COATING-PAPER INTERACTIONS FOR METERED SIZE PRESS COATED MECHANICAL GRADES BASED ON TMP AND SGW PULPS

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ABSTRACT

For paper production lines with on-line coating, productivity is often as important as quality. Metered size press (MSP) coating is gaining ground in these applications, due to good paper web runnability especially in the coating sequence. To further improve paper and print quality for MSP coated paper, the base paper needs optimization. It is known that the base paper properties are among the most important factors influencing the paper and print quality of coated paper. In this work the effect of base sheet structure on paper and print quality has been studied for MSP coated mechanical paper. Variations in base sheet structure were created by precalendering and by varying the filler content and by varying the type of mechanical pulp; SGW (stone groundwood) and TMP (thermomechanical pulp). The work also points at some useful methods for coating-paper interaction studies. The results showed that by reducing the pore size distribution in the paper structure and the roughness volume of the base paper, a better coating coverage was attained. This consequently led to a better print result regarding print gloss and evenness in the printed image. The reason for this was probably less coating solids and liquid phase penetration into the base sheet. Reducing the pore size distribution of the base paper structure can be done by means of lowering the freeness level of the pulp, increasing the filler content or by precalendering. The choice of fiber raw material is of course of fundamental importance for the interaction between base paper and coating layer.

INTRODUCTION

For production lines with on-line coating, productivity is often as important as paper quality. With increasing cost consciousness, metered size press (MSP) coating is gaining ground for wood containing paper grades, e.g. LWC for offset printing. New developments of multi-nip calenders, giving lower bulk losses than conventional supercalendering, will also increase the potential for the MSP coating. There is, however, a need to increase process knowledge regarding paper-coating interaction in MSP applications, to further improve paper quality and runnability [1].

A substantial amount of work has been done in the area of runability and quality coupled to coating color characteristics. Studies on MSP coating at high speeds without mist, clearly showed the importance of high solids content for the coating color, to minimize color penetration into base sheet and to avoid gloss unevenness and print mottle. Several studies have also shown the possibility of coating at speeds above 2000 m/min without runnability problems like misting [1,2,3,4,13].

Among the most important factors influencing the paper and print quality of coated paper are the base paper properties. Base paper for coating should have sufficiently small pores to minimize penetration of liquid phase and pigment particles into the pores [5]. There are some doubts in earlier studies whether coating can penetrate deeply into the base paper or just fill the roughness volume in the surface and the upper parts of the surface voids. The voids are reported to be cone shaped [33] and would thus not permit deeper penetration of pigment particles [25,31].

The influence of filler content on fiber rising and dimensional stability of base papers has been pointed at in several studies. An increased filler content reduces the fiber-to-fiber contact, which during water contact reduces the hygroexpansion and swelling pressure but increases the fiber rising [18, 20, 21, 22, 28]. Increased filler content will also reduce the expansion of a precalendered paper [23, 25]. An increased filler content reduces the pore volume, which consequently leads to decreased water penetration during pressure penetration [28].

Precalendering has in some cases improved the print quality of film coated paper through improved coat weight uniformity, i.e. homogeneously distributed coating layer [4,7,24]. Precalendering has however not in every case reduced the surface roughness of the coated product due to base sheet roughening during coating. It is a common understanding that when the liquid phase of the coating comes into contact with the base paper, a release of the internal stresses in the fiber structure takes place. Other phenomena suggested to occur during coating are fiber swelling, fiber rising, softening and breakage of fiber-to-fiber bonds [4,6,7,16,18,23,25,27]. Other studies showed that precalendering mainly compressed the fiber flocs, which expanded upon wetting [23,26]. It has been suggested that the pressure imposed stress relaxation for mechanical fibers when inducing moisture, results from recovery of their tubular shape. It has been found that chemical pulp fibers do not show any tendency for decollapse or recovery [23,25]. The precalendering process also diminishes the pore radius and the surface roughness. Less water and liquid penetration is a result of the reduced pore radius, where a pressure penetration in contrast to a pressureless, increases the difference between precalendered and *not* precalendered base papers [28].

The fiber raw material is suggested to be chosen so that a minimum of fiber roughening takes place during coating and printing and so that the smoothest possible surface is attained before coating with a minimum of precalendering [5,8,29]. There are more long and coarse fibers in TMP pulp than PGW (pressurized groundwood), which increases the risk of fibers rising and fiber roughening during water application [9,14,23,29]. Because of this, PGW papers have shown higher print gloss and lower tendency for fiber roughening than TMP papers [9,12,13,14]. This is confirmed in a work by Gane et. al. where TMP compared to GW as well as increased amounts of TMP in the furnish gave more "profile roughening" during coating. In their case the paper was blade coated and the furnish also contained 50% of chemical pulp [34]. There is a common understanding that high quality LWC paper can be produced from both TMP and PGW if processed correctly. From a quality point of view the key issue is refining of the coarse fiber fraction of the TMP pulp in a proper way [9,10,14,29,34]. SGW is closely related to PGW, but has a slightly lower amount of long fibers than PGW [10].

In this work the effect of base sheet structure on paper and print quality has been studied for MSP coated mechanical paper. Variations in base sheet structure were created by precalendering by varying the filler content and the type of mechanical pulp; SGW (stone groundwood) and TMP (thermomechanical pulp).

EXPERIMENTAL

Testing

Conventional paper testing

The following paper properties were measured according to the appropriate SCAN standard testing methods; grammage (SCAN-P 5:63), coat weight (SCAN-P 5:63), filler content, ash content (SCAN-P 5:63), moisture content (SCAN-P 4:63), ß-formation (Ambertec Beta Formation Tester), Hunter 75º/75º gloss, porosity with the PPS-S10 air-leak method, Bendtsen smoothness (SCAN-P 21:67), PPS-S10 (Parker Print-Surf apparatus with a clamp pressure of 1.0 MPa) roughness (SCAN-P 21:67), Cobb-Unger CU10 oil absorption (SCAN-P 37:77), opacity (SCAN-P 8:75), density (SCAN P 7:96) and stiffness (SCAN-P 64:90). All paper testing was performed in a conditioned test atmosphere of 23ºC ± 1ºC and 50% ± 2% RH (SCAN-P 2:75). The base paper properties are reported in Table 2.

Fiber rising tendency

Fiber rising tendency of the base papers (FIBRO 100 FRT, Fibro System AB Stockholm, Sweden) was measured by applying a certain amount of water (0-9.9 g/m^2) followed by rapid drying with a hot air jet (0-199ºC). After drying the base paper, the sample is moved over an edge with an angle of 90º. The fibers rising above the baseline of the paper are monitored by image analysis and converted into areas of short fiber rising (lengths up to 0.1 mm) or long fiber rising (lengths between 0.1 mm and 1.5 mm) [18].

Dimensional stability

A method to measure dimensional stability of paper (Fibro DST 1200, Fibro Systems Ab, Stockholm, Sweden) enables analysis of dynamic displacement across a specimen surface exposed to changes in moisture, temperature or tension [19]. The method is based on application of a speckle pattern on the test specimen, which is held flat under a pixel-synchronous CCD video camera capturing an image. The surface is then exposed to different levels of humidity, temperature or tension. After a selectable conditioning time, a second image of the specimen is captured. A full test involves a sequence of two or more captured images at different specimen conditions. The images are compared on the submicron level and the displacement in microns is calculated across the specimen surface. In our study, the hygroexpansivity was measured with a cycle of 50-20-50-80-50 RH % and a conditioning time of one hour. The temperature during the measurement procedure was constant at 20ºC, [19, 20].

Coat weight variations

Coat weight variations were measured using a standard method at Stora Enso Research, Falun, Sweden. The evaluation was done by image analysis of burn-out samples, where the coefficient of variation of reflectance of the burn-out sample was measured. The area analyzed is 90.3x34.9 mm^2 and the reported value in this report is in the flock size range 1-8 mm.

Surface topography

The topographical CD-variations in the coated paper were detected by a laser beam moving over the surface (UBM Meßtechnik GmbH, Ettlingen, Germany). The result is presented as a variance spectrum of the surface topography. The topographical CD-variations in the coated paper were detected by a laser beam with a spot size diameter of 1 µm and a probe speed of 0.5 mm/s. Twenty 58 mm long tracks were scanned at 3 mm intervals. The vertical range was 2.5 µm on a sampling distance of 20 µm.

Print mottle

Print mottle was measured on a 40% black half tone area in accordance with a standard method at Stora Enso Research based on image analysis. Variations in print density are measured and divided into different floc sizes, with a band pass filter. The best correlation with visual appearance has been found in a floc size range of 1-8 mm.

Fiber roughening

Fiber roughening is the increase in surface roughness of the sheet during heat-set web offset printing. The fiber roughening is in this paper defined as the difference between surface roughness (Parker Print Surf with a clamp pressure of 0.5 MPa, PPS-S5) of printed and unprinted sheet. It is measured on a printed area consisting of two full tones printed on top of each other.

Prüfbau printing.

Laboratory printing was done on the Prüfbau Printability Tester with a black heat-set ink for magazine paper from Sun Chemicals, Stockholm, Sweden. The printing was done at five

different inking levels. The print density measurements were done with the Elrepho 2000 (Y-function) and the gloss measurements with the Zehntner Gloss-meter according to TAPPI T480, 75º, at an ink level of 1 g/m². The evaluation of test prints was done according to SCAN-P 36:96. The print conditions were the following:

Ink distribution time/ inking time: 15 s/ 15 s
Linear pressure: 15 kN/m
Printing speed: 2.0 m/s

Pilot trials

Base paper

Two types of base papers, based on SGW and TMP, were produced on production paper machines equipped with gap formers, to a basis weight of 45 g/m². The SGW based paper was produced to the three filler content levels of 10, 15 and 20% and the TMP based to 10 and 15%. The furnishes contained 20% of kraft pulp and the starch content was 0.7% in both base papers. The formation was slightly better for the SGW papers than for the TMP. Base paper properties are shown in ***Table 1***. Data on the pulp properties are to be found in *Appendix A*.

Furnish/ precalendered	Filler cont. [%]	Opacity [%]	Porosity, Bendtsen [ml/min]	β-Form. [g/m²]	Density [kg/m³]	Bendtsen [ml/min]	Tensile stiffness MD [kN/m]	Tensile strength MD [kN/m]
TMP/ precal.	10	90.4	451	3.5	500	435/334	401	3.2
TMP	10	90.2	501	3.4	464	703/526	431	3.5
TMP/ precal.	15	90.9	451	3.5	518	399/273	394	3.1
TMP	15	91	498	3.5	466	657/497	406	3.1
SGW/ precal.	10	-	-	3.1	980	435/460	460	3.7
SGW	10	89.3	138	3.2	1015	703/813	457	3.7
SGW/ precal.	15	-	-	-	1044	242/266	458	3.5
SGW	15	90.1	146	-	999	466/700	451	3.4
SGW/ precal.	20	-	-	2.9	1040	235/249	441	3.3
SGW	20	91.1	149	3.0	1030	437/633	446	3.3

Table 1. Base paper properties.

Precalender

Precalendering was done at 1800 m/min, with one hard steel/ steel roll nip at a linear load of 50 kN/m to reach a smoothness target of 400 ml/min Bendtsen.

Coating Color Composition

The coating color formulation is presented in ***Table 2***.

Content	pph
Clay, SPS [pph] (English China Clay International, Cornwall, England)	100
Styronal FD-516, S/B Latex [pph] (Raisio Chemicals Oy, Raisio, Finland)	12
FinnFix 5, CMC [pph] (Metsa Specialty Chemicals Oy, Äänekoski, Finland)	0.3
Optical brightener, Blankophor P [pph] (Bayer AG, Leverkusen, Germany)	0.8
Solids content [%]	57
Brookfield viscosity at 100 rpm [mPas]	400

Table 2. Coating color composition.

Coater

The paper was coated on a pilot coater with a metered size press unit, in two separate passes (C1S+C2S) at the Valmet Finishing Technology Center in Järvenpää, Finland (SymCoat, Valmet Corporation). The machine speed was 1800 m/min and the coat weight 8 g/m²/side. The pilot coater is shown in ***Figure 1***.

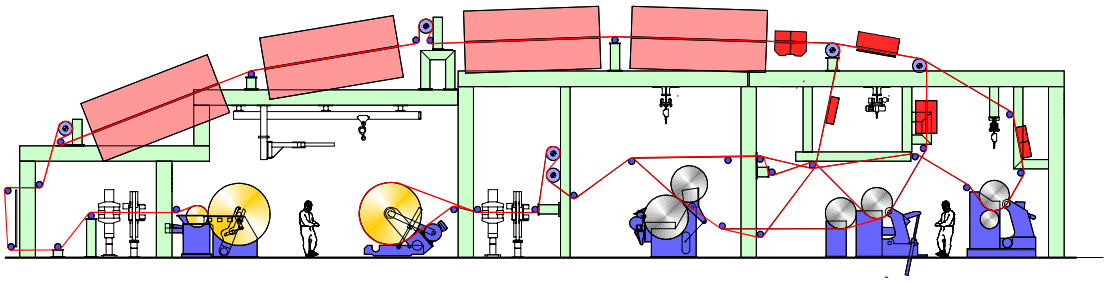


Figure 1. Illustration of the pilot coater at the Valmet Finishing Technology Center in Järvenpää, Finland.

Conventional supercalender

The supercalendering was done at the Valmet Finishing Technology Center in a conventional supercalender with 11 nips and a double finisher in the 6/7-nip position. The speed was 700 m/min and the linear load 310 kN/m. Cotton/ wool rolls were used as soft rolls with a hardness of 85 ShD. The roll temperatures of the steel rolls were 60/80/100ºC.

Printing Press

The printing trials were performed on an Albert-Frankenthal heat-set web offset printing press at the Finnish Pulp and Paper Research Institute in Espoo, Finland. The order of colors was black, cyan, magenta and yellow and the speed was 6 m/s (366 m/min). The dampening water contained 10% isopropanol. Negative printing plates were used (Osasol N71). The black ink (Challenge) was supplied by Sun Chemicals and the other inks by Sicpa; cyan (2054-6790K), magenta (2054-5090K) and yellow (2054-2390K).

RESULTS AND DISCUSSION

Influence of fiber raw material on base paper characteristics.

Physical sheet structure

The SGW base sheet had a lower porosity and a higher density than the TMP, as expected. Mercury porosimetry measurements of the base paper consequently show that the total pore volume was greater for the TMP papers than for SGW ***(Figure 2)***. This is due to the higher amount of coarse and long fibers in the TMP pulp. Both precalendering and increased filler content level had additionally a slightly reducing effect on the total pore volume.

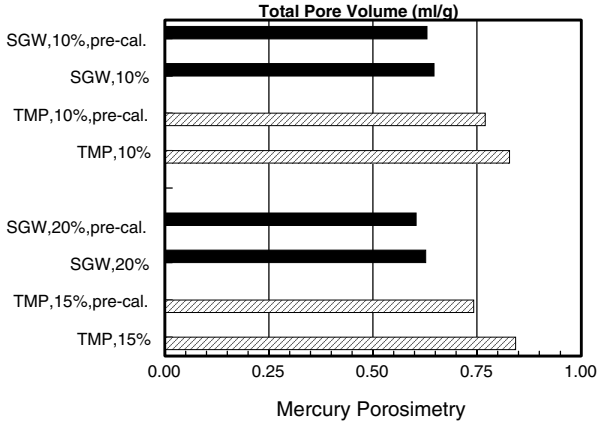


Figure 2. Total pore volume of base papers based on SGW and TMP respectively. The total pore volume was generally higher for the TMP. Both precalendering and increased filler content level had a slightly reducing effect on the total pore volume.

Figure 3 shows the pore radius size distribution for different base papers. The TMP papers contained a larger amount of large diameter pores and a smaller amount of small diameter pores than the SGW papers. An increase in filler content from 10% to 20% for the SGW paper reduced the amount of large diameter pores and increased the amount of small diameter pores. The pore radius size distribution of the TMP paper was not affected significantly by increasing filler content from 10 to 15%.

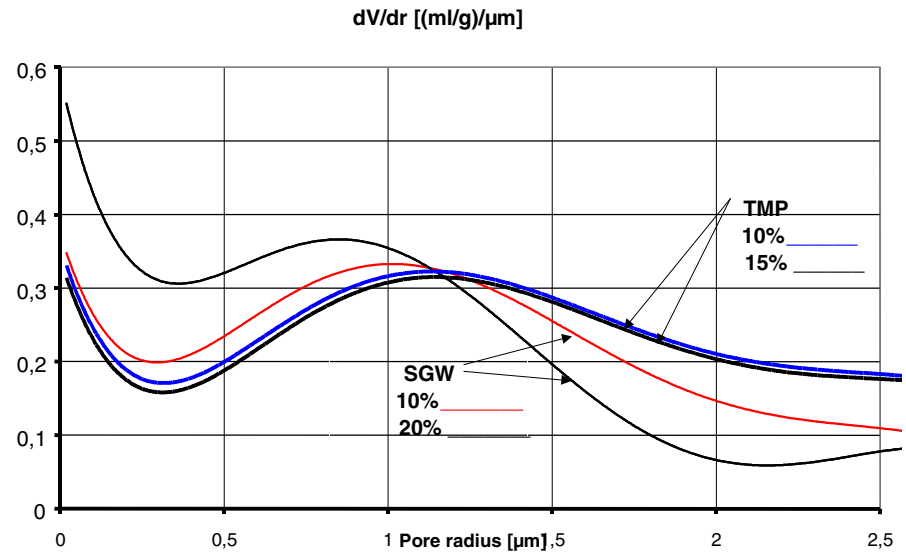


Figure 3. Pore radius size distribution for base papers based on SGW and TMP for two filler content levels. The TMP papers contained a greater amount of large diameter pores and a smaller amount of small diameter pores than the SGW papers. An increase in filler content from 10% to 20% for the SGW paper reduced the amount of large diameter pores and increased the amount of small diameter pores.

Precalendering of both SGW and TMP papers reduced the total pore volume of the large pores and increased the total pore volume of fine pores. This is shown in ***Figure 4***, for the filler level 10% (see *Appendix A*).

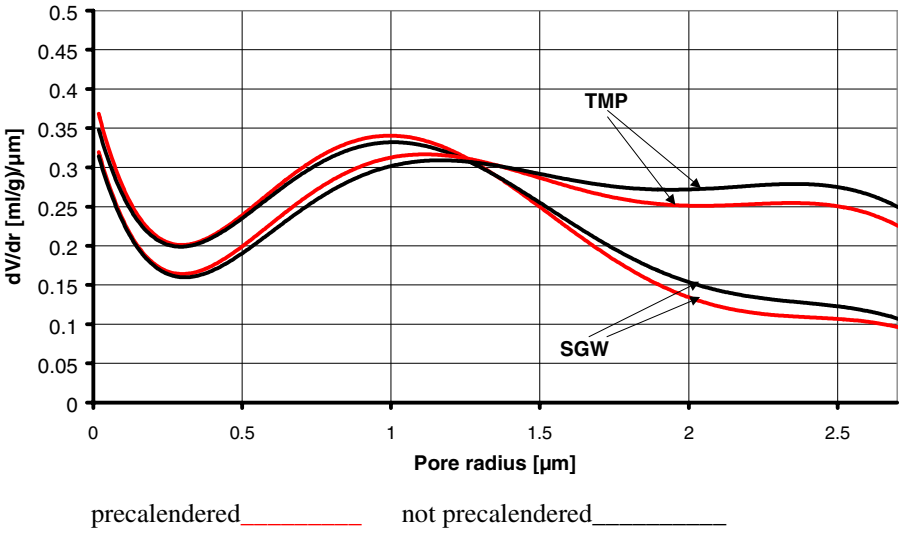


Figure 4. Distribution of pore radius size for base papers based on SGW and TMP. Precalendering of SGW papers reduces the total pore volume of the large pores and increased the total pore volume of fine pores. Precalendering of the TMP papers reduced the pore volume of the largest pores to a greater extent than for SGW. The filler level is 10%.

The Bendtsen surface roughness is on the same level for the two types of base papers, based on TMP and SGW respectively (***Figure 5***). Precalendering as well as higher filler content reduced the surface roughness for both types of base papers.

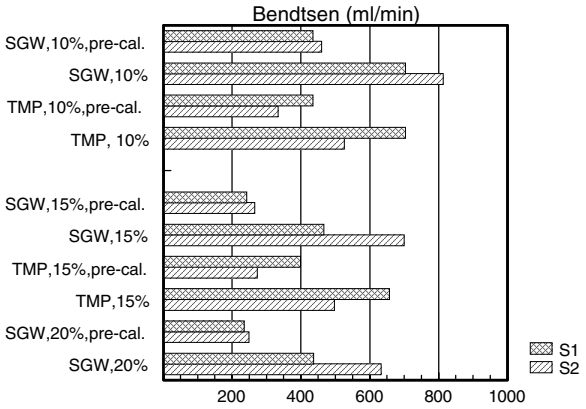


Figure 5. Bendtsen surface roughness of base papers based on SGW and TMP. The Bendtsen surface roughness is on the same level for base paper based on the two pulps. Precalendering reduced the surface roughness of the base paper.

Influence of base paper characteristics on coating layer formation.

Interaction between base paper and water

Both fiber rising tendency and hygroexpansion were higher for the TMP base papers than for the SGW according to ***Table 3***, which confirms many earlier findings [9,14,23,29]. This is explained by the higher content of long and coarse fibers in the TMP pulp than in the SGW (Appendix A).

Furnish	**Fiber rising Long (0.1 - 1.5 μm) ts/ bs MD**	**Hygroexpansion MD/CD**
SGW, 10%	2.21/ 5.95	0.00/ 0.13
SGW, 15%	2.17/ 5.76	0.00/ 0.13
SGW, 20%	1,81/ 4.03	0.06/ -0.05
TMP, 10% precal.	27.5/ 14.7	0.372/ 0.059
TMP, 10%	29.5/ 13.7	0.345/ 0.064
TMP 15% precal.	32.2/ 8.79	0.379/ 0.095
TMP, 15%	21.8/ 8.79	0.274/ 0.048

Table 3. Fiber rising and dimensional stability for SGW and TMP base papers. The precalendered papers based on SGW were not measured.

There was less hygroexpansion, i.e. better dimensional stability for the SGW papers than the TMP. Precalendering increased the hygroexpansion for the TMP papers. This can be explained by internal stress build up during the precalendering, which later can be released and gives rise to a higher degree of hygroexpansion.

Interaction between base paper and coating.

How the base sheet porosity/openness effects the coating result is shown in ***Figure 6***. SEM-BSE (back scattered electron) images of coated paper surfaces are shown, where dark spots represent areas poorly covered with coating. The images clearly show that the more closed base sheet structure of the coated SGW papers, results in a better coating coverage than the TMP papers. It can also be seen that both precalendering and increased filler level improve fiber coverage. The better fiber coverage in these cases is possibly due to a lower degree of solids phase penetration into the base paper, and a smaller roughness volume. The better coating coverage could also be explained by a lower degree of fiber swelling and fiber rising of the SGW papers than the TMP papers. It can be concluded from the images that by reducing the amount of large diameter pores, e.g. closing the sheet structure, the coating is prevented from penetrating into the base paper.

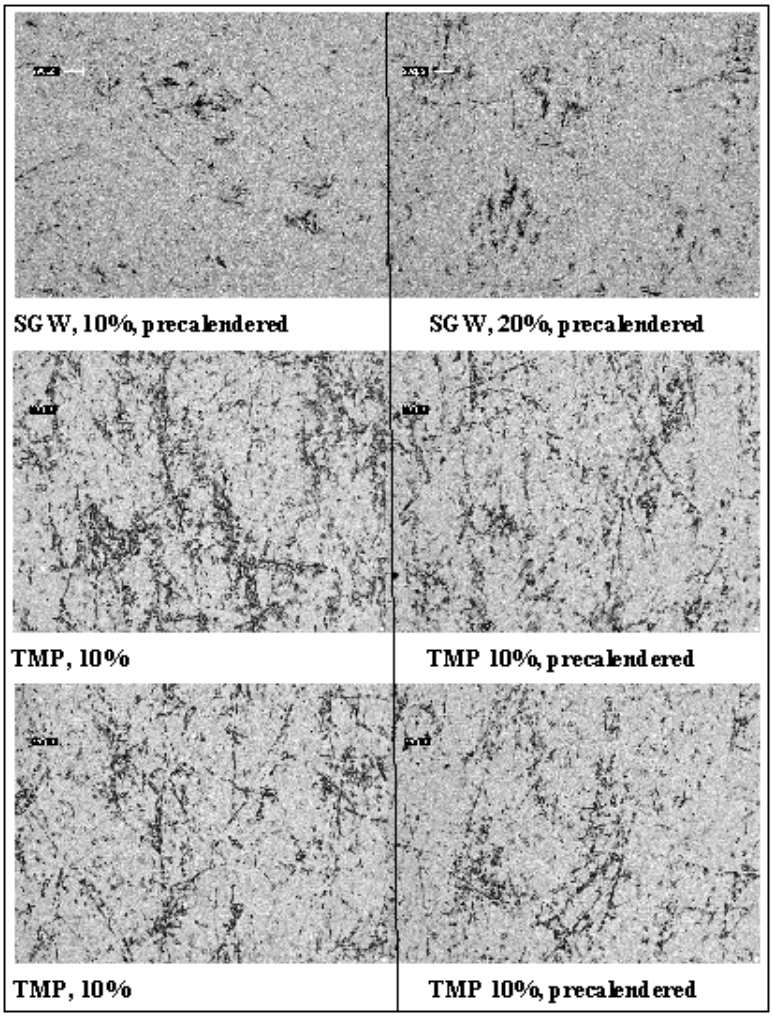


Figure 6. SEM-BSE (back scattered electron) images of coated paper surfaces.The papers are based on TMP and SGW papers. The darker areas represent spots with poorer fiber coverage. The fiber coverage of the SGW based paper was better than for the TMP-based papers. Precalendering and higher filler content improved the fiber coverage.

Coating penetration

Analysis of cross sections *(**Figures 7a** and **7b**)* of coated papers was done to obtain the coating distribution in the z-direction. The images below clearly demonstrate that the TMP base paper used in the study had a more open structure and was more prone to coating penetration into the sheet than the SGW. From these types of images the coating distribution in the z-direction can be obtained as curves, according to ***Figure 8***. In this graph the slopes of the coating curves at the coating-fiber interface give information regarding coating penetration into the base sheet. A steeper inner slope of the z-directional curve for coating distribution indicates less coating penetration into the base sheet. As expected, the SGW base paper generated steeper curves in the interface fiber-coating, compared to the TMP paper, indicating less coating penetration. The results are confirmed in an earlier study by Gane et. al. [34], where incresed TMP content in a furnish gave a tendency to a broader coating thickness distribution, i.e. increased void filling.

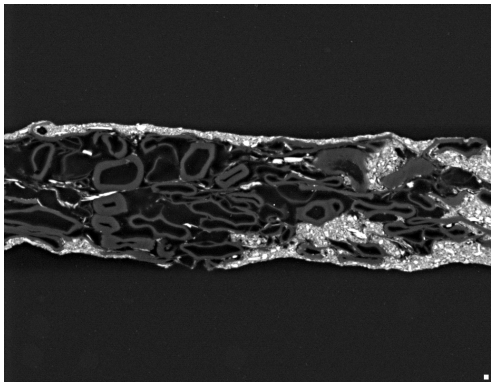


Figure 7a. Cross section image of coated TMP paper. Not precalendered and filler content 10%. The paper is not supercalendered.

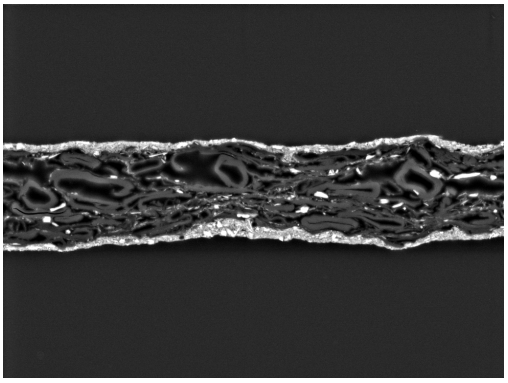


Figure 7b. Cross section image of coated SGW paper. Not precalendered and filler content 10%. The paper is not supercalendered.

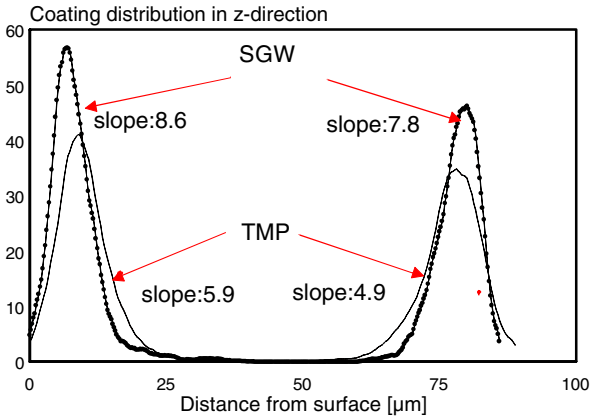


Figure 8. Coating distribution in z-direction of coated, not supercalendered sheets based on TMP and SGW respectively. The filler content is 10% and the paper was not precalendered.

The SGW base papers with a lower porosity and a more closed base paper, showed lower oil absorption values according to the Cobb-Unger test, ***Figure 9***. Increased filler content level lowered the oil absorption values and has been reported to also lower the water absorption under pressure [28]. Precalendering also gave a slight reduction in oil absorption. The results in this study suggest that large diameter pores promote oil absorption and consequently also coating color penetration into the base paper during the coating process (compare Mercury Porosimetry Measurements in *Figures 3 and 4*).

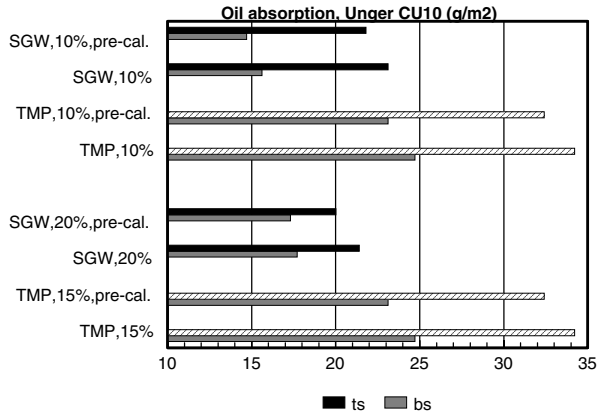


Figure 9. Cobb-Unger Oil absorption for SGW and TMP papers. The SGW papers showed lower oil absorption CU_{10} values than the TMP papers.

At this point it can be concluded that the more closed SGW sheet with a lower total pore volume and a lower amount of large diameter pores, gave better coating coverage, lower fiber rising tendency and lower hygroexpansion than the TMP paper.

Coating distribution variations

Coat weight variations for the different papers, i.e. mass distribution of coating, are shown in ***Figure 10***. A lower value indicates a more even coat weight distribution. In the range 1-8 mm the SGW base papers gave lower coat weight variations than the TMP papers. The more even coating distribution on the coated SGW papers can be explained by the more closed base paper structure and lower absorption, but the slightly better formation of the SGW paper may also have played a part. Previous studies have also shown that precalendering and higher filler content levels have reduced coat weight variations [4,7,24].

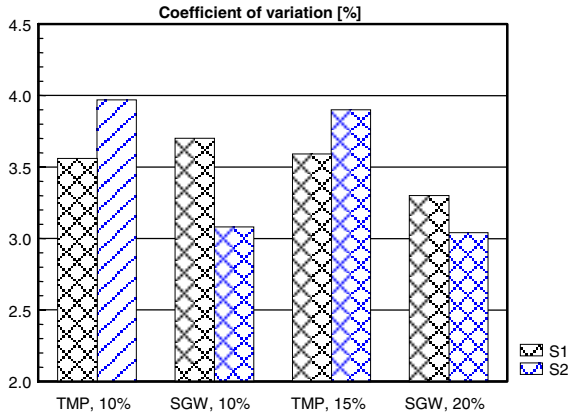


Figure 10. Coat weight variations for coated papers based on SGW and TMP respectively, with different filler content levels. A lower value indicates a lower coat weight variation, i.e. a more uniform coating layer distribution. The papers were not supercalendered and the floc size of the variation was 1-8 mm.

Variations in surface coating layer

Less coating solid phase penetration into the base paper, provides a more even surface with better coating coverage and higher smoothness. ***Figure 11*** shows the variance spectra of coated but not supercalendered TMP and SGW paper. The coated TMP papers show higher topography variations than the SGW papers, which indicates a rougher surface. The figure shows that precalendering reduces the topography variations. It has earlier been found that also a higher filler content reduces the topography variations [3]. It cannot be neglected that a reduced amount of large diameter pores also reduces water penetration under pressure [28], which may indirectly reduce surface roughness through less fiber swelling and relaxation.

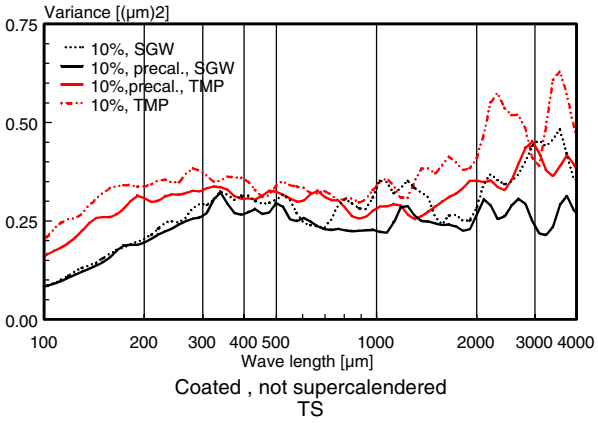


Figure 11. Variance spectra of the surface topography of coated, non- supercalendered TMP and SGW papers. Effect of precalendering and filler content.

Influence of coated paper substrate properties on the printed image characteristics.

In the following part the effects of base paper properties on print quality, will be discussed.

Surface structure and ink demand.

Prüfbau printing provided results regarding ink demand and print gloss for the coated TMP and SGW papers. The coated TMP papers gave a lower print gloss and print density than the SGW papers, despite the fact that the Parker Print surface roughness was lower (*Appendix B*). This is most likely a combination of the more open sheet structure and poorer coating coverage (***Figure 12** and **13***) as well as the coarse, long fiber fraction for the TMP papers. Increased filler content levels gave higher print gloss and print density, due to a more closed sheet structure and possibly also due to a lower surface roughness. Higher filler contents in the sheet gave slightly less fiber rising and a slightly better dimensional stability which might give an increased print gloss.

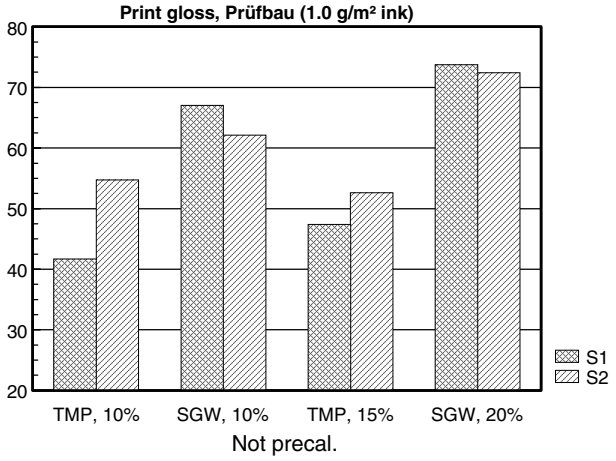


Figure 12. Print gloss for coated TMP and SGW paper. Prüfbau printing. The coated TMP paper, with higher porosity, gave a lower print gloss. Increased filler content level increased the print gloss.

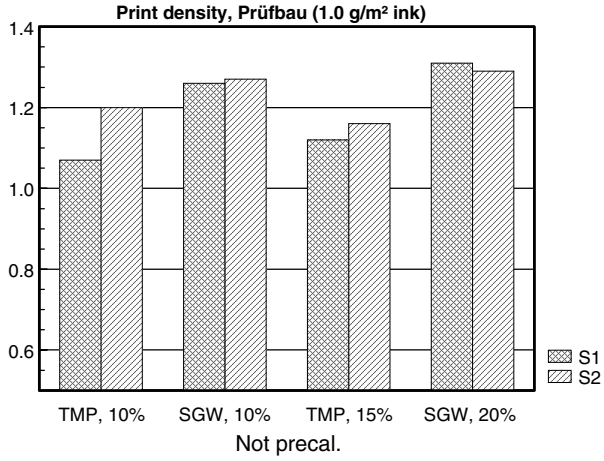


Figure 13. Print density for coated TMP and SGW paper. Prüfbau printing. The coated TMP papers, with higher porosity, gave a lower print density. Higher filler content increased the print density.

Evenness in coating coverage and smoothness reflected in print quality.

A base paper surface with an even and good coating coverage, promotes an even ink absorption and consequently leads to less print mottle, (see Experimental for mottle evaluation). In the study, coated TMP paper gave in general more print mottle than the SGW papers (***Figure 14**).* The reasons for this were poorer fiber coverage and higher coat weight variations for the coated TMP papers and possibly also the slightly poorer formation. Precalendering and higher filler content also reduced print mottle, since the base paper porosity is reduced in both cases.

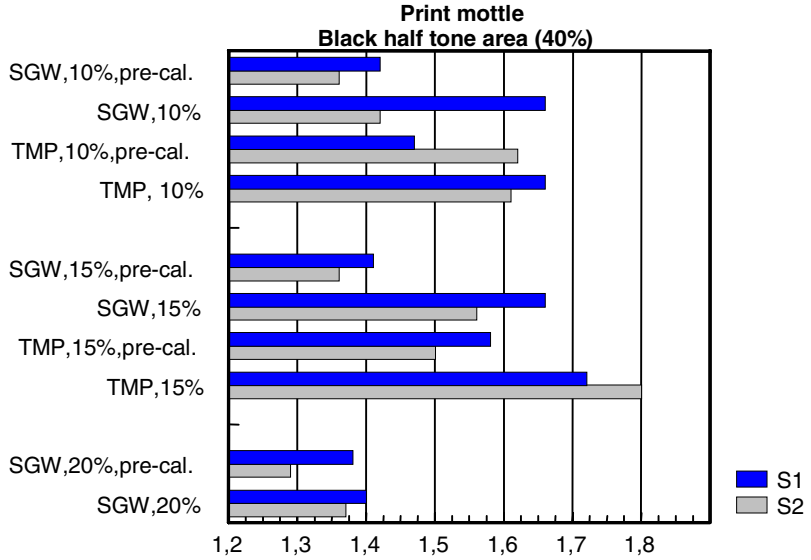


Figure 14. Print mottle in 40% black half tone area for coated SGW and TMP papers. The TMP papers gave in general more print mottle. Precalendering and higher filler content reduced print mottle.

Dot gain is an important quality parameter for wood containing coated papers. A low dot gain value promotes a good image reproduction. Dot gain indicates the increase in dot size between the film and the printed image; i.e. a low dot gain value is desirable. Increased ink demand, which can be caused by high surface roughness or high porosity, generally increases the dot gain. The reason for this is that a thicker ink layer is more prone to dot gain than a thin [17]. As expected, dot gain was lower for the coated SGW papers than for the TMP papers, due to the lower ink demand and more closed sheet structure of the coated SGW papers (***Figure 15***). A higher filler content also gave a reduction in dot gain, probably caused by the more closed sheet structure but possibly also by the lower surface roughness.

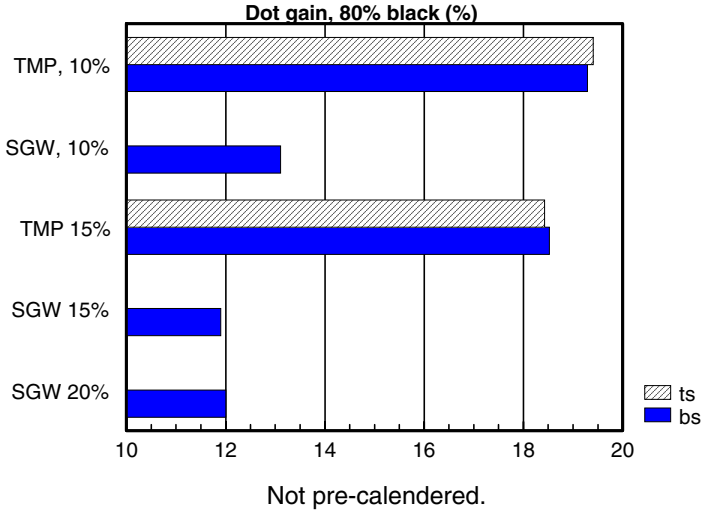


Figure 15. Dot gain for coated SGW and TMP papers. The dot gain is lower for the SGW papers than for the TMP papers. Also a higher filler content reduces dot gain. A lower value indicates a better print result.

Stress release and roughening during printing process.

During HSWO printing, part of the built-in stress in the sheet is released due to water penetration into the paper. ***Figure 16*** shows the fiber roughening measured as Parker Print surface roughness before and after printing. Surprisingly enough, no difference in surface roughening measured as PPS-S5 is seen between the TMP and SGW papers, in contradiction with results in the literature [9]. Despite higher fiber rising values and poorer dimensional stability for the TMP base paper, the fiber-roughening tendency is on the same level for both types of papers. However, a significant roughening takes place for both types of papers.

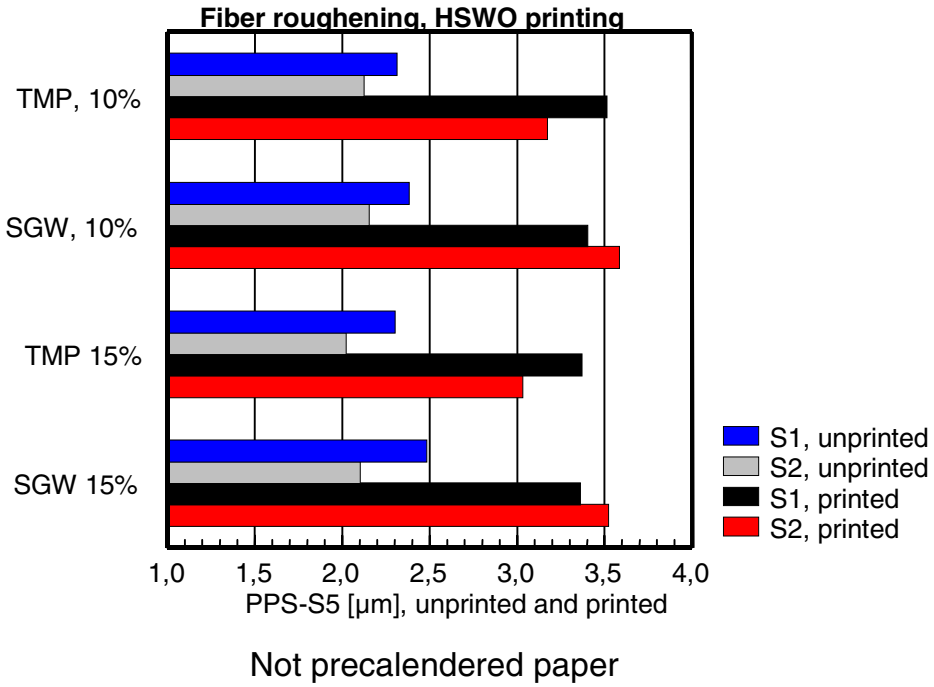


Figure 16. Fiber roughening in HSWO printing measured as Parker Print surface roughness (PPS-S5), for paper not precalendered. No difference in surface roughening is seen between the coated TMP and SGW papers.

The effects of precalendering and filler amount for both coated TMP and SGW papers are presented in ***Figures 17*** *and* ***18***. For the TMP papers, precalendering had no effect on fiber roughening. Increasing filler content slightly reduced fiber roughening. For the SGW papers the situation is slightly different. Both precalendering and increased filler amount had reducing effects on fiber roughening.

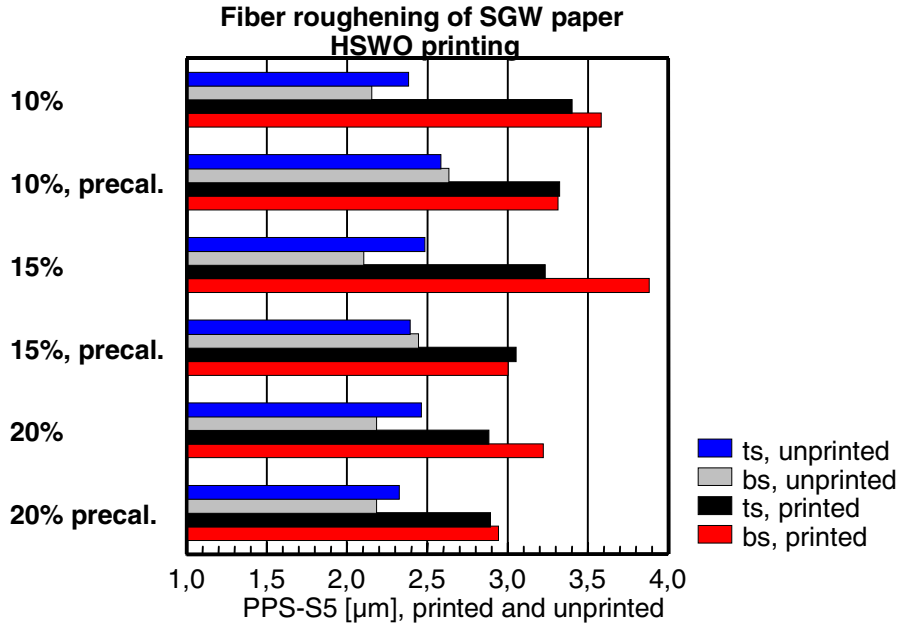


Figure 17. Fiber roughening for SGW paper in HSWO printing. Effect of precalendering and filler content.

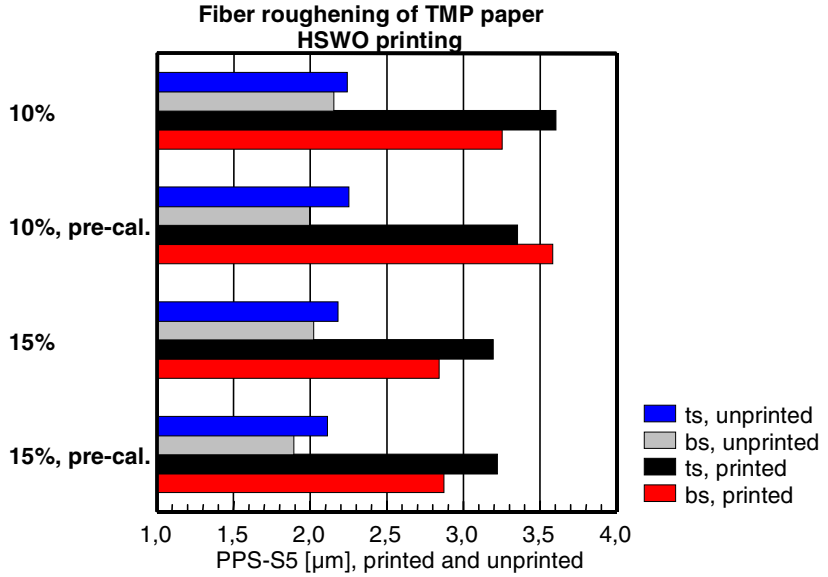


Figure 18. Fiber roughening for TMP paper in HSWO printing. Effect of precalendering and filler content.

The results point to the importance of a fairly closed base paper structure giving a good coating coverage, which is beneficial for the print quality. The results also illustrate the negative effects on print quality that the long and coarse fiber fraction in the TMP pulp gives.

Concluding remarks

The study has shown that by closing the base paper structure and the base paper surface, coating is prevented from penetrating into the base sheet. Closing the base paper structure can be done by means of pulp choice, lowering the freeness level, increasing the filler content or by precalendering. The choice of fiber raw material is of course of fundamental importance for the interaction between base paper and coating layer. Closing the base paper structure enhances coating coverage of the base paper surface, which leads to improved coated surface properties and an improved print result.

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Property		SGW	TMP
CSF	[ml]	27	80
Coarse (+14) fibers	[%]	3.8	19
Long (-14/+28) fibers	[%]	20.4	44
Fines (-200)	[%]	37.9	26
Density	[kg/m³]	443	368
Tensile index	[Nm/g]	45	41.8
Tear index	[mNm²/g]	3.7	7.0
Scattering coefficient	[%]	65.9	55

Appendix A. Pulp properties of the SGW and TMP pulp.

Furnish	Filler level [%]	Precal.	Total pore volume [ml/g]	PR >2 µm [ml/g]	PR <2>0.25 µm [ml/g]	PR <0.25>0.025 µm [ml/g]
SGW	10	yes	0.6295	0.0940	0.4784	0.0528
SGW	10	no	0.6459	0.1094	0.4814	0.051
SGW	20	yes	0.6031	0.0537	0.4546	0.0895
SGW	20	no	0.6264	0.0630	0.4692	0.0891
TMP	10	yes	0.769	0.2544	0.4656	0.0458
TMP	10	no	0.8279	0.3211	0.4582	0.0447
TMP	15	yes	0.7415	0.2381	0.455	0.0456
TMP	15	no	0.8425	0.3216	0.4689	0.0487

Appendix B. Pore volume of base papers (ml/g), measured with Mercury porosimetry.

Pulp/ filler content [%]	Precal.	PPS-S10 ts/bs [µm]	Gloss ts/bs [%]
TMP/ 10	yes	1.54/1.32	37.8/ 40.4
TMP/ 10	no	1.59/ 1.41	32.6/ 38.2
TMP/ 15	yes	1.45/1.28	39.6/ 44.1
TMP/ 15	no	1.59/ 1.37	33.6/ 38.2
SGW/ 10	yes	1.77/ 1.80	37.8/ 39.7
SGW/ 10	no	1.52/ 1.65	45.7/ 43.1
SGW/ 15	yes	1.63/ 1.69	40.6/ 44.9
SGW/ 15	no	1.48/ 1.79	49.5/ 43.1
SGW/ 20	yes	1.50/1.67	39.7/ 56.7
SGW/ 20	no	1.53/ 1.67	45.3/ 41.8

Appendix C. Paper properties of coated and calendered paper.