



Effects of different starch applications on the properties of test liner paper

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Abstract: In this study, test liner papers were manufactured by using starch in pulp preparation unit and at size press in order to determine the effects of starch application on the properties of the papers. Firstly, 8, 10, 12, and 15% starch were applied in the pulp preparation unit and the physical and optical properties were determined. Likewise, starch was applied at size press in 15, 18, 22, and 26% rates. Then, papers were produced in different grammages using rates that gave the best results in the physical properties. The physical and optical properties of these papers were measured to determine effects of different starch applications on these properties. According to results, starch application at size press improved the physical and optical properties of test liner papers when compared with pulp preparation unit. Besides, the strength values of the papers produced by using size press were higher than the specified standards.

Keywords: Starch, Size press, Test liner, Physical and optical properties

1. Introduction

Starch has been used in many industrial applications for many years. It's used extensively in various applications in the paper industry. Besides, food industry is uses the starch for viscosity control while the pharmaceutical industry uses starches as fillers and carrier materials (Wurzburg, 1986). In paper industry, starch is the third largest component after cellulose fibers and fillers (Maurer, 2001). Its main application areas are coating, surface sizing, effluent treatment, furnish preparation, and conversion of paperboard to packing grades. Starch is generally used to increase paper strength both in internal and surface sizing (Smook, 1994; Muller et al., 2000).

Two or three layered liner paper produced by adding dark or white primary or secondary fibers onto secondary fibers is called a test liner. In recent years when recycling has become important, test liner papers are widely used. It is used in top and bottom layers in corrugated cardboard making. Their appearance must be clean and their colors are free of ripples due to their use on the outside of the packaging. The weights range from 90-350 gr.m⁻² and resistance to moisture can be increased by using additives. Starch and coloring agents can be used to improve strength properties and to provide surface smoothness (Onen, 2002).

Paper used in the packing paper production is subject to less deformation and the products it contains should be less exposed to internal and external effects in the transfer process. For this reason, the materials used in paper production must have maximum strength (Casey, 1960). Almost all of the packaging paper is produced by recycling in Turkey, and the strength of the fibers obtained from recycling is lower than virgin fibers. Some searches are being done to increase the strength values; and one of these is starch application on the surface of papers.

Starch application on paper surface process can be considered in three types. These are film size press, classic size press, and spray size press. Classic size press has also three types; horizontal, vertical, and angled size press (Tunca, 2010). Many important paper qualities can be improved by surface application. The sizing process is generally used to improve the strength properties of papers, while reducing penetration of the aqueous solutions. As mentioned before, there are two different sizing methods as internal and surface sizing (Smook, 1994). Surface sizing is commonly used for the fine papers, coated base papers and paper boards (Knowpaw, 2013).

The aim of the study was to determine effects of the different starch applications on the test liner paper properties. For this purpose, test liner papers were manufactured by adding starch at size press and in pulp preparation unit. Angled size press which is one of the classic size press method was used to apply starch in this study. The optical and physical properties of the test liners produced with different starch application were analyzed and the differences between them were examined.

2. Materials and methods

Test liner paper production was performed in Kayseri Parteks Paper Mill. Fluting, test liner, white liner and kraft wastes were used for test liner paper production. Test liner papers were produced in ten different grammages as 90, 100, 110, 125, 130, 140, 150, 160, 170, and 175 gr.m⁻².

Firstly, in pulp preparation unit, test liner papers with 100 gr.m² were produced with adding starch in different dosages (8, 10, 12 and 15 kg/ton) in order to determine the best dosage. The best strength values were obtained with adding 15 kg / ton starch in test liner paper production (data not shown). Then, test liner papers with ten different grammages were manufactured

with adding starch as 15 kg/ton. Likewise, papers were produced with adding 15, 18, 22, and 26 kg/ton starch at size press. Paper produced using 26 kg/ton starch gave the best result in the strength properties and papers with ten different grammages were manufactured with adding this dosage. In order to decrease COBB (water absorptiveness) values of the papers, 8 kg/ton AKD (Alkyl ketene dimer) was added in pulp preparation unit.

The physical and optical properties of the papers were analyzed in accordance with applicable standards given in Table 1.

Table 1. Standards used to determine the physical and optical properties.

Physical and Optical Pro.	Standards	References
Grammages	TS 3122 EN ISO 536	Anon., 1998
Breaking Length (M. D.)	TS 3121-2 ISO 1924-1	Anon., 1997a
Breaking Length (C. D.)	TS 3121-2 ISO 1924-2	Anon., 1997a
CMT	TS 6717 EN ISO 7263	Anon., 2002
CCT	TS 12735	Anon., 2001a
RCT	TS 12734	Anon., 2001b
Burst Index	TS 3123 EN ISO 2759	Anon., 2004
Tear Index	TS 4423 EN 21974	Anon., 1996
ISO Brightness	ISO/DIS 2470	Anon., 1997b
ISO Opacity	ISO/DIS 2471	Anon., 1997b

The important required physical properties of the packaging papers are RCT, CCT, CMT, and bursting strength (Levin and Söderhjelm, 1999; Marin et al., 2009). Corrugated Medium Test (CMT): measures the crushing resistance of a laboratory-fluted strip of a corrugating medium. Corrugated Crush Test (CCT): measures the edgewise compression strength of a laboratory-fluted strip of a corrugating medium. Ring Crush Test (RCT): measures the resistance of a short cylinder of paper in the axial direction. Bursting strength: maximum pressure that the paper can resist without breaking with pressure applied perpendicular to the plane of the test piece.

3. Results and discussion

The physical and optical properties of the test liner papers produced using 15 kg/ton starch added in pulp preparation were presented in Table 2.

Table 2. The physical and optical properties of the test liner papers with different grammages produced using 15 kg/ton starch added in pulp preparation unit

Grammages (gr/m ²)	90	100	110	125	130	140	150	160	170	175
Tensile Index (C.D.) (Nm/g)	18.53	20.27	21.35	19.04	18.66	17.39	21.36	22.48	21.92	25.78
Tensile Index (M.D.) (Nm/g)	43.01	43.06	43.91	44.20	44.21	44.24	43.63	41.15	38.92	37.96
CMT Index (Nm ² /g)	149	151	190	174	186	179	198	184	176	175
CCT Index (Nm/g)	12.22	11.30	10.73	10.00	10.62	10.07	10.13	9.13	9.41	9.43
RCT Index (Nm/g)	5.67	5.70	5.69	5.36	6.62	5.60	6.07	6.5	6.76	6.57
Burst Index (kPam ² /g)	2.07	2.06	2.07	1.96	2.04	2.23	2.16	2.08	1.99	1.96
Tear Index (C.D) (mNm ² /g)	9.04	9.25	9.01	8.4	8.38	8	7.8	7.41	7.03	6.97
Tear Index (M.D) (mNm ² /g)	8.69	7.63	7.23	6.44	6.5	6.52	6.61	6.7	6.5	6.64
Brightness (%ISO)	14.76	17.63	19.04	19.47	18.30	18.52	18.28	18.96	19.20	19.00
Whiteness (%ISO)	24.85	27.80	29.91	30.33	28.98	29.23	28.90	30.31	29.54	29.72

CD: Cross direction, MD: Machine direction

According to the table, the findings were found at the intervals specified in the standards. The effects of the grammages on the physical and optical properties of the papers can be also clearly seen in Table 2. With increases in grammages, it was observed that the brightness, whiteness, CMT, RCT, tensile (CD) indices were increased and CCT, tensile (MD), burst and tear indices were decreased.

The physical and optical properties of the test liner papers produced using 26 kg/ton starch added at size press were presented in Table 3.

Table 3. The physical and optical properties of the test liner papers with different grammages produced using 15 kg/ton starch added at size press

Grammages (gr/m ²)	90	100	110	125	130	140	150	160	170	175
Tensile Index (C.D.) (Nm/g)	26.22	24.71	23.18	21.55	21.07	19.52	15.98	17.66	24.23	24.28
Tensile Index (M.D.) (Nm/g)	52.30	51.78	51.12	46.92	46.77	44.46	42.73	40.14	40.08	40.15
CMT Index (Nm ² /g)	180	185	238	250	247	242	226	217	213	210
CCT Index (Nm/g)	13.33	13.00	13.18	16.80	16.77	16.79	16.42	16.58	16.00	15.77
RCT Index (Nm/g)	10.1	9.8	9.18	8.24	8.23	8	7.62	7.52	7.24	7.14
Burst Index (kPam ² /g)	2.62	2.55	2.41	2.39	2.35	2.28	2.17	2.08	2.02	2.02
Tear Index (C.D.) (mNm ² /g)	9.89	10.6	10.5	9.42	9.41	9.05	8.77	8.41	8.1	7.99
Tear Index (M.D.) (mNm ² /g)	8.98	8.51	7.96	7.06	8.46	8.21	7.91	7.68	7.39	7.4
Brightness (%ISO)	17.05	18.70	17.37	17.19	17.94	18.02	18.52	18.64	18.76	18.29
Whiteness (%ISO)	26.80	29.18	26.97	27.11	27.63	28.06	29.57	28.43	28.56	29.18

When Table 2 and 3 compared with each other, the effect of size press application appears quite obviously. The use of starch at size press improved the physical and optical properties of papers with low grammages. But, these improvements have been ineffective with increasing grammages. The important physical properties CCT, CMT, RCT, and burst indices of the papers with different grammages were compared with each other in order to determine differences illustrated in Fig. 1

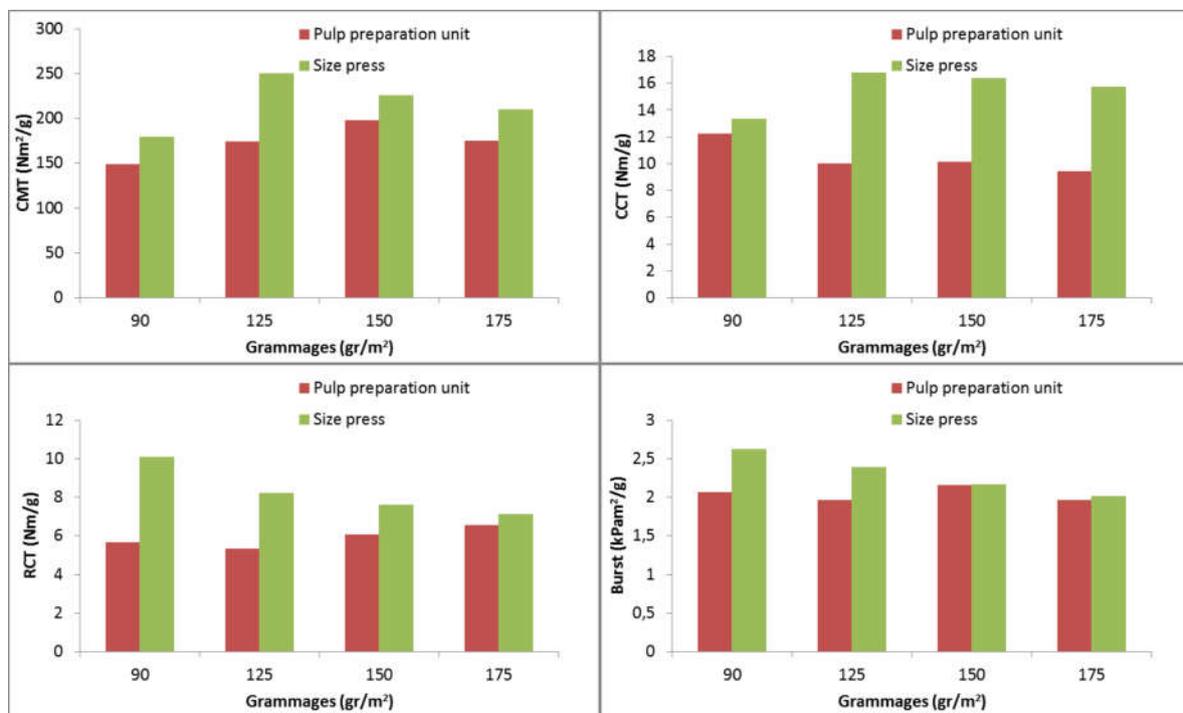


Figure 1. The physical properties of the papers with different grammages produced using starch in pulp preparation unit and at size press

As can be seen in the figure above, the papers (SP) produced using starch added at size press have better physical properties. CMT, CCT, RCT, and burst index of SP with 90 gr.m⁻² were increased about 20.80%, 9.08%, 78.13%, and 26.57%, respectively, when compared with the papers produced using starch added in pulp preparation unit (PP). The most significant increases for physical and optical properties were obtained on test liner papers with 90 gr.⁻² after size press application. Kuusisto (2014) reported that tensile strength increased up to 108 kN/m, compared to tensile strength of 97-100 kN/m for base paper from same run without sizing. In a study, Biricik et al., (2011) have found that the physical properties of the papers applied starch to surface improved. Besides, the optical properties were increased by using starch added at size press. As a result, adding starch at size press improved significantly the physical and optical properties of the test liner papers.

4. Conclusion

In this study, the effects of different starch application on the test liner paper properties were investigated and the physical and optical properties of the papers produced using starch added in pulp preparation unit and at size press were determined. The conclusions obtained from this study were given below:

- Application starch at size press were improved the important physical properties such as CCT, CMT, RCT, and burst indices for test liner papers. In particularly, CCT values have shown a large increase about 78.13% compared to PP.
- The physical properties are considered to be more important for packing papers. Starch application at size press has an important role to improve the physical properties of the test liner papers.

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