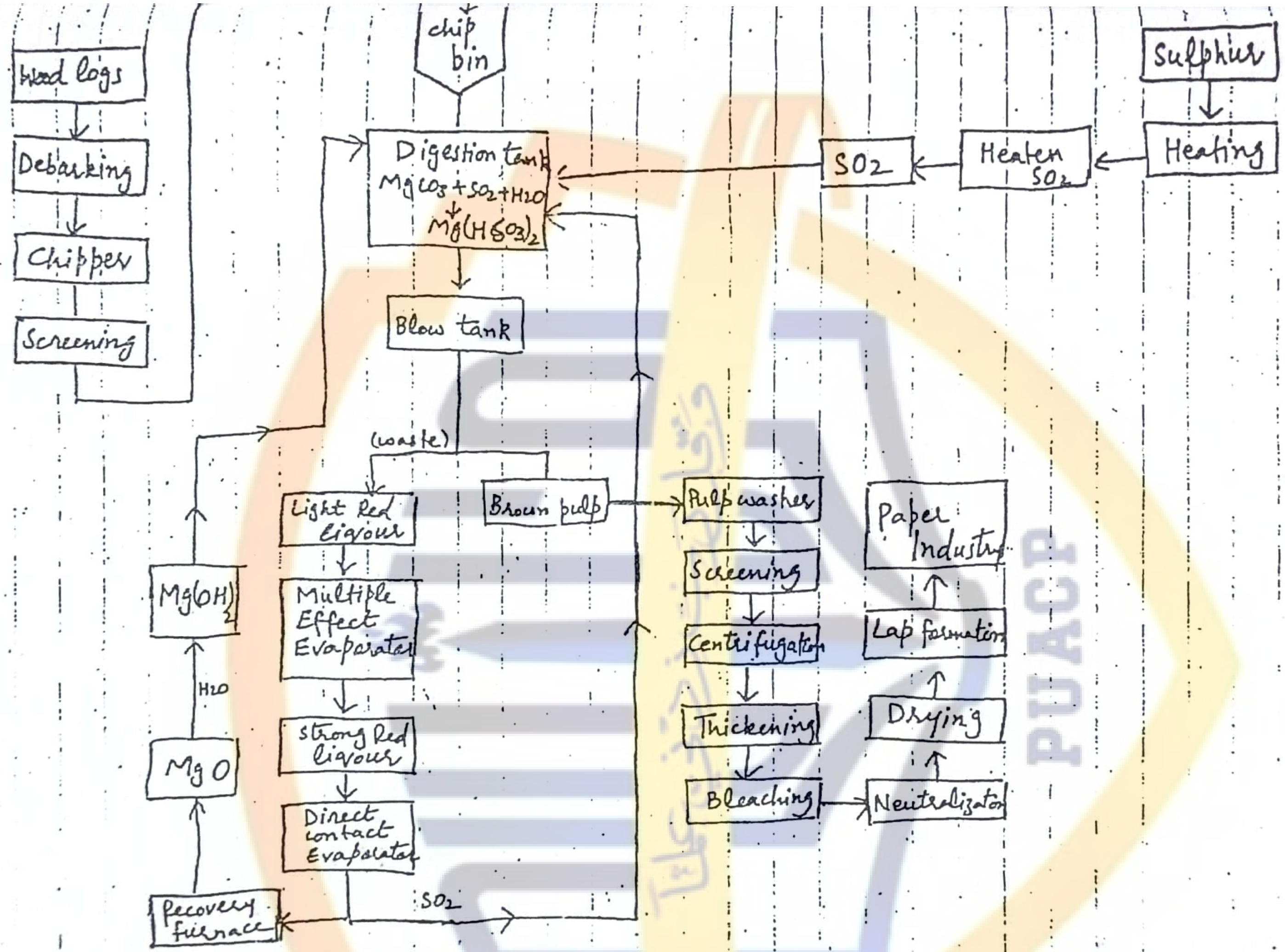


Fig: Flow Sheet Diagram of Sulphite Process

SODA PROCESS

Soda process of pulp formation, which is also called chemical process, is an alkaline process and NaOH is used as cooking liqour. For soda process pulp is formed from the decideus wood (hard wood) e.g popular, birch, maple, chestnut etc.

Steps of Soda Process

1- Debarking
2- Chips formation
3- Screening of chips
4- Digester tank
5- Blow tank
6- Pulp washer
7- Screening Chest
8- Thickening
9- Bleaching
10- Drying
11- Laps formation

First three steps are same as for the Kraft (sulphate) process

4- Digester Tank:

Cooking process is done with the help of cooking liqour which is Na_2CO_3 & NaOH in case of soda process. Cooking liqour's density is 11-13 Bé containing 6-7% NaOH. Cooking process is done in the digester tank. The conditions of the cooking process depend upon the nature of the wood, the composition of the cooking liqour.

and the quality of the pulp to be produced. The typical cooking conditions for soda process are:

Pressure	90–105 lb/in²
Temperature	330–340 F°
Time	6–8 hrs.

5- Blow tank:-

The function of blow tank is to separate the soluble and insoluble parts. In blow tank the pulp i.e cellulose is separated from cooking liquor and other ingredients, the pulp is then passes to next unit.

Thus blow tank divides the whole reaction mixture into

(a) Weak waste liquor (soluble portion)

(b) Dark pulp (Insoluble portion).

6- Pulp washers:-

Pulp is now washed with excess of water to remove impurities.

7- Screening Chest:-

Here, small pieces of unreacted wood are removed and then to fine screen to remove any impurity. Knots and large lumps of fibers are also removed here.

8- Thickening:-

The %age of water is controlled by thickening process. It consists of cylinderical frames covered with fine wire screens. As the water passes through wire screens, the

pulp remained on the screen, hence the pulp becomes thick but its color is still dark.

9- Bleaching :-

Bleaching is done with calcium hypochlorite to get cream colored paper. If we want to prepare white color paper, first bleach with Cl_2 then neutralizing it with lime and then bleach again with calcium hypochlorite.

10- Drying :-

The pulp after drying bleaching is dried with hot air.

11- Laps formation :-

The dried pulp is then rolled into sheets in the form of coarse sheets which are called laps. Laps are made with a wet thickner consisting of a suction cylinder dipping into vat filled tho with pulp. This pulp is load by squeez rolls (for removal of water) and then to press rolls (for removal of water & also for shaping. Thus laps are formed and ready for paper manufacturing.

* Soda pulp is used to produce paper for
  - → Books and magazine
  - → Colored paper
  - → Tissues

RECOVERY OF WASTE LIQUOR

The weak liquor from blow tank which contains about 10% solids and 4-5% total alkali (mostly Na_2CO_3, NaOH), is concentrated in the multiple effect evaporator. Thus strong waste liquor is obtained. This strong waste liquor is now fed to rotary or stationary furnace to produce black ash containing 25% free carbon. The ash is charged to a series of leaching tanks. The ash is leached with water as weak alkali through counter current process. The resulting solution is fed to slaking tank. Free carbon is settled down and is discarded.

Now unslaked lime (CaO) is added to liquor in the slaking tank and the slurry is fed to the caustisizing tank where Na_2CO_3 is added. Reaction is

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

$$Ca(OH)_2 + Na_2CO_3 \longrightarrow 2NaOH + CaCO_3$$

$CaCO_3$ sludge is filtered off and sent to the kiln where

$$CaCO_3 \longrightarrow CaO + CO_2\uparrow$$

The CaO is reused in the slaked tank. After the removal of $CaCO_3$ sludge, the filterate i.e. NaOH is white liquor and is reused in digester tank.

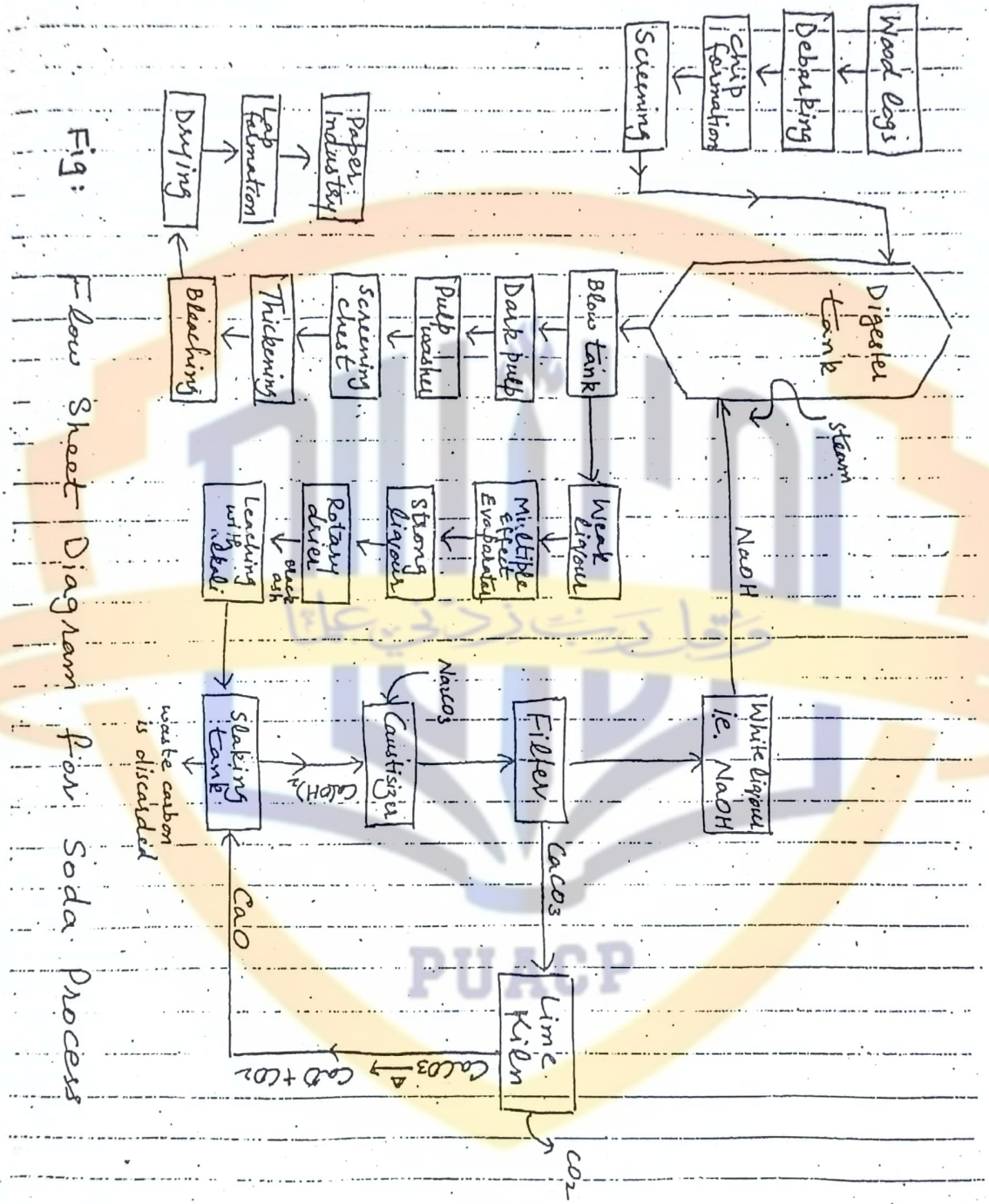


Fig: Flow Sheet Diagram for Soda Process

(iv)

COMPARISON OF ALL THE THREE PROCESSES

Process	Sulphate	Sulphite	Soda
① Raw material	Any kind of wood soft or hard.	Coniferous (soft) light colored wood	Short fibered, hard wood is used
② Reaction in digester	Hydrolysis of lignin ⟶ alcohols/acids	$RC{=}CR' + Ca(HSO_3)_2 \rightarrow$ $RCH-CR'-SO_3Ca$	Hydrolysis of lignin to alcohols/acids
③ Condition type	It is alkaline process	It is acidic process	It is alkaline process
④ Composition of cooking liquors	NaOH soln 12.5% (as Na₂O) NaOH — 58% Na₂S — 27.1% Na₂CO₃ — 14.3	7% by wt. SO_2, of which 4.5% as H_2SO_3 & 2.5% as $Ca(HSO_3)_2$/$Mg(HSO_3)_2$	12.5% soln of Na_2CO_3 and NaOH in ration 15 : 85
⑤ Cooking conditions	Pressure ⟶ 100–125 lb/in² Temperature ⟶ 340–355 F° Time ⟶ 2–5 hrs	Pressure ⟶ 70–90 lb/in² Temperature ⟶ 265–300 F° Time ⟶ 7–12 hrs	Pressure ⟶ 90–15 lb/in² Temperature ⟶ 330–340 F° Time ⟶ 6–8 hrs.
⑥ Chemical Recovery	Chemicals are expensive but recovery of chemicals is possible	No recovery of chemicals bcoz recovery of chemical cost is more than of actual price	NaOH is recoverable but Na_2CO_3 is not.

① Material of construction	Digester pipe lines, pumps and tanks are of steel or iron bcoz NaOH does not corrode them.	Digester lining is of acid-proof bricks of fittings of Cr-Ni steel, lead and bronze	Same as Kraft material
② Pulp characteristics	Brown in color, fibers are strong, difficult to bleach offer resistance to mechanical refining	Dull white color, fibers are weak, easily bleached	Brown in color fibers are weaker than Kraft or sulphite, easily bleached.
③ Typical paper products	Wrapping paper, Building paper, strong white paper, Paper board used for cartoons, milk bottles.	White grade book paper, bread wrap, tissue etc.	Usually blended with other papers; book paper, magazine paper,

BLEACHING PROCESS

Bleaching is a very important process in the manufacturing of pulp and consequent in the production of paper. Because it does effect the properties of final paper to be produced. It involves!

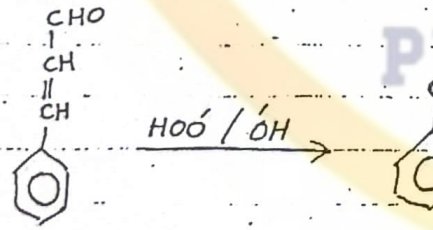
The removal of residual lignin, tannic acid, quinones and other coloured compounds from pulp.

"A number of undesired colour causing compound left in the pulp during destruction of pulp wood, removal of these compounds is called bleaching."

Bleaching cause whiteness and brightness to the product by removing of undesired compounds.

→ Mechanical pulp retains high proportion of lignin, therefore it needs more bleaching.

Bleach of mechanical pulp
- oxidative → Peroxides, ozone, hypochlarites, Peracetic acid are used.
- Reductive → Bisulphite, dithionate, Borohydride are used.



→ Bleaching of chemical pulp involves the removal of lignin. Chlorine and chlorine compounds are mostly used but environmentally hazardous. The most common approach is with Cl_2 in aqous solution or chlorine dioxide (ClO_2).

The main function of chlorination is to convert the residual insoluble lignin in the pulp and consumed in a few minutes.

Correct dosage of chlorine compounds is very important as extra amount weakens the fibers.

→ ClO_2 is less damaging than Cl_2, to the carbohydrates. ClO_2 is very unstable i.e, very reactive and cause whiteness and brightness to the products within a very short time.

→ Hypochlarides are mostly used due to low cost and favourable action. Principally chloriates, chlarites, permengnates, H_2O_2 and Na_2O_2 can also be used but seldom used due to various reasons

→ Cl_2 is either used directly or first bubbled in $Ca(OH)_2$ or NaOH to produce hypochlarites.

$$Cl_2 + H_2O \longrightarrow HCl + HOCl$$

HOCl is the real oxidizing agent. It reacts with NaOH as

$$HOCl + NaOH \longrightarrow NaOCl + H_2O$$

→ Cl_2/H_2O system depends upon the pH.

PH → 2	Cl_2 present as elemental Cl_2
PH → 2–3	Elemental Cl_2 + little HOCl
PH → 4–6	Hypochlorous acid mainly
PH → 9	As hypochlarite

REAGENTS USED FOR BLEACHING OF PULP

1- HYPOCHLORITES:

Hypochlorites are salts of very weak acid HOCl. In aqueous solution free alkali should be present to prevent the formation of HOCl. Bleaching powder ($Ca(OCl)_2$) is an example of hypochlorite.

$$2\,Cl_2 + Ca(OH)_2 \longrightarrow CaCl_2 + Ca(OCl)_2 + H_2O$$

In stepwise,

$$Cl_2 + H_2O \longrightarrow HCl + HOCl$$

$$2HCl + 2HOCl + 2Ca(OH)_2 \longrightarrow CaCl_2 + Ca(OCl)_2 + H_2O$$

Bleaching powder contains 15% free lime and 85% Cl_2

2- SODA BLEACH:

A solution of NaOCl!

$$Cl_2 + NaOH \longrightarrow NaOCl + HCl$$

Mainly used for bleaching rag pulp.

The bleaching time is directly proportional to the temperature.

Time ∝ Temperature

And both these depend on the consistency of pulp and brightness desired.

3- ANTICHLOR:

One commonly used antichlor is $Na_2S_2O_3$ (Sod. thiosulphate). Others may be sod. sulphite and cal. sulphite. Sulphite may be used in excess as it can act as fillers as

Sulphite liquous used for wood cooking may also be used as antichlor.

→ Hydro peroxide (hydrogen peroxide) H_2O_2 may also be used, but it is expensive.

Washing:

Impurities resulted from different reactions of modern bleaching needs to be removed by washing the fibers with water.

About 80000 to 100000 gallons of water may be required per ton of pulp.

PAPER MANUFACTURING

Different types of pulp are carried to the paper manufacturing units and thus the quality of paper depends mainly on the quality of pulp, bleached. The pulp is processed in order to develop the following properties in the paper to be manufactured:

(i) Refining of pulp
(ii) Control of density
(iii) Increase of opacity
(iv) Causing whiteness & brightness.

STEPS INVOLVED IN PAPER MANUFACTURING

For achieving all the above properties in the final paper, the paper manufacturing involves the following steps:

1. Beating
2. Refining
3. Use of fillers
4. Sizing
5. Colouring Coating
6. Colouring
7. Paper manufacture machine

1. BEATING:

The pulp produced by any process is not yet ready to produce paper of desired finish, smoothness, opacity, strength and feel. Therefore, first of all, the pulp is subjected to the process of beating.

The main object of beating is to increase the mechanical strength of paper sheet.

In early stages of treatment, the constricting outer layers of the fiber are disrupted and partially removed, permitting the fibers imbibe water freely. As a result of this swelling, the fibers are internally fiberillated. This results in the further penetration of water between microfibrils.

As the water is gradually removed in paper making process, the fibers are brought together and removal of capillary water brings the fibers into closer contact. When the distance b/w the neighbouring cellulose molecules is small enough, hydrogen bonding can occur.

The most commonly used beater is Hollander Beater". (First used in Holland in 1750). It consists of a wooden or metallic tank having rounded ends. There is a roller fitted in the centre, equiped with sharp knives or blades and directly below to this roller; the boundry of tank is fitted with stationary knives or blades.

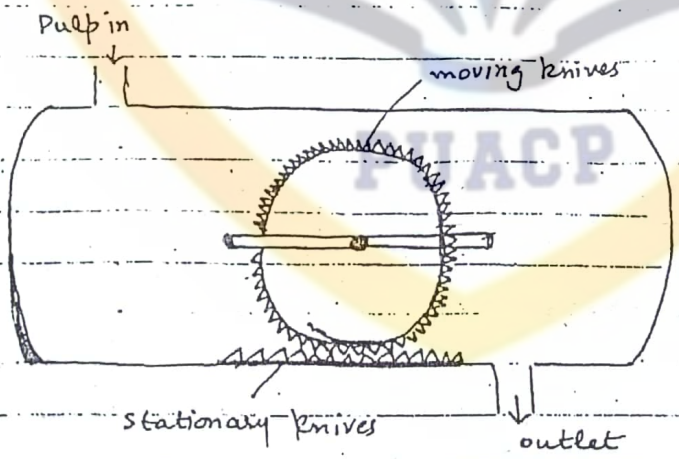


Fig. Hollander Beater

In practice, the circulating pulp is forced between the blades on the revolving roll and the stationary bars of the bed plate. The roll may be raised or lowered to get the desired results.

Beating the fibers makes the paper more uniform, dense, opaque and less porous.

2- REFINING:

For further improvement of the quality of the paper, beaten pulp is subjected to the process of refining. The refiners are similar to the beater in principle and their working except that a different type of operatus is used for refining.

Generally refiners (Jarden Engine) consist of a conical shell with stationary bars inside it. Inside the shell, a core is revolving which is also set with bars. The pulp is crushed b/w two sets of bars, stationary of shell and revolving with cone.

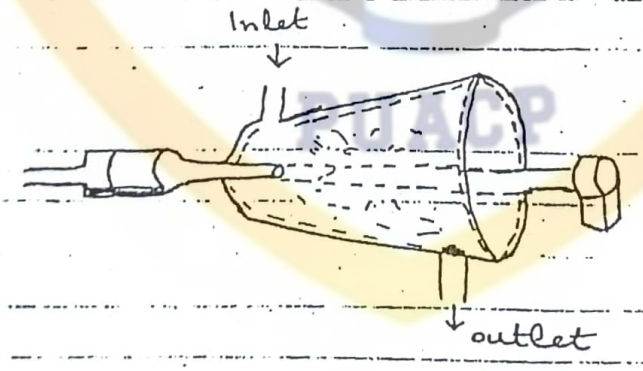
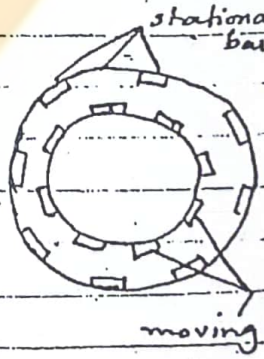


Fig.: Jordan Engine Refiner



Inside view of conical shell

The pulp enters the small end and after being crushed by bars, leaves at the other end.

3- USE OF FILLERS:

Fillers are usually inorganic materials mostly occur in nature and some synthesized. Naturally occuring fillers are fine special clay and synthetic are precipitated $CaCO_3$, TiO_2 and SiO_2 (grand.) The fillers are always used in finely ground state to occupy microscopic pores in paper.

Fillers may be added in the beater, in Jarden engine or in bath. All papers except absorbant type must have fillers. The purpose of fillers is to occupy the space between the fibers giving smoother surface, brilliant whiteness, increasing printability and improve opacity.

4- SIZING:

The application of sizers to the pulp after the addition of fillers is called sizing. It can also be added in beating, refining or in bath. Sizers are the chemicals added to prevent the penetration of liquids into the paper. Resin treated with NaOH give soap (sponification) wax emulsion, which is used for sizing by precitation with alum. Resins like ammonia aldehyde or urea formaldehyde are used to prevent the breakage of paper in water. It increases the strength of paper in wet conditions.

5- COATING:

Potash alum or aluminium sulphate ($Al_2(SO_4)_3 \cdot 18H_2O$) is used as coating agent. It forms a thin layer on the fibers of paper. The soap added during sizing cause the precipitation of this thin layer and it loses the water of hydration and gets hardened. This hardened surface of paper makes it impossible to penetration of liquids.

6- COLOURING:

Almost 98% papers need colouring. Colouring is also added either in beater or on the paper. 95% colouring is added in beater. All types of dyes i.e. acidic, basic, direct and pigments (both natural & synthetic) are used as colouring agents. The acidic dyes may cause damage to cellulose. To overcome this problem, alum is added to form a thin layer on fibers and it saves the paper from damaging.

Potash alum ($K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$) acts as a mordant by forming a thin layer of aluminium hydroxide $\{Al(OH)_3\}$. It gets woven with the fibers of the paper. It sticks firmly to the paper fibers and absorbs the colour of the dye uniformaly, i.e. firmly & evenly.

7- PAPER MANUFACTURE MACHINE:

Two types of machines are generally used for paper making:

(a) The Fourdrinier Machine

(b) Cylinder machine

The basic principle of both machines is same.

(a). FOURDRINIER MACHINE:

In this case, pressing and dewatering is done by filteration and heating. Before paper formation, the pulp is suspended in excess of water and then transferred to flow box. The function of flow box is to provide a continuous flow of stock at constant velocity across the width of a machine. From the flow box, the stock flows through the outlet onto a moving endless fine mesh bronze wire screen. The pulp fibers remain on the screen while excess water drains through. This screen also is equiped with a suction pump.

As the screen moves along, it has a sidewise shaking (zig zag) motion which helps in uniforming the surface. While still on the screen, the paper sheet passes through suction rolls to remove water and under a dandy roll which smooth the surface. The water contents of paper sheet at this level are 65%.

Now the paper sheet is transferred to a set of felt drying blanket, and heat is also supplied. This process decreases water contents upto 20%. The paper is given water mark if desired.

Leaving the felt blanket, the paper passes through steel smoothing rolls heated internally by steam. In the next step, the sheet of paper is passed over a set of calendering rolls. Calendering rolls are in verticle series, smooth and heavy steel rolls which impact the final surface finish. Moisture contents at this level are only 6%.

The resulted product is wound on a roller/reel and is ready for use.

* The operating speed of machine vary from 200 ft/min for fine grade papers to 1700 ft/min for newspaper print.

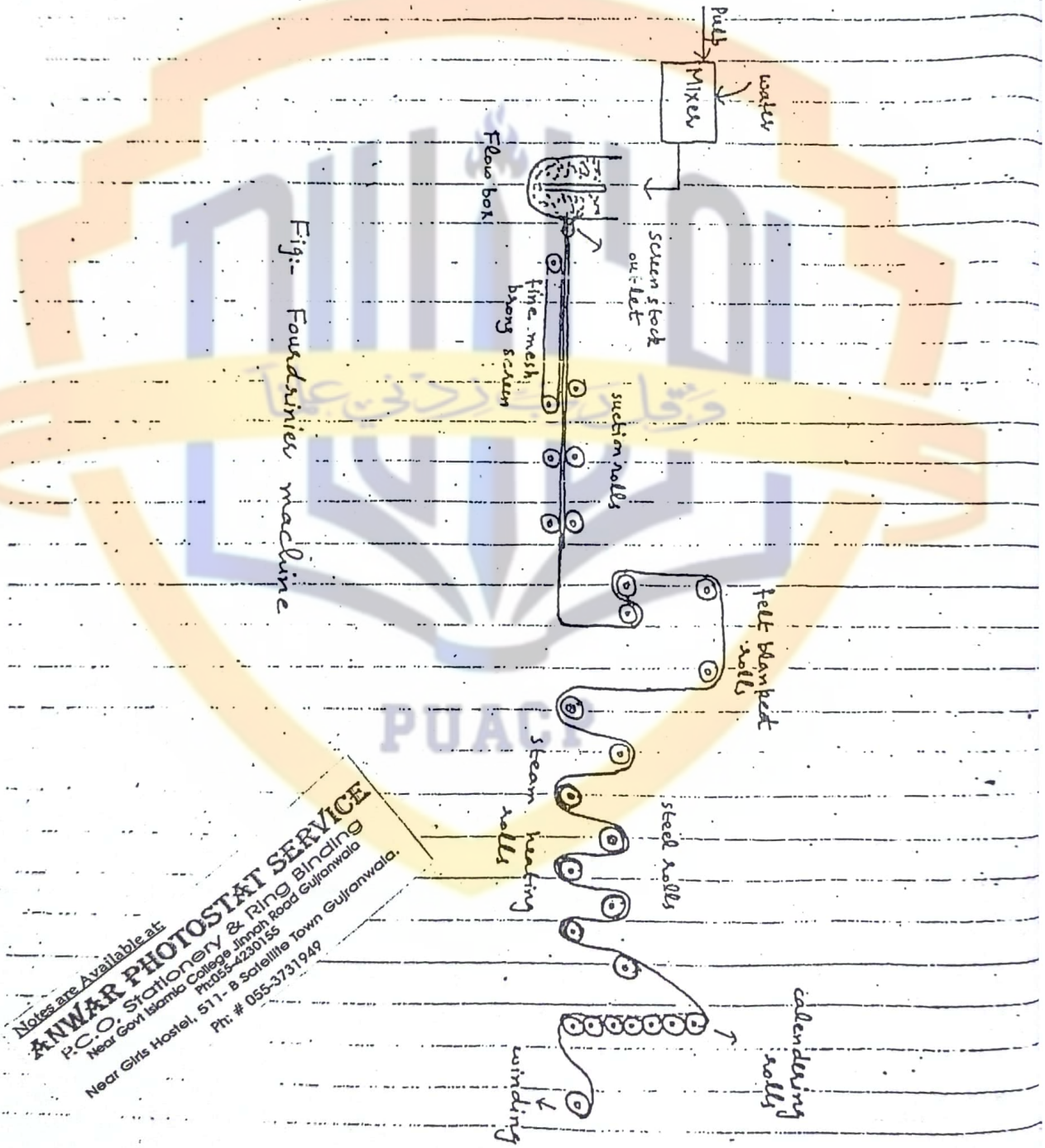


Fig:- Fourdrinier machine

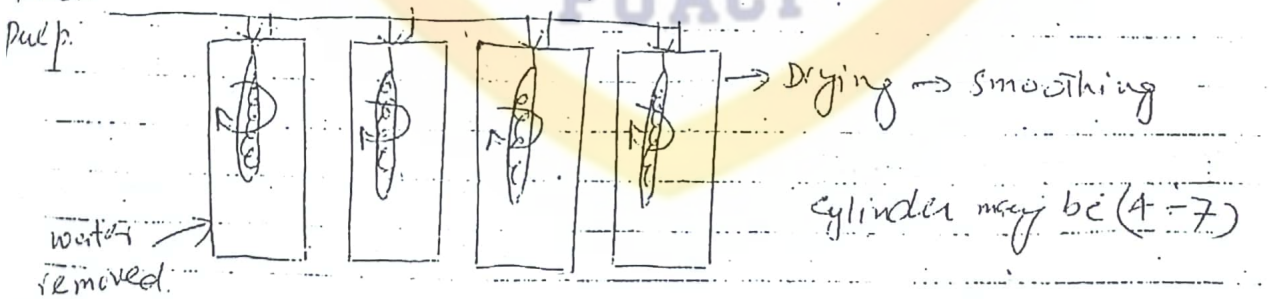
(b). CYLINDER MACHINE:

Cylinder machines are employed for the manufacture of heavy paper, card board and non-uniform paper. It enables several layers of paper to be united together into one heavy sheet.

The cylinder machine consists four to seven (4–7) parallel vats, into each of which dilute pulp stocks are charged. A wire covered rotating cylinder dips into each vat. The pulp is deposited on revolving screen, the water inside the cylinder is removed.

As the cylinder keeps on revolving, the paper reaches the top, where the wet layers comes in contact with a moving felt. This felt and paper comes in contact with top of next cylinder and picks up another layer of paper. Extra water is removed by press roll felt and paper reaches at the top of the last cylinder gradually. Thus a composite wet sheet or board is formed and passed through drying and smoothing rolls.

Such board may have outer layers of good stuff while inner layer of inferior type of pulp.



ENVIRONMENTAL ASPECTS OF PAPER & PULP INDUSTRY

Paper & pulp industry is one of the anti-environment industry b.coz many toxic chemicals are produced by this industry.

Now-a-days, new chemistry is emerging that is called green chemistry. In this chemistry we try to convert toxic chemicals into environmently friend chemicals.

Paper industry is responsible to produce land water & air pollution. In this industry, there are some natural chemicals which come from wood and mainly they are organic in nature. Some chemicals are those which are used in digesting process. e.g. NaOH, Na_2CO_3, Na_2S, SO_2 etc. Mostly these chemicals are inorganic in nature and comes out from the cooking liqour.

In bleaching process, we also use HOCl, free Cl_2, bleaching powder etc. All these are chlorinating derivative compounds. These compounds react with organic compounds and convert into very dangerous chemicals due to some toxic reactions. e.g. P.C.Bs., D.D.T.

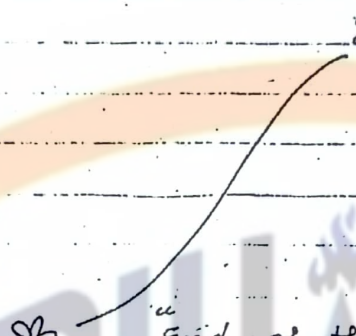
Due to these reactions, chlorination process is discarded for the purification of water in some countries.

Cooking liqours are less toxic than the chlorine chemicals. Other than these chemicals, fillers, oxidizing agents are also toxic but less than these.

Now-a-days, new researches are providing that we should avoid to use chlorine

- compounds in paper industry.

Paper industry should be in open areas, away from cities.



"End of the chapter; but not end of the knowledge. You can improve it a lot"