The Influence of Coating Binders and Base Paper to Printed Paper Attributes and Runnability of Matt LWC Grades in Cold Set Web Offset Printing

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1 Introduction

The objective of this study is to define the influence of coating binders and base paper to the printed paper attributes and to the runnability performance of the matt LWC papers in cold set web off set (CSWO) printing. Based on customer's expectations following attributes of printed paper are defined to be most relevant to matt LWC grades in CSWO printing in this study:

- Sharpness (dot-gain) and contrast of printed images
- Cleanliness of printed product correlating to set-off and print-through

Printers have various expectations of runnability of the matt LWC grades in CSWO printing. These expectations are mainly related to production efficiency of the printing process and can be summarized as:

- Good runnability: minimum web-breaks in the printing machine and finishing process
- High time efficiency: minimum time used for cleaning of various parts of the printing machine; blankets, common impression cylinders, rollers, etc.

The matt LWC grade in CSWO printing has generally good runnability. In this study the performance of matt LWC grades in printing situation was studied at a satellite type CSWO press. Runnability was specifically defined to mean the mail-room performance and build-up (dusting) at various parts of the printing machine.

This study has been carried out exclusively in industrial scale using commercial production lines, printing machine and raw materials. Only the coatings were carried out in pilot scale using film coating technology.

1.1 The influence of base paper to the printed paper attributes and printing runnability-theoretical aspects

Previous studies have shown that base paper influences the coating layer formation when using film coating technology.[1] The researchers have so far studied the influence of different variables (coating colour, base paper, various film coating parameters, etc.) on few printed attributes of LWC and ULWC grades in heat set web off set (later referred to as HSWO) process or on the paper quality of these grades in general terms. Less material was found in the literature that would have defined the influence of these variables on the printed paper attributes and runnability with regards to the customer expectations of these grades. No literature was found either about the effect of theses variables on the printed paper attributes or on the runnability of matt LWC grades (hunter gloss <20) in CSWO printing process.[2-6]

Depending on targets, different base paper is recommended for film coating. Grön *et al.*[7] state that base paper should have small number of large pores in order to minimize the penetration of coating colour into the pores. Varsa *et al.* have demonstrated the influence of raw material fibre composition on print gloss and fibre roughening during HSWO printing.[8] Grön *et al.*[9] found in their studies that better coating coverage improves coated surface properties and print result, when considering HSWO printing in general. Print result was defined in Grön's[9] study as ink demand, evenness, print gloss, dot-gain and roughening during HSWO printing. The same study showed as well that coating coverage can be improved by closing the base structure.

On the other hand Drage *et al*. found in their study that some changes in base paper, for example improving formation, did not have any clear influence on the printed paper attributes in the case of film coating.[10] The ideal coating layer for CSWO printing has not been reported in earlier studies.

Särelä proposes in his work[11] that ink setting in CSWO printing on uncoated surface is defined as change of set-off as function of time. The main influencing factor according to Särelä is solvent separation. Särelä's solvent release factor is composed of paper surface variables and various ink variables, but he does not exactly define the relation of measurable properties of ink and/or paper surface to the solvent release factor.

Based on earlier studies, following hypothesis were formed for this study:

1. Base paper influences the printed paper attributes and the runnability of the matt LWC grades in CSWO printing
2. Level of coating coverage of the matt LWC grades has influence to the printed paper attributes and runnability in CSWO printing

1.2 Influence of latex on printed paper attributes and runnability at printing

No previous study was found about the influence of latex or other binders to the print quality or runnability of matt LWC grades in CSWO printing. The influence of coating binders to the print quality or runnability of the matt LWC grades in HSWO has been reported earlier. The previous work in HSWO area mainly concentrates to ink setting phenomenon, which is often assumed to have direct influence to print quality and runnability.

Several attempts have been done earlier to model the ink setting phenomenon on coated grades with HSWO inks and to model the ink setting on uncoated surfaces using CSWO inks. There is not yet a common understanding about these mechanisms. Several different mechanisms for the HSWO ink setting on coated substrate were found. Desjumaux found in her work that ink setting on coating is determined by pore structure at low binder content, but at higher latex rates the solubility characteristics of latex are found to be dominant. Desjumaux found as well, that on slow setting papers ink rheology and elastic recovery properties influence ink setting.[12]

Xiang *et al.*[13] define more specifically that in laboratory scale coating pore structure determine the ink setting rate when using latex levels of 12-14 pph. On the other hand Aspler *et al.*[14] have found that all conditions exist for chromatographic separations during ink film consolidation on coated substrates. Aspler *et al.*[14] found out that different ink polymers had different sorption isotherms onto coating pigments. Van Gilder *et al.*[15] showed that ink setting was related to the degree of latex polymer solubility in the ink solvents. They showed that the latex solubility parameters depended on amount of cross-linking, surface energy and polarity. Their study suggested that moving the solubility parameter of latex away from that of the ink solvent decreased the interaction of ink with the polymer film and produced lower ink-tack build-up.[15] Triantafillopoulos *et al.* found that latex particle size among other variables had influence on ink tack build-up.[16]

Rousu[17] states in her work that in theory latex can affect the absorption kinetics and thereby ink setting by either affecting physical arrangement of the porous structure of the coating and/or affecting the surface chemistry of the coating or by introducing a diffusion driven transportation mechanism of its own. According to Rousu's results the changes in pore structure of coating caused by latex properties (hardness level and size distribution) do not influence the capillary driven absorption of ink oils and thereby ink setting rate, but diffusion of ink oil into the latex, which dictates the rate of ink setting on a coated surface when pigmentation is constant.[17] According to Nordström *et al.*[18] Rousu's theories are valid, if the ink film transfer is in region II, where the ink film is continuously covering the paper surface. Nordström *et al.* define three different regions on the film transfer curve as shown in *figure 1*.

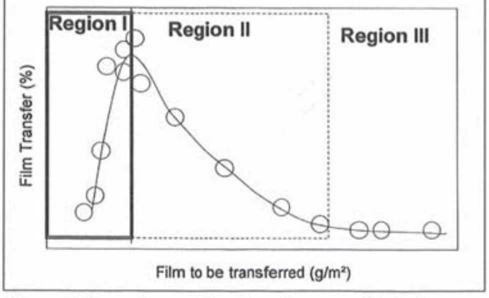

Figure 1. Percentage of film transfer versus film to be transferred showing the regions I, II and III.[18]

At printing nip under pressure pulse some of the low-molecular weight oils of the thin ink film are penetrating in the paper and separating from the original ink film. This immobilizes part of the ink film, but as ink pigment particles start to block some of the capillaries and voids at the surface which is in contact with the ink film, part of the ink layer stays mobile at the surface and film splitting occurs at the exit of the printing nip at this mobile layer. In CSWO printing the significant part of the volume of the ink film applied under pressure pulse most likely disappears in the empty pores and holes present at the coated paper surface. This part of the ink can no any longer stay in contact with the rest of the ink film, leaving behind incomplete ink coverage at the surface. According to Nordström *et al.*[18] this is typical to film transfer phenomenon in region I. Nordström *et al.*[18] state further that stable film transfer process (region II) requires that demands set by the film properties are fulfilled by the area/volume properties of the substrate. If applied ink volume is high enough, region II in film transfer and continuous film coverage is reached. In region II the ink film transfer is determined by absorptive and volumetric properties of the surfaces, if pressure and geometry of the printing nip and rheological properties of the ink are kept constant.[18]

The influence of coating pigments on area/volume properties and further on printed paper attributes and runnability of matt LWC in CSWO printing has been studied in earlier works.[19,20] Earlier results indicate that there are other variables besides coating pigments' influencing runnability and printed paper attributes of matt LWC in CSWO printing.

Based on this previous information from studies about the ink setting of HSWO ink on coated surfaces and its influence to printed paper attributes and runnability, following hypothesis was formed for this study:

- Latex type influences printed paper attributes and runnability of matt LWC grade in CSWO printing.

2 Experimental

Five different base papers were produced in industrial scale using two different production lines. These base papers were film coated in two different occasions using two different pilot coaters. All reels were printed using standard printing procedure in commercial, satellite type CSWO printing machine.

2.1 Methods and Materials

The experiment was divided to latex-part and to base paper-part. *Table 1* summarizes the trial points in base paper part and

Trial point	Description	Fibre mix
1	Base 3+CC 1	A
2	Base 3+ CC2	A
3	Base 4+CC1	B
4	Base 4+ CC2	B
5	Base 1+CC2	A
6	Base 2+ CC2	A
7 (identical to 2)	Base 3 + CC2	A

Table 1. Trial point markings and used material in base paper experiment

8	9	10	11	12	13
Latex A	Latex B	Latex C	Latex D	Latex A	Latex E
Starch A	Starch A	Starch A	Starch A	Starch A	No Starch
Base 5	Base 5	Base 5	Base 5	Base 5	Base 5
Pigment 1	Pigment 1	Pigment 1	Pigment 1	Pigment 1	Pigment 1
				Additive 1	

Table 2. Trial points and materials used in latex experiment

table 2 summarizes the trial points in latex part. Base papers 3 and 4 have fundamental differences due to different paper machine, different raw material and different process conditions. Base papers 1 to 3 had same fibre raw material mixture. Coating colours 1 and 2 have different pigment and different binder systems. Both coating colours are used in industrial scale at high-speed film coating applications.

In the latex experiment latecies A and E are commercial latecies; all the others were specially developed for this experiment. The latecies differ in particle size distribution, degree of hardness, solubility factor and degree of cross-linkage. *Table 3* summarizes the main characteristics of the latecies. The coating pigment and base paper were the same for all trial points. Dosage level of latex and starch was the same for all trial points, except for 13, were no starch was used and solebinder dosage was 1 pph-unit higher than in other trial points. Trial point 12 had a special hydrophobic additive in the coating recipe.

2.1.1 *Coating*

The coating trials for base paper experiment were carried out at Metso Paper in Järvenpää. Base papers were film coated with an Optisizer pilot coater shown in *Figure 2*. Both sides of the paper were coated simultaneously.

Coating colour was premetered onto the roll surface with a smooth rod. The target coat weight was 6 g/m² per side. In order to reach the target coat weight rod diameters were different depending on the base paper and coating colour formulation.

	Tg/MFFT (°C)	particle size (μm)
Latex A	20/18	0.14
Latex B	21/20	0.13
Latex C	0/-1	0.19
Latex D	20/18	0.14
Latex E	<0/<0	
Latex F	17/15	0.14

Table 3. Description of latecies

The nip pressure between the pivoted roll and a bottom roll was 20 kN/m and the hardness of the polyurethane rolls was 35 P&J. The machine speed during trials was 1500 m/min. After the MSP unit the web was dried with air flotation dryers and an IR dryer as shown in *Figure 2*. The target moisture content of coated paper was 6.5 %. No preheating was used at the coater. Coated papers were calendared with an Optiload pilot calender with one soft nip to a constant roughness target.

The coating for the latex trial was done at Dow Europe's pilot coating machine in Horgen. The conditions and targets were similar to the Järvenpää trials.

2.1.2 *Printing*

The press used in the printing test was a WIFAG of 790 stacked satellite type CSWO press. The press configuration is shown in *Figure 3*. The first satellite unit consists of nine cylinders and the second satellite unit of a ten cylinders. Distance between the satellite units was 6.5 m and speed of the press 7.8 m/s.

Inks used at the first satellite unit were cyan, magenta, yellow and black. Black and cyan were used at the second satellite unit. A standard CSWO additive was used in the fountain solution at 3% concentration. Conductivity and pH of the fountain solution were monitored and kept constant during the test (pH 5 and conductivity 1230 μS/cm).

Rate of deposit build-up on 1st common impression cylinder (CIC) of the 2nd satellite was evaluated (shown as criteria B on *figure 3*). As well build-up rate on blankets (criteria A) and general mailroom performance were monitored. Each trial point consisted of app. 30,000 printed copies. At the end of each trial point the printing machine was stopped and common impression cylinders were inspected and digitally imaged. Build-up rate was visually evaluated from the digital pictures. Results were expressed as build-up index in scale 1-9, where build-up index 9 was given to the lowest build-up rate ("best performance") and 1 to the highest build-up rate ("worst performance").

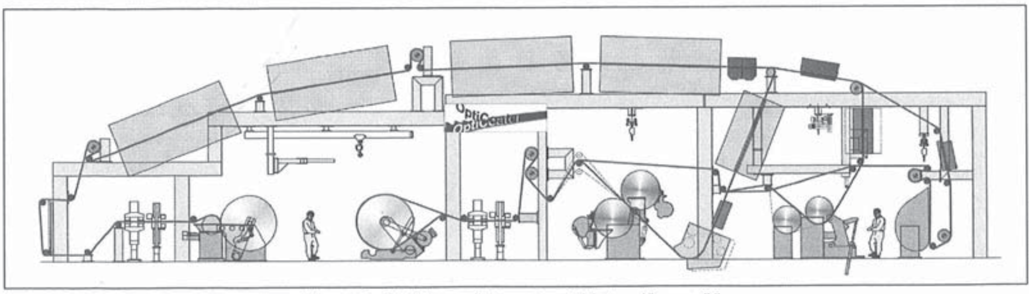

Figure 2. Optisizer pilot coater at Metso Järvenpää.

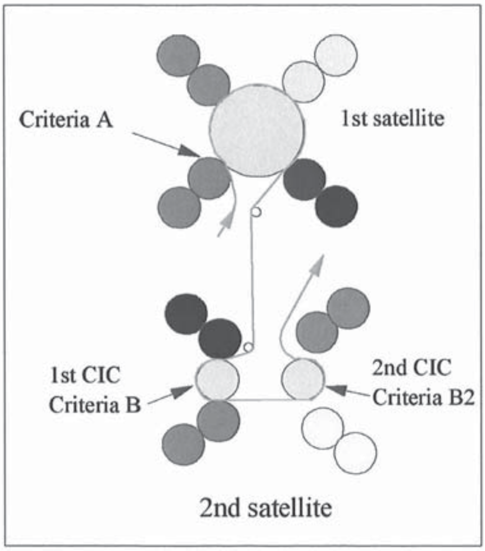

Figure 3. WIFAG OF 790 CSWO satellite printing press.

2.1.3 Analysing methods

Basic paper properties were measured at UPM Research Centre, Finland using SCAN or TAPPI standards. Absorption tests and printed paper attributes were as well measured at UPM Research Centre. Measurements for base paper included grammage, ash content, thickness, formation, Bendtsen porosity, PPS roughness, Bendtsen roughness and roughness by UBM laser profilometer. Filler distribution was analysed by using SEM/EDS images of base paper cross-sections. Coating coverage was measured using a back scattered electron mode in the SEM. As well coat weight was measured. Tensile strength, elongation and tear resistance were measured both in machine and cross-machine directions. Basic optical properties were tested from base paper. Measurements included brightness (both ISO and D65), Y-value, opacity, light scattering coefficient, absorption coefficient and L*, a*, b*-values.

Absorptivity of all papers was investigated by carrying out Cobb-Unger oil absorption, K&N ink absorption, dynamic penetration of liquids (EMCO) and contact angle measurement (FIBRO Dynamic absorption tester). Ink setting tests included ISIT and Prüfbau testing.

A special ink setting test (penetration rate and rheology change) was carried out to all coated papers at Sun Chemical's Coldset centre in London. This test gave information about the ink penetration rate (no pressure applied) and changes in ink rheology, while it had been in contact with paper surface. The testing was performed according to Sun Chemical's standard procedure.

Printed paper attributes were measured from a specially designed test form where it was possible to measure dot-gain, contrast, print-through and set-off. A visual inspection of the printed samples was as well carried out.

3 Results and Discussion

The difference in runnability between the tested papers was seen in CIC build-up tendency (criteria B). Mail room performance and blanket build-up behaviour were good for all tested papers. In printed paper attributes differences could be seen in set-off, print-through and contrast.

3.1 Influence of base paper to printed paper attributes-trial points 1-4

When same coating colour is applied on two different base papers, they do not produce the same printed paper attributes as *figure 4* shows.

Base paper 4 shows a clear improvement in contrast, when coating colour is changed from CC2 to CC1. At the same time the coating coverage improves. Base 3 does not show the same response in contrast or in coating coverage. Interestingly it can be seen from *figure 4* that when same coating colour is applied to two different base papers, the difference in contrast was up to 15%.

Same phenomena can partially be found in set-off and print-through. As *figure 5* shows, coating colour modification has smaller influence on the coverage of base 3 than on base 4, but base 3 seems to be otherwise sensitive to changes in coating colour, which is why similar change in set-off and print-through can be seen on both base papers. This could mean that the ink-setting mechanism of coated surface of base 3 is different than of base 4.

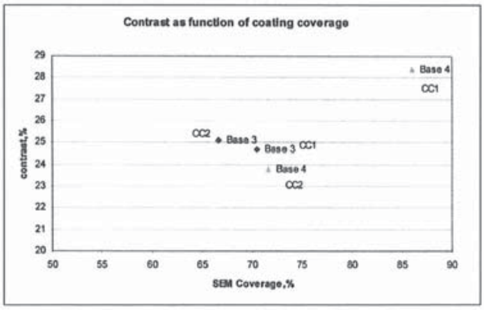

Figure 4. Contrast (75% coverage) of black test areas as function of coating coverage

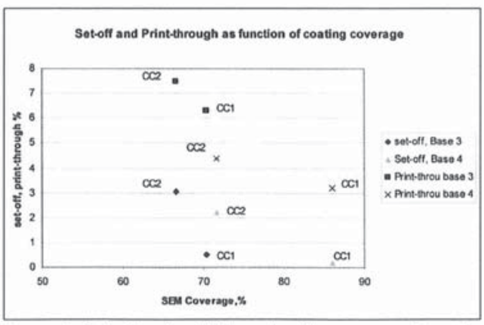

Figure 5. Set-off and print-through of base papers 3 and 4 in combination with coating colours CC1 and CC2

By looking at *figure 6*, it can be seen that the general set-off level is very low. The set-off behaviour of the two base papers when coated with same coating colour is slightly different. Set-off and ink penetration are increasing when coating colour 1 is changed to coating colour 2 on base 4. Coating colour 2 gives higher set-off on base 3 as well, but ink penetration is not much changing. The differences in ink penetration could be explained by differences in roughness volume of the surface, which is influenced by coating coverage. As *figure 5* shows, the coating coverage of base 4 increases significantly when changing CC2 to CC1. Ink penetration is decreasing accordingly on base 4. Increase of Set-off in base 3 coated with CC2 is caused by a different mechanism while coating coverage for base 3 stays below 70% with both coating colours, and ink penetration stays constant.

3.2 ISIT results - Ink setting of CSWO ink on matt LWC substrate

In ISIT device a thin ink film is transferred twice. First transfer occurs at the printing nip (from ink roll to paper). Second transfer is from paper substrate to tack wheel. Usually, when testing HSWO materials, the film transfer between paper and tack wheel is in region II and the film transfer is influenced by absorption properties of the paper substrate. The spring of the tack wheel records differences in the second film transfer. If the film transfer was independent of the base paper, same coating colour on different base should give similar correlation between set-off and max tack force, for example. As *Figure 7* shows in this experiment correlation of ISIT Max tack force to set-off (paper-to-paper) is very questionable and gives contradictory results when same coating colours are applied on two different base papers.

Explanation for this result could be the differences between CSWO and HSWO process materials in combination with matt LWC paper substrate. The oil content of CSWO ink is lower than in HSWO inks, which partially explains why its rheology is different as well. This means that behaviour of these two inks under pressure is different. When the CSWO ink is applied on matt LWC which has relatively low coating coverage it creates a combination, where film transfer stays in the 1st region, as defined by Nordström *et al*[18]. This means as a consequence that filling of the pores with ink and the ink coverage of the surfaces is incomplete and the characteristic structures of the involved surfaces dominate the film transfer. It means further that in this case the ISIT is not measuring differences in film transfer caused by different absorption properties of the paper substrate, but rather differences in ink film coverage of the paper substrate in contact with ISIT tack roll. Therefore the incomplete ink film coverage combined with unrealistic compressing forces applied in ISIT testing could be the reason, why the max tack force measured at base 3 does not show any significant change between CC1 and CC2, while set-off value of the printed sample changes.

In the case of HSWO inks and LWC paper in printing nip or in ISIT testing, the combination of ink film properties and area/volume properties of the substrate keep the film transfer conditions most likely in region II (or eventually in region III), where a continuous ink film is formed and the film immobilization and the ink transfer are mainly determined by absorptive and volumetric properties of the substrates. The proportion of oils in HSWO inks (up to 80%) is together with coating and/or surface structure and chemistry of the surface determining the absorptive characters and thus the ink film transfer and immobilization.

3.2.1 CIC build-up as function of ISIT Max tack force

The formation of positive ink build-up on the surface of the CIC of a satellite type printing machine can as well be considered to be a thin film transfer process. The first film splitting in printing nip has left behind a thin ink film on the paper substrate. The fluid properties of the ink have changed during the delay (1 s) between 1st and 2nd printing satellite. The area/volume properties of the surfaces (printed paper and steel cylinder) in the second satellite are different than in the first printing nip (blanket and paper substrate).

Positive build-up rate seem to vary as function of max tack force on base 4 as *figure 8* shows. On the other hand the low coating coverage of base 3 leads to incomplete ink film coverage at ISIT printing. This could further explain why positive build-up rate of base 3 seems to be independent of max tack force measured with the ISIT device. Ink consumption recorded during ISIT printing was 15% higher for CC1 than for CC2 on base 3, which could mean bigger surface volume and

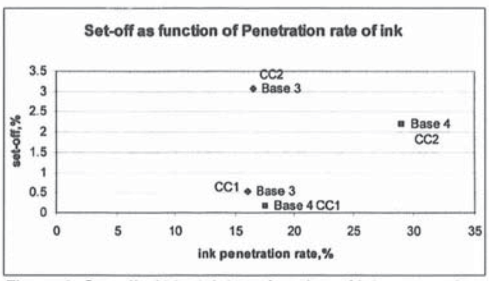

Figure 6. Set-off of black ink as function of ink penetration rate

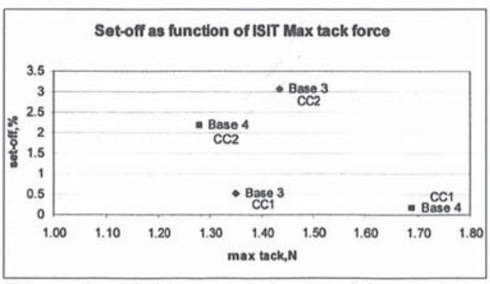

Figure 7. Set-off of Black ink as function of ISIT max tack force

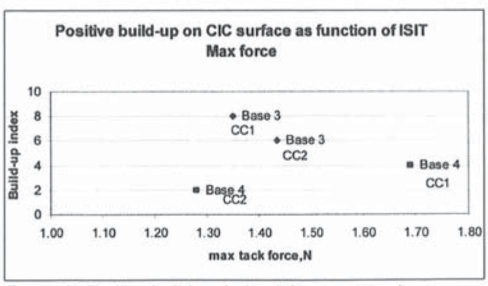

Figure 8. Positive build-up index (bigger means less build-up) as function of ISIT Max tack force.

roughness for CC1. This could indicate that contact area between paper surface and steel cylinder surface in the first nip of the second satellite of industrial scale printing machine is bigger for CC2 leading to bigger build-up, as *figure 8* shows.

One explanation can be as well the differences in compressing radial forces between ISIT and commercial CSWO printing machine. These forces have significant influence to positive build-up rate. The tack wheel nip at ISIT device has lower radial forces than the steel-blanket printing nip at commercial printing machine.

The ISIT measurement does not tell if the detected tack forces are created in the ink-film splitting or in the separation of the ink film from the coating-fibre matrix. Chemical analyses of the positive build-up collected from the CIC of the commercial printing machine show, that it contains inorganic coating pigments (majority) and organic compounds of printing inks. This could mean that CIC build-up is caused by pigments loosening from the fibre matrix and further attaching to the CIC's surface with ink. No explanation was found for the behaviour of base 4. On base 4 increasing max tack force gives less build-up.

Further investigations with three other base papers were carried out, as *figure 9* shows. The coating coverage of these papers was between 60% and 72%. These results show that when max tack force increases the build-up at printing machine increases as well. It is not possible to say exactly why this correlation exists, but one explanation could be that when ink film coverage at paper surface increases, the measuring wheel at ISIT testing has increasing contact area with ink instead of fibres and fillers, which increases the detected force. The same could happen at the printing machine: if filling of the pores and holes with ink is increasing, the ink will be squeezed in contact with the surface of the steel cylinder at the second satellite. This offers bigger contact area between low surface energy ink and the steel cylinder surface resulting in pigments attaching to the steel cylinder.

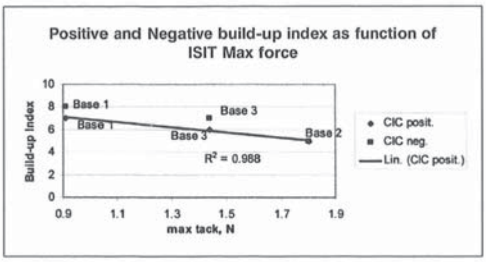

Figure 9. Negative and Positive build-up index (bigger means lower build-up rate) as function of ISIT max tack force of coated paper.

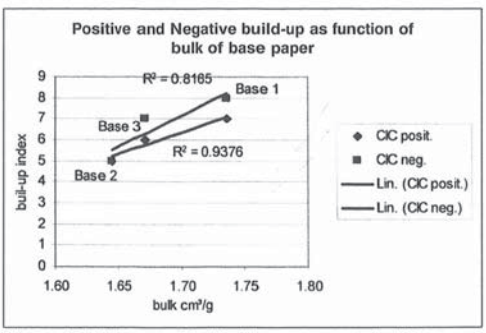

Figure 10. Influence of bulk of base paper to build-up index on the CIC surface (positive and negative, higher index means lower build-up rate).

3.3 Influence of base paper to deposit build-up rate

The next trial series with three different base papers (same fibre raw material) showed that bulk, Bendtsen porosity, oil and water absorption and surface properties (measured as contact angle for water) of the base paper influence both positive and negative build-up rate, when coating colour was kept constant. Base paper with higher bulk results in smaller ink build-up rate (positive and negative) as *figure 10* shows. Most likely bulk is related to contact area during film transfer at coating and later during the film transfer in printing. Bulk differences between base papers were not levelled out during coating and calendaring process, as *figure 11* illustrates.

The absorption properties and free surface volume in the surface of base paper seem to influence the film transfer in coating and thereby affect the rate of positive and negative build-up of the final product, as can be seen from *figure 12*.

The coating process does not seem to change the differences in absorption and free surface volume detected in the base paper.

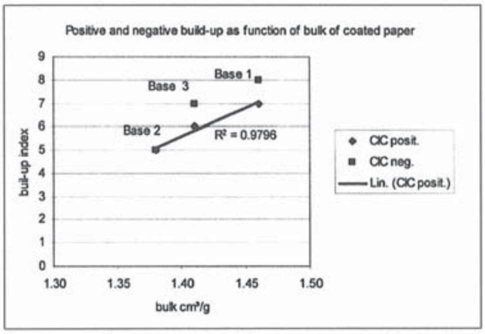

Figure 11. Influence of bulk of final paper to build-up index on the CIC surface (positive and negative, higher build-up index means lower build-up rate)

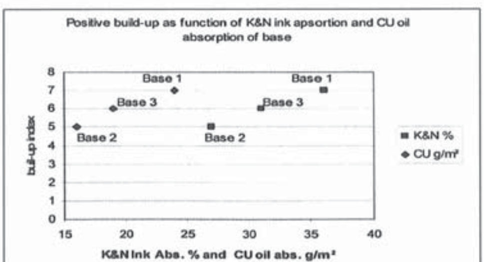

Figure 12. Positive and negative build-up index (bigger means slower build-up rate) as function of K&N ink absorption and Cobb-Unger oil absorption of the base paper.

The build-up rate of final product decreases when its ink absorption rate increases, as *figure 13* shows. This result could indicate that when coating coverage stays incomplete, the base paper properties dominate the volume/contact area properties of the final product in printing nip. As a consequence the ink film transfer, which is influenced by volume/area available in the substrate, and the build-up rate are depending on the base paper properties.

Porosity of the base influences most likely both film transfers: coating colour and ink. This can be seen from *figures 14 and 15*. *Figure 14* show that porosity of base influences build-up rate of the final paper. *Figure 15* shows that porosity differences between the base papers are not levelled out at coating.

Interestingly it seems to be that in this experiment, the desired low build-up rate is reached with high porosity base paper, although it is often stated generally in the literature that for lithographic printing of LWC grades closed and dense base paper in combination with film coating gives best results /9/.

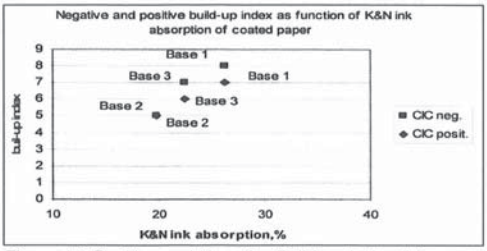

Figure 13. Positive and Negative Build-up index (bigger means slower build-up rate) as function of K&N ink absorption rate of coated paper

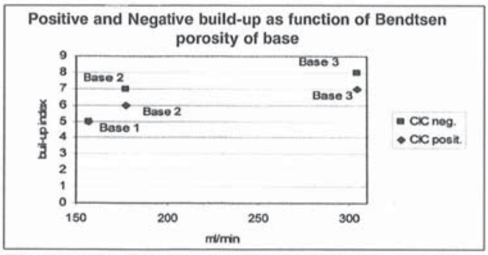

Figure 14. Positive and negative build-up index (bigger means lower build-up rate) as function of base paper porosity.

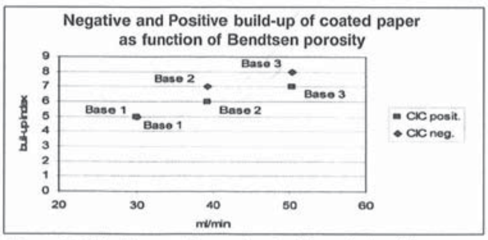

Figure 15. Positive and negative build-up index (bigger means lower build-up rate) as function of coated paper porosity.

The results of this study support the hypothesis that runnability of matt LWC grade in CSWO printing, is depending on the base paper characteristics.

3.4 Influence of base paper to print quality, constant fibre raw material

When the fibre raw material was constant, the base paper influenced contrast, print-through and set-off of the defined printed paper attributes. Main variable influencing printed paper attributes was ash content of base sheet. It influenced contrast and print-through as *figures 16 and 17* show. When ash content in base increased, the contrast of final product improved.

Print-through was decreased when ash content of the base increased, as *figure 16* shows.

Also the contact angle results of the base correlated with the print-through, as can be seen from *figure 18*. Oil or ink absorption rates did not correlate with print-through in this experiment.

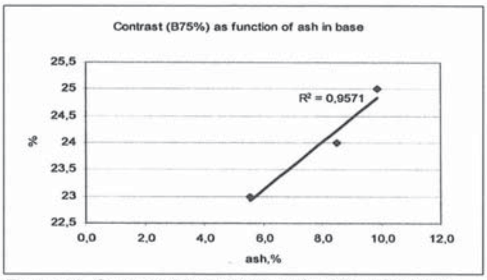

Figure 16. Contrast (black, 75%) as function of ash content of base sheet.

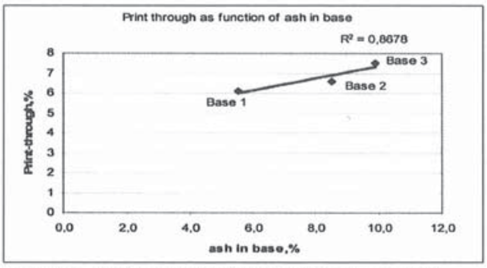

Figure 17. Print-through as function of ash content in base sheet

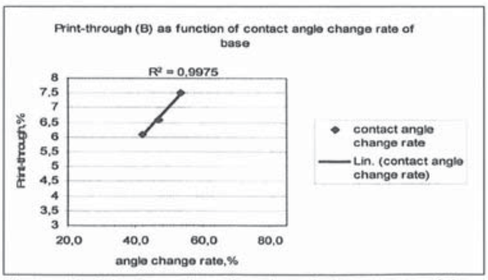

Figure 18. Print-through as function of change rate of the contact angle of water with base sheet. (Fibro measurement).

Set-off was influenced by base paper formation in this experiment, although it has to be considered that differences in both formation and set-off were small. *Figure 19* shows that increased formation index decreased set-off. It could be that grammage variation somehow increases the roughness volume of the surface of base paper. This could be through local variations in density at the surface, which further influence film transfer in coating. As a result a different surface roughness volume and density of the final product is produced and it further modifies the film transfer in printing nip.

3.5 Influence of latex to deposit build-up rate

Build-up rate (positive and negative) of matt LWC grades in CSWO printing is not greatly influenced by single latex variables, except for particle size of latex. As *figure 20* shows, it looks like increasing particle size of the latex along with improving its interaction with coating pigments, gives slightly lower negative build-up rate.

3.6 Influence of latex to printed paper attributes

Contradictory to earlier studies[12,17] small changes in degree of cross linking, degree of softness or particle size of latex did not show any influence to most printed paper attributes (contrast, set-off or print-through) in this study. Only dot-gain showed some response to latex variables. Decreasing minimum film formation temperature of the latex slightly reduced dot-gain, as *figure 21* shows.

Increasing particle size slightly reduces dot-gain, as *figure 22 shows.*

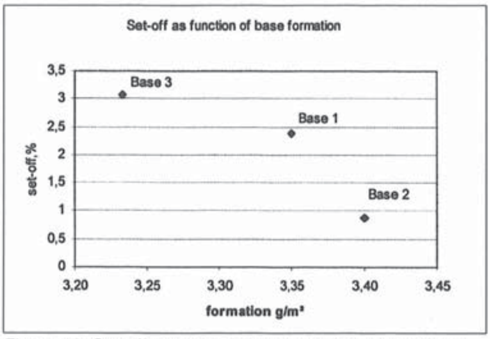

Figure 19. Set-off measured at printed samples as function of base paper formation index

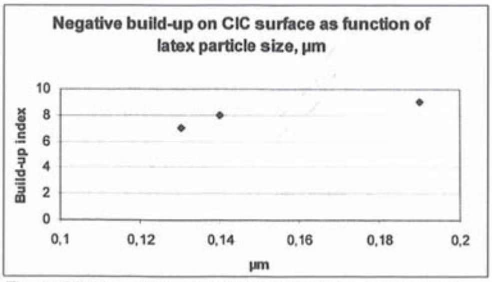

Figure 20. Negative build-up rate (bigger means lower build-up rate) as function of particle size of latex

4 Conclusions

Applying ink on the surface of matt LWC in CSWO printing is a thin film transfer process. Based on results and findings of this study it looks like the filling of pores with ink and the ink film coverage of the paper surface is incomplete, if coating coverage of the paper is low (<75%). Therefore the characteristics of the involved surfaces determine the ink film transfer at the printing nip. The situation can be slightly different when coating coverage increases. Based on the results of the ink penetration tests it could be possible that when coating coverage is higher (>75%), the filling of the pores and the ink film coverage becomes more complete and the film transfer conditions are approaching region II, as defined by Nordström *et al.*[18] Even though differences in ink transfer occur when coating coverage is changing, no evidence was found that increasing coating coverage alone would generally result in better printed paper attributes and runnability of the matt LWC grades in CSWO printing. The hypothesis that coating coverage influences printed paper attributes and build-up rate of matt LWC in CSWO printing proved to be correct.

It was proven that base paper characteristics influence both printed paper attributes and build-up rate of the matt LWC paper in CSWO printing (satellite type printing machine). Filler content of base paper had biggest influence to printed paper attributes. Increasing filler content improved print-through and contrast. Set-off was only influenced by formation of base paper. Density and porosity of base paper did not influence printed paper attributes in this study.

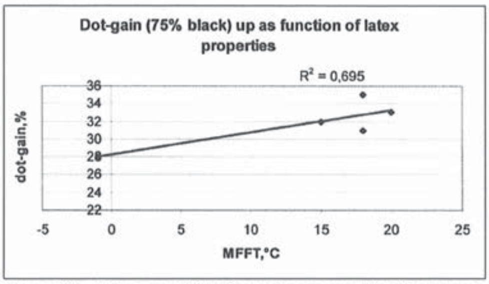

Figure 21. Influence of film formation properties (temperature) of the latex to dot-gain (75% coverage, black) of matt LWC grade in CSWO printing.

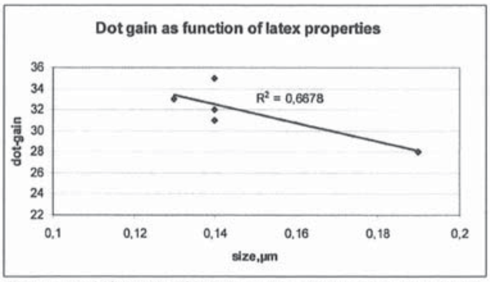

Figure 22. Influence of latex particle size to dot-gain (75% coverage, black) of matt LWC grade in CSWO printing

	Bulk	Filler content	Bendtsen roughness	ink abs.	Oil abs.	Formation	air permeability
Build-up rate	XX			XX	XX		XX
Set-off		XX				XX	
Print-through		XX					
Contrast		XX					

Table 4. Most important base paper characteristics' influencing printed paper attributes and build-up rate of matt LWC paper in CSWO printing

High bulk, porosity and absorption of ink and oil of the base paper decreased build-up rate. *Table 4* summarizes the influence of most important characteristics of the base paper to the printed paper attributes and build-up rate.

It was proven that latex type has some influence on build-up rate of matt LWC paper in CSWO printing. Printed paper attributes were not much influenced by latex variables, only dot-gain showed some response. Film formation characteristic and particle size of the latex had some influence on dot-gain. It can be concluded that high particle size of latex combined with good film formation characteristics have positive influence to printed paper attributes and build-up rate of matt LWC grades in CSWO printing.

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