Role of Wet-End-Additives in Process And Quality Control in Paper Mills

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SUMMARY

Bamboo and hardwoods (mixed) are used as the fibre source by large mills. The smaller mills use bagasse, agricultural wastes and recycle paper. Consequently, their pulp quality may be poor. More over, the fine-fibre loss at the *'wire'* may be excessive to upset process economics of the smaller paper mills. Small and medium scale mills account for about 35 percent paper capacity in India. Improved fibre recovery and better quality control for smaller mills are desirable.

Hemicelluloses are essential to impart hydration properties to the pulp and thererby contribute to the strength of paper sheets. Unfortunately, they are lost during the drastic pulping process conditions. Wet-end-additives are required to prevent fine fibre loss and to supplement functions of hemicellulose to build-up strength properties of the paper. Starches, carboxymethyl cellulose and guar gum are among the popular beater/wet-end-additives. A judicious use of wet-end-additives would help in obtaining the desired results This paper discusses the role of wet-end-additives in process and quality control of paper mills. The importance of wet-end-additives for smaller units has been pointed out

Indian paper industry is a typical mix of small and large paper mills. While wood and bamboo are the principal raw materials for large mills, the smaller units process bagasse, recycle paper, grasses and other agricultural residues. Raw material situation is not too happy for both the sectors. The total installed capacity is 19.15 lakh tons and the capacity utilization is about 65 percent. Currently, the industry is afflicted with many problems including unsatisfactory position of power and coal supplies to smaller mills. Recently some developmental aspects of the paper industry have been highlighted[1-3]. Efficient process operations and proper quality control are the need of hour. This paper discusses the role of wet-end-additives in process and quality control in paper mills.

The quality of paper obtained depends greatly on the fibre quality. Each fibre is itself a highly complex structure, having a definite shape, formed from smaller entities called fibrils, which in turn, have a cellular structure. By pouring the dilute fibre suspension on to an endless moving sievelike belt, a mat of fibres is formed continuously. When sufficient water has been removed, this mat is separated from the endless belt and forms a continuous web of paper. The formation of a continuous web of desired strength properties from a dilute suspensions of fibres containing suitable additives is the focal point of the paper making process. Upstream, the fibres and various additives are extracted from their natural state, subjected to appropriate treatment and brought together in the required proportions. Downstream, the wet web ispresseed and dried, surface sized when required before it ends up as finished paper of desired quality.

The strength of paper sheet is a complex function of fibre length, conditions of surface, orientation of fibres in the sheet and the density of the sheet. Deficiencies in the strength of paper are usually attributed to deficiencies in the bonding not to be lack of intrinsic fibre strength.

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Paper with satisfactory strength cannot be made unless there is a high degree of bonding between the fibres in the sheet. Fibre-to-fibre bonding is mainly due to hydrogen bonding effects. Fibre hydration improved by the beating process results in enhanced strength properties The presence of hemicelluloses imparts improved hydration to the pulp. Unfortunately, a large amount of hemicelluloses are lost during the drastic pulping process conditions. Addition of internal bonding agents to the pulp stock is. therefore, found essential to improve paper quality.

WET-END-ADDITIVES

The need for internal bonding agents for pulp fibres to obtain good quality paper is obvious. Beater and/or refiner are the proper stages for the entry of these bonding agents into the pulp stock. Hence, they are termed as wet-end-additives. There are many materials which can be used to increase the fibre bonding and reduce the detrimental effect of excessive beating on fibre but the choice is to be limited to less expensive and abundantly available materials. Starches, carboxymethyl cellulose and guar gum are among the popular organic compounds used as wet-end-additives. Rosin, alum, China clay and other pigments and colouring matter are also added to the pulp stock to import certain other properties to the paper, but they are not used as internal bonding agents. Guha et al[4-6] and Negi[7] have discussed some aspects of beater additives. Recently, Rai et al[8] reviewed this field.

STARCHES

The principal function of starch is to increase strength of the sheet and to reduce the surface fuzz. The fibre-to-starch-to-fibre bonding is stronger than fibre-to-fibre bonding. This results in increased tensile and bursting strengths of paper. Tearing strength is usually lowered and folding endurance increases slightly. Maize and tapioca starches are commercially available. Gehlawat and Pandya[9] developed a pre-gelatinized starch. Figure 1 shows improvements obtained in tensile strength of paper sheets using pregelatininized starch. ATIRA are working on the development and testing of cationic starches[10].

CARBOXY METHYL CELLULOSE

Among synthetic water soluble materials, carboxymethyl cellulose (C.M.C.) has been used as beater additive. However, one of the problems with C.M.C. has been in obtaining sufficient retention[8]. Laurell[11] found that unless alum was added, the retention was practically negligible and that the retention was satisfactory when the addition of alumn preceded that of CMC. Table 1 gives data on strength properties of paper sheets on using C.M.C. as the wet-end-additive. It is noted that while the drop in freeness value is considerable, the improvement in strength properties is nominal.

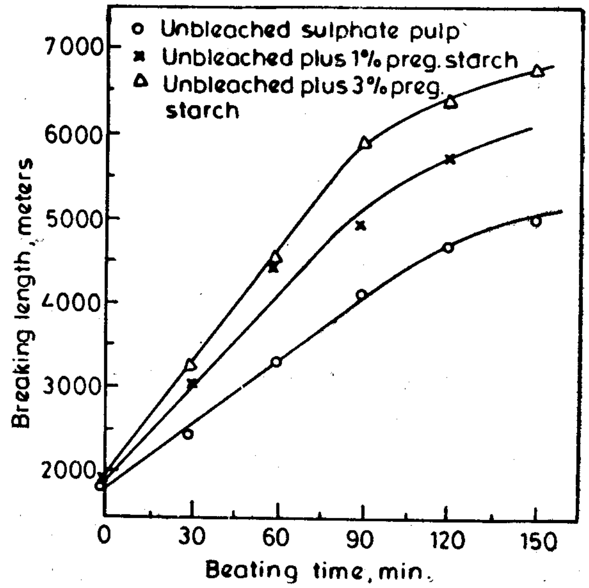

Fig. 1 - Improvement in tensile strength of paper sheets on addition of gelatinised starch.

GUAR GUM

Guar gum and locust bean gum are among the popular natural vegetable gums which find extensive use in paper making. These gums are similar in that both are galactomannans having a straight mannose chain linked 1.4 in a beta position, with galactose branchings. Guar gum has more frequent branchings than locust bean gum. Consequently, it is cold water soluble whereas locust bean gum must be cooked. India does not produce locust bean gum. Guar gum is available in abundance.

Table 2 gives strength properties of paper sheets from bamboo kraft pulp treated with commercial guar gums as per TAPPI standards. The data in Table 3 are reported in S.I. units. Appreciable improvements in tensile strength, bursting strength and folding endurance are noted. This is achieved partly due to greater fibre-to-gum-to-fibre bonding strength and partly as a result of improved sheet formation with more regular distribution of pulp fibres (less fibre bundles). At 1 5% level of addition increase in strength properties of paper is found to be optimum.

TABLE—1 PHYSICAL STRENGTH PROPERTIES OF PAPER FROM BAMBOO KRAFT PULP WITH C. M. C.

Sl. No.	Trade name of additive	% of additive	Freeness value (C.S.F.), ml	Breaking length, m	Burst Factor	Tear factor	Ash content %
1.	Control pulp	nil	210	3130	22.8	85.7	3.1
2.	Cellprp LVB	0.5	180	3340	25.0	88.0	4.6
3.	—do—	1.0	160	3500	25.0	89.0	4.7
4.	—do—	1.5	130	3630	26.4	91.1	5.4

Source : Rai, et al. (Ref. 8)

IMPORTANCE OF WET-END-ADDITIVES FOR SMALL MILLS

Presently small and medium scale mills account for about 35% paper capacity. The demand projections for the next 15 years (by the turn of century) are put at about 40 lakh tons. It means that the capacity must be doubled during the coming decade. This indicates bright prospects for the industry provided raw material situation improves and that adequate resources can be generated to build additional capacity. Future increase in capacity is likely to be more in the small and medium scale sector. An improvement in the efficiency of small mills is, therefore, of national importance. They use a variety of raw materials including recycle paper due to seasonal and other factors. Consequently, their paper quality may not be at par with that produced by large mills from virgin pulp (from wood or bamboo). Moreover, the fine fibre loss at the '**wire**' may be excessive to upset the process economics of the smaller paper mills. Obviously, the major attention for control on paper quality and fine fibre loss must begin at the stage of pulp stock preparation. In this regard a judicious use of wet-end-additives appears desirable.

TABLE—2 PHYSICAL STRENGTH PROPERTIES OF PAPER FROM DIFFERENT PULPS WITH GUAR GUM

Sl. No.	Trade name of additive	% of additive	Freeness value (C.S.F.), ml	Breaking length, m	Burst factor	Tear factor	Folding endurance (double fold)	% ash content
1.	Control pulp	nil	250	4360	26.8	107.6	25	—
2.	Daicol GSP	0.25	230	4600	29.2	97.9	28	—
3.	—do—	0.50	220	4760	31.2	95.3	34	—
4.	—do—	1.00	180	5020	33.4	88.8	45	—
5.	Control pulp	nil	250	1880	9.3	43.7	—	6.1
6.	Guar gum HK	0.5	175	2000	11.4	52.9	—	7.7
7.	—do—	1.0	170	2420	13.7	54.0	—	8.3
8.	—do—	1.5	150	2670	14.0	58.0	—	8.5
9.	Control pulp	nil	250	1880	9.3	43.7	—	6.1
10.	Higum PC	0.5	175	2200	12.2	48.6	—	7.0
11.	—do—	1.0	170	2340	12.5	50.8	—	7.8
12.	—do—	1.5	170	2400	13.4	53.7	—	8.1

Source : Rai, et al. (Ref. 8)

TABLE—3 PHYSICAL STRENGTH PROPERTIES OF UNBLEACHED PAPER FROM BAMBOO KRAFT WITH GUAR GUM

Particulars of test	Control pulp	Guar Gum A % on pulp (wt)			Control pulp	Guar gum B % on pulp		
		1.0	1.5	2.0		1.0	1.5	2.0
Tensile index (N. mg.)	50.87	51.01	53.60	55.40	46.59	48.29	49.46	55.64
Stretch %	2.93	2.72	2.65	2.7[illegible]	2.50	2.73	2.29	2.97
Tear index N. m²/g	16.67	13.83	13.47	13.80	14.72	14.20	14.00	13.80
Burst index N. m²/g	3.14	3.46	3.79	3.86	3.20	3 70	3.79	4.13
Air resistance N/100 ml	16	25	34	23	10	26	25	37
Fold, Kohler	382	501	381	388	350	355	444	398

Source : Rai et al. (Ref. 8)

It may be noted from the results and discussions elsewhere on individual wet-end-additives that guar gum is more effective. Being cheaper and readily available, on cost-equivalent considerations, guar gum appears to be a better choice. Composed of cross-linked galactomannan units with primary and secondary hydroxyl groups guar gum is ideal bonding agent for paper fibres. It is readily absorbed by the cellulosic fibres probably because of its close similarity to hemicelluloses. Hence, addition of guar gum to pulp stock is known to improve the retention of fine fibre and minerals additives in to the paper mat on wire (8, 12). This property of guar gum is of considerable importance to small paper mills where fine fibre losses are generally excessive and the pulp quality is poor on account of secondary fibres in the furnish.

Fine fibre loss of 5-8% is not uncommon for small mills. Installation of mechanical system for fine fibre recovery is not only an additional investment, its operating costs are excessive. A built-in process control on fine fibre loss through the use of guar gum as a wet-end-additive should be found an advantageously simple proposition. For example, an addition of about 1 to 1 5% guar gum to the pulp stock at the beater/refiner stage would not only prevent fine fibre loss considerably, it would enhance retention of inorganic fillers in addition to its main function of increasing the strength properties of paper. Consequently, the product quality and process efficiency will be improved with considerable cost benefits to the paper mills.

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