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Effects of Carboxymethyl Cellulose as a Surface Sizing Agent on the Printable Properties of Newspaper

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The objective of the study is to determine effects of carboxymethyl cellulose as a surface sizing agent on the printable properties of sized newspaper. In this study, the commercial newspapers were sized by K-control coater with using various concentrated carboxymethyl cellulose solutions. Sized newspapers were used for the offset print tests, which were made by IGT C1 test print machine. One property of carboxymethyl cellulose is its ability to improve the surface properties of paper when it is applied to the surface. As a result, it has been found that carboxymethyl cellulose can improve the printable properties of newspaper.

Key Words: Surface sizing, Printability, Newspaper, Offset printing, Printing ink.

INTRODUCTION

Surface sizing is an important process to improve the surface properties of paper and board. It strengthens the surface and binds particles such as fibers and fillers to the surface. In addition, it provides water resistance to the surface. All of these, improve ink receptivity, gloss, blister resistance and give better screen dot reproduction, which are important properties in sized paper grades[1].

There are two types of such processes; internal sizing and surface sizing. Internal sizing consists of mixing the sizing agent with the fibrous furnish and forming the entire mass into a sheet containing a relatively uniform distribution of fibers and sizing agent.

Surface sizing differs from internal sizing in which the sizing agent is applied to the surface of the paper where it cements the fibers to the body of the paper and deposits a more or less continuous film on the paper surface. The advantage of surface sizing in the case of writing and printing papers is that a film is produced on the surface of the paper which does not catch the pen when the paper is written on and even not pick if the paper is printed with tacky inks.

Some times surface sizing is more important than internal sizing for writing and printing papers and certain grades of wrapping papers. Surface sizing is usually

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done in a size press, or on the calendars. The most common chemicals used commercially are oxidized or enzyme-treated natural starches, cationic starches, acrylamide polymers, latexes, polyvinyl alcohol and soluble cellulose derivatives, such as carboxymethyl cellulose[2].

There are two types of sizing agents, internal and surface applied. Internal sizes are added to the pulp furnish before the sheet is formed and surface sizes are added to the surface of finished sheet. Often surface sizes are added to improve printable characteristics. A smooth, hard surface is ideal for most industrial printing processes. Heated rollers can be used to achieve this type of surface. The terms "calendared" and "super calendared" are used to describe an exceptionally hard, smooth and printable finish. Calendaring helps smooth the peaks and valleys of the paper[1]. However, the ideal solution is to coat or size the paper surface with clay-like material or a suitable additive to create coated paper or sized paper.

Sizing agents such as modified starches, sodium carboxymethyl cellulose (NaCMC), polyvinyl alcohol (PVOH), *etc*., improve printing and other properties of the web[3].

Sodium carboxymethyl cellulose (NaCMC or more commonly only CMC) is a polyelectrolyte derived from cellulose. Today, CMC is one of the most important cellulose derivatives. Sodium carboxymethyl cellulose has been developed to a versatile product group and it is used in a number of different industrial and regulatory applications. The CMC structure is based on the β-(1→4)-D-glucopyranose polymer of cellulose[4].

Sodium carboxymethyl cellulose is produced from cellulose (hardwood, softwood or cotton linters), monochloroacetic acid (MCA) and sodium hydroxide (NaOH) as the third essential ingredient. Fig. 1 illustrates the different steps in the CMC process[5].

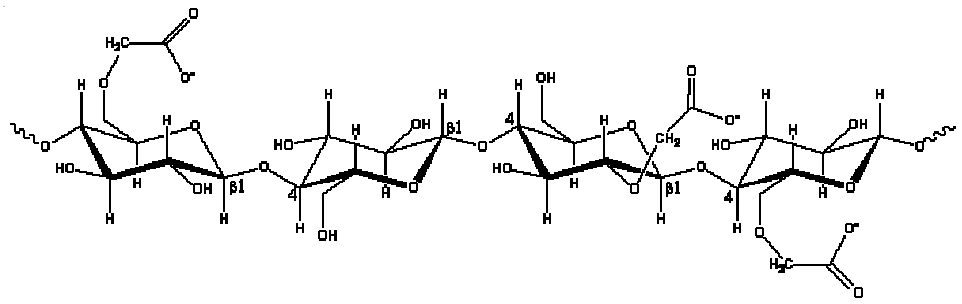

Fig. 1. Structural unit of carboxymethyl cellulose (CMC)

Carboxymethyl cellulose (CMC) is commonly used thickener for coating colour formulations, because of its ability to immobilize water molecules, giving an important thickening effect[6,7]. Several papers have been published about the influence of CMC characteristics such as molecular weight and concentration as well as pigment concentration on rheology of coating colours and on properties of coated papers[8-10].

They showed that CMC plays an important role in terms of rheology of the coating colors and this fact exerts an influence on the properties of the coated papers. Several aspects must be taken into account *i.e.*, CMC molecular weight, added amount and pigment concentration[11].

During the 1980s, surface sized newsprint was produced both in Japan and North America for the Japanese market. The target was to produce more stable paper with clear printing of fine characters and without a need for additional printing press washings due to linting. The linting tendency was reduced by the surface sizing of newsprint papers. Low-quality pulp with high DIP content, for example, could be used when surface sizing. The size amounts were initially quite high, which required higher consistency inks to eliminate ink setting related problems[12].

EXPERIMENTAL

Commercial CMC and unsized newspaper were used to size the surface of paper. A commercial newspaper, non-precoated was supplied from the paper mill. It was used as the substrate for the sizing. These characteristics of base substrate are given in Table-1.

TABLE-1
PROPERTIES OF USED SAMPLE

Tests	Test Methods	Newspaper
Grammage, g/m^2	T 410om-88	48.8
Thickness, μm	T 411om-89	73
Ash (%)	T 413om-85	7.0
Bulk (cm^3/g)	T 220om-88	150
Cobb$_{60}$ (g/m^2)	T 441om-90	83
Opacity (%)	T 425om-88	96
Brightness (%)	T 425om-88	57
Yellowness (%)	T 425om-88	10.06
L*		83
a*		-0.24
b*		6.31

Properties of base paper

Preparation of carboxymethyl cellulose: Two CMC solutions were prepared using a mechanical mixer. After mixing for 30 min, pH and percentage of dry solid contents of CMC were measured. Dry solid contents of CMC solutions were 4 and 10 % at pH 5.5.

Paper sizing: Newspapers were sized by K-Control Laboratory Coater. Number 2 and number 3 rods were used on the coater. After, sized newspapers were dried at the room temperature, they were conditioned before testing. The properties are shown in Table-2.

TABLE-2
PROPERTIES OF COATED SAMPLES

Tests	Sized newspaper with 4 % CMC	Sized newspaper with 4 % CMC	Sized newspaper with 10 % CMC	Sized newspaper with 10 % CMC
	#2 Rod	#3 Rod	#2 Rod	#3 Rod
Grammage (g/m^2)	49.34	50.47	50.48	51.69
Thickness (μm)	90	100	95	100
Cobb (g/m^2)	75.60	71.82	73.41	62.20

Tests: Sized and non-sized newspapers were conditioned for tests in a special room that was set at 23 ºC with 50 % RH. Mechanical and optical properties of newspapers were measured according to the TAPPI test methods (Table-1). Optical properties were measured using an Elrepho 3000 series spectro.

In order to determine the liquid absorption capacities, "Cobb size tests" (according to TAPPI T441om-90) were performed to the papers that were sized by rod numbers 2 and 3, before and after surface sizing process. As a result of measurements, it is seen that carboxymethyl cellulose (CMC) as a surface-sizing chemical, affected the fluid absorption capability of the paper, which is shown in tables and with graphs.

Test prints were performed by IGT C1 test printing machine with 350 N print force. 1.5 mL of ink whose properties are given in Table-3, were put on the form rollers of IGT C1 test printing machine by pipette and these rollers were run for 240 s to squeeze the ink for proper print.

TABLE-3
PROPERTIES OF INK USED IN TEST PRINTS

Boiling point (ºC)	250
Flash point (ºC)	> 100
Ignition temperature (ºC)	200
Explosion for the critical point (high)	6.5 volume
Vapor pressure	20 ºC < 0.1 hPa
Intensity (g/cm^3)	1.088
Solvent content (organic solvent/water) (%)	< 0.5/< 0.5

After test prints, it was left to dry for 4 h. Then the L a*b* values of test prints were measured by 0/45 geometry spectrophotometer and are shown in tables and graphs.

Test printing surface and interface morphologies were viewed through the microscope 120 times enlarged (Figs. 2 and 3). At the end of the assessments, it is found out that carboxymethyl cellulose (CMC) as a surface-sizing chemical, affected the printability features of paper and its resistance to liquid penetration.

RESULTS AND DISCUSSION

The test prints were performed by IGT C1 test-printing machine with cyan colored offset printing ink on two types of newspapers, one of which was sized

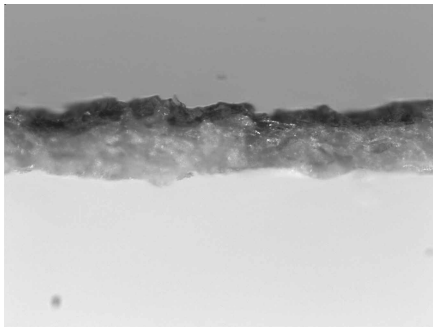

Fig. 2. Printed non-sized newspaper

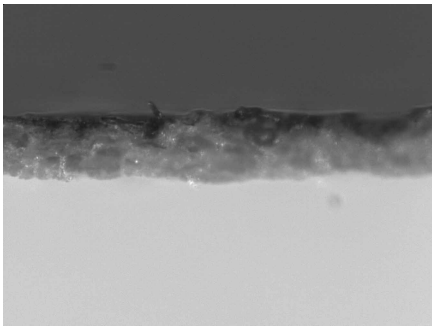

Fig. 3. Printed sized newspaper

with the CMC and the other was not sized. After the test prints, ΔE differences were measured between non-sized papers and sized papers with different concentrated CMC solutions (Fig. 4).

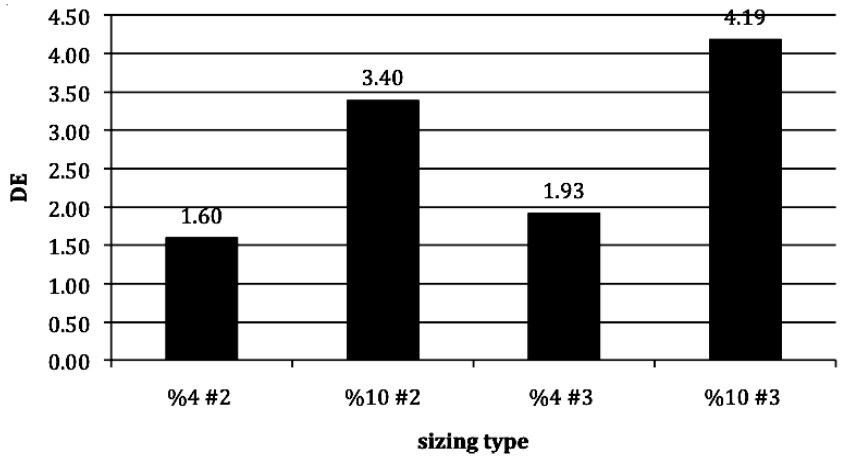

Fig. 4. Results of test prints

According to ISO standard[13] the color difference should be maximum ΔE 3 for newspaper printing for cyan color. As shown in Fig. 4, the printed newspapers sized with rod numbers 2 and 3 in 4 % of CMC concentration stayed within the standard.

The process of sizing increases the newspaper resistance against water, thus, printing newspaper with offset printing method consumes less water. By using less water, the dot gain decreases and more glossy prints can be obtained.

The linting tendency was reduced by surface sizing of newspapers, which can be seen in Fig. 3. The surface of newspaper that was sized by carboxymethyl cellulose (CMC) is stabile, smooth and has not any peaks and valleys. Surface sizing is more important than internal sizing for printing papers as it improves printability characteristics of a paper. As shown in Fig. 3, ink penetration is more homogeneous on the sized newspaper.

As shown in Fig. 2, the surface of unsized newspaper is not stabile because of the tack of printing ink. As a result, the surface properties of newspaper can be improved by a suitable surface sizing material. Carboxymethyl cellulose (CMC) is a suitable surface sizing material to use for this purpose.

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