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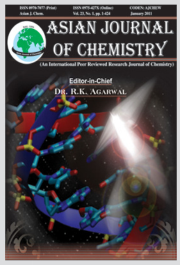

Effects of Surface Sizing with Starch on Physical Strength Properties of Paper

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The main role of the surface sizing is to increase the strength of the paper surface and to bind particles such as fiber and pigments to paper surface. For this purpose, starch, animal glue, methyl cellulose, carboxymethyl cellulose, polyvinyl alcohol and wax emulsions can be used and many resins polymers can be used for some special purposes. Among these, the starch is the most frequently used one. This study was performed to determine the changes on strength and printing properties of sulfite base paper and vegetable parchment base paper with sizing by starch having a solid content of 10 % on the K-Coater laboratory type. According to the results of paper strengths and printing tests, it has been found that surface sizing with starch improves positively paper physical strength properties and printability.

Key Words: Starch, Surface sizing, Strength properties, Printability.

INTRODUCTION

Surface sizing is a process that starts with a previously-formed web then adds a sizing agent[1]. The desired goal of the process is to promote desired surface properties by creating a stronger surface and binding fibers and fillers to that surface. Liquid starch penetrates in the z-direction and is expected to add internal strength[2].

The importance of starch in the surface sizing is to increase the resistance and surface strength against water, oil and solvents. Surface sizing with starch improves positively the physical strengths of the paper. The bonding between fibers such as bursting strength, tensile strength and folding strength increases. It is known that the more dimensional stability and the less wrinkle and folding defects are formed if the strength is obtained with surface sizing in paper making. Besides that, drainage possibility can be obtained easily in the paper machine[3].

The coating starch most importantly acts as a binder. The stiffness of the starch film also brings posture to the paper. While stiffness promotes runnability in the printing press and readability of the paper, use of starch in higher amounts must be limited for papers and boards for gravure printing where surface elasticity is important[4].

Ozden[5] found that the paper has the best physical and optical properties and the best printability after the coating which contains three different starch mixtures solids, between 3 and 13 %, is applied to two different base paper types. According to the results of laboratory tests, when the starch ratio was increased, the viscosity increased and starch penetration of paper decreased.

Glittenberg[6] investigated the effects of potato and corn starches on paper strengths, drainage and retention. By adding potato starch in a ratio of 1.6 %, internal bonding and tensile strength increased by 33 % and 17 %, respectively. By adding potato starch in a ratio of 0.5 %, the drainage decreased 26 %. When the papers were sized with corn starch, the strength and internal bond properties did not change.

Brogly and Harvey[7] conducted a study in which starch pickup is varied at a constant (7 %) solids content and found consistent effects on tensile and ply bond strength that concur with the finding of Kustermann[8] and Felder[9]. Surface sizing starch, especially if it concentrates on the sheet surface through different surface sizing techniques or starch solids contents, increases the bending stiffness of paper according to their reports.

The aim of this study is to size the sulfite and vegetable parchment base paper surface with potato starch and to compare the physical and printing properties.

EXPERIMENTAL

In this study, sulfite papers, vegetable parchment papers and commercial starch were used. The mixture of starch was prepared at 10 % solid in 270 mL distilled water. This mixture was put in a volumetric flask and heated up to 95 °C while stirring continuously in a jacketed mixer. It was kept at 95 °C for 5 to 10 min. This mixture was ready to use when temperature decreased to 40-50 °C.

The prepared starch was applied on wire and felt surfaces of sulfite and parchment papers by Mayer bars number 2 and 3. Surface sizing treatments were performed with K-Coater laboratory type. Mayer bar numbers were chosen according to the desired amount on surface and the speed of the coating system was adjusted according to solid contents of the binder. After sizing, the samples were air dried overnight under TAPPI conditions. The samples were not calendered.

All samples were conditioned for 24 h at 50 % relative humidity and 23 ºC (73.4 ºF) before testing. In the sized papers that obtained, the basis weight (ISO 536-TAPPI T 410), tensile strength (ISO 1924-2-TAPPI T 404), bursting strength (ISO 2758-TAPPI T 403), tearing strength (ISO 1974-TAPPI T 414) and value of Cobb (ISO 535-TAPPI T 441) were determined. These physical strength tests were made by a Zwick Roell test machine.

Samples were printed with an IGT testing system using a Micheal Huber München Resista Cyan 43FY0RS ink. Print density values of all printed samples were measured with a GretagMacbeth spectrophotometer at 100 % tint on the printed samples, just after the printing and 2, 4, 8, 12 and 24 h after the printing. At the end of these measurements, the average print density values of unsized and sized paper samples were obtained.

RESULTS AND DISCUSSION

Basis weights of parchment and sulfite base paper samples are respectively, 25 g/m^2 and 10 g/m^2. The changes in surface sizing and paper basis weights are given in Table-1.

TABLE-1
BASIS WEIGHTS OF PARCHMENT AND SULFITE PAPERS WITH AND WITHOUT SIZING

Parchment paper basis weight (g/m^2)			Sulfite paper basis weight (g/m^2)		
Without sizing	With sizing #2	With sizing #3	Without sizing	With sizing #2	With sizing #3
25.25	27.50	28.00	10.25	11.00	11.25

Fig. 1 shows that the Cobb values of paper samples decreased depending on the amount of starch. This implies that the strength of paper surfaces against water increased, this means the strength against water and Cobb value are inversely proportional. The felt and wire surfaces of parchment paper with or without sizing are more resistance against water than sulfite papers. For both types of paper, water resistance of wire surfaces was much more than that of felt surfaces. The felt-surface water resistance of the parchment base paper increased 14.23 % with a #2 bar and the felt-surface water resistance of the parchment base paper with a #3 bar increased by 31.51 %. The felt-surface water resistance of the sulfite base paper increased 11.11 % with a #2 bar and increased 20.15% with a #3 bar.

The tension strengths in machine direction (MD) were found out as twice as the tension strength in cross-machine direction (CD) for both kind of paper samples *i.e.*, starch applied or without starch. The tension strength of parchment papers in machine direction (82.65 Nm/g) reach up to 82.73 Nm/g with a #2 bar, up to 84.97 Nm/g with a #3 bar. The highest tension strength values were obtained from parchment papers. In machine direction, sized-parchment base papers strength with a #3 bar increased by 2.81%, sized-sulfite base papers strength with a #3 bar increased by 10.66 %. This implies the starch penetration is better in sulfite papers (Fig. 2).

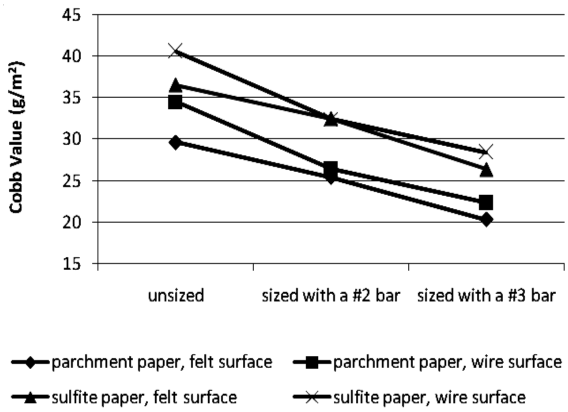

Fig. 1. Cobb values of parchment and sulfite papers

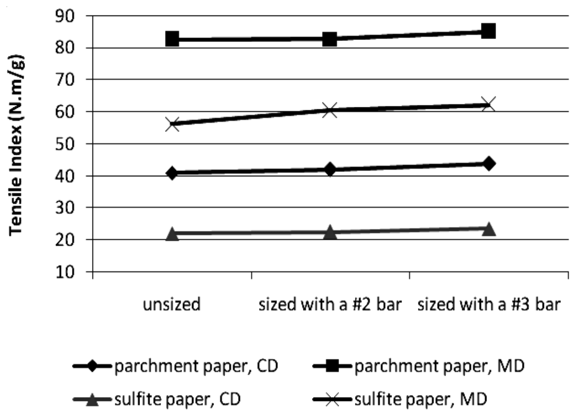

Fig. 2. Tensile index values of parchment and sulfite papers

Fig. 3 demonstrates that the bursting strength of parchment base papers was higher than the sulfite papers. The strength value of sulfite papers increased more clearly and sharply depending on the amount of sizing and reached up to 0.116 kPa.m^2/g with a #3 bar. However, in the parchment papers this value reached up to 0.084 kPa.m^2/g.

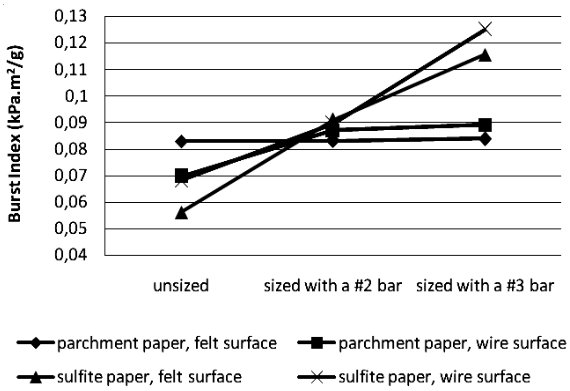

Fig. 3. Burst index values of parchment and sulfite papers

While all of the strength values increased, the tearing strength decreased. This decrease is significant in the sulfite papers (Fig. 4).

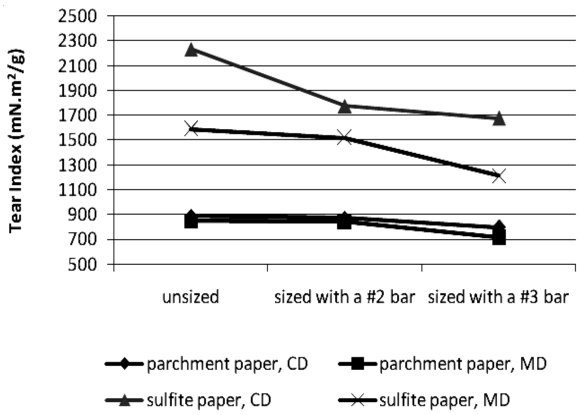

Fig. 4. Tear index values of parchment and sulfite papers

Figs. 5 and 6 show print density values in offset printing system of two sides sized and unsized sulfite papers, which applied starch using 2 and 3 bars.

Fig. 5 demonstrates the print density values of printed-sized paper samples with a 3 bar were the highest (1.30). While the initial print density values of printed-unsized paper samples were equal amount of the initial print density values of printed-sized paper samples with a 2 bar, after 24 h, the print density values of printed-unsized paper samples were lower than the print density values of printed-sized paper samples with a 2 bar.

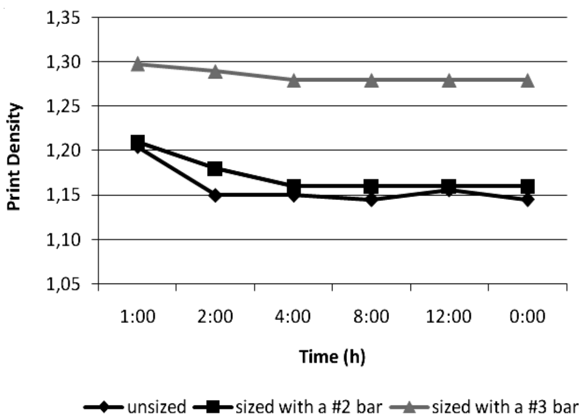

Fig. 5. Print density values of sulfite papers (wire surface)

Fig. 6 demonstrates the print density values of printed-sized paper samples with a 3 bar and printed-unsized paper samples were higher than the print density values of printed-sized paper samples with a 2 bar (1.22). Nevertheless, after 24 h, the print density values of printed-unsized paper samples significantly decreased relative to the print density values of printed-sized paper samples with 2 and 3 bars. However, the printed-sized paper samples with a 3 bar had the highest print density due to the increase of coat weight.

The coat weight did not have a significantly effect on print density values of printed-unsized and printed-sized sulfide paper samples unlike the printed-sized sulfide paper samples with a 3 bar. The wire side print density values of printed-

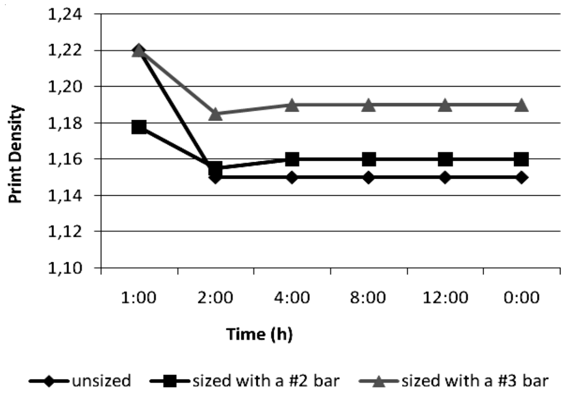

Fig. 6. Print density values of sulfite papers (felt surface)

sized sulfide paper samples with a 3 bar had higher than the felt side print density values of printed-sized sulfide paper samples with a 3 bar.

In Figs. 7 and 8, the print density values in offset printing system of two sides sized and unsized parchment papers, which applied the starch with 2 and 3 bars, have seen.

The print density values of printed-unsized parchment paper samples were significantly higher than the print density values of printed-sized parchment paper samples with 2 and 3 bars (1.32). However, after 2 h, the printed-unsized parchment paper samples had the lowest print density value. After 4 h, there was no change visible the print density values of all printed samples (Fig. 7).

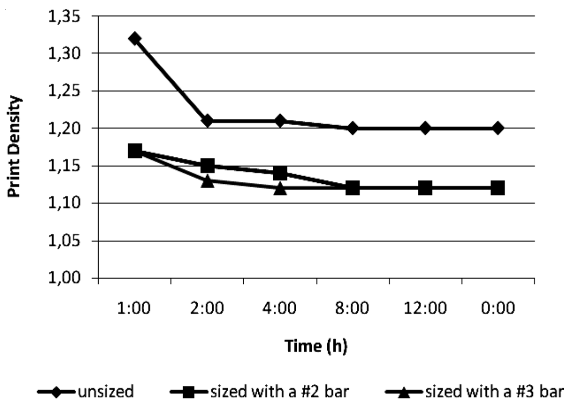

Fig. 7. Print density values of parchment papers (wire surface)

Fig. 8 shows that the print density values of printed-sized paper samples with a 2 bar were slightly higher than the print

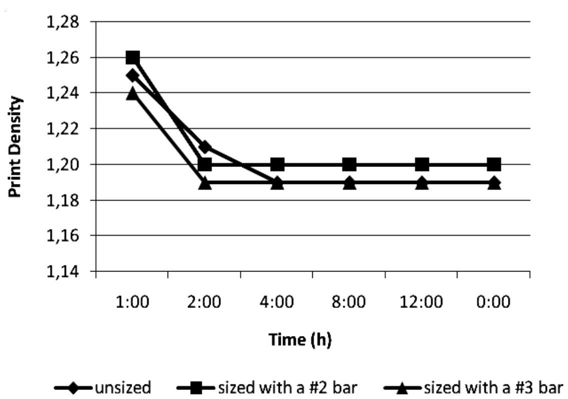

Fig. 8. Print density values of parchment papers (felt surface)

density values of printed-unsized paper samples and printed-sized paper samples with a 3 bar. After 2 h, there was no change visible the print density values of printed-sized paper samples with 2 and 3 bars. However, print density values of printed-unsized paper samples continued to decrease until 4 h.

Compared between wire and felt side print density values of printed-sized parchment paper samples, while the wire side print density values reduced, the felt side print density values did not have a positive or negative change.

Conclusion

It has been determined that the starch used on paper surface sizing, contributes to physical properties of the paper positively depending on kind of paper, paper surface, number of Mayer rod used in sizing and basis weight of paper.

The basis weight increased as the amount of starch increased. The increase was 10.89 % in parchment paper, 9.75 % in sulfite paper by sizing with a 3 bar.

Cobb values of both kinds of papers decreased depending on amount of starch, this means that water resistance values increased. The kind of paper with the most water resistant was the felt surface of parchment paper with a 3 bar. Before sizing, the highest tensile strength, bursting strength and tearing strength were obtained from parchment paper. But after sizing, the increase of tensile strength and bursting strength were obtained from sulfite paper much more than from parchment paper.

The tension strengths in machine direction were found out as twice as the tension strength in cross-machine direction for both kind of paper samples which were starch applied or without starch. Tensile strength increased 2.81 % in machine direction of parchment base paper and 10.66 % in machine direction of sulfite base paper with a 3 bar. While the bursting strength of parchment papers increased clearly, that of sulfite papers increased sharply depending on amount by sizing.

While all of the strength values increased, the tearing strength decreased. The decrease was more obvious in the sulfite paper.

The physical strength properties of parchment base papers did not significantly change. However, the physical strength properties of sulfide base papers increased. The parchment papers have a good smoothness and resistance against water and oil. Therefore, the starch absorption of parchment papers is less than sulfite papers. Also the basis weights of parchment base paper were higher than sulfite base paper. In sizing, the basis weight is an important factor. When the basis weight of a paper increases, decreases the amount of starch that is held on the surface. Consequently, positive effects of sizing are less on parchment base paper.

Sizing had a significantly effect on print densities of printed sulfite papers. Increased coat weight increased print density values of printed-sized sulfite papers. However, the print density values of printed parchment paper samples decreased after sizing. Depending on the printing conditions, increased coat weight was shorter ink setting times of all printed samples.

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