Development in high yield pulping process

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SUMMARY

Development in high yield pulping from mechanical to chemical processes have been discussed on existing theories and technique available. To achieve high yield pulp, main difficulty is experienced in preserving of fibrous material which is damaged due to physicochemical changes during the pulping. Pulp yield depends on the nature of raw material used, pulping process and process variables There are three general approaches to high yield pulp—improved uniformity of delignification adopting optimization of pulping conditions, stabilization of carbohydrate fraction and resorption of polymeric carbohydrates dissolved in early stages of cooking.

Recently various organic catalysts like quinones and amines have been introduced to improve the pulping economics. AQ alkaline pulping process has been supposed to be an alternative process. An attempt has been made on alkaline sulfite AQ process for wheat straw resulting to 60—65 percent pulp yield. This process gives 7-10 percent higher pulp yield on soda AQ and kraft with comparable physical strength properties. Also this pulp has been found to have light ye low colour with 55-60° GE brightness. This pulping process could be utilized in small scale industries for newsprint, lower grade of writing & printing, and grease proof paper.

The scarcity of raw material is being felt a serious problem all over the world, specially in developing countries. In our country, the pulp and paper production is below the normal needs due to growing population and more demand of paper and its products. Our forest resources are limited. In this context, high yield pulping offers one way to the solution of the problem of scarcity of raw material. This makes a way to minimize the gap between availability and requirement of raw material.

MECHANICAL PROCESS :

The main factors to this process are the absence of chemicals costs and the almost quantitative yield from wood, the yield losses being only 2—5 percent[1,2]. Mechanical pulping in grinders has several drawbacks resulting to the pulp of low purity and inferior strength.

To achieve acceptable grade of mechanical pulp from lower priced hardwood and softwood saw mill waste, methods have been developed which start from chips and use of disc refiners of various types[3-6]. Various types of chemical pre-treatments have also been tried from simple addition of sulfite and bisulfite in the refiner to achieve somewhat brighter as well as stronger pulps. In order to reduce energy consumption with or without chemicals, thermal softening of the inter-fibre bonds can be utilized. Hence, during last 10 years, thermomechanical, chemimechanical and chemithermomechanical pulping processes are being developed to overcome the drawbacks of mechanical pulp [7-10]. Ultra-high yield pulps are also attracting, increasing commercial interest[11].

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SEMICHEMICAL PROCESS :

Semichemical process involves with chemical treatment followed by the treatment in advanced mechanical fiberizing equipment. By addition of chemicals to the grinder showers, it is possible to achieve certain effect[12]. These processes are representing a transitional stage to semichemical. As impregnation was found to be one of the main problem in semichemical pulping of bolts, interest soon concentrated on the treatment of chips. Hydrolysis of wood has been studied from different angle and thermal softening has been considered the main purpose of this rocess[13,15]. However, the treatment in cold alkali lie at concentrations of 7—8 gpl NaOH followed by mechanical fiberizing, gives cold caustic straw pulps in 75—85 percent yield, suitable for Corrugating board[16].

To obtain acid sulfite pulp in high yield, pulping conditions should be chosen to give somewhat slower reactions. Slower reaction is achieved by lower temperature or higher combined So_2 (lower acidity)[17,19]. The semichemical kraft pulps are obtained in 55—70 percent yield, corresponding to Roe number 17—31 for American softwoods[20,24]. The yield of hardwoods pulps is somewhat higher than 55 percent.

Pulping in neutral or alkaline sulfite solutions was already suggested[25] and then repeatedly investigated[26,32]. A semichemical process using the neutral sulfite process had been worked out by the U.S. Forest Products Laboratory[33,34]. The most common yield range of 85—70 percent for well-buffered neutral sulfite cooks[35,38]. Neutral sulfite pulps from eucalyptus give very interesting paper characteristics[9]. Hardwood pulps made from this process are frequently stronger than chemical hardwood pulp[40] Extremely mi d neutral sulfite cooks, giving pulp yield of 85—95 percent from both hardwood and softwoods, are also of interest for newsprint[41].

CHEMICAL PROCESS :

Mc Govern[42] has reported that there are three general approaches to high yield chemical pulping process.

(i) Improved uniformity of delignification adopting optimization of pulping conditions.

(ii) Stabilization of Carbohydrate fraction.

(iii) Resorption of polymeric carbohydrates in early stages of cooking.

The attack of chemicals on cellulose and hemicellulose depends on the type and concentration of chemicals employed in cooking. The extent of attack on the particular fraction of carbohydrate may be dependent on its degree of polymerization, manner of combination with other carbohydrates as well as lignin.

ALKALINE CHEMICAL PROCESS :

High yield kraft pulps in the yield range of 60-70 percent have been obtained by various worker[43-45] by optimizing the pulping conditions The increase in yields of practical interest, attempt. have been made with the use of inorganic chemicals A systematic search for oxidents and reductantss have been tested[46]. Sodium dithionite and Sodium. tetrahydroborate are investigated[47-51]. The increase in yield was found to originate entirely from an increase in gluco-mannan yield, 6 percent of wood and possibly some increase in cellulose yield, 1 percent of wood.

Polysulfide pulping is one of the recent innovations in the field of high yield pulping. Data of Kleppe [2] based on the experience of mill scale polysulfide pulping indicate that yield could be increased by 1.5-2.0 times the amount of added sulfur when 20-30 Kgs. of sulfur per metric ton of pulp dissolved in white liquor charged to a dual vessel Kamyr digester although the sulfidity of cooking liquor was 40-5 percent. An increase of 6.3 percent in the pulp yield was observed with addition of 2-5 percent polysulfide sulfur to the cooking liquor.

SULFITE PROCESS :

The removal of lignin was significantly more by sulfite cooking while the attack on extractive was considerably less The carbohydrates of sulfite cook are subjected to several changes and the most important reaction of which is acid hydrolysis of the glycosidic bonds. The extent of carbohydrate decomposition is largely controlled by three factors time, temperature and acidity. On the increasing of pH of the cooking liquor, and thereby bysulfite ion concentration, more favourable conditions for the preservation of acid-sensitive carbohydrates are secured. Therefore, only significant higher yields at certain degree of delignification are secured on increasing the combined SO_2 charge from the normal level[53-55].

ORGANIC CATALYST TO HIGH YIELD PULPING

Recently trials have confirmed the benefits to be gained by employing the organic catalyst in digester.

Various quinones and amines have been tried to accelerate the delignification with stabilization in carbohydrate fraction[56-63]. The cost and availability of the catalyst could prove limiting factors. Acceptance of anthraquinone (AQ) as an attractive means of improving pulping economics has been faster than is typical in the paper industry.

CIL Laboratory results[59] showed that 0.05 percent AQ increased the yield of southern softwood pulp by 2-3 percent. At this time there are about 10 Companies in the world which are operating AQ pulp mills. In Japan, AQ producer Kawasaki Kasei chemicals has patented and commercialized its technology concurrently with CIL.

What Holtan[59] does predict is that one of the optimum ways of using AQ will be as a combination to reduce the H factor as well as the alkalinity in order to control its effects. A 10-15 percent reduction in the amount of active alkalinity or in H-Factor is possible at standard AQ application rates. AQ can and will be used in many different way and as Holtan says "The reasons chosen by actual mills will be as unique as the mill themselves".

AQ PULPING TECHNOLOGY :

AQ is only effective in alkaline pulping where it accelerates delignification and also improves pulp yield of between 2.5–4 percent. Laboratory results[60] indicate that larger reductions in alkali charge could be made and that use of yield gains of as much as 2—3 percent on wood at constant kappa number for southern pine chips. Ghosh *et al*[61] reported that addition of small amounts of AQ resulted in significant increases in the delignification and pulp yield, and reduction of rejects without significant losses in strength for hard-woods. Virkola *et al*[62] presented the details of NS AQ pulping, then its potential application. The alkaline liquor consists mostly of Na_2So_3 plus some Na_2Co_3 and NaOH, the apparent optimum Na_2So_3 proportion being 80—85 percent of the total alkali. Light coloured unbleached softwood pulp is achieved with a big yield advantage over conventional kraft pulp (7 - 10 percent points higher than total yield at – 40 kappa number). The yield gain is primarily due to better retention of hemicellulose NS—AQ pulp at about 80 kappa, is about 19 percent points higher yield than kraft. With maritine pine, Alcaper provides 2 percent higher yield than kraft at 30 kappa adopting a new technique by combining the catalytic effect of anthraquinone and the delignifying capability of hydrogen peroxide into a single process[63].

POLYSULFIDE–AQ PROCESS[63] :

Glen Brown of Head Corp. spoke about pilot-scale trials of maxy polysulfide pulping with and without AQ and also about AQ's effect on the soda and kraft processes. Brown's Key piece of information about AQ in polysulfide pulping : "The yield increases of polysulfide and AQ the kraft process are additive." First describing results on mixed hard-woods, Brown provided that 0.1 percent AQ on wood gave upto 3.5 percent greater yielq in soda pulping, and about 1.4 percent higher yield in the kraft and polysulfide processes. The observation with a pine spruce mixture were similar upto 2 percent higher yield using 0.15 percent AQ in either kraft or polysulfide processes.

ALKALINE SULFITE—AQ PULPING

Paper units are facing a problem of high cost of production. This problem is due to ever increasing cost of raw material, cooking, bleaching and pollution treatment chemicals. One way to solve this problem is to investigate an alternate high yield pulping process which will result to high yield of semibleached pulp. In this direction, an attempt has been made in our laboratory using wheat straw as a raw material.

The cooking liquor for alkaline sulfite pulping consists NaOH and Na_2SO_3. The cooks were conducted to achieve the optimum Na_2SO_3 proportion with and without AQ. The optimum Na_2SO_3 proportion was found to be having 65-70 percent of the total alkali for wheat straw. The effect of AQ charge was studied and optimum charge was found to be 0.05 percent on o.d. straw. Soda and Kraft like alkali concentration and material to, liquor ratio were used. It is observed that in the study of alkaline sulfite pulping, the pH of cooking liquor drops quickly during the early part of the cook and most of the pulping is progressed at pH 9.5-10.2. The temperature was kept 150°C for two hours. The pulps so formed are 60-65 percent yield having Kappa number 20-25. In this study, it is interesting to note that the pulps are light yellow in colour having the brightness 55-60° GE. The properties of the pulp is shown in Table No. 1.

TABLE NO. I—STRENGTH PROPERTIES OF ALKALINE SULFITE AQ WHEAT STRAW PULP

Chemical Charge 8 % as NaOH

Na_2SO_3 55 % ($Na_2SO_3 \times 100$/Total alkali)—both as NaOH

Pulp Yield 62 %

Kappa Number 24.0

Particulars	Unit	Pulp Properties 1	2	3	4
Beating time	minutes	5	10	15	20
Freeness	°SR	28	34	40	48
Drainage time	Sec.	11	14	15	18
Burst factor	—	36.4	39.0	40.8	41.5
Breaking length	Metres	6690	7260	7700	7750
Tear factor	—	36.3	34.0	32.6	29.5

TABLE NO. 2—ALKALINE SULFITE—AQ, SODA AQ AND KRAFT PULPS OF WHEAT STRAW[1]

Particulars		Pulping Process Alkaline Sulfite-AQ	Soda AQ	Kraft
Chemical Charge as NaOH on o. d. straw	%	0.8	12.0	13.5
AQ on o. d. straw	%	0.05	0.05	—
Na_2SO_3	%	5.2	—	—
NaOH	%	2.8	12.0	10.9
Na_2S	%	—	—	2.8
Pulp yield	%	62.0	54.5	54.0
Kappa Number		24.00	24.1	23.4
Unbleached Pulp Brightness	°GE	56	35	34
Burst factor		40.8	41.0	42.5
Breaking length	Metres	7700	7510	7710
Tear factor		32.6	31.7	34.0

Pulps were beaten at 40SR.

The Soda-AQ, Kraft pulps were fully compared to alkaline sulfite AQ pulps, at similar kappa level. Alkaline sulfite-AQ pulp has 7-10 percent higher yield than soda AQ and kraft pulps. The brightness of the pulp is also observed 20-22°GE higher than Soda AQ and kraft with almost comparable physical strength properties. The results have been shown in table No 2.

The results of table No. 1 shows that this alkaline sulfite AQ pulp can be used for newsprint and lower grade of writing and printing paper. The cpacity of the pulp is observed about 85-90 percent. When high yield pulp of alkaline sulfite AQ was beaten to 85° SR level, then the results were observed as Burst factor 50, Breaking length 6 50 Km, Tear factor 24 and blister test 'good'. Therefore, this pulp also can be used for grease proof paper.

From the results of table No. 2, it is clear that alkaline sulfite AQ process gives the possibility of minimizing or reducing altogether pulping and bleaching chemicals which in turn shall save the cost of pulping and bleaching chemicals as well as pollution treatment.

EXPERIMENTAL

The wheat straw was chopped to a length of 2.5-5 Cm. All cooks were carried out in a tumbling digester of 15 litres capacity. The constant cooking conditions were as, Cooking temperature 150°C, time to maximum temperature 60 minutes, Cooking time 120 minutes and liquor to straw material ratio 6 : 1. The resulting pulps were washed in diffuser and evaluated using Tappi Standard Methods.

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