Improvement of Paper Properties Part II : Addition of Kaolin and Starch to Bagasse Paper Sheets Treated with Gelatin-Hexamine

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The purpose of addition of Kaolin is to increase the printing opacity of the unbleached and bleached bagasse paper sheets. In this study, 15% kaolin was added to unbleached and bleached bagasse pulp containing 0.5% gelatin and 0.6% hexamine using in-pulp, dipping or spraying techniques.

Addition of 10% starch to the previous pulps to increase the strength of the formed sheets. Mechanical and optical properties were tested in each case as well as water retention and permeability.

INTRODUCTION

The process of adding mineral matters (fillers) to paper stock prior to the formation of the sheet has been practiced since the ancient days of papermaking. The benefits of fillers are generally accepted, and the addition of filler such as clay, calcium carbonate, titanium dioxide and kaolin is regarded as an integral part of the papermaking process. Fillers are highly desirable in printing papers where they increase the opacity, raise the brightness, and generally improve the printing properties. The application of fillers is especially important when opacity is needed at a low basis weight, and they are invaluable in packaging grades where low permeability should be combined with opacity for light protection of the foodstuff.

Starch (1) is a complex and valuable material. It is widely used industrially, and its most important industrial use is papermaking. Wet-end application is one important part of its use in the papermaking process.

Several studies have been expended to improve on the empirical approaches to the application of starch in papermaking. Physical, chemical and genetic modifications and combinations of these have been invoked to enhance the useful properties of starches. Physical methods include the fractionation of starch into its component linear and branched molecules, and thermomechanical conversion of starch by high-shear, steam-jet cooking. Chemical methods or modifications included oxidation and derivatization with monomers and polymers. Genetic manipulations led to starches with varying linear: branched molecular components ratios.

A review on the properties and use of starch as an additive derived from renewable raw materials in the paper industry was presented by Bergh(2). Topics discussed include: principles of starch technology, starch modification, surface application methods, properties required for size-press application, starch properties required for blade application and as a coating color binder, starch properties required when applied by liquid application system, and size-press starch application to waste-based packaging paper.

This study is carried out to investigate the effect of kaolin and starch addition on the unbleached and bleached bagasse sheets treated with gelatin hexamine mixture in order to improve the opacity and permeability of the sheets.

EXPERIMENTAL

1-Raw Materials

(a) Bagasse pulps unbleached and bleached with 3% potassium permanganate, or 4% hydrogen peroxide, were treated with 0.5% gelatin and 0.6% hexamine, optimum conditions, applying the methods mentioned in part I. (published in vol. 17, Issue No.4 of 2005 IPPTA Journal)

(b) Egyptian upgraded kaolin prepared on pilot scale at CMRDI(3) was used as a filler for bagasse pulp. In previous work (4), several series of experiments were carried out using different amounts of kaolin, 5-25% based on pulp, then paper sheets were prepared and all the properties were tested in each case. It was found that the best kaolin amount was 15% based on pulp to maintain the physical properties as high as possible.

(c) 15% starch based on pulp was added.

2- Testing of paper

Physical properties were tested according to standard method (5)

RESULTS

1. Effect of addition of kaolin then starch with gelatin-hexamine mixture on :

(a) Breaking length

Figure 1: A, B & C shows the effect of addition of kaolin on the breaking length of unbleached and bleached bagasse pulps. It is well known from previous studies that the addition of kaolin decreases the breaking length of the pulp.

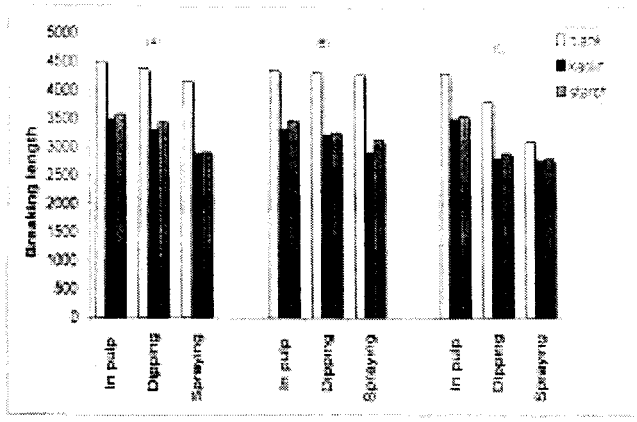

Figure 1: Effect of addition of kaolin and starch on breaking length of unbleached and bleached.

For all bagasse pulps, it is clear that the highest breaking length in attained in case of in pulp technique, followed by dipping then spraying techniques, respectively. In case of unbleached bagasse pulp (fig 1:A), the breaking length of the pulp treated internally with gelatin-hexamine mixture exceeds the breaking length of the dipped samples by 5.7%, and that of sprayed samples by 18.3%. For bagasse pulp bleached with potassium permangenate (fig. 1:B), the breaking length of the pulp treated internally is only 3.3% higher than that of the dipped samples, and 15.1% higher than the sprayed samples. However, for bagasse pulp bleached with hydrogen peroxide, fig. 1:C, the breaking length when using the in pulp technique is superior than the other two techniques by about 17.6%.

Fig. 1:A, B & C also shows the influence of addition of insoluble starch on the breaking length of paper sheets made from unbleached and bleached bagasse pulp. From this figure it is clear that, the addition of starch to unbleached bagasse pulp, using in pulp or dipping techniques increased the breaking length by 4%. On using spraying technique, the breaking length increased by 3%. In case of addition starch to bagasse pulp bleached with permanganate using in pulp technique,the breaking length increased by 1%

only. On spraying gelatin-haxamine then adding starch increased the breaking length by 12% which is the highest increase in all samples. The breaking length of bagasse pulp when bleached with peroxide then applying kaolin and starch increases by 7,3 and 1% for in pulp, dipping and spraying respectively.

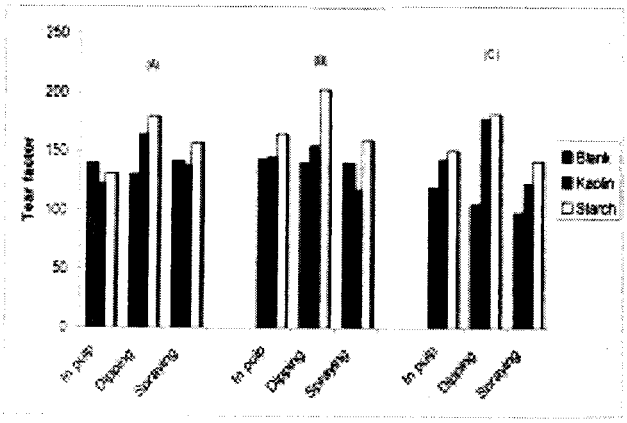

Figure 2: Effect of addition of kaolin and starch on tear factor of unbleached and bleached

(b) Tear factor

Fig. 2:A,B&C, clarifies that the behaviour of the tear factor of all bagasse pulps differs from the breaking length. The tear factor of the unbleached bagasse sample using in the pulp technique (fig. 2:A) shows a lower value than using other techniques (lower by 24.8% than by dipping and 10.1% than by spraying). This may be related to the possible formation of inter-fibre bonding between the gelatin-hexamine mixture and the oxidized lignin producing some sort of brittleness.

The effect of addition of 10% starch on the tear factor of unbleached and bleached bagasse pulps containing gelatin-hexamine and 15% kaolin is also plotted in fig. 2:A, B&C. It is clear that the tear factors of all the investigated pulps increase by adding starch due to the polar hydroxyl groups in starch.

From fig. 2: A unbleached bagasse pulp, it is clear that addition of starch increased the tear factor by 7,8 and 10% when using in the pulp, dipping and spraying techniques, respectively. Fig. 2:B, bagasse pulp bleached with permanganate, shows an increase of 13, 29 and 37% in the tear factors, while the improvement in tear factors, fig. 2:C bagasse pulp bleached with peroxide, is by 5, 2 and 10%, respectively.

(c) Water retention

The effect of the chemical modification on the fibre swellability is very important. The water retention value is the most widely measured parameter of the fibre swellability in water. The water retention values of unbleached and bleached bagasse pulps treated with gelatin-hexamine after the addition of kaolin are calculated and the results are plotted in fig.3: A,B&C. It is clear from this figure, that the water retention value in case of the pulp technique is the highest especially for unbleached bagasse pulp. The water retention values of all pulps dipped in gelatin-hexamine mixture are almost the same regardless the pretreatment of the pulp. The water retention values of the sprayed bagasse pulps bleached with either permanganate or peroxide are equal and are slightly higher than those of the unbleached samples.

This can be explained on the basis that the water retention of the pulp is directly proportional to the amount of the disordered region in the fibres. Therefore, on bleaching, the lignin (which is considered as a highly disordered matter) is changed to a more ordered substance, or it may be removed, leading to a decrease in the water retention value.

Using the dipping or spraying technique produced coated fibres possessing minimum water retention value.

Fig. 3:A, B&C shows the effect of addition of starch on water retention value. It is clear that

addition of starch increased the water retention values by approximately 7-11%. This increase is

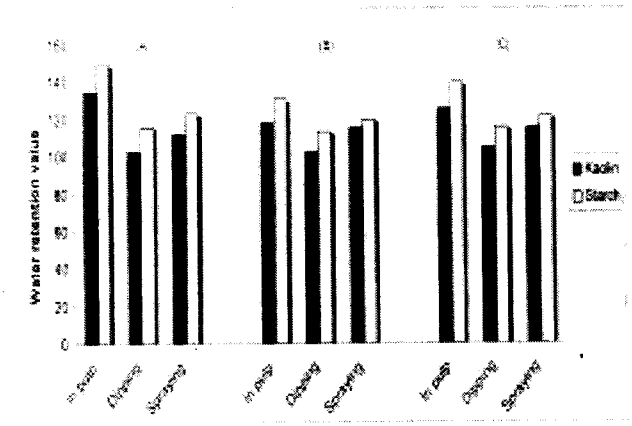

Figure 3: Effect of addition of kaolin and starch on water retention of unbleached and bleached pulp

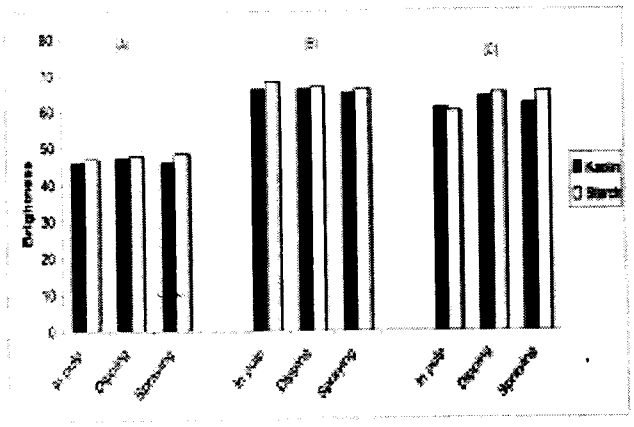

Figure 4: Effect of addition of kaolin and starch on brightness of unbleached and bleached

explained on the fact that starch increases the retention of kaolin in the pulp which, by its turn, fills the spaces between fibres leading to an increase in water retention. It can be also explained on the basis that starch possesses a non-ordered property leading to an increase in the water retention values.

(d) Brightness

The highest brightness obtained was that of bagasse pulp bleached with permanganate, followed by bagasse pulp bleached with peroxide and finally comes the unbleached bagasse pulp, Fig. 4: A,B&C. It must be said that the brightness of the different bagasse pulps are not affected by the technique used in the addition of gelatine-heximine mixture.

The effect of addition of starch on the brightness of unbleached and bleached bagasse pulp is shown in Fig.4: A,B&C. It is clear that the highest brightness values are obtained when bagasse pulp is bleached with potassium permanganate. It can be said that addition of starch and the method of treatment with gelatine-hexamine, both have negligible effect on brightness.

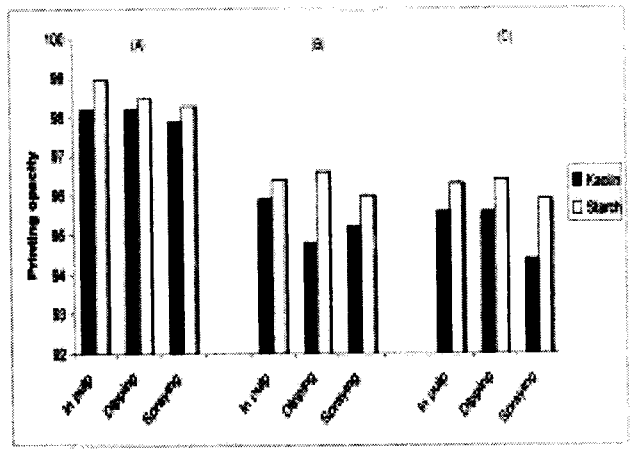

Figure 5: Effect of addition of kaolin and starch on printing opacity of unbleached and bleached

(e) Printing opacity

Fig. 5:A, B&C shows the effect of addition of kaolin on the printing opacity of unbleached and bleached bagasse pulp. It is clear that unbleached bagasse pulp possesses the highest printing opacity. At the same time, bagasse pulp bleached with either potassium permanganate or hydrogen peroxide showed negligible differences in their printing opacities.

It can be concluded that the printing opacities of

all pulps are affected only to a limited extent with the method of addition of gelatin-hexamine mixture.

Fig. 5:A,B&C shows the effect of addition of starch on the printing opacity of unbleached and bleached bagasse pulp. It is noticed that addition of starch increases to a little extent the printing opacity of all pulps as starch increases the retention of kaolin. Unbleached bagasse pulp has the superiority among bleached pulps in its printing opacity. It is also observed that negligible differences are present between the three different techniuques of adding gelatin-hexamine.

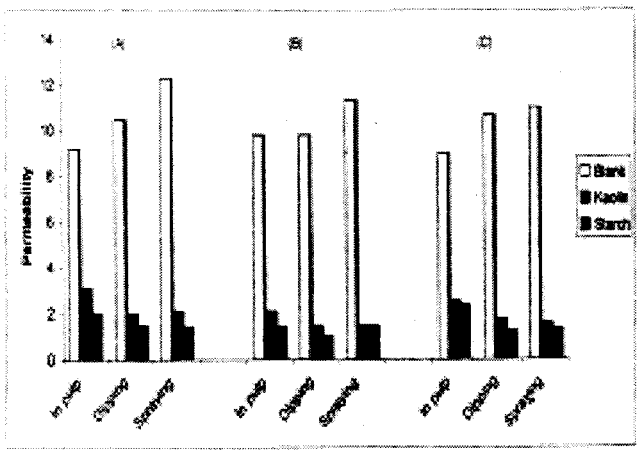

Figure 6: Effect of addition of kaolin and starch on permeability of unbleached and bleached

(f) Permeability

Fig. 6 : A,B&C reveals that permeability is the highest in case of unbleached bagasse pulp, then the pulp bleached with permanganate and finally comes the pulp bleached with peroxide. It is also clear that the permeability of all bagasse pulps treated with gelatin-hexamine mixture is the highest when the pulp technique was used. Using the dipping or spraying techniques gives close permeability values. It must be said that addition of kaolin highly decreases the permeability of the pulp as it blocks the gaps between the fibres.

Examination of Fig.6: A, B&C reveals that addition of starch decreases the permeability of the different investigated pulps. The lowest permeability obtained is in case of bagasse pulp bleached with potassium permanganate, containing 15% kaolin and dipped in gelatin-hexamine mixture.

CONCLUSION

Addition of kaolin and starch to the unbleached and bleached pulps previously treated with gelatin-hexamine mixtures produced sheets with improved printing opacity and permeability, but the breaking length was slighthly affected.

These treatments make the produced sheets applicable for mild wrapping purposes.

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