Optimised Precoats for Multilayer Coating

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ABSTRACT

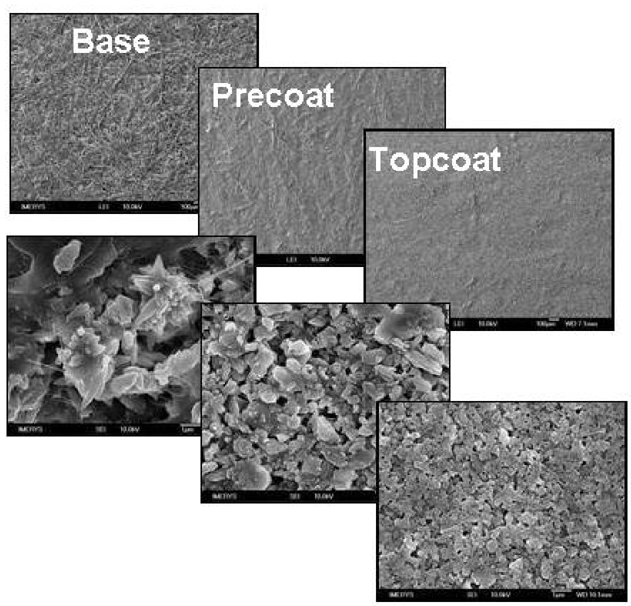
In today's fine paper and coated board markets we now believe it can make more sense to use the functionality of kaolin in precoating rather than in topcoating. While carbonates can be made fine enough to deliver gloss they cannot be modified sufficiently in shape to improve coverage . As a result, we conclude that the value of kaolin in today's cost focussed coated fine paper market is therefore in its ability to cover the surface, not in its ability to generate paper gloss.

In this paper we show how low levels of kaolin (20-25 parts) can improve precoat coverage and evenness through pilot coater evaluations of different precoat concepts on a fine paper and board basestocks. We go on to explore the impact of precoat design on finished paper properties through a series of laboratory studies in which topcoat pigment selection and formulation was varied. We show that using optimised precoats can give more degrees of freedom for reducing kaolin and binder in the topcoat which can lead to improved quality or reduced cost in regions where imported kaolin is significantly higher in price than local carbonates.

INTRODUCTION

Much of the coated woodfree and board produced globally is multi-coated with two or three coating layers applied to each side of the paper.

Figure 1. SEM of Woodfree Base, Precoated and Topcoated Paper



In multilayer coating, coverage and performance is built up in layers. The role of the precoat and mid coat layers is principally to provide physical coverage of the base and optical performance, while the role of the topcoat is to produce the desired surface finish (gloss, silk or matt) and printability.

Now, however, cost considerations have become paramount. As a result in the majority of multilayer applications today, the precoat is based on 100% coarse, inexpensive carbonate. Likewise topcoat formulations have also been impacted by cost reduction initiatives. In most regions today glossing kaolin is significantly more expensive than standard fine carbonates. As a result there have been clear trends to reduce or eliminate glossing kaolin in topcoating and kaolin-free topcoating concepts have now become well established on many large machines in Europe and Asia.

Although low-kaolin or kaolin-free topcoating is well established, it is not without its difficulties. Developing sheet gloss and print gloss remains a challenge and often requires significant reformulation in terms of binders and additives. Porosity control and mottle tendency can also be an issue. Often solving these problems can lead to increased formulation costs, which can offset the margins associated with fine kaolin reduction. There is also a risk that a paper or boards brand image can suffer if printability and quality issues persist.

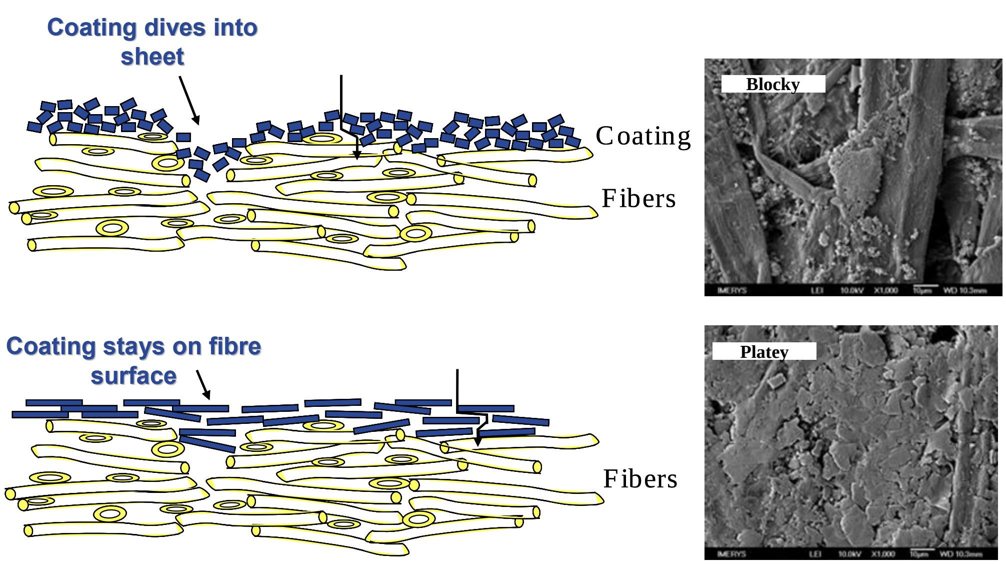
In many cases, the problems associated with low-kaolin topcoating can be linked to base effects, unevenness in the coating layers and their porosity characteristics. Achieving good base coverage is often central to these issues. In this respect focusing on improving the precoat, rather than the topcoat itself can lead to the best overall solution.

In this paper we show how low levels of kaolin can improve precoat coverage and evenness through pilot coater evaluations of different precoat concepts on fine paper and board basestocks. We go on to explore the impact of precoat design on finished paper properties through a series of studies in which topcoat pigment selection and formulation was varied. We show that using optimised precoats can give more degrees of freedom in topcoat formulation design for improving quality or reducing cost.

COVERAGE AND BULKING EFFECTS IN PRECOATING

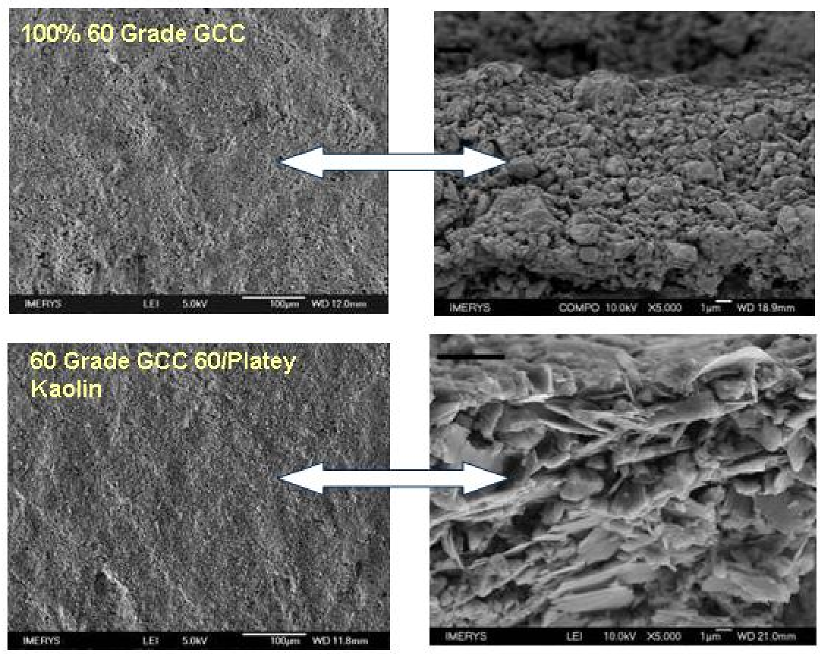
Pigment selection for precoating will certainly have a marked influence on basepaper coverage and its ability to provide a good barrier layer for topcoat application. When considering the coverage and barrier aspects of a precoat it is well known that kaolin can have a significant influence on coverage [1,2] as illustrated below in Figure 2. This is true even when the kaolin is used at relatively low levels in the recipe

Figure 2. Shape Effects on Coverage



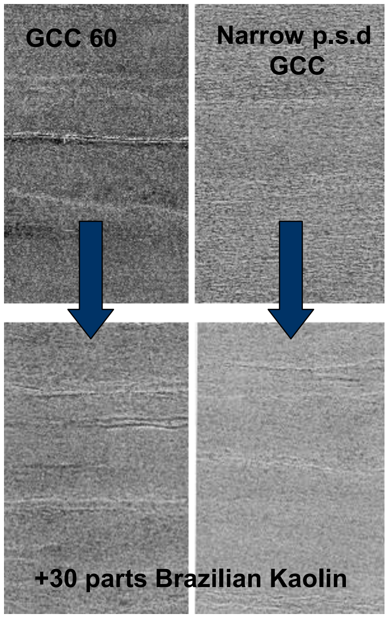
In addition to the coverage aspects, high aspect ratio kaolins can also give a bulky structure when combined with GCC. This will further improve coverage, but also improve optical performance through increased light scattering. As a result, it can often provide better hiding of a mottled base which is a significant benefit in the board and packaging sector. However, the structure will also retain a high degree of tortuosity making fluid flow and migration of topcoat binders more difficult. This is illustrated below in Figure 3 which shows surface and cross-sectional SEMs of precoats based on 100% coarse GCC and coarse GCC combined with 50 parts of high aspect ratio kaolin.

Figure 3. Bulking Effects of High Shape Kaolin and GCC



An illustration of the optical and coverage benefits associated with combinations of kaolin and GCC was very evident in a woodfree metered size press precoating study which was carried out at pilot scale (Figure 4). Inclusion of 30 parts of kaolin in the precoat gave much improved coverage when to either standard or narrow p.s.d. (engineered) GCC. The results showed significantly improved smoothness in the precoated paper even though the applied coating solids were lower. The structuring effect was also evident when assessing the balance between brightness and opacity. Kaolin addition to standard GCC had only a minor impact on brightness but increased opacity by 1 unit. Similar effects were also seen when kaolin was added to narrow p.s.d. carbonate. However, one telling comparison is that of standard GCC and kaolin with 100% steep carbonate. In this case it is evident that the recipe with kaolin gives much better coverage and smoothness and similar opacity to the engineered carbonate with only 1 unit lower brightness. The improved coverage and smoothness may enable kaolin to be reduced in topcoating while still maintaining gloss targets. This would likely compensate for the brightness loss and further lower the pigment cost across both coating layers.

Figure 4. Coverage and Optical Effects in MSP Precoating



Formulation	Solids (wt%)	B'ness (-UV)	Opacity	PPS (µm)
Coarse GCC (60)	70.8	85.2	85.6	6.0
Narrow p.s.d GCC (95)	65.6	85.9	86.6	5.7
70:30 Standard GCC/ Platey Kaolin	64.9	84.9	86.6	4.9
70:30 Narrow p.s.d. GCC/ Platey Kaolin	63.1	85.7	87.3	4.6

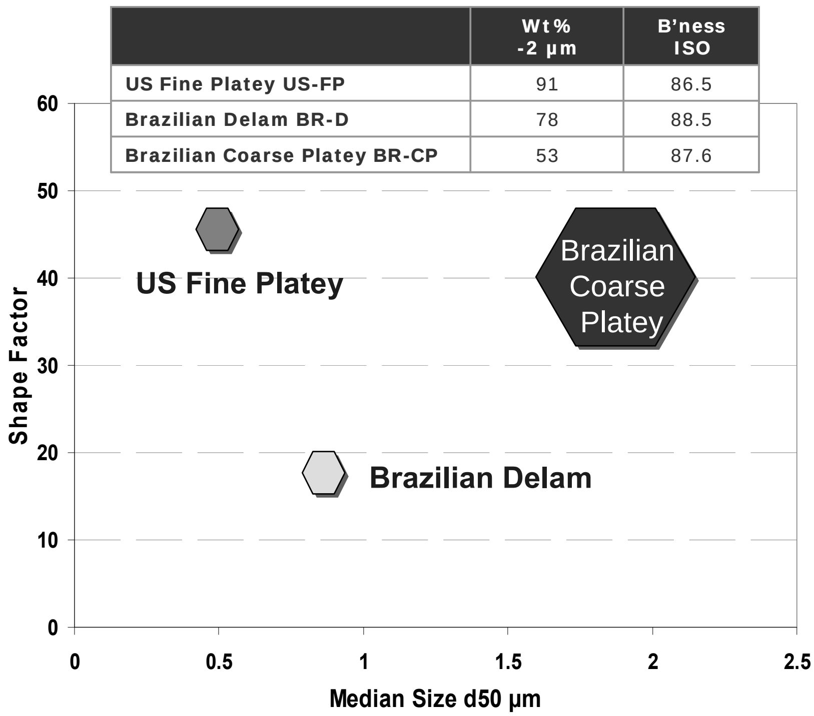
Pilot MSP Precoat Example 1500 m/min
Latex/Starch recipe
10 gsm coatings

So in summary it is apparent that kaolin use in the precoat can improve coverage significantly compared to 100% carbonate based precoats. The key to the improved coverage lies in the aspect ratio of the kaolin, with higher shape kaolins better than lower shape kaolins. An additional benefit is the structuring effect of kaolin and GCC which increases precoat bulk, coverage and optical properties and goes some way towards matching the performance of engineered carbonates. However, these conclusions are based on a range of generic studies each of which was limited in scope. Recent work has therefore focussed on more systematic studies at pilot and laboratory scale to try to understand how kaolin choice influences performance in precoating when used at a common (low) level in the recipe and how this can effect the finished paper and board quality.

PILOT COATER PRECOATING STUDIES – COATED WOODFREE

A pilot coating study was conducted at KCL in Finland to assess precoat kaolin options when used as a low level blend component with GCC (60<2µm GCC was used). Blade coating onto a European woodfree basepaper was carried out at 1200m/min using a jet applicator to give coatweights of 9gsm to the topside. The back side in all cases was coated with a 100% reference GCC formulation. The kaolin options were carefully selected with a view to giving good physical coverage of the base sheet even at low addition. Pigment and formulation details are shown in Figure 5 and Table 1 below.

Figure 5. Precoat Kaolin Properties



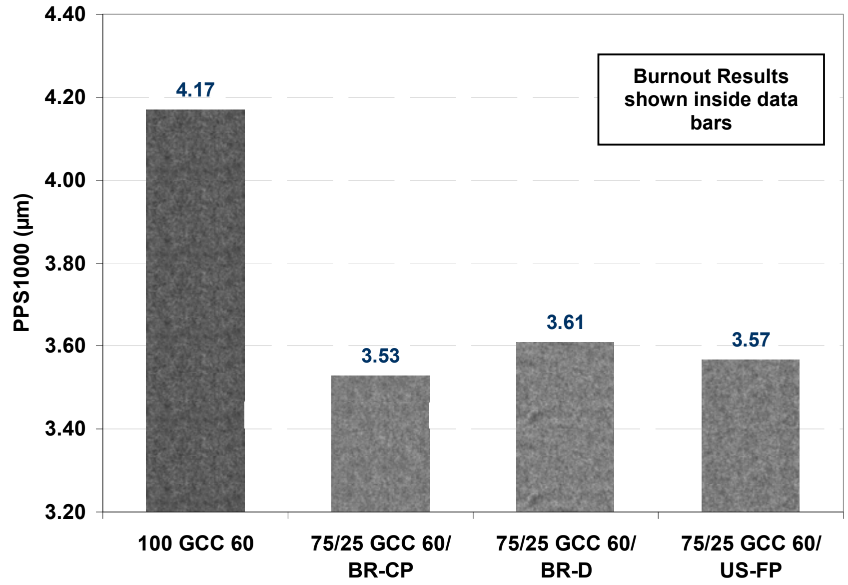
	Wt% -2 µm	B'ness ISO
US Fine Platey US-FP	91	86.5
Brazilian Delam BR-D	78	88.5
Brazilian Coarse Platey BR-CP	53	87.6

Table 1. Formulation Details for Pilot Precoating

	1	2	3	4
US Fine Platey US-FP				25.0
Brazilian Delam BR-D			25.0	
Coarse Platey Brazilian BR-CP		25.0		
GCC 60	100.0	75.0	75.0	75.0
Starch	6.0	6.0	6.0	6.0
Latex	6.0	6.0	6.0	6.0
Cross-linker	0.3	0.3	0.3	0.3
Colour Solids %	66.5	65.0	65.5	64.0

The pilot precoated papers were characterised in terms of their roughness and the extent to which the coatings had covered the base paper. Figure 6 shows that the overall PPS values are improved when any of the kaolins are added to the precoat. This was also evident in the burnout tests [3] which showed that the darkened fibres were much less evident through the kaolin-containing precoats.

Figure 6: Coverage and Smoothness after Precoating



Further studies using laser profilometry and Walsh analysis [4,5] analysis sought to show precoat selection influenced roughness on different length scales. SEM analysis of coating thickness distribution [6] was also carried out. The results shown in Figures 7 and 8 clearly show that the kaolin containing precoats reduce roughness at fibre length scales and that the bulkier nature of the coating has lead to improved coating thickness as measured by optical microscopy.

Figures 7: Roughness on Different Length Scales

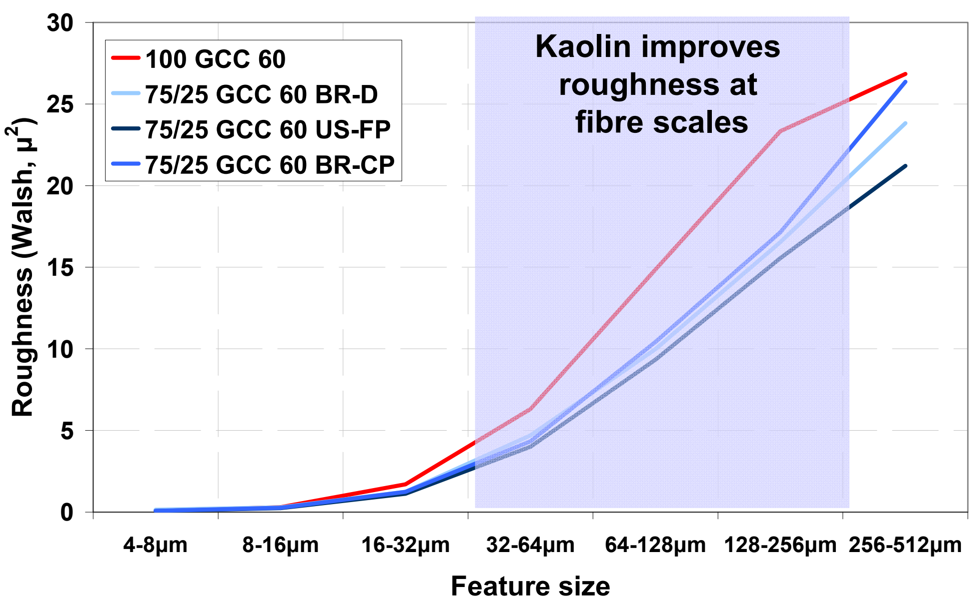
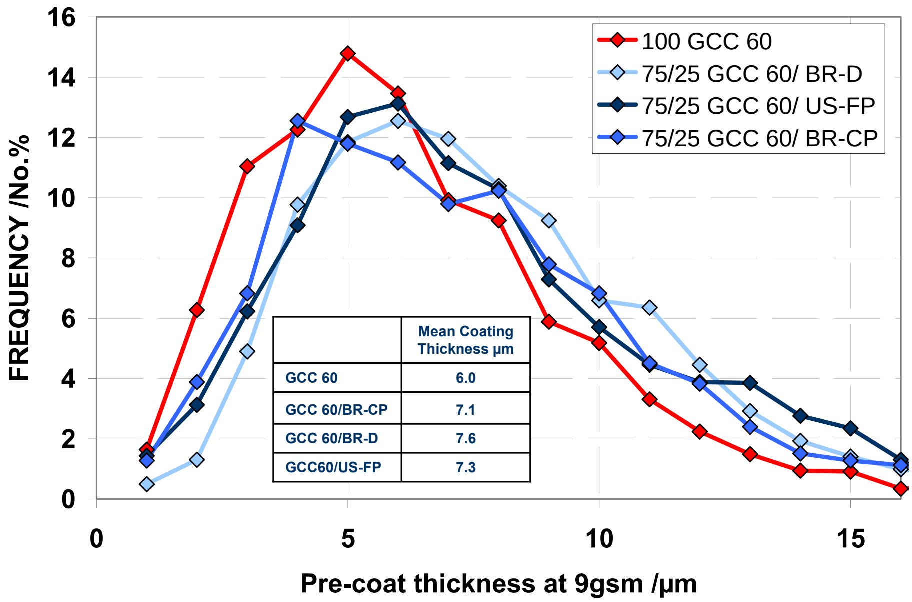


Figure 8: Coating Thickness Distribution

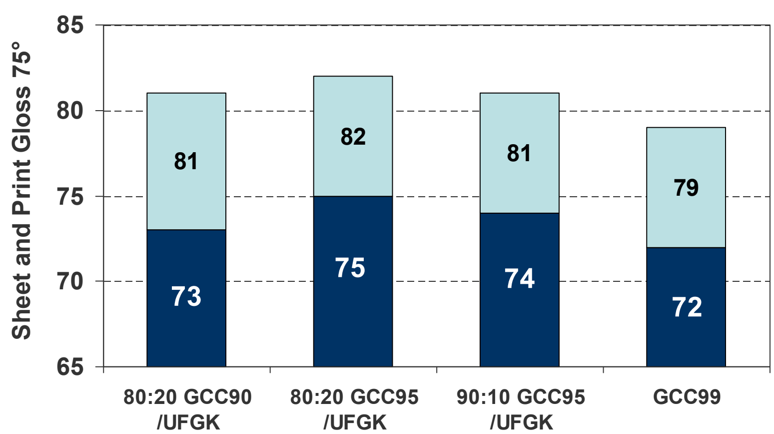


Overall, the results for these pilot precoating studies were consistent with what had been observed earlier and showed categorically that low levels of kaolin in the precoat can give significant benefits to basepaper coverage.

INFLUENCE OF PRECOAT IN GLOSSY WOODFREE

As discussed earlier, kaolin-free topcoats have become well established in multilayer coating applications. However, in many situations the degrees of freedom for using kaolin free topcoats can be limited. Paper and print gloss development remain the key challenges with these systems. This can be seen in the following woodfree example where typical fine paper topcoating recipes based on 90 and 95 grade GCCs and ultrafine glossing kaolin (UFGK) were compared with 100% ultrafine GCC (GCC 99). In this study the binder and thickener systems (latex/CMC) were kept constant for all points. Results below all refer to 11gsm coatweights.

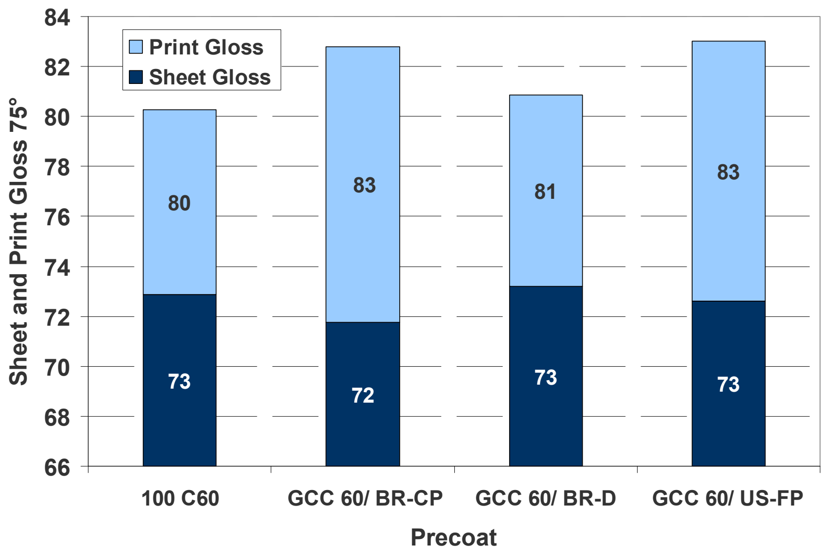
Figure 9: Gloss and Print Gloss of Topcoat Concepts



It is clear from this data that in the absence of formulation optimisation, the 100% GCC topcoat remains slightly deficient in sheet gloss and print gloss compared to standard approaches. Increasing the sheet and print gloss in the kaolin free systems can often mean changing to finer binders with lower ink interactivity while also increasing calendar load which can be detrimental to opacity and stiffness.

In the current study the influence of modifying the precoat on the performance of a kaolin free topcoat was explored using the precoated basepapers described earlier. The topcoat recipe evaluated consisted of 100 parts Ultrafine GCC, 10 parts SB latex, 0.2 parts CMC with some lubricant and immobiliser. Coatings were applied at 69% solids in the laboratory using a Helicoater™ at 1000 m/min to give 11 gsm coatweights. The resulting coated papers were then laboratory supercalendered to give gloss levels for the all carbonate reference of close to 75.

Figure 10: Effect of Precoat on Gloss and Print Gloss of Kaolin Free-Topcoat

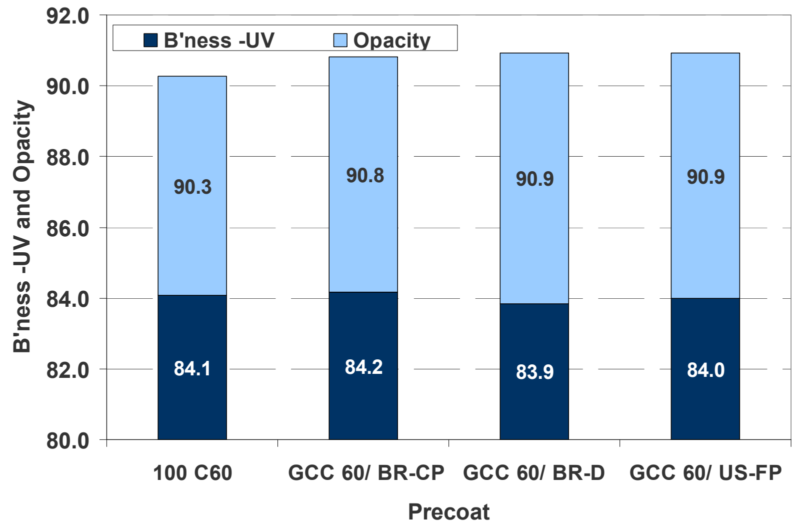


The results from this study showed that while using low levels of kaolin in the precoat had relatively little influence on the sheet gloss, there were clear benefits to print gloss. This was especially true when the precoat contained the highest aspect ratio kaolins. In some respects these results were surprising given that the basepaper used for this work was relatively smooth with a PPS 10 of only 5.6 µm before precoating. On rougher or more porous base stocks we might expect even bigger differences to be seen from adding kaolin to the precoat.

Opacity and brightness considerations are also important in coated woodfree applications. In general reducing kaolin in topcoat can be detrimental to opacity, especially if harder calendering is required to restore gloss. In this work we have seen that adding low levels of kaolin to the precoat has relatively little impact on finished paper brightness after application of the topcoat (Figure 11). This is in part due to bulk structuring (as discussed earlier) resulting in improved light scatter. This also has implications for opacity and in this work we saw close to 0.5 units increase in the finished paper from kaolin addition in the precoat. While this in itself is beneficial, as many fine papers, especially at the lighter grammages are limited in opacity, it also gives more degrees of freedom for adjusting calendering to regain gloss.

One point to note, however, is that while non-UV brightness is largely unaffected from kaolin in the precoat fluorescence can be reduced resulting in lower overall UV brightness. That said, this drop is more than offset by kaolin removal from the topcoat and could also be adjusted through changing the balance between OBA in pre and topcoat.

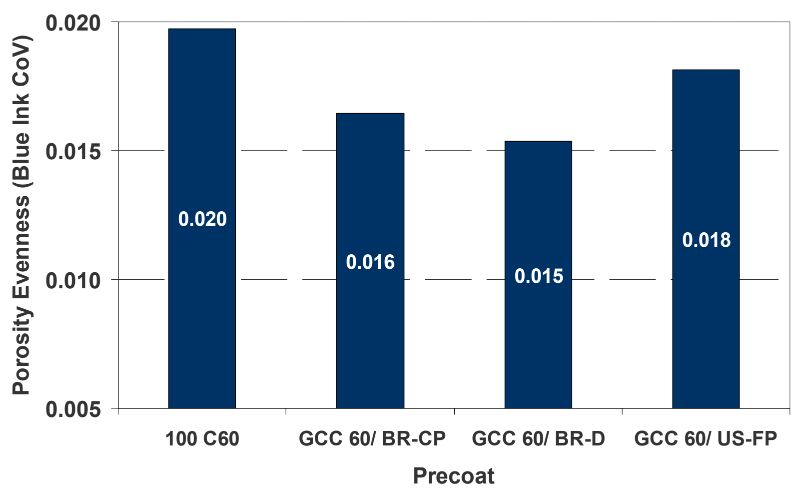
Figure 11: Effect of Precoat on Brightness and Opacity of Kaolin Free-Topcoat



A common issue cited in many coating applications is the presence of mottle. This may relate to unevenness in porosity in the coating layers or may again be due to poor coverage of basepaper unevenness. In this work we looked at the evenness of the porosity characteristics in the topcoat using an ink penetration method. Blue ink was applied to the paper with a motorised bench top blade coater so that ink which did not penetrate the surface was quickly removed by the metering blade. The resulting printed paper was then analysed for porosity evenness using image analysis techniques to assess the coefficient of variance in the ink density [7].

The results in Figure 12 show some benefits in terms of topcoat porosity evenness from adding kaolin in the precoat. The effects were most pronounced with the Brazilian kaolins and it might be expected that this could lead to a lower tendency for porosity related mottle such as secondary or backtrap mottle.

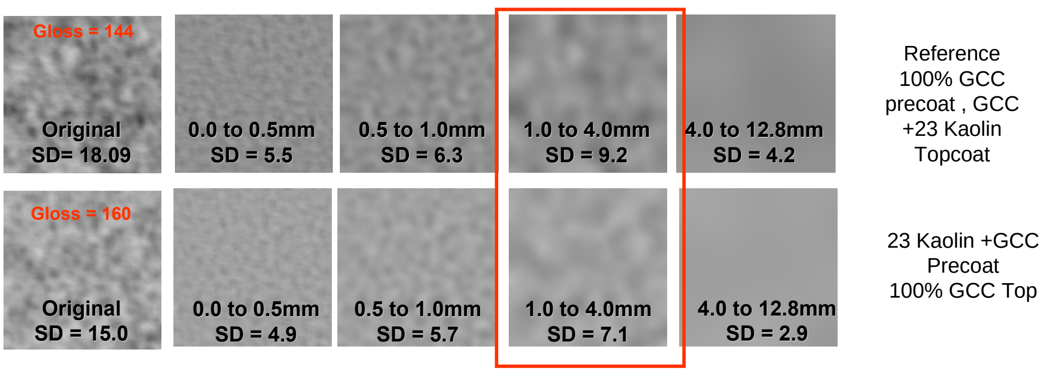
Figure 12: Effect of Precoat on Porosity Evenness



Mottle effects in relation to precoat and topcoat selection were further assessed in a separate study carried out at pilot scale with a major European coated woodfree producer. In this study 12 gsm precoats and topcoats were applied at 1800 m/min on to a 64gsm base using a jet applicator. In one situation a conventional coated woodfree recipe containing 100% 60 grade GCC in the precoat and a combination of 95 grade GCC with 23 parts of Ultrafine glossing kaolin in the topcoat was applied. This was then compared with an alternative concept based on 60 grade GCC with 23 parts of a 90 < 2 µm ultra-platey US kaolin (see Table 1) in the precoat and 100% 95 grade GCC in the topcoat. The topcoat was further optimised in terms of binders and thickeners. Latex level was reduced from 10.5 to 9.5 parts. PVA from 0.45 to 0.2 parts and CMC from 0.3 to 0.1 parts in order to reduce costs and enhance gloss development In noting the runnability aspects of the precoating and topcoating, it was observed that the kaolin containing precoat was run at 2% lower solids than the 100% GCC precoat with similar blade loads. In contrast removing kaolin, co-binder and thickener from the topcoat enabled the solids here to be increased by 3%

Gloss mottle after super calendering was determined by generating a gloss map of the using an reflectometer [8] together and then carrying out a statistical analysis of the point to point variation in gloss. This involved converting the gloss map to a greyscale image (gloss scaling to 256 grey levels: Min = 25, Max = 75) then applying a fast fourier transform to provide information about the scale of variation across the surface [7]. The result is shown below

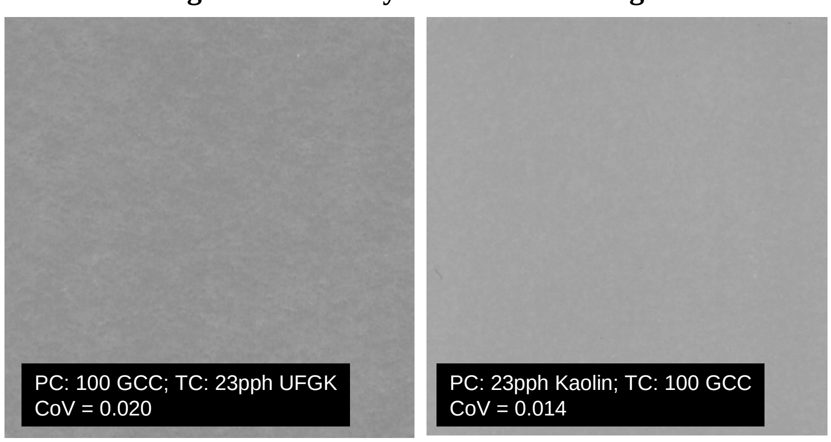
Figure 13 Gloss Mottle at Different Length Scales



The results show clearly that overall gloss mottle is reduced in the system where kaolin is used in the precoat and glossing kaolin is removed from the topcoat. Furthermore it is clear that in this case, much of the mottle occurred on lengths scales relating to formation. It was at this scale that the kaolin addition to the precoat also has the biggest positive impact.

These papers were then printed with a non-drying ink as used in the red wipe test [9]. The excess ink was then removed from the surface after a given time interval and the evenness of the print assessed. An improvement in the evenness was again seen in the system where kaolin was used in the precoat. As before the image of the printed paper has been converted to greyscale then the co-efficient of variance determined. Results are illustrated below

Figure 14 Porosity Mottle on Printing



In addition to the mottle benefits some other interesting results were seen in this trial .

Table 2 Paper and Print Properties of Contrasting Double Coating Concepts

	100% GCC Precoat	GCC/Kaolin Precoat
	GCC/UF kaolin Topcoat	100% GCC Topcoat Reduced Binder
Tappi 75 Gloss 10 ° Acceptance	77	72
Reflectometer Gloss 2° Acceptance	52	53
PPS 10 µm	0.60	0.51
D65 B'ness + UV	93.5	97.0
D65 Opacity	94.2	94.0
Print Gloss 100% Black (Commercial Press)	86*	89*
Delta Gloss 100% Black (Commercial Press)	9*	17*
Pick Strength cm/s	382	355

* Tappi 75 °

One of the more striking results is the impact on paper gloss. It was clear that when kaolin is removed from the topcoat then sheet gloss is significantly reduced. Adding kaolin back in to the precoat does little to change this when the gloss is measured using the relatively insensitive Tappi gloss measurement. However, when gloss is measured using an instrument with a much narrower acceptance angle then we can see that the gloss levels of the two approaches appear similar. This effect likely relates to the difference in micro and macro roughness in dictating the gloss. In a system where coverage is poorer, a wider angle reflectance would be expected than in a system where coverage is good and gloss is more dictated by the micro-roughness of the surface [10-12]. However, with a wider angle acceptance meter, this non- specularly reflected light can still be measured as gloss artificially inflating the gloss value. The Surfoptic gloss is perhaps then a truer measure of sheet gloss and indicates that reduced fineness in the topcoat can be compensated by reduced macro-roughness from good coverage in the precoat. This also seems to be the case when it comes to print gloss. In this study the print gloss on a commercial press was 3 units higher when kaolin was used in the precoat. This effect has been seen in several studies now. It can be speculated that either macro-roughness affects print gloss more significantly than micro-roughness, or that perhaps the improved coverage and reduced porosity in the precoat reduces effects such as fibre roughening.

Some other points to note from the data in this double coating study are slightly better smoothness from the system with kaolin in the precoat and significantly better brightness (even though OBA and activator have been reduced) and similar coating strength in spite of reduced topcoat binder.

Overall it appeared that the approach of replacing kaolin in the topcoat with kaolin in the precoat is beneficial not only to the total cost of the coating (eg reduced binder and additives) but also to the overall paper and print quality in this coated woodfree application.

In the next part of the project we sought to establish if similar observations could be made for a board and packaging application

PRECOAT EFFECTS IN MULTILAYER BOARD

As was the case with the coated woodfree studies a pilot trial was run at KCL in Finland to generate a set of precoated boards which varied in terms of the precoat recipe. The board substrate used was a white lined chipboard grade (similar to coated recycle board in North America). This was selected because coverage effects are critical in this application especially with respect to mottle generation on this lower brightness base stock.

In the pilot trial a base board with a PPS roughness of 5.2 µm and a D65 brightness (-UV) of 59.9 was used. Precoats were applied using a bent blade at 450 m/min with a solids level of 66.5%. One precoat was 100% 60 grade GCC, the others contained 25 and 50 parts of coarse Brazilian kaolin (properties shown in Table 1) together with 60 grade GCC. All recipes contained 8 parts of latex and 5 parts of starch and 0.5 parts cross-linker. Coatweight was 12 gsm. The rationale in running the trial was to select a typical solids level for the 100% GCC precoat then run the kaolin containing precoats at as close a level to this as possible without significant runnability problems. Runnability of the various trial points is summarised below in Table 3.

Table 3. Precoat Runnability

Precoat	Solids wt%	Beam Angle °	B100 Viscosity mPa.s	Observation
GCC 60	66.6	24.5	835	No streaks
GCC 60 + 25% Kaolin	66.8	27.8	970	Isolated short streaks
GCC 60 + 50 % kaolin	66.3	28.8	1060	Occasional streaks

Results suggest that the kaolin containing coatings were run at slightly too high a solids and that a 2% dilution would perhaps be needed for optimum runnability. However, this is unlikely to significantly affect the coverage aspects of the coatings which are much less sensitive to solids variation than coatings based on 100% GCC.

Subsequent topcoating was carried out in the laboratory using a Helicoater. Again 12 gsm were applied with a stiff blade in a 14 parts latex /0.3 parts CMC recipe. Two topcoat pigment systems were applied. The first was the standard concept of 95 grade GCC with 15 parts of glossing kaolin. In the second, 100% ultrafine (99 < 2 µm) GCC was used. In this case latex level was also varied between 14 and 8 parts.

Table 4. Board Trial Matrix

Precoat	Topcoat	Latex
GCC 60	GCC95/UFGK	14
GCC 60	99 Grade GCC	14
GCC 60 + 25 % kaolin	99 Grade GCC	14
		11
		8
GCC 60 + 50 % kaolin	99 Grade GCC	14

Uncalendered coated board properties are shown blow in Table 5 for coatings made with the same amount of latex in the topcoat (14 parts).

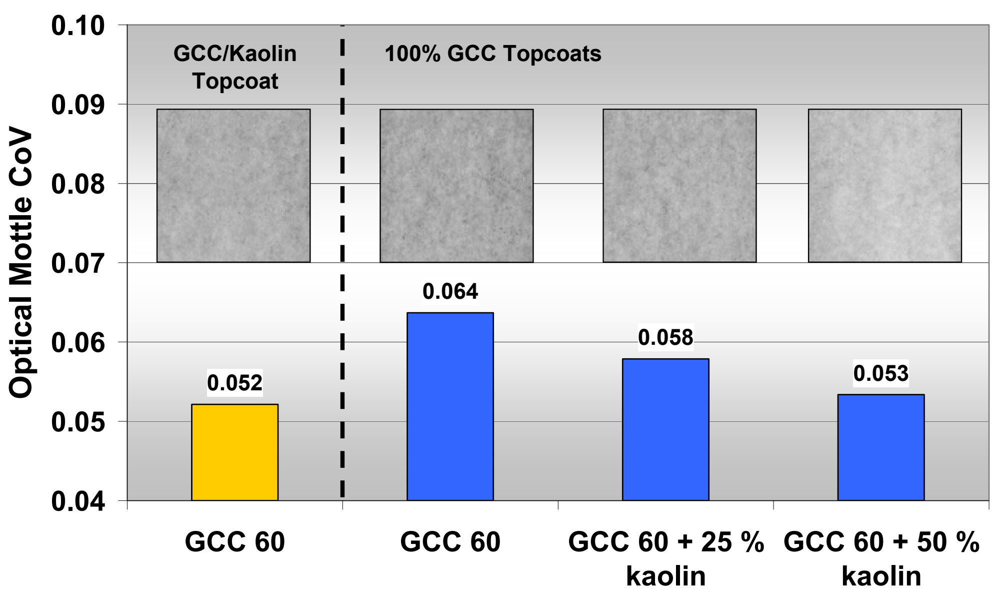
Table 5. Coated Board Properties

Precoat	Topcoat	Board Gloss	PPS 1000	Brightness D65 -UV
GCC 60	GCC95/UFGK	48	1.47	74.9
GCC 60	99 Grade GCC	47	1.47	73.3
GCC 60 + 25 % kaolin	99 Grade GCC	50	1.33	75.6
GCC 60 + 50 % kaolin	99 Grade GCC	50	1.38	77.1

The results clearly showed the importance of optical and physical coverage in this application. Both gloss and smoothness are clearly better where coarse kaolin has been added to the precoat than in the situation where the precoat is 100% carbonate. The benefits do, however, plateau and in this study 50% kaolin addition offered no real benefits over 25% in terms of physical coverage. This is in line with previous experience. The study also shows that the concept of using kaolin in precoat together with a 100% carbonate topcoat can give better gloss and smoothness than the conventional approach of 100% coarse GCC in the precoat and a topcoat based on fine GCC and glossing kaolin.

Similarly we saw benefits to optical coverage on this darker baseboard when kaolin was present in the recipe. This was the case whether kaolin was used in precoat or topcoat. In this case the benefit from kaolin continued to increase with increasing kaolin amount. 50% kaolin addition to the precoat gave nearly 4 units higher brightness than a 100% GCC precoat. The optical evenness of the finished board was also assessed. Optical maps were generated using a computer scanner where greyscale images were collected and the variation assessed using image analysis techniques (Image J [7]). The results in Figure 15 below show the greyscale images of the board surfaces together with the co-efficient of variance.

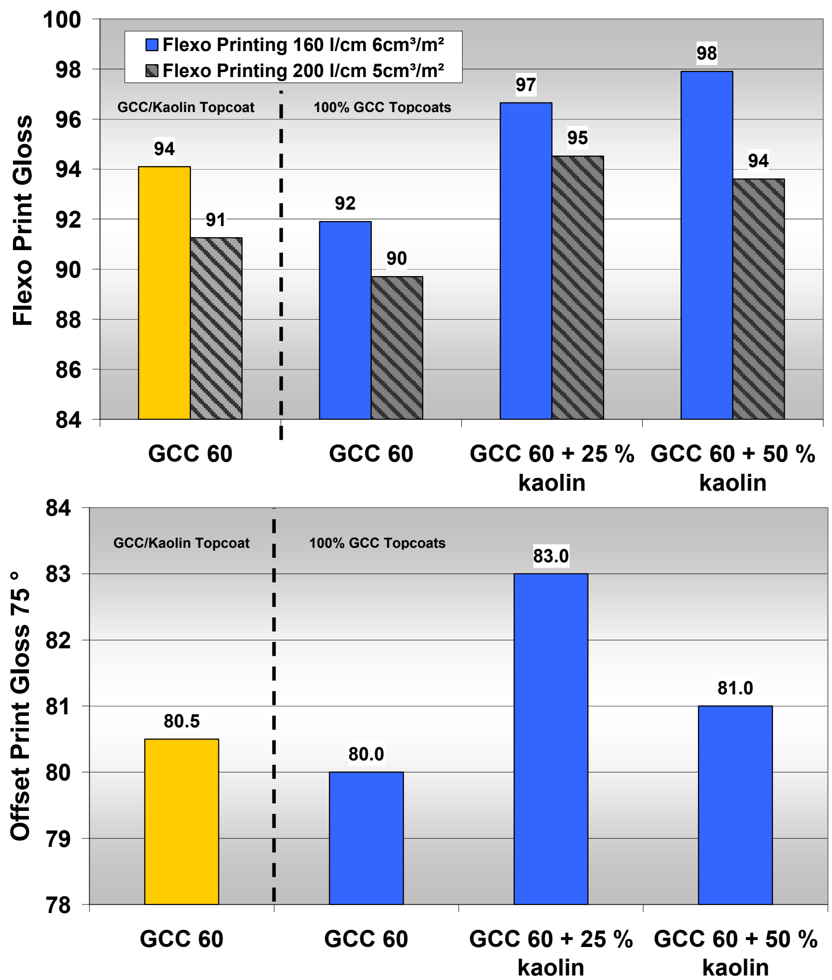
Figure 15. Optical Coverage



The results clearly show that the optical mottle is greatest in the totally kaolin free coated board and better where kaolin was present in either the precoat or the topcoat.

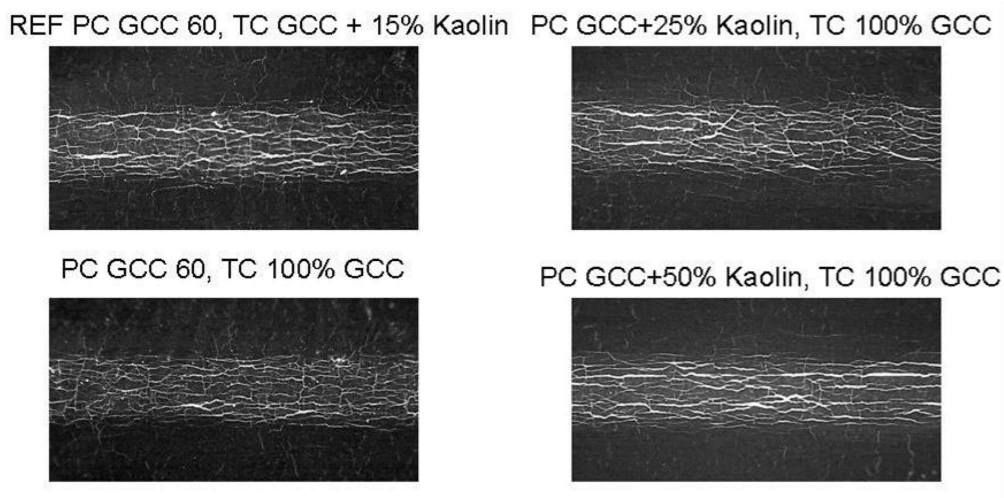
Print quality is also an important consideration and in this study the uncalendered boards were printed in the laboratory using both flexographic and offset presses. In the flexographic printing two conditions were used; 160 lines/cm with 6 cm3 ink/m2 and the more demanding 200 lines/cm with 5 cm3 ink/m2 which is more representative of higher quality end use applications. In offset printing, print gloss was determined at a constant print density of 1.5. Results are shown below in Figure 16 and once again illustrate the role kaolin can play in enhancing print gloss, especially when the kaolin is used to improve precoat coverage. In both flexographic and offset printing the coated boards based on coarse GCC and kaolin in the precoat with a kaolin free topcoat gave the best overall print gloss. Compared to a totally kaolin free concepts, this approach gave up to 3 units higher offset print gloss and up to 5-6 units higher flexo print gloss. Relative to the conventional 100% GCC precoat and fine GCC/Kaolin topcoat, offset print gloss was 2 units higher and flexo 3-4 units higher. As with the board gloss, 25% kaolin addition was sufficient to realise most of the print gloss benefits and little further gain was seen in increasing the kaolin to 50 parts in the precoat recipe.

Figure 16. Offset and Flexo Print Gloss



Another key property for coated boards is cracking resistance during folding. The boards from this study were assessed for differences in cracking tendency after printing with black ink (to enhance visualisation) and folding in a controlled way. Optical images of the cracking tendency is shown in Figure 17. From these images it was evident that cracking tendency, or at least the severity of individual cracks, is decreased when no kaolin is present in the either of the coating layers. It was, however, also apparent that moving from the conventional approach of kaolin in the topcoat to a low level of kaolin in the precoat has not impacted cracking tendency significantly even though kaolin level in the precoat was higher (25 parts compared to 15 parts in the topcoat). However, if kaolin level is increased to 50 parts in the precoat it does appear that cracking severity increases. Further work is ongoing in this area to try and understand the mechanisms related to cracking tendency and this will be reported in a further publication.

Figure 17. Cracking at the Fold



In the coated woodfree studies we showed that replacing conventional topcoat recipes with a kaolin free approach and some kaolin in the precoat could lead to reductions in the overall binder demand of the coating recipes. For coated board, the limiting factor with any binder reduction is likely to be the impact on coating crack. If, however, latex can be reduced then this will further benefit light scatter, optical coverage and gloss development. (Table 5)

Table 6. Effect of Topcoat Latex level on Board Properties

Precoat	Topcoat	Latex Parts	Board Gloss	PPS 1000 µm	B'ness D65 -UV	Flexo Print Gloss 160 l/cm 6cm³/m²	Flexo Print Gloss 200 l/cm 5cm³/m²	Offset Print Gloss
GCC 60 + 25 % kaolin	99 Grade GCC	14	50	1.33	75.6	97	95	83
GCC 60 + 25 % kaolin	99 Grade GCC	11	56	1.30	76.4	98	96	83
GCC 60 + 25 % kaolin	99 Grade GCC	8	61	1.22	77.1	98	96	83

It is clear from the data above that latex reduction has a very marked effect on board gloss and brightness without significantly impacting print gloss.

In summary, this work sought to establish whether kaolin is more effective in the base coat than in the topcoat of a multi-layer board application and what the compromises are with a totally kaolin-free approach in both coating layers.

Table 7. Multi-layer Board Summary

Precoat	Topcoat	Latex	Board Gloss	PPS 1000	Bright-ness	Mottle	Cracking	Print Gloss
GCC 60	GCC95/ UFGK	14	=	=	=	=	=	=
GCC 60	99 Grade GCC	14	-	=	--	-	+	-
GCC 60 + 25 % kaolin	99 Grade GCC	14	+	-	+	=/+	=	+
		11	++	-	++	+	-	+
		8	+++	--	+++	+	--	+
GCC 60 + 50 % kaolin	99 Grade GCC	14	+	-	+++	+	=/-	+

Note - on PPS means better smoothness

The results have indicated that going from a conventional concept with fine GCC and glossing kaolin in the topcoat and coarse GCC in the precoat to a 100% kaolin free system has both pros and cons. On the positive side there were signs of reduced cracking tendency which could lead to reductions in binder requirement and further reduce cost compared to a kaolin containing recipe. However, the compromises were clear in terms of reduced sheet gloss, print gloss and optical coverage. This suggests that this approach is probably best utilised on smoother brighter baseboards and may therefore be more applicable to the virgin fibre boxboard sector than recycled boards.

In contrast the concept of using kaolin in the precoat instead of the topcoat is probably more robust. In this case we saw that adding kaolin to the precoat gave marked improvements in sheet gloss, print gloss, smoothness and optical coverage compared to the 100% carbonate system. It also outperformed the conventional approach in all of these properties. However, the scope to reduce cost through binder reduction may well be less than with the 100% carbonate approach because there was clear evidence that kaolin in either precoat or topcoat can be detrimental to crack resistance. That said the nature of the coating crack in relation to binder reduction and kaolin level is different. More work is therefore needed in order to optimise these systems to extract the most value. However, it is clear that in terms of performance, using coarse kaolin the board precoat was clearly better than using fine glossing kaolin in the topcoat.

COST ANALYSIS

During the course of this paper we have suggested that the approach of using kaolin in precoat while replacing topcoat kaolin with fine GCC and reducing binder and additives can be a lower cost solution than the more established approaches of using 100% carbonate precoats and fine kaolin/GCC in the topcoat.

A typical example of possible recipe changes for a woodfree application is shown below. This is based on the example given in Table 2 but allowing for a finer grade GCC in the topcoat

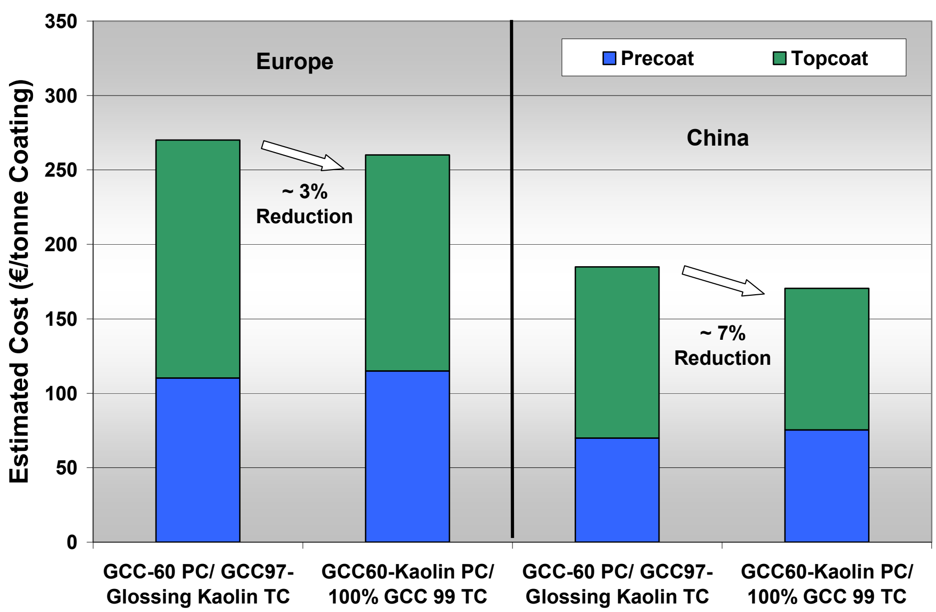
Table 8. Fine Paper Recipe Development

	Conventional		Kaolin Precoat	
	Pre	Top	Pre	Top
Coatweight	12	12	12	12
GCC 60	100		77	
GCC 97		77		
GCC 99				100
Glossing Kaolin		23		
Precoat kaolin			23	
Latex	6	10.5	6	9.5
CMC/PVA		0.75		0.3
Starch	6		6	

If we then take generic pigment, binder and additive costs for Europe and China in which the reference formulation practice is close to the example presented we find that modifying the recipe as presented above yields cost savings. The magnitude of these is shown below in Figure 18 and for a typical 500 ktpa tonne woodfree mill could represent savings of in the region of €2 million euros per annum. Of course these numbers are very subjective and will vary considerably within a given region depending on a mills location and specific pricing arrangements. Nonetheless these serve as indication of the potential.

In North America, however, the situation is very different. Coated freesheet applications are typically single coated, not double, and where double coating is carried out (principally in the board sector) kaolin levels in the topcoat are typically much higher than those presented here. It is also clear that kaolin and GCC pricing differential is much smaller in North America than elsewhere with significant regional variations with North America itself. All of this makes it difficult to translate the cost analysis to a North American situation.

Figure 18. Cost Analysis



OVERALL SUMMARY AND CONCLUSIONS

In these studies we have seen that using kaolin together with coarse carbonate in precoating applications can have a significant impact on the ability of the precoat to cover the roughness characteristics of the basepaper or board. Selecting kaolins which are relatively coarse in particle size and have high aspect ratios and hence large plate diameters are key to making this approach successful.

Good basepaper coverage is essential in maintaining quality in multi-layer coating applications and can also offer potential for cost reduction. For example improved coverage can reduce tendencies for gloss or optical mottles. Additionally, improved precoat coverage can facilitate the use of kaolin free topcoats especially on rougher bases or boards. This can bring value in many ways. In essence we are replacing high cost ultrafine glossing kaolin with lower cost precoating kaolin. In replacing the topcoat kaolin there are often benefits in terms of topcoat binder reduction, (typically 1-2 parts reduction) which will yield significant savings. Although in the board sector attention must be paid to cracking which could limit the extent of any binder reduction. We have also seen that kaolin in precoating improves print gloss with kaolin-free topcoats. This may offset the need for more expensive binders to control printability thus further increasing the cost savings with kaolin-free topcoating.

Overall it is evident that while carbonates can be made fine enough to deliver gloss they cannot be modified sufficiently in shape to improve coverage. As a result, we conclude that the value of kaolin in today's cost focussed coated fine paper market is therefore in its ability to cover the surface, not in its ability to generate paper gloss.

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