRC (mm/m)	48	30	14
SRA(mm^2/m)	14.4	9.6	7.1
Sp.Scatt coeff (m^2/kg)	40.6	29.8	37.5
Brightness (%)	62.5	58.5	61.6
Print uniformity index	50	55	65

Table IV: Hard nip calendering of newsprint using different conditions.

Pressure (kN/m)	**Temp (°C)**	**Bulk (cm^3/g)**	**Smoothness Bendtsen (ml/min)**	**Tensile index (N.m/g)**	**Sp. Scatt. Coeff. (m^2/kg)**	**Gloss (%)**
0	60	2.38	1530	48.0	54.5	3.8
80	60	1.71	290	35.0	52.5	6.5
120	60	1.54	175	28.0	51.5	7.2
160	60	1.48	165	18.0	50.5	8.0
80	80	1.55	250	34.0	52.5	8.1
120	80	1.40	150	26.0	48.5	8.8
40*	120	1.70	230	39.5	53.8	9.4
80*	120	1.60	130	37.5	52.1	9.8

* Water spray on the sheet

7.2 Deinking Trials

In general, the newsprint produced by medium scale Indian Paper Mills based on waste paper has been observed to be specky. The specks are mainly the ink particles. All the seven mills studied have deinking cells; still the paper was having excessive specks. This implies that the pulping/ deinking operations are not probably properly optimized. Different mills are using different chemicals like sodium hydroxide, sodium silicate, hydrogen peroxide and deinking chemicals. To optimize the deinking conditions for newsprint furnishes different laboratory deinking trials were conducted using Lamort deinking cell. Different deinking chemicals collected from mills were tried.

The deinkability was evaluated using following two parameters.

- Deinkability factor
- Residual ink value

Deinkability factor DEM was calculated from ISO brightness (R_{457}) of the unprinted deinked pulp (US) i.e. made from unprinted paper subjected to deinking process, the printed undeinked pulp (BS) and deinked pulp (DS) using formulas

$$\text{DEM} = \frac{\text{Brightness (DS) - Brightness (BS)}}{\text{Brightness (US) - Brightness (BS)}} \times 100$$

A value of 100% describes complete removal of the printing ink.

Results indicated that deinkability could be improved by using proper deinking chemicals (***Table V***).

Table X: Deinkability of pulps using different deinking chemicals.

Chemical	Chemical dose (%)	Deinkability factor (%)	Deinkability by residual ink method (%)	Pulp appearance
Mill –I	0.03	65	58	Specky
Mill –II	0.03	60	51	Specky
Chemical imported A	0.01	80	85	Specky
Chemical imported B	0.01	94	93	Free from specks
Chemical imported B	0.01	96	95	Free from specks

7.3 Deinkability of Indian newspapers vs. foreign newspapers

The printing of newspaper is normally by web offset printing without thermal drying (Cold set). The inks therefore do not contain large proportion of oxidative drying oils or mineral oils. The mineral oils contained therein absorb quickly on the paper and leave resin and the pigment bound on the paper surface. It has been observed that when ink amount in printing is less then proportional amount of ink pigment compared to ink oil is constant through the paper, but when the ink amount is more then oil separates from the pigment and the oil is penetrated deeper into the paper. Printed materials of this type in a fresh, unaged state are usually easily deinkable. Conventional flexographic print is poorly deinkable. In most commonly used alkaline floatation deinking process the binder of water based flexographic inks (usually acrylate resins) dissolves in finely distributed manner. This release very small ink particles that remain equally with the fiber stock and the filtrate. Due to their small particle size, wash deinking will more effectively remove flexographic inks. Ink manufactures are trying to improve the floatation deinkability of flexographic inks for newspaper printing.

In India, the mill is using Indian newspapers as well newspapers (ONP) imported from other countries. During the investigations it was observed that deinkability of foreign newspapers is comparatively easy as compared to Indian newspapers especially printed in local languages. These newspapers have ink containing comparatively higher amount of oil. So to get proper deinking in such case, it is important that the deinking chemical to be used should be of special nature. Different deinking chemical having chemical composition

- Sodium soap of fatty acid and sodium silicate (A).
- Sodium soap of fatty acid with copolymer based on ethylene propylene oxide plus emulsifier (B).

were tried. It was observed that chemical of B type gave best deinkability (***Table X***). The probable reason is that besides the action of soaps as droppers of ink and foam formation, the copolymer helps to kidnap the ink particles and make them float hence better elimination with foam. Clearly by usage of proper deinking chemical it will be possible to get better-deinked pulp for newsprint manufacturer.

7.4 Impact of raw material quality and storage on deinking performance

In addition to process design and chemistry, raw material quality plays an important role in the performance of deinking. The composition of waste papers and age are the most important factors affecting the ink removal efficiency, yield and final pulp properties. In comparison to raw material dominator by ONP, a high rates provides higher initial brightness, easier ink detachment and removal and less sensitivity to aging. The main drawback of raw material with high ash content is the low process yield due to the selectivity of floatation towards fillers.

The effect of ageing on the brightness after deinking of offset printed newsprints having different ash contents (ranging 0.5 to 8%) is depicted in Fig a. The type of ink used in printing was a type that dried by oxidation. The resulting brightness obtained in case of freshly printed deinking was only 2–3% lower in brightness. The values decreased with age and low ash content.

The loss of brightness due to the aging period is considerably lossing in the case of offset ink that do not contain component that dry by oxidation. The deinkiability of newspapers printed by the letterpress process shows a lower effect of age.

Besides being influenced by the printing process used (heat set offset or rotogravure), the effect of aging on deinkiability of magazines is a function of use of uncoated or coated paper. Offset and rotogravure inks printed on coated paper detach easily even after aging resulting in an adequate deinkability. The aging of uncoated magazine paper causes a significant reduction in the deinkability of offset inks and has less influence on the deinkability of rotogravure inks.

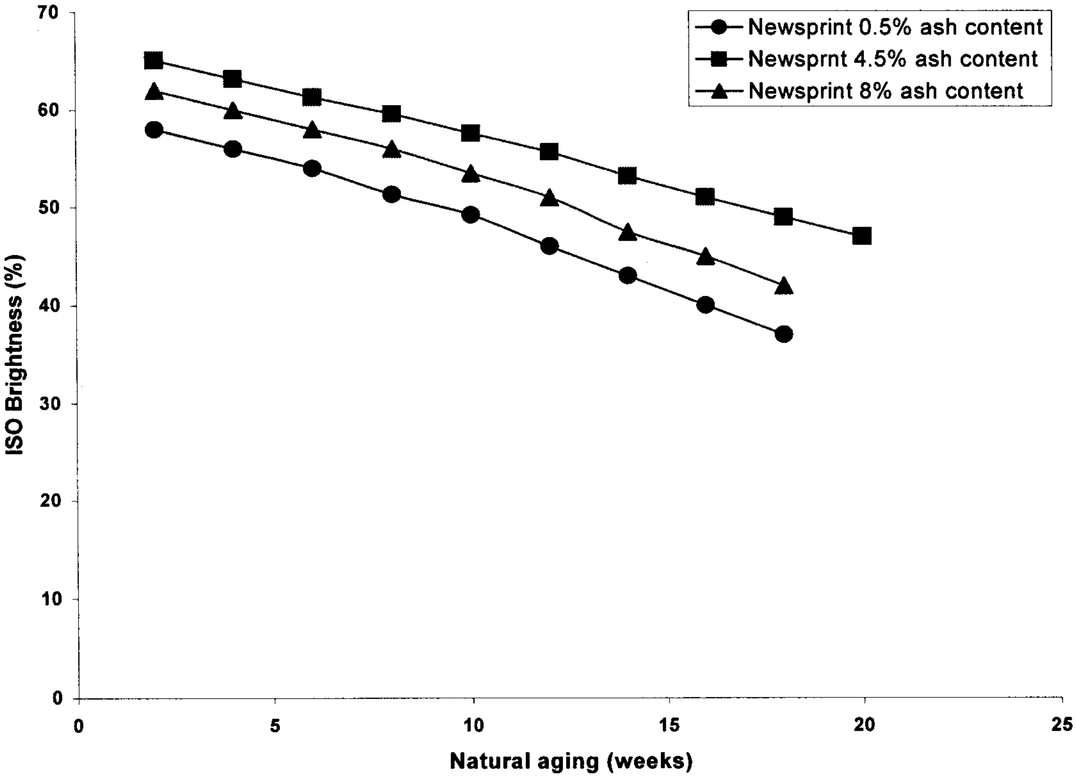


Fig. a: Effect on brightness after flotation deinking for different newsprint

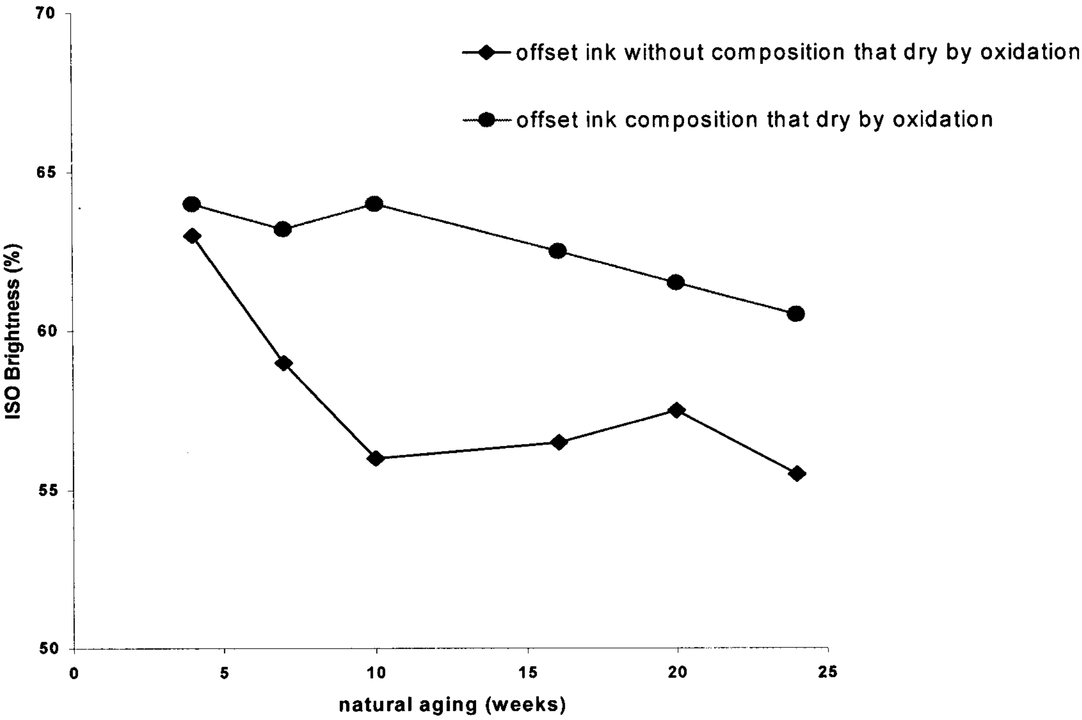


Fig a: Brightness of wood-containing deinking material after flotation deinking influenced by natural aging

7.5 Evaluation of yield

One of the major queries raised during the mill a visit was that the method of evaluating the yield. Different experiments have shown that the yield can be evaluated quite satisfactorily using following formula; the deinked pulp of yield can be evaluated

$$\text{Yield } (\%) = (1-(A_b-A_a))/(A_r-A_a)\times 100$$

Where A_b = Ash content of flow (floatation inlet)

A_a = Ash content of accept (floatation accept)

A_r = Ash content of reject (floatation foam)

The ash content is measured to 500^0 C temperatures. This formula can also be used to evaluate the industrial RCF process yield. For this pulping outlet, final pulp and rejects ash content data is used. However the formula derived already does not take into consideration the impact of dilution water and chemical, so slight variation can be expected.

8.0 CASE STUDY I

A team of CPPRI scientists visited the mill selected for conducting actual trial on the production scale. The mill was producing newsprint from waste paper and was lacking BIS standard for following parameters

- Presence of excessive ink speck
- Higher roughness

The block layout of the unit operation of mill is given in ***Fig. 1.1***. The mill was using 20% ONP, 40% old magazine and remaining notebooks and office waste. The characteristics of the newsprint sample manufactured by the mill are given in ***Table II***. Flow sheet diagram of the mill indicates that the mill has all the unit operations, which are generally required in a good waste paper treatment mill. So the optimization of the different unit operation was carried out. The following steps were done

- Deinking cell was adjusted to 1.5% Cy, temperature 60^0C and pH 8.0. The air load which is expressed as total air volume to total suspension volume was adjusted to 400%
- Kneader consistency got reduced from 32% to 25% to avoid fibre crinkling
- Refining action in TDR refiners got reduced to avoid excessive cutting
- Cationic starch about 0.5% added in stock preparation
- Nip loading is first press got increased by 5%
- Usage of alum to get back water pH 5.5–6.0

The newsprint thus produced was found to be having smoothness satisfying BIS standard (***Table XI***). This probably due to better retention of fines, avoiding excessive damage of fibres in kneading and refining.

Still better newsprint quality maybe expected if following steps be adopted

- TDR refiners be replaced with conflow type refiner
- Soft nip calendering instead of hard nip calendering

Table XI: Characteristics of newsprint before and after modification at mill.

Property	IS:11688/1999 specifications	Values obtained	
		Before	After
Grammage (g/m^2)	40 to 52± 4%	50.0	49.5
Thickness (micron)	56 to 90±4%	75	76
Range	———	56–78	65–78
Brightness (%)	52.0 min.	52.2	52.6
Opacity (%)	90.0 min.	96.7	93.7
Smoothness Bendtsen (ml/min)			
Top	250 max.	370	235
Wire	300 max.	490	275
Porosity Bendtsen (ml/min)	800max.	790	760
Tensile index (N.m/g)			
CD	15.0 min.	19.0	25.5
MD	35.0 min.	48.5	44.5
Tear index ($mN.m^2/g$)			
CD	4.50 min.	5.70	6.8
Paper appearance (Specky/ Notspecky)	–	Specky	Not Specky
Formation Index (Paprican)	–	43	55
Furnish Composition			
Mechanical / chemimechanical (%) Pulp		40	60
Chemical pulp(%)		60	40

9.0 CASE STUDY II

A team of CPPRI scientist visited the mill selected for conducting actual trial on the production scale. The mill was producing newsprint from waste paper and was lacking BIS standards for following parameters.

- Presence of excessive inks specks.
- Higher Roughness
- Low Tear index
- Slightly low Opacity

The general process layout of the mill was given in Fig. .1.6. The mill was using 30% ONP, 30–33% special record and 30–33% exercise book. The characteristics of the newsprint sample manufactured by the mill are given in ***Table XII***. Flow sheet diagram of the mill indicates that the mill has all the unit operations, which are generally required in good waste paper treatment mill. So the optimization of different unit operations was carried out. The following steps were done.

- The amount of special record paper was increased from existing 30–33% to 40–45% and the amount of exercise books was reduced in furnish.
- The consistency of hydrapulper is increased to 15% from running 12% and the cooking time also increased by half an hour.
- In pulping 1% caustic on o.d. basis was used against only the sodium silicate being used by the mill.
- Refining action in DDR refiner reduced to avoid excess cutting.
- The reject flow rate of primary and secondary centricleaners was increased to clean the pulp from specks.
- Soap stone about 5% added in the stock.
- Steam shower was given to paper before calendering.
- Dryer temperature at final group was reduced by 8^0C.

The newsprint thus produced was found to be having properties satisfying BIS standard (***Table XI***). This probably due to increased fibre strength, better moisture control at dryers and avoiding excessive damage of fibers in refining. Still better newsprint quality may be expected if following steps were adopted.

- DDR refiner should be replaced with Conflow refiner.
- Installation of one more centricleaning system in approach flow of paper machine.
- Soft nip calendering instead of hard nip calendering.

Table XII: Characteristics of newsprint before and after modification at mill.

Property	IS:11688/1999 specifications	Values obtained	
		Before	After
Grammage (g/m^2)	40 to 52± 4%	49.2	49.4
Thickness (micron)	56 to 90±4%	78	81
Range	———	70–79	77–81
Brightness (%)	52.0 min.	54.5	52.1
Opacity (%)	90.0 min.	89.5	95.4
Smoothness Bendtsen (ml/min)			
Top	250 max.	270	240
Wire	300 max.	400	290
Porosity Bendtsen (ml/min)	800max.	350	310
Tensile index (N.m/g)			
CD	15.0 min.	16.5	21.0
MD	35.0 min.	35.5	37.0
Tear index ($mN.m^2/g$)			
CD	4.50 min.	4.00	5.10
Paper appearance (Specky/ Notspecky)	–	Specky	Not specky
Formation Index (Paprican)	–	42	58
Furnish Composition			
Mechanical / chemimechanical (%) Pulp	–	38	55
Chemical pulp(%)	–	62	45

10.0 CASE STUDY III

A team of CPPRI scientists visited the mill selected for conducting actual trial on the production scale. The mill was producing newsprint from waste paper and was lacking BIS standards for surface smoothness.

The block layout of the unit operation of mill is given in ***Fig. 2.7***. The mill was using ONP 70% (70% indigenous and 30% imported) and mixed cutting 30%. The characteristics of the newsprint sample manufactured in the mill are given in ***Table II***. Flow sheet diagram of the mill indicates that the mill has all the unit operations, which are generally required in a good waste paper treatment mill. The unit operation conditions were optimum. The mill was suggested to

- slightly increase refining
- Increase loading pressure on the calender keeping in view that it does not adversely affect the brightness.

The newsprint thus produced was found to have smoothness satisfying BIS standard (***Table XIII***).

Table XIII: Characteristics of newsprint before and after modification at mill.

Property	IS:11688/1999 specifications	Values obtained	
		Before	After
Grammage (g/m^{2})	40 to 52± 4%	46.3	47.7
Thickness (micron)	56 to 90 ±4%	69	62
Range	———	60–72	64–69
Brightness (%)	52.0 min.	55.4	52.4
Opacity (%)	90.0 min.	96.1	93.3
Smoothness Bendtsen (ml/min)			
Top	250 max.	293	211
Wire	300 max.	413	252
Porosity Bendtsen (ml/min)	800max.	550	187
Tensile index (N.m/g)			
CD	15.0 min.	22.0	22.5
MD	35.0 min.	36.5	55.0
Tear index (mN.m^{2}/g)			
CD	4.50 min.	5.30	5.50
Paper appearance (Specky/ Notspecky)	_	Not Specky	Not specky
Formation Index (Paprican)	_	54	59

11.0 CASE STUDY IV

A team of CPPRI scientists visited the mill, which was producing newsprint from waste paper and the paper was lacking BIS standard for

- The paper was specky.
- Surface smoothness was lower.

The block layout of the unit operations of mill is given in Fig.2.8. The mill was using 40% ONP, 20% coated book stock, 30% exercise note book and 10% fly leaf cutting. Flow diagram of the mill indicated that mill has Lamort Helico pulper with Andritz centrifugal screens and Lamort Macell (five stages) deinking cell. The characteristics of newsprint being manufactured are given in ***Table XIV***. To reduce the ink specks the deinking cell functioning was optimized and to improve smoothness the loss of fines was controlled. The newsprint produced after modification was of better quality conforming to BIS standard.

Table XIV: Characteristics of newsprint before and after modification at mill.

Property	IS:11688/1999 specifications	Values obtained	
		Before	After
Grammage (g/m^2)	40 to 52± 4%	50.6	45.3
Thickness (micron)	56 to 90% ± 4%	74	64
Range	———	69–79	60–66
Brightness (%)	52.0 min.	54.1	56.1
Opacity (%)	90.0 min.	92.6	92.1
Smoothness Bendtsen (ml/min)			
Top	250 max.	297	230
Wire	300 max.	400	255
Porosity Bendtsen (ml/min)	800max.	330	182
Tensile index (N.m/g)			
CD	15.0 min.	26.0	20.5
MD	35.0 min.	62.0	67.0
Tear index ($mN.m^2/g$)			
CD	4.50 min.	5.90	5.40
Paper appearance (Specky/ Notspecky)	–	Specky	Not specky
Formation Index (Paprican)	–	60	75

12.0 CASE STUDY V

CPPRI scientists visited the mill, which was producing newsprint from waste paper, and the paper was lacking BIS standard for

- The paper was specky
- Surface smoothness was lower

The block layout of the unit operation of mill is given in Fig. 2.9. The mill was using 30% ONP, 30% white records, 20% text book, 20% mixed cover cutting. The characteristics of the newsprint being manufactured are given in ***Table XV***. To reduce the ink speck the deinking chemical was changed and to improve smoothness the ONP content was increased from 30% to 5%. The newsprint produced after modification was of better quality conforming to BIS standard.

Table XV: Characteristics of newsprint before and after modification at mill

Property	IS:11688/1999 specifications	Values obtained	
		Before	After
Grammage (g/m^2)	40 to 52± 4%	49.2	49.0
Thickness (micron)	56 to 90±4%	68	71
Range	———	65–74	66–69
Brightness (%)	52.0 min.	67.1	65.1
Opacity (%)	90.0 min.	90.1	90.8
Smoothness Bendtsen (ml/min)			
Top	250 max.	278	141
Wire	300 max.	380	173
Porosity Bendtsen (ml/min)	800max.	920	355
Tensile index (N.m/g)			
CD	15.0 min.	28.0	31.0
MD	35.0 min.	40.0	49.0
Tear index ($mN.m^2/g$)			
CD	4.50 min.	4.55	4.75
Paper appearance (Specky/ Notspecky)	–	Specky	Not Specky
Formation Index (Paprican)	–	54	66

13.0 RETENTION AID

Generally it has been observed in the mills manufacturing newsprint from waste paper that not proper attention is paid to the retention of fines. The effect of retention of fines on the surface properties was evaluated in the laboratory with DFS – 03 dynamic filtration system using alum, poly aluminum chloride (PAC) and retention aid (polyethylene amine type) as wet end chemical. The results are recovered in ***Table XVI***

Properties	Blank	0.2% Alum	0.6% Alum	0.2% PAC	0.6% PAC	0.2% Retention Aid	0.6% Retention Aid
Bulk(cm^3/g)	1.69 (1.16)	1.70 (1.18)	1.72 (1.19)	1.73 (1.19)	1.73 (1.19)	1.74 (1.21)	1.74 (1.22)
Porosity, ml/min	883	832	836	835	806	823	761
Roughness, Bendtsen (ml/min)	171 (30)	164 (29)	155 (28)	155 (27)	151 (25)	151 (23)	144 (20)
Sp. Scatt. Coeff.	53.5 (48.1)	54.1 (50.8)	54.8 (51.2)	54.7 (51.8)	55.1 (52.0)	56.6 (54.0)	57.9 (55.9)
Ash Content (%)	9.8	10.1	10.4	10.5	10.7	11.8	11.9

Figure in parenthesis are the values obtained after calendaring.

Clearly retention of fines is helpful in improving the smoothness, porosity and Sp. Scattering co-efficient including bulk. The improvement is maintained after calendaring also. So paper mills should use proper retention aid.

14.0 CONCLUSIONS

1. The quality of newsprint being manufactured from waste papers by medium scale paper mills can be improved by systematic optimization of different process unit operations provided the mill has proper Deinking system, Screening system, Calendering.
2. Foreign printed newspapers are comparatively easy to deink as compared to Indian newspapers especially the papers printed in local languages. This is

probably due to excessive amount of oil content in the printing inks in latter. The unaged newspapers are relatively easy to deink.

3. The deinking chemicals being used by the mills need proper evaluation and selection. The chemicals suitable for Indian papers should preferably have sodium soap of fatty acid and copolymers.
4. To get proper bulk, opacity and smoothness in newsprint the waste paper selection should be in such a way that the final furnishes content contains at least 50 % mechanical pulp content.
5. High consistency pulper (HC) should be preferred over low consistency pulper (LC) for newsprint manufacture as it gives better reduction in dirt specks area at particular specific energy input.
6. The moisture content in newsprint should be kept in the range of 9 to 10 % instead of 5 to 6 % as observed. This will give better runnability on printing press. This will also give appreciable financial saving to the manufactures.
7. The smoothness. gloss, and printing characteristics of newsprint from waste papers can be improved by improving formation and soft nip calendering. Soft nip calendering will help to get better smoothness and linting control than hard nip calendering.
8. Double disc refiners which are generally being employed in mills for refining of waste paper pulp are sometimes not suitable in the development of proper fibre flexibility, which may cause higher linting. The conflow refiners are generally more suitable for such furnish.
9. The retention of fines is extremely important in improving the surface characteristics of newsprint. Retention aid of polyethylene imine type was quite effective as compared to alum or polyaluminium chloride.
10. The production trials (Case Study) at five mills had shown that it is possible to manufacture newsprint conforming to BIS: 11688/1999 specifications after alterations/optimization of manufacturing process. Each mill required different approach.

15.0 INFRASTRUCTURE CREATED

For carrying out studies on the ' Evaluation and Improvement of surface properties of newsprint manufactured from recycled fibers' the following instrument has been procured, installed and commissioned.

- Magedana DFS -03 dynamic filtration system

This is an automatic instrument with graphic display for the study of retention measurement of pulps. It thus helps to find out the effect of papermaking additives on the pulp and paper properties.

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Appendix 1

Table I : Data of nine medium scale newsprint mills manufacturing newsprint from waste paper as raw material

S. No.	Parameters	Mill1	Mill 2	Mill 3	Mill 4	Mill 5
1.	Raw Material Furnish - Type of waste paper used & its %	100% waste paper Printers off cut (POC), Magazine trimmings, Mixed color cuttings, LCC (Imported), exercise note book, office records etc	100% waste paper ONP, Coated book stock, fly leaf, SOW	100% waste paper Imported waste paper – 80% Magazine trimmings, LCC, SOW, Mixed color cuttings Indigenous waste paper – 20% ONP, Printers cutoff, office waste etc	100% waste paper Notebook, OMG, Color trimmings, office records	100% waste paper ONP-20% Note book-20% Old magazine-20% White leadgers-20% Color leadgers-20%

2.	Pulping Process details - Type of Hydrapulper Operating consistency - Chemicals used in hydrapulper (%) - Temperature (ºC)	Low consistency 6% NaOH- 1% Sod. Silicate- 1.5% Deinking chemicals- 0.2% 60 ºC	High consistency 20% NaOH (0.7 – 0.8%) Surfex (0. 2%) 40 –45º C	High consistency 12% H_2O_2 NaOH 0.7-0.8% Deinking Chemical – 0.3% 45-50 ºC	High consistency - NaOH-0.8% Na_2SiO_3 –0.8% Deinking Chemicals – 0.5% 60 ºC	Low consistency 5% NaOH (0.75 –0.85%) Deinking Chemicals- 0.2 -0.4% 45 ºC
3.	High density cleaning - Operating consistency - Type of equipment used - Hole/slot size	2.5% High density cleaner 8mm	4.5% High density cleaner (Poire) 8mm hole	4.5% High density cleaner 6mm hole	5% High density cleaner 8mm hole	5% High density cleaner 6 mm hole
4.	Thickener	Twin drum thickener	-	Single drum thickener	Single drum thickener	-

5.	Deinking Cell	Floatation type Cy 1%	-	Flotation type 3 cell	-	Flotation type 2 caustic lye – 1% soap oil- 0.3% H_2O_2- 1% $MgSO_4$ – 0.3% Na_2 SiO_3 – 1.5%
6.	Cleaning System	3 stages Centricleaning & Pressure Sceening Slot basket 0.15 perforated		3 stage centricleaning & Fine Screening 2 Stage Vertical screens 0.2 mm Slot		-
7.	Dispersing system - Type of Equipment used - Consistency (%) - Chemicals used -Temperature (^{0}C)	Kneader (3 screws) Outlet cy. 32% H_2O_2 3% , NaOH 0.5% Na_2Sio_3 1% 70 -90	N.A.	Hot dispersing with oxidative bleaching	Kneader	N. A.
8.	Centrifugal cleaning - No. of stages	-	- -	-	-	Present

9.	Screening (fine) - Type of equipment used - Size of hole/slots	-	-	-	-	N.A.
10.	Deinking Process - Type of cell - No. of cells - Deinking chemicals used (%)	-	Flotation type (Voith Ecocell) 5 cell -	-	Flotation type 3 H_2O_2 0.5%-1% Na_2Sio_3 1.3%	-
11.	Cleaning System	-	-	-	2 Stage Vertical screen followed by Side hill screen 0.15 mm slot	-
12.	Thickner	Inlet cy. 3% Outlet cy. 1%	3 nos.	-	-	1 no. followed by potch washer
13.	Refining Process - Type & no. of refiners	2 refiners; 1-DDR, 1- TDR	-	-	2 refiners DDR	2 TDR

14.	Stock Preparation - Different chemicals added in stock preparation	Dyes – as required Fillers – Soap stone	Dyes – as required Fillers –soap stone	Dyes – Methyl violet (as required) Filler- soap stone	DSA – Starch Filler – Soap stone Dyes- V-blue, Rodhamine Retention & drainage aids Deformer- rarely	DSA- Starch Filler- Talcum powder Retention/drainage aid- Indfloc 49C Slimicide- AC770 Deformers- Napco
15.	Paper Machine details - Type of Paper machine - Capacity (T/day) - Deckle (m) - Speed(m/min)	Fourdrinier 25 2.15 235	Fourdrinier - - 350	Fourdrinier 40 2.35 250	Fourdrinier 40-50 3.20 100-250	Fourdrinier 20 2.46 180
16.	Head box - Type - Head box consistency (%)	Pressurized 0.6	Pressurized 0.5 –0.8	Closed step diffuser type 0.6 –0.8	Closed step diffuser type 0.6 –0.8	Open 0.5-0.7
17.	Wire part - Type of wire - Dryness after couch roll (%)	Synthetic 20%	Synthetic 18%	Synthetic 22%	Synthetic 20%	Synthetic 22%

18.	Press part - Type of presses - No. of presses - Dryness after presses (%)	Plain 2 35	Plain 2 36	Plain 2 35 – 38	Ist press-blind drill press II press- Inverse press 41	Plain 2 35 -36
19.	Dryer part - No. of dryers - Steam pressure in dryers (kg/cm^2)	28 1.8-2.0	27 3.5	28 3.2	36 3.0 – 3.5	27 + 1 M.G. dryer 3.2 –3.4
20.	Calenders - Type of calendars - No. of nips/rolls - Loading system - Presence of aqua thermal roll	Solid 3 nips/4 rolls Self loading No	Solid 3 nips/4 rolls Self loading No	Solid 3 nips/4 rolls Self loading No	Solid 3 nips/4 rolls Self loading No	Solid 3 nips/4 rolls Self loading No

(Continued)

S. No.	Parameters	Mill 6	Mill 7	Mill 8	Mill 9
1.	Raw Material Furnish - Type of waste paper used & its %	100% Indigenous waste paper ONP – 33%, Special record – 30 –33%, Exercise book –30-33%.	70% indigenous 30% Imported ONP_70% Mixes cuttings-30%	100% waste paper ONP40%, coated book stock 20%, exercise note book 30%, flyleaf cutting 10%	30% White Records 20% Text Books 20% Imported LCC Mixed Color Cuttings 30% ONP
2.	Pulping Process details - Type of Hydrapulper Operating consistency - Chemicals used in hydrapulper (%) - Temperature (ºC)	High Cosistency 15% Deinking chemicals – 0.3% 60 – 80 C	High Consistency 15% NaOH - 0.4% $NaSiO_4$ - 0.6% H_2O_2-0.5% Deinking Chemicals-0.16% 60^0C	Lomort 30 m^3 Helico Pulper 15% - 18% Hydrogen Peroxide, Caustic, Sodium Silicate, Surfax $60\text{-}65^0$	High consistency Batch Pulper 16–18 % De-inking Chemical, Caustic, Sodium Silicate 60–65ºC

3.	High density cleaning - Operating consistency - Type of equipment used - Hole/slot size	3% High density cleaner	3% High Density Cleaner -	3.5%/1% Anaritz Centrifugal screens 1.6 mm/0.14 mm slot	4% Conical cleaner -
4.	Thickener	Single drum thickner	GLB Thickener	Poly Disc Fiter	Twin drum thickener
5.	Deinking Cell	Two stages Flotation type (Lamort make) Six Used in hydrapulper	Flotation type (Lamort make) Used in hydrapulper	-	Voith Cell
6.	Cleaning System				
7.	Dispersing system - Type of Equipment used - Consistency (%) - Chemicals used -Temperature (^{0}C)	N. A.	Kriama Disperger 25% H_2O_2 -2% NaOH - 0.4% Na_2SiO_3 –1.5% 95^{0}C	N.A.	Kneader 25% - 50°C
8.	Centrifugal cleaning - No. of stages	Present in pulp mill Three	Present in pulp mill Four	Present Two stage	Present in pulp mill 3 stages

9.	Screening (fine) - Type of equipment used - Size of hole/slots	Vertical screen (2 nos.) in pulp mill & one pressure screen in Paper M/c. Hole with size of 1.8mm & 2mm in pulp mill & 0.18mm slot in paper m/c.	Vertical screen (3 Stage) in pulp mill & one in Paper M/c Hole with size of 1.5 mm	Anartiz Screen 1.6mm hole/0.14 mm slot	Low Consistency Pressure Screen 0.35 mm Slot
10.	Deinking Process - Type of cell - No. of cells - Deinking chemicals used (%)	Two stages Flotation type (Lamort make) Six Used in hydrapulper	Flotation type (Lamort make) pH-8.0	Lamort Mac cell One Surfax	Voith Cell 5+2=7 cells
11.	Cleaning System				
12.	Thickner		-	Poly Disc Filter	Washer
13.	Refining Process - Type & no. of refiners	One refiner DDR	One refiner DDR	N.A.	Tri Disc Refiner 17″
14.	Stock Preparation - Different chemicals added in stock preparation	DSA – 0.5 –1.5% Alum – 0.3%	-	Starch	-

15.	Paper Machine details - Type of Paper machine - Capacity (T/day) - Deckle (m) - Speed(m/min)	Fourdrinier 35 2.8 180 –250	Fourdrinier 110 3.5 250	Fourdriner 125 MT 4.2 550	M.F. Machine 40 3.0 185
16.	Head box - Type - Head box consistency (%)	Open 0.5 –0.7%	Hydraulic Pressurized 0.5-0.7%	Pressurized 0.8%	Open 0.5–0.8
17.	Wire part - Type of wire - Dryness after couch roll (%)	Synthetic 22%	Synthetic 20%	Two half layer synthetic	Cantilever Wire Part with all Foils 20%
18.	Press part - Type of presses - No. of presses - Dryness after presses (%)	Blind drill press Two 41 – 43%	Bi nip press with blind drill Two 42-43%	Binip third press 3 -	Ist press-double felted) II press- Reverse press 2 38%

19.	Dryer part - No. of dryers - Steam pressure in dryers (kg/cm^2)	10 3.0 –3.5%	22 3.0-3.5	21 2	22 2.2
20.	Calenders - Type of calendars - No. of nips/rolls - Loading system - Presence of aqua thermal roll	Solid 3nips/4 rolls Pneumatic Not present	Solid 1 nip/ 2 roll Hydraulic	Single Stack 3 nips/4 rolls Pneumatic Bellows Not present	3 nips Pneumatic None

Fig.1.1: General Process Flow Diagram of Mill-1

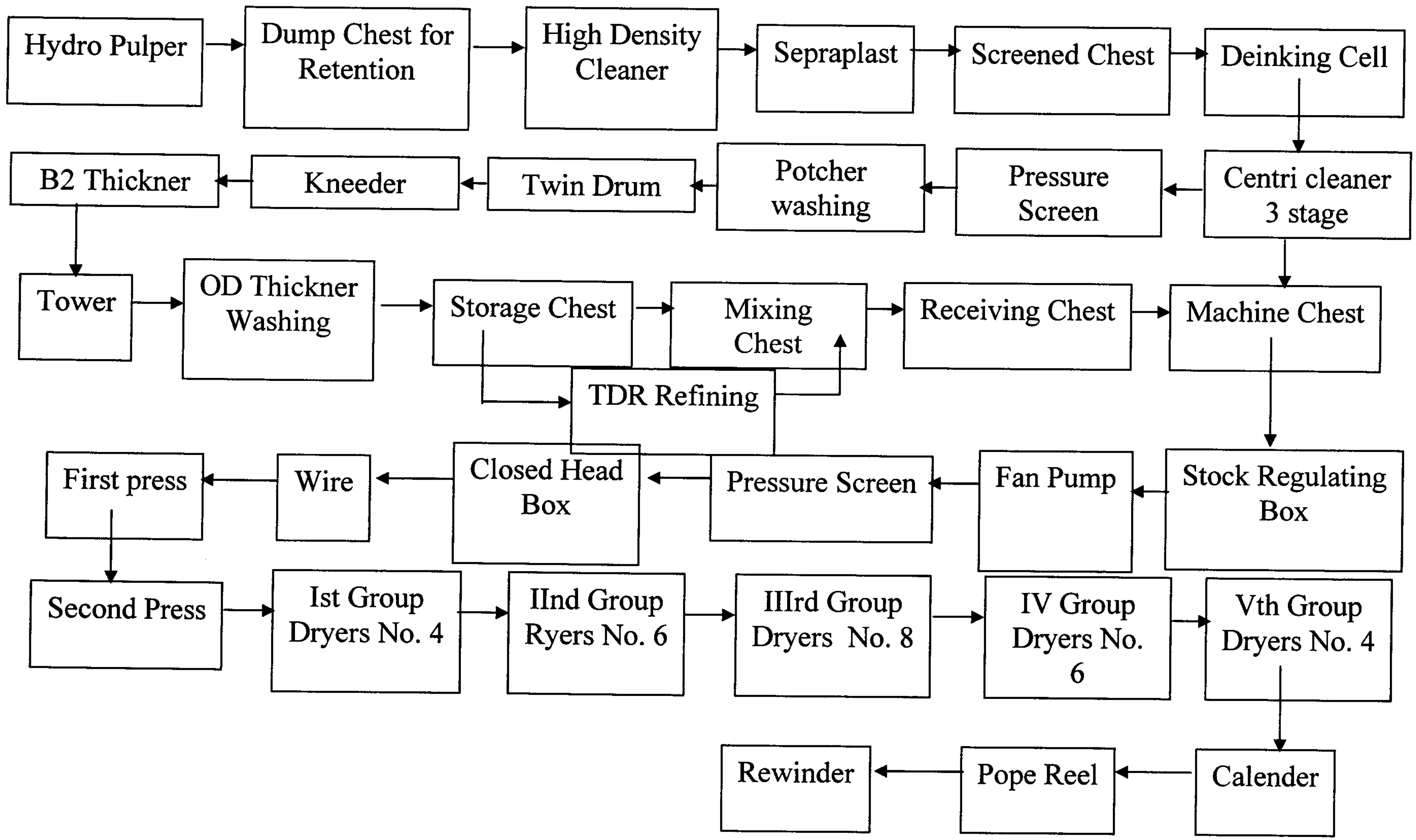


Fig.1.2 General Process Flow Diagram of Mill-2

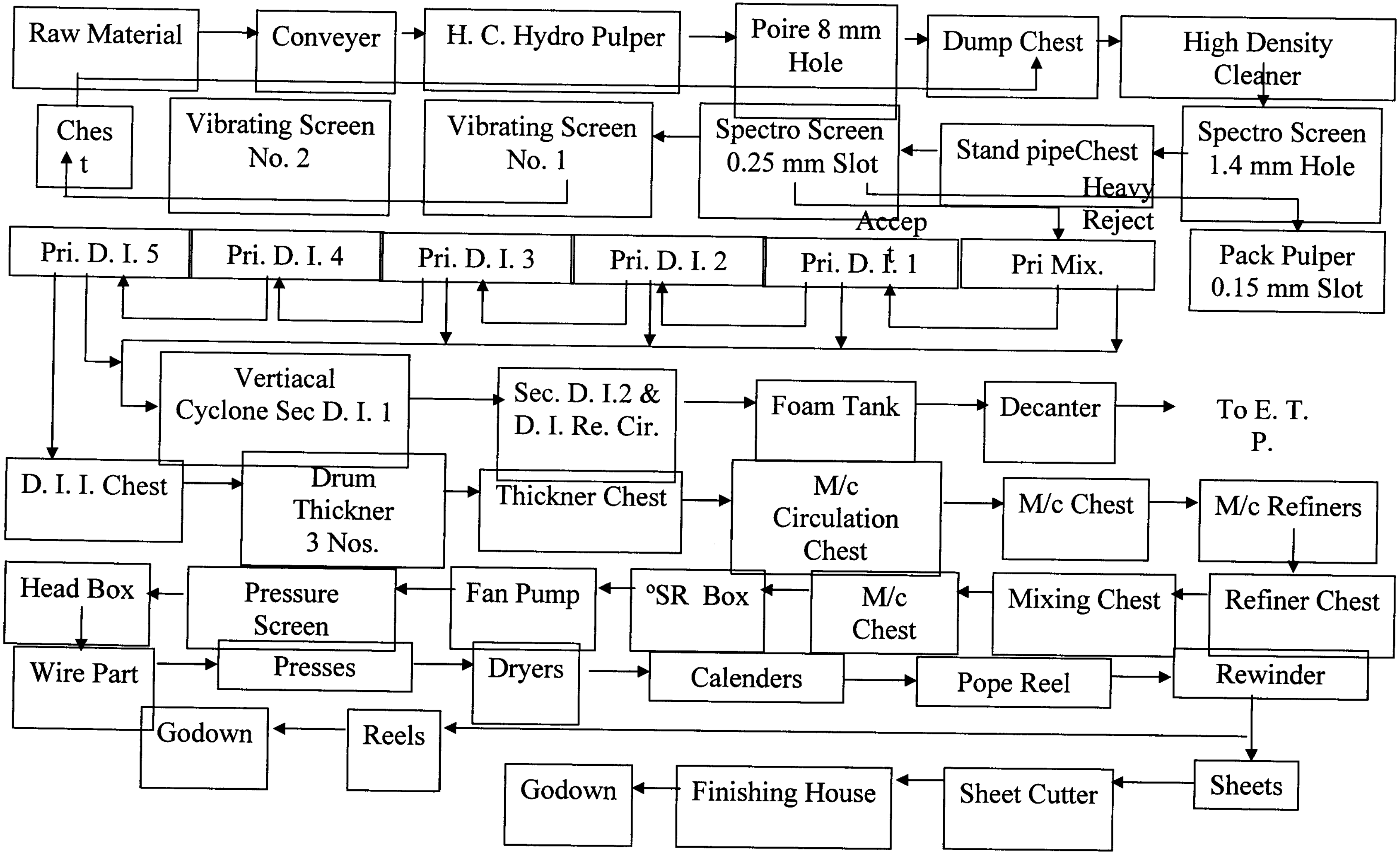


Fig.1.3: General Process Flow Diagram of Mill-3

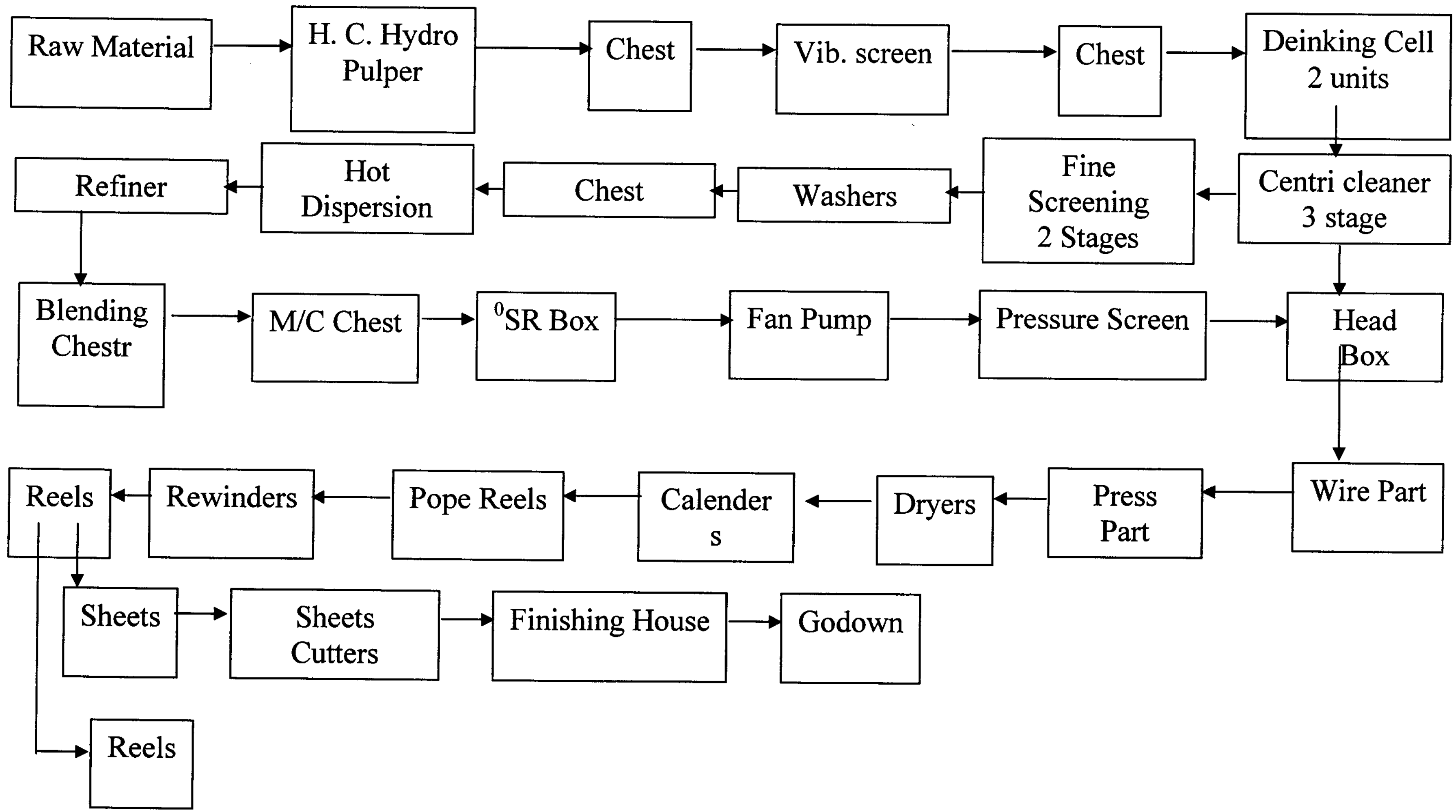


Fig.1.4: General Process Flow Diagram of Mill-4

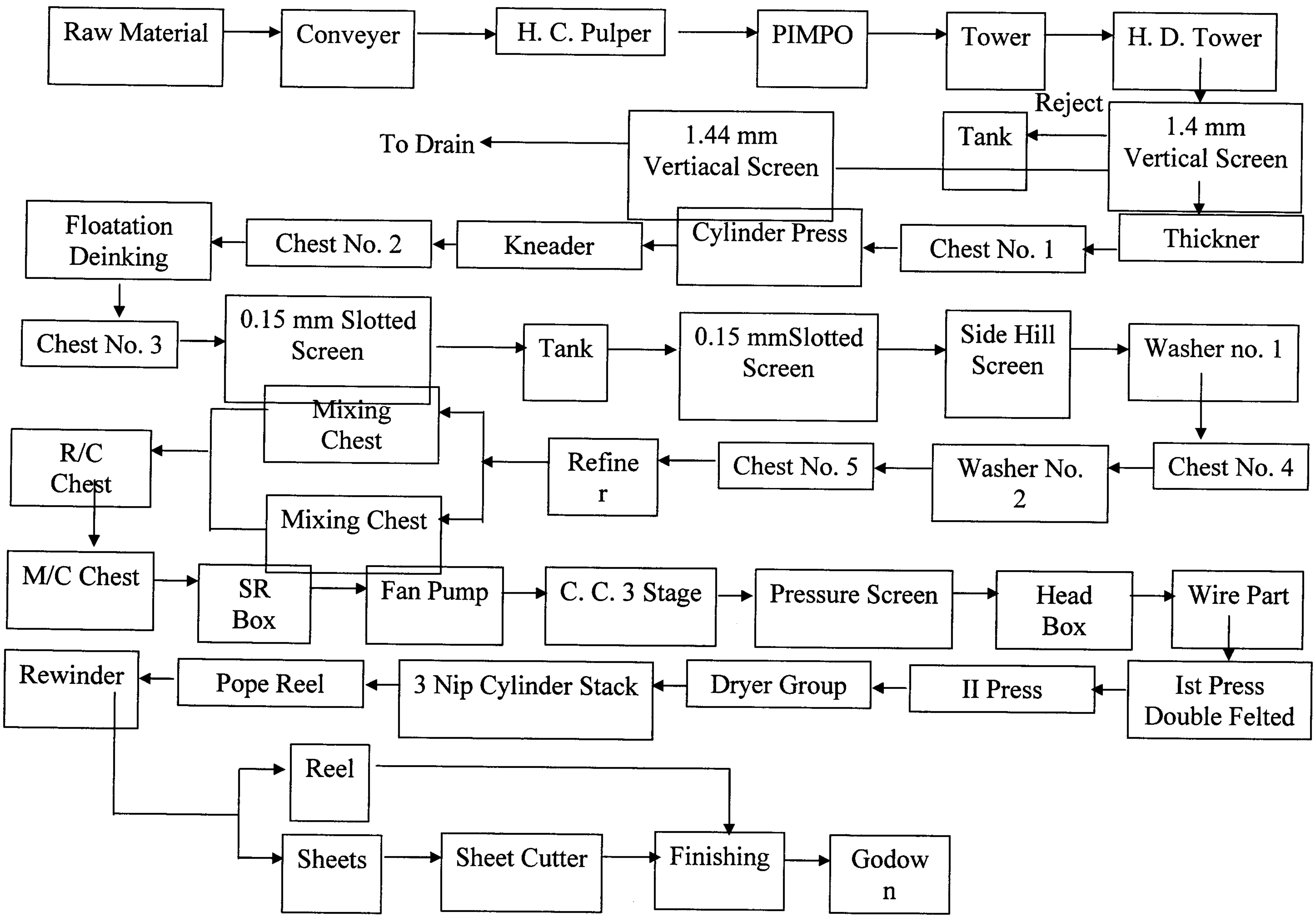


Fig. 1.5: General Process Flow Diagram of Mill-5

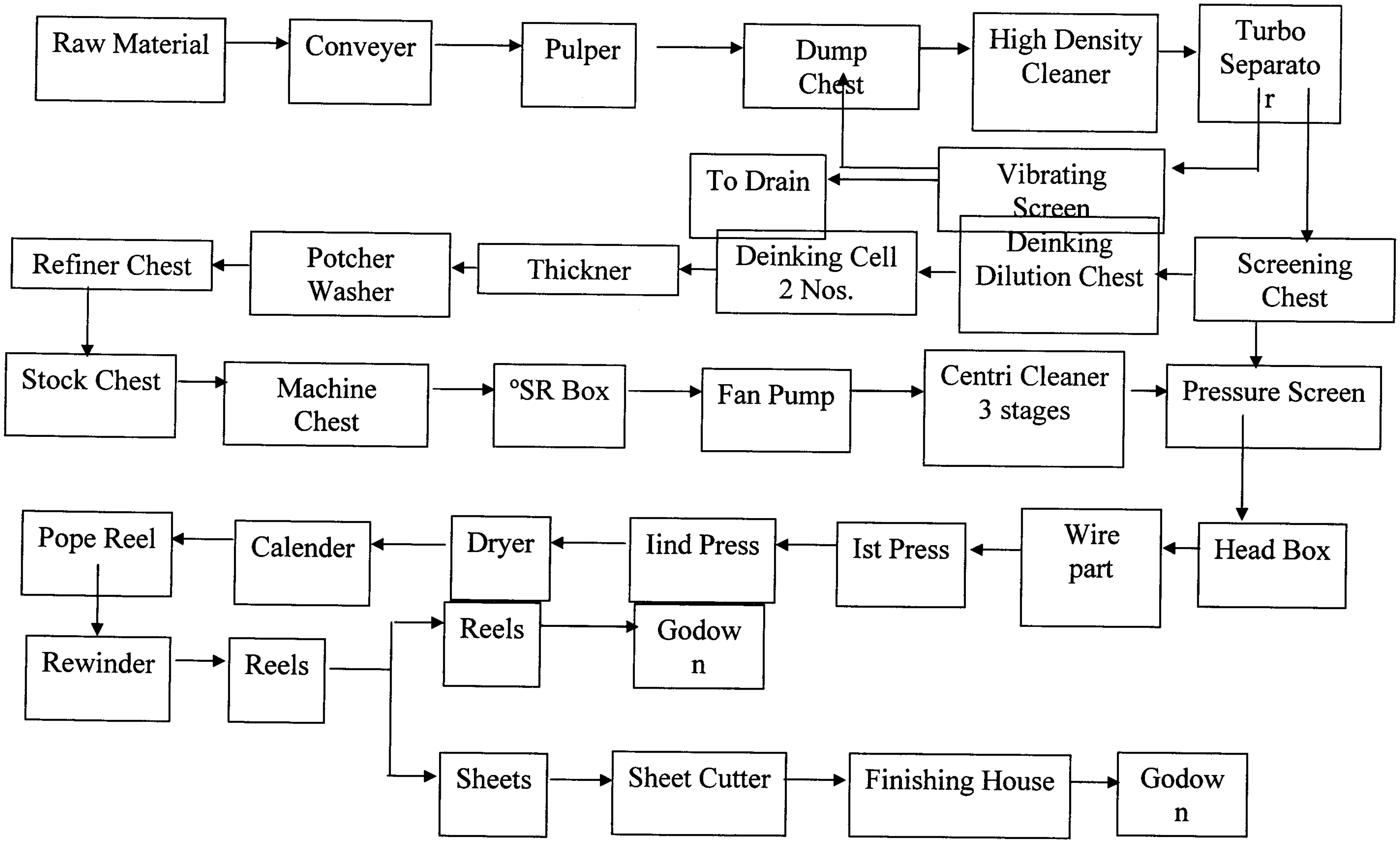


Fig.1.6 General Process Flow Diagram of Mill-6

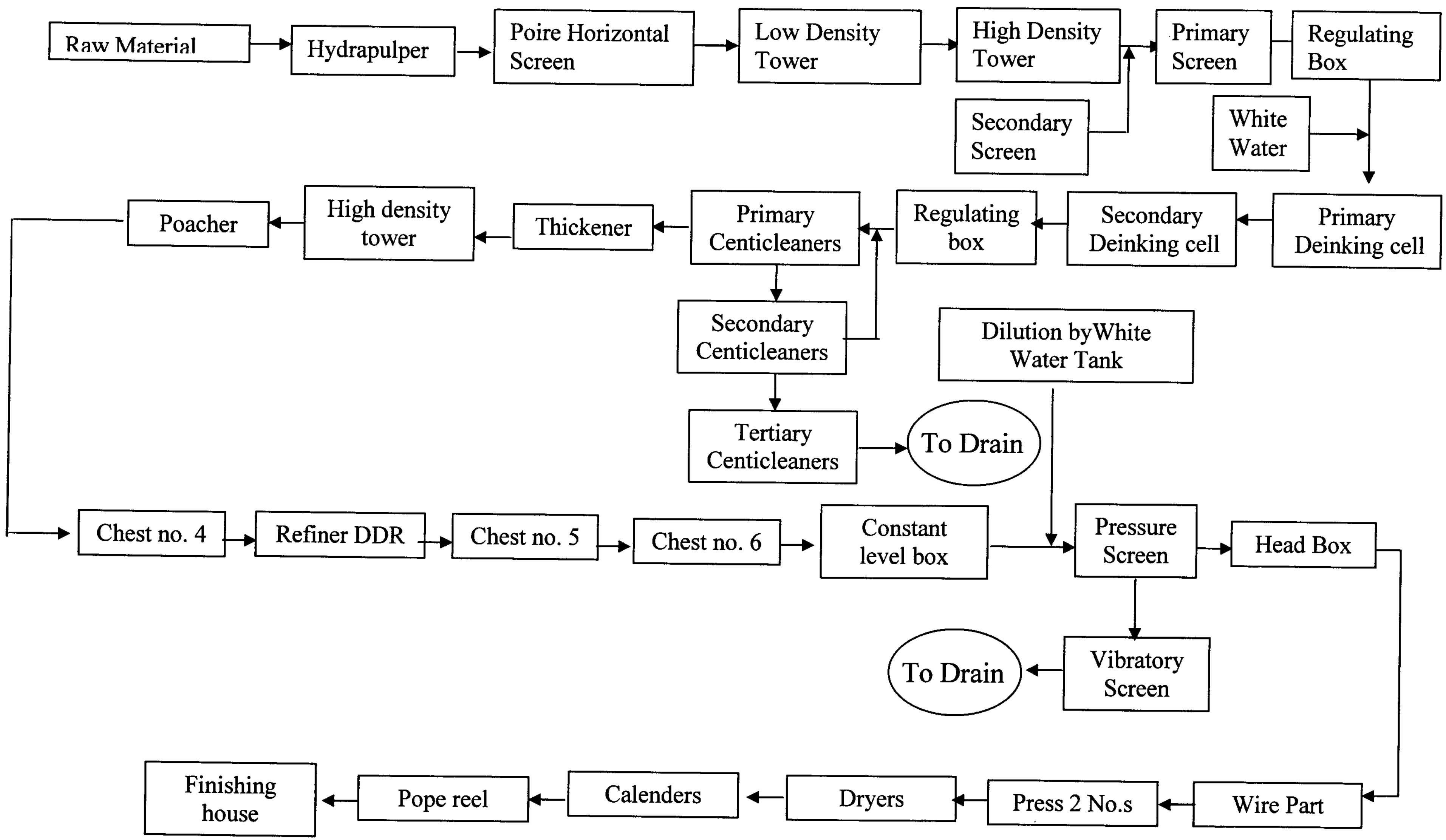


Fig.1.7 General Process Flow Diagram of Mill-7

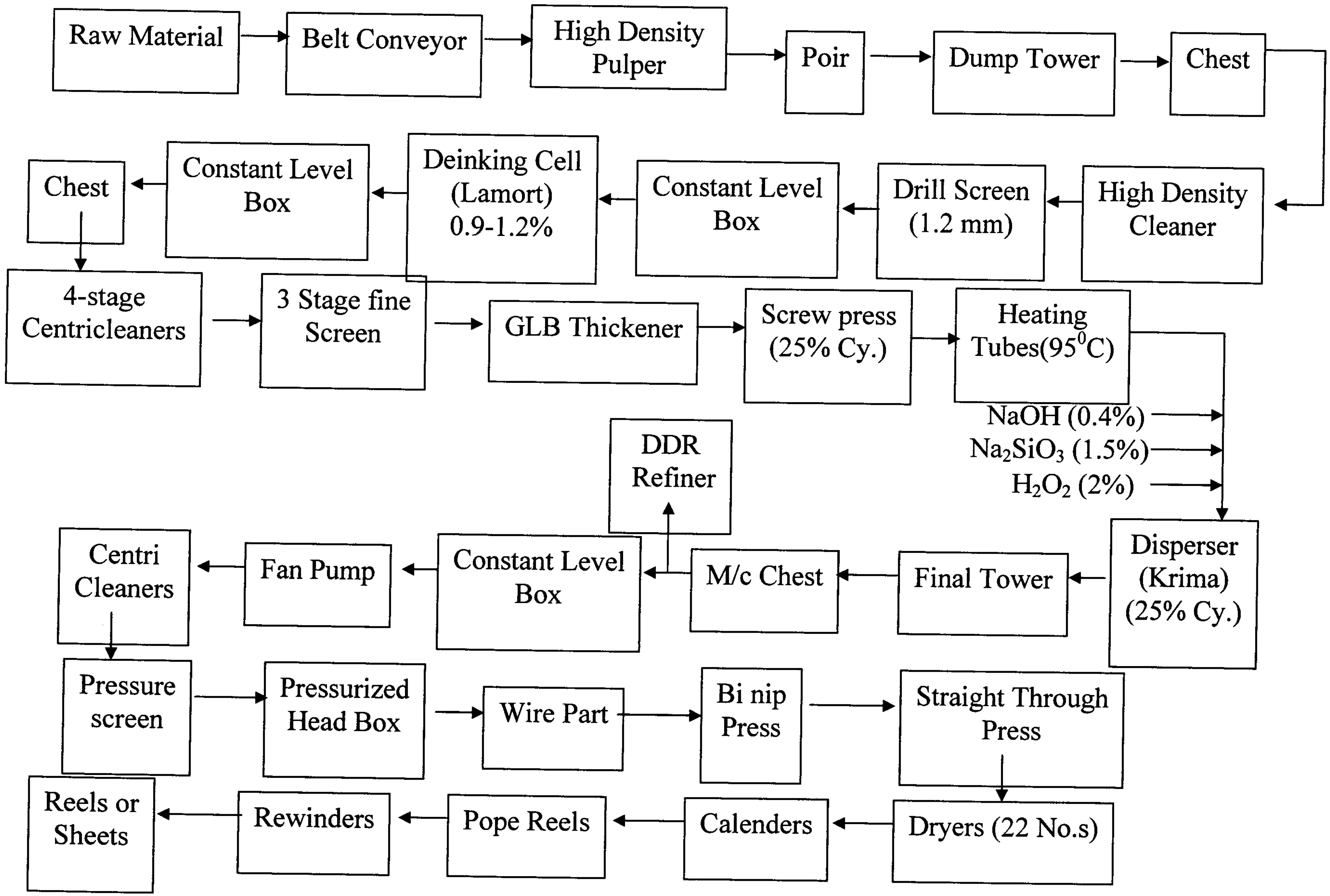


Fig 1.8 General Process Flow Diagram of Mill-8

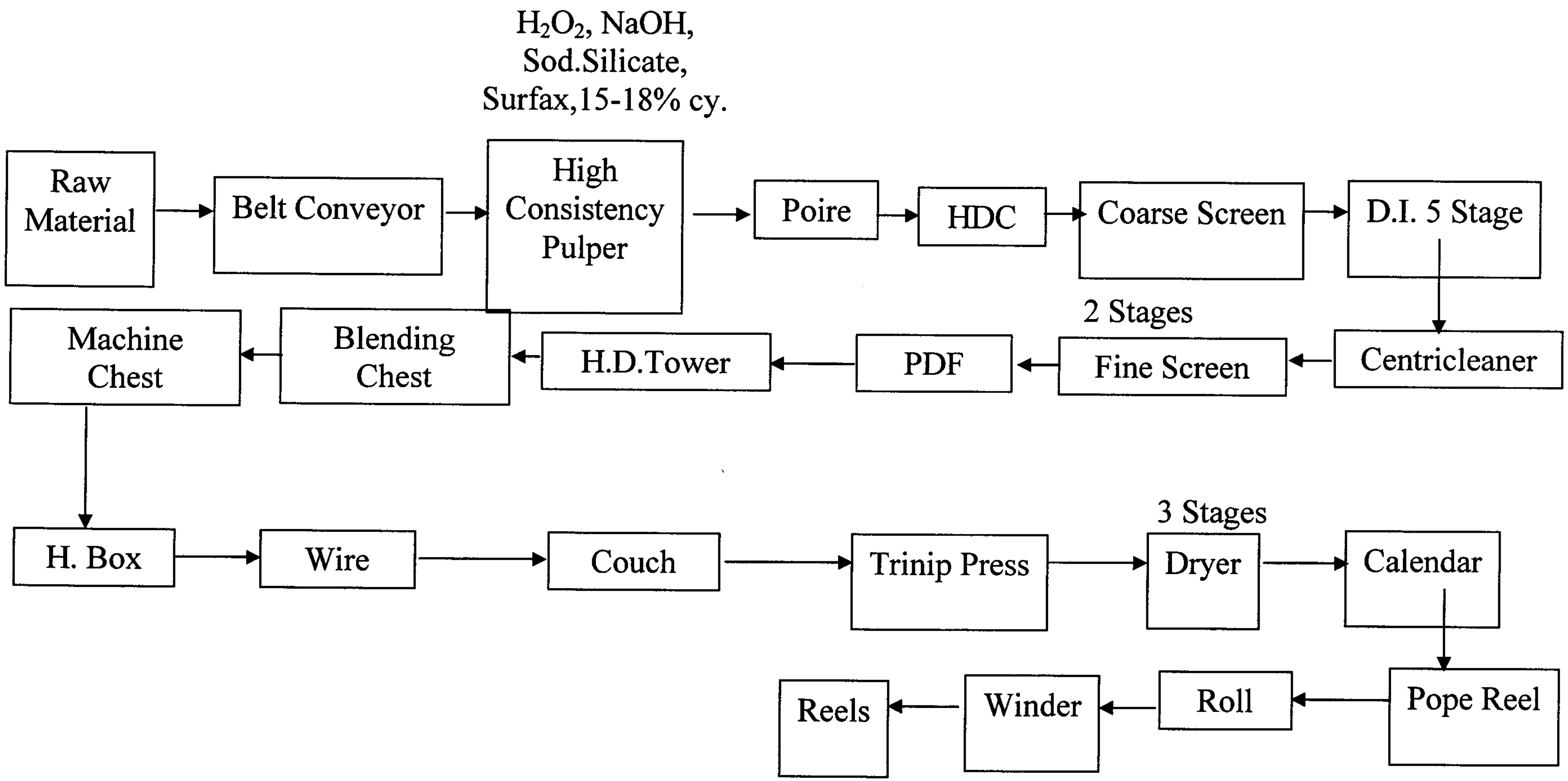
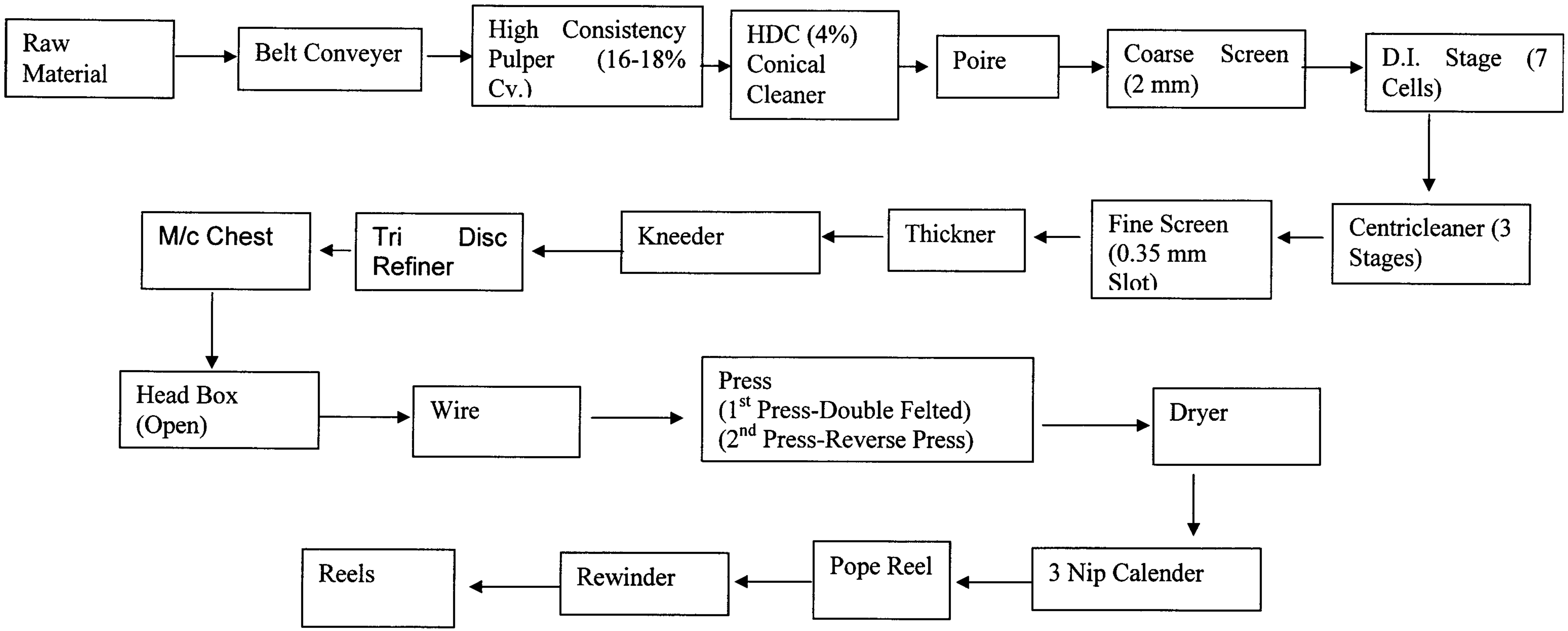


Fig. 1.9: General Process Flow Diagram of Mill-9



DYNAMIC FILTRATION SYSTEM

PARKER PRINT SURF (PPS) TESTER