Effective utilization of chemicals in pulp and paper mills

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SUMMARY

A review of the existing trend of utilisation of chemicals effectively in Pulp and Paper Mills, is given. The three main aspects of making the utilisation given are : a) minimising the losses in various sections due to process variables or the operating negligence, b) modification and optimisation of the process and c) making the whole paper mill a close system.

In larger paper mills the importance of reduced chemical consumption in pulping, improved retention at the machine wire, reuse of maximum bleach filtrate and machine back water is mentioned. As regards the smaller mills the importance of recovering the chemicals in the form of fresh cooking chemicals or by-products from the spent chemicals is stressed.

The history of 'Paper Making' shows that chemicals are the main tools used for conversion of raw materials into variety of papers. The mode of conversion into free cellulosic fibres may be the old conventional pulping processess like sulphite, soda, sulphate and mechanical etc. or the later developed ones like neutral sulphite semichemical, chemimechanical, thermo mechanical and refiner mechanical etc. The utilisation of chemicals in some or the other form is a necessity for any of the processess mentioned.

Reutilisation of chemicals, particularly for chemical processes, started more or less side by side of the process developed. The idea was to convert spent chemicals (black liquor chemically back to fresh cooking chemicals (white liquor) in case of sulphate process). This chemical regeneration section is called 'Recovery Section' and rightly heart of the paper mill. Because, the job of the recovery section in a paper mill is more or less identical with that of heart of living animal i.e. purification of spent chemicals in the case of paper mill. The cost of the cooking chemicals is so high that without this 'reutilisation' the running of the paper mill economically would have been impossible.

As far as India is concerned, mainly two processes are adopted for pulping viz. sulphate and soda. This in view, the discussion on "Effective Utilisation of Chemicals in Pulp and Paper Mill" will be limited to these two processes only. Larger paper mills have opted for sulphate for easy and more economical recovery sections while smaller mills opted for soda process utilising agricultural residues and waste papers, without any recovery system in the mill.

The discussion will not be extended in details to the commonly existing means of utilisation of chemicals in various sections of larger paper mills, but stress will be given to more modern techniques used all over the world in the light of catalysts used for reducing chemical consumption and increase of yields, chemical economy, possible recovery of by-products which otherwise go waste. In case of small paper mills, in addition, the discussion will be extended to explore the possibilities of utilising the spent waste chemicals on the lines or otherwise adopted by larger paper mills. So that the economy of small mills will be improved, which is presently less because of the draining of spent liquor

The importance of the effective utilisation of chemicals in pulp and paper mills is of vital economic interest. The economic impact on the production cost of paper will be linearly related to the extent of effectiveness of utilising chemicals.

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The utilisation of the chemicals can be made effective by :

1) Minimising losses in the various sections e.g. leakages in pump gland packings, valves etc., overflows of chemical tanks etc., chemicals in the form of volatile gases while cooking in pulp mill, or in the form of soot particles in flue gases in recovery furnace, chemicals going with improperly washed pulp in brown stock washing and lime mud in causticizing section etc.

2) Optimisation and modification of a particular process variables so that the desired result is achieved at the minimum chemical demand. The modification may include addition of some catalyst, variation in temp. or even supplementing the existing process by a secondary process which will help in reducing the chemical demand.

3) Making the whole paper mill a close system that is the chemicals going out of the system may be reclaimed and used again in the system e.g white water from machine house, back water from bleach plant and lime mud etc. Reclaiming has been used in the sense that the streams containing chemicals may be used at the convenient place. This usage will have additional benefit of chemical cost reduction in the treatment of effluents.

On the basis of these three aspects of making the utilisation of chemicals effective, the modern trend all over the world is discussed sectionwise with special reference to soda and kraft process.

DIGESTER HOUSE :

In sulphate cooking the chemicals are absorbed through diffusion. The most of the chemicals will be transported the shortest way i.e. perpendicularly to the surfaces which are at the shortest distance from each other. Or, in other words, chip thickness is of maximum importance for sulphate cooking. From the chemical consumption point of view, Akhtrauzza man has reported that effective alkali consumption decreased very little with increasing chip dimensions under the same cooking conditions. At a given kappa number, however, increasing chip dimensions increased the effective alkali consumption, with thickness having more pronounced role.[1,2]

The most modern modification to reduce chemical consumption in alkaline pulping is the use of anthraquinone and its derivatives. The details of laboratory and full scale trials are given to view Anthraquinone and anthraquinone derivatives as a pulping catalyst in alkaline process, leading to increased rates of delignification under constant conditions. Conditions may be altered to result in reduced alkaline requirements[3,4,5,6].

The mechanism of the reaction with which these compounds are producing such results are elaboratly discussed by various authors in their findings[7,8]. To sum up their finding the addition of anthraquinone in soda pulping leads to oxidation of reducing sugar end groups in cellulose and hemicelluloses to form aldonic acids end groups, which are comparatively stable with respect to end wise alkaline degradation. Since anthraquinone in hot alkaline solution was readily and reversibly reduced by glucose. The reduced anthraquinone be comes oxidized again by reducing a lignin intermediate produced in an initial reaction. Thus, the reduced anthraquinone prevents the reversal there by accelerating the net forward reaction. The lignin intermediate increase i e. β—ether cleavage of free phenolic moieties in lignin is suggested as the reason for the increased rate of alkaline delignification with anthraquinone[9]. Further investigation on anthraquinone was to study effect of addition of reducing agents and advantages of using the oxygen free conditions[10,11]. The other catalysts recommended for faster delignification are O-benzoquinone[12] Nitrogenous redox catalysts such as Phenazine[13], Amines and Sodaamines[14] Flourenone[15] and Benzocinnoline[16], though these are not as effective as anthraquinone and its derivatives. The feasibility of using anthraquinone from all the aspects is given by Virkola[17]. The addition of catalysts for faster delignification may be effective for unconventional raw materials also say agricultural wastes, as a means of reducing the chemical consumption for digestion in small paper mills.

The other method of making the digestion system economical is to recover the chemicals from relief gases and heat and chemicals from blow vapours. A process for recovering sulphur compounds, volatile alcohols, turpentine and the like, from digester blow gas condensates is described. The blow gases are passed through a series of direct condensers to a gas storage means before being conducted to on indirect condensers. The uncondensed gases leaving the indirect condenser are scrubbed while condensate mixture leaving the indirect condenser is conducted to a turpentine separating means[18,19].

Yet another method for reducing the chemical consumption in digesting the raw material is to introduce a refining stage before the brown stock washing. This will make it possible to produce unbleached kraft pulp, for producing stronger wrapping papers, at the same time reducing alkali in cooking and separating the fibres by what is known 'hot stock refining'. In addition to chemical savings there will be increase in pulp yield and strength of the kraft paper (unbleached) made from it. This system will have additional advantages of eliminating screens (Jonson Knotter), avoid risk of over bleaching usually applied in order to achieve cleanliness target (free of knots); thus reducing the bleaching cost also[20]. However, all this will be at the cost of some energy consumed in hot stock refining.

Brown Stock Washing : In this section the aim to remove maximum spent chemicals is achieved by washing the cooked material with hot water. The more hot water we use, the more chemicals will be drawn out of pulp. But, there is always a check to fresh water used as the more dilution will create problem for concentrating more volume of water/ ton of chemicals. So the only alternative to increase efficiency of the washing system at a given dilution is to put one more washer. The installation of an additional counter current brown stock washer in a report, reduced unbleached white water losses from 55 to 12.4 lb/a.d. ton (as salt cake). In addition, suspended solids were reduced in the effluent. Further benefit included chemical savings in nutrients, salt cake make up, bleach consumption and defoamer[21]. Of course, this installation of additional washer will depend on the amount of chemicals going with the washed pulp i.e. to see whether installation is actually economical. Collister has described the optimization of brown stock drum washer system. The economics have been calculated based on the cost of evaporation of the resulting first stage filtrate.

If the filtrate from first washer (Weak Black Liquor) is somehow made to have contact with the waste foul blow or vent gases of the digester, there will be considerable recovery of heat and chemicals.

Chemical Recovery Section :

As regards the recovery system of large size mill, there is nothing much to say about the effective utilisation of chemicals, except, the losses through pump glands, foaming and entrainment in evaporators, condensable vent gases of evaporators and furnace flue gases etc should be kept minimum. Sapre has discussed the alkali losses in recovery system[22].

The greater the loss of sulphur relative to sodium in the recovery process, the lower the sulphidity of the white liquor. Normally, the efficiency of soda recovery in the sulphate process is about 85% compared with an efficiency of 90% in the better run soda mills, but improved efficiency of alkali recovery in sulphate mills has made it increasingly difficult to maintain high sulphidity because less salt cake is required as makeup and consequently less sulphur is added to the system. Sulphur is lost, independently of soda, at all stages of the sulphate process due to the thermal ins ability of the sulphur compounds This sulphur is lost in the form of gases not containing soda, such as SO_2 and H_2S. Thus the equilibrium of sulphidity is normally in the range of 18 to 34% when salt cake is used as make up. As mentioned above, this disproportionate loss of sulphur compared with that of sodium in the pulping and liquor recovery processes makes it difficult to obtain a high sulphidity. About 2 to 8% of the sulphur present in the cooking liquor is lost to the atmosphere in the form of gases at the digesters, filters and evaporators and in a finely divided solid form on the stack gases from the recovery furnace. Sometimes it is necesary to add elemental sulphur as makeup chemical. This is done when the recovery of sulphur is not great enough in relation to the recovery of soda to maintain the required sulphidity.

In Tappi conference on Environment held at San-Francisco in May 1979 a process for chemical scrubbing of TRS (total reduced sulphur) from kraft mill recovery gases was discussed The process would reduce particulate and sulphur dioxide emission and permit sulphur and sodium sulphate to be recovered and recirculated. The essential equipment of the scrubbing system after the electro-static precipitator includes 2 absorption towers, two generation oxidising tanks, a solid bowel centrifuge for sulphur removal and a crystallizer for removing soda sulphate[23]. Walther and others have described another method of scrubbing of recovery furnace gases for the removal of total sulphur and particulates[24]. In this process is described a system using alkaline and activated carbon absorption and oxidation with which particulate emissions have been reduced to less than 10 ppm.

Auto-causticizing alkali and its use in pulping has been recommended in a nunber of references [25,26,27]. The method is based on the known fact that certain chemical compounds like amphoteric oxides, sodium borate, silicate, phosphate and aluminate etc. were observed to liberate carbon dioxide from sodium carbonate during heating at high temp. The resulting smelt when dissolved in water acted satisfactorily as delignifying agents capable of replacing sodium hydroxide in soda and kraft pulping. This principle of alkali regeneration is called autocausticizing, which eliminates conventional causticizing of carbonate by lime which will lead to considerable savings in future capital investment system for new mills or mill expansions. The sodium borate seems to hold the best promise for both pulping and regeneration. Other benefits are reduced chemical losses through flue gases emissions.

To improve the economic viability of small mills (25-60 tonnes) based on unconventional raw materials e.g. Agricultural wastes mainly the following can be the approaches :

1. To utilise the spent chemicals (from black liquor) in the normal way as done in larger mills and convert them back to cooking chemicals (white liquor/sodium hydroxide).
2. The other way out is to recover the various by-products from the spent liquors.

As regards first approach simple recovery system with about 75% efficiency has been suggested by Hackl[28]. Though the details of the recovery system are not available here but the people concerned, who make bigger liquor/fuel fed boilers and evaporators can go for the development of their boilers and evaporators design which will be economical to smaller pulp mill also. The approach is also possible, if the smaller paper mills (25-60 tonnes) are installed near the bigger mills. The spent liquor produced in the smaller mills may be sent for recovering the chemicals in the bigger mills.

Coming to the second approach i.e. to recover the chemicals as by-products from spent liquors from kraft cooks. Guha[29] has presented the possibility of utilising the spent liquor for the manufacture of Vanilin and related compounds, organic sulphur compounds from lignins, phenolic products from lignin, polymeric products and Monomeric sugars and other products. It has been pointed by Guha, for example that Bamboo Liginin is not suitable for vanilin where as soft wood lignin is preferred. Similarly kraft lignin from soft wood and hard wood is very useful for the manufacture of Dimethyl sulphide, (DMS) or Dimethyl sulphoxide (DMSO). Guha also recommended the utilisation of spent liquors from the small paper mill for producing polymeric products starting from Lignosulphonates after sulphonating the liquor. The possibility of isolating the lignin derivatives from desilicated rice straw soda black liquor has been described by El-Taraboulsi[30].

A special report from Indian Pulp and Paper Technical Association under the heading "Guidelines for chemical recovery and effluent disposal in small paper plants" has identified the problems of effluent disposal, mode of treatment and chemical recovery and recommended the means for economical solutions in mills of 10, 20 or 30 tons/day capacity[31].

The mills, using cereal straws (capacity between 25 - 30 tonnes/day) have been suggested the wet air oxidation for chemical and heat recovery from the spent liquors for the better economy. The WAD (Wet air Oxidation) plant (designed by Zimpro Inc in Roths child, Wis is diagrammed and its operation is briefly described[32]. Studies on the development of a chemical recovery system for a sulphate straw pulp mill has been outlined, highlighting the desilification by Cao[33].

In a conference held in China recently Hartler, outlined various cooking and recovery processes including a new one under development by Sund's Defibrator. For straw liquor recovery, he recommended the Broby process for its simplicity and low cost compared to the Zimpro wet combustion process. The Broby process is less affected by scaling caused by the presence of silicates. Since straw contains high silica and this silica is concentrated in the leaves and ears of the straw. Hartler recommended that a separation would make pulping and recovery a lot easier[34].

Bleach Plant :

From the effective chemical utilisation and effluent disposal point of view, it will not be surpising to hear that a direct counter current washing system has been tried with C (D) EHDED bleach sequence[35]. The main idea is to reuse the waste waters (filtrates) from individual washer of bleach plant. The filtrate of caustic extraction has been recommended for the initial (say first two washers) of the brown steck washing section[36]. The optimum level of water reuse in a bleach plant, the combined cost of chemicals and energy is reported to be minimum and its effect on the chemical consumption and quality of pulp is also given[37]. The concept of the closed mill or zero discharge have reduced the water volumes required and at the same time canserve fiber, chemicals and energy. The advantages and disadvantages of the zero discharge implementation has been elaboratedly discussed by Bush[38]. Similar closed cycle bleached kraft pulp mill has been discussed by Reeve[39]. The main conclusion of his discussions are, kraft bleach plant effluent can be eliminated by using it to wash the unbleached pulp and to prepare cooking liquor. Chlorination stage filtrate reuse has been tecommended by Rapson[40] to dilute the thoroughly washed unbleached pulp to reduce the end pH in chlorination. Advantages in doing so has also been reported.

This reuse of bleach plant effluent has a draw back of accumulating the sodium chloride in the system. To remove this chemical from system a number of methods are recommended[41-44]. The main method recommended for the removal of chlorides is the evaporation and crystallisation of the Green liquor or white liquor.

As regards the conservation of chemicals in bleach plant particularly in chlorine stage, the importance of chlorine pulp mixing efficiency cannot be ruled out. The inclusion of chlorine dioxide along with chlorine in chlorination has stated to increase the chlorination rate particularly at lower chemical dose and lower temp. thus, can be a method of reducing the overall chemical in chlorination[45]. Peroxide bleaching has also been recommended in the first stage of multistage bleaching to reduce the utilisation of chlorine or even eliminate the same[46,47]. A bleaching aid has been recommended to reduce the bleaching agent(Hypochlorite) comprising a water soluble acrylic acid polymer or salt (e g sodium polyacrylate) having a mol. wt. of 500-20,000 and water soluble CMC[48]. The treatment of pulp with chelating agents such as nitrilo triacetic acid or its salt, EDTA or its salts or diethylenetriamine penta acetic acid or its salts preferably in amounts of 0.01-5% based on dry pulp, is recommended to reduce the consumption of bleaching chemicals. The treatment may be in the presence of surfactant[49]. The use of chelating agents in pulp and paper industries has been described in broader details by Hart[50]. He has described the chemistry of the chelating agents and their ability to react with and "tie up". metal ions into a stable and very water soluble complex form. These are used during pulping producing brighter pulps with less bleach chemical consumption. A new accelerated (6-15 min) high density peroxide bleach, the Bolt-Kuhu process, has been patented and has operated well on commercial scale. The shortened action of alkali not only prevents carbohydrates degradation and yellowing but also saves 25-30% of chemicals, despite the high initial peroxide concentration. Similarly, linter and rag pulps can be bleached continuously with considerable savings in hypochlorite, by generating nascent chlorine through the addition of dil acid to high density stock mixer chest. For Flax and other cellulosic fibres, the process can be modified by adding NaOH to the tower-chlorinated pulp to generate nascent NaO Cl[51]. In another modified bleaching technique the Kappa number of pulp was reduced, hypochlorite added to first alkaline extraction stage and using peroxide in the second extraction stage, the consumption of active chlorine was reduced by 30% and NaOH by 15%. The most marked reduction in chemical demand was achieved from chlorine dioxide. These process modification also reduced the bleach plant effluent colour and decreased the effluent COD by 25%[52].

Apart from filtrate reuse in bleach plant the excess bleach effluent can be tried for the by-products. Pulp is bleached with chlorination followed by ammonia treatment and post bleaching with washing stages, between the steps. Waste waters resulting from washing stages are parified by electrodyalises and recovering ammonium chaloride from purified waste water[53].

Chemical And Stock Preparation :

The intermediate stage between pulp and paper is the step of stock preparation, which includes mainly beating, sizing, loading and dying.

A lot has been said in the literature for the effective sizing of paper and boards.[54-60] Apart from common variables in sizing e.g. pH before addition of size solution, effect of anions, presence of sodium aluminate along with alum etc. few uncommon variables which result improvement in sizing are recommended. A very small amount of alum present in the water prior to addition of size is beneficial to sizing[61]. Long since it has been recommended that high free rosin in paper sizing develops higher water repellancy than less free rosin in the rosin sized papers This idea has developed to the fact that even dispersed rosin is said to give better sizing than rosin soap sizes[62]. The improved sizing performance achieved by the use of rosin dispersions has been attributed, at least in part, to the more hydrophobic character of the rosin dispersion/alum complex. The mechanism of rosin soap size and dispersion rosin is described by Strazdins,[63]. Precipitates formed by colloidal and soap type of rosins are entirely different chemically. The colloidal free rosin reacts to form aluminium resinate only on the surface, if at all, most of it remains in the unreacted form. The Al. resinate forms only during paper drying

$$\mathrm{AcOH} + \mathrm{OH{-}\overset{\overset{\large O}{\|}}{C}{-}R} \xrightarrow{-H_2O} \mathrm{Ac{-}O{-}\overset{\overset{\large O}{\|}}{C}{-}R}$$

when rosin melts and it reacts with the alumina. The soap form of rosin cannot easily react with hydroxyl groups of alumina. to form the aluminium resinate during the drying step. Achieving uniform size distribution and proper orientation of Aluminium resinate on fibres offers the greatest challenge. These requirements can be best met by using colloidal or dispresion type of rosin.

Sizing agents other than rosin and rosin soap recommended are like, wax emulsions, mixture of rosin – wax emulsion, mersize (a reaction product of rosin and maleic anhydride or fumaric acid), Bituminous emulsions, silicones etc.[54] Fatty acids having a carbon chain of C_{18} to C_{22} are reported to give effective water proofness[64].

The recommendation of using sulphuric acid in the admix with Alum solution for the precipitation of rosin size has produced paper with higher strength better sizing and reduced pitch and scale deposits[54]. This will reduce the overall alum consumption.

The method of conserving the loading material is well known and is possible only when the one pass retention on the machine is maximum. The filler material may be a very cheap (China clay) or very costly (Titanium dioxide) a high retention is desirable so as to reduce the loss of pigments. The factors which affect retention are e.g retention increases with increased sheet weight, increased beating or refining of the stock, increased fibre length and increased white water reused; but decreases with increased suction at wire, increased wire shake, increased wire mesh and higher pH values[54]. Therein, is also mentioned the effect of some other substances known as retention aids. Materials like rosin size/alum, vegetable gums, cationic starches, potato starch, sodium aluminate, colloidal animal glue and acrylamide resin have been recommended for the purpose.

Colouring of paper is done because of the reasons known to all. Considerable quantity of dye stuffs is used by the paper industry for the production of coloured papers. Like fillers, the effective utilisation of dyestuff is achieved by the proper retention. The mechanism of the retention is different for basic, acid and direct dye stuffs[54]. Acid dyes have no affinity for the cellulose and both rosin and alum are necessary for the best retention of acid dyestuffs. Acid dyestuff tend to migrate to one side of the paper during drying, unless alum is used to fix them. The pH is important as a considerable loss in colouring value results if the pH is increased towards the neutral point. Some metallic cations, such as calcium, magnesium and lead will decrease the dye solubility of paper.

Basic dyes have slight affinity for pure cellulose. These dyes however have a verystrong affinity for unbleached and ground wood pulps. To dye bleached pulp with basic dyes mordants are frequently used Tannic acid or a complex formed from tannic acid and tartar emertic are frequently used as mordants. Mordants should be added with the dye before size and alum. The retention of dye is poor at the neutral point. Direct dye has a strong affinity for cellulose and be used without the assistance of rosin size or mordants. When used for deep shades on unsized papers the addition of sodium chloride increases retention and in most cases heating the stock increases the depth and brilliance of the shade (100-140°F) Sodium carbonate and sodium aluminate improve the brilliance of some direct dye stuffs (e g. Benzopurine). Some of the direct dyes are very sensitive to hard water. The retention of direct dye stuffs can be increased through the use of rosin size and alum.

Paper Machine : In the retention of sizing chemicals, filling materials and other wet end additives like pigments etc. the paper machine plays a very important role. The most important is the wire shake and white water reuse. The importance of turbulance and shake has been reviewed in a Tappi engineering conference held at New Orleans on 27-29 Nov. 1979. The main conclusions drawn were :

In a fibre suspension containing polymeric flocculants, the first pass retention, water removal and sheet structure are closely inter-related, so that a change in any one of these characteristics usually effects the others. The three characteristics can vary widely for the same furnish and the same additive depending upon turbulence during and after final polymer addition. different floculant types are affected differently by turbulence. Thus, inorganic salts and low mol wt. polymers (such as Poly ethyline Imine) which have little resistance to redispersion, whereas the flocs obtained with high molecular wt. polymers are more resistant to dispersion but inclined to reflocculate. High turbulence during and after flocculent additionleither requires excessive flocculant or causes low retention (while dewatering and sheet structure remains normal). Too low a turbulence during or after flocculant addition gives a high retention, but a low dryness at the couch and poor formation. Optimising the turbulence during and after polymer addition can either decrease the chemical consumption at equal retention or improve retention at identical additive dosage. If the turbulence can be optimised for a particular additive, then the first pass retention should be nearly complete (over 98% of the fine fraction) while permitting high dewatering rates in both forming and vaccuum zones thus giving dryer sheet at the couch and a possible speed increase[65].

Similar results were observed by Nelson while investigating the effects of process variables on retention and performance[66]. The colloidal aspects of the retention of positively charged additives (polystyrene latex) has been described by Alince[67]. In his paper he concludes that although the colloidal concept of mutual intraction of oppositely charged particles is applicable, the intimate contact required for irreversible deposition is not achieved. As a result, the energy introduced by even slow mixing is sufficient to redisperse the polystyrene latex when the double-layer attraction is reduced and when the latex exceeds, a limiting size. The aggregates of destabilized latex are apparently of such a size that hydro dynamic forces prevent their deposition. The behaviour of alumina is different, probably because of much smaller particle size, which makes it less sensitive to stirring and which may permit better contact with fibre. Destabilization of alumina results in more deposition.

The maximum water reuse in a paper machine is desirable from economy and ecology point of view. In an experimental trial water reuse was increased from 72% to 97%[68]. This reuse did not seriously effect the quality of paper, in strength properties, dirt count and printability and there were only minor differences in felt filling, press efficiency and suspended solids, although dissolved solids increased. Despite the higher BOD concentration total effluent BOD was reduced 50%. At the same time chemical saving amounted to 18% of filler consumption (without reduction in opacity and ash content) 50% alum, 20% of rosin consumption (while maintaining the same sizing degree). These savings could easily compensate for the neeessary modifications in equipment.

Further recovery of fines and chemicals can be recovered using the efficient save alls from the surplus back water.

Some costly fillers like Titanium Dioxide and Zinc sulphate have been recommended to use atleast partly in surface sizing which will reduce the total consumption of costly filler without reducing the degree of opacity[69].

Dryer section in a paper machine has also some effect on paper sizing The rate of water removal during drying is an important factor in sizing. If the temperature is raised too rapidly, the vapour pressure within the paper will exceed the rate of moisture escape; with the result that rosin size precipitate attached to the fibre will be disrupted. If heavy paper are heated too rapidly, a temporary film will be formed on the surface of paper which is later disrupted by vapour escaping from the interior. Under severe conditions, the rosin size precipitate may migrate to one surface of the sheet. As a remedy the excessive temperature in the initial dryers should be avoided, otherwise this will create an additional size consumption to achieve optimum sizing level.

Effluents :

In all the sections of the paper mill emphasis is placed on the disposal of minimum chemicals in the form of gases or liquid streams particularly in bleach plant and paper machine. In the existing state of semi closed paper mill system in our country there is strong economic drive to recover the chemicals from the effluent streams. The devices for recovering suspended solids are discussed by Roberts[70]. These include gravity settling chambers, floatation devices and mechanical filters, The chemicals recovered from the effluents will be a added economy and a last step in making the utilisation of chemicals. The recovery of chemicals from effluents will also discharge the waste streams well satisfying the discharge regulations put by the Government.

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