ISSN: 0379-5462
IPPTA: Quarterly Journal of Indian Pulp and Paper Technical Association
Vol. 29, E2, 2017, pp.24-28

ENHANCING PRINTING AND OPTICAL PROPERTIES OF PAPER BY USING IMPROVED TECHNIQUES OF FILLER RETENTION

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Summary :

The enhancement in filler retention in the furnish of mixed hardwood pulp (eucalyptus and poplar) in the ratio 50:50 can be obtained by adopting the different approaches including addition of cationic starch, a dual type retention aid, pre-flocculation of filler or using a described polarity treatment technique. The polarity treatment results in better retention as compared to other techniques. Addition of filler upto 40% in refined pulp devoid of fines gives better results as compared to refined pulp with primary fines. Particle size of filler has tremendous effect on different properties viz: strength, optical and surface properties. With increase in the filler retention printing characteristics like print density and print uniformity were also improved. Soft nip calendering of filler sheets gave better results than hard nip calendering on selected calendering parameters. The print through tendency was reduced with addition of fillers.

Keywords: Mixed hardwood pulp, pre flocculated filler, talc, particle size, print density, filler retention.

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INTRODUCTION

Paper making fillers have been becoming an important component of paper making furnishes owing to two most important reasons. First is the ever increasing cost of virgin pulp and the energy associated with its transformation into paper. The replacement of pulp fibers with less expensive filler material has proved particularly economical. Therefore fillers are used in papermaking to provide cost and energy savings. The second reason is the improvement of paper properties especially in terms of improvement in optical properties, sheet formation, smoothness, printability, dimensional stability and appearance of paper. However, the addition of filler inevitably reduces paper strength and increasing loading levels of inorganic fillers have negative effects on filler retention, resulting in higher solids contents of the circulating system [1,2,12,13].

The use of filler depends upon the nature of fibers, wet-end process parameters/ conditions, wet-end chemicals and additives and end use of paper. In India the papermakers are not in a position to increase filler content beyond a certain limit (~ 15% max). The reason could be stability of filler with wet-end chemicals (mainly dry and wet strength additives and retention aids) and fibers i.e. short hardwood fibers, agro-residue fibers and recycled fibers. Thus Indian paper makers are struggling to increase filler content in paper so as to reduce cost and achieve desirable properties of paper.

Increasing filler content in pulp products has been an area of interest for a long time by paper industry worldwide. Fillers are selected to provide distinct functions in paper making [3,10]. They have a remarkable influence on paper quality and in particular on paper production economics. The incorporation of fillers into the paper making process gives positive effect to sheet formation, smoothness, brightness, opacity, dimensional stability and printing characteristics [15, 21, 22]. The paper industry utilizes fillers either to decrease paper cost or to provide desirable functional or end-use properties of paper or both [5,6,13,14,18, 22] .

During the formation of a paper sheet, filler particles can be retained by mechanical entrapment or by charge interactions. In

general, the average dimension for most papermaking fibers are 0.5-2 mm long and 5-50 µm wide, fibrils 100-500 µm long and 0.2-0.5 µm wide, fiber debris 50-100 µm long and 5-50 µm wide, and fillers 0.2-1.5 µm long and 0.1-10µm wide. The paper network generally contains more than 50 % of void space. The fibres forms the framework and filler particles are not large enough in dimensions to cause major spatial disruption.

The retention of filler on pulp can be improved by various means including addition of cationic starch, a dual type retention aid, pre-flocculation of filler or by using polarity treatment technique [4,6,10,16,18,20].Pre-flocculation technique has been reported in literature for improving the filler retention [8,13,19]. This approach was tried to improve the filler retention. Pre flocculation is treating the filler particles with a chemical modifier which causes them to flocculate, prior to paper stock. This method will be helpful in increasing filler contents in Indian fine papers without compromising paper strength. Beside this, following conventional approaches can also be used to achieve increased filler retention without any problems to papermaking process and to enhance fiber bonding.

- Pulp selection for strength properties, for example, it may be necessary to increase the percentage of the long fiber component of paper furnish.
- Optimisation of refining to increase strength, to enhance those product properties that are likely to be degraded by addition of filler.
- Use of different size press additives and technology to improve surface properties and reduce picking and dusting.
- Wet-end addition of strength aids to increase the level of bonding.
- Use of pre-flocculated techniques to agglomerate the filler into a spongy mass to lower specific surface area to minimize the debonding effect of higher specific surface area fillers.
- Use of pre-adsorbed additives on the filler surface to enhance the bonding on the fiber surface.

In India, talc is predominantly used as filler for paper making. Chemically, talc is hydrated magnesium silicate $3MgO.\ 4SiO_2.H_2O$. The particles are very thin platelets, possessing the unusual characteristics of having both hydrophilic and hydrophobic surface. Presently the maximum amount of filler used by Indian mills in cultural papers is 15%, except for few mills where higher levels are achieved. Hence, in this study few options were tried to improve talc filler loading in paper made from hardwood pulp.

In the present investigation the possibility of improving the talc filler retention in paper made from the furnish of mixed hardwood pulp has been studied.

EXPERIMENTAL

Commercial bleached hardwood kraft pulp (eucalyptus: poplar =50:50) was collected from an integrated Pulp & Paper mill. Other wet end chemicals like cationic starch, hydrocol, anionic flocculant and filler talc were procured from the reputed suppliers.

Different laboratory equipments used for carrying above work are PFI mill, Rapid Kothen sheet former, fiber fractionator, Horiba LA 920 laser scattering particle size analyser, L&W elerepho, tensile tester, tear tester, DAT 1100 Fibro System, DT laboratory calender, densometer, fiber rising tester and L&W air permeance tester.

Bleached hardwood kraft pulp collected from mill was treated in fiber fractionator using 250 mesh to remove the primary fines. After the removal of primary fines beating, was carried out in the PFI mill to freeness level of 300±50 ml CSF using a pulp charge of 30 g and 10% stock consistency, at a beating load of 17.7 N/cm, as per the ISO 5264-2:2002 method.

Handsheets were prepared in accordance with the ISO 5269-2:1998 method on a rapid kothen sheet former equipped with a back water recirculation facility. The first few sheets were rejected and the remaining sheets were prepared using the back water from the earlier sheets. Filler with different particle size were added to handsheets along with the retention aid.

The handsheets thus prepared were conditioned at the temperature of 27±1˚C and relative humidity of 65±2% and tested for the following properties in accordance with standards mentioned along.

- Apparent density ISO 534
- Tensile Index ISO 1924
- Tear Index ISO 1974
- Sp. Scattering co-efficient ISO 9416
- Brightness ISO 2470

- All the printing test were carried out on laboratory IGT - Printability Tester AIC2 -5.

Talc used as filler in this study was analysed for different parameters as under

- Brightness 93%
- Refractive index 1.57
- Sp. gravity 2.70 g/cm3

The fillers of different particle size were tried. The particle size (0.2-11µ) of fillers was evaluated using Horiba LA 920 based on laser scattering technique.

In the present investigation, different approaches apart from conventional approach were undertaken to increase the filler retention on pulp and to visualize its effect on different properties. Following approaches were followed:

- Single-component retention aid: Cationic starch of charge density 176.6µ.eq/g (1% on O.D. pulp basis) was used as the retention aid.
- Dual-component retention aid: A Hydrocol® program comprising of 0.2% polymer (cationic polyacrylamide resin charge density 1200µ.eq/g) and 0.2% montmorillonite pigment (charge density negative 60.2 µ.eq/g) was used as retention aid.

- Pre flocculated filler: The filler was dispersed in water to prepare slurry. To this slurry 0.1% anionic flocculant was added followed by 1% cationic starch. The pre-flocculated filler thus obtained was added to pulp slurry.
- Polarity treatment to filler and pulp: The filler was treated with anionic polymer (0.1% Anionic polyacrylamide resin charge density 2925 µ.eq/g), and the pulp was separately treated with 1% cationic starch. Both filler and pulp were mixed together.

RESULTS AND DISCUSSION

1. Effect of addition of retention aid using different approaches.

In all the cases, filler i.e. talc was add up-to 40%. The sheets obtained by following different retention approaches were studied for different properties. The results were tabulated as below in Table 1.

Usage of micro particle retention aid has been described in the literature for improving filler retention (2). Cationic starch and the hydrocol® microparticle retention aid were tried. Micro particle system gave 3.5% better filler retention than starch alone and also it is helped in retaining better tensile index, tear index and sp. scatt. co-efficient (Table 1).

Table 1. Properties of Hardwood Pulp under Different Retention Treatment at 40% Talc Addition

Pulp with filler	Apparent density (g/cm^3)	Tensile index (N.m/g)	Tear index ($mN.m^2/g$)	Sp. scatt. co-eff. (m^2/kg)	Filler retention (%)
Blank	0.75	62.0	5.76	39.5	Nil
Talc only	0.79	37.5	4.80	44.8	58.2
Talc + starch	0.83	41.5	4.92	45.7	59.7
Talc + hydrocol	0.84	45.5	5.20	46.9	63.5
Pre flocculated talc	0.81	44.5	5.09	45.2	62.8
Polarity treated talc	0.82	46.0	5.30	48.3	66.3

The results show that pre flocculated filler when added to pulp slurry gave better retention, marginally high tensile index and tear index but lower sp. scatt. co-efficient than starch alone. However these properties were lower than those observed in the case of micro particle retention aid (Table 1).

Another approach tried was to create a system where filler itself takes part in bonding process. This results in more loading of filler in paper with enhanced paper properties. It was observed that this method results in better retention value (about 2.8 to 6.3%) than the other methods. The paper characteristics viz. tensile index, tear index and sp. scatt. co-efficient were best in this case.

2. Effect of pulp refining on filler retention using different approaches of retention aid

Refining generally carried out to open the fiber structure and producing fibrillation in fibers. This helps in increasing fines and fillers retention in pulp due to mechanical entanglement between fiber structures. Presence of primary fines in pulp results in lower bonding. Removal of these primary fines leads to better fibrillation of pulp during refining. In order to correctly determine the effect of refining, two approaches were followed. In one approach refined pulp was taken as such and filler addition upto 40% was done using different approaches of filler retention. In another approach, unrefined pulp was devoid of primary fines by passing it through fiber fractionator. This fractionated pulp was refined to required freeness level and then filler (talc) was added upto 40% using different approaches of filler retention. The results are tabulated in Table 2. It was observed that the pulp devoid of primary fines could retain more filler (by about 4.4 to 5%). This was probably due to reason that the pulp fibres get better fibrillated on refining in the absence of primary

Table 2. Properties of Hardwood Pulp after Removal of Primary Fines under Different Retention Treatment

Pulp with filler	Apparent density (g/cm^3)	Tensile index (N.m/g)	Tear index ($mN.m^2/g$)	Sp. scatt. co-eff. (m^2/kg)	Filler retention (%)
Blank	0.73	69.8	6.48	38.0	-
Talc only	0.78	45.2	5.67	46.8	63.4
Talc + starch	0.82	48.2	5.87	48.1	65.2
Talc + hydrocol	0.81	52.1	6.07	48.9	68.8
Pre flocculated talc	0.80	51.3	5.97	47.2	67.2
Polarity treated talc	0.82	52.8	6.02	50.1	71.0

fines which in turn caused better retention of filler.

3. Effect of Filler Particles Size on its Retention ability and Paper Characteristics.

a. Strength, optical and surface properties.

The particle size of filler is a dominant factor in deciding its retention on pulp and consequent properties of paper. In present study talc of different particle size were taken and added in pulp slurry. Results shows that the larger particle size (> 5 µm) has lesser disruption effect on the tensile strength than that of finer particles. This is probably due to the attachment of small filler particles to fibrils thus preventing collapse and consolidation on drying (Fig. 1).

Similarly for optical properties the maximum scattering is around 65m^2/kg for the filler of particle size 1.4µ. Further with increasing particle size the sp. scatt. co-efficient falls down. Although there appears a simple relationship between the filler particles size and light scattering for filler but it is not always true as anything which influences the void structure of the sheet or the filler will have significant effect.

Figure 3 shows porosity as function of the filler particle size. The porosity of paper increases with increase in particle size of filler. This is probably due to that the coarse particles increase the void spaces of the sheet hence porosity.

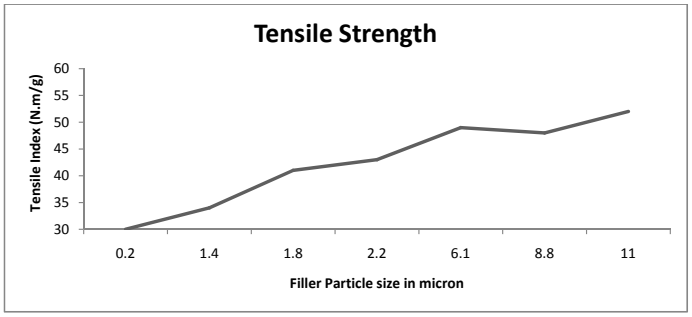

Figure 1: Effect of particle size (talc) on tensile strength of hardwood pulp at 40% addition level

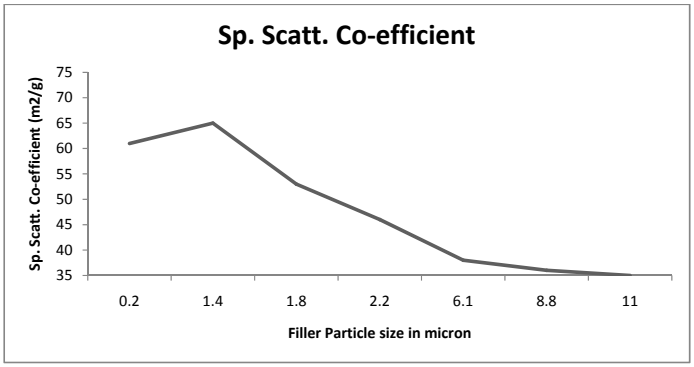

Figure 2: Effect of particle size (talc) on specific light scattering coefficient at 40% addition level

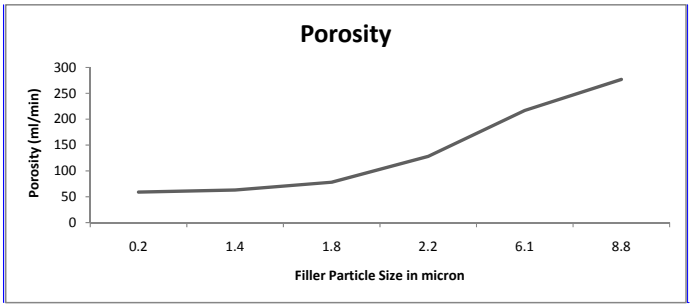

Figure 3: Effect of particle size (talc) on porosity of hardwood pulp at 40 % addition level

4. Effect of filler addition on printing characteristics of paper.

To observe the effect of increased filler loading on the printing characteristics, handsheets were prepared using different dosages of the talc as filler under different conditions. The sheets were given sizing treatment using 0.8% AKD. These sheets were calendared using laboratory calendar under hard nip and soft nip configuration at 10 bar pressure and 90˚C temperature. Different printing properties like print density and print through were evaluated. Print density and print through parameters were evaluated

Table 3. Printing characteristics of paper having different amount of filler after hard nip and soft nip calendering

Filler addition (%)	Ash (%)	Printing characteristics				
		Hard nip calendering		Soft nip calendering		Print through
		m	D∞	m	D∞	
Blank	1.2	0.39	1.21	0.40	1.31	0.73
10	7.6	0.40	1.28	0.42	1.34	0.61
20	15.2	0.42	1.30	0.45	1.37	0.57
30	20.2	0.43	1.33	0.47	1.42	0.55
40	26.0	0.45	1.35	0.48	1.44	0.48
50	32.1	0.46	1.39	0.47	1.48	0.45
40+Cat. starch	27.3	0.47	1.38	0.49	1.45	0.46
40+Hydrocol	28.0	0.47	1.38	0.49	1.45	0.46
Preflocculation	27.6	0.46	1.37	0.47	1.46	0.48
Polarity treated talc	29.3	0.47	1.39	0.51	1.49	0.42

after printing on IGT printability tester (AIC 2-5 model). Results are shown in Table 3.

Print density curve parameters i.e. Contact factor m and Saturation density D∞ were evaluated as method described in literature [21]. It was observed that contact factor (m) and saturation density are improved with the addition of filler. Contact factor got improved from 0.39 to 0.50 and saturation density got increased from 1.21 to 1.49. Soft nip calendaring gave better improvement than hard nip calendaring. The print through tendency got reduced with the addition of filler. The value of print through is 0.73 for blank which was reduced by 33% at filler level of 26.2%.

CONCLUSIONS

- The retention of filler in hardwood pulp can be improved by use of dual component retention aids or pre-flocculation of fillers or using polarity treatment technique. Preflocculated filler gave better retention, marginally higher tensile index and tear index but lower sp. scatt. co-efficient than starch alone. The properties were lower than those observed in case of hydrocol addition. Best result was obtained using polarity treatment as compared to other methods. The filler retention was improved by refining. Better retention was obtained in refined pulp when primary fines were removed from the pulp. With an increase in particle size of filler retention ability of filler also increases which has significant effects on strength, optical and surface properties of paper.

- Filler addition resulted in improved printing characteristics. The print contact factor and print saturation density got improved. Soft nip calendering gave better improvement than hard nip calendering. The print through density got reduced with the addition of filler.

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