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Cationic Starch as a Dry Strength Agent in Magnetic Papermaking

(Kanji Kation sebagai Agen Kekuatan Kering
di dalam Pembuatan Kertas Magnet)

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ABSTRACT

The mechanical strength of magnetic lumen loaded handsheets was reported to be lower than the unloaded handsheets. This effect is due to the deposition of filler inside the fiber lumen and some on the fibre surface which interfere with the fibre to fibre bonding. Hence, in order to improve the handsheets strength, cationic starch is used as a dry strength additive. In this study, mixed tropical hardwood pulps were used throughout the experiment. The magnetite particles were deposited in the fibre lumen via the lumen loading technique. The addition of cationic starch was found to increase the handsheet strength. However, it disturbed and influenced the location and distribution of the magnetic fillers. Some of the magnetite particles were observed to be displaced from the fiber lumen and pit apertures. The charges of the filler particles and cationic starch played an important role in producing charge repulsion and pulling effect which lead to filler dislocation.

Keywords: Dry strength agent; lumen loading technique; magnetic paper; papermaking; polyacrylamide

ABSTRAK

Kekuatan mekanik kertas makmal menggunakan teknik pemasukan lumen dilaporkan lebih rendah daripada kertas makmal tanpa pemasukan lumen. Kesan ini adalah disebabkan kemasukan pengisi ke dalam lumen gentian dan terdapat gangguan pada ikatan antara gentian. Oleh itu, bagi memperbaiki kekuatan kertas makmal, kanji kation digunakan sebagai penambah kekuatan. Dalam kajian ini, pulpa tropika campuran digunakan. Partikel magnetit dimasukkan ke dalam lumen melalui kaedah pemasukan lumen. Penambahan kanji kation didapati meningkatkan kekuatan kertas. Namun begitu, penambahan ini telah mengganggu lokasi kemasukan dan taburan pengisi. Terdapat partikel magnet yang tersasar dari kawasan lumen dan bukaan pit. Dipercayai cas partikel magnet dan kanji kation memainkan kesan yang penting untuk menghasilkan gangguan cas dan kesan penarikan yang mengakibatkan kemasukan pengisi yang rendah.

Kata kunci : Agen kekuatan kering; kertas magnet; pembuatan kertas; poliakrilamida; teknik pemasukan lumen

INTRODUCTION

In magnetic handsheet making, fillers are used in order to obtain magnetically responsive kind of paper (Rioux et al. 1992; Zakaria et al. 2004a, 2004b; Zakaria 2005). However, the addition of fillers results in a decrease of paper strength. To overcome this problem, cationic starch is chosen to strengthen the paper mechanical properties. Cationic starch is a well known dry strength agent especially for the improvement of interfiber bonding in the sheet (Marton & Marton 1976). It is usually added during the wet end stage of the paper production. It's efficiency as a dry strength agent is related to it's ability to adsorb onto the fibers and on its distribution on the fiber material. Besides strengthening the paper, cationic starch may also act as a retention improver or dewatering aid (Hofreiter 1981). In this study, cationic starch was used to strengthen the mechanical properties of the lumen loaded magnetic handsheets.

EXPERIMENTAL TECHNIQUES

The bleached mixed tropical hardwood kraft pulps used were supplied by Sabah Forest Industries (SFI) Sdn. Bhd. The chosen magnetic pigment was Fe_3O_4 (< 5 μm, 98%) supplied by Aldrich Chemical. Aluminum sulphate (alum), $Al_2(SO_4)_3.18H_2O$ and polyacrylamide (PAM) at low and high molecular weight were used as retention aids. Low molecular weight PAM was labeled as PAM A whereas high molecular weight PAM was labeled as PAM E (2×10^6 g/mol) were supplied by Malayan Adhesive Chemical (MAC) Sdn. Bhd. Cationic starch was supplied by National Starch (M) Sdn. Bhd. labeled as CATO 302.

Thirty gram of pigment was dispersed in 250 mL distilled water using a mechanical stirrer. Then, in another beaker, 15 g of dry weight unbeaten pulp was fiberized in 1250 mL distilled water. Each suspension was added 0.1 g/L alum and stirred at a standard rotor speed, 1000 r.p.m. After 15 minutes, both suspensions were mixed into a pulp disintegrator and subjected to 3000 r.p.m. agitation for 20 min. This stage is called impregnation. After impregnation, during the inter-stage treatment PAM at 1 w/w polymer on pulp was added. The mixture was left for 3 hours and gently stirred at 600 r.p.m.. The washing stage was done in a self-designed washing box equipped with a filter screen (45 μm) for an hour using filtered tap water at the rate of 6 L/min.

The cationic starch was mixed in distilled water and heated at 95°C for 20 minutes in a water bath. Then it was diluted to 0.1% concentration. The cationic starch solution was then added to the pulp slurry during the handsheet making.

The magnetic handsheet making was carried out according to TAPPI T 295 om-88. SEM Leo 1450VP was used to observe the morphological structure of samples prepared focusing on the location of fillers.

Tensile strength and burst strength were measured according to TAPPI T 494 om-88 and TAPPI T 403 om-91 respectively. Paper samples of circular shape with 5 mm diameter were prepared. The samples (~ 2 mg) were examined using VSM (LDJ 9500). From the magnetisation value, the percentage of filler content were calculated based on the ratio of saturation magnetisation of filler in pulp over it's standard.

RESULTS AND DISCUSSION

KMTA was a magnetic paper using PAM A as retention polymer while KMTE was a magnetic paper using PAM E as retention polymer. KMT which functions as a control is the magnetic paper produced without the addition of PAM. While KMTA(302) and KMTE(302) represent handsheets produced with the addition of PAM A together with CATO 302 and PAM E with the addition of CATO 302, respectively. Figure 1 shows that the addition of CATO 302, improved the tensile properties of the magnetic handsheets. The addition of cationic starch either of the PAM A or PAM E has influenced the strength of the paper by 8% and 58%, respectively. The tensile index has a large influence on the hydrogen bonding between fibre more than the strength of the individual fibre. The addition of dry strength agent normally increased the bonding interaction, hence, the addition is required to improve the fibre strength (Zakaria et al. 2005). In our study, it seems that the interaction between the magnetic particle and PAM has disturbed the inter fibre bonding interaction due to the existance of some fillers on the fibre surface. There is possibility that the addition of CATO 302 has neutralised the charge between fibre and and increased the tensile and burst. The same trend of results were also obtained for burst strength as shown in Figure 2. High value in both tensile and burst index after the addition of cationic starch required a good interfibre bonding.

Figure 3 shows the effect after the addition of cationic starch (refer KMTA-KMTA(302) and KMTE-KMTE(302)). The difference was due to the usage of different molecular weight of PAM as retention aids. Since PAM E had long chain polymer, it may trapped flocculated fillers from entering the lumen or pit apertures along the fibers whereas PAM A polymer chain was shorter than PAM E.

Figure 3 indicates that cationic starch influences the filler content of both KMTA and KMTE. However, it's effect on these samples were different. Cationic starch increased the filler content of KMTA but decreased the KMTE. The phenomenon was due to the different molecular weight of used. The combination of PAM and cationic starch might resulted in more flocs. Cationic starch as well as other cationic polyelectrolytes may also increase the flocculation of the fiber stock (Björklund & Wågberg 1995). Only some flocs of filler may then enter the fiber lumens and pit apertures. KMTA seems to be adapted with the addition of cationic starch. For KMTE, high molecular weight PAM was used which resulted in bigger and heavier flocs of fillers (Ainun et al. 2003). This phenomenon may be also due to filler dislocation and dislodgement from the narrow sizes of fibre apertures. These flocs may then attached to the outer surfaces of the fiber or even will be washed away.

Figures 4 and 5, show that the fillers were dislocated and dislodged from the exact places. The target of

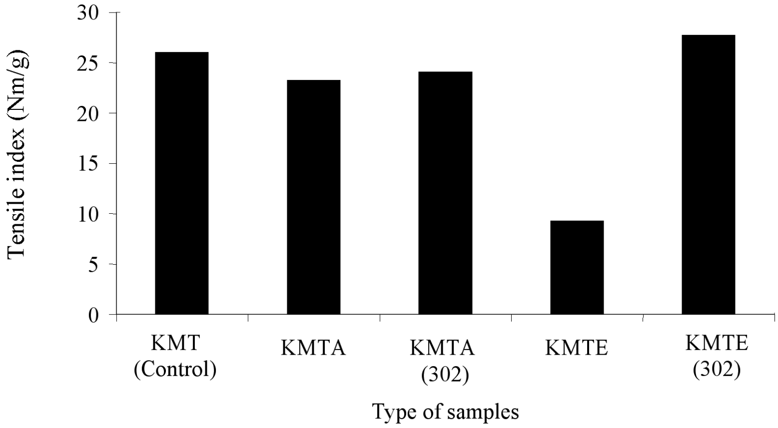

FIGURE 1. Tensile index of various magnetic paper using different treatments

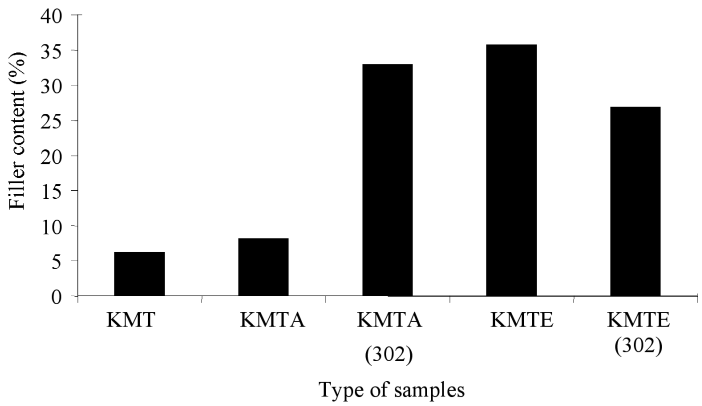

FIGURE 2. Burst index of magnetic paper using different treatments

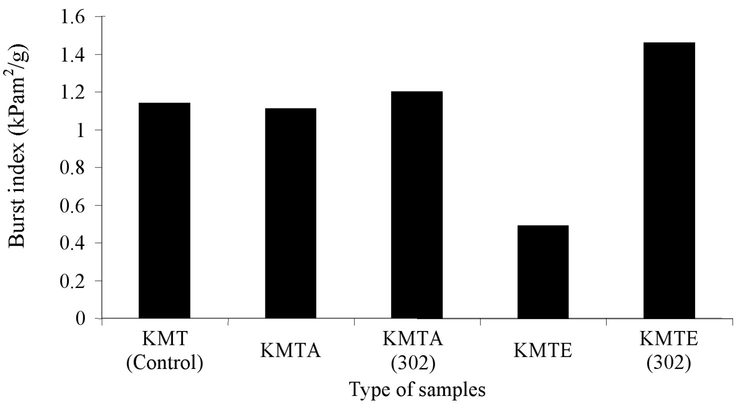

FIGURE 3. Filler content for types of samples

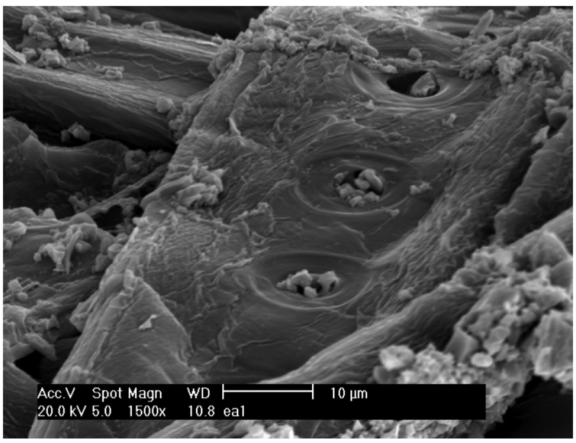

FIGURE 4. Micrograph of KMTE (302) showing the dislocation of fillers from the pit apertures

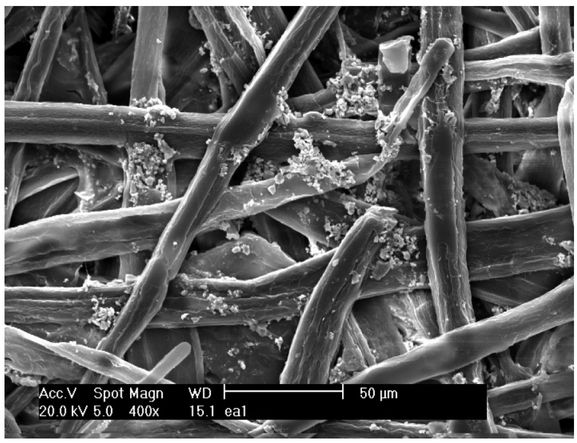

FIGURE 5. Micrograph of KMTE (302) showing the filler particles on the fibre surface

practising lumen loading technique is that the filler will be concentrated inside the lumen and pit apertures while leaving the outer surfaces free from any fillers. However, in this case using cationic starch lead the fillers to dislocate from the inner part of the fibre and attach on the outer surface of the fibre. It is believed that the charges of the filler particles and cationic starch play an important role in producing charge repulsion and pulling effect which lead to filler dislocation. This phenomenon may become worst if high molecular weight PAM is used where larger and heavier flocs of filler will be discharged and may not be involved in the papermaking systems.

Cationic starch is useful in order to strengthen the mechanical properties of paper such as tensile and burst strengths. However, the addition of cationic starch with different types of PAM should be evaluated. In this study, cationic starch worked well with low molecular weight PAM (PAM A), not only to strengthen the magnetic paper but also it seems to aid the lumen loading process itself. Due to it's positive charge and polymeric nature, cationic starch can potentially serve both purposes; as a retention aid and as a reinforcing agent. The absorption depth of starch on fibres is suggested to be carried out in further investigation.

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